DIAGNOSTIC CODE INDEX

DIAGNOSTIC CODE INDEX

DTC	Description
B1810	DRIVER DOOR AJAR INPUT CIRCUIT LOW
B1811	DRIVER DOOR AJAR INPUT CIRCUIT HIGH
B1BE3	DRIVER PRESENCE DETECTION SENSOR PERFORMANCE
B1BE7	DRIVER PRESENCE DETECTION SENSOR CIRCUIT LOW
B1BE9	DRIVER PRESENCE DETECTION SENSOR CIRCUIT HIGH
B23BB	STOP/START DISABLE SWITCH 1 CIRCUIT OPEN
B23BC	STOP/START DISABLE SWITCH 1 CIRCUIT PERFORMANCE
B23BD	STOP/START DISABLE SWITCH 1 CIRCUIT LOW
B23BE	STOP/START DISABLE SWITCH 1 CIRCUIT HIGH
B23BF	STOP/START DISABLE SWITCH 2 CIRCUIT OPEN
B23C0	STOP/START DISABLE SWITCH 2 CIRCUIT PERFORMANCE
B23C1	STOP/START DISABLE SWITCH 2 CIRCUIT LOW
B23C2	STOP/START DISABLE SWITCH 2 CIRCUIT HIGH
B23C3	STOP/START DISABLE SWITCH 1/2 CORRELATION
B25BC	LEFT FRONT DOOR AJAR SWITCH STUCK CLOSED
B25C7	DRIVER DOOR AJAR SWITCH 2 CIRCUIT LOW
B25C8	DRIVER DOOR AJAR SWITCH 2 CIRCUIT HIGH
B25C9	DRIVER DOOR AJAR SWITCH 2 STUCK CLOSED
B25CB	DRIVER DOOR AJAR SWITCH 1/DRIVER DOOR AJAR SWITCH 2 CORRELATION
C0062	LONGITUDINAL ACCELERATION SENSOR
C0501	WHEEL SPEED SIGNAL LEFT FRONT RATIONALITY
C0507	WHEEL SPEED SIGNAL RIGHT FRONT RATIONALITY
C050D	WHEEL SPEED SIGNAL LEFT REAR RATIONALITY
C0513	WHEEL SPEED SIGNAL RIGHT REAR RATIONALITY
C053D	BRAKE PRESSURE SENSOR 1 PERFORMANCE
C0572	MASTER CYLINDER PRESSURE SENSOR CIRCUIT HIGH
C10F5	BRAKE TORQUE PERFORMANCE
P000A	BANK 1 CAMSHAFT 1 POSITION SLOW RESPONSE
P000B	BANK 1 CAMSHAFT 2 POSITION SLOW RESPONSE
P000C	BANK 2 CAMSHAFT 1 POSITION SLOW RESPONSE
P000D	BANK 2 CAMSHAFT 2 POSITION SLOW RESPONSE
P0010	BANK 1 CAMSHAFT 1 POSITION ACTUATOR CIRCUIT OPEN
P0013	BANK 1 CAMSHAFT 2 POSITION ACTUATOR CIRCUIT OPEN
P0016	CRANKSHAFT/CAMSHAFT TIMING MISALIGNMENT - BANK 1 SENSOR 1
P0017	CRANKSHAFT/CAMSHAFT TIMING MISALIGNMENT - BANK 1 SENSOR 2
P0018	CRANKSHAFT POSITION - CAMSHAFT POSITION CORRELATION BANK 2 SENSOR 1
P0019	CRANKSHAFT POSITION - CAMSHAFT POSITION CORRELATION BANK 2 SENSOR 2
P0020	BANK 2 CAMSHAFT 1 POSITION ACTUATOR CIRCUIT OPEN
P0023	BANK 2 CAMSHAFT 2 POSITION ACTUATOR CIRCUIT OPEN

DTC	Description
P0031	O2 SENSOR 1/1 HEATER CIRCUIT LOW
P0032	O2-SENSOR 1/1 HEATER CIRCUIT HIGH
P0037	O2-SENSOR 1/2 HEATER CIRCUIT LOW
P0038	O2-SENSOR 1/2 HEATER CIRCUIT HIGH
P0051	O2-SENSOR 2/1 HEATER CIRCUIT LOW
P0052	O2-SENSOR 2/1 HEATER CIRCUIT HIGH
P0057	O2 SENSOR 2/2 HEATER CIRCUIT LOW
P0058	O2-SENSOR 2/2 HEATER CIRCUIT HIGH
P0069	MANIFOLD PRESSURE/BAROMETRIC PRESSURE CORRELATION
P0071	AMBIENT AIR TEMPERATURE SENSOR PERFORMANCE
P0072	AMBIENT AIR TEMPERATURE SENSOR CIRCUIT LOW
P0073	AMBIENT AIR TEMPERATURE SENSOR CIRCUIT HIGH
P00FD-00	BATTERY B STATE OF CHARGE PERFORMANCE
P0107	MANIFOLD ABSOLUTE PRESSURE SENSOR CIRCUIT LOW
P0108	MANIFOLD ABSOLUTE PRESSURE SENSOR CIRCUIT HIGH
P0111	INTAKE AIR TEMPERATURE SENSOR 1 PERFORMANCE
P0112	INTAKE AIR TEMPERATURE SENSOR 1 CIRCUIT LOW
P0113	INTAKE AIR TEMPERATURE SENSOR 1 CIRCUIT HIGH
P0116	ENGINE COOLANT TEMPERATURE SENSOR PERFORMANCE
P0117	ENGINE COOLANT TEMPERATURE SENSOR CIRCUIT LOW
P0118	ENGINE COOLANT TEMPERATURE SENSOR CIRCUIT HIGH
P0121	THROTTLE POSITION SENSOR 1 PERFORMANCE
P0122	THROTTLE POSITION SENSOR 1 CIRCUIT LOW
P0123	THROTTLE POSITION SENSOR 1 CIRCUIT HIGH
P0125	INSUFFICIENT COOLANT TEMP FOR CLOSED-LOOP FUEL CONTROL
P0128	THERMOSTAT RATIONALITY
P0129	BAROMETRIC PRESSURE OUT OF RANGE LOW
P0131	O2 SENSOR 1/1 CIRCUIT LOW
P0132	O2 SENSOR 1/1 CIRCUIT HIGH
P0133	O2 SENSOR 1/1 SLOW RESPONSE
P0135	O2 SENSOR 1/1 HEATER PERFORMANCE
P0137	O2 SENSOR 1/2 CIRCUIT LOW
P0138	O2 SENSOR 1/2 CIRCUIT HIGH
P0139	O2 SENSOR 1/2 SLOW RESPONSE
P0140	O2 SENSOR 1/2 NO ACTIVITY DETECTED
P0141	O2 SENSOR 1/2 HEATER PERFORMANCE
P0151	O2 SENSOR 2/1 CIRCUIT LOW
P0152	O2 SENSOR 2/1 CIRCUIT HIGH
P0153	O2 SENSOR 2/1 SLOW RESPONSE
P0155	O2 SENSOR 2/1 HEATER PERFORMANCE
P0157	O2 SENSOR 2/2 CIRCUIT LOW
P0158	O2 SENSOR 2/2 CIRCUIT HIGH
P0159	O2 SENSOR 2/2 SLOW RESPONSE
P0160	O2 SENSOR 2/2 NO ACTIVITY DETECTED
P0161	O2 SENSOR 2/2 HEATER PERFORMANCE
P0171	FUEL SYSTEM 1/1 LEAN
P0172	FUEL SYSTEM 1/1 RICH
P0174	FUEL SYSTEM 2/1 LEAN

DTC	Description
P0175	FUEL SYSTEM 2/1 RICH
P018B	FUEL PRESSURE SENSOR CIRCUIT PERFORMANCE
P018C	FUEL PRESSURE SENSOR CIRCUIT LOW
P018D	FUEL PRESSURE SENSOR CIRCUIT HIGH
P0196	ENGINE OIL TEMPERATURE SENSOR PERFORMANCE
P0197	ENGINE OIL TEMPERATURE SENSOR CIRCUIT LOW
P0198	ENGINE OIL TEMPERATURE SENSOR CIRCUIT HIGH
P0201	FUEL INJECTOR 1 CIRCUIT/OPEN
P0202	FUEL INJECTOR 2 CIRCUIT/OPEN
P0203	FUEL INJECTOR 3 CIRCUIT/OPEN
P0204	FUEL INJECTOR 4 CIRCUIT/OPEN
P0205	FUEL INJECTOR 5 CIRCUIT/OPEN
P0206	FUEL INJECTOR 6 CIRCUIT/OPEN
P0221	THROTTLE POSITION SENSOR 2 PERFORMANCE
P0222	THROTTLE POSITION SENSOR 2 CIRCUIT LOW
P0223	THROTTLE POSITION SENSOR 2 CIRCUIT HIGH
P025A	FUEL PUMP MODULE CONTROL CIRCUIT OPEN
P025B	FUEL PUMP MODULE CONTROL CIRCUIT PERFORMANCE
P025C	FUEL PUMP MODULE CONTROL CIRCUIT LOW
P025D	FUEL PUMP MODULE CONTROL CIRCUIT HIGH
P0298	ENGINE OIL TEMPERATURE TOO HIGH
P0300	MULTIPLE CYLINDER MISFIRE
P0301	CYLINDER 1 MISFIRE
P0302	CYLINDER 2 MISFIRE
P0303	CYLINDER 3 MISFIRE
P0304	CYLINDER 4 MISFIRE
P0305	CYLINDER 5 MISFIRE
P0306	CYLINDER 6 MISFIRE
P0325	KNOCK SENSOR 1 CIRCUIT
P0327	KNOCK SENSOR 1 CIRCUIT LOW
P0328	KNOCK SENSOR 1 CIRCUIT HIGH
P032F	COMBUSTION ENGINE PRODUCING INSUFFICIENT TORQUE
P0330	KNOCK SENSOR 2 CIRCUIT
P0332	KNOCK SENSOR 2 CIRCUIT LOW
P0333	KNOCK SENSOR 2 CIRCUIT HIGH
P0335	CRANKSHAFT POSITION SENSOR CIRCUIT
P0339	CRANKSHAFT POSITION SENSOR INTERMITTENT
P0340	CAMSHAFT POSITION SENSOR CIRCUIT - BANK 1 SENSOR 1
P0344	CAMSHAFT POSITION SENSOR INTERMITTENT - BANK 1 SENSOR 1
P0345	CAMSHAFT POSITION SENSOR CIRCUIT - BANK 2 SENSOR 1
P0349	CAMSHAFT POSITION SENSOR INTERMITTENT - BANK 2 SENSOR 1
P0351	IGNITION COIL 1 PRIMARY CIRCUIT
P0352	IGNITION COIL 2 PRIMARY CIRCUIT
P0353	IGNITION COIL 3 PRIMARY CIRCUIT
P0354	IGNITION COIL 4 PRIMARY CIRCUIT
P0355	IGNITION COIL 5 PRIMARY CIRCUIT
P0356	IGNITION COIL 6 PRIMARY CIRCUIT
P0365	CAMSHAFT POSITION SENSOR CIRCUIT - BANK 1 SENSOR 2

DTC	Description
P0369	CAMSHAFT POSITION SENSOR INTERMITTENT - BANK 1 SENSOR 2
P0390	CAMSHAFT POSITION SENSOR CIRCUIT - BANK 2 SENSOR 2
P0394	CAMSHAFT POSITION SENSOR INTERMITTENT - BANK 2 SENSOR 2
P0401	EGR SYSTEM PERFORMANCE
P0404	EGR POSITION SENSOR PERFORMANCE
P0405	EGR POSITION SENSOR CIRCUIT LOW
P0406	EGR POSITION SENSOR CIRCUIT HIGH
P040B	EXHAUST GAS RECIRCULATION TEMPERATURE SENSOR 1 CIRCUIT PERFORMANCE
P0420	CATALYST SYSTEM EFFICIENCY BELOW THRESHOLD BANK 1
P0430	CATALYST SYSTEM EFFICIENCY BELOW THRESHOLD BANK 2
P0440	GENERAL EVAP SYSTEM FAILURE
P0441	EVAP PURGE SYSTEM PERFORMANCE
P0443	EVAP PURGE 1 CONTROL CIRCUIT
P0452	EVAP PRESSURE SWITCH STUCK CLOSED
P0455	EVAP SYSTEM LARGE LEAK
P0456	EVAP SYSTEM SMALL LEAK
P0457	EVAP SYSTEM - LOOSE FUEL CAP
P0461	FUEL LEVEL SENSOR 1 PERFORMANCE
P0462	FUEL LEVEL SENSOR 1 CIRCUIT LOW
P0463	FUEL LEVEL SENSOR 1 CIRCUIT HIGH
P0480	COOLING FAN 1 CONTROL CIRCUIT (VARIABLE SPEED FAN)
P0489	EGR CONTROL CIRCUIT LOW
P0490	EGR CONTROL CIRCUIT HIGH
P04CE	COOLED EGR TEMPERATURE SENSOR CIRCUIT
P04D0	COOLED EGR TEMPERATURE SENSOR CIRCUIT LOW
P04D1	COOLED EGR TEMPERATURE SENSOR CIRCUIT HIGH
P04D2	COOLED EGR TEMPERATURE SENSOR CIRCUIT INTERMITTENT/ERRATIC
P04FC	CRANKCASE VENTILATION SYSTEM PERFORMANCE
P0501	VEHICLE SPEED SENSOR 1 PERFORMANCE
P0506	IDLE SPEED PERFORMANCE LOWER THAN EXPECTED
P0507	IDLE SPEED PERFORMANCE HIGHER THAN EXPECTED
P050B	COLD START IGNITION TIMING PERFORMANCE
P0513	INVALID SKIM KEY
P0520	ENGINE OIL PRESSURE SENSOR CIRCUIT
P0521	ENGINE OIL PRESSURE SENSOR PERFORMANCE
P0522	ENGINE OIL PRESSURE SENSOR CIRCUIT LOW
P0523	ENGINE OIL PRESSURE SENSOR CIRCUIT HIGH
P0532	A/C PRESSURE SENSOR CIRCUIT LOW
P0533	A/C PRESSURE SENSOR CIRCUIT HIGH
P0562	BATTERY/SYSTEM VOLTAGE LOW
P0563	BATTERY/SYSTEM VOLTAGE HIGH
P057B	BRAKE PEDAL POSITION SENSOR "A" CIRCUIT PERFORMANCE
P057C	BRAKE PEDAL POSITION SENSOR CIRCUIT LOW
P057D	BRAKE PEDAL POSITION SENSOR CIRCUIT HIGH
P0585	SPEED CONTROL SWITCH 1/2 CORRELATION
P058A	BATTERY MONITOR MODULE PERFORMANCE
P0600	SERIAL COMMUNICATION LINK

DTC	Description
P0601	INTERNAL MEMORY CHECKSUM INVALID
P0602	CONTROL MODULE PROGRAMMING ERROR/NOT PROGRAMMED
P0606	INTERNAL CONTROL PROCESSOR
P0607	ECU INTERNAL PERFORMANCE
P060B	ETC A/D GROUND PERFORMANCE
P060D	ETC LEVEL 2 APP PERFORMANCE
P060E	ETC LEVEL 2 TPS PERFORMANCE
P060F	ETC LEVEL 2 ECT PERFORMANCE
P0615	STARTER CONTROL CIRCUIT/OPEN
P061A	LEVEL 2 TORQUE PERFORMANCE
P061C	ETC LEVEL 2 RPM PERFORMANCE
P0622	GENERATOR FIELD CONTROL CIRCUIT/OPEN
P0627	FUEL PUMP CONTROL CIRCUIT OPEN
P0628	FUEL PUMP CONTROL CIRCUIT LOW
P0629	FUEL PUMP CONTROL CIRCUIT HIGH
P062A	FUEL PUMP CONTROL PERFORMANCE
P062C	ETC LEVEL 2 MPH PERFORMANCE
P0630	VIN NOT PROGRAMMED IN PCM
P0632	ODOMETER NOT PROGRAMMED IN PCM
P0633	SKIM SECRET KEY NOT STORED IN PCM
P063A	GENERATOR VOLTAGE SENSE CIRCUIT
P0642	SENSOR REFERENCE VOLTAGE 1 CIRCUIT LOW
P0643	SENSOR REFERENCE VOLTAGE 1 CIRCUIT HIGH
P0645	A/C CONTROL CIRCUIT/OPEN
P064A	FUEL PUMP CONTROL MODULE 1
P0652	SENSOR REFERENCE VOLTAGE 2 CIRCUIT LOW
P0653	SENSOR REFERENCE VOLTAGE 2 CIRCUIT HIGH
P0685	ASD/MAIN CONTROL CIRCUIT
P0688	ASD/MAIN SENSE CIRCUIT
P0698	SENSOR REFERENCE VOLTAGE 3 CIRCUIT LOW
P0699	SENSOR REFERENCE VOLTAGE 3 CIRCUIT HIGH
P06DA	ENGINE OIL PRESSURE CONTROL CIRCUIT
P06DD	ENGINE OIL PRESSURE CONTROL CIRCUIT STUCK OFF
P06DE	ENGINE OIL PRESSURE CONTROL CIRCUIT STUCK ON
P06E9	ENGINE STARTER PERFORMANCE
P06EF	ENGINE RESTART PERFORMANCE
P0850	PARK/NEUTRAL SWITCH PERFORMANCE
P1050	INTAKE VALVE CONTROL SOLENOID 1 CIRCUIT/OPEN
P1051	INTAKE VALVE CONTROL SOLENOID 1 CIRCUIT LOW
P1052	INTAKE VALVE CONTROL SOLENOID 1 CIRCUIT HIGH
P1053	INTAKE VALVE CONTROL SOLENOID 2 CIRCUIT/OPEN
P1054	INTAKE VALVE CONTROL SOLENOID 2 CIRCUIT LOW
P1055	INTAKE VALVE CONTROL SOLENOID 2 CIRCUIT HIGH
P1056	INTAKE VALVE CONTROL SOLENOID 3 CIRCUIT/OPEN
P1057	INTAKE VALVE CONTROL SOLENOID 3 CIRCUIT LOW
P1058	INTAKE VALVE CONTROL SOLENOID 3 CIRCUIT HIGH
P1059	INTAKE VALVE CONTROL SOLENOID 4 CIRCUIT/OPEN
P105A	INTAKE VALVE CONTROL SOLENOID 4 CIRCUIT LOW

DTC	Description
P105B	INTAKE VALVE CONTROL SOLENOID 4 CIRCUIT HIGH
P105C	INTAKE VALVE STUCK IN LOW LIFT POSITION
P105D	INTAKE VALVE STUCK IN HIGH LIFT POSITION
P1070	INTAKE VALVE CONTROL SOLENOID 1 RANGE/PERFORMANCE
P1071	INTAKE VALVE CONTROL SOLENOID 2 RANGE/PERFORMANCE
P1072	INTAKE VALVE CONTROL SOLENOID 3 RANGE/PERFORMANCE
P1073	INTAKE VALVE CONTROL SOLENOID 4 RANGE/PERFORMANCE
P1115	GENERAL TEMPERATURE RATIONALITY
P1128	CLOSED LOOP FUELING NOT ACHIEVED - BANK 1 UPSTREAM
P1129	CLOSED LOOP FUELING NOT ACHIEVED - BANK 2 UPSTREAM
P1205	FUEL PUMP CONTROL MODULE INTERNAL PERFORMANCE
P1206	FUEL PUMP CONTROL MODULE OPEN CIRCUIT TO FUEL PUMP
P1239	ENGINE OIL TEMPERATURE TOO LOW
P1300	CRANKSHAFT POSITION LEARN OUT OF RANGE
P1404	EGR CLOSE POSITION PERFORMANCE
P141B	STARTER CONTROL 1 CIRCUIT PERFORMANCE
P141C	STARTER CONTROL 2 CIRCUIT PERFORMANCE
P141D	STARTER RELAY FEEDBACK OPEN CIRCUIT PERFORMANCE
P1456	FUEL TANK PRESSURE SENSOR CIRCUIT LOW
P1457	FUEL TANK PRESSURE SENSOR CIRCUIT HIGH
P1495	LEFT FRONT SEATBELT SWITCH CIRCUIT HIGH
P1496	LEFT FRONT SEATBELT SWITCH CIRCUIT LOW
P1524	OIL PRESSURE OUT OF RANGE - CAMSHAFT ADVANCE/RETARD DISABLED
P152C	ENGINE HOOD SWITCH 2 CIRCUIT RANGE/PERFORMANCE
P152D	ENGINE HOOD SWITCH 2 CIRCUIT LOW
P152E	ENGINE HOOD SWITCH 2 CIRCUIT HIGH
P152F	ENGINE HOOD SWITCH 2 / ENGINE HOOD SWITCH 1 CORRELATION
P1572	BRAKE PEDAL STUCK ON
P1573	BRAKE PEDAL STUCK OFF
P1593	SPEED CONTROL SWITCH 1/2 STUCK
P1609	INTERNAL CONTROL MODULE ENGINE OIL TEMPERATURE PERFORMANCE
P1618	SENSOR REFERENCE VOLTAGE 1 CIRCUIT ERRATIC
P1628	SENSOR REFERENCE VOLTAGE 2 CIRCUIT ERRATIC
P1684	BATTERY WAS DISCONNECTED
P1696	EEPROM MEMORY WRITE DENIED/INVALID
P1697	EMR (SRI) MILEAGE NOT STORED
P1718	EEPROM INTEGRITY FAILURE
P1C4E	ABS DTC PRESENT
P1D83	IMPLAUSIBLE ENGINE OIL TEMPERATURE SIGNAL RECEIVED
P1E08	STOP/START DISABLED - AIRBAG DEPLOYMENT
P1E09	CLOSED LOOP FUELING NOT ACHIEVED - BANK 1 DOWNSTREAM
P1E0A	CLOSED LOOP FUELING NOT ACHIEVED - BANK 2 DOWNSTREAM
P1E26	INTERNAL CONTROL MODULE COOLED EGR TEMPERATURE PERFORMANCE
P1E27	EGR 1 HIGH SIDE CONTROL CIRCUIT LOW
P1E28	EGR 1 HIGH SIDE CONTROL CIRCUIT HIGH
P2072	ELECTRONIC THROTTLE CONTROL SYSTEM - ICE BLOCKAGE

DTC	Description
P2096	DOWNSTREAM FUEL TRIM SYSTEM 1 LEAN
P2097	DOWNSTREAM FUEL TRIM SYSTEM 1 RICH
P2098	DOWNSTREAM FUEL TRIM SYSTEM 2 LEAN
P2099	DOWNSTREAM FUEL TRIM SYSTEM 2 RICH
P2100	ELECTRONIC THROTTLE CONTROL MOTOR CIRCUIT
P2101	ELECTRONIC THROTTLE CONTROL MOTOR PERFORMANCE
P2107	ELECTRONIC THROTTLE CONTROL MODULE PROCESSOR
P2110	ELECTRONIC THROTTLE CONTROL - FORCED LIMITED RPM
P2111	ELECTRONIC THROTTLE CONTROL - UNABLE TO CLOSE
P2112	ELECTRONIC THROTTLE CONTROL - UNABLE TO OPEN
P2115	ACCELERATOR PEDAL POSITION SENSOR 1 MINIMUM STOP PERFORMANCE
P2116	ACCELERATOR PEDAL POSITION SENSOR 2 MINIMUM STOP PERFORMANCE
P2118	ELECTRONIC THROTTLE CONTROL MOTOR CURRENT PERFORMANCE - BANK 1
P2122	ACCELERATOR PEDAL POSITION SENSOR 1 CIRCUIT LOW
P2123	ACCELERATOR PEDAL POSITION SENSOR 1 CIRCUIT HIGH
P2127	ACCELERATOR PEDAL POSITION SENSOR 2 CIRCUIT LOW
P2128	ACCELERATOR PEDAL POSITION SENSOR 2 CIRCUIT HIGH
P2135	THROTTLE POSITION SENSOR 1/2 CORRELATION
P2138	ACCELERATOR PEDAL POSITION SENSOR 1/2 CORRELATION
P2166	ACCELERATOR PEDAL POSITION SENSOR 1 MAXIMUM STOP PERFORMANCE
P2167	ACCELERATOR PEDAL POSITION SENSOR 2 MAXIMUM STOP PERFORMANCE
P2172	HIGH AIRFLOW/VACUUM LEAK DETECTED (INSTANTANEOUS ACCUMULATION)
P2173	HIGH AIRFLOW/VACUUM LEAK DETECTED (SLOW ACCUMULATION)
P2174	LOW AIRFLOW/RESTRICTION DETECTED (INSTANTANEOUS ACCUMULATION)
P2181	COOLING SYSTEM PERFORMANCE
P219A	AIR-FUEL RATIO CYLINDER IMBALANCE BANK 1
P219B	AIR-FUEL RATIO CYLINDER IMBALANCE BANK 2
P2226	BAROMETRIC PRESSURE SENSOR
P2228	BAROMETRIC PRESSURE CIRCUIT LOW
P2229	BAROMETRIC PRESSURE CIRCUIT HIGH
P2271	O2 SENSOR 1/2 SIGNAL BIASED RICH
P2273	O2 SENSOR 2/2 SIGNAL BIASED RICH
P2299	BRAKE PEDAL POSITION/ACCELERATOR PEDAL POSITION INCOMPATIBLE
P232A	TCM REQUEST FORCED ENGINE SHUTDOWN
P2457	EXHAUST GAS RECIRCULATION COOLING SYSTEM PERFORMANCE
P2503	CHARGING SYSTEM OUTPUT LOW
P2504	CHARGING SYSTEM OUTPUT HIGH
P257E	ENGINE HOOD SWITCH CIRCUIT LOW
P257F	ENGINE HOOD SWITCH CIRCUIT HIGH
P258A	ELECTRIC VACUUM PUMP CIRCUIT
P258B	ELECTRONIC VACUUM PUMP PERFORMANCE

DTC	Description
P2610	PCM INTERNAL ENGINE OFF TIMER PERFORMANCE
P26E4	STARTER CONTROL 2 CIRCUIT
P2AF5	STARTER RELAY 3 STUCK ON
P2AF6	STARTER RELAY 3 STUCK OFF
P2AF7	STARTER RELAY "D" CONTROL CIRCUIT/OPEN
P2AF8	STARTER RELAY "D" CONTROL CIRCUIT LOW
P2AF9	STARTER RELAY "D" CONTROL CIRCUIT HIGH
P2B57	LOW ENGINE OIL PRESSURE - CAMSHAFT CONTROL DISABLED
P3090	UPSTREAM O2 SENSOR RETURN VOLTAGE LOW
P3091	UPSTREAM O2 SENSOR RETURN VOLTAGE HIGH
P3092	DOWNSTREAM O2 SENSOR RETURN VOLTAGE LOW
P3093	DOWNSTREAM O2 SENSOR RETURN VOLTAGE HIGH
U0001-00	CAN C BUS
U0101-00	LOST COMMUNICATION WITH TCM
U0102-00	LOST COMMUNICATION WITH TRANSFER CASE CONTROL MODULE / AWD
U0109	LOST COMMUNICATION WITH FUEL PUMP CONTROL MODULE
U0121	LOST COMMUNICATION WITH ABS
U0125	LOST COMMUNICATION WITH DYNAMICS SENSOR
U0129	LOST COMMUNICATION WITH BRAKE SYSTEM CONTROL MODULE 1
U0140-00	LOST COMMUNICATION WITH BODY CONTROL MODULE
U0151	LOST COMMUNICATION WITH OCCUPANT RESTRAINT CONTROLLER
U0155	LOST COMMUNICATION WITH CLUSTER/CCN
U0164	LOST COMMUNICATION WITH HVAC CONTROL MODULE
U0168	LOST COMMUNICATION WITH VEHICLE SECURITY CONTROL MODULE
U017E	LOST COMMUNICATION WITH SEATBELT SENSOR 1
U0212	LOST COMMUNICATION WITH SCM
U0402	IMPLAUSIBLE DATA RECEIVED FROM TCM
U0405	INVALID DATA RECEIVED FROM CRUISE CONTROL MODULE
U0416	IMPLAUSIBLE DATA RECEIVED FROM ESP
U0418	IMPLAUSIBLE DATA RECEIVED FROM BRAKE SYSTEM CONTROL MODULE 1
U0424	IMPLAUSIBLE DATA RECEIVED FROM HVAC CONTROL MODULE
U0426	IMPLAUSIBLE DATA RECEIVED FROM VEHICLE SECURITY CONTROL MODULE
U0427	INVALID DATA RECEIVED FROM VEHICLE SECURITY CONTROL MODULE
U0428	IMPLAUSIBLE DATA RECEIVED FROM STEERING ANGLE SENSOR
U0429	IMPLAUSIBLE DATA RECEIVED FROM STEERING CONTROL MODULE
U0432	INVALID DATA RECEIVED FROM MULTI-AXIS ACCELERATION SENSOR MODULE
U047F	IMPLAUSIBLE DATA RECEIVED FROM SEATBELT SENSOR 1
U110A	LOSS OF COMMUNICATIONS WITH SCM - CAN C
U110C	LOST FUEL LEVEL MESSAGE
U110E	LOST AMBIENT TEMPERATURE MESSAGE
U1110	LOST VEHICLE SPEED MESSAGE
U1120	LOST WHEEL DISTANCE MESSAGE
U1133	LOST STOP/START SWITCH 1 MESSAGE
U1134	LOST STOP/START SWITCH 2 MESSAGE

DTC	Description
U113E	LOST COMMUNICATION WITH INTELLIGENT BATTERY SENSOR
U1141	LOST-ESP-TORQUE-REQUEST-MESSAGE
U115F	LOST COMMUNICATION WITH DRIVER PRESENCE DETECTION MODULE
U1186	LOST COMMUNICATION WITH ADAPTIVE CRUISE CONTROL MODULE
U1199	LOST HOOD AJAR SWITCH VOLTAGE MESSAGE
U11BC	LOST BRAKE SWITCH MESSAGE
U11BF	LOST BRAKE PEDAL POSITION MESSAGE
U11C2	LOST TRANSMISSION MESSAGE
U11DE	LOST SPEED CONTROL MESSAGE
U120C	LOST BRAKE BOOSTER SIGNAL
U120D	LOST ROLLS MODE SIGNAL
U12A8	LOST COMMUNICATION WITH MASTER CYLINDER PRESSURE SENSOR
U1409	IMPLAUSIBLE LEFT FRONT WHEEL SPEED SIGNAL RECEIVED
U140A	IMPLAUSIBLE RIGHT FRONT WHEEL SPEED SIGNAL RECEIVED
U140B	IMPLAUSIBLE LEFT REAR WHEEL SPEED SIGNAL RECEIVED
U140C	IMPLAUSIBLE RIGHT REAR WHEEL SPEED SIGNAL RECEIVED
U1412	IMPLAUSIBLE VEHICLE SPEED SIGNAL RECEIVED
U1417	IMPLAUSIBLE LEFT WHEEL DISTANCE SIGNAL RECEIVED
U1418	IMPLAUSIBLE RIGHT WHEEL DISTANCE SIGNAL RECEIVED
U1431	IMPLAUSIBLE DATA RECEIVED FROM CRUISE CONTROL MODULE
U1440	IMPLAUSIBLE TRANSFER CASE RATIO HIGH RECEIVED
U1442	IMPLAUSIBLE DATA RECEIVED FROM DRIVER PRESENCE DETECTION MODULE
U148C	IMPLAUSIBLE DATA RECEIVED FROM STOP/START BUTTON
U1494	IMPLAUSIBLE DATA SENT FROM ADAPTIVE CRUISE CONTROL MODULE
U1504	IMPLAUSIBLE MESSAGE DATA LENGTH RECEIVED FROM STEERING ANGLE SENSOR

DIAGNOSIS AND TESTING

B1810-DRIVER DOOR AJAR INPUT CIRCUIT LOW

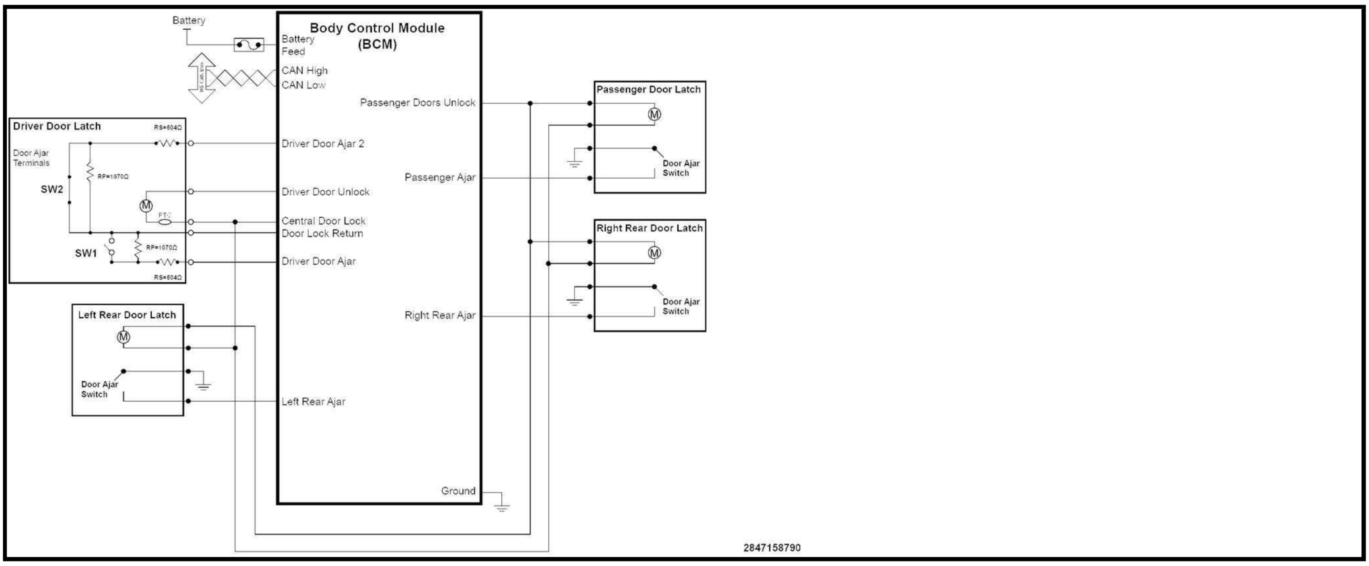
For a complete DOORS/LOCK SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Unlike the passenger ajar signals that function like traditional open/closed ajar switches, the Driver Door Latch has redundant switches and signals for diagnostic purposes. The two switches share a common sensor ground. The Powertrain Control Module (PCM) receives the state (open/closed) of each switch over the CAN Bus from the Drivers Door Module (DDM) or Body Control Module (BCM) depending on the vehicles configuration and which module the latches are hard-wired to. The PCM continuously monitors the functioning status of the Driver Door Ajar Switch states for the operation of certain features such as Electric Stop/Start (ESS).

For further information on the effect of this DTC to the operation of ESS, see **ENGINE START/STOP (ESS) INOPERATIVE.** . Refer to ENGINE STOP/START (ESS) SYSTEM INOPERATIVE .

COMPONENT FUNCTIONAL DESCRIPTION - DOOR LATCH SYSTEM



Functional Operation of the Lock Motors: The Body Control Module (BCM) uses an H-Bridge configuration to drive the lock/unlock motors. To lock the doors, voltage is applied to the Lock pin circuit and ground is applied to both Unlock pin circuits. To unlock the doors, voltage is applied to the Unlock pins and ground is applied to the Lock pin. The passenger doors have a separate Unlock pin so that only the Driver's Door can be unlocked with the first button press on the keyless remote. When the lock motors are activated BCM will drive the motors for approximately 370 ms. The BCM and lock motors operate in the voltage range of 9.0 and 16.0 volts. Typical current draw for the motors are listed in Amps in the table below.

NOTE: **The amperage values listed in the table are approximate.**

BATTERY VOLTAGE	IN-RUSH CURRENT	CONTINUOUS OPERATION (NO LOAD)	STALL CURRENT
9.0	3.9	3.1	4.3
12.0	5.22	1.75	6.2
13.5	5.8	1.5	6.9
16.0	6.7	2.0	7.0

Functional Operation of the Latch Switches: All of the Door Latches are monitored to determine if they are closed or ajar. All of the ajar switches are wake-up signals to the BCM. The Driver Door Latch must be rationalized in order for some vehicle features to function. Unlike the passenger ajar signals that function like traditional open/closed ajar switches, the Driver Door Latch has redundant switches and signals for diagnostic purposes. The two switches share a common sensor ground. The Door Ajar Switch signals use Battery voltage for a reference. The switches operate in the following manner:

- **Driver Door Ajar Switches:** The BCM has an internal pull up 1000 Ohm resistor for each ajar signal. Each switch has an internal 604 Ohm and 1070 Ohm resistor. When the switches are open the resistance through the switches are 1674 Ohms. When the switches are closed the resistance through the switches are 604 Ohms. The switch states are opposing each other, meaning that when the **door latch is closed** , switch 1 is in the open state and switch 2 is in the closed state. The opposite is true when the **door latch is opened** . For more information refer to the tables below.
- **Passenger Ajar Switches:** The ajar switches are open when the latch is closed. When the door latch is ajar the switch closes allowing the signal to connect to ground through the switch. Therefore the signal inputs to the BCM are high when the door is closed and low when the door is ajar.

The BCM monitors the Driver Door Ajar Switch signal circuit and converts the voltage signal into counts to broadcast over the CAN Bus network.

- Electronic Control Modules read an analog signal voltage and converts it to digital counts. Each count is an equal percentage of the signal reference voltage. This can be seen when viewing some sensor or switch voltages and converted values on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts to a battery voltage reference.
- The resolution of the signal is determined by the required precision of the input by the ECU. Typically, sensor signals are high resolution. This allows the module to read small changes over a wide range in a variable resistance sensor signal. These are typically used on a temperature, pressure, position or MUX type of sensor.
- Switches typically have a much lower resolution than sensors. This is because an ECU is generally looking for a switch to be in only a few positions that use fixed resistors. The lower resolution also helps the ECU to overcome some resistance in a circuit and still read the correct state. This also lowers the sensitivity to setting DTCs.
- The voltage and percentages can vary slightly with calibration changes. The voltage values and percentages in the table are approximate and can be slightly different. Typically, a failure will be noticeably different than the values in the table. The voltage ranges given are based on a nominal reference voltage of 13.5 volts. The voltage on the signal will change with system voltage but the percentage of system voltage should not change.

The Driver Door Ajar Switch signal voltage is divided into 15 counts typically. The table below shows the relation between the Driver Door Ajar Switch states and **approximate voltage percentages/ranges.**

DOOR AJAR SWITCH 1

VOLTAGE PERCENTAGE/VALUE TO SWITCH STATE			
Percentage of Battery Voltage	**Voltage Range @ 13.5 volts nominal**	**Door Latch Position**	**Ajar Switch State (Open/Closed)**
87 - 100%	Range: 11.7v - 13.5v	-	CIRCUIT HIGH FAULT RANGE - OPEN CIRCUIT
54 - 86%	Nominal: 8.5v Range: 7.2v - 9.9v	CLOSED	SWITCH OPEN
20 - 53%	Nominal: 4.5v Range: 2.7v- 6.3v	AJAR	SWITCH CLOSED
0 - 19%	Range: 0v - 1.8v	-	CIRCUIT LOW FAULT RANGE-SHORT TO GROUND

DOOR AJAR SWITCH 2

Percentage of Battery Voltage	Voltage Range @ 13.5 volts nominal	Door Latch Position	Ajar Switch State (Open/Closed)
87 - 100%	Range: 11.7v - 13.5v	-	CIRCUIT HIGH FAULT RANGE - OPEN CIRCUIT
54 - 86%	Nominal: 8.5v Range: 7.2v - 9.9v	AJAR	SWITCH OPEN
20- 53%	Nominal: 4.5v Range: 2.7v- 6.3v	CLOSED	SWITCH CLOSED
0 - 19%	Range: 0v - 1.8v	-	CIRCUIT LOW FAULT RANGE-SHORT TO GROUND

DIAGNOSTIC OVERVIEW-DOOR LOCK MOTORS AND SWITCHES:

- **Lock Motors:** The BCM is capable of detecting opens and shorts in the H-Bridge control circuits. The locks are not thermally protected by the BCM. The protection is done by limiting the number of actuations within a calibrated time period.
- **Door Latch Switches:** The resistors in the latch switches allows the BCM to perform diagnostics on the circuits and switches. Unlike the passenger door switches the voltage on the two signals should not be high or low. If the BCM determines that either signal falls into the high or low range, a fault is set. If the door latch positions do not match between the two Driver Door Ajar Switches, a correlation fault will set.

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Primary Driver Door Ajar Switch signal voltage received over the CAN C BUS from the Body Control Module (BCM) is below a calibrated threshold.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
DRIVER DOOR LATCH AJAR SWITCH SENSE CIRCUIT SHORTED TO GROUND
DRIVER DOOR LATCH AJAR SWITCH SENSE CIRCUIT SHORTED TO THE DRIVER DOOR LATCH RETURN CIRCUIT
DRIVER DOOR LATCH
BODY CONTROL MODULE (BCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to **PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .**

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
   1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

      Are there any applicable Service Bulletins or Flash updates?

      Yes

- Perform the applicable repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 2

2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **DISCONNECT THE DRIVER DOOR LATCH HARNESS CONNECTOR AND VERIFY THE ABILITY OF THE BCM TO READ THE B1811-DRIVER DOOR AJAR INPUT CIRCUIT HIGH DTC**
    1. The Electronic Control Unit (ECU) harness connectors must be connected to the ECU during this test step.
    2. With the ignition in the off position, disconnect the sensor harness connector.
    3. Turn the ignition on.
    4. With the scan tool, read DTCs.

    Does the scan tool display the B1811-DRIVER DOOR AJAR INPUT CIRCUIT HIGH with the connector disconnected?

    Yes

    - Replace the faulty switch (door latch) in accordance with the Service Information. Refer to **LATCH, DOOR, REMOVAL AND INSTALLATION** .
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

    No

    - Go To 4
4. **ISOLATE AND CHECK THE DRIVER DOOR LATCH (G75) AJAR SWITCH SENSE CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.

2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Connect the negative lead of the Digital Volt Ohm Meter DVOM to a known good ground.
4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

No

- Go To 5

5. **ISOLATE AND CHECK THE DRIVER DOOR LATCH (G75) AJAR SWITCH SENSE CIRCUIT FOR A SHORT TO THE DRIVER DOOR LATCH (P371) RETURN CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **There should be no continuity between the circuits being tested.**

    Is there continuity between the circuits?

    Yes

    - Repair the short between the circuits.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 6

6. **CHECK RELATED BCM AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.

4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Body Control Module (BCM) in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM), REMOVAL AND INSTALLATION** .
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

B1811-DRIVER DOOR AJAR INPUT CIRCUIT HIGH

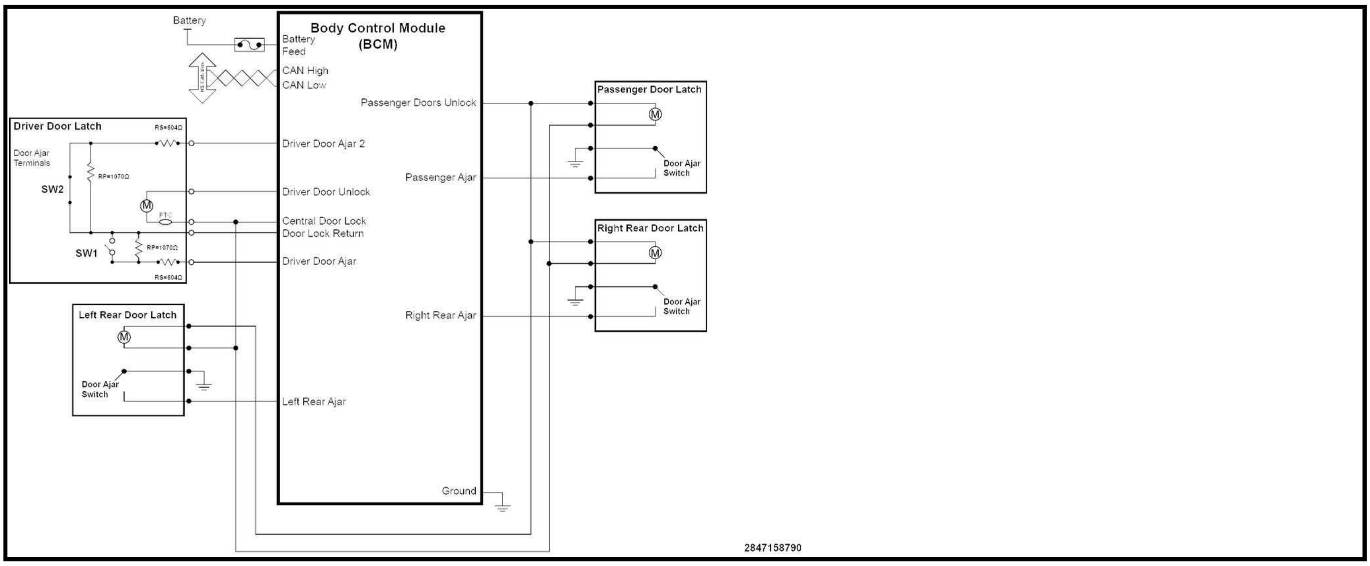
For a complete DOORS/LOCK SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Unlike the passenger ajar signals that function like traditional open/closed ajar switches, the Driver Door Latch has redundant switches and signals for diagnostic purposes. The two switches share a common sensor ground. The Powertrain Control Module (PCM) receives the state (open/closed) of each switch over the CAN Bus from the Drivers Door Module (DDM) or Body Control Module (BCM) depending on the vehicles configuration and which module the latches are hard-wired to. The PCM continuously monitors the functioning status of the Driver Door Ajar Switch states for the operation of certain features such as Electric Stop/Start (ESS).

For further information on the effect of this DTC to the operation of ESS, see **ENGINE START/STOP (ESS) INOPERATIVE.** . Refer to **ENGINE STOP/START (ESS) SYSTEM INOPERATIVE** .

COMPONENT FUNCTIONAL DESCRIPTION - DOOR LATCH SYSTEM



Functional Operation of the Lock Motors: The Body Control Module (BCM) uses an H-Bridge configuration to drive the lock/unlock motors. To lock the doors, voltage is applied to the Lock pin circuit and ground is applied to both Unlock pin circuits. To unlock the doors, voltage is applied to the Unlock pins and ground is applied to the Lock pin. The passenger doors have a separate Unlock pin so that only the Driver's Door can be unlocked with the first button press on the keyless remote. When the lock motors are activated BCM will drive the motors for approximately 370 ms. The BCM and lock motors operate in the voltage range of 9.0 and 16.0 volts. Typical current draw for the motors are listed in Amps in the table below.

NOTE: The amperage values listed in the table are approximate.

BATTERY VOLTAGE	IN-RUSH CURRENT	CONTINUOUS OPERATION (NO LOAD)	STALL CURRENT
9.0	3.9	3.1	4.3
12.0	5.22	1.75	6.2
13.5	5.8	1.5	6.9
16.0	6.7	2.0	7.0

Functional Operation of the Latch Switches: All of the Door Latches are monitored to determine if they are closed or ajar. All of the ajar switches are wake-up signals to the BCM. The Driver Door Latch must be rationalized in order for some vehicle features to function. Unlike the passenger ajar signals that function like traditional open/closed ajar switches, the Driver Door Latch has redundant switches and signals for diagnostic purposes. The two switches share a common sensor ground. The Door Ajar Switch signals use Battery voltage for a reference. The switches operate in the following manner:

- **Driver Door Ajar Switches:** The BCM has an internal pull up 1000 Ohm resistor for each ajar signal. Each switch has an internal 604 Ohm and 1070 Ohm resistor. When the switches are open the resistance through the switches are 1674 Ohms. When the switches are closed the resistance through the switches are 604 Ohms. The switch states are opposing each other, meaning that when the **door latch is closed** , switch 1 is in the open state and switch 2 is in the closed state. The opposite is true when the **door latch is opened** . For more information refer to the tables below.
- **Passenger Ajar Switches:** The ajar switches are open when the latch is closed. When the door latch is ajar the switch closes allowing the signal to connect to ground through the switch. Therefore the signal inputs to the BCM are high when the door is closed and low when the door is ajar.

The BCM monitors the Driver Door Ajar Switch signal circuit and converts the voltage signal into counts to broadcast over the CAN Bus network.

- Electronic Control Modules read an analog signal voltage and converts it to digital counts. Each count is an equal percentage of the signal reference voltage. This can be seen when viewing some sensor or switch voltages and converted values on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts to a battery voltage reference.

- The resolution of the signal is determined by the required precision of the input by the ECU. Typically, sensor signals are high resolution. This allows the module to read small changes over a wide range in a variable resistance sensor signal. These are typically used on a temperature, pressure, position or MUX type of sensor.
- Switches typically have a much lower resolution than sensors. This is because an ECU is generally looking for a switch to be in only a few positions that use fixed resistors. The lower resolution also helps the ECU to overcome some resistance in a circuit and still read the correct state. This also lowers the sensitivity to setting DTCs.
- The voltage and percentages can vary slightly with calibration changes. The voltage values and percentages in the table are approximate and can be slightly different. Typically, a failure will be noticeably different than the values in the table. The voltage ranges given are based on a nominal reference voltage of 13.5 volts. The voltage on the signal will change with system voltage but the percentage of system voltage should not change.

The Driver Door Ajar Switch signal voltage is divided into 15 counts typically. The table below shows the relation between the Driver Door Ajar Switch states and **approximate voltage percentages/ranges.**

DOOR AJAR SWITCH 1

VOLTAGE PERCENTAGE/VALUE TO SWITCH STATE			
Percentage of Battery Voltage	**Voltage Range @ 13.5 volts nominal**	**Door Latch Position**	**Ajar Switch State (Open/Closed)**
87 - 100%	Range: 11.7v - 13.5v	-	CIRCUIT HIGH FAULT RANGE - OPEN CIRCUIT
54 - 86%	Nominal: 8.5v Range: 7.2v - 9.9v	CLOSED	SWITCH OPEN
20 - 53%	Nominal: 4.5v Range: 2.7v- 6.3v	AJAR	SWITCH CLOSED
0 - 19%	Range: 0v - 1.8v	-	CIRCUIT LOW FAULT RANGE-SHORT TO GROUND

DOOR AJAR SWITCH 2

Percentage of Battery Voltage	Voltage Range @ 13.5 volts nominal	Door Latch Position	Ajar Switch State (Open/Closed)
87 - 100%	Range: 11.7v - 13.5v	-	CIRCUIT HIGH FAULT RANGE - OPEN CIRCUIT
54 - 86%	Nominal: 8.5v Range: 7.2v - 9.9v	AJAR	SWITCH OPEN
20- 53%	Nominal: 4.5v Range: 2.7v- 6.3v	CLOSED	SWITCH CLOSED
0 - 19%	Range: 0v - 1.8v	-	CIRCUIT LOW FAULT RANGE-SHORT TO GROUND

DIAGNOSTIC OVERVIEW-DOOR LOCK MOTORS AND SWITCHES:

- **Lock Motors:** The BCM is capable of detecting opens and shorts in the H-Bridge control circuits. The locks are not thermally protected by the BCM. The protection is done by limiting the number of actuations within a calibrated time period.
- **Door Latch Switches:** The resistors in the latch switches allows the BCM to perform diagnostics on the circuits and switches. Unlike the passenger door switches the voltage on the two signals should not be

high or low. If the BCM determines that either signal falls into the high or low range, a fault is set. If the door latch positions do not match between the two Driver Door Ajar Switches, a correlation fault will set.

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Primary Driver Door Ajar Switch signal voltage received over the CAN C BUS from the Body Control Module (BCM) is above a calibrated threshold.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
DRIVER DOOR LATCH AJAR SWITCH SENSE CIRCUIT SHORTED TO VOLTAGE
DRIVER DOOR LATCH AJAR SWITCH SENSE CIRCUIT OPEN/HIGH RESISTANCE
DRIVER DOOR LATCH RETURN CIRCUIT OPEN/HIGH RESISTANCE
DOOR LATCH
BODY CONTROL MODULE (BCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

        Are there any applicable Service Bulletins or Flash updates?

        Yes

        - Perform the applicable repair.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.

7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 3

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **CHECK THE DRIVER DOOR LATCH (G75) AJAR SWITCH SENSE CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

NOTE:	The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.

Is the voltage above 5.2 volts?

Yes

- Go To 4

No

- Go To 5

4. **ISOLATE AND CHECK THE DRIVER DOOR LATCH (G75) AJAR SWITCH SENSE CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

NOTE:	With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

No

- Go To 8

5. **ISOLATE AND CHECK THE DRIVER DOOR LATCH (G75) AJAR SWITCH SENSE CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the ECU harness connector and measure the resistance of the circuit.

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 6

    No

    - Repair the circuit for an open or high resistance.
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

6. **ISOLATE AND CHECK THE DRIVER DOOR LATCH (P371) RETURN CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

        NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

        Is the resistance below 3.0 Ohms?

        Yes

        - Go To 7

        No

        - Repair the circuit for an open or high resistance.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CONNECT A FUSED JUMPER BETWEEN THE DRIVER DOOR LATCH (G75) AJAR SWITCH SENSE CIRCUIT AND THE DRIVER DOOR LATCH (P371) RETURN CIRCUIT AT THE DOOR LATCH HARNESS CONNECTOR - VERIFY ABILITY OF THE BCM TO DETECT THE B1810-DRIVER DOOR AJAR INPUT CIRCUIT LOW DTC**
   1. The Electronic Control Unit (ECU) harness connectors must be connected to the ECU during this test step.
   2. Disconnect the sensor harness connector.
   3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the sensor ground circuit at the sensor harness connector.
   4. Turn the ignition on.
   5. With the scan tool, read DTCs.

   Does the scan tool display the B1810-DRIVER DOOR AJAR INPUT CIRCUIT LOW with the jumper in place?

   Yes

   - Replace the faulty switch (door latch) in accordance with the Service Information. Refer to **LATCH, DOOR, REMOVAL AND INSTALLATION** .
   - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

   No

   - Go To 8
8. **CHECK RELATED BCM AND COMPONENT CONNECTIONS**
   1. Disconnect all BCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.
   5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. With the scan tool, erase DTCs.

9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Body Control Module (BCM) in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM), REMOVAL AND INSTALLATION** .
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

B1BE3-DRIVER PRESENCE DETECTION SENSOR PERFORMANCE

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) receives over the CAN Bus a message from the Driver Presence Detection Module (DPDM) that an error is being detected.

DEFAULT ACTION

- This is a non MIL fault.

POSSIBLE CAUSES

Possible Causes
DRIVER PRESENCE DETECTION MODULE (DPDM) DTCS PRESENT
DRIVER PRESENCE DETECTION MODULE (DPDM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to **PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE** .

DIAGNOSTIC TEST

1. **CHECK FOR DPDM MODULE DTCS**
    1. With the scan tool, read Driver Presence Detection Module (DPDM) DTCs.

        Are there any DPDM DTCs present?

        Yes

        - Perform the appropriate DPDM diagnostic procedure(s). Refer to **DIAGNOSIS AND TESTING** .

        No

        - Go To 2
2. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

Are there any applicable Service Bulletins or Flash updates?

Yes

- Perform the applicable repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **CHECK RELATED DPDM MODULE AND COMPONENT CONNECTIONS**
    1. Turn the ignition off.
    2. Disconnect all DPDM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all DPDM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Driver Presence Detection Module (DPDM) in accordance with the Service information. Refer to **MODULE, DRIVER PRESENCE DETECTION (DPDM), REMOVAL AND INSTALLATION** .
        - Perform the DPDM VERIFICATION TEST. Refer to **DRIVER PRESENCE DETECTION MODULE (DPDM) VERIFICATION TEST** .

        No

- The wiring or poor connection problem has been repaired.
- Perform the DPDM VERIFICATION TEST. Refer to **DRIVER PRESENCE DETECTION MODULE (DPDM) VERIFICATION TEST** .

B1BE7-DRIVER PRESENCE DETECTION SENSOR CIRCUIT LOW

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) receives a message from the Driver Presence Detection Module (DPDM) over the CAN Bus that a short to ground on the sensor circuit is detected.

DEFAULT ACTION

- This is a non MIL fault.

POSSIBLE CAUSES

Possible Causes
DRIVER PRESENCE DETECTION MODULE (DPDM) DTCS PRESENT
DRIVER PRESENCE DETECTION MODULE (DPDM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to **PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE** .

DIAGNOSTIC TEST

1. **CHECK FOR DPDM MODULE DTCS**
    1. With the scan tool, read Driver Presence Detection Module (DPDM) DTCs.

        Are there any DPDM DTCs present?

        Yes

        - Perform the appropriate DPDM diagnostic procedure(s). Refer to **DIAGNOSIS AND TESTING** .

        No

        - Go To 2
2. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

        Are there any applicable Service Bulletins or Flash updates?

        Yes

        - Perform the applicable repair.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 3
3. **CHECK RELATED DPDM MODULE AND COMPONENT CONNECTIONS**

1. Turn the ignition off.
2. Disconnect all DPDM harness connectors.
3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
   - Proper connector installation.
   - Damaged connector locks.
   - Corrosion.
   - Other signs of water intrusion.
   - Weather seal damage (if equipped).
   - Bent terminals.
   - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
   - Terminals that have been pushed back into the connector cavity.
   - Check for spread terminals and verify proper terminal tension.

   Repair any conditions that are found.
6. Reconnect all DPDM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Driver Presence Detection Module (DPDM) in accordance with the Service information. Refer to **MODULE, DRIVER PRESENCE DETECTION (DPDM), REMOVAL AND INSTALLATION** .
    - Perform the DPDM VERIFICATION TEST. Refer to **DRIVER PRESENCE DETECTION MODULE (DPDM) VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the DPDM VERIFICATION TEST. Refer to **DRIVER PRESENCE DETECTION MODULE (DPDM) VERIFICATION TEST** .

B1BE9-DRIVER PRESENCE DETECTION SENSOR CIRCUIT HIGH

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) receives over the CAN Bus a message from the Driver Presence Detection Module (DPDM) that an short to voltage on the sensor circuit is being detected.

DEFAULT ACTION

- This is a non MIL fault.

POSSIBLE CAUSES

Possible Causes
DRIVER PRESENCE DETECTION MODULE (DPDM) DTCS PRESENT
DRIVER PRESENCE DETECTION MODULE (DPDM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to **PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE** .

DIAGNOSTIC TEST

1. **CHECK FOR DPDM MODULE DTCS**
    1. With the scan tool, read Driver Presence Detection Module (DPDM) DTCs.

       Are there any DPDM DTCs present?

       Yes

       - Perform the appropriate DPDM diagnostic procedure(s). Refer to **DIAGNOSIS AND TESTING** .

       No

       - Go To 2
2. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 3
3. **CHECK RELATED DPDM MODULE AND COMPONENT CONNECTIONS**
    1. Turn the ignition off.
    2. Disconnect all DPDM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.

- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all DPDM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Driver Presence Detection Module (DPDM) in accordance with the Service information. Refer to **MODULE, DRIVER PRESENCE DETECTION (DPDM), REMOVAL AND INSTALLATION** .
- Perform the DPDM VERIFICATION TEST. Refer to **DRIVER PRESENCE DETECTION MODULE (DPDM) VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the DPDM VERIFICATION TEST. Refer to **DRIVER PRESENCE DETECTION MODULE (DPDM) VERIFICATION TEST** .

B23BB-STOP/START DISABLE SWITCH 1 CIRCUIT OPEN

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Engine running for more than five seconds.
- Battery voltage between 10.0 and 15.75 volts.

SET CONDITION

- The Powertrain Control Module (PCM) receives the Stop/Start Disable Switch voltage input over CAN Bus from the Integrated Center Stack (ICS) Switch Bank Module. The PCM detects an open in the Stop/Start Disable Switch input for more than 2.24 seconds.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
INTEGRATED CENTER STACK (ICS) SWITCH BANK MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK RELATED INTEGRATED CENTER STACK AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.

- Corrosion.
- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Integrated Center Stack (ICS) in accordance with the Service Information. Refer to **MODULE, INTEGRATED CENTER STACK (ICSM), REMOVAL AND INSTALLATION** .
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

B23BC-STOP/START DISABLE SWITCH 1 CIRCUIT PERFORMANCE

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Engine running for more than five seconds.
- Battery voltage between 10.0 and 15.75 volts.

SET CONDITION

- The Powertrain Control Module (PCM) receives the Stop/Start Disable Switch voltage input over CAN Bus from the Integrated Center Stack (ICS) Switch Bank Module. The PCM detects that the Stop/Start Disable Switch 1 input is irrational.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
INTEGRATED CENTER STACK (ICS) SWITCH BANK MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK RELATED INTEGRATED CENTER STACK AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.

- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Integrated Center Stack (ICS) in accordance with the Service Information. Refer to **MODULE, INTEGRATED CENTER STACK (ICSM), REMOVAL AND INSTALLATION** .
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

B23BD-STOP/START DISABLE SWITCH 1 CIRCUIT LOW

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Engine running for more than five seconds.
- Battery voltage between 10.0 and 15.75 volts.

SET CONDITION

- The Powertrain Control Module (PCM) receives the Stop/Start Disable Switch voltage input over CAN Bus from the Integrated Center Stack (ICS) Switch Bank Module. The PCM detects that the Stop/Start Disable Switch 1 circuit voltage is less than 0.004 volts.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
INTEGRATED CENTER STACK (ICS) SWITCH BANK MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK RELATED INTEGRATED CENTER STACK AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.

- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Integrated Center Stack (ICS) in accordance with the Service Information. Refer to **MODULE, INTEGRATED CENTER STACK (ICSM), REMOVAL AND INSTALLATION** .
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

B23BE-STOP/START DISABLE SWITCH 1 CIRCUIT HIGH

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Engine running for more than five seconds.
- Battery voltage between 10.0 and 15.75 volts.

SET CONDITION

- The Powertrain Control Module (PCM) receives the Stop/Start Disable Switch voltage input over CAN Bus from the Integrated Center Stack (ICS) Switch Bank Module. The PCM detects an open in the Stop/Start Disable Switch 2 input for more than 2.24 seconds.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
INTEGRATED CENTER STACK (ICS) SWITCH BANK MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK RELATED INTEGRATED CENTER STACK AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.

- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Integrated Center Stack (ICS) in accordance with the Service Information. Refer to **MODULE, INTEGRATED CENTER STACK (ICSM), REMOVAL AND INSTALLATION** .
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

B23BF-STOP/START DISABLE SWITCH 2 CIRCUIT OPEN

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Engine running for more than five seconds.
- Battery voltage between 10.0 and 15.75 volts.

SET CONDITION

- The Powertrain Control Module (PCM) receives the Stop/Start Disable Switch voltage input over CAN Bus from the Integrated Center Stack (ICS) Switch Bank Module. The PCM detects an open in the Stop/Start Disable Switch 2 input for more than 2.24 seconds.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
INTEGRATED CENTER STACK (ICS) SWITCH BANK MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK RELATED INTEGRATED CENTER STACK AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.

- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Integrated Center Stack (ICS) in accordance with the Service Information. Refer to **MODULE, INTEGRATED CENTER STACK (ICSM), REMOVAL AND INSTALLATION** .
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

B23C0-STOP/START DISABLE SWITCH 2 CIRCUIT PERFORMANCE

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Engine running for more than five seconds.
- Battery voltage between 10.0 and 15.75 volts.

SET CONDITION

- The Powertrain Control Module (PCM) receives the Stop/Start Disable Switch voltage input over CAN Bus from the Integrated Center Stack (ICS) Switch Bank Module. The PCM detects that the Stop/Start Disable Switch 2 input is irrational.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
INTEGRATED CENTER STACK (ICS) SWITCH BANK MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK RELATED INTEGRATED CENTER STACK AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.

- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Integrated Center Stack (ICS) in accordance with the Service Information. Refer to **MODULE, INTEGRATED CENTER STACK (ICSM), REMOVAL AND INSTALLATION** .
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

B23C1-STOP/START DISABLE SWITCH 2 CIRCUIT LOW

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Engine running for more than five seconds.
- Battery voltage between 10.0 and 15.75 volts.

SET CONDITION

- The Powertrain Control Module (PCM) receives the Stop/Start Disable Switch voltage input over CAN BUS from the Integrated Center Stack (ICS) Switch Bank Module. The PCM detects that the Stop/Start Disable Switch 2 circuit voltage is less than 0.004 volts.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
INTEGRATED CENTER STACK (ICS) SWITCH BANK MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK RELATED INTEGRATED CENTER STACK AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.

- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Integrated Center Stack (ICS) in accordance with the Service Information. Refer to **MODULE, INTEGRATED CENTER STACK (ICSM), REMOVAL AND INSTALLATION** .
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

B23C2-STOP/START DISABLE SWITCH 2 CIRCUIT HIGH

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Engine running for more than five seconds.
- Battery voltage between 10.0 and 15.75 volts.

SET CONDITION

- The Powertrain Control Module (PCM) receives the Stop/Start Disable Switch voltage input over CAN BUS from the Integrated Center Stack (ICS) Switch Bank Module. The PCM detects that the Stop/Start Disable Switch 2 circuit voltage is greater than 4.9 volts.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
INTEGRATED CENTER STACK (ICS) SWITCH BANK MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK RELATED INTEGRATED CENTER STACK AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.

    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.
5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Integrated Center Stack (ICS) in accordance with the Service Information. Refer to **MODULE, INTEGRATED CENTER STACK (ICSM), REMOVAL AND INSTALLATION** .
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

B23C3-STOP/START DISABLE SWITCH 1/2 CORRELATION

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Engine running for more than five seconds.
- Battery voltage between 10.0 and 15.75 volts.

SET CONDITION

- The Powertrain Control Module (PCM) receives the Stop/Start Disable Switch voltage input over Controlled Area Network (CAN) Bus from the Integrated Center Stack (ICS) Switch Bank Module. The PCM detects that the difference between the Stop/Start Disable Switch 1 and Switch 2 circuit voltages are greater than 1.0 volt for more than 0.08 seconds.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this Diagnostic Trouble Code (DTC) is active.

POSSIBLE CAUSES

Possible Causes
INTEGRATED CENTER STACK (ICS) SWITCH BANK MODULE

Always perform the Pre-Diagnostic Troubleshooting procedure before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK RELATED INTEGRATED CENTER STACK AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.

- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Integrated Center Stack (ICS) in accordance with the Service Information. Refer to **MODULE, INTEGRATED CENTER STACK (ICSM), REMOVAL AND INSTALLATION** .
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

B25BC-LEFT FRONT DOOR AJAR SWITCH STUCK CLOSED

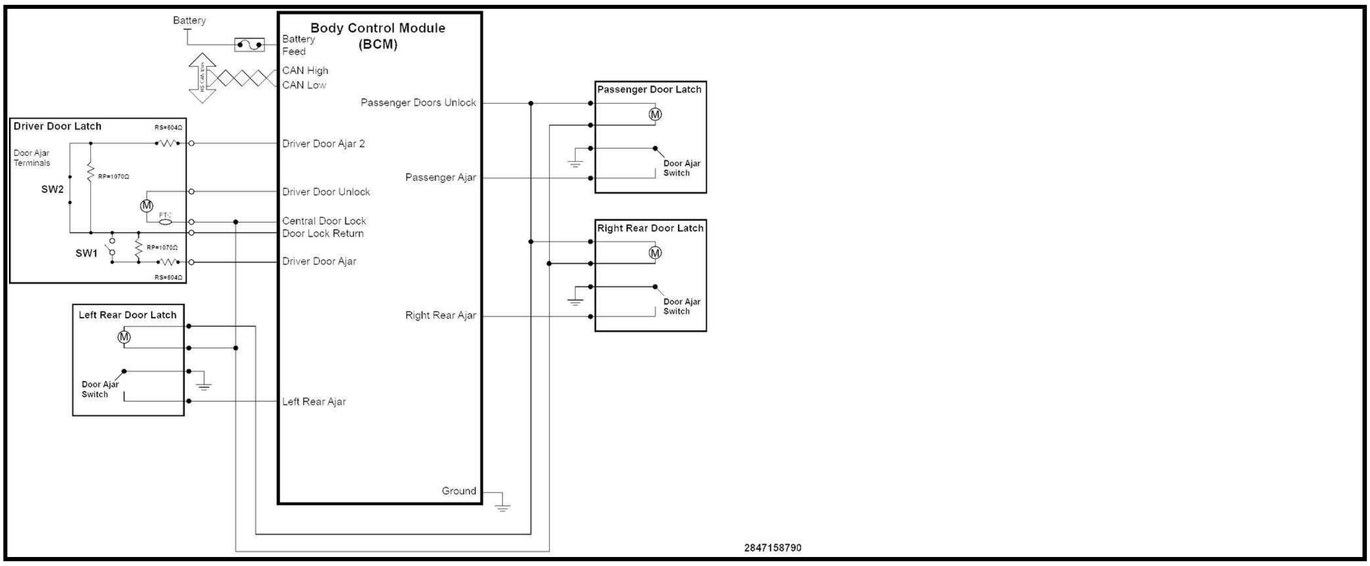
For a complete DOORS/LOCK SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Unlike the passenger ajar signals that function like traditional open/closed ajar switches, the Driver Door Latch has redundant switches and signals for diagnostic purposes. The two switches share a common sensor ground. The Powertrain Control Module (PCM) receives the state (open/closed) of each switch over the CAN Bus from the Drivers Door Module (DDM) or Body Control Module (BCM) depending on the vehicles configuration and which module the latches are hard-wired to. The PCM continuously monitors the functioning status of the Driver Door Ajar Switch states for the operation of certain features such as Electric Stop/Start (ESS).

For further information on the effect of this DTC to the operation of ESS, see **ENGINE START/STOP (ESS) INOPERATIVE.** . Refer to **ENGINE STOP/START (ESS) SYSTEM INOPERATIVE** .

COMPONENT FUNCTIONAL DESCRIPTION - DOOR LATCH SYSTEM



Functional Operation of the Lock Motors: The Body Control Module (BCM) uses an H-Bridge configuration to drive the lock/unlock motors. To lock the doors, voltage is applied to the Lock pin circuit and ground is applied to both Unlock pin circuits. To unlock the doors, voltage is applied to the Unlock pins and ground is applied to the Lock pin. The passenger doors have a separate Unlock pin so that only the Driver's Door can be unlocked with the first button press on the keyless remote. When the lock motors are activated BCM will drive the motors for approximately 370 ms. The BCM and lock motors operate in the voltage range of 9.0 and 16.0 volts. Typical current draw for the motors are listed in Amps in the table below.

NOTE: **The amperage values listed in the table are approximate.**

BATTERY VOLTAGE	IN-RUSH CURRENT	CONTINUOUS OPERATION (NO LOAD)	STALL CURRENT
9.0	3.9	3.1	4.3
12.0	5.22	1.75	6.2
13.5	5.8	1.5	6.9
16.0	6.7	2.0	7.0

Functional Operation of the Latch Switches: All of the Door Latches are monitored to determine if they are closed or ajar. All of the ajar switches are wake-up signals to the BCM. The Driver Door Latch must be rationalized in order for some vehicle features to function. Unlike the passenger ajar signals that function like traditional open/closed ajar switches, the Driver Door Latch has redundant switches and signals for diagnostic purposes. The two switches share a common sensor ground. The Door Ajar Switch signals use Battery voltage for a reference. The switches operate in the following manner:

- **Driver Door Ajar Switches:** The BCM has an internal pull up 1000 Ohm resistor for each ajar signal. Each switch has an internal 604 Ohm and 1070 Ohm resistor. When the switches are open the resistance through the switches are 1674 Ohms. When the switches are closed the resistance through the switches are 604 Ohms. The switch states are opposing each other, meaning that when the **door latch is closed** , switch 1 is in the open state and switch 2 is in the closed state. The opposite is true when the **door latch is opened** . For more information refer to the tables below.
- **Passenger Ajar Switches:** The ajar switches are open when the latch is closed. When the door latch is ajar the switch closes allowing the signal to connect to ground through the switch. Therefore the signal inputs to the BCM are high when the door is closed and low when the door is ajar.

The BCM monitors the Driver Door Ajar Switch signal circuit and converts the voltage signal into counts to broadcast over the CAN Bus network.

- Electronic Control Modules read an analog signal voltage and converts it to digital counts. Each count is an equal percentage of the signal reference voltage. This can be seen when viewing some sensor or switch voltages and converted values on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts to a battery voltage reference.

- The resolution of the signal is determined by the required precision of the input by the ECU. Typically, sensor signals are high resolution. This allows the module to read small changes over a wide range in a variable resistance sensor signal. These are typically used on a temperature, pressure, position or MUX type of sensor.
- Switches typically have a much lower resolution than sensors. This is because an ECU is generally looking for a switch to be in only a few positions that use fixed resistors. The lower resolution also helps the ECU to overcome some resistance in a circuit and still read the correct state. This also lowers the sensitivity to setting DTCs.
- The voltage and percentages can vary slightly with calibration changes. The voltage values and percentages in the table are approximate and can be slightly different. Typically, a failure will be noticeably different than the values in the table. The voltage ranges given are based on a nominal reference voltage of 13.5 volts. The voltage on the signal will change with system voltage but the percentage of system voltage should not change.

The Driver Door Ajar Switch signal voltage is divided into 15 counts typically. The table below shows the relation between the Driver Door Ajar Switch states and **approximate voltage percentages/ranges.**

DOOR AJAR SWITCH 1

VOLTAGE PERCENTAGE/VALUE TO SWITCH STATE			
Percentage of Battery Voltage	**Voltage Range @ 13.5 volts nominal**	**Door Latch Position**	**Ajar Switch State (Open/Closed)**
87 - 100%	Range: 11.7v - 13.5v	-	CIRCUIT HIGH FAULT RANGE - OPEN CIRCUIT
54 - 86%	Nominal: 8.5v Range: 7.2v - 9.9v	CLOSED	SWITCH OPEN
20 - 53%	Nominal: 4.5v Range: 2.7v- 6.3v	AJAR	SWITCH CLOSED
0 - 19%	Range: 0v - 1.8v	-	CIRCUIT LOW FAULT RANGE-SHORT TO GROUND

DOOR AJAR SWITCH 2

Percentage of Battery Voltage	**Voltage Range @ 13.5 volts nominal**	**Door Latch Position**	**Ajar Switch State (Open/Closed)**
87 - 100%	Range: 11.7v - 13.5v	-	CIRCUIT HIGH FAULT RANGE - OPEN CIRCUIT
54 - 86%	Nominal: 8.5v Range: 7.2v - 9.9v	AJAR	SWITCH OPEN
20- 53%	Nominal: 4.5v Range: 2.7v- 6.3v	CLOSED	SWITCH CLOSED
0 - 19%	Range: 0v - 1.8v	-	CIRCUIT LOW FAULT RANGE-SHORT TO GROUND

DIAGNOSTIC OVERVIEW-DOOR LOCK MOTORS AND SWITCHES:

- **Lock Motors:** The BCM is capable of detecting opens and shorts in the H-Bridge control circuits. The locks are not thermally protected by the BCM. The protection is done by limiting the number of actuations within a calibrated time period.
- **Door Latch Switches:** The resistors in the latch switches allows the BCM to perform diagnostics on the circuits and switches. Unlike the passenger door switches the voltage on the two signals should not be

high or low. If the BCM determines that either signal falls into the high or low range, a fault is set. If the door latch positions do not match between the two Driver Door Ajar Switches, a correlation fault will set.

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) receives the door ajar status over the CAN C BUS from the Body Control Module (BCM). The PCM detects that the Driver Door Latch Ajar Switch state is stuck closed.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
LEFT FRONT DOOR LATCH WIRING ISSUE
LEFT FRONT DOOR LATCH ASSEMBLY
BODY CONTROL MODULE (BCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. Open and close the door several times.
    8. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 3

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any Door Ajar Switch circuit high or low faults present?

      Yes

      - Perform the applicable diagnostic procedure(s).

      No

      - Go To 4
4. **REPLACE THE LEFT FRONT DOOR LATCH ASSEMBLY AND RETEST FOR DTCS**
   1. Turn the ignition off.
   2. Replace the component (Door Latch) in accordance with the Service Information.
   3. Connect the component and Electronic Control Unit (ECU) harness connectors.
   4. Turn the ignition on.
   5. With the scan tool, erase all DTCs.
   6. Turn the ignition off for a minimum of 10.0 seconds.
   7. Turn the ignition on.
   8. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   9. Open and close the door several times.
   10. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 5

   No

   - Replacing the faulty component repaired the fault.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **CHECK RELATED BCM AND COMPONENT CONNECTIONS**
   1. Disconnect all BCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.

- Damaged connector locks.
- Corrosion.
- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Body Control Module (BCM) in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM), REMOVAL AND INSTALLATION** .
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

B25C7-DRIVER DOOR AJAR SWITCH 2 CIRCUIT LOW

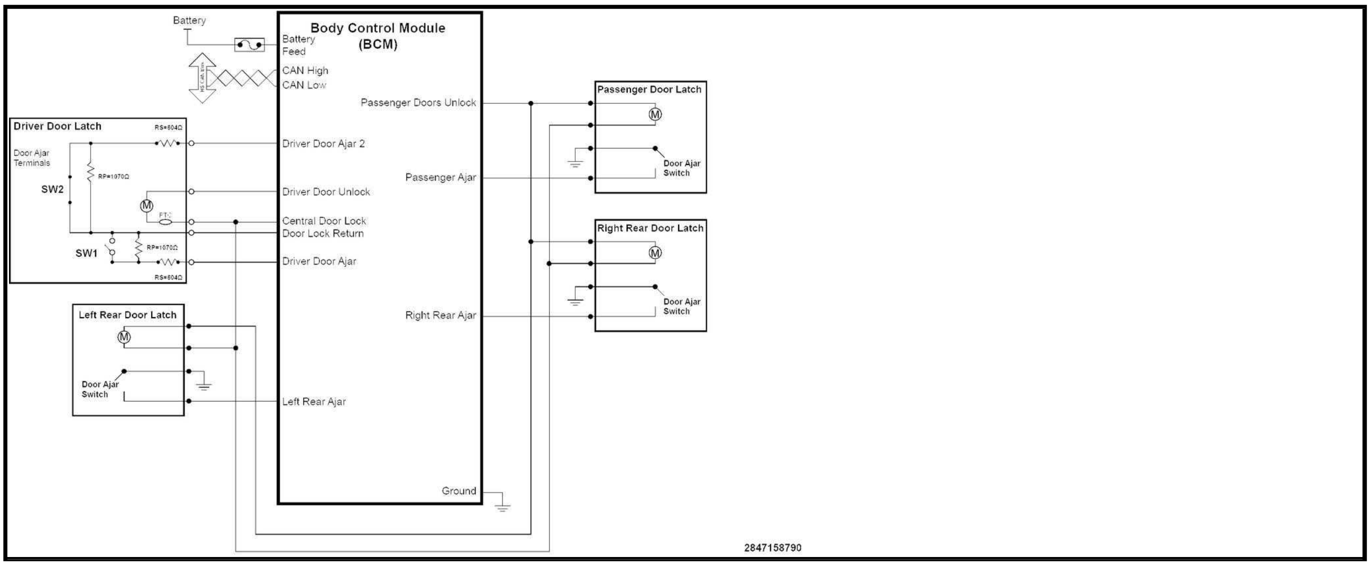
For a complete DOORS/LOCK SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Unlike the passenger ajar signals that function like traditional open/closed ajar switches, the Driver Door Latch has redundant switches and signals for diagnostic purposes. The two switches share a common sensor ground. The Powertrain Control Module (PCM) receives the state (open/closed) of each switch over the CAN Bus from the Drivers Door Module (DDM) or Body Control Module (BCM) depending on the vehicles configuration and which module the latches are hard-wired to. The PCM continuously monitors the functioning status of the Driver Door Ajar Switch states for the operation of certain features such as Electric Stop/Start (ESS).

For further information on the effect of this DTC to the operation of ESS, see **ENGINE START/STOP (ESS) INOPERATIVE.** . Refer to **ENGINE STOP/START (ESS) SYSTEM INOPERATIVE** .

COMPONENT FUNCTIONAL DESCRIPTION - DOOR LATCH SYSTEM



Functional Operation of the Lock Motors: The Body Control Module (BCM) uses an H-Bridge configuration to drive the lock/unlock motors. To lock the doors, voltage is applied to the Lock pin circuit and ground is applied to both Unlock pin circuits. To unlock the doors, voltage is applied to the Unlock pins and ground is applied to the Lock pin. The passenger doors have a separate Unlock pin so that only the Driver's Door can be unlocked with the first button press on the keyless remote. When the lock motors are activated BCM will drive the motors for approximately 370 ms. The BCM and lock motors operate in the voltage range of 9.0 and 16.0 volts. Typical current draw for the motors are listed in Amps in the table below.

NOTE: **The amperage values listed in the table are approximate.**

BATTERY VOLTAGE	IN-RUSH CURRENT	CONTINUOUS OPERATION (NO LOAD)	STALL CURRENT
9.0	3.9	3.1	4.3
12.0	5.22	1.75	6.2
13.5	5.8	1.5	6.9
16.0	6.7	2.0	7.0

Functional Operation of the Latch Switches: All of the Door Latches are monitored to determine if they are closed or ajar. All of the ajar switches are wake-up signals to the BCM. The Driver Door Latch must be rationalized in order for some vehicle features to function. Unlike the passenger ajar signals that function like traditional open/closed ajar switches, the Driver Door Latch has redundant switches and signals for diagnostic purposes. The two switches share a common sensor ground. The Door Ajar Switch signals use Battery voltage for a reference. The switches operate in the following manner:

- **Driver Door Ajar Switches:** The BCM has an internal pull up 1000 Ohm resistor for each ajar signal. Each switch has an internal 604 Ohm and 1070 Ohm resistor. When the switches are open the resistance through the switches are 1674 Ohms. When the switches are closed the resistance through the switches are 604 Ohms. The switch states are opposing each other, meaning that when the **door latch is closed** , switch 1 is in the open state and switch 2 is in the closed state. The opposite is true when the **door latch is opened** . For more information refer to the tables below.
- **Passenger Ajar Switches:** The ajar switches are open when the latch is closed. When the door latch is ajar the switch closes allowing the signal to connect to ground through the switch. Therefore the signal inputs to the BCM are high when the door is closed and low when the door is ajar.

The BCM monitors the Driver Door Ajar Switch signal circuit and converts the voltage signal into counts to broadcast over the CAN Bus network.

- Electronic Control Modules read an analog signal voltage and converts it to digital counts. Each count is an equal percentage of the signal reference voltage. This can be seen when viewing some sensor or switch voltages and converted values on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts to a battery voltage reference.

- The resolution of the signal is determined by the required precision of the input by the ECU. Typically, sensor signals are high resolution. This allows the module to read small changes over a wide range in a variable resistance sensor signal. These are typically used on a temperature, pressure, position or MUX type of sensor.
- Switches typically have a much lower resolution than sensors. This is because an ECU is generally looking for a switch to be in only a few positions that use fixed resistors. The lower resolution also helps the ECU to overcome some resistance in a circuit and still read the correct state. This also lowers the sensitivity to setting DTCs.
- The voltage and percentages can vary slightly with calibration changes. The voltage values and percentages in the table are approximate and can be slightly different. Typically, a failure will be noticeably different than the values in the table. The voltage ranges given are based on a nominal reference voltage of 13.5 volts. The voltage on the signal will change with system voltage but the percentage of system voltage should not change.

The Driver Door Ajar Switch signal voltage is divided into 15 counts typically. The table below shows the relation between the Driver Door Ajar Switch states and **approximate voltage percentages/ranges.**

DOOR AJAR SWITCH 1

VOLTAGE PERCENTAGE/VALUE TO SWITCH STATE			
Percentage of Battery Voltage	**Voltage Range @ 13.5 volts nominal**	**Door Latch Position**	**Ajar Switch State (Open/Closed)**
87 - 100%	Range: 11.7v - 13.5v	-	CIRCUIT HIGH FAULT RANGE - OPEN CIRCUIT
54 - 86%	Nominal: 8.5v Range: 7.2v - 9.9v	CLOSED	SWITCH OPEN
20 - 53%	Nominal: 4.5v Range: 2.7v- 6.3v	AJAR	SWITCH CLOSED
0 - 19%	Range: 0v - 1.8v	-	CIRCUIT LOW FAULT RANGE-SHORT TO GROUND

DOOR AJAR SWITCH 2

Percentage of Battery Voltage	Voltage Range @ 13.5 volts nominal	Door Latch Position	Ajar Switch State (Open/Closed)
87 - 100%	Range: 11.7v - 13.5v	-	CIRCUIT HIGH FAULT RANGE - OPEN CIRCUIT
54 - 86%	Nominal: 8.5v Range: 7.2v - 9.9v	AJAR	SWITCH OPEN
20- 53%	Nominal: 4.5v Range: 2.7v- 6.3v	CLOSED	SWITCH CLOSED
0 - 19%	Range: 0v - 1.8v	-	CIRCUIT LOW FAULT RANGE-SHORT TO GROUND

DIAGNOSTIC OVERVIEW-DOOR LOCK MOTORS AND SWITCHES:

- **Lock Motors:** The BCM is capable of detecting opens and shorts in the H-Bridge control circuits. The locks are not thermally protected by the BCM. The protection is done by limiting the number of actuations within a calibrated time period.
- **Door Latch Switches:** The resistors in the latch switches allows the BCM to perform diagnostics on the circuits and switches. Unlike the passenger door switches the voltage on the two signals should not be

high or low. If the BCM determines that either signal falls into the high or low range, a fault is set. If the door latch positions do not match between the two Driver Door Ajar Switches, a correlation fault will set.

WHEN MONITORED

- With the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Secondary Driver Door Ajar Switch signal voltage received over the CAN C BUS from the Body Control Module (BCM) is below a calibrated threshold.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
DRIVER DOOR LATCH AJAR SWITCH 2 SENSE CIRCUIT SHORTED TO GROUND
DRIVER DOOR LATCH AJAR SWITCH 2 SENSE CIRCUIT SHORTED TO THE DRIVER DOOR LATCH RETURN CIRCUIT
DRIVER DOOR LATCH
BODY CONTROL MODULE (BCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

        Are there any applicable Service Bulletins or Flash updates?

        Yes

        - Perform the applicable repair.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.

6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 3

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **DISCONNECT THE DRIVER DOOR LATCH HARNESS CONNECTOR AND VERIFY THE ABILITY OF THE BCM TO READ THE DRIVER DOOR AJAR SWITCH 2 CIRCUIT HIGH DTC**
    1. The Electronic Control Unit (ECU) harness connectors must be connected to the ECU during this test step.
    2. With the ignition in the off position, disconnect the sensor harness connector.
    3. Turn the ignition on.
    4. With the scan tool, read DTCs.

Does the scan tool display the B25C8-DRIVER DOOR AJAR SWITCH 2 CIRCUIT HIGH with the connector disconnected?

Yes

- Replace the Door Latch in accordance with the Service Information. Refer to **LATCH, DOOR, REMOVAL AND INSTALLATION** .
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

No

- Go To 4

4. **ISOLATE AND CHECK THE DRIVER DOOR LATCH (G755) AJAR SWITCH 2 SENSE CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

No

- Go To 5

5. **ISOLATE AND CHECK THE DRIVER DOOR LATCH (G755) AJAR SWITCH 2 SENSE CIRCUIT FOR A SHORT TO THE DRIVER DOOR LATCH (P371) RETURN CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

NOTE: **There should be no continuity between the circuits being tested.**

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK RELATED BCM AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.

10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Body Control Module (BCM) in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM), REMOVAL AND INSTALLATION** .
    - Perform the BODY VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

B25C8-DRIVER DOOR AJAR SWITCH 2 CIRCUIT HIGH

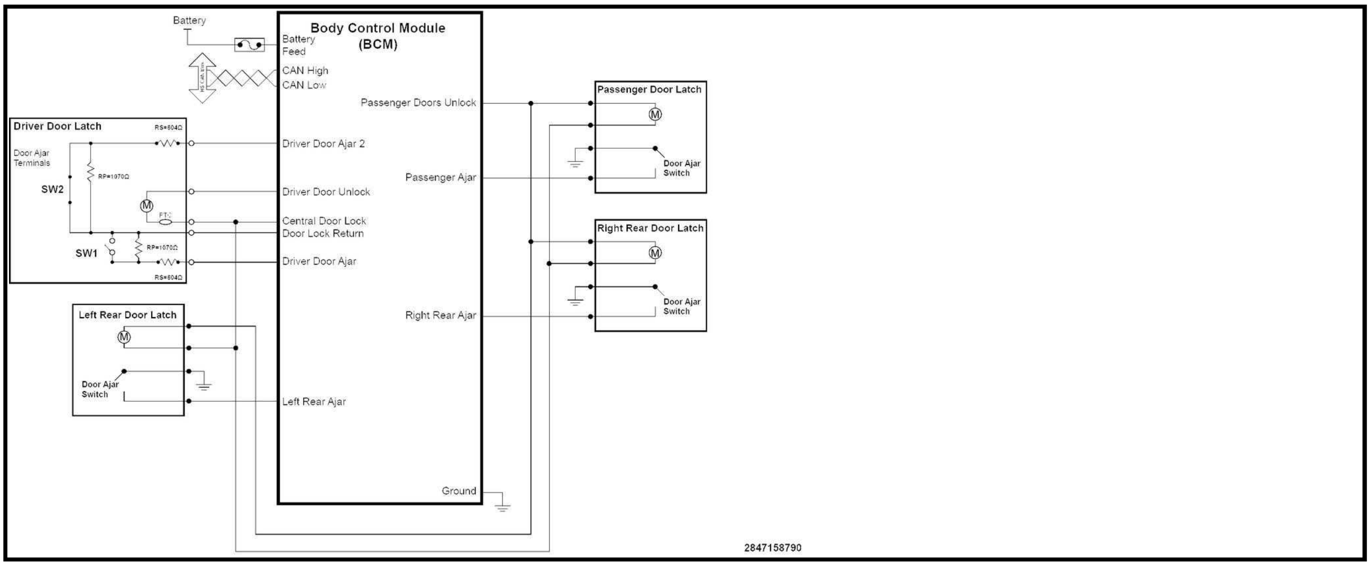
For a complete DOORS/LOCK SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Unlike the passenger ajar signals that function like traditional open/closed ajar switches, the Driver Door Latch has redundant switches and signals for diagnostic purposes. The two switches share a common sensor ground. The Powertrain Control Module (PCM) receives the state (open/closed) of each switch over the CAN Bus from the Drivers Door Module (DDM) or Body Control Module (BCM) depending on the vehicles configuration and which module the latches are hard-wired to. The PCM continuously monitors the functioning status of the Driver Door Ajar Switch states for the operation of certain features such as Electric Stop/Start (ESS).

For further information on the effect of this DTC to the operation of ESS, see **ENGINE START/STOP (ESS) INOPERATIVE.** . Refer to **ENGINE STOP/START (ESS) SYSTEM INOPERATIVE** .

COMPONENT FUNCTIONAL DESCRIPTION - DOOR LATCH SYSTEM



Functional Operation of the Lock Motors: The Body Control Module (BCM) uses an H-Bridge configuration to drive the lock/unlock motors. To lock the doors, voltage is applied to the Lock pin circuit and ground is applied to both Unlock pin circuits. To unlock the doors, voltage is applied to the Unlock pins and ground is applied to the Lock pin. The passenger doors have a separate Unlock pin so that only the Driver's Door can be unlocked with the first button press on the keyless remote. When the lock motors are activated BCM will drive the motors for approximately 370 ms. The BCM and lock motors operate in the voltage range of 9.0 and 16.0 volts. Typical current draw for the motors are listed in Amps in the table below.

NOTE: **The amperage values listed in the table are approximate.**

BATTERY VOLTAGE	IN-RUSH CURRENT	CONTINUOUS OPERATION (NO LOAD)	STALL CURRENT
9.0	3.9	3.1	4.3
12.0	5.22	1.75	6.2
13.5	5.8	1.5	6.9
16.0	6.7	2.0	7.0

Functional Operation of the Latch Switches: All of the Door Latches are monitored to determine if they are closed or ajar. All of the ajar switches are wake-up signals to the BCM. The Driver Door Latch must be rationalized in order for some vehicle features to function. Unlike the passenger ajar signals that function like traditional open/closed ajar switches, the Driver Door Latch has redundant switches and signals for diagnostic purposes. The two switches share a common sensor ground. The Door Ajar Switch signals use Battery voltage for a reference. The switches operate in the following manner:

- **Driver Door Ajar Switches:** The BCM has an internal pull up 1000 Ohm resistor for each ajar signal. Each switch has an internal 604 Ohm and 1070 Ohm resistor. When the switches are open the resistance through the switches are 1674 Ohms. When the switches are closed the resistance through the switches are 604 Ohms. The switch states are opposing each other, meaning that when the **door latch is closed** , switch 1 is in the open state and switch 2 is in the closed state. The opposite is true when the **door latch is opened** . For more information refer to the tables below.
- **Passenger Ajar Switches:** The ajar switches are open when the latch is closed. When the door latch is ajar the switch closes allowing the signal to connect to ground through the switch. Therefore the signal inputs to the BCM are high when the door is closed and low when the door is ajar.

The BCM monitors the Driver Door Ajar Switch signal circuit and converts the voltage signal into counts to broadcast over the CAN Bus network.

- Electronic Control Modules read an analog signal voltage and converts it to digital counts. Each count is an equal percentage of the signal reference voltage. This can be seen when viewing some sensor or switch voltages and converted values on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts to a battery voltage reference.
- The resolution of the signal is determined by the required precision of the input by the ECU. Typically, sensor signals are high resolution. This allows the module to read small changes over a wide range in a variable resistance sensor signal. These are typically used on a temperature, pressure, position or MUX type of sensor.
- Switches typically have a much lower resolution than sensors. This is because an ECU is generally looking for a switch to be in only a few positions that use fixed resistors. The lower resolution also helps the ECU to overcome some resistance in a circuit and still read the correct state. This also lowers the sensitivity to setting DTCs.
- The voltage and percentages can vary slightly with calibration changes. The voltage values and percentages in the table are approximate and can be slightly different. Typically, a failure will be noticeably different than the values in the table. The voltage ranges given are based on a nominal reference voltage of 13.5 volts. The voltage on the signal will change with system voltage but the percentage of system voltage should not change.

The Driver Door Ajar Switch signal voltage is divided into 15 counts typically. The table below shows the relation between the Driver Door Ajar Switch states and **approximate voltage percentages/ranges.**

DOOR AJAR SWITCH 1

VOLTAGE PERCENTAGE/VALUE TO SWITCH STATE			
Percentage of Battery Voltage	**Voltage Range @ 13.5 volts nominal**	**Door Latch Position**	**Ajar Switch State (Open/Closed)**
87 - 100%	Range: 11.7v - 13.5v	-	CIRCUIT HIGH FAULT RANGE - OPEN CIRCUIT
54 - 86%	Nominal: 8.5v Range: 7.2v - 9.9v	CLOSED	SWITCH OPEN
20 - 53%	Nominal: 4.5v Range: 2.7v- 6.3v	AJAR	SWITCH CLOSED
0 - 19%	Range: 0v - 1.8v	-	CIRCUIT LOW FAULT RANGE-SHORT TO GROUND

DOOR AJAR SWITCH 2

Percentage of Battery Voltage	Voltage Range @ 13.5 volts nominal	Door Latch Position	Ajar Switch State (Open/Closed)
87 - 100%	Range: 11.7v - 13.5v	-	CIRCUIT HIGH FAULT RANGE - OPEN CIRCUIT
54 - 86%	Nominal: 8.5v Range: 7.2v - 9.9v	AJAR	SWITCH OPEN
20- 53%	Nominal: 4.5v Range: 2.7v- 6.3v	CLOSED	SWITCH CLOSED
0 - 19%	Range: 0v - 1.8v	-	CIRCUIT LOW FAULT RANGE-SHORT TO GROUND

DIAGNOSTIC OVERVIEW-DOOR LOCK MOTORS AND SWITCHES:

- **Lock Motors:** The BCM is capable of detecting opens and shorts in the H-Bridge control circuits. The locks are not thermally protected by the BCM. The protection is done by limiting the number of actuations within a calibrated time period.
- **Door Latch Switches:** The resistors in the latch switches allows the BCM to perform diagnostics on the circuits and switches. Unlike the passenger door switches the voltage on the two signals should not be high or low. If the BCM determines that either signal falls into the high or low range, a fault is set. If the door latch positions do not match between the two Driver Door Ajar Switches, a correlation fault will set.

WHEN MONITORED

- With the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Secondary Driver Door Ajar Switch signal voltage received over the CAN C BUS from the Body Control Module (BCM) is above a calibrated threshold.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
DRIVER DOOR LATCH AJAR SWITCH 2 SENSE CIRCUIT OPEN/HIGH RESISTANCE

Possible Causes
DRIVER DOOR LATCH RETURN CIRCUIT OPEN/HIGH RESISTANCE
DRIVER DOOR LATCH
BODY CONTROL MODULE (BCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **ISOLATE AND CHECK THE DRIVER DOOR LATCH (G755) AJAR SWITCH 2 SENSE CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.

4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the ECU harness connector and measure the resistance of the circuit.

Is the resistance below 3.0 Ohms?

Yes

- Go To 4

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE DRIVER DOOR LATCH (P371) RETURN CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the ECU harness connector and measure the resistance of the circuit.

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 5

    No

    - Repair the circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **CONNECT A FUSED JUMPER BETWEEN THE DRIVER DOOR LATCH (G755) AJAR SWITCH 2 SENSE CIRCUIT AND THE DRIVER DOOR LATCH (P371) RETURN CIRCUIT AT THE DOOR LATCH HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SWITCH SIGNAL CIRCUIT LOW DTC**
    1. The Electronic Control Unit (ECU) harness connectors must be connected to the ECU during this test step.
    2. Disconnect the sensor harness connector.
    3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the sensor ground circuit at the door latch harness connector.
    4. Turn the ignition on.
    5. With the scan tool, read DTCs.

    Does the scan tool display the B25C7-DRIVER DOOR AJAR SWITCH 2 CIRCUIT LOW with the jumper in place?

    Yes

- Replace the Door Latch in accordance with the Service Information. Refer to **LATCH, DOOR, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK RELATED BCM AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Body Control Module (BCM) in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM), REMOVAL AND INSTALLATION** .
        - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

B25C9-DRIVER DOOR AJAR SWITCH 2 STUCK CLOSED

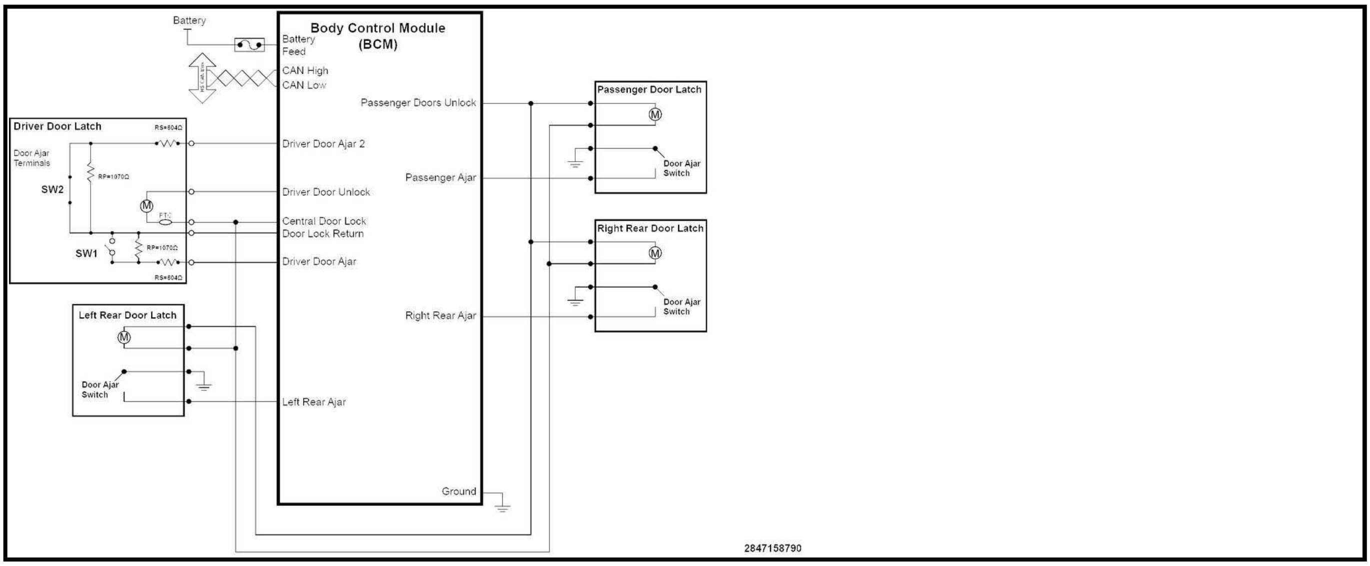
For a complete DOORS/LOCK SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Unlike the passenger ajar signals that function like traditional open/closed ajar switches, the Driver Door Latch has redundant switches and signals for diagnostic purposes. The two switches share a common sensor ground. The Powertrain Control Module (PCM) receives the state (open/closed) of each switch over the CAN Bus from the Drivers Door Module (DDM) or Body Control Module (BCM) depending on the vehicles configuration and which module the latches are hard-wired to. The PCM continuously monitors the functioning status of the Driver Door Ajar Switch states for the operation of certain features such as Electric Stop/Start (ESS).

For further information on the effect of this DTC to the operation of ESS, see **ENGINE START/STOP (ESS) INOPERATIVE.** . Refer to ENGINE STOP/START (ESS) SYSTEM INOPERATIVE .

COMPONENT FUNCTIONAL DESCRIPTION - DOOR LATCH SYSTEM



Functional Operation of the Lock Motors: The Body Control Module (BCM) uses an H-Bridge configuration to drive the lock/unlock motors. To lock the doors, voltage is applied to the Lock pin circuit and ground is applied to both Unlock pin circuits. To unlock the doors, voltage is applied to the Unlock pins and ground is applied to the Lock pin. The passenger doors have a separate Unlock pin so that only the Driver's Door can be unlocked with the first button press on the keyless remote. When the lock motors are activated BCM will drive the motors for approximately 370 ms. The BCM and lock motors operate in the voltage range of 9.0 and 16.0 volts. Typical current draw for the motors are listed in Amps in the table below.

NOTE: **The amperage values listed in the table are approximate.**

BATTERY VOLTAGE	IN-RUSH CURRENT	CONTINUOUS OPERATION (NO LOAD)	STALL CURRENT
9.0	3.9	3.1	4.3
12.0	5.22	1.75	6.2
13.5	5.8	1.5	6.9
16.0	6.7	2.0	7.0

Functional Operation of the Latch Switches: All of the Door Latches are monitored to determine if they are closed or ajar. All of the ajar switches are wake-up signals to the BCM. The Driver Door Latch must be rationalized in order for some vehicle features to function. Unlike the passenger ajar signals that function like traditional open/closed ajar switches, the Driver Door Latch has redundant switches and signals for diagnostic purposes. The two switches share a common sensor ground. The Door Ajar Switch signals use Battery voltage for a reference. The switches operate in the following manner:

- **Driver Door Ajar Switches:** The BCM has an internal pull up 1000 Ohm resistor for each ajar signal. Each switch has an internal 604 Ohm and 1070 Ohm resistor. When the switches are open the resistance through the switches are 1674 Ohms. When the switches are closed the resistance through the switches are 604 Ohms. The switch states are opposing each other, meaning that when the **door latch is closed** , switch 1 is in the open state and switch 2 is in the closed state. The opposite is true when the **door latch is opened** . For more information refer to the tables below.
- **Passenger Ajar Switches:** The ajar switches are open when the latch is closed. When the door latch is ajar the switch closes allowing the signal to connect to ground through the switch. Therefore the signal inputs to the BCM are high when the door is closed and low when the door is ajar.

The BCM monitors the Driver Door Ajar Switch signal circuit and converts the voltage signal into counts to broadcast over the CAN Bus network.

- Electronic Control Modules read an analog signal voltage and converts it to digital counts. Each count is an equal percentage of the signal reference voltage. This can be seen when viewing some sensor or switch voltages and converted values on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts to a battery voltage reference.
- The resolution of the signal is determined by the required precision of the input by the ECU. Typically, sensor signals are high resolution. This allows the module to read small changes over a wide range in a variable resistance sensor signal. These are typically used on a temperature, pressure, position or MUX type of sensor.
- Switches typically have a much lower resolution than sensors. This is because an ECU is generally looking for a switch to be in only a few positions that use fixed resistors. The lower resolution also helps the ECU to overcome some resistance in a circuit and still read the correct state. This also lowers the sensitivity to setting DTCs.
- The voltage and percentages can vary slightly with calibration changes. The voltage values and percentages in the table are approximate and can be slightly different. Typically, a failure will be noticeably different than the values in the table. The voltage ranges given are based on a nominal reference voltage of 13.5 volts. The voltage on the signal will change with system voltage but the percentage of system voltage should not change.

The Driver Door Ajar Switch signal voltage is divided into 15 counts typically. The table below shows the relation between the Driver Door Ajar Switch states and **approximate voltage percentages/ranges.**

DOOR AJAR SWITCH 1

VOLTAGE PERCENTAGE/VALUE TO SWITCH STATE			
Percentage of Battery Voltage	**Voltage Range @ 13.5 volts nominal**	**Door Latch Position**	**Ajar Switch State (Open/Closed)**
87 - 100%	Range: 11.7v - 13.5v	-	CIRCUIT HIGH FAULT RANGE - OPEN CIRCUIT
54 - 86%	Nominal: 8.5v Range: 7.2v - 9.9v	CLOSED	SWITCH OPEN
20 - 53%	Nominal: 4.5v Range: 2.7v- 6.3v	AJAR	SWITCH CLOSED
0 - 19%	Range: 0v - 1.8v	-	CIRCUIT LOW FAULT RANGE-SHORT TO GROUND

DOOR AJAR SWITCH 2

Percentage of Battery Voltage	Voltage Range @ 13.5 volts nominal	Door Latch Position	Ajar Switch State (Open/Closed)
87 - 100%	Range: 11.7v - 13.5v	-	CIRCUIT HIGH FAULT RANGE - OPEN CIRCUIT
54 - 86%	Nominal: 8.5v	AJAR	SWITCH OPEN

Percentage of Battery Voltage	Voltage Range @ 13.5 volts nominal	Door Latch Position	Ajar Switch State (Open/Closed)
	Range: 7.2v - 9.9v		
20- 53%	Nominal: 4.5v Range: 2.7v- 6.3v	CLOSED	SWITCH CLOSED
0 - 19%	Range: 0v - 1.8v	-	CIRCUIT LOW FAULT RANGE-SHORT TO GROUND

DIAGNOSTIC OVERVIEW-DOOR LOCK MOTORS AND SWITCHES:

- **Lock Motors:** The BCM is capable of detecting opens and shorts in the H-Bridge control circuits. The locks are not thermally protected by the BCM. The protection is done by limiting the number of actuations within a calibrated time period.
- **Door Latch Switches:** The resistors in the latch switches allows the BCM to perform diagnostics on the circuits and switches. Unlike the passenger door switches the voltage on the two signals should not be high or low. If the BCM determines that either signal falls into the high or low range, a fault is set. If the door latch positions do not match between the two Driver Door Ajar Switches, a correlation fault will set.

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) receives the door ajar status over the CAN C BUS from the Body Control Module (BCM). The PCM detects that the Driver Door Latch Ajar Switch 2 state is stuck closed.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
LEFT FRONT DOOR LATCH WIRING ISSUE
LEFT FRONT DOOR LATCH ASSEMBLY
BODY CONTROL MODULE (BCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

- Go To 2

2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. Open and close the door several times.
    8. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any Door Ajar Switch 2 circuit high or low faults present?

        Yes

        - Perform the applicable diagnostic procedure(s).

        No

        - Go To 4
4. **REPLACE THE LEFT FRONT DOOR LATCH ASSEMBLY AND RETEST FOR DTCS**
    1. Turn the ignition off.
    2. Replace the component (Door Latch) in accordance with the Service Information.
    3. Connect the component and Electronic Control Unit (ECU) harness connectors.
    4. Turn the ignition on.
    5. With the scan tool, erase all DTCs.
    6. Turn the ignition off for a minimum of 10.0 seconds.
    7. Turn the ignition on.
    8. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    9. Open and close the door several times.
    10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

- Go To 5

No

- Replacing the faulty component repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED BCM AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Body Control Module (BCM) in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM), REMOVAL AND INSTALLATION** .
        - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

B25CB-DRIVER DOOR AJAR SWITCH 1/DRIVER DOOR AJAR SWITCH 2 CORRELATION

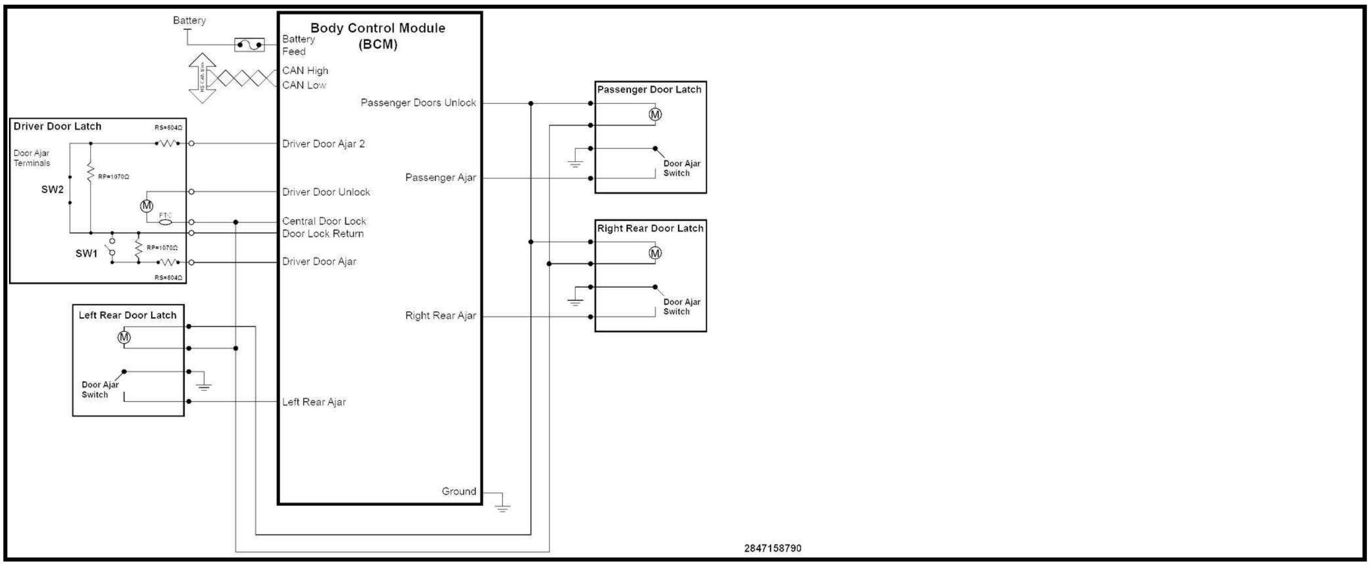
For a complete DOORS/LOCK SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Unlike the passenger ajar signals that function like traditional open/closed ajar switches, the Driver Door Latch has redundant switches and signals for diagnostic purposes. The two switches share a common sensor ground. The Powertrain Control Module (PCM) receives the state (open/closed) of each switch over the CAN Bus from the Drivers Door Module (DDM) or Body Control Module (BCM) depending on the vehicles configuration and which module the latches are hard-wired to. The PCM continuously monitors the functioning status of the Driver Door Ajar Switch states for the operation of certain features such as Electric Stop/Start (ESS).

For further information on the effect of this DTC to the operation of ESS, see **ENGINE START/STOP (ESS) INOPERATIVE.** . Refer to ENGINE STOP/START (ESS) SYSTEM INOPERATIVE .

COMPONENT FUNCTIONAL DESCRIPTION - DOOR LATCH SYSTEM



Functional Operation of the Lock Motors: The Body Control Module (BCM) uses an H-Bridge configuration to drive the lock/unlock motors. To lock the doors, voltage is applied to the Lock pin circuit and ground is applied to both Unlock pin circuits. To unlock the doors, voltage is applied to the Unlock pins and ground is applied to the Lock pin. The passenger doors have a separate Unlock pin so that only the Driver's Door can be unlocked with the first button press on the keyless remote. When the lock motors are activated BCM will drive the motors for approximately 370 ms. The BCM and lock motors operate in the voltage range of 9.0 and 16.0 volts. Typical current draw for the motors are listed in Amps in the table below.

NOTE: **The amperage values listed in the table are approximate.**

BATTERY VOLTAGE	IN-RUSH CURRENT	CONTINUOUS OPERATION (NO LOAD)	STALL CURRENT
9.0	3.9	3.1	4.3
12.0	5.22	1.75	6.2
13.5	5.8	1.5	6.9
16.0	6.7	2.0	7.0

Functional Operation of the Latch Switches: All of the Door Latches are monitored to determine if they are closed or ajar. All of the ajar switches are wake-up signals to the BCM. The Driver Door Latch must be rationalized in order for some vehicle features to function. Unlike the passenger ajar signals that function like traditional open/closed ajar switches, the Driver Door Latch has redundant switches and signals for diagnostic purposes. The two switches share a common sensor ground. The Door Ajar Switch signals use Battery voltage for a reference. The switches operate in the following manner:

- **Driver Door Ajar Switches:** The BCM has an internal pull up 1000 Ohm resistor for each ajar signal. Each switch has an internal 604 Ohm and 1070 Ohm resistor. When the switches are open the resistance through the switches are 1674 Ohms. When the switches are closed the resistance through the switches are 604 Ohms. The switch states are opposing each other, meaning that when the **door latch is closed** , switch 1 is in the open state and switch 2 is in the closed state. The opposite is true when the **door latch is opened** . For more information refer to the tables below.
- **Passenger Ajar Switches:** The ajar switches are open when the latch is closed. When the door latch is ajar the switch closes allowing the signal to connect to ground through the switch. Therefore the signal inputs to the BCM are high when the door is closed and low when the door is ajar.

The BCM monitors the Driver Door Ajar Switch signal circuit and converts the voltage signal into counts to broadcast over the CAN Bus network.

- Electronic Control Modules read an analog signal voltage and converts it to digital counts. Each count is an equal percentage of the signal reference voltage. This can be seen when viewing some sensor or switch voltages and converted values on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts to a battery voltage reference.
- The resolution of the signal is determined by the required precision of the input by the ECU. Typically, sensor signals are high resolution. This allows the module to read small changes over a wide range in a variable resistance sensor signal. These are typically used on a temperature, pressure, position or MUX type of sensor.
- Switches typically have a much lower resolution than sensors. This is because an ECU is generally looking for a switch to be in only a few positions that use fixed resistors. The lower resolution also helps the ECU to overcome some resistance in a circuit and still read the correct state. This also lowers the sensitivity to setting DTCs.
- The voltage and percentages can vary slightly with calibration changes. The voltage values and percentages in the table are approximate and can be slightly different. Typically, a failure will be noticeably different than the values in the table. The voltage ranges given are based on a nominal reference voltage of 13.5 volts. The voltage on the signal will change with system voltage but the percentage of system voltage should not change.

The Driver Door Ajar Switch signal voltage is divided into 15 counts typically. The table below shows the relation between the Driver Door Ajar Switch states and **approximate voltage percentages/ranges.**

DOOR AJAR SWITCH 1

VOLTAGE PERCENTAGE/VALUE TO SWITCH STATE			
Percentage of Battery Voltage	**Voltage Range @ 13.5 volts nominal**	**Door Latch Position**	**Ajar Switch State (Open/Closed)**
87 - 100%	Range: 11.7v - 13.5v	-	CIRCUIT HIGH FAULT RANGE - OPEN CIRCUIT
54 - 86%	Nominal: 8.5v Range: 7.2v - 9.9v	CLOSED	SWITCH OPEN
20 - 53%	Nominal: 4.5v Range: 2.7v- 6.3v	AJAR	SWITCH CLOSED
0 - 19%	Range: 0v - 1.8v	-	CIRCUIT LOW FAULT RANGE-SHORT TO GROUND

DOOR AJAR SWITCH 2

Percentage of Battery Voltage	**Voltage Range @ 13.5 volts nominal**	**Door Latch Position**	**Ajar Switch State (Open/Closed)**
87 - 100%	Range: 11.7v - 13.5v	-	CIRCUIT HIGH FAULT RANGE - OPEN CIRCUIT
54 - 86%	Nominal: 8.5v	AJAR	SWITCH OPEN

Percentage of Battery Voltage	Voltage Range @ 13.5 volts nominal	Door Latch Position	Ajar Switch State (Open/Closed)
	Range: 7.2v - 9.9v		
20- 53%	Nominal: 4.5v Range: 2.7v- 6.3v	CLOSED	SWITCH CLOSED
0 - 19%	Range: 0v - 1.8v	-	CIRCUIT LOW FAULT RANGE-SHORT TO GROUND

DIAGNOSTIC OVERVIEW-DOOR LOCK MOTORS AND SWITCHES:

- **Lock Motors:** The BCM is capable of detecting opens and shorts in the H-Bridge control circuits. The locks are not thermally protected by the BCM. The protection is done by limiting the number of actuations within a calibrated time period.
- **Door Latch Switches:** The resistors in the latch switches allows the BCM to perform diagnostics on the circuits and switches. Unlike the passenger door switches the voltage on the two signals should not be high or low. If the BCM determines that either signal falls into the high or low range, a fault is set. If the door latch positions do not match between the two Driver Door Ajar Switches, a correlation fault will set.

WHEN MONITORED

- With the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) receives a message over CAN C BUS from the Body Control Module (BCM) indicating that the Driver Door Ajar Switch states do not match.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
HIGH RESISTANCE IN THE DRIVER DOOR LATCH AJAR SWITCH SENSE CIRCUIT
HIGH RESISTANCE IN THE DRIVER DOOR LATCH AJAR SWITCH 2 SENSE CIRCUIT
DRIVER DOOR LATCH
BODY CONTROL MODULE (BCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 2

2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **ISOLATE AND CHECK THE DRIVER DOOR LATCH (G75) AJAR SWITCH SENSE CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the ECU harness connector and measure the resistance of the circuit.

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 4

    No

    - Repair the circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE DRIVER DOOR LATCH (G755) AJAR SWITCH 2 SENSE CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide

to follow the path of the circuit.
3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the ECU harness connector and measure the resistance of the circuit.

Is the resistance below 3.0 Ohms?

Yes

- Go To 5

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **REPLACE THE DOOR LATCH AND RETEST FOR DTCS**
   1. Turn the ignition off.
   2. Replace the component in accordance with the Service Information. Refer to **LATCH, DOOR, REMOVAL AND INSTALLATION** .
   3. Connect the component and Electronic Control Unit (ECU) harness connectors.
   4. Turn the ignition on.
   5. With the scan tool, erase all DTCs.
   6. Turn the ignition off for a minimum of 10.0 seconds.
   7. Turn the ignition on.
   8. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   9. Open and close the door several times.
   10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 6

No

- Replacing the faulty component repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK RELATED BCM AND COMPONENT CONNECTIONS**
   1. Disconnect all BCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.

- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Body Control Module (BCM) in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM), REMOVAL AND INSTALLATION** .
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

C0062-LONGITUDINAL ACCELERATION SENSOR

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) receives a message over the CAN BUS from the Anti-lock Brake System (ABS) Module that there is a fault with the Dynamic Sensor. The Dynamic Sensor is located within the Occupant Restraint Controller (ORC).

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
OCCUPANT RESTRAINT CONTROLLER (ORC)
ANTI-LOCK BRAKE SYSTEM (ABS) MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

CHECK FOR AN ACTIVE DTC

1. With the scan tool, read all DTCs and record on the repair order.

   Is the DTC active or pending?

   Yes

   - Refer to **ANTILOCK BRAKE SYSTEM (ABS) - DIAGNOSTIC CODE INDEX** and perform the appropriate diagnostic test.

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

C0501-WHEEL SPEED SIGNAL LEFT FRONT RATIONALITY

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE:	**If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.
- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)
- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves

- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
		determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.
- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways.

Check the Battery or Batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.

4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

    1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
    2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.
4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.
    1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
    2. If the temp sensor signal and ground circuits test good, Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).

- If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
- If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

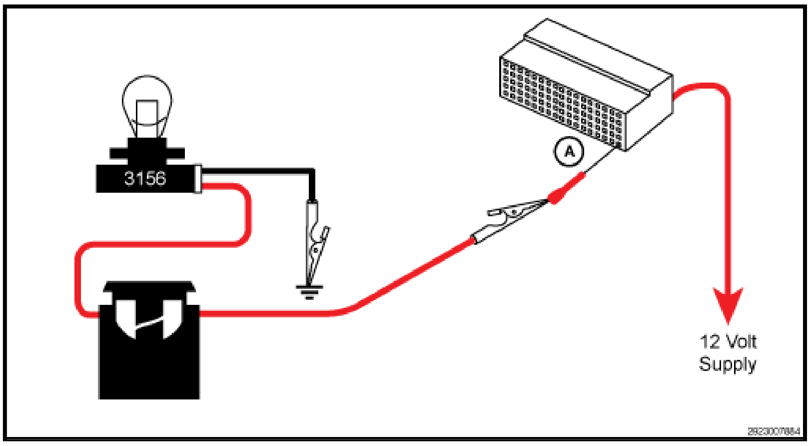
PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

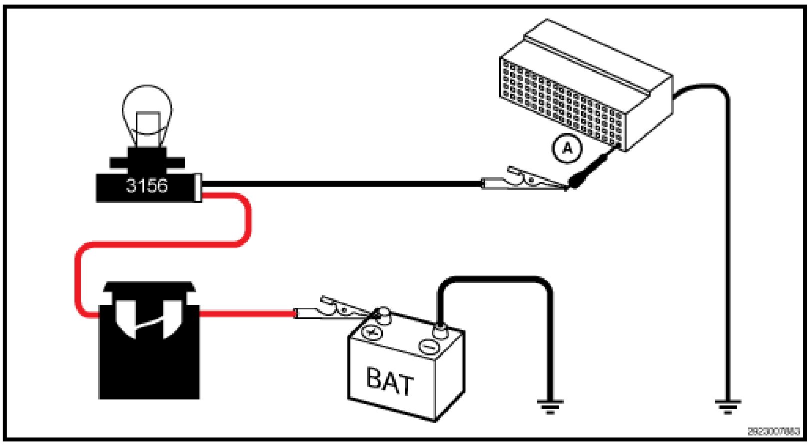
NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.

4. Using the wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
   1. If the fuse(s) are good, continue testing in step 5.
   2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

   Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

   1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .
   2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
      - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
      - If both circuits pass the load test, continue testing in step 6.
6. 

   Load test the BSCM Ground circuit.

   1. If the ground circuit fails load testing, repair the BSCM chassis ground.
   2. If the ground circuit tests good, continue testing in step 7.
7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
   1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

2. If both voltage readings match the values given, the BSCM is likely faulty. Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

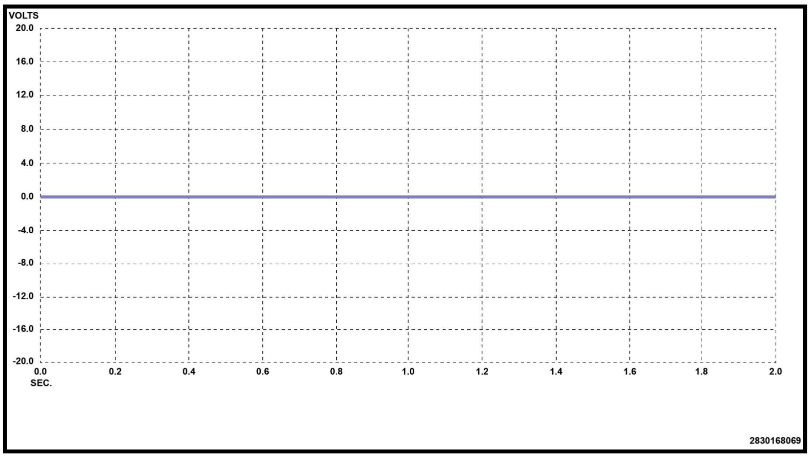
1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
   1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
   2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

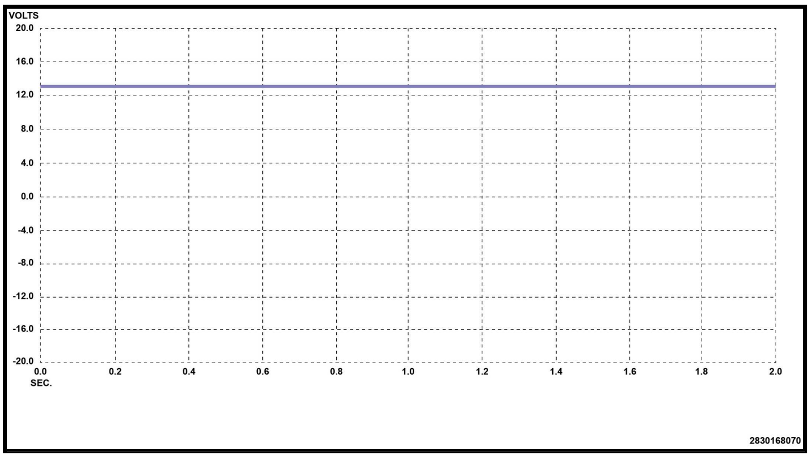
1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the

signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.

1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
   - Check the WSS for physical damage and verify it is mounted and fastened properly.
   - If equipped with a tone wheel, inspect the tone wheel for physical damage.
   - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
   - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.
3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
    1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
    2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.
    1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.

1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

C0507-WHEEL SPEED SIGNAL RIGHT FRONT RATIONALITY

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE: **If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.

- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)
- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
		on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.

- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.

2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.

4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.

    1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
    2. If the temp sensor signal and ground circuits test good, Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some**

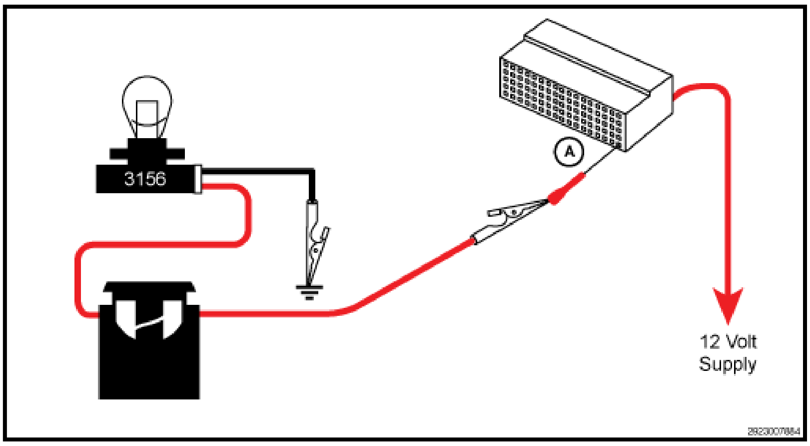
vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

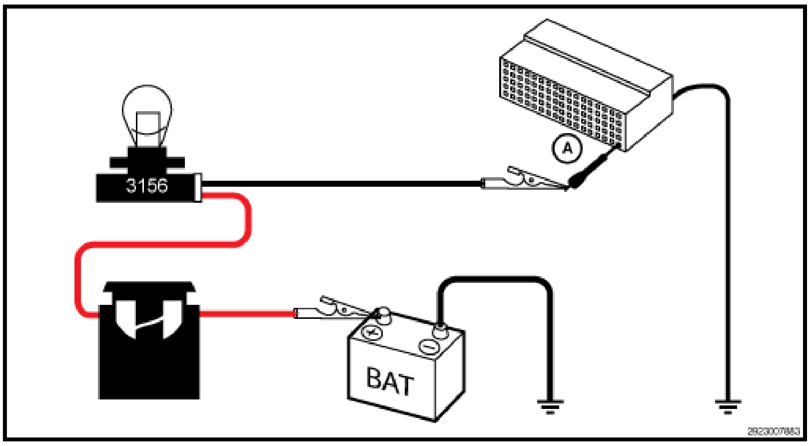
1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.
4. Using the wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
    1. If the fuse(s) are good, continue testing in step 5.
    2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

    Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

    1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing

information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .

2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
    - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
    - If both circuits pass the load test, continue testing in step 6.

6. 

Load test the BSCM Ground circuit.

1. If the ground circuit fails load testing, repair the BSCM chassis ground.
2. If the ground circuit tests good, continue testing in step 7.

7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
    1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

    NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

    2. If both voltage readings match the values given, the BSCM is likely faulty. Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)

- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

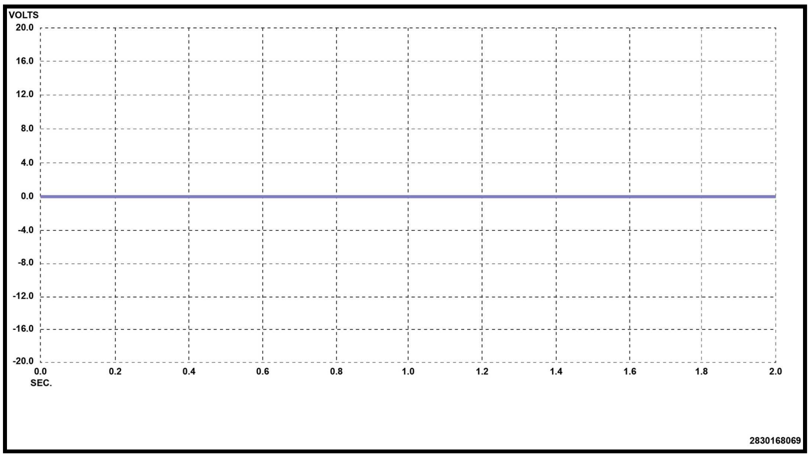
DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
    1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
    2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

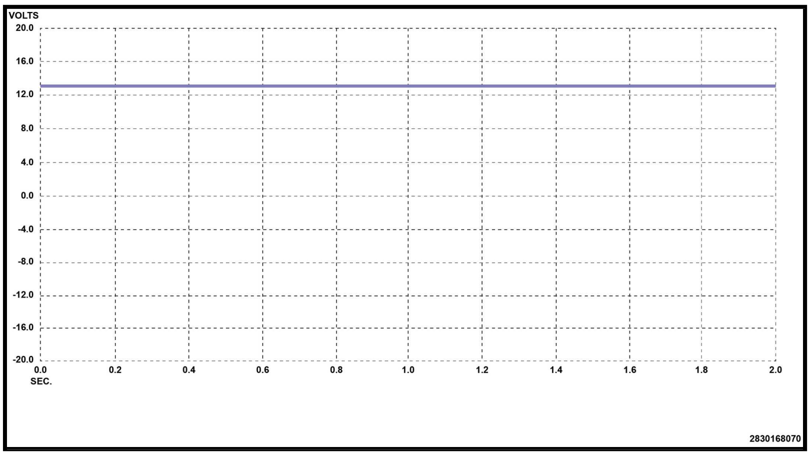
PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.
    1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
    2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
        - Check the WSS for physical damage and verify it is mounted and fastened properly.
        - If equipped with a tone wheel, inspect the tone wheel for physical damage.
        - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
        - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.

3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
   1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
   2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.

    1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.
    1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

C050D-WHEEL SPEED SIGNAL LEFT REAR RATIONALITY

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE: **If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.
- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes

during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)

- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.
- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS

signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU

and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.

2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

    1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
    2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.

4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.
    1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
    2. If the temp sensor signal and ground circuits test good, Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).

- If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
- If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

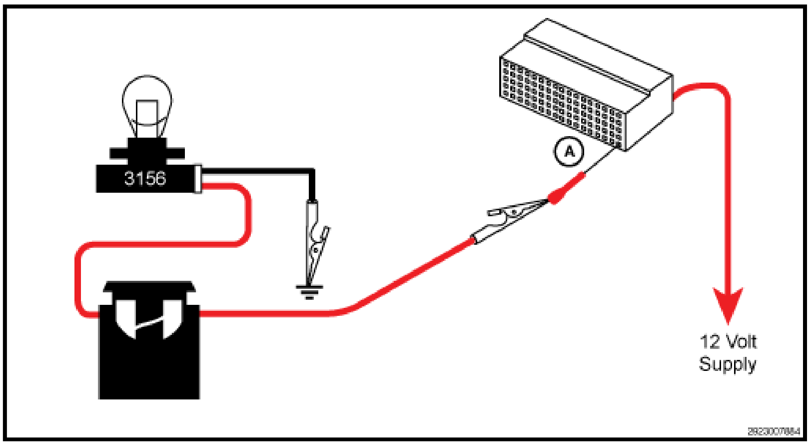
PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

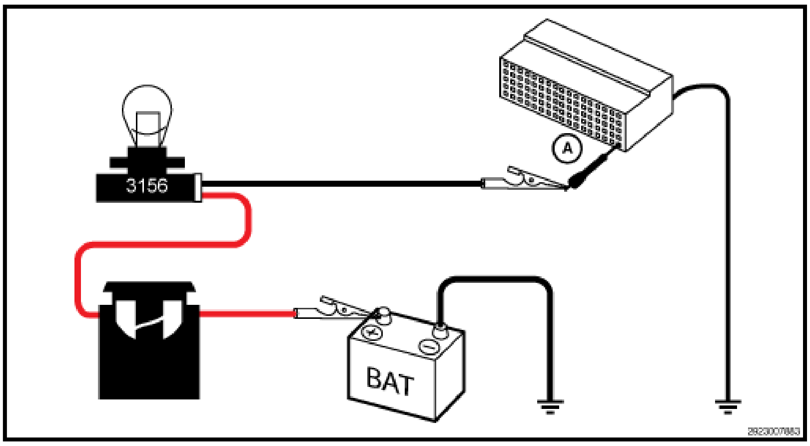
NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.

4. Using the wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
    1. If the fuse(s) are good, continue testing in step 5.
    2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

    Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

    1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .
    2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
        - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
        - If both circuits pass the load test, continue testing in step 6.
6. 

    Load test the BSCM Ground circuit.

    1. If the ground circuit fails load testing, repair the BSCM chassis ground.
    2. If the ground circuit tests good, continue testing in step 7.
7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
    1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

2. If both voltage readings match the values given, the BSCM is likely faulty. Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

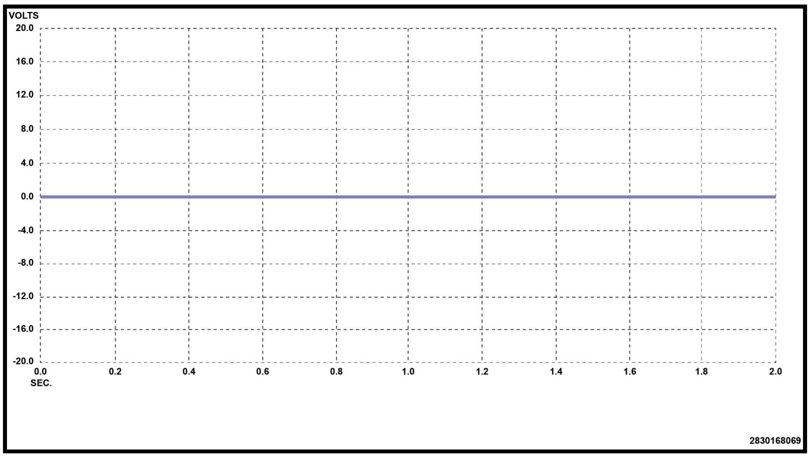
1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
    1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
    2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

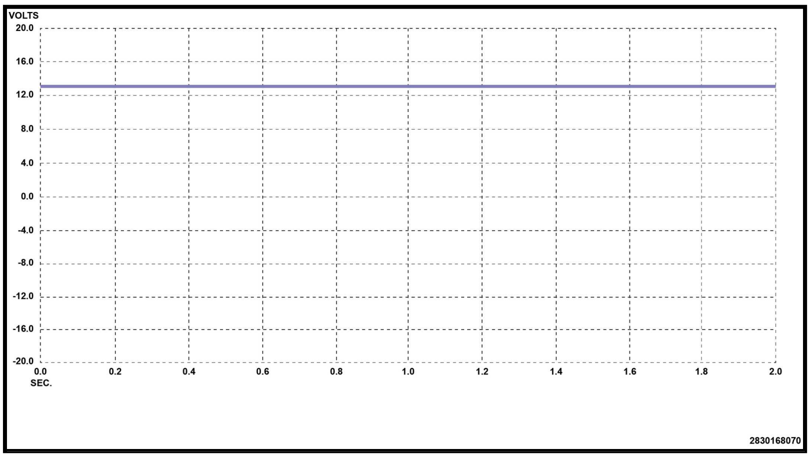
1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the

signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.

1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
    - Check the WSS for physical damage and verify it is mounted and fastened properly.
    - If equipped with a tone wheel, inspect the tone wheel for physical damage.
    - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
    - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.
3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
    1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
    2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.
    1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.

1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

C0513-WHEEL SPEED SIGNAL RIGHT REAR RATIONALITY

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE: **If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.

- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)
- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
		on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.

- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.

2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

    1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
    2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.
4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.

    1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
    2. If the temp sensor signal and ground circuits test good, Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some**

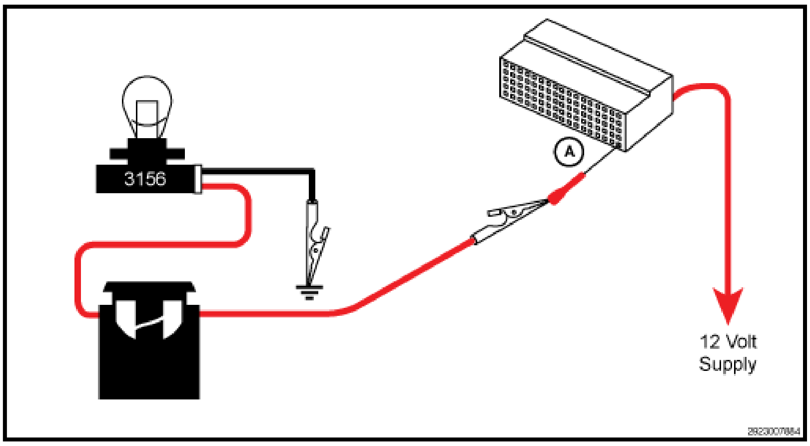
vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

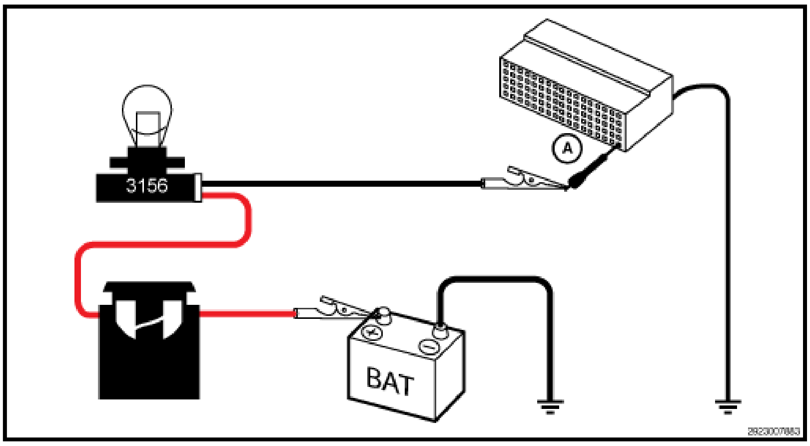
1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.
4. Using the wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
    1. If the fuse(s) are good, continue testing in step 5.
    2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

    Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

    1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing

information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .

2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
    - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
    - If both circuits pass the load test, continue testing in step 6.

6. 

   Load test the BSCM Ground circuit.

    1. If the ground circuit fails load testing, repair the BSCM chassis ground.
    2. If the ground circuit tests good, continue testing in step 7.

7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
    1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

    NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

    2. If both voltage readings match the values given, the BSCM is likely faulty. Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)

- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

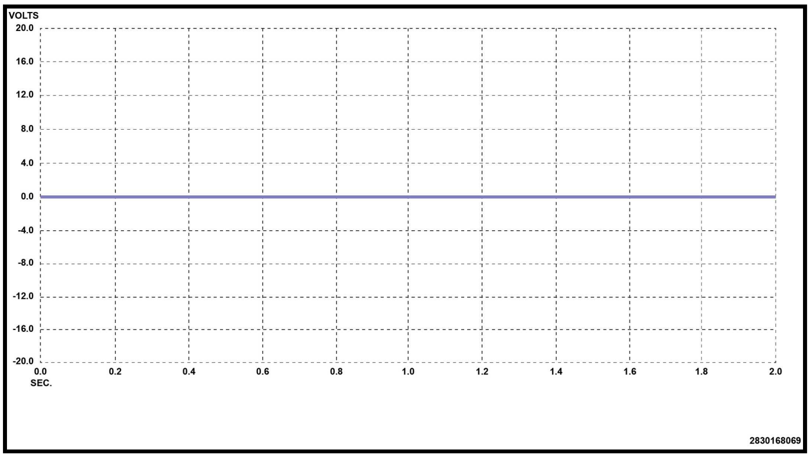
DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
    1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
    2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

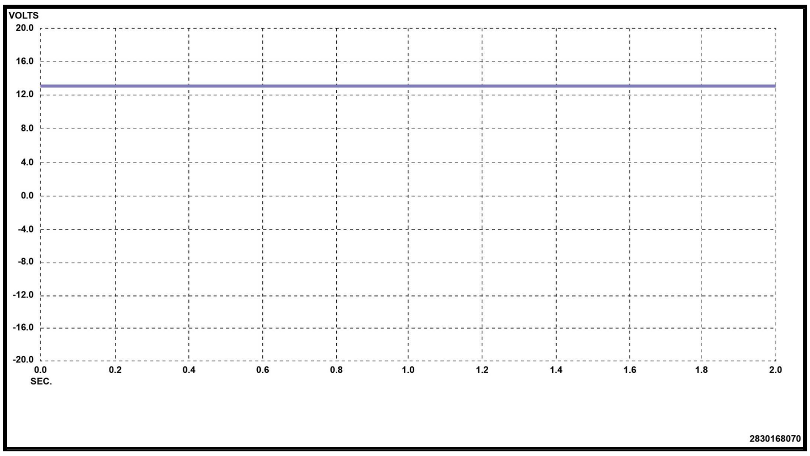
PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.
    1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
    2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
        - Check the WSS for physical damage and verify it is mounted and fastened properly.
        - If equipped with a tone wheel, inspect the tone wheel for physical damage.
        - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
        - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.

   3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



   4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
   1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
   2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.

    1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.
    1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

C053D-BRAKE PRESSURE SENSOR 1 PERFORMANCE

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE: **If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.
- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes

during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)

- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.
- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS

signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU

and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.

2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

   1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
   2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.
4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.
   1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
   2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
   1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
   2. If the temp sensor signal and ground circuits test good, Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).

- If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
- If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

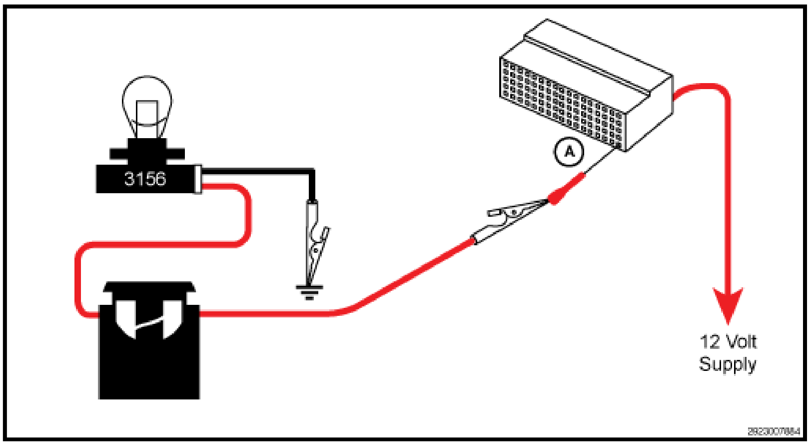
PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

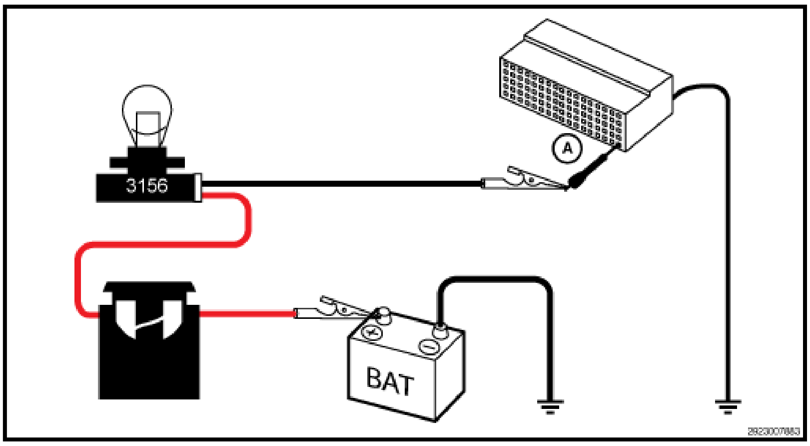
NOTE: The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.

4. Using the wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
    1. If the fuse(s) are good, continue testing in step 5.
    2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

    Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

    1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .
    2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
        - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
        - If both circuits pass the load test, continue testing in step 6.
6. 

    Load test the BSCM Ground circuit.

    1. If the ground circuit fails load testing, repair the BSCM chassis ground.
    2. If the ground circuit tests good, continue testing in step 7.
7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
    1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

2. If both voltage readings match the values given, the BSCM is likely faulty. Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

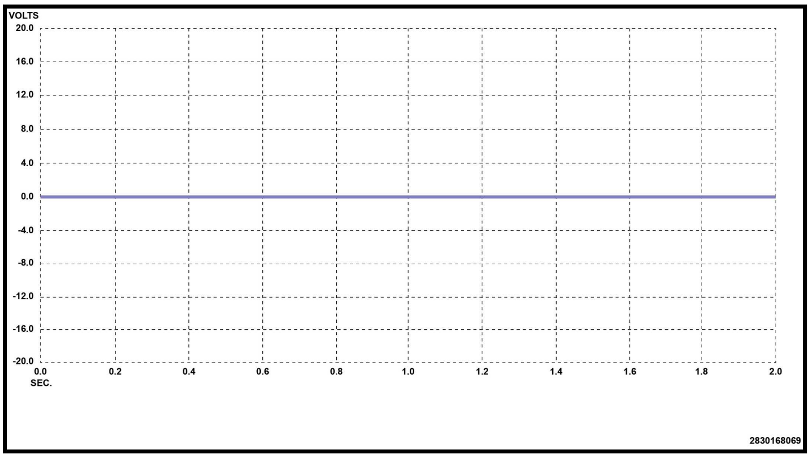
1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
   1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
   2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

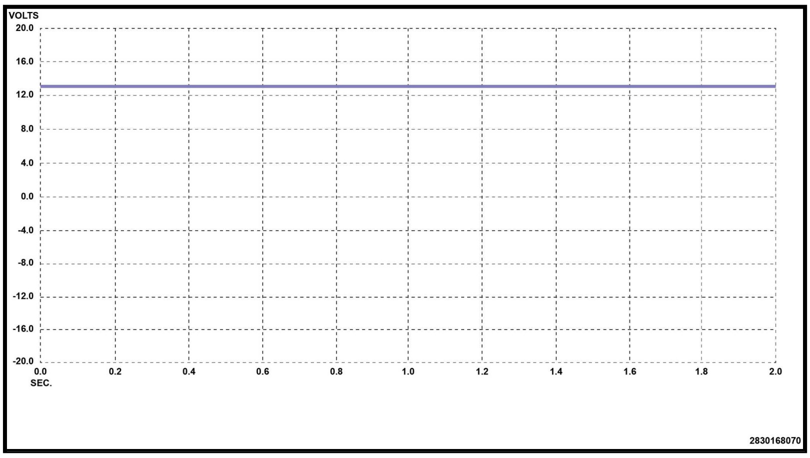
1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the

signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.

1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
    - Check the WSS for physical damage and verify it is mounted and fastened properly.
    - If equipped with a tone wheel, inspect the tone wheel for physical damage.
    - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
    - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.
3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
    1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
    2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.
    1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.

1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

C0572-MASTER CYLINDER PRESSURE SENSOR CIRCUIT HIGH

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) detects a fault in the Brake Pressure Sensor signal that is received over the CAN BUS from the Anti-lock Brake System (ABS) Module.

DEFAULT ACTION

- The MIL will illuminate.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
HYDRAULIC CONTROL UNIT (HCU)
INTEGRATED CONTROL UNIT (ICU)
ANTI-LOCK BRAKE SYSTEM (ABS) MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
   1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

      Are there any applicable Service Bulletins or Flash updates?

      Yes

      - Perform the applicable repair.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.

5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- This is a informational DTC indicating a fault is set in the Antilock Brake System (ABS) Module. Perform the appropriate diagnostic procedure(s). Refer to **ANTILOCK BRAKE SYSTEM (ABS) - DIAGNOSTIC CODE INDEX** .

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

C10F5-BRAKE TORQUE PERFORMANCE

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE:	If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.
- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)
- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves

- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
		determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.
- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways.

Check the Battery or Batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.

4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.

4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.
    1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
    2. If the temp sensor signal and ground circuits test good, Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).

- If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
- If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

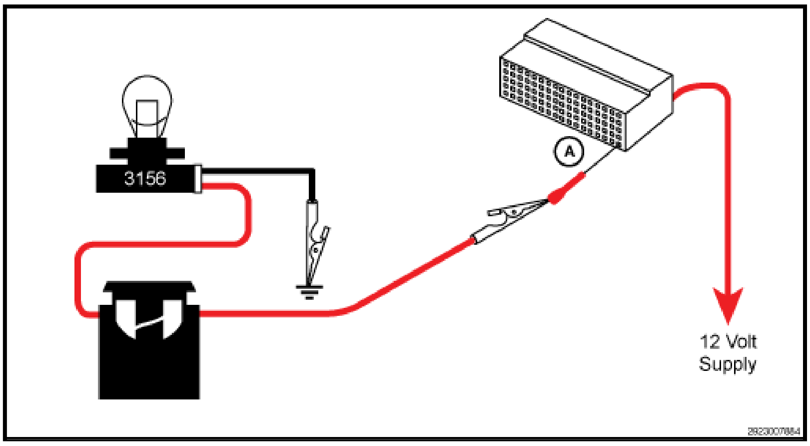
PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

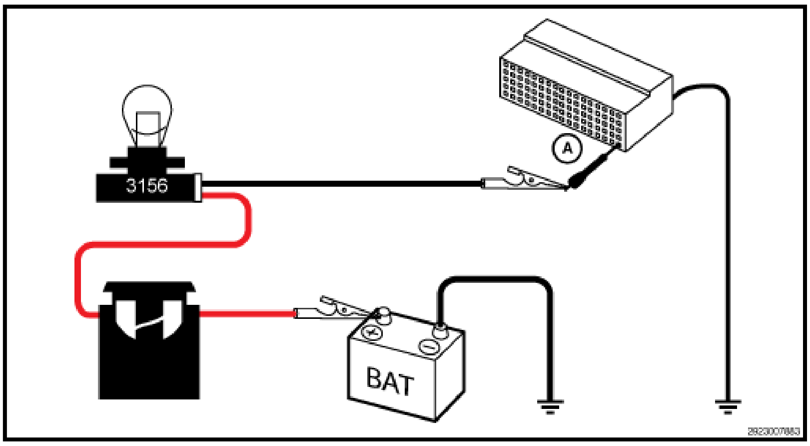
NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.

4. Using the wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
    1. If the fuse(s) are good, continue testing in step 5.
    2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

   Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

    1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .
    2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
        - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
        - If both circuits pass the load test, continue testing in step 6.
6. 

   Load test the BSCM Ground circuit.

    1. If the ground circuit fails load testing, repair the BSCM chassis ground.
    2. If the ground circuit tests good, continue testing in step 7.
7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
    1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

2. If both voltage readings match the values given, the BSCM is likely faulty. Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

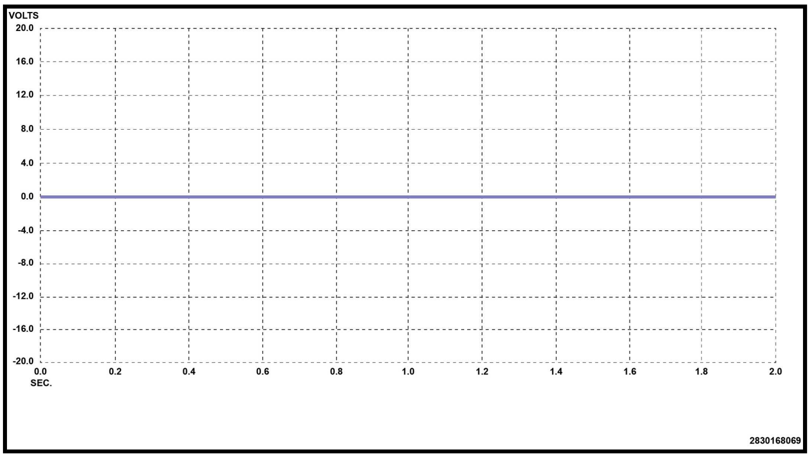
1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
   1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
   2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

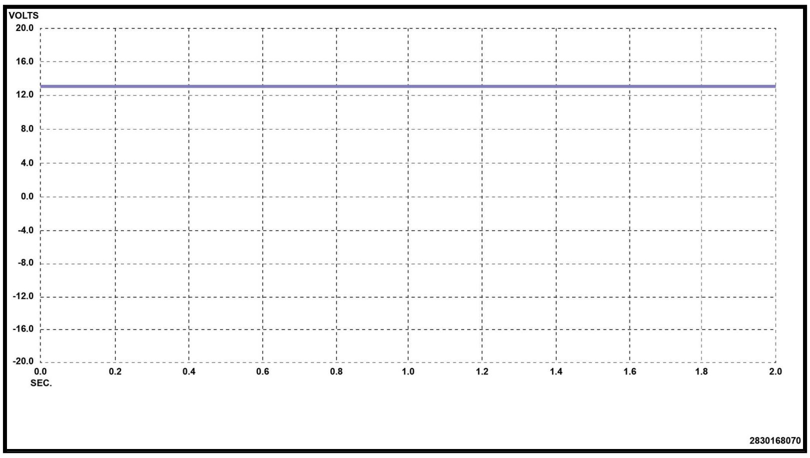
1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the

signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.

1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
    - Check the WSS for physical damage and verify it is mounted and fastened properly.
    - If equipped with a tone wheel, inspect the tone wheel for physical damage.
    - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
    - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.
3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
    1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
    2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.
    1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.

1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

P000A-BANK 1 CAMSHAFT 1 POSITION SLOW RESPONSE

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Variable Valve Timing (VVT) system continuously varies the Camshaft target position based on the engine operating parameters. Based on these parameters, the Powertrain Control Module (PCM) calculates or models the optimum Camshaft position. The Camshaft angular position is varied by the oil control valve. The VVT solenoid pushes on a plunger (spring loaded spool valve) in the center of the Oil Control Valve (OCV) which directs oil pressure to the hydraulic actuator (Phaser) on the Camshaft Sprocket to change the Camshaft position relative to the Crankshaft position. The VVT Solenoid, acting on the Oil Control Valve and Phaser, is controlled by the PCM. The Camshaft Position (CMP) Sensor is used to monitor the position of the Camshaft.

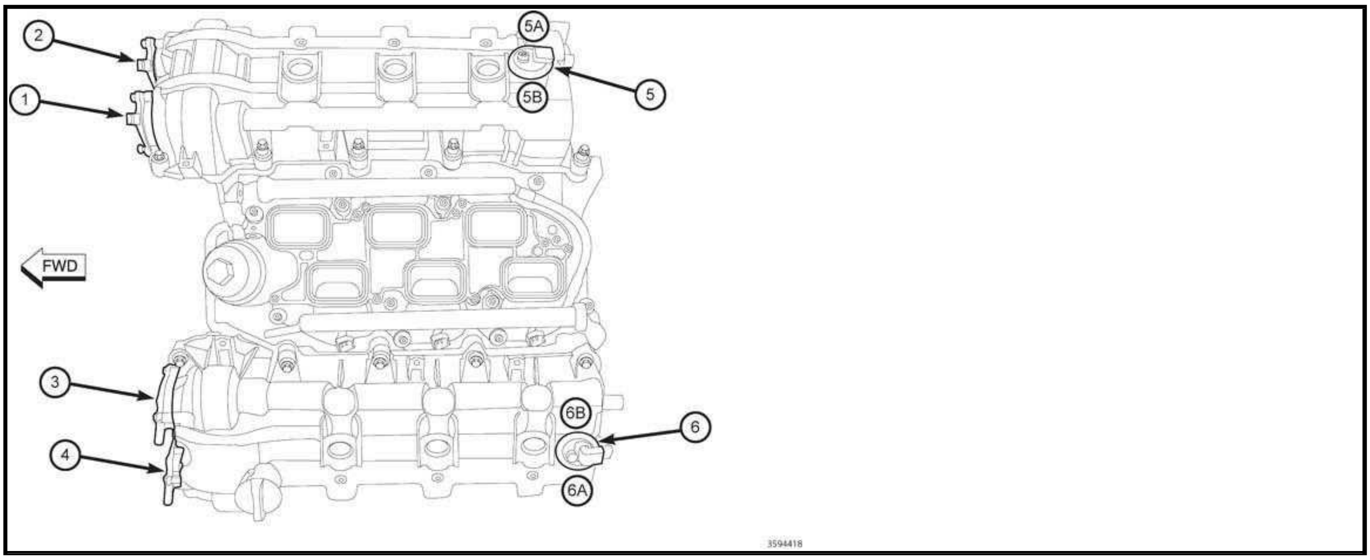
NOTE: **For the PCM to run this diagnostic the CMP Sensor and CKP Sensor signals must be locked with no sensor faults present. A missing or erratic CMP or CKP signal cannot cause a slow response fault to set. Replacing either sensor will not fix the vehicle.**

The PCM performs the typical diagnostic checks on the control circuits. During operation of the system the PCM also performs a **Target Error** and a **Slow Response** diagnostic check of the Camshaft phasing since these conditions could potentially increase tailpipe emissions. The diagnostic is primarily performed by comparing the actual Camshaft position to that of a calculated model for the Camshaft position. This diagnostic is continuous once the enable conditions are met. The Slow Response and Target Error conditions are not performed simultaneously.

- **The Target Error** diagnostic evaluates the actual Camshaft position versus the modeled position when the Camshaft is in a relatively stable position. The difference between the two is considered to be the amount of "error". If the error amount is greater than a calibrated threshold, it is considered failing.
- **The Slow Response** diagnostic is only performed when the modeled Camshaft position is moving (phasing) in a particular direction, advancing or retarding. The modeled Camshaft phasing position is created to match only the worst possible case of a passing Camshaft position. If the actual Camshaft phasing operates slower than the model by a calibrated threshold, it is considered failing.

If either of these diagnostics fail, the Camshaft Position Slow Response fault will set. **Any oil pressure issues, VVT Solenoid or Oil Pump Solenoid Control circuit faults should be diagnosed before diagnosing a Camshaft Position Slow Response fault.**

NOTE: **On occasion a small piece of debris or metal chip can get lodged in the OCV causing the spool valve to stick. The contamination can either dislodge on it's own or when the PCM is running a cleaning procedure on the OCV causing an intermittent fault condition for a Camshaft Position Slow Response that is no longer present.**



NOTE: **There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and table below indicating the specific orientation of the DTCs to the Camshafts).**

3.2L/3.6L DTCs RELATED TO EACH CAMSHAFT				
CAMSHAFT POSITION	RELATED CAM SENSOR DTCS	PHASER/ACTUATOR DTCS	MISALIGNMENT DTCS	COLD START PERF DTCS
(1) Bank 1 Intake Camshaft	P0365, P0369	P000A, P0010	P0017	P052A, P052B
(2) Bank 1 Exhaust Camshaft	P0340, P0344	P000B, P0013	P0016	P054A, P054B
(3) Bank 2 Intake Camshaft	P0390, P0394	P000C, P0020	P0019	P052C, P052D
(4) Bank 2 Exhaust Camshaft	P0345, P0349	P000D, P0023	P0018	P054C, P054D

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Engine speed is at least 650 to 1400 rpm, depending on oil temperature.
- Oil temperature is between -7Â°C to 139Â°C (19Â°F to 282Â°F).
- Battery voltage is above 10.0 volts.
- No CMP Sensor, Crankshaft Position (CKP) Sensor, or OBDI plausibility errors.
- Cam phasing is being commanded.

SET CONDITION

- The actual Camshaft position does not match the desired Camshaft position during Camshaft phasing for approximately 30.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.
- The PCM will attempt to return the Camshaft Phaser to lock pin when the fault is active.

POSSIBLE CAUSES

Possible Causes
ENGINE OIL LEVEL LOW
CAM/CRANK LEARNED VALUES OUT OF TOLERANCE
ENGINE OIL AERATED OR CONTAMINATED
INCORRECT ENGINE OIL FILTER
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
VVT INTAKE SOLENOID 1/1 FAULTY OR INTERMITTENTLY BINDING/STICKING
CAMSHAFT 1/1 OIL CONTROL VALVE FAULTY OR INTERMITTENTLY BINDING/STICKING SPOOL VALVE
CAMSHAFT TONE WHEEL MISALIGNED
CAMSHAFT 1/1 PHASER FAULTY OR INTERMITTENTLY BINDING/STICKING
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **CHECK FOR OTHER DTCS**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs and Freeze Frame Data and record on the repair order.

       Are there any system voltage, Oil Pump or Camshaft Position DTCs present?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 3
3. **VERIFY THE CAM/CRANK LEARNED VALUES ARE WITHIN TOLERANCE**
    1. With the scan tool, read the Cam/Crank Difference Learned values in the Data Display.

NOTE: **When the Cam/Crank Learn is performed the Camshaft position is learned in High Lift and Low Lift modes on the Variable Valve Lift (VVL) equipped engines. The difference between the High Lift and Low Lift learned values should be less than 2Â° for each Camshaft.**

NOTE: **If the Cam/Crank Difference Learned values are not in the Data Display, go to 4.**

Are the Intake Cam 1 High Lift and Low Lift learned values within 2Â° of each other?

Yes

- Go To 4

No

- With the scan tool perform the **Cam/Crank Relearn** procedure and retest for DTC.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE ENGINE OIL/ENGINE MECHANICAL CONDITION**
   1. Turn the ignition off.
   2. The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.
      - LOW ENGINE OIL LEVEL
      - CONTAMINATED, DIRTY, AERATED OR DETERIORATED ENGINE OIL
      - INCORRECT ENGINE OIL VISCOSITY
      - ENGINE MECHANICAL TOLERANCES OUT OF SPECIFICATION
      - ENGINE OIL PRESSURE OUT OF SPECIFICATION
      - INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)

   Were any of the above conditions present?

   Yes

   - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.) in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

   NOTE: **During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.**

   1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
   2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
   3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
   4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor.
   5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

NOTE: If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.

Is the oil pressure reading stable and above 16.0 psi?

Yes

- Go To 6

No

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE ENGINE OIL PRESSURE TO THE CYLINDER HEAD**
   1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
   2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid and install an oil pressure gauge to the adaptor.
   3. Start the engine and allow it to idle.
   4. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

NOTE: The oil pressure reading at the Cylinder Head should be above 14.0 psi.

Is the oil pressure reading stable and above 14.0 psi?

Yes

- Go To 7

No

- Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **VERIFY AN ACTIVE CONDITION BY CHECKING THE CAM PHASER POSITION**

NOTE: If a Cam Phaser or Oil Control Valve is stuck, there may also be a Crankshaft/Camshaft Timing Misalignment and/or Multiple Cylinder Misfire DTC present.

NOTE: The Intake Camshaft is phased less frequently than the Exhaust Camshaft during engine operation. Therefore it may be necessary to test drive the vehicle under different load conditions to get enough phasing of the Intake Camshaft to duplicate the condition and check the values.

1. What to monitor for during the test step:

- **The phaser not coming back to lock pin at idle.** This his could indicate a faulty phaser or oil control valve that is permanently stuck off lock pin or a VVT Solenoid that is electrically stuck on.
- **The actual position lagging or moving slowly toward the desired position.** This could indicate a faulty phaser or tarnished oil control valve that is dragging.
- **The actual position lagging and then overshooting the desired position** This could indicate a faulty phaser, oil control valve or VVT Solenoid that is intermittently sticking or binding and then overshoot when the condition goes away.

2. Start the engine and allow the engine to idle.
3. With the scan tool, monitor and compare the Intake Cam 1 **actual** position value with the Intake Cam 1 **desired** position value. After comparing the two values at idle, check and compare the values at several different engine speeds during the following steps.
4. While monitoring the Intake Cam 1 actual position and desired position values:
   - Raise the engine speed quickly and hold steady for up to 30 seconds.
   - Lower the engine speed and hold steady at a level above idle (off of lock pin) for up to 30 seconds.
5. Repeat the above steps multiple times and allow the engine to come back to idle while monitoring the actual position value to verify that the phaser is returning to lock pin position.

   Is the difference between the actual value and the desired value readings more than 6.0 degrees at idle or is the actual value lagging behind or overshooting the desired value?

   Yes, the difference is greater than 6.0 degrees at idle indicating that the camshaft will not return to lock pin:

   - Go To 8

   Yes, the actual reading is lagging or overshooting when changing the engine speeds indicating a binding or sticking:

   - Go To 9

   No

   - This fault is occurring due to an intermittent condition. The problem could be due to an intermittent sticking or dragging condition of one of the timing components listed in the possible causes table. The issue could be temperature related (I.E. Incorrect or broken down oil affecting operation during a cold start, or a tolerance issue in a component that is affected after a cold start/heat soak or after the engine is warmed to operating temperature). The issue could also be occurring during certain specific driving conditions. It may be necessary to test drive the vehicle under different load conditions to duplicate the issue.

8. **DETERMINE IF THE CAM PHASER ISSUE IS ELECTRICAL OR MECHANICAL**
   1. While the engine is at idle, disconnect the VVT Intake Solenoid 1/1 harness connector.

      NOTE: **The Intake Cam 1 actual position value should change to lock pin with the solenoid disconnected. The Intake Cam position should be at approximately 146.0Â° at lock pin.**

      Did the Intake Cam 1 actual value change to lock pin position when the solenoid is unplugged?

      Yes

      - Check the VVT Intake Solenoid 1/1 (K76) Control circuit for a short to voltage. If the circuit is not shorted to voltage, Go To 13

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 9

9. **CHECK THE CAMSHAFT 1/1 OIL CONTROL VALVE OPERATION**
   1. Turn the ignition off.
   2. Remove the VVT Intake Solenoid 1/1.
   3. Inspect the spring loaded spool valve on the Oil Control Valve.

      NOTE: The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.

   4. Push and release the spring loaded spool valve against the return spring with a small punch.

      NOTE: The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.

   Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

   Yes

   - Go To 10

   No

   - Replace the Camshaft 1/1 Oil Control Valve in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .
   - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CHECK THE VVT INTAKE SOLENOID 1/1 OPERATION**
    1. Turn the ignition off.
    2. With the solenoid still removed, reconnect the VVT Intake Solenoid 1/1 harness connector.
    3. Turn the ignition on.
    4. With the scan tool, actuate the VVT Intake Solenoid 1/1 on and off several times.

    Does the VVT Intake Solenoid 1/1 move freely without binding or sticking during actuation?

    Yes

    - Go To 11

    No

    - Replace the VVT Intake Solenoid 1/1 in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. .
    - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **VERIFY THAT THE VVT INTAKE SOLENOID 1/1 IS ABLE TO MOVE THE PHASER**
    1. Exchange the VVT Intake Solenoid 1/1 with the other VVT Intake Solenoid 2/1.

       NOTE: **The Intake and Exhaust Solenoids should not be interchanged.**

    2. Reconnect the solenoid harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs in the PCM.
    5. Test drive the vehicle under the conditions in which the fault was set.
    6. With the scan tool, read DTCs.

    Did the DTC move with the solenoid or stay with the original camshaft?

    Moved with the solenoid

    - Replace the VVT Intake Solenoid 1/1 in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. .
    - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    Stayed with the original camshaft

    - Go To 12

12. **CHECK THE INTAKE CAMSHAFT 1/1 TONE WHEEL**
    1. Turn the ignition off.
    2. Check the alignment of the CMP Sensor Tone Wheel in accordance with the service information.

    Is the CMP Sensor Tone Wheel aligned correctly?

    Yes

    - Replace the Cam 1/1 Phaser in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .
    - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Replace the Intake Camshaft Assembly in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION** .
    - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

DIAGNOSIS AND TESTING

P000B-BANK 1 CAMSHAFT 2 POSITION SLOW RESPONSE

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Variable Valve Timing (VVT) system continuously varies the Camshaft target position based on the engine operating parameters. Based on these parameters, the Powertrain Control Module (PCM) calculates or models the optimum Camshaft position. The Camshaft angular position is varied by the oil control valve. The VVT solenoid pushes on a plunger (spring loaded spool valve) in the center of the Oil Control Valve (OCV) which directs oil pressure to the hydraulic actuator (Phaser) on the Camshaft Sprocket to change the Camshaft position relative to the Crankshaft position. The VVT Solenoid, acting on the Oil Control Valve and Phaser, is controlled by the PCM. The Camshaft Position (CMP) Sensor is used to monitor the position of the Camshaft.

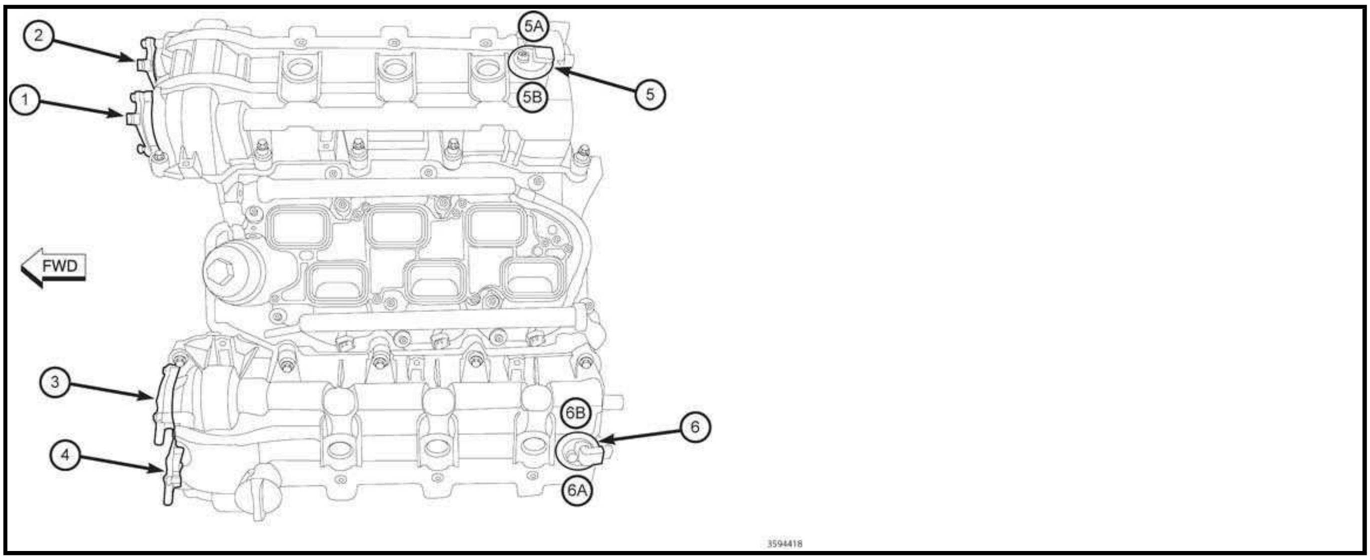
NOTE: **For the PCM to run this diagnostic the CMP Sensor and CKP Sensor signals must be locked with no sensor faults present. A missing or erratic CMP or CKP signal cannot cause a slow response fault to set. Replacing either sensor will not fix the vehicle.**

The PCM performs the typical diagnostic checks on the control circuits. During operation of the system the PCM also performs a **Target Error** and a **Slow Response** diagnostic check of the Camshaft phasing since these conditions could potentially increase tailpipe emissions. The diagnostic is primarily performed by comparing the actual Camshaft position to that of a calculated model for the Camshaft position. This diagnostic is continuous once the enable conditions are met. The Slow Response and Target Error conditions are not performed simultaneously.

- **The Target Error** diagnostic evaluates the actual Camshaft position versus the modeled position when the Camshaft is in a relatively stable position. The difference between the two is considered to be the amount of "error". If the error amount is greater than a calibrated threshold, it is considered failing.
- **The Slow Response** diagnostic is only performed when the modeled Camshaft position is moving (phasing) in a particular direction, advancing or retarding. The modeled Camshaft phasing position is created to match only the worst possible case of a passing Camshaft position. If the actual Camshaft phasing operates slower than the model by a calibrated threshold, it is considered failing.

If either of these diagnostics fail, the Camshaft Position Slow Response fault will set. **Any oil pressure issues, VVT Solenoid or Oil Pump Solenoid Control circuit faults should be diagnosed before diagnosing a Camshaft Position Slow Response fault.**

NOTE: **On occasion a small piece of debris or metal chip can get lodged in the OCV causing the spool valve to stick. The contamination can either dislodge on it's own or when the PCM is running a cleaning procedure on the OCV causing an intermittent fault condition for a Camshaft Position Slow Response that is no longer present.**



NOTE: **There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and table below indicating the specific orientation of the DTCs to the Camshafts).**

3.2L/3.6L DTCs RELATED TO EACH CAMSHAFT				
CAMSHAFT POSITION	**RELATED CAM SENSOR DTCS**	**PHASER/ACTUATOR DTCS**	**MISALIGNMENT DTCS**	**COLD START PERF DTCS**
(1) Bank 1 Intake Camshaft	P0365, P0369	P000A, P0010	P0017	P052A, P052B
(2) Bank 1 Exhaust Camshaft	P0340, P0344	P000B, P0013	P0016	P054A, P054B
(3) Bank 2 Intake Camshaft	P0390, P0394	P000C, P0020	P0019	P052C, P052D
(4) Bank 2 Exhaust Camshaft	P0345, P0349	P000D, P0023	P0018	P054C, P054D

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Engine speed is at least 650 to 1400 rpm, depending on oil temperature.
- Oil temperature is between -7B°C to 139B°C (19B°F to 282B°F).
- Battery voltage is above 10.0 volts.
- No CMP Sensor, Crankshaft Position (CKP) Sensor, or OBDI plausibility errors.
- Cam phasing is being commanded.

SET CONDITION

- The actual Camshaft position does not match the desired Camshaft position during Camshaft phasing for approximately 30.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.
- The PCM will attempt to return the Camshaft Phaser to lock pin when the fault is active.

POSSIBLE CAUSES

Possible Causes
ENGINE OIL LEVEL LOW
CAM/CRANK LEARNED VALUES OUT OF TOLERANCE
ENGINE OIL AERATED OR CONTAMINATED
INCORRECT ENGINE OIL FILTER
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
VVT EXHAUST SOLENOID 1/2 FAULTY OR INTERMITTENTLY BINDING/STICKING
CAMSHAFT 1/2 OIL CONTROL VALVE FAULTY OR INTERMITTENTLY BINDING/STICKING SPOOL VALVE
CAMSHAFT TONE WHEEL MISALIGNED
CAMSHAFT 1/2 PHASER FAULTY OR INTERMITTENTLY BINDING/STICKING
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **CHECK FOR OTHER DTCS**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs and Freeze Frame Data and record on the repair order.

       Are there any system voltage, Oil Pump or Camshaft Position DTCs present?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 3
3. **VERIFY THE CAM/CRANK LEARNED VALUES ARE WITHIN TOLERANCE**
    1. With the scan tool, read the Cam/Crank Difference Learned values in the Data Display.

NOTE:	When the Cam/Crank Learn is performed the Camshaft position is learned in High Lift and Low Lift modes on the Variable Valve Lift (VVL) equipped engines. The difference between the High Lift and Low Lift learned values should be less than 2B° for each Camshaft.

NOTE: **If the Cam/Crank Difference Learned values are not in the Data Display, go to 4.**

Are the Exhaust Cam 1 High Lift and Low Lift learned values within 2B° of each other?

Yes

- Go To 4

No

- With the scan tool perform the **Cam/Crank Relearn** procedure and retest for DTC.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE ENGINE OIL/ENGINE MECHANICAL CONDITION**
    1. Turn the ignition off.

NOTE: **The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.**

- **LOW ENGINE OIL LEVEL**
- **CONTAMINATED, DIRTY, AERATED OR DETERIORATED ENGINE OIL**
- **INCORRECT ENGINE OIL VISCOSITY**
- **ENGINE MECHANICAL TOLERANCES OUT OF SPECIFICATION**
- **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
- **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**

Were any of the above conditions present?

Yes

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.) in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

NOTE: **During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.**

1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.

4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor.
5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

NOTE: **If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.**

Is the oil pressure reading stable and above 16.0 psi?

Yes

- Go To 6

No

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE ENGINE OIL PRESSURE TO THE CYLINDER HEAD**
   1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
   2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid and install an oil pressure gauge to the adaptor.
   3. Start the engine and allow it to idle.
   4. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

NOTE: **The oil pressure reading at the Cylinder Head should be above 14.0 psi.**

Is the oil pressure reading stable and above 14.0 psi?

Yes

- Go To 7

No

- Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **VERIFY AN ACTIVE CONDITION BY CHECKING THE CAM PHASER POSITION**

NOTE: **If a Cam Phaser or Oil Control Valve is stuck, there may also be a Crankshaft/Camshaft Timing Misalignment and/or Multiple Cylinder Misfire DTC present.**

   1. What to monitor for during the test step:

        - **The phaser not coming back to lock pin at idle.** This his could indicate a faulty phaser or oil control valve that is permanently stuck off lock pin or a VVT Solenoid that is electrically stuck on.
        - **The actual position lagging or moving slowly toward the desired position.** This could indicate a faulty phaser or tarnished oil control valve that is dragging.
        - **The actual position lagging and then overshooting the desired position** This could indicate a faulty phaser, oil control valve or VVT Solenoid that is intermittently sticking or binding and then overshoot when the condition goes away.
    2. Start the engine and allow the engine to idle.
    3. With the scan tool, monitor and compare the Exhaust Cam 1 **actual** position value with the Exhaust Cam 1 **desired** position value. After comparing the two values at idle, check and compare the values at several different engine speeds during the following steps.
    4. While monitoring the Exhaust Cam 1 actual position and desired position values:
        - Raise the engine speed quickly and hold steady for up to 30 seconds.
        - Lower the engine speed and hold steady at a level above idle (off of lock pin) for up to 30 seconds.
    5. Repeat the above steps multiple times and allow the engine to come back to idle while monitoring the actual position value to verify that the phaser is returning to lock pin position.

       Is the difference between the actual value and the desired value readings more than 6.0 degrees at idle or is the actual value lagging behind or overshooting the desired value?

       Yes, the difference is greater than 6.0 degrees at idle:

        - Go To 8

       Yes, the actual reading is lagging or overshooting when changing the engine speeds indicating a binding or sticking:

        - Go To 9

       No

        - This fault is occurring due to an intermittent condition. The problem could be due to an intermittent sticking or dragging condition of one of the timing components listed in the possible causes table. The issue could be temperature related (I.E. Incorrect or broken down oil affecting operation during a cold start, or a tolerance issue in a component that is affected after a cold start/heat soak or after the engine is warmed to operating temperature). The issue could also be occurring during certain specific driving conditions. It may be necessary to test drive the vehicle under different load conditions to duplicate the issue.
8. **DETERMINE IF THE CAM PHASER ISSUE IS ELECTRICAL OR MECHANICAL**
    1. While the engine is at idle, disconnect the VVT Exhaust Solenoid 1/2 harness connector.
    2. The Exhaust Cam 1 actual position value should change to lock pin with the solenoid disconnected. The Exhaust Cam position should be at approximately 123.0 degrees at lock pin.

       Did the Exhaust Cam 1 actual value change to lock pin position with the solenoid unplugged?

       Yes

        - Check the (K276) VVT Exhaust Control 1/2 circuit for a short to voltage. If the circuit is not shorted to voltage, Go To 13
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

- Go To 9

9. **CHECK THE CAMSHAFT 1/2 OIL CONTROL VALVE OPERATION**
    1. Turn the ignition off.
    2. Remove the VVT Exhaust Solenoid 1/2.
    3. Inspect the spring loaded spool valve on the Oil Control Valve.

       NOTE: **The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.**

    4. Push and release the spring loaded spool valve against the return spring with a small punch.

       NOTE: **The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.**

    Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

    Yes

    - Go To 10

    No

    - Replace the Camshaft 1/2 Oil Control Valve in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .
    - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CHECK THE VVT EXHAUST SOLENOID 1/2 OPERATION**
    1. Turn the ignition off.
    2. With the solenoid still removed, reconnect the VVT Exhaust Solenoid 1/2 harness connector.
    3. Turn the ignition on.
    4. With the scan tool, actuate the VVT Exhaust Solenoid 1/2 on and off several times.

    Does the VVT Exhaust Solenoid 1/2 move freely without binding or sticking during actuation?

    Yes

    - Go To 11

    No

    - Replace the VVT Exhaust Solenoid 1/2 in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. .
    - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **VERIFY THAT THE VVT EXHAUST SOLENOID 1/2 IS ABLE TO MOVE THE PHASER**
    1. Exchange the VVT Exhaust Solenoid 1/2 with the VVT Exhaust Solenoid 2/2.

NOTE: **The Intake and Exhaust Solenoids should not be interchanged.**

2. Reconnect the solenoid harness connectors.
3. Turn the ignition on.
4. With the scan tool, erase DTCs in the PCM.
5. Test drive the vehicle under the conditions in which the fault was set.
6. With the scan tool, read DTCs.

   Did the DTC move with the solenoid or stay with the original Camshaft?

   Moved with the solenoid

   - Replace the VVT Exhaust Solenoid 1/2 in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. .
   - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   Stayed with the original camshaft

   - Go To 12

12. **CHECK THE EXHAUST CAMSHAFT 1/2 TONE WHEEL**
    1. Turn the ignition off.
    2. Remove the Cylinder Head Cover and check the alignment of the CMP Sensor Tone Wheel in accordance with the service information.

       Is the CMP Sensor Tone Wheel aligned correctly?

       Yes

       - Replace the Cam 1/2 Phaser in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .
       - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Replace the Exhaust Camshaft Assembly in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION** .
       - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.

3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
   - Proper connector installation.
   - Damaged connector locks.
   - Corrosion.
   - Other signs of water intrusion.
   - Weather seal damage (if equipped).
   - Bent terminals.
   - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
   - Terminals that have been pushed back into the connector cavity.
   - Check for spread terminals and verify proper terminal tension.

   Repair any conditions that are found.
6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P000C-BANK 2 CAMSHAFT 1 POSITION SLOW RESPONSE

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Variable Valve Timing (VVT) system continuously varies the Camshaft target position based on the engine operating parameters. Based on these parameters, the Powertrain Control Module (PCM) calculates or models the optimum Camshaft position. The Camshaft angular position is varied by the oil control valve. The VVT solenoid pushes on a plunger (spring loaded spool valve) in the center of the Oil Control Valve (OCV) which directs oil pressure to the hydraulic actuator (Phaser) on the Camshaft Sprocket to change the Camshaft position relative to the Crankshaft position. The VVT Solenoid, acting on the Oil Control Valve and Phaser, is controlled by the PCM. The Camshaft Position (CMP) Sensor is used to monitor the position of the Camshaft.

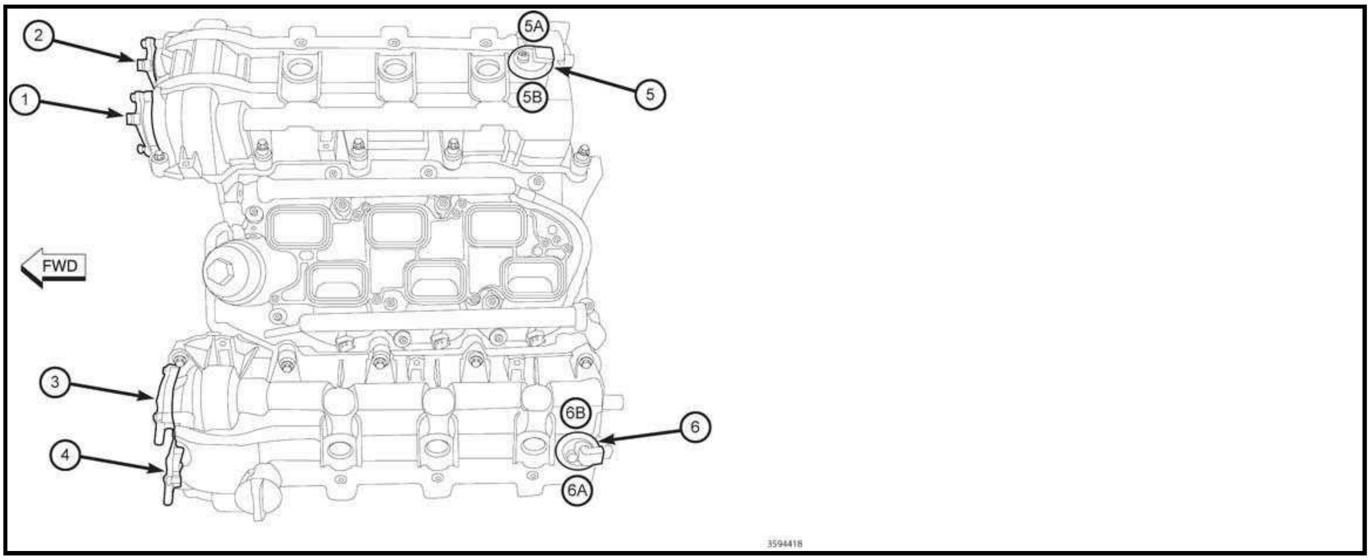
NOTE:	**For the PCM to run this diagnostic the CMP Sensor and CKP Sensor signals must be locked with no sensor faults present. A missing or erratic CMP or CKP signal cannot cause a slow response fault to set. Replacing either sensor will not fix the vehicle.**

The PCM performs the typical diagnostic checks on the control circuits. During operation of the system the PCM also performs a **Target Error** and a **Slow Response** diagnostic check of the Camshaft phasing since these conditions could potentially increase tailpipe emissions. The diagnostic is primarily performed by comparing the actual Camshaft position to that of a calculated model for the Camshaft position. This diagnostic is continuous once the enable conditions are met. The Slow Response and Target Error conditions are not performed simultaneously.

- **The Target Error** diagnostic evaluates the actual Camshaft position versus the modeled position when the Camshaft is in a relatively stable position. The difference between the two is considered to be the amount of "error". If the error amount is greater than a calibrated threshold, it is considered failing.
- **The Slow Response** diagnostic is only performed when the modeled Camshaft position is moving (phasing) in a particular direction, advancing or retarding. The modeled Camshaft phasing position is created to match only the worst possible case of a passing Camshaft position. If the actual Camshaft phasing operates slower than the model by a calibrated threshold, it is considered failing.

If either of these diagnostics fail, the Camshaft Position Slow Response fault will set. **Any oil pressure issues, VVT Solenoid or Oil Pump Solenoid Control circuit faults should be diagnosed before diagnosing a Camshaft Position Slow Response fault.**

NOTE:	**On occasion a small piece of debris or metal chip can get lodged in the OCV causing the spool valve to stick. The contamination can either dislodge on it's own or when the PCM is running a cleaning procedure on the OCV causing an intermittent fault condition for a Camshaft Position Slow Response that is no longer present.**



NOTE:	**There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and table below indicating the specific orientation of the DTCs to the Camshafts).**

3.2L/3.6L DTCs RELATED TO EACH CAMSHAFT				
CAMSHAFT POSITION	**RELATED CAM SENSOR DTCS**	**PHASER/ACTUATOR DTCS**	**MISALIGNMENT DTCS**	**COLD START PERF DTCS**
(1) Bank 1 Intake Camshaft	P0365, P0369	P000A, P0010	P0017	P052A, P052B
(2) Bank 1 Exhaust Camshaft	P0340, P0344	P000B, P0013	P0016	P054A, P054B
(3) Bank 2 Intake Camshaft	P0390, P0394	P000C, P0020	P0019	P052C, P052D
(4) Bank 2 Exhaust Camshaft	P0345, P0349	P000D, P0023	P0018	P054C, P054D

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Engine speed is at least 650 to 1400 rpm, depending on oil temperature.
- Oil temperature is between -7B°C to 139B°C (19B°F to 282B°F).
- Battery voltage is above 10.0 volts.
- No CMP Sensor, Crankshaft Position (CKP) Sensor, or OBDI plausibility errors.
- Cam phasing is being commanded.

SET CONDITION

- The actual Camshaft position does not match the desired Camshaft position during Camshaft phasing for approximately 30.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.
- The PCM will attempt to return the Camshaft Phaser to lock pin when the fault is active.

POSSIBLE CAUSES

Possible Causes
ENGINE OIL LEVEL LOW
CAM/CRANK LEARNED VALUES OUT OF TOLERANCE
ENGINE OIL AERATED OR CONTAMINATED
INCORRECT ENGINE OIL FILTER
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
VVT EXHAUST SOLENOID 2/1 FAULTY OR INTERMITTENTLY BINDING/STICKING
CAMSHAFT 2/1 OIL CONTROL VALVE FAULTY OR INTERMITTENTLY BINDING/STICKING SPOOL VALVE
CAMSHAFT TONE WHEEL MISALIGNED
CAMSHAFT 2/1 PHASER FAULTY OR INTERMITTENTLY BINDING/STICKING
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to **PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .**

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **CHECK FOR OTHER DTCS**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs and Freeze Frame Data and record on the repair order.

       Are there any system voltage, Oil Pump or Camshaft Position DTCs present?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 3
3. **VERIFY THE CAM/CRANK LEARNED VALUES ARE WITHIN TOLERANCE**
    1. With the scan tool, read the Cam/Crank Difference Learned values in the Data Display.

       NOTE: When the Cam/Crank Learn is performed the Camshaft position is learned in High Lift and Low Lift modes on the Variable Valve Lift (VVL) equipped engines. The difference between the High Lift and Low Lift learned values should be less than 2B° for each Camshaft.

       NOTE: If the Cam/Crank Difference Learned values are not in the Data Display, go to 4.

       Are the Intake Cam 2 High Lift and Low Lift learned values within 2B° of each other?

       Yes

       - Go To 4

       No

       - With the scan tool perform the **Cam/Crank Relearn** procedure and retest for DTC.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
4. **CHECK THE ENGINE OIL/ENGINE MECHANICAL CONDITION**
    1. Turn the ignition off.
    2. The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.
        - LOW ENGINE OIL LEVEL

- CONTAMINATED, DIRTY, AERATED OR DETERIORATED ENGINE OIL
- INCORRECT ENGINE OIL VISCOSITY
- ENGINE MECHANICAL TOLERANCES OUT OF SPECIFICATION
- ENGINE OIL PRESSURE OUT OF SPECIFICATION
- INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)

Were any of the above conditions present?

Yes

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.) in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

NOTE: **During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.**

1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor.
5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

NOTE: **If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.**

Is the oil pressure reading stable and above 16.0 psi?

Yes

- Go To 6

No

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE ENGINE OIL PRESSURE TO THE CYLINDER HEAD**
   1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
   2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid and install an oil pressure gauge to the adaptor.

3. Start the engine and allow it to idle.
4. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

NOTE: **The oil pressure reading at the Cylinder Head should be above 14.0 psi.**

Is the oil pressure reading stable and above 14.0 psi?

Yes

- Go To 7

No

- Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **VERIFY AN ACTIVE CONDITION BY CHECKING THE CAM PHASER POSITION**

NOTE: **If a Cam Phaser or Oil Control Valve is stuck, there may also be a Crankshaft/Camshaft Timing Misalignment and/or Multiple Cylinder Misfire DTC present.**

NOTE: **The Intake Camshaft is phased less frequently than the Exhaust Camshaft during engine operation. Therefore it may be necessary to test drive the vehicle under different load conditions to get enough phasing of the Intake Camshaft to duplicate the condition and check the values.**

1. What to monitor for during the test step:
   - **The phaser not coming back to lock pin at idle.** This his could indicate a faulty phaser or oil control valve that is permanently stuck off lock pin or a VVT Solenoid that is electrically stuck on.
   - **The actual position lagging or moving slowly toward the desired position.** This could indicate a faulty phaser or tarnished oil control valve that is dragging.
   - **The actual position lagging and then overshooting the desired position** This could indicate a faulty phaser, oil control valve or VVT Solenoid that is intermittently sticking or binding and then overshoot when the condition goes away.
2. Start the engine and allow the engine to idle.
3. With the scan tool, monitor and compare the Intake Cam 2 **actual** position value with the Intake Cam 2 **desired** position value. After comparing the two values at idle, check and compare the values at several different engine speeds during the following steps.
4. While monitoring the Intake Cam 2 actual position and desired position values:
   - Raise the engine speed quickly and hold steady for up to 30 seconds.
   - Lower the engine speed and hold steady at a level above idle (off of lock pin) for up to 30 seconds.
5. Repeat the above steps multiple times and allow the engine to come back to idle while monitoring the actual position value to verify that the phaser is returning to lock pin position.

Is the difference between the actual value and the desired value readings more than 6.0 degrees at idle or is the actual value lagging behind or overshooting the desired value?

Yes, the difference is greater than 6.0 degrees at idle:

- Go To 8

Yes, the actual reading is lagging or overshooting when changing the engine speeds indicating a binding or sticking:

- Go To 9

No

- This fault is occurring due to an intermittent condition. The problem could be due to an intermittent sticking or dragging condition of one of the timing components listed in the possible causes table. The issue could be temperature related (I.E. Incorrect or broken down oil affecting operation during a cold start, or a tolerance issue in a component that is affected after a cold start/heat soak or after the engine is warmed to operating temperature). The issue could also be occurring during certain specific driving conditions. It may be necessary to test drive the vehicle under different load conditions to duplicate the issue.

8. **DETERMINE IF THE CAM PHASER ISSUE IS ELECTRICAL OR MECHANICAL**
   1. While the engine is at idle, disconnect the VVT Intake Solenoid 2/1 harness connector.
   2. The Intake Cam 2 actual position value should change to lock pin with the solenoid disconnected. The Intake Cam position should be at approximately 146.0 degrees at lock pin.

   Did the Intake Cam 2 actual value change to lock pin position with the solenoid unplugged?

   Yes

   - Check the (K78) VVT Intake Control 2/1 circuit for a short to voltage. If the circuit is not shorted to voltage, Go To 13
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 9

9. **CHECK THE CAMSHAFT 2/1 OIL CONTROL VALVE OPERATION**
   1. Turn the ignition off.
   2. Remove the VVT Intake Solenoid 2/1.
   3. Inspect the spring loaded spool valve on the Oil Control Valve.

   NOTE: **The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.**

   4. Push and release the spring loaded spool valve against the return spring with a small punch.

   NOTE: **The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.**

   Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

   Yes

   - Go To 10

No

- Replace the Camshaft 2/1 Oil Control Valve in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .
- The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CHECK THE VVT INTAKE SOLENOID 2/1 OPERATION**
    1. Turn the ignition off.
    2. With the solenoid still removed, reconnect the VVT Intake Solenoid 2/1 harness connector.
    3. Turn the ignition on.
    4. With the scan tool, actuate the VVT Intake Solenoid 2/1 on and off several times.

    Does the VVT Intake Solenoid 2/1 move freely without binding or sticking during actuation?

    Yes

    - Go To 11

    No

    - Replace the VVT Intake Solenoid 2/1 in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .
    - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
11. **VERIFY THAT THE VVT INTAKE SOLENOID 2/1 IS ABLE TO MOVE THE PHASER**
    1. Exchange the VVT Intake Solenoid 2/1 with the VVT Intake Solenoid 1/1.

    NOTE: The Intake and Exhaust Solenoids should not be interchanged.

    2. Reconnect the solenoid harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs in the PCM.
    5. Test drive the vehicle under the conditions in which the fault was set.
    6. With the scan tool, read DTCs.

    Did the DTC move with the solenoid or stay with the original Camshaft?

    Moved with the solenoid

    - Replace the VVT Intake Solenoid 2/1 in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .
    - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

Stayed with the original camshaft

- Go To 12

12. **CHECK THE INTAKE CAMSHAFT 2/1 TONE WHEEL**
    1. Remove the Cylinder Head Cover and inspect the Camshaft Sensor Tone Wheel for any looseness or signs of damage.
    2. Using the (special tool #2027901090, Check Tool, Tone Wheel Left) check the alignment of the CMP Sensor Tone Wheel in accordance with the service information.

    Were any issues found with the CMP Sensor Tone Wheel?

    Yes

    - Replace the Intake Camshaft Assembly in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION** .
    - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Replace the Cam 2/1 Phaser in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .
    - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
13. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P000D-BANK 2 CAMSHAFT 2 POSITION SLOW RESPONSE

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Variable Valve Timing (VVT) system continuously varies the Camshaft target position based on the engine operating parameters. Based on these parameters, the Powertrain Control Module (PCM) calculates or models the optimum Camshaft position. The Camshaft angular position is varied by the oil control valve. The VVT solenoid pushes on a plunger (spring loaded spool valve) in the center of the Oil Control Valve (OCV) which directs oil pressure to the hydraulic actuator (Phaser) on the Camshaft Sprocket to change the Camshaft position relative to the Crankshaft position. The VVT Solenoid, acting on the Oil Control Valve and Phaser, is controlled by the PCM. The Camshaft Position (CMP) Sensor is used to monitor the position of the Camshaft.

NOTE: **For the PCM to run this diagnostic the CMP Sensor and CKP Sensor signals must be locked with no sensor faults present. A missing or erratic CMP or CKP signal cannot cause a slow response fault to set. Replacing either sensor will not fix the vehicle.**

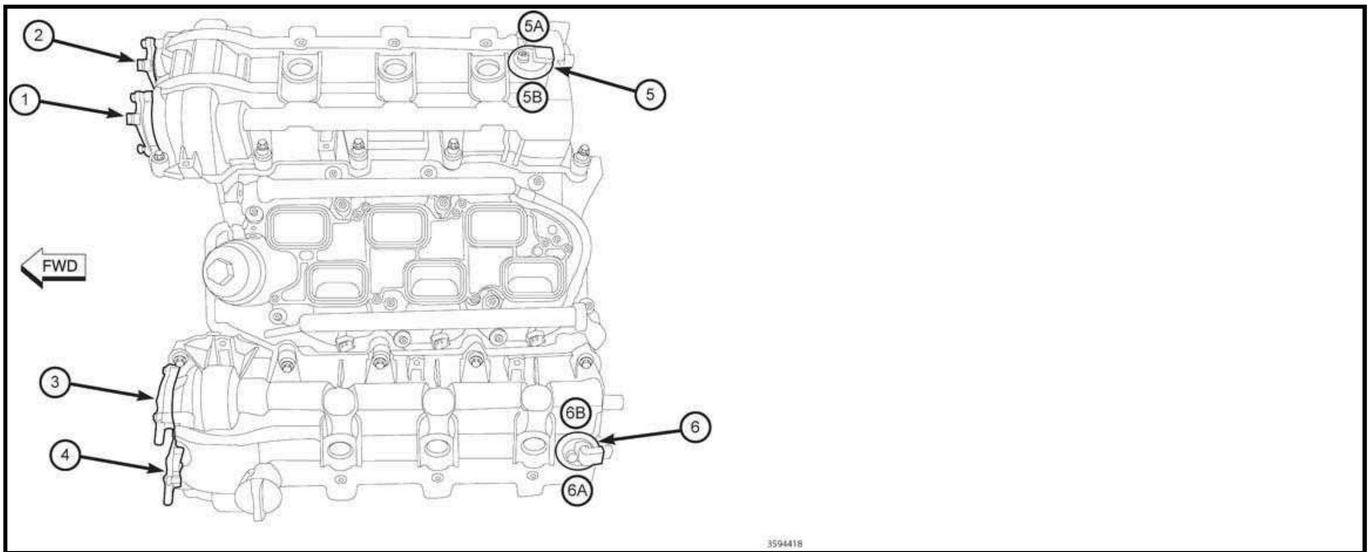
The PCM performs the typical diagnostic checks on the control circuits. During operation of the system the PCM also performs a **Target Error** and a **Slow Response** diagnostic check of the Camshaft phasing since these conditions could potentially increase tailpipe emissions. The diagnostic is primarily performed by comparing the actual Camshaft position to that of a calculated model for the Camshaft position. This diagnostic is continuous once the enable conditions are met. The Slow Response and Target Error conditions are not performed simultaneously.

- **The Target Error** diagnostic evaluates the actual Camshaft position versus the modeled position when the Camshaft is in a relatively stable position. The difference between the two is considered to be the amount of "error". If the error amount is greater than a calibrated threshold, it is considered failing.

- **The Slow Response** diagnostic is only performed when the modeled Camshaft position is moving (phasing) in a particular direction, advancing or retarding. The modeled Camshaft phasing position is created to match only the worst possible case of a passing Camshaft position. If the actual Camshaft phasing operates slower than the model by a calibrated threshold, it is considered failing.

If either of these diagnostics fail, the Camshaft Position Slow Response fault will set. **Any oil pressure issues, VVT Solenoid or Oil Pump Solenoid Control circuit faults should be diagnosed before diagnosing a Camshaft Position Slow Response fault.**

NOTE: **On occasion a small piece of debris or metal chip can get lodged in the OCV causing the spool valve to stick. The contamination can either dislodge on it's own or when the PCM is running a cleaning procedure on the OCV causing an intermittent fault condition for a Camshaft Position Slow Response that is no longer present.**



NOTE: **There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and table below indicating the specific orientation of the DTCs to the Camshafts).**

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(2) Bank 1 Exhaust Camshaft	P0340, P0344	P000B, P0013	P0016	P054A, P054B
(3) Bank 2 Intake Camshaft	P0390, P0394	P000C, P0020	P0019	P052C, P052D
(4) Bank 2 Exhaust Camshaft	P0345, P0349	P000D, P0023	P0018	P054C, P054D

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Engine speed is at least 650 to 1400 rpm, depending on oil temperature.
- Oil temperature is between -7B°C to 139B°C (19B°F to 282B°F).

- Battery voltage is above 10.0 volts.
- No CMP Sensor, Crankshaft Position (CKP) Sensor, or OBDI plausibility errors.
- Cam phasing is being commanded.

SET CONDITION

- The actual Camshaft position does not match the desired Camshaft position during Camshaft phasing for approximately 30.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.
- The PCM will attempt to return the Camshaft Phaser to lock pin when the fault is active.

POSSIBLE CAUSES

Possible Causes
ENGINE OIL LEVEL LOW
CAM/CRANK LEARNED VALUES OUT OF TOLERANCE
ENGINE OIL AERATED OR CONTAMINATED
INCORRECT ENGINE OIL FILTER
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
VVT EXHAUST SOLENOID 2/2 FAULTY OR INTERMITTENTLY BINDING/STICKING
CAMSHAFT 2/2 OIL CONTROL VALVE FAULTY OR INTERMITTENTLY BINDING/STICKING SPOOL VALVE
CAMSHAFT TONE WHEEL MISALIGNED
CAMSHAFT 2/2 PHASER FAULTY OR INTERMITTENTLY BINDING/STICKING
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

       No

       - Go To 2
2. **CHECK FOR OTHER DTCS**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs and Freeze Frame Data and record on the repair order.

       Are there any system voltage, Oil Pump or Camshaft Position DTCs present?

Yes

- Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

No

- Go To 3

3. **VERIFY THE CAM/CRANK LEARNED VALUES ARE WITHIN TOLERANCE**
   1. With the scan tool, read the Cam/Crank Difference Learned values in the Data Display.

NOTE:	**When the Cam/Crank Learn is performed the Camshaft position is learned in High Lift and Low Lift modes on the Variable Valve Lift (VVL) equipped engines. The difference between the High Lift and Low Lift learned values should be less than 2B° for each Camshaft.**

NOTE:	**If the Cam/Crank Difference Learned values are not in the Data Display, go to 4.**

Are the Exhaust Cam 2 High Lift and Low Lift learned values within 2B° of each other?

Yes

- Go To 4

No

- With the scan tool perform the **Cam/Crank Relearn** procedure and retest for DTC.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE ENGINE OIL/ENGINE MECHANICAL CONDITION**
   1. Turn the ignition off.

NOTE:	**The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.** • **LOW ENGINE OIL LEVEL** • **CONTAMINATED, DIRTY, AERATED OR DETERIORATED ENGINE OIL** • **INCORRECT ENGINE OIL VISCOSITY** • **ENGINE MECHANICAL TOLERANCES OUT OF SPECIFICATION** • **ENGINE OIL PRESSURE OUT OF SPECIFICATION** • **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**

Were any of the above conditions present?

Yes

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.) in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

   NOTE: During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.

   1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
   2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
   3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
   4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor.
   5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

      NOTE: If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.

   Is the oil pressure reading stable and above 16.0 psi?

   Yes

   - Go To 6

   No

   - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE ENGINE OIL PRESSURE TO THE CYLINDER HEAD**
   1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
   2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid and install an oil pressure gauge to the adaptor.
   3. Start the engine and allow it to idle.
   4. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

      NOTE: The oil pressure reading at the Cylinder Head should be above 14.0 psi.

   Is the oil pressure reading stable and above 14.0 psi?

   Yes

   - Go To 7

   No

   - Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **VERIFY AN ACTIVE CONDITION BY CHECKING THE CAM PHASER POSITION**

NOTE: **If a Cam Phaser or Oil Control Valve is stuck, there may also be a Crankshaft/Camshaft Timing Misalignment and/or Multiple Cylinder Misfire DTC present.**

1. What to monitor for during the test step:
   - **The phaser not coming back to lock pin at idle.** This his could indicate a faulty phaser or oil control valve that is permanently stuck off lock pin or a VVT Solenoid that is electrically stuck on.
   - **The actual position lagging or moving slowly toward the desired position.** This could indicate a faulty phaser or tarnished oil control valve that is dragging.
   - **The actual position lagging and then overshooting the desired position** This could indicate a faulty phaser, oil control valve or VVT Solenoid that is intermittently sticking or binding and then overshoot when the condition goes away.
2. Start the engine and allow the engine to idle.
3. With the scan tool, monitor and compare the Exhaust Cam 2 **actual** position value with the Exhaust Cam 2 **desired** position value. After comparing the two values at idle, check and compare the values at several different engine speeds during the following steps.
4. While monitoring the Exhaust Cam 2 actual position and desired position values:
   - Raise the engine speed quickly and hold steady for up to 30 seconds.
   - Lower the engine speed and hold steady at a level above idle (off of lock pin) for up to 30 seconds.
5. Repeat the above steps multiple times and allow the engine to come back to idle while monitoring the actual position value to verify that the phaser is returning to lock pin position.

   Is the difference between the actual value and the desired value readings more than 6.0 degrees at idle or is the actual value lagging behind or overshooting the desired value?

   Yes, the difference is greater than 6.0 degrees at idle:

   - Go To 8

   Yes, the actual reading is lagging or overshooting when changing the engine speeds indicating a binding or sticking:

   - Go To 9

   No

   - This fault is occurring due to an intermittent condition. The problem could be due to an intermittent sticking or dragging condition of one of the timing components listed in the possible causes table. The issue could be temperature related (I.E. Incorrect or broken down oil affecting operation during a cold start, or a tolerance issue in a component that is affected after a cold start/heat soak or after the engine is warmed to operating temperature). The issue could also be occurring during certain specific driving conditions. It may be necessary to test drive the vehicle under different load conditions to duplicate the issue.

8. **DETERMINE IF THE CAM PHASER ISSUE IS ELECTRICAL OR MECHANICAL**

1. While the engine is at idle, disconnect the VVT Exhaust Solenoid 2/2 harness connector.
2. The Exhaust Cam 2 actual position value should change to lock pin with the solenoid disconnected. The Exhaust Cam position should be at approximately 123.0 degrees at lock pin.

   Did the Exhaust Cam 2 actual value change to lock pin position with the solenoid unplugged?

   Yes

   - Check the (K277) VVT Exhaust Control 2/2 circuit for a short to voltage. If the circuit is not shorted to voltage, Go To 13
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 9

9. **CHECK THE CAMSHAFT 2/2 OIL CONTROL VALVE OPERATION**
   1. Turn the ignition off.
   2. Remove the VVT Exhaust Solenoid 2/2.
   3. Inspect the spring loaded spool valve on the Oil Control Valve.

      NOTE: **The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.**

   4. Push and release the spring loaded spool valve against the return spring with a small punch.

      NOTE: **The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.**

   Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

   Yes

   - Go To 10

   No

   - Replace the Camshaft 2/2 Oil Control Valve in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .
   - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CHECK THE VVT EXHAUST SOLENOID 2/2 OPERATION**
    1. Turn the ignition off.
    2. With the solenoid still removed, reconnect the VVT Exhaust Solenoid 2/2 harness connector.
    3. Turn the ignition on.
    4. With the scan tool, actuate the VVT Exhaust Solenoid 2/2 on and off several times.

    Does the VVT Exhaust Solenoid 2/2 move freely without binding or sticking during actuation?

    Yes

- Go To 11

No

- Replace the VVT Exhaust Solenoid 2/2 in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .
- The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **VERIFY THAT THE VVT EXHAUST SOLENOID 2/2 IS ABLE TO MOVE THE PHASER**
    1. Exchange the VVT Exhaust Solenoid 2/2 with the VVT Exhaust Solenoid 1/2.

       NOTE: The Intake and Exhaust Solenoids should not be interchanged.

    2. Reconnect the solenoid harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs in the PCM.
    5. Test drive the vehicle under the conditions in which the fault was set.
    6. With the scan tool, read DTCs.

    Did the DTC move with the solenoid or stay with the original Camshaft?

    Moved with the solenoid

    - Replace the VVT Exhaust Solenoid 2/2 in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .
    - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    Stayed with the original camshaft

    - Go To 12

12. **CHECK THE EXHAUST CAMSHAFT 2/2 TONE WHEEL**
    1. Remove the Cylinder Head Cover and inspect the Camshaft Sensor Tone Wheel for any looseness or signs of damage.
    2. Using the (special tool #2027901090, Check Tool, Tone Wheel Left) check the alignment of the CMP Sensor Tone Wheel in accordance with the service information.

    Were any issues found with the CMP Sensor Tone Wheel?

    Yes

    - Replace the Exhaust Camshaft Assembly in accordance with the Service Information. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION** .
    - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Replace the Cam 2/2 Phaser in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** .
- The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

P0010-BANK 1 CAMSHAFT 1 POSITION ACTUATOR CIRCUIT OPEN

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Variable Valve Timing (VVT) system continuously varies the Camshaft target position based on the engine operating parameters. Based on these parameters, the Powertrain Control Module (PCM) calculates or models the optimum Camshaft position. The Camshaft angular position is varied by the oil control valve. The VVT solenoid pushes on a plunger (spring loaded spool valve) in the center of the Oil Control Valve (OCV) which directs oil pressure to the hydraulic actuator (Phaser) on the Camshaft Sprocket to change the Camshaft position relative to the Crankshaft position. The VVT Solenoid, acting on the Oil Control Valve and Phaser, is controlled by the PCM. The Camshaft Position (CMP) Sensor is used to monitor the position of the Camshaft.

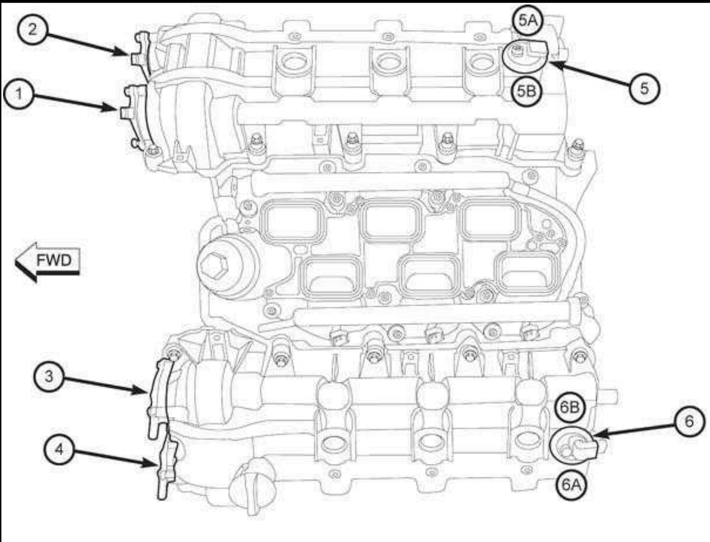
NOTE: **For the PCM to run this diagnostic the CMP Sensor and CKP Sensor signals must be locked with no sensor faults present. A missing or erratic CMP or CKP signal cannot cause a slow response fault to set. Replacing either sensor will not fix the vehicle.**

The PCM performs the typical diagnostic checks on the control circuits. During operation of the system the PCM also performs a **Target Error** and a **Slow Response** diagnostic check of the Camshaft phasing since these conditions could potentially increase tailpipe emissions. The diagnostic is primarily performed by comparing the actual Camshaft position to that of a calculated model for the Camshaft position. This diagnostic is continuous once the enable conditions are met. The Slow Response and Target Error conditions are not performed simultaneously.

- **The Target Error** diagnostic evaluates the actual Camshaft position versus the modeled position when the Camshaft is in a relatively stable position. The difference between the two is considered to be the amount of "error". If the error amount is greater than a calibrated threshold, it is considered failing.
- **The Slow Response** diagnostic is only performed when the modeled Camshaft position is moving (phasing) in a particular direction, advancing or retarding. The modeled Camshaft phasing position is created to match only the worst possible case of a passing Camshaft position. If the actual Camshaft phasing operates slower than the model by a calibrated threshold, it is considered failing.

If either of these diagnostics fail, the Camshaft Position Slow Response fault will set. **Any oil pressure issues, VVT Solenoid or Oil Pump Solenoid Control circuit faults should be diagnosed before diagnosing a Camshaft Position Slow Response fault.**

NOTE: **On occasion a small piece of debris or metal chip can get lodged in the OCV causing the spool valve to stick. The contamination can either dislodge on it's own or when the PCM is running a cleaning procedure on the OCV causing an intermittent fault condition for a Camshaft Position Slow Response that is no longer present.**



NOTE: **There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and table below indicating the specific orientation of the DTCs to the Camshafts).**

3.2L/3.6L DTCs RELATED TO EACH CAMSHAFT				
CAMSHAFT POSITION	**RELATED CAM SENSOR DTCS**	**PHASER/ACTUATOR DTCS**	**MISALIGNMENT DTCS**	**COLD START PERF DTCS**
(1) Bank 1 Intake Camshaft	P0365, P0369	P000A, P0010	P0017	P052A, P052B
(2) Bank 1 Exhaust Camshaft	P0340, P0344	P000B, P0013	P0016	P054A, P054B
(3) Bank 2 Intake Camshaft	P0390, P0394	P000C, P0020	P0019	P052C, P052D
(4) Bank 2 Exhaust Camshaft	P0345, P0349	P000D, P0023	P0018	P054C, P054D

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The Powertrain Control Module (PCM) has detected a circuit failure on the VVT Intake Solenoid 1/1 control circuitry.

DEFAULT ACTION

- The MIL will illuminate.
- The stop/start system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVT INTAKE SOLENOID 1/1 CONTROL CIRCUIT SHORTED TO GROUND

Possible Causes
VVT INTAKE SOLENOID 1/1 CONTROL CIRCUIT SHORTED TO VOLTAGE
VVT INTAKE SOLENOID 1/1 CONTROL CIRCUIT OPEN/HIGH RESISTANCE
VVT INTAKE SOLENOID 1/1 GROUND CIRCUIT OPEN/HIGH RESISTANCE
VVT INTAKE SOLENOID 1/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK THE VVT INTAKE SOLENOID 1/1 CONNECTOR AND TERMINALS**
    1. Turn the ignition off.
    2. Check the VVT Intake Solenoid 1/1 harness connector for proper connection at the VVT Intake Solenoid 1/1.
    3. Verify that the connector is completely plugged in and properly locked prior to disconnecting.

4. Disconnect the VVT Intake Solenoid 1/1 harness connector and check for any pushed out, damaged or spread terminals.

   Were any issues found with the connector or terminals?

   Yes

   - Repair the damaged terminal or properly connect and lock the VVT Intake Solenoid 1/1 harness connector and retest for DTCs.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **ISOLATE AND CHECK THE VVT INTAKE SOLENOID 1/1 (K76) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

      NOTE: **There should be no continuity between ground and the circuit being tested.**

      Is there continuity between ground and the circuit being tested?

      Yes

      - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 5

5. **ISOLATE AND CHECK THE VVT INTAKE SOLENOID 1/1 (K76) CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.

4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

   Is there continuity between the circuit being tested and any other circuit?

   Yes

   - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6

6. **CHECK THE (Z904) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
   1. Disconnect the component harness connector to isolate the ground circuit.
   2. Connect the positive lead of the load test tool to the positive side of the Battery.
   3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
   4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

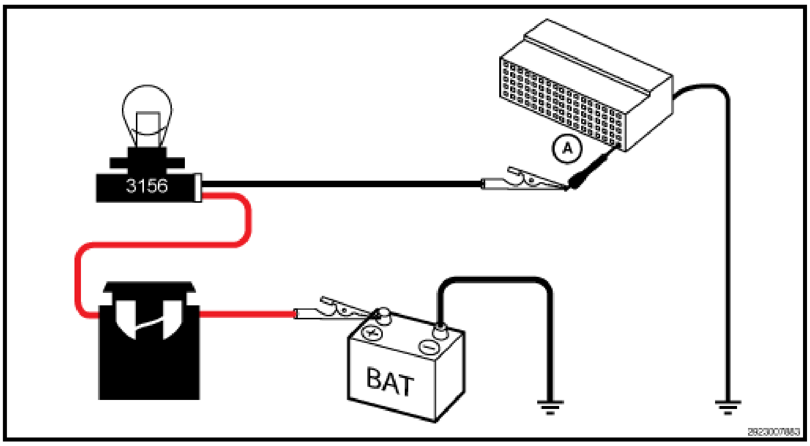
NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
- **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 7

   No

   - Repair the ground circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **ISOLATE AND LOAD TEST THE VVT INTAKE SOLENOID 1/1 (K76) CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
    3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
    4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
    5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
    6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

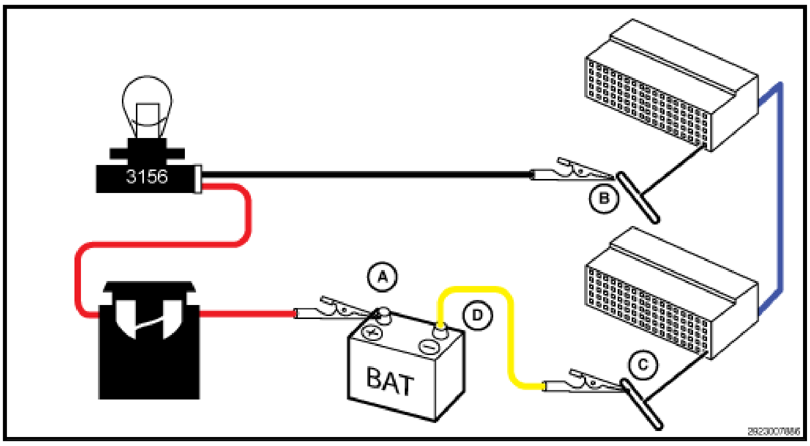
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
- **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



WARNING: **To avoid possible serious or fatal injury, DO NOT load test any air bag/restraint system components or circuits using the procedures listed here. Refer to the Service Information for proper air bag/restraint system testing procedures.**

CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 8

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **ACTUATE AND CHECK THE OPERATION OF THE VVT INTAKE SOLENOID 1/1 DRIVER**
   1. Reconnect the PCM C2 harness connector.
   2. Turn the ignition on.
   3. Using a 12-volt test light connected to ground, probe the VVT Intake Solenoid 1/1 (K76) Control circuit in the VVT Intake Solenoid 1/1 harness connector.

NOTE: The PCM will command the solenoid ON briefly after the ignition is turned on. This is a normal condition. The test light will illuminate briefly and then turn off and stay off if there is not a short to voltage.

4. With the scan tool, actuate the VVT Intake Solenoid 1/1 Control to the highest duty cycle (80%) position.

   NOTE: The test light should be illuminated and bright. Compare the brightness to that of a direct connection to the Battery.

   Is the test light illuminated and bright?

   Yes

   - Replace the VVT Intake Solenoid 1/1 in accordance with the Service Information. With the scan tool perform the **Cam/Crank Relearn** procedure. Refer to **SOLENOID, REMOVAL AND INSTALLATION** .
   - The **Cam/Crank Relearn** procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 9

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.
   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.

10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0013-BANK 1 CAMSHAFT 2 POSITION ACTUATOR CIRCUIT OPEN

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Variable Valve Timing (VVT) system continuously varies the Camshaft target position based on the engine operating parameters. Based on these parameters, the Powertrain Control Module (PCM) calculates or models the optimum Camshaft position. The Camshaft angular position is varied by the oil control valve. The VVT solenoid pushes on a plunger (spring loaded spool valve) in the center of the Oil Control Valve (OCV) which directs oil pressure to the hydraulic actuator (Phaser) on the Camshaft Sprocket to change the Camshaft position relative to the Crankshaft position. The VVT Solenoid, acting on the Oil Control Valve and Phaser, is controlled by the PCM. The Camshaft Position (CMP) Sensor is used to monitor the position of the Camshaft.

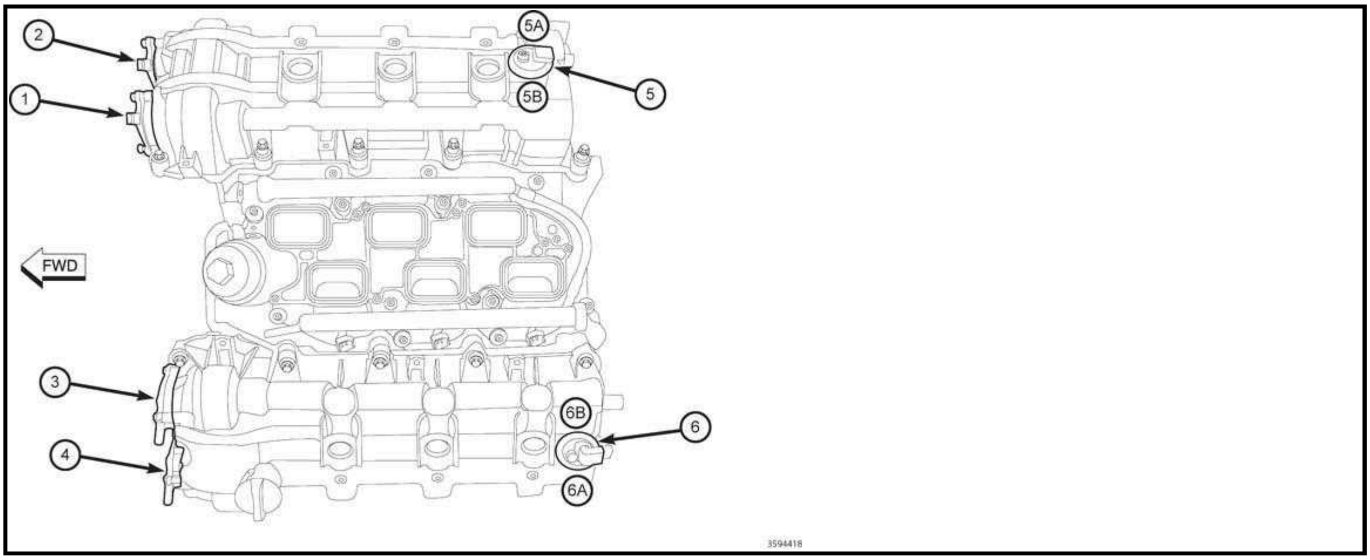
NOTE: **For the PCM to run this diagnostic the CMP Sensor and CKP Sensor signals must be locked with no sensor faults present. A missing or erratic CMP or CKP signal cannot cause a slow response fault to set. Replacing either sensor will not fix the vehicle.**

The PCM performs the typical diagnostic checks on the control circuits. During operation of the system the PCM also performs a **Target Error** and a **Slow Response** diagnostic check of the Camshaft phasing since these conditions could potentially increase tailpipe emissions. The diagnostic is primarily performed by comparing the actual Camshaft position to that of a calculated model for the Camshaft position. This diagnostic is continuous once the enable conditions are met. The Slow Response and Target Error conditions are not performed simultaneously.

- **The Target Error** diagnostic evaluates the actual Camshaft position versus the modeled position when the Camshaft is in a relatively stable position. The difference between the two is considered to be the amount of "error". If the error amount is greater than a calibrated threshold, it is considered failing.
- **The Slow Response** diagnostic is only performed when the modeled Camshaft position is moving (phasing) in a particular direction, advancing or retarding. The modeled Camshaft phasing position is created to match only the worst possible case of a passing Camshaft position. If the actual Camshaft phasing operates slower than the model by a calibrated threshold, it is considered failing.

If either of these diagnostics fail, the Camshaft Position Slow Response fault will set. **Any oil pressure issues, VVT Solenoid or Oil Pump Solenoid Control circuit faults should be diagnosed before diagnosing a Camshaft Position Slow Response fault.**

NOTE: **On occasion a small piece of debris or metal chip can get lodged in the OCV causing the spool valve to stick. The contamination can either dislodge on it's own or when the PCM is running a cleaning procedure on the OCV causing an intermittent fault condition for a Camshaft Position Slow Response that is no longer present.**



NOTE: **There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and table below indicating the specific orientation of the DTCs to the Camshafts).**

3.2L/3.6L DTCs RELATED TO EACH CAMSHAFT				
CAMSHAFT POSITION	**RELATED CAM SENSOR DTCS**	**PHASER/ACTUATOR DTCS**	**MISALIGNMENT DTCS**	**COLD START PERF DTCS**
(1) Bank 1 Intake Camshaft	P0365, P0369	P000A, P0010	P0017	P052A, P052B
(2) Bank 1 Exhaust Camshaft	P0340, P0344	P000B, P0013	P0016	P054A, P054B
(3) Bank 2 Intake Camshaft	P0390, P0394	P000C, P0020	P0019	P052C, P052D
(4) Bank 2 Exhaust Camshaft	P0345, P0349	P000D, P0023	P0018	P054C, P054D

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The PCM detects an open or shorted condition on the VVT Exhaust Solenoid 1/2 Control circuitry.

DEFAULT ACTION

- The MIL will illuminate.
- The stop/start system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVT EXHAUST SOLENOID 1/2 CONTROL CIRCUIT SHORTED TO GROUND
VVT EXHAUST SOLENOID 1/2 CONTROL CIRCUIT SHORTED TO VOLTAGE
VVT EXHAUST SOLENOID 1/2 CONTROL CIRCUIT OPEN/HIGH RESISTANCE
VVT EXHAUST SOLENOID 1/2 GROUND CIRCUIT OPEN/HIGH RESISTANCE
VVT EXHAUST SOLENOID 1/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK THE VVT EXHAUST SOLENOID 1/2 CONNECTOR AND TERMINALS**
    1. Turn the ignition off.

2. Check the VVT Exhaust Solenoid 1/2 harness connector for proper connection at the VVT Exhaust Solenoid 1/2.
3. Verify that the connector is completely plugged in and properly locked prior to disconnecting.
4. Disconnect the VVT Exhaust Solenoid 1/2 harness connector and check for any pushed out, damaged or spread terminals.

Were any issues found with the connector or terminals?

Yes

- Repair the damaged terminal or properly connect and lock the VVT Exhaust Solenoid 1/2 harness connector and retest for DTCs.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **ISOLATE AND CHECK THE VVT EXHAUST SOLENOID 1/2 (K276) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **ISOLATE AND CHECK THE VVT EXHAUST SOLENOID 1/2 (K276) CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
   4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to**

pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK THE (Z904) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Disconnect the component harness connector to isolate the ground circuit.
    2. Connect the positive lead of the load test tool to the positive side of the Battery.
    3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
    4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

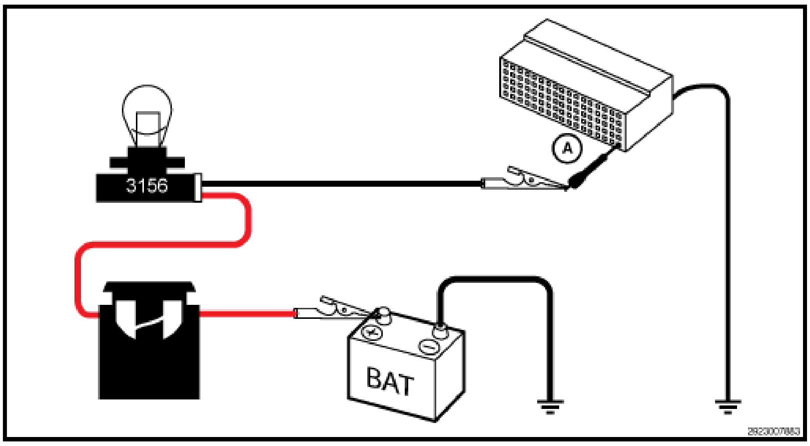
NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**

3. 3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 7

   No

   - Repair the ground circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

7. **ISOLATE AND LOAD TEST THE VVT EXHAUST SOLENOID 1/2 (K276) CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.

3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

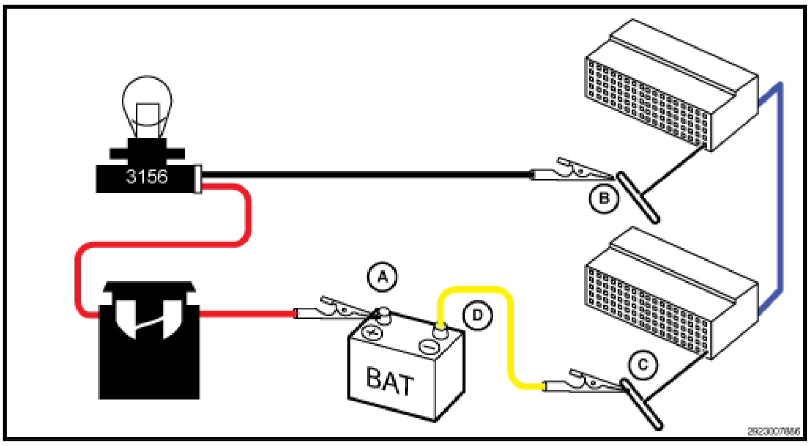
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 8

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **ACTUATE AND CHECK THE OPERATION OF THE VVT EXHAUST SOLENOID 1/2 DRIVER**
   1. Reconnect the PCM C2 harness connector.
   2. Turn the ignition on.
   3. Using a 12-volt test light connected to ground, probe the VVT Exhaust Solenoid 1/2 (K276) Control circuit in the VVT Exhaust Solenoid 1/2 harness connector.

   NOTE: **The PCM will command the solenoid ON briefly after the ignition is turned on. This is a normal condition. The test light will illuminate briefly and then turn off and stay off if there is not a short to voltage.**

   4. With the scan tool, actuate the VVT Exhaust Solenoid 1/2 Control to the highest duty cycle (80%) position.

   NOTE: **The test light should be illuminated and bright. Compare the brightness to that of a direct connection to the Battery.**

Is the test light illuminated and bright?

Yes

- Replace the VVT Exhaust Solenoid 1/2 in accordance with the Service Information. Refer to **SOLENOID, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 9

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0016-CRANKSHAFT/CAMSHAFT TIMING MISALIGNMENT - BANK 1 SENSOR 1

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

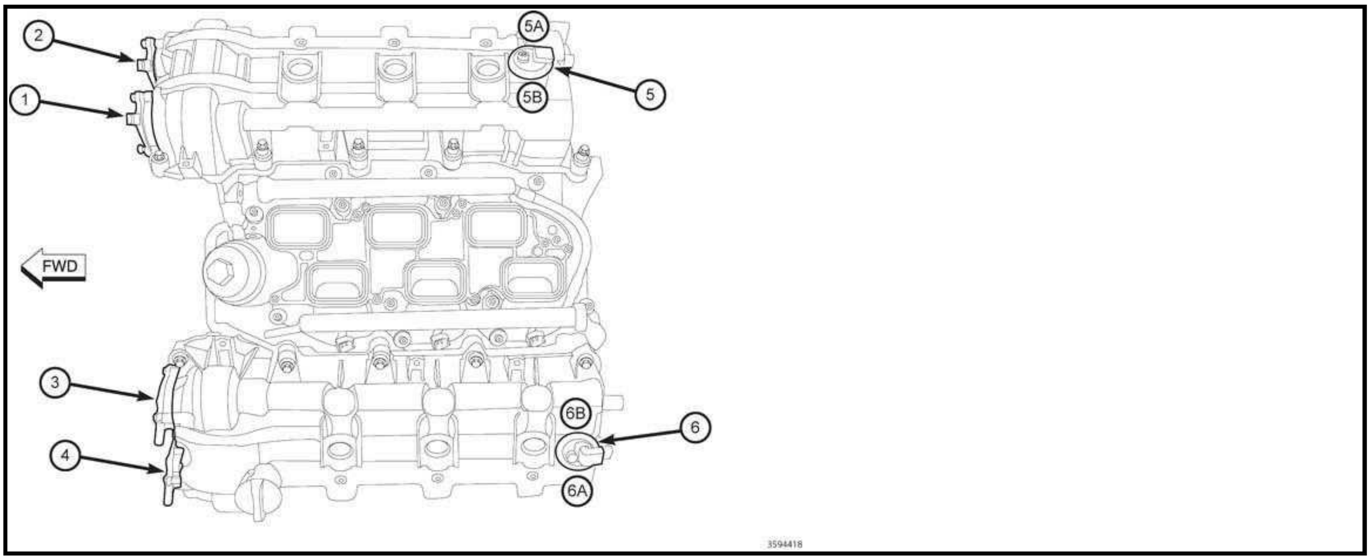
For proper engine control and combustion stability the Camshaft (CMP) and Crankshaft (CKP) positions must be aligned and known so that fuel injection and spark timing can be introduced at the intended Piston and Intake/Exhaust Valve positions. During vehicle manufacturing, at end of line, or if a Cam/Crank Relearn is performed, the system learns the difference between the Camshaft and Crankshaft position in terms of engine degrees and stores it in the EEPROM. During every following driving cycle, the Powertrain Control Module (PCM) uses this value to compare.

Within a driving cycle, once the CMP position and CKP position are known and verified they are considered "locked." This diagnostic will only run when both sensor signals are in the "locked" state. Engine position is constantly tracked as the CMP Sensor and CKP Sensor signals are monitored by the PCM. An engine rotating at a constant speed would produce engine signals that match the nominal pattern exactly. With engine acceleration and deceleration the engine signals are compressed or stretched in time relative to nominal timing. The PCM takes into account and adjusts for any acceleration/deceleration rates that are in effect.

The misalignment fault accounts for angular deviation between the CMP Sensor and CKP Sensor signals due to miss builds, chain stretch, or skipped tooth. This fault results from the difference between the positions as indicated by the CMP Sensor and CKP Sensor signals. The result is only valid if both positions are "locked".

NOTE: **A missing or erratic CMP or CKP signal cannot cause a Cam/Crank Misalignment fault to set. Replacing either sensor will not fix the vehicle.**

NOTE: **On occasion a small piece of debris or metal chip can get lodged in the OCV causing the spool valve to stick. The contamination can either dislodge on it's own or when the PCM is running a cleaning procedure on the OCV causing an intermittent fault condition for a Camshaft/Crankshaft Misalignment that is no longer present.**



NOTE: **There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and table below indicating the specific orientation of the DTCs to the Camshafts).**

3.2L/3.6L DTCs RELATED TO EACH CAMSHAFT					
CAMSHAFT LOCATIONS	**CALLOUT #**	**RELATED CAM SENSOR DTCS**	**PHASER/ACTUATOR DTCS**	**MISALIGNMENT DTCS**	**COLD START PERF DTCS**
Bank 1 Intake Camshaft	1	P0365, P0369	P000A, P0010	P0017	P052A, P052B
Bank 1 Exhaust Camshaft	2	P0340, P0344	P000B, P0013	P0016	P054A, P054B
Bank 2 Intake Camshaft	3	P0390, P0394	P000C, P0020	P0019	P052C, P052D
Bank 2 Exhaust Camshaft	4	P0345, P0349	P000D, P0023	P0018	P054C, P054D

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Battery voltage above 11.0 volts.
- Engine speed between approximately 500 - 6000 rpm, depending on PCM calibration.
- Engine coolant temperature above 10B°C (50B°F).
- Engine oil temperature is above between 5B°C (41B°F) and 10B°C (50B°F), depending on PCM calibration.
- Camshaft has been driven to lock pin for approximately 3 - 4 seconds or more (to allow enough time to attain lock pin position).

SET CONDITION

- The difference between the Bank 1 Exhaust Camshaft position and the Crankshaft position is more than 10.0 degrees.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
INCORRECT ENGINE OIL VISCOSITY OR OIL FILTER
CAM/CRANK LEARNED VALUES OUT OF TOLERANCE
ENGINE OIL AERATED OR CONTAMINATED
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
CAMSHAFT 1/2 OIL CONTROL VALVE FAULTY OR INTERMITTENTLY BINDING/STICKING SPOOL VALVE
CAMSHAFT TONE WHEEL MISALIGNED
CAMSHAFT 1/2 PHASER
TIMING CHAIN/SPROCKET ALIGNMENT
BROKEN OR FAULTY TIMING CHAIN TENSIONER OR GUIDES
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE DTC**

   NOTE: **Perform any Service Bulletins or Star Cases relating to this fault before continuing with this test procedure.**

   1. Turn the ignition on.
   2. With the scan tool, read DTCs and record on the repair order.
   3. Record the related Freeze Frame data.
   4. With the scan tool, erase DTCs.
   5. Start the engine and allow it to idle. It maybe necessary to tests drive the vehicle and allow cam phasing to occur in order to reset the fault.

      WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

   6. With the scan tool, read DTCs.

      Is the DTC active or pending?

      Yes

      - Go To 2

      No

      - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are the P0340 or P0344 DTCs present?

      Yes

      - Perform the applicable diagnostic procedure(s) before continuing with this test procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3
3. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any VVT Solenoid Circuit Open or Slow Response DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 4
4. **VERIFY THE CAM/CRANK LEARNED VALUES ARE WITHIN TOLERANCE**

1. With the scan tool, read the Cam/Crank Difference Learned values in the Data Display.

   NOTE: **When the Cam/Crank Learn is performed the Camshaft position is learned in High Lift and Low Lift modes on the Variable Valve Lift (VVL) equipped engines. The difference between the High Lift and Low Lift learned values should be less than 2B° for each Camshaft.**

   NOTE: **If the Cam/Crank Difference Learned values are not in the Data Display, go to 5.**

   Are the Exhaust Cam 1 High Lift and Low Lift learned values within 2B° of each other?

   Yes

   - Go To 5

   No

   - With the scan tool perform the **Cam/Crank Relearn** procedure and retest for DTC.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ENGINE OIL/ENGINE MECHANICAL**

   NOTE: **The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.**

   - **ENGINE MECHANICAL TOLERANCES OUT OF SPECIFICATION**
   - **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
   - **LOW ENGINE OIL LEVEL**
   - **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**
   - **DETERIORATED OR DIRTY OIL**
   - **CONTAMINATED ENGINE OIL**
   - **INCORRECT ENGINE OIL VISCOSITY**
   - **AERATED ENGINE OIL**

   1. If any of the above conditions are found, repair as necessary.

      Were any of the above conditions present?

      Yes

      - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 6

6. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**
   1. Install the applicable adaptor to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
   2. Start the engine and allow it to idle.

3. Monitor the engine oil pressure reading on the gauge or scan tool.

NOTE: **If the oil pressure is below 14 psi or oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or Cam/Crank Misalignment DTC.**

Is the oil pressure reading stable and above 14.0 psi?

Yes

- Go To 7

No

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **VERIFY AN ACTIVE CONDITION BY CHECKING THE CAM PHASER POSITION**

NOTE: **If a Cam Phaser or Oil Control Valve is stuck, there may also be a Crankshaft/Camshaft Timing Misalignment and/or Multiple Cylinder Misfire DTC present.**

NOTE: **It may be necessary to drive the vehicle to allow the Cam Phaser to operate normally and then return to lock pin at idle. The purpose is to check for a phaser that may not be responding quick enough and causing this DTC.**

NOTE: **The Cam Phaser slow response fault can take approximately 30 seconds to fail, where as the misalignment fault generally fails within 5-10 seconds.**

1. What to monitor for during the test step:
   - **The phaser not coming back to lock pin at idle.** This his could indicate a faulty phaser or oil control valve that is permanently stuck off lock pin or a Camshaft Position Solenoid that is electrically stuck on.
   - **The actual position lagging or moving slowly toward the desired position.** This could indicate a faulty phaser or tarnished oil control valve that is dragging.
   - **The actual position lagging and then overshooting the desired position** This could indicate a faulty phaser, oil control valve or Camshaft Position Solenoid that is intermittently sticking or binding and then overshoot when the condition goes away.
2. Start the engine and allow the engine to idle.
3. With the scan tool, monitor and compare the Exhaust Cam 1 **actual** position value with the Exhaust Cam 1 **desired** position value. After comparing the two values at idle, check and compare the values at several different engine speeds during the following steps.
4. While monitoring the Exhaust Cam 1 actual position and desired position values:
   - Raise the engine speed quickly and hold steady for up to 30 seconds.
   - Lower the engine speed and hold steady at a level above idle (off of lock pin) for up to 30 seconds.
5. Repeat the above steps multiple times and allow the engine to come back to idle while monitoring the actual position value to verify that the phaser is returning to lock pin position.

   Is the difference between the actual value and the desired value readings more than 10.0 degrees at idle or is the actual value lagging behind or overshooting the desired value?

Yes, the difference is greater than 10.0 degrees at idle:

- Go To 8

Yes, the actual reading is lagging or overshooting when changing the engine speeds indicating a binding or sticking condition:

- Go To 9

No

- Go To 12

8. **DETERMINE IF THE CAM PHASER ISSUE IS ELECTRICAL OR MECHANICAL**
    1. While the engine is at idle, disconnect the Camshaft 1/2 Position Solenoid harness connector.
    2. The Exhaust Cam 1 actual position value should change to lock pin with the solenoid disconnected. The Exhaust Cam position should be at approximately 123.0 degrees at lock pin.

    Did the Exhaust Cam 1 actual value change to lock pin position with the solenoid unplugged?

    Yes

    - Check the (K276) VVT Exhaust Control 1/2 circuit for a short to voltage. If the circuit is not shorted to voltage, replace the Powertrain Control Module in accordance with the service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 9
9. **CHECK THE CAMSHAFT 1/2 OIL CONTROL VALVE OPERATION**
    1. Turn the ignition off.
    2. Remove the Camshaft 1/2 Position Solenoid.
    3. Inspect the spring loaded spool valve on the Oil Control Valve.

    NOTE: **The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.**

    4. Push and release the spring loaded spool valve against the return spring with a small punch.

    NOTE: **The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.**

    Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

    Yes

    - Go To 10

    No

    - Replace the Camshaft 1/2 Oil Control Valve in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing

chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CHECK THE CAMSHAFT 1/2 POSITION SOLENOID OPERATION**
    1. Turn the ignition off.
    2. With the solenoid still removed, reconnect the Camshaft 1/2 Position Solenoid harness connector.
    3. Turn the ignition on.
    4. With the scan tool, actuate the Camshaft 1/2 Position Solenoid on and off several times.

    Does the Camshaft 1/2 Position Solenoid move freely without binding or sticking during actuation?

    Yes

    - Go To 11

    No

    - Replace the Camshaft 1/2 Position Solenoid in accordance with the Service Information.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **VERIFY THAT THE CAMSHAFT 1/2 POSITION SOLENOID IS ABLE TO MOVE THE PHASER**
    1. Exchange the Camshaft 1/2 Position Solenoid with the Camshaft 2/2 Position Solenoid.

    NOTE: The Intake and Exhaust Solenoids should not be interchanged.

    2. Reconnect the solenoid harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs in the PCM.
    5. Test drive the vehicle under the conditions in which the fault was set.
    6. With the scan tool, read DTCs.

    Did the DTC move with the solenoid or stay with the original Camshaft?

    Moved with the solenoid:

    - Replace the faulty Camshaft 1/2 Position Solenoid in accordance with the Service Information.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    Stayed with the original camshaft:

    - Go To 12

12. **INSPECT CAMSHAFT SENSOR TONE WHEEL FOR DAMAGE OR LOOSENESS**
    1. Turn the ignition off.
    2. Remove the Cylinder Head Cover and inspect the Camshaft Sensor Tone Wheel for any looseness or signs of damage.
    3. Using the (special tool #2027902090, Check Tool, Tone Wheel Right) check the alignment of the CMP Sensor Tone Wheel in accordance with the service information.

    Is the CMP Sensor Tone Wheel aligned correctly?

Yes

- Go To 13

No

- Replace the Exhaust Camshaft Assembly in accordance with the Service Information. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, Flywheel, Valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **CHECK THE ENGINE TIMING ALIGNMENT**
    1. Verify proper alignment of the Timing Chain and gears in accordance with the Service Information. Also check the Timing Chain Tensioner and Guide for faulty or broken components.

       Were any issue found with the timing alignment or components?

       Yes

       - Perform the appropriate repair in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, Flywheel, Valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Replace the Cam Phaser Assembly in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, Flywheel, Valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0017-CRANKSHAFT/CAMSHAFT TIMING MISALIGNMENT - BANK 1 SENSOR 2

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

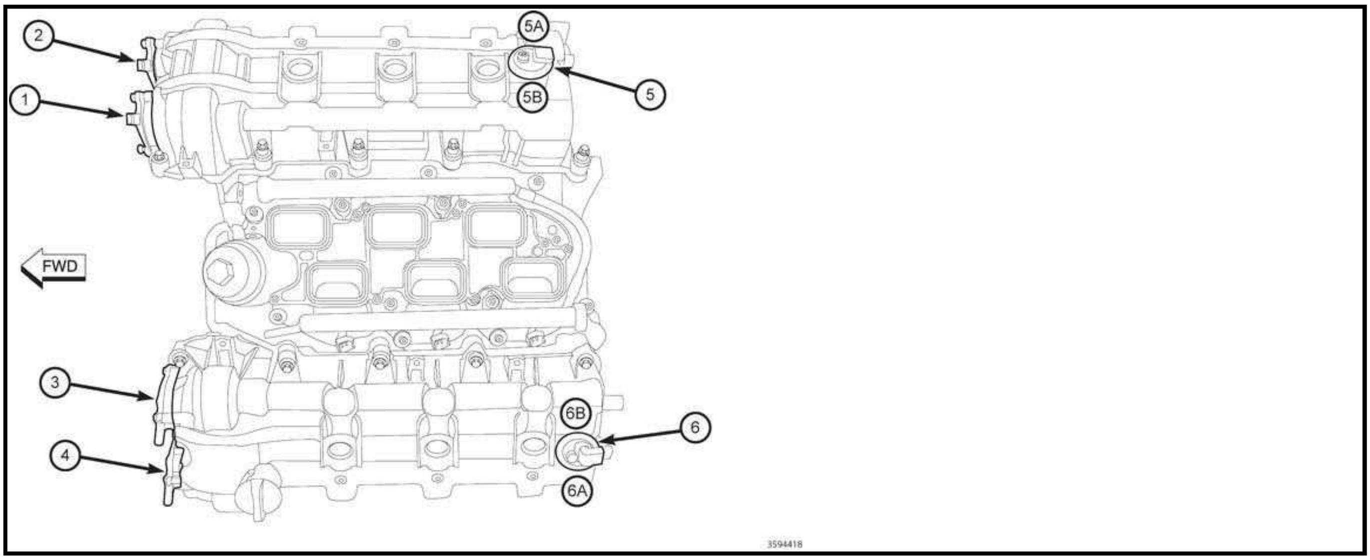
For proper engine control and combustion stability the Camshaft (CMP) and Crankshaft (CKP) positions must be aligned and known so that fuel injection and spark timing can be introduced at the intended Piston and Intake/Exhaust Valve positions. During vehicle manufacturing, at end of line, or if a Cam/Crank Relearn is performed, the system learns the difference between the Camshaft and Crankshaft position in terms of engine degrees and stores it in the EEPROM. During every following driving cycle, the Powertrain Control Module (PCM) uses this value to compare.

Within a driving cycle, once the CMP position and CKP position are known and verified they are considered "locked." This diagnostic will only run when both sensor signals are in the "locked" state. Engine position is constantly tracked as the CMP Sensor and CKP Sensor signals are monitored by the PCM. An engine rotating at a constant speed would produce engine signals that match the nominal pattern exactly. With engine acceleration and deceleration the engine signals are compressed or stretched in time relative to nominal timing. The PCM takes into account and adjusts for any acceleration/deceleration rates that are in effect.

The misalignment fault accounts for angular deviation between the CMP Sensor and CKP Sensor signals due to miss builds, chain stretch, or skipped tooth. This fault results from the difference between the positions as indicated by the CMP Sensor and CKP Sensor signals. The result is only valid if both positions are "locked".

NOTE: **A missing or erratic CMP or CKP signal cannot cause a Cam/Crank Misalignment fault to set. Replacing either sensor will not fix the vehicle.**

NOTE: **On occasion a small piece of debris or metal chip can get lodged in the OCV causing the spool valve to stick. The contamination can either dislodge on it's own or when the PCM is running a cleaning procedure on the OCV causing an intermittent fault condition for a Camshaft/Crankshaft Misalignment that is no longer present.**



NOTE: **There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and table below indicating the specific orientation of the DTCs to the Camshafts).**

3.2L/3.6L DTCs RELATED TO EACH CAMSHAFT					
CAMSHAFT LOCATIONS	CALLOUT #	RELATED CAM SENSOR DTCS	PHASER/ACTUATOR DTCS	MISALIGNMENT DTCS	COLD START PERF DTCS
Bank 1 Intake Camshaft	1	P0365, P0369	P000A, P0010	P0017	P052A, P052B
Bank 1 Exhaust Camshaft	2	P0340, P0344	P000B, P0013	P0016	P054A, P054B
Bank 2 Intake Camshaft	3	P0390, P0394	P000C, P0020	P0019	P052C, P052D
Bank 2 Exhaust Camshaft	4	P0345, P0349	P000D, P0023	P0018	P054C, P054D

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the engine running between approximately 500 - 6000 rpm.

- Battery voltage above 11.0 volts.
- Engine coolant temperature above 10B°C (50B°F).
- Engine oil temperature above 10B°C (50B°F).
- After the Camshaft has been commanded to lock pin long enough that lock pin should be attained (more than approximately three seconds).

SET CONDITION

- The difference between the Bank 1 Intake Camshaft position and the Crankshaft position is more than 10.0 degrees.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
INCORRECT ENGINE OIL VISCOSITY OR OIL FILTER
CAM/CRANK LEARNED VALUES OUT OF TOLERANCE
ENGINE OIL AERATED OR CONTAMINATED
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
CAMSHAFT 1/1 OIL CONTROL VALVE FAULTY OR INTERMITTENTLY BINDING/STICKING SPOOL VALVE
CAMSHAFT TONE WHEEL MISALIGNED
CAMSHAFT 1/1 PHASER
TIMING SPROCKET ALIGNMENT
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are the P0340 or P0344 DTCs present?

      Yes

      - Perform the applicable diagnostic procedure(s) before continuing with this test procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3
3. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any VVT Solenoid Circuit Open or Slow Response DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 4
4. **VERIFY THE CAM/CRANK LEARNED VALUES ARE WITHIN TOLERANCE**
   1. With the scan tool, read the Cam/Crank Difference Learned values in the Data Display.

      NOTE: When the Cam/Crank Learn is performed the Camshaft position is learned in High Lift and Low Lift modes on the Variable Valve Lift (VVL) equipped engines. The difference between the High Lift and Low Lift learned values should be less than 2B° for each Camshaft.

      NOTE: If the Cam/Crank Difference Learned values are not in the Data Display, go to 5.

      Are the Intake Cam 1 High Lift and Low Lift learned values within 2B° of each other?

      Yes

      - Go To 5

      No

      - With the scan tool perform the **Cam/Crank Relearn** procedure and retest for DTC.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **ENGINE OIL/ENGINE MECHANICAL**

   NOTE: The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.

   - **ENGINE MECHANICAL TOLERANCES OUT OF SPECIFICATION**

- **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
- **LOW ENGINE OIL LEVEL**
- **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**
- **DETERIORATED OR DIRTY OIL**
- **CONTAMINATED ENGINE OIL**
- **INCORRECT ENGINE OIL VISCOSITY**
- **AERATED ENGINE OIL**

1. If any of the above conditions are found, repair as necessary.

   Were any of the above conditions present?

   Yes

   - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6

6. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**
   1. Install the applicable adaptor to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
   2. Start the engine and allow it to idle.
   3. Monitor the engine oil pressure reading on the gauge or scan tool.

      NOTE: **If the oil pressure is below 14 psi or oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or Cam/Crank Misalignment DTC.**

   Is the oil pressure reading stable and above 14.0 psi?

   Yes

   - Go To 7

   No

   - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **VERIFY AN ACTIVE CONDITION BY CHECKING THE CAM PHASER POSITION**

   NOTE: **If a Cam Phaser or Oil Control Valve is stuck, there may also be a Crankshaft/Camshaft Timing Misalignment and/or Multiple Cylinder Misfire DTC present.**

   NOTE: **It may be necessary to drive the vehicle to allow the Cam Phaser to operate normally and then return to lock pin at idle. The purpose is to check for a phaser that may not be responding quick enough and causing this DTC.**

NOTE: **The Cam Phaser slow response fault can take approximately 30 seconds to fail, where as the misalignment fault generally fails within 5-10 seconds.**

1. What to monitor for during the test step:
   - **The phaser not coming back to lock pin at idle.** This his could indicate a faulty phaser or oil control valve that is permanently stuck off lock pin or a Camshaft Position Solenoid that is electrically stuck on.
   - **The actual position lagging or moving slowly toward the desired position.** This could indicate a faulty phaser or tarnished oil control valve that is dragging.
   - **The actual position lagging and then overshooting the desired position** This could indicate a faulty phaser, oil control valve or Camshaft Position Solenoid that is intermittently sticking or binding and then overshoot when the condition goes away.
2. Start the engine and allow the engine to idle.
3. With the scan tool, monitor and compare the Intake Cam 1 **actual** position value with the Intake Cam 1 **desired** position value. After comparing the two values at idle, check and compare the values at several different engine speeds during the following steps.
4. While monitoring the Intake Cam 1 actual position and desired position values:
   - Raise the engine speed quickly and hold steady for up to 30 seconds.
   - Lower the engine speed and hold steady at a level above idle (off of lock pin) for up to 30 seconds.
5. Repeat the above steps multiple times and allow the engine to come back to idle while monitoring the actual position value to verify that the phaser is returning to lock pin position.

   Is the difference between the actual value and the desired value readings more than 10.0 degrees at idle or is the actual value lagging behind or overshooting the desired value?

   Yes, the difference is greater than 10.0 degrees at idle:

   - Go To 8

   Yes, the actual reading is lagging or overshooting when changing the engine speeds indicating a binding or sticking condition:

   - Go To 9

   No

   - Go To 12

8. **DETERMINE IF THE CAM PHASER ISSUE IS ELECTRICAL OR MECHANICAL**
   1. While the engine is at idle, disconnect the Camshaft 1/1 Position Solenoid harness connector.
   2. The Intake Cam 1 actual position value should change to lock pin with the solenoid disconnected. The Intake Cam position should be at approximately 146.0 degrees at lock pin.

      Did the Intake Cam 1 actual value change to lock pin position with the solenoid unplugged?

      Yes

      - Check the (K76) VVT Intake Control 1/1 circuit for a short to voltage. If the circuit is not shorted to voltage, replace the Powertrain Control Module in accordance with the service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

- Go To 9

9. **CHECK THE CAMSHAFT 1/1 OIL CONTROL VALVE OPERATION**
    1. Turn the ignition off.
    2. Remove the Camshaft 1/1 Position Solenoid.
    3. Inspect the spring loaded spool valve on the Oil Control Valve.

    NOTE: **The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.**

    4. Push and release the spring loaded spool valve against the return spring with a small punch.

    NOTE: **The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.**

    Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

    Yes

    - Go To 10

    No

    - Replace the Camshaft 1/1 Oil Control Valve in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CHECK THE CAMSHAFT 1/1 POSITION SOLENOID OPERATION**
    1. Turn the ignition off.
    2. With the solenoid still removed, reconnect the VVT Intake Solenoid 1/1 Camshaft 1/1 Position Solenoid harness connector.
    3. Turn the ignition on.
    4. With the scan tool, actuate the Camshaft 1/1 Position Solenoid on and off several times.

    Does the Camshaft 1/1 Position Solenoid move freely without binding or sticking during actuation?

    Yes

    - Go To 11

    No

    - Replace the Camshaft 1/1 Position Solenoid in accordance with the Service Information.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **VERIFY THAT THE CAMSHAFT 1/1 POSITION SOLENOID IS ABLE TO MOVE THE PHASER**
    1. Exchange the Camshaft 1/1 Position Solenoid with the Camshaft 2/1 Position Solenoid.

NOTE: **The Intake and Exhaust Solenoids should not be interchanged.**

2. Reconnect the solenoid harness connectors.
3. Turn the ignition on.
4. With the scan tool, erase DTCs in the PCM.
5. Test drive the vehicle under the conditions in which the fault was set.
6. With the scan tool, read DTCs.

   Did the DTC move with the solenoid or stay with the original Camshaft?

   Moved with the solenoid:

   - Replace the faulty Camshaft 1/1 Position Solenoid in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   Stayed with the original camshaft:

   - Go To 12

12. **CHECK THE INTAKE CAMSHAFT 1/1 TONE WHEEL**
    1. Turn the ignition off.
    2. Check the alignment of the CMP Sensor Tone Wheel on the Intake Camshaft in accordance with the service information.

    Is the CMP Sensor Tone Wheel aligned correctly?

    Yes

    - Go To 13

    No

    - Replace the Intake Camshaft Assembly in accordance with the Service Information. . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, Flywheel, Valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **CHECK THE ENGINE TIMING ALIGNMENT**
    1. Verify proper alignment of the Timing Chain and gears in accordance with the Service Information. Also check the Timing Chain Tensioner and Guide for faulty or broken components.

    Were any issue found with the timing alignment or components?

    Yes

    - Perform the appropriate repair in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, Flywheel, Valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Replace the Cam Phaser Assembly in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, Flywheel, Valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0018-CRANKSHAFT POSITION - CAMSHAFT POSITION CORRELATION BANK 2 SENSOR 1

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

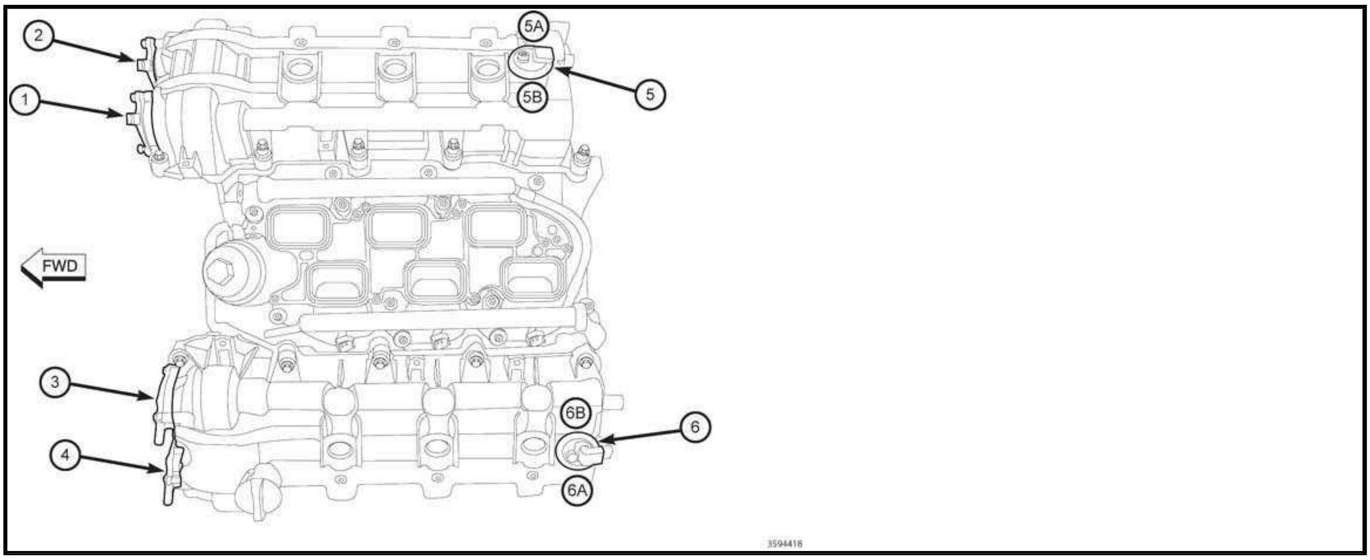
For proper engine control and combustion stability the Camshaft (CMP) and Crankshaft (CKP) positions must be aligned and known so that fuel injection and spark timing can be introduced at the intended Piston and Intake/Exhaust Valve positions. During vehicle manufacturing, at end of line, or if a Cam/Crank Relearn is performed, the system learns the difference between the Camshaft and Crankshaft position in terms of engine degrees and stores it in the EEPROM. During every following driving cycle, the Powertrain Control Module (PCM) uses this value to compare.

Within a driving cycle, once the CMP position and CKP position are known and verified they are considered "locked." This diagnostic will only run when both sensor signals are in the "locked" state. Engine position is constantly tracked as the CMP Sensor and CKP Sensor signals are monitored by the PCM. An engine rotating at a constant speed would produce engine signals that match the nominal pattern exactly. With engine acceleration and deceleration the engine signals are compressed or stretched in time relative to nominal timing. The PCM takes into account and adjusts for any acceleration/deceleration rates that are in effect.

The misalignment fault accounts for angular deviation between the CMP Sensor and CKP Sensor signals due to miss builds, chain stretch, or skipped tooth. This fault results from the difference between the positions as indicated by the CMP Sensor and CKP Sensor signals. The result is only valid if both positions are "locked".

NOTE: **A missing or erratic CMP or CKP signal cannot cause a Cam/Crank Misalignment fault to set. Replacing either sensor will not fix the vehicle.**

NOTE: **On occasion a small piece of debris or metal chip can get lodged in the OCV causing the spool valve to stick. The contamination can either dislodge on it's own or when the PCM is running a cleaning procedure on the OCV causing an intermittent fault condition for a Camshaft/Crankshaft Misalignment that is no longer present.**



NOTE: **There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and table below indicating the specific orientation of the DTCs to the Camshafts).**

3.2L/3.6L DTCs RELATED TO EACH CAMSHAFT					
CAMSHAFT LOCATIONS	**CALLOUT #**	**RELATED CAM SENSOR DTCS**	**PHASER/ACTUATOR DTCS**	**MISALIGNMENT DTCS**	**COLD START PERF DTCS**
Bank 1 Intake Camshaft	1	P0365, P0369	P000A, P0010	P0017	P052A, P052B
Bank 1 Exhaust Camshaft	2	P0340, P0344	P000B, P0013	P0016	P054A, P054B
Bank 2 Intake Camshaft	3	P0390, P0394	P000C, P0020	P0019	P052C, P052D
Bank 2 Exhaust Camshaft	4	P0345, P0349	P000D, P0023	P0018	P054C, P054D

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- During engine cranking.
- With the engine running.
- Battery voltage above 11.0 volts.
- Engine coolant temperature above 10B°C (50B°F).
- Engine oil temperature above 10B°C (50B°F).
- After the Camshaft has been commanded to lock pin long enough that lock pin should be attained (more than approximately three seconds).

SET CONDITION

- The difference between the Bank 2 Exhaust Camshaft position and the Crankshaft position is more than 10.0 degrees.

DEFAULT ACTION

- The MIL will illuminate.

- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
INCORRECT ENGINE OIL VISCOSITY OR OIL FILTER
CAM/CRANK LEARNED VALUES OUT OF TOLERANCE
ENGINE OIL AERATED OR CONTAMINATED
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
CAMSHAFT 2/2 OIL CONTROL VALVE FAULTY OR INTERMITTENTLY BINDING/STICKING SPOOL VALVE
CAMSHAFT TONE WHEEL MISALIGNED
CAMSHAFT 2/2 PHASER
TIMING SPROCKET ALIGNMENT
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE DTC**

   NOTE: Perform any Service Bulletins or Star Cases relating to this fault before continuing with this test procedure.

   1. Turn the ignition on.
   2. With the scan tool, read DTCs and record on the repair order.
   3. Record the related Freeze Frame data.
   4. With the scan tool, erase DTCs.
   5. Start the engine and allow it to idle. It maybe necessary to tests drive the vehicle and allow cam phasing to occur in order to reset the fault.

      WARNING: When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.

   6. With the scan tool, read DTCs.

      Is the DTC active or pending?

      Yes

      - Go To 2

      No

      - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are the P0340 or P0344 DTCs present?

Yes

- Perform the applicable diagnostic procedure(s) before continuing with this test procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

No

- Go To 3

3. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

    Are there any VVT Solenoid Circuit Open or Slow Response DTCs active or pending?

    Yes

    - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

    No

    - Go To 4

4. **VERIFY THE CAM/CRANK LEARNED VALUES ARE WITHIN TOLERANCE**
    1. With the scan tool, read the Cam/Crank Difference Learned values in the Data Display.

    NOTE: **When the Cam/Crank Learn is performed the Camshaft position is learned in High Lift and Low Lift modes on the Variable Valve Lift (VVL) equipped engines. The difference between the High Lift and Low Lift learned values should be less than 2B° for each Camshaft.**

    NOTE: **If the Cam/Crank Difference Learned values are not in the Data Display, go to 5.**

    Are the Exhaust Cam 2 High Lift and Low Lift learned values within 2B° of each other?

    Yes

    - Go To 5

    No

    - With the scan tool perform the **Cam/Crank Relearn** procedure and retest for DTC.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ENGINE OIL/ENGINE MECHANICAL**

NOTE: **The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.**

- **ENGINE MECHANICAL TOLERANCES OUT OF SPECIFICATION**
- **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
- **LOW ENGINE OIL LEVEL**
- **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**
- **DETERIORATED OR DIRTY OIL**
- **CONTAMINATED ENGINE OIL**

- **INCORRECT ENGINE OIL VISCOSITY**
- **AERATED ENGINE OIL**

1. If any of the above conditions are found, repair as necessary.

   Were any of the above conditions present?

   Yes

   - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6

6. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**
   1. Install the applicable adaptor to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
   2. Start the engine and allow it to idle.
   3. Monitor the engine oil pressure reading on the gauge or scan tool.

   NOTE: **If the oil pressure is below 14 psi or oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or Cam/Crank Misalignment DTC.**

   Is the oil pressure reading stable and above 14.0 psi?

   Yes

   - Go To 7

   No

   - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **VERIFY AN ACTIVE CONDITION BY CHECKING THE CAM PHASER POSITION**

   NOTE: **If a Cam Phaser or Oil Control Valve is stuck, there may also be a Crankshaft/Camshaft Timing Misalignment and/or Multiple Cylinder Misfire DTC present.**

   NOTE: **It may be necessary to drive the vehicle to allow the Cam Phaser to operate normally and then return to lock pin at idle. The purpose is to check for a phaser that may not be responding quick enough and causing this DTC.**

   NOTE: **The Cam Phaser slow response fault can take approximately 30 seconds to fail, where as the misalignment fault generally fails within 5-10 seconds.**

   1. What to monitor for during the test step:

- **The phaser not coming back to lock pin at idle.** This his could indicate a faulty phaser or oil control valve that is permanently stuck off lock pin or a Camshaft Position Solenoid that is electrically stuck on.
- **The actual position lagging or moving slowly toward the desired position.** This could indicate a faulty phaser or tarnished oil control valve that is dragging.
- **The actual position lagging and then overshooting the desired position** This could indicate a faulty phaser, oil control valve or Camshaft Position Solenoid that is intermittently sticking or binding and then overshoot when the condition goes away.

2. Start the engine and allow the engine to idle.
3. With the scan tool, monitor and compare the Exhaust Cam 2 **actual** position value with the Exhaust Cam 2 **desired** position value. After comparing the two values at idle, check and compare the values at several different engine speeds during the following steps.
4. While monitoring the Exhaust Cam 2 actual position and desired position values:
    - Raise the engine speed quickly and hold steady for up to 30 seconds.
    - Lower the engine speed and hold steady at a level above idle (off of lock pin) for up to 30 seconds.
5. Repeat the above steps multiple times and allow the engine to come back to idle while monitoring the actual position value to verify that the phaser is returning to lock pin position.

   Is the difference between the actual value and the desired value readings more than 10.0 degrees at idle or is the actual value lagging behind or overshooting the desired value?

   Yes, the difference is greater than 10.0 degrees at idle:

   - Go To 8

   Yes, the actual reading is lagging or overshooting when changing the engine speeds indicating a binding or sticking condition:

   - Go To 9

   No

   - Go To 12

8. **DETERMINE IF THE CAM PHASER ISSUE IS ELECTRICAL OR MECHANICAL**
    1. While the engine is at idle, disconnect the Camshaft 2/2 Position Solenoid harness connector.
    2. The Exhaust Cam 2 actual position value should change to lock pin with the solenoid disconnected. The Exhaust Cam position should be at approximately 123.0 degrees at lock pin.

       Did the Exhaust Cam 2 actual value change to lock pin position with the solenoid unplugged?

       Yes

       - Check the (K277) VVT Exhaust Control 2/2 circuit for a short to voltage. If the circuit is not shorted to voltage, replace the Powertrain Control Module in accordance with the service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 9
9. **CHECK THE CAMSHAFT 2/2 OIL CONTROL VALVE OPERATION**
    1. Turn the ignition off.

2. Remove the Camshaft 2/2 Position Solenoid.
3. Inspect the spring loaded spool valve on the Oil Control Valve.

NOTE: **The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.**

4. Push and release the spring loaded spool valve against the return spring with a small punch.

NOTE: **The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.**

Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

Yes

- Go To 10

No

- Replace the Camshaft 2/2 Oil Control Valve in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CHECK THE CAMSHAFT 2/2 POSITION SOLENOID OPERATION**
    1. Turn the ignition off.
    2. With the solenoid still removed, reconnect the Camshaft 2/2 Position Solenoid harness connector.
    3. Turn the ignition on.
    4. With the scan tool, actuate the Camshaft 2/2 Position Solenoid on and off several times.

    Does the Camshaft 2/2 Position Solenoid move freely without binding or sticking during actuation?

    Yes

    - Go To 11

    No

    - Replace the Camshaft 2/2 Position Solenoid in accordance with the Service Information.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **VERIFY THAT THE CAMSHAFT 2/2 POSITION SOLENOID IS ABLE TO MOVE THE PHASER**
    1. Exchange the Camshaft 2/2 Position Solenoid with the Camshaft 1/2 Position Solenoid.

    NOTE: **The Intake and Exhaust Solenoids should not be interchanged.**

    2. Reconnect the solenoid harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs in the PCM.

5. Test drive the vehicle under the conditions in which the fault was set.
6. With the scan tool, read DTCs.

   Did the DTC move with the solenoid or stay with the original Camshaft?

   Moved with the solenoid:

   - Replace the faulty Camshaft 2/2 Position Solenoid in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   Stayed with the original camshaft:

   - Go To 12

12. **INSPECT CAMSHAFT SENSOR TONE WHEEL FOR DAMAGE OR LOOSENESS**
    1. Turn the ignition off.
    2. Remove the Cylinder Head Cover and inspect the Camshaft Sensor Tone Wheel for any looseness or signs of damage.
    3. Using the (special tool #2027902090, Check Tool, Tone Wheel Right) check the alignment of the CMP Sensor Tone Wheel in accordance with the service information.

       Is the CMP Sensor Tone Wheel aligned correctly?

       Yes

       - Go To 13

       No

       - Replace the Exhaust Camshaft Assembly in accordance with the Service Information. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, Flywheel, Valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **CHECK THE ENGINE TIMING ALIGNMENT**
    1. Verify proper alignment of the Timing Chain and gears in accordance with the Service Information. Also check the Timing Chain Tensioner and Guide for faulty or broken components.

       Were any issue found with the timing alignment or components?

       Yes

       - Perform the appropriate repair in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, Flywheel, Valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

- Replace the Cam Phaser Assembly in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, Flywheel, Valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0019-CRANKSHAFT POSITION - CAMSHAFT POSITION CORRELATION BANK 2 SENSOR 2

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

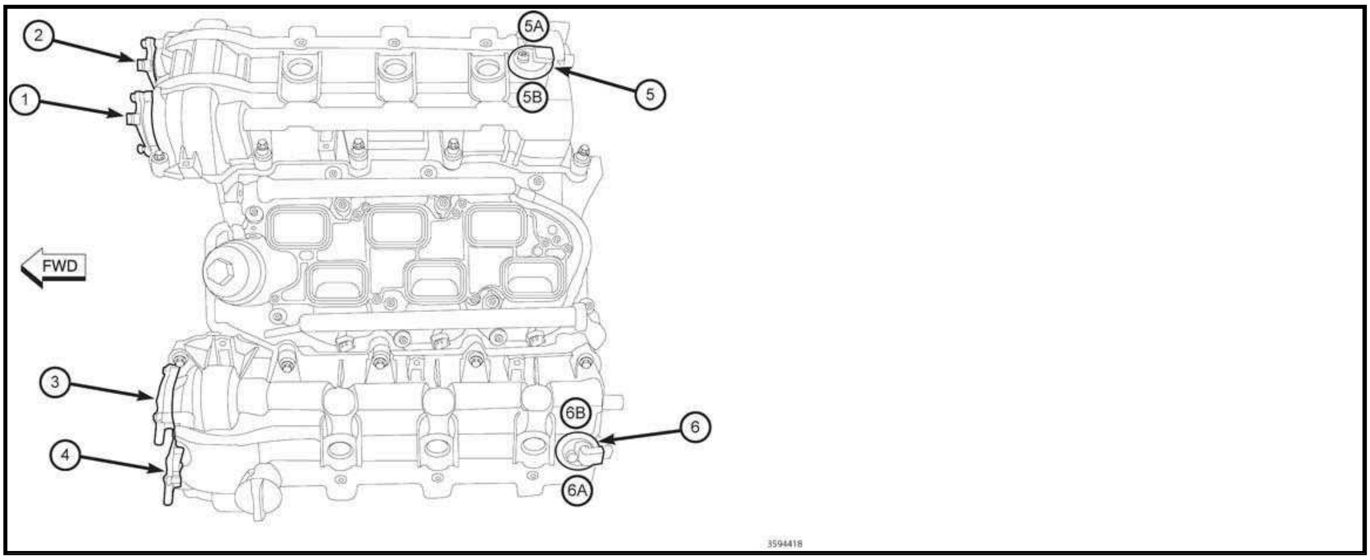
For proper engine control and combustion stability the Camshaft (CMP) and Crankshaft (CKP) positions must be aligned and known so that fuel injection and spark timing can be introduced at the intended Piston and Intake/Exhaust Valve positions. During vehicle manufacturing, at end of line, or if a Cam/Crank Relearn is performed, the system learns the difference between the Camshaft and Crankshaft position in terms of engine degrees and stores it in the EEPROM. During every following driving cycle, the Powertrain Control Module (PCM) uses this value to compare.

Within a driving cycle, once the CMP position and CKP position are known and verified they are considered "locked." This diagnostic will only run when both sensor signals are in the "locked" state. Engine position is constantly tracked as the CMP Sensor and CKP Sensor signals are monitored by the PCM. An engine rotating at a constant speed would produce engine signals that match the nominal pattern exactly. With engine acceleration and deceleration the engine signals are compressed or stretched in time relative to nominal timing. The PCM takes into account and adjusts for any acceleration/deceleration rates that are in effect.

The misalignment fault accounts for angular deviation between the CMP Sensor and CKP Sensor signals due to miss builds, chain stretch, or skipped tooth. This fault results from the difference between the positions as indicated by the CMP Sensor and CKP Sensor signals. The result is only valid if both positions are "locked".

NOTE: **A missing or erratic CMP or CKP signal cannot cause a Cam/Crank Misalignment fault to set. Replacing either sensor will not fix the vehicle.**

NOTE: **On occasion a small piece of debris or metal chip can get lodged in the OCV causing the spool valve to stick. The contamination can either dislodge on it's own or when the PCM is running a cleaning procedure on the OCV causing an intermittent fault condition for a Camshaft/Crankshaft Misalignment that is no longer present.**



NOTE: **There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and table below indicating the specific orientation of the DTCs to the Camshafts).**

3.2L/3.6L DTCs RELATED TO EACH CAMSHAFT					
CAMSHAFT LOCATIONS	**CALLOUT #**	**RELATED CAM SENSOR DTCS**	**PHASER/ACTUATOR DTCS**	**MISALIGNMENT DTCS**	**COLD START PERF DTCS**
Bank 1 Intake Camshaft	1	P0365, P0369	P000A, P0010	P0017	P052A, P052B
Bank 1 Exhaust Camshaft	2	P0340, P0344	P000B, P0013	P0016	P054A, P054B
Bank 2 Intake Camshaft	3	P0390, P0394	P000C, P0020	P0019	P052C, P052D
Bank 2 Exhaust Camshaft	4	P0345, P0349	P000D, P0023	P0018	P054C, P054D

WHEN MONITORED

This diagnostic runs continuously when the following condition is met:

- During engine cranking.
- Engine running in closed loop mode.

SET CONDITION

- The difference between the Bank 2 Intake Camshaft position and the Crankshaft position is more than 10.0 degrees.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
INCORRECT ENGINE OIL VISCOSITY OR OIL FILTER
CAM/CRANK LEARNED VALUES OUT OF TOLERANCE
ENGINE OIL AERATED OR CONTAMINATED
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
CAMSHAFT 2/1 OIL CONTROL VALVE FAULTY OR INTERMITTENTLY BINDING/STICKING SPOOL VALVE
CAMSHAFT TONE WHEEL MISALIGNED
CAMSHAFT 2/1 PHASER
TIMING SPROCKET ALIGNMENT
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE DTC**

NOTE: **Perform any Service Bulletins or Star Cases relating to this fault before continuing with this test procedure.**

NOTE: **Diagnose and repair any VVT Solenoid Circuit Open or Slow Response DTCs before continuing with this test.**

1. Turn the ignition on.
2. With the scan tool, read DTCs and record on the repair order.
3. Record the related Freeze Frame data.
4. With the scan tool, erase DTCs.
5. Start the engine and allow it to idle. It maybe necessary to tests drive the vehicle and allow cam phasing to occur in order to reset the fault.

   WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

6. With the scan tool, read DTCs.

   Is the DTC active or pending?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **VERIFY THE CAM/CRANK LEARNED VALUES ARE WITHIN TOLERANCE**
   1. With the scan tool, read the Cam/Crank Difference Learned values in the Data Display.

      NOTE: **When the Cam/Crank Learn is performed the Camshaft position is learned in High Lift and Low Lift modes on the Variable Valve Lift (VVL) equipped engines. The difference between the High Lift and Low Lift learned values should be less than 2B° for each Camshaft.**

      NOTE: **If the Cam/Crank Difference Learned values are not in the Data Display, go to 3.**

   Are the Intake Cam 2 High Lift and Low Lift learned values within 2B° of each other?

   Yes

   - Go To 3

   No

   - With the scan tool perform the **Cam/Crank Relearn** procedure and retest for DTC.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **ENGINE OIL/ENGINE MECHANICAL**

NOTE: **The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.**

- **ENGINE MECHANICAL TOLERANCES OUT OF SPECIFICATION**
- **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
- **LOW ENGINE OIL LEVEL**
- **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**
- **DETERIORATED OR DIRTY OIL**
- **CONTAMINATED ENGINE OIL**
- **INCORRECT ENGINE OIL VISCOSITY**
- **AERATED ENGINE OIL**

1. If any of the above conditions are found, repair as necessary.

   Were any of the above conditions present?

   Yes

   - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**
   1. Install the applicable adaptor to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
   2. Start the engine and allow it to idle.
   3. Monitor the engine oil pressure reading on the gauge or scan tool.

   NOTE: **If the oil pressure is below 14 psi or oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or Cam/Crank Misalignment DTC.**

   Is the oil pressure reading stable and above 14.0 psi?

   Yes

   - Go To 5

   No

   - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **VERIFY AN ACTIVE CONDITION BY CHECKING THE CAM PHASER POSITION**

NOTE: **If a Cam Phaser or Oil Control Valve is stuck, there may also be a Crankshaft/Camshaft Timing Misalignment and/or Multiple Cylinder Misfire DTC present.**

NOTE: **It may be necessary to drive the vehicle to allow the Cam Phaser to operate normally and then return to lock pin at idle. The purpose is to check for a phaser that may not be responding quick enough and causing this DTC.**

NOTE: **The Cam Phaser slow response fault can take approximately 30 seconds to fail, where as the misalignment fault generally fails within 5-10 seconds.**

1. What to monitor for during the test step:
    - **The phaser not coming back to lock pin at idle.** This his could indicate a faulty phaser or oil control valve that is permanently stuck off lock pin or a Camshaft Position Solenoid that is electrically stuck on.
    - **The actual position lagging or moving slowly toward the desired position.** This could indicate a faulty phaser or tarnished oil control valve that is dragging.
    - **The actual position lagging and then overshooting the desired position** This could indicate a faulty phaser, oil control valve or Camshaft Position Solenoid that is intermittently sticking or binding and then overshoot when the condition goes away.
2. Start the engine and allow the engine to idle.
3. With the scan tool, monitor and compare the Intake Cam 2 **actual** position value with the Intake Cam 2 **desired** position value. After comparing the two values at idle, check and compare the values at several different engine speeds during the following steps.
4. While monitoring the Intake Cam 2 actual position and desired position values:
    - Raise the engine speed quickly and hold steady for up to 30 seconds.
    - Lower the engine speed and hold steady at a level above idle (off of lock pin) for up to 30 seconds.
5. Repeat the above steps multiple times and allow the engine to come back to idle while monitoring the actual position value to verify that the phaser is returning to lock pin position.

    Is the difference between the actual value and the desired value readings more than 10.0 degrees at idle or is the actual value lagging behind or overshooting the desired value?

    Yes, the difference is greater than 10.0 degrees at idle:

    - Go To 6

    Yes, the actual reading is lagging or overshooting when changing the engine speeds indicating a binding or sticking condition:

    - Go To 7

    No

    - Go To 10

6. **DETERMINE IF THE CAM PHASER ISSUE IS ELECTRICAL OR MECHANICAL**
    1. While the engine is at idle, disconnect the Camshaft 2/1 Position Solenoid harness connector.
    2. The Intake Cam 2 actual position value should change to lock pin with the solenoid disconnected. The Intake Cam position should be at approximately 146.0 degrees at lock pin.

        Did the Intake Cam 2 actual value change to lock pin position with the solenoid unplugged?

        Yes

        - Check the (K78) VVT Intake Control 2/1 circuit for a short to voltage. If the circuit is not shorted to voltage, replace the Powertrain Control Module in accordance with the service information.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **CHECK THE CAMSHAFT 2/1 OIL CONTROL VALVE OPERATION**
    1. Turn the ignition off.
    2. Remove the Camshaft 2/1 Position Solenoid.
    3. Inspect the spring loaded spool valve on the Oil Control Valve.

    NOTE: **The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.**

    4. Push and release the spring loaded spool valve against the return spring with a small punch.

    NOTE: **The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.**

    Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

    Yes

    - Go To 8

    No

    - Replace the Camshaft 2/1 Oil Control Valve in accordance with the Service Information. . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
8. **CHECK THE CAMSHAFT 2/1 POSITION SOLENOID OPERATION**
    1. Turn the ignition off.
    2. With the solenoid still removed, reconnect the Camshaft 2/1 Position Solenoid harness connector.
    3. Turn the ignition on.
    4. With the scan tool, actuate the Camshaft 2/1 Position Solenoid on and off several times.

    Does the Camshaft 2/1 Position Solenoid move freely without binding or sticking during actuation?

    Yes

    - Go To 9

    No

    - Replace the Camshaft 2/1 Position Solenoid in accordance with the Service Information.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
9. **VERIFY THAT THE CAMSHAFT 2/1 POSITION SOLENOID IS ABLE TO MOVE THE PHASER**

1. Exchange the Camshaft 2/1 Position Solenoid with the Camshaft 1/1 Position Solenoid.

   NOTE: The Intake and Exhaust Solenoids should not be interchanged.

2. Reconnect the solenoid harness connectors.
3. Turn the ignition on.
4. With the scan tool, erase DTCs in the PCM.
5. Test drive the vehicle under the conditions in which the fault was set.
6. With the scan tool, read DTCs.

   Did the DTC move with the solenoid or stay with the original Camshaft?

   Moved with the solenoid:

   - Replace the faulty Camshaft 2/1 Position Solenoid in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   Stayed with the original camshaft:

   - Go To 10

10. **INSPECT CAMSHAFT SENSOR TONE WHEEL FOR DAMAGE OR LOOSENESS**
    1. Turn the ignition off.
    2. Remove the Cylinder Head Cover and inspect the Camshaft Sensor Tone Wheel for any looseness or signs of damage.
    3. Using the (special tool #2027902090, Check Tool, Tone Wheel Right) check the alignment of the CMP Sensor Tone Wheel in accordance with the service information.

       Is the CMP Sensor Tone Wheel aligned correctly?

       Yes

       - Go To 11

       No

       - Replace the Intake Camshaft Assembly in accordance with the Service Information. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, Flywheel, Valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **CHECK THE ENGINE TIMING ALIGNMENT**
    1. Verify proper alignment of the Timing Chain and gears in accordance with the Service Information. Also check the Timing Chain Tensioner and Guide for faulty or broken components.

       Were any issue found with the timing alignment or components?

       Yes

       - Perform the appropriate repair in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, Flywheel, Valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.

No

- Replace the Cam Phaser Assembly in accordance with the Service Information. Refer to PHASER, CAMSHAFT, REMOVAL AND INSTALLATION . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, Flywheel, Valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

P0020-BANK 2 CAMSHAFT 1 POSITION ACTUATOR CIRCUIT OPEN

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Variable Valve Timing (VVT) system continuously varies the Camshaft target position based on the engine operating parameters. Based on these parameters, the Powertrain Control Module (PCM) calculates or models the optimum Camshaft position. The Camshaft angular position is varied by the oil control valve. The VVT solenoid pushes on a plunger (spring loaded spool valve) in the center of the Oil Control Valve (OCV) which directs oil pressure to the hydraulic actuator (Phaser) on the Camshaft Sprocket to change the Camshaft position relative to the Crankshaft position. The VVT Solenoid, acting on the Oil Control Valve and Phaser, is controlled by the PCM. The Camshaft Position (CMP) Sensor is used to monitor the position of the Camshaft.

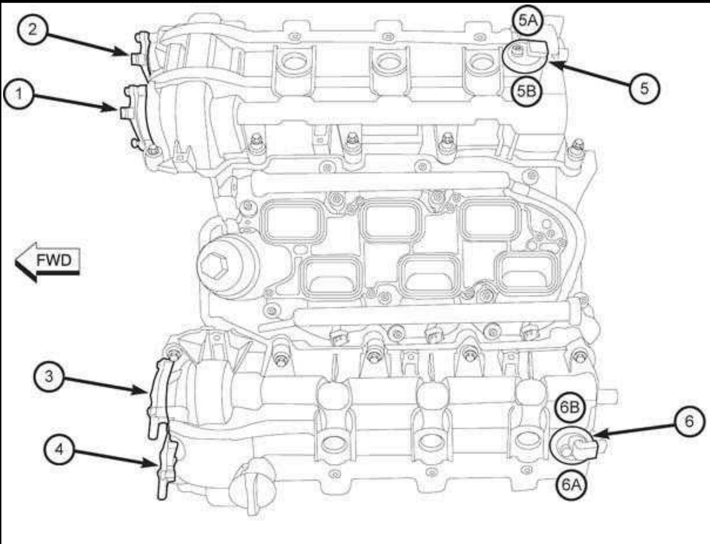
NOTE: **For the PCM to run this diagnostic the CMP Sensor and CKP Sensor signals must be locked with no sensor faults present. A missing or erratic CMP or CKP signal cannot cause a slow response fault to set. Replacing either sensor will not fix the vehicle.**

The PCM performs the typical diagnostic checks on the control circuits. During operation of the system the PCM also performs a **Target Error** and a **Slow Response** diagnostic check of the Camshaft phasing since these conditions could potentially increase tailpipe emissions. The diagnostic is primarily performed by comparing the actual Camshaft position to that of a calculated model for the Camshaft position. This diagnostic is continuous once the enable conditions are met. The Slow Response and Target Error conditions are not performed simultaneously.

- **The Target Error** diagnostic evaluates the actual Camshaft position versus the modeled position when the Camshaft is in a relatively stable position. The difference between the two is considered to be the amount of "error". If the error amount is greater than a calibrated threshold, it is considered failing.
- **The Slow Response** diagnostic is only performed when the modeled Camshaft position is moving (phasing) in a particular direction, advancing or retarding. The modeled Camshaft phasing position is created to match only the worst possible case of a passing Camshaft position. If the actual Camshaft phasing operates slower than the model by a calibrated threshold, it is considered failing.

If either of these diagnostics fail, the Camshaft Position Slow Response fault will set. **Any oil pressure issues, VVT Solenoid or Oil Pump Solenoid Control circuit faults should be diagnosed before diagnosing a Camshaft Position Slow Response fault.**

NOTE: **On occasion a small piece of debris or metal chip can get lodged in the OCV causing the spool valve to stick. The contamination can either dislodge on it's own or when the PCM is running a cleaning procedure on the OCV causing an intermittent fault condition for a Camshaft Position Slow Response that is no longer present.**



NOTE: **There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and table below indicating the specific orientation of the DTCs to the Camshafts).**

3.2L/3.6L DTCs RELATED TO EACH CAMSHAFT				
CAMSHAFT POSITION	**RELATED CAM SENSOR DTCS**	**PHASER/ACTUATOR DTCS**	**MISALIGNMENT DTCS**	**COLD START PERF DTCS**
(1) Bank 1 Intake Camshaft	P0365, P0369	P000A, P0010	P0017	P052A, P052B
(2) Bank 1 Exhaust Camshaft	P0340, P0344	P000B, P0013	P0016	P054A, P054B
(3) Bank 2 Intake Camshaft	P0390, P0394	P000C, P0020	P0019	P052C, P052D
(4) Bank 2 Exhaust Camshaft	P0345, P0349	P000D, P0023	P0018	P054C, P054D

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The PCM has detected a circuit failure on the VVT Intake Solenoid 2/1 Control circuitry.

DEFAULT ACTION

- The MIL will illuminate.
- The stop/start system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVT INTAKE SOLENOID 2/1 CONTROL CIRCUIT SHORTED TO GROUND
VVT INTAKE SOLENOID 2/1 CONTROL CIRCUIT SHORTED TO VOLTAGE

Possible Causes
VVT INTAKE SOLENOID 2/1 SOLENOID CONTROL CIRCUIT OPEN/HIGH RESISTANCE
VVT INTAKE SOLENOID 2/1 SOLENOID GROUND CIRCUIT OPEN/HIGH RESISTANCE
VVT INTAKE SOLENOID 2/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK THE VVT INTAKE SOLENOID 2/1 CONNECTOR AND TERMINALS**
    1. Turn the ignition off.
    2. Check the VVT Intake Solenoid 2/1 harness connector for proper connection at the VVT Intake Solenoid 2/1.
    3. Verify that the connector is completely plugged in and properly locked prior to disconnecting.

4. Disconnect the VVT Intake Solenoid 2/1 harness connector and check for any pushed out, damaged or spread terminals.

   Were any issues found with the connector or terminals?

   Yes

   - Repair the damaged terminal or properly connect and lock the VVT Intake Solenoid 2/1 harness connector and retest for DTCs.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **ISOLATE AND CHECK THE VVT INTAKE SOLENOID 2/1 (K78) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **ISOLATE AND CHECK THE VVT INTAKE SOLENOID 2/1 (K78) CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.

4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK THE (Z904) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
   1. Disconnect the component harness connector to isolate the ground circuit.
   2. Connect the positive lead of the load test tool to the positive side of the Battery.
   3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
   4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

NOTE: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .

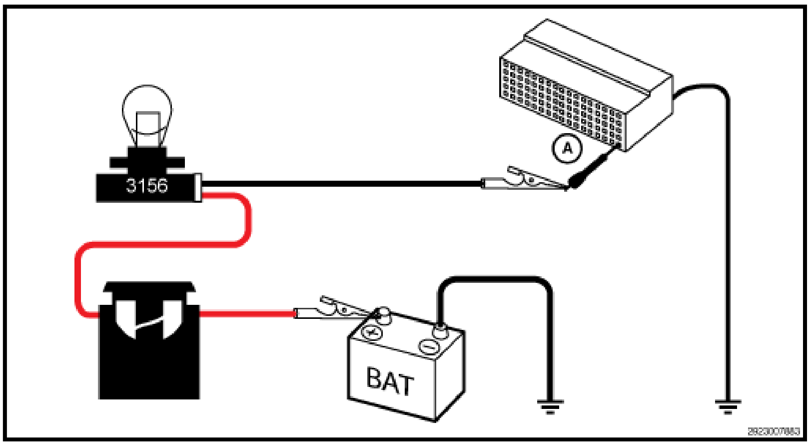
NOTE: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**

- 3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 7

   No

   - Repair the ground circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

7. **ISOLATE AND LOAD TEST THE VVT INTAKE SOLENOID 2/1 (K78) CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.

3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

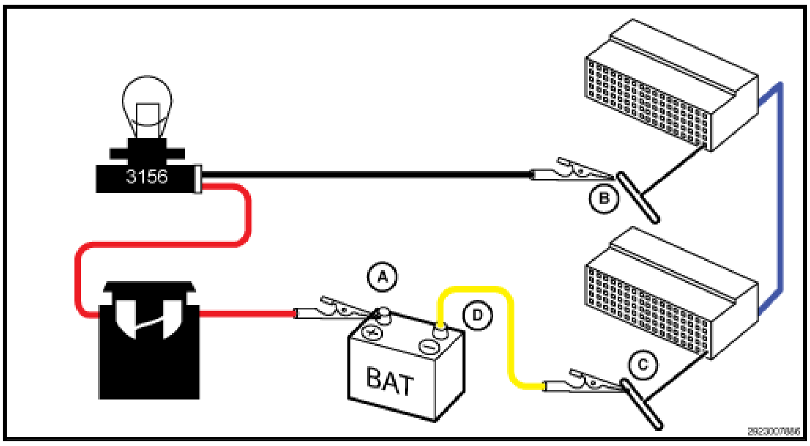
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to** **CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
- **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES .**



WARNING: **To avoid possible serious or fatal injury, DO NOT load test any air bag/restraint system components or circuits using the procedures listed here. Refer to the Service Information for proper air bag/restraint system testing procedures.**

CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 8

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. ACTUATE AND CHECK THE OPERATION OF THE VVT INTAKE SOLENOID 2/1 DRIVER
   1. Reconnect the PCM C2 harness connector.
   2. Turn the ignition on.
   3. Using a 12-volt test light connected to ground, probe the VVT Intake Solenoid 2/1 (K78) Control circuit in the VVT Intake Solenoid 2/1 harness connector.

NOTE: **The PCM will command the solenoid ON briefly after the ignition is turned on. This is a normal condition. The test light will illuminate briefly and then turn off and stay off if there is not a short to voltage.**

4. With the scan tool, actuate the VVT Intake Solenoid 2/1 Control to the highest duty cycle (80%) position.

   NOTE: **The test light should be illuminated and bright or illuminate with a steady pulse.**

   Is the test light illuminated and bright or illuminate with a steady pulse?

   Yes

   - Replace the VVT Intake Solenoid 2/1 in accordance with the Service Information. .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 9

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.
   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

   Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0023-BANK 2 CAMSHAFT 2 POSITION ACTUATOR CIRCUIT OPEN

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Variable Valve Timing (VVT) system continuously varies the Camshaft target position based on the engine operating parameters. Based on these parameters, the Powertrain Control Module (PCM) calculates or models the optimum Camshaft position. The Camshaft angular position is varied by the oil control valve. The VVT solenoid pushes on a plunger (spring loaded spool valve) in the center of the Oil Control Valve (OCV) which directs oil pressure to the hydraulic actuator (Phaser) on the Camshaft Sprocket to change the Camshaft position relative to the Crankshaft position. The VVT Solenoid, acting on the Oil Control Valve and Phaser, is controlled by the PCM. The Camshaft Position (CMP) Sensor is used to monitor the position of the Camshaft.

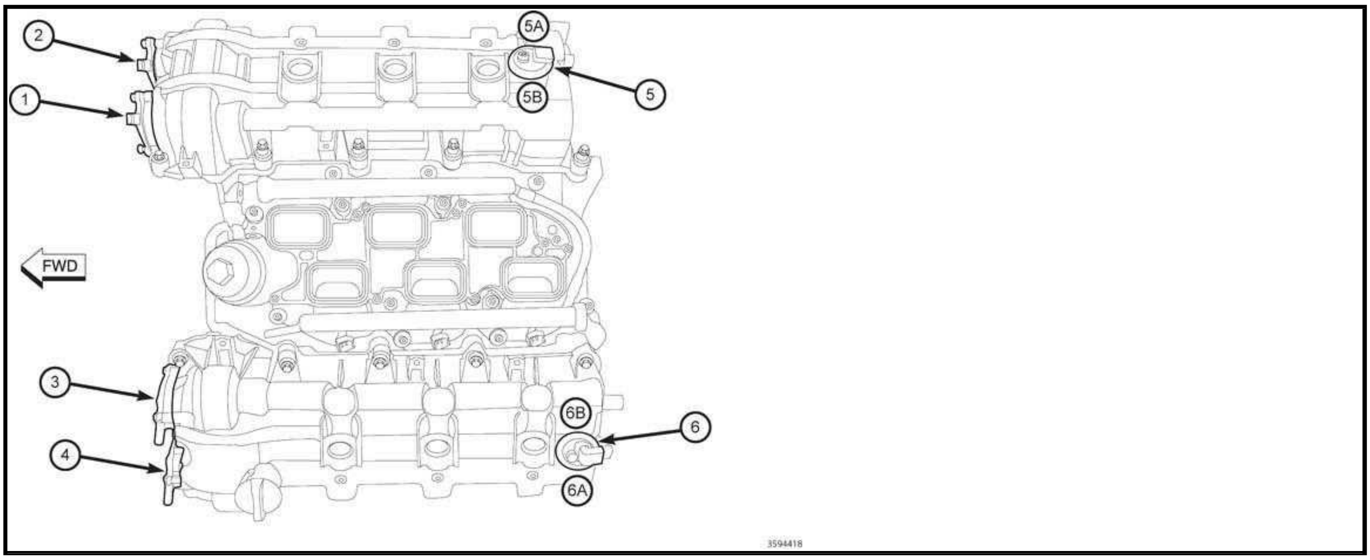
NOTE: **For the PCM to run this diagnostic the CMP Sensor and CKP Sensor signals must be locked with no sensor faults present. A missing or erratic CMP or CKP signal cannot cause a slow response fault to set. Replacing either sensor will not fix the vehicle.**

The PCM performs the typical diagnostic checks on the control circuits. During operation of the system the PCM also performs a **Target Error** and a **Slow Response** diagnostic check of the Camshaft phasing since these conditions could potentially increase tailpipe emissions. The diagnostic is primarily performed by comparing the actual Camshaft position to that of a calculated model for the Camshaft position. This diagnostic is continuous once the enable conditions are met. The Slow Response and Target Error conditions are not performed simultaneously.

- **The Target Error** diagnostic evaluates the actual Camshaft position versus the modeled position when the Camshaft is in a relatively stable position. The difference between the two is considered to be the amount of "error". If the error amount is greater than a calibrated threshold, it is considered failing.
- **The Slow Response** diagnostic is only performed when the modeled Camshaft position is moving (phasing) in a particular direction, advancing or retarding. The modeled Camshaft phasing position is created to match only the worst possible case of a passing Camshaft position. If the actual Camshaft phasing operates slower than the model by a calibrated threshold, it is considered failing.

If either of these diagnostics fail, the Camshaft Position Slow Response fault will set. **Any oil pressure issues, VVT Solenoid or Oil Pump Solenoid Control circuit faults should be diagnosed before diagnosing a Camshaft Position Slow Response fault.**

NOTE: **On occasion a small piece of debris or metal chip can get lodged in the OCV causing the spool valve to stick. The contamination can either dislodge on it's own or when the PCM is running a cleaning procedure on the OCV causing an intermittent fault condition for a Camshaft Position Slow Response that is no longer present.**



NOTE: **There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and table below indicating the specific orientation of the DTCs to the Camshafts).**

3.2L/3.6L DTCs RELATED TO EACH CAMSHAFT				
CAMSHAFT POSITION	RELATED CAM SENSOR DTCS	PHASER/ACTUATOR DTCS	MISALIGNMENT DTCS	COLD START PERF DTCS
(1) Bank 1 Intake Camshaft	P0365, P0369	P000A, P0010	P0017	P052A, P052B
(2) Bank 1 Exhaust Camshaft	P0340, P0344	P000B, P0013	P0016	P054A, P054B
(3) Bank 2 Intake Camshaft	P0390, P0394	P000C, P0020	P0019	P052C, P052D
(4) Bank 2 Exhaust Camshaft	P0345, P0349	P000D, P0023	P0018	P054C, P054D

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The PCM has detected a circuit failure on the VVT Exhaust Solenoid 2/2 Control circuitry.

DEFAULT ACTION

- The MIL will illuminate.
- The stop/start system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVT EXHAUST SOLENOID 2/2 CONTROL CIRCUIT SHORTED TO GROUND
VVT EXHAUST SOLENOID 2/2 CONTROL CIRCUIT SHORTED TO VOLTAGE

Possible Causes
VVT EXHAUST SOLENOID 2/2 CONTROL CIRCUIT OPEN/HIGH RESISTANCE
VVT EXHAUST SOLENOID 2/2 GROUND CIRCUIT OPEN/HIGH RESISTANCE
VVT EXHAUST SOLENOID 2/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK THE VVT EXHAUST SOLENOID 2/2 CONNECTOR AND TERMINALS**
    1. Turn the ignition off.
    2. Check the VVT Exhaust Solenoid 2/2 harness connector for proper connection at the VVT Exhaust Solenoid 2/2.
    3. Verify that the connector is completely plugged in and properly locked prior to disconnecting.

4. Disconnect the VVT Exhaust Solenoid 2/2 harness connector and check for any pushed out, damaged or spread terminals.

   Were any issues found with the connector or terminals?

   Yes

   - Repair the damaged terminal or properly connect and lock the VVT Exhaust Solenoid 2/2 harness connector and retest for DTCs.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **ISOLATE AND CHECK THE VVT EXHAUST SOLENOID 2/2 (K277) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

      NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **ISOLATE AND CHECK THE VVT EXHAUST SOLENOID 2/2 (K277) CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.

4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK THE (Z904) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
   1. Disconnect the component harness connector to isolate the ground circuit.
   2. Connect the positive lead of the load test tool to the positive side of the Battery.
   3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
   4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

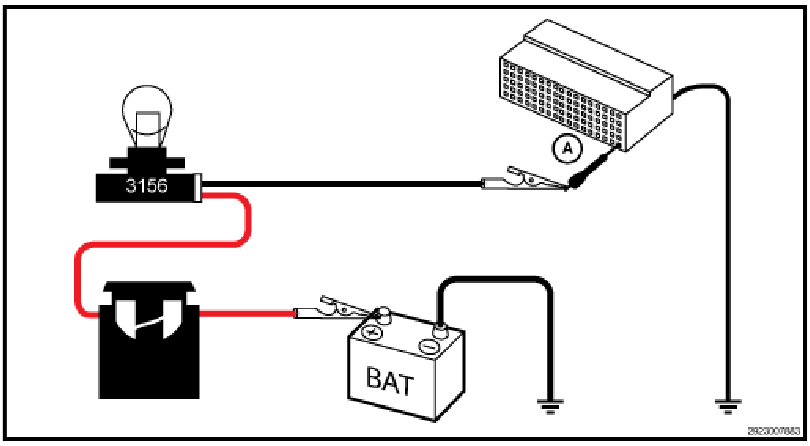
NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**

- 3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 7

   No

   - Repair the ground circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

7. **ISOLATE AND LOAD TEST THE VVT EXHAUST SOLENOID 2/2 (K277) CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.

3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

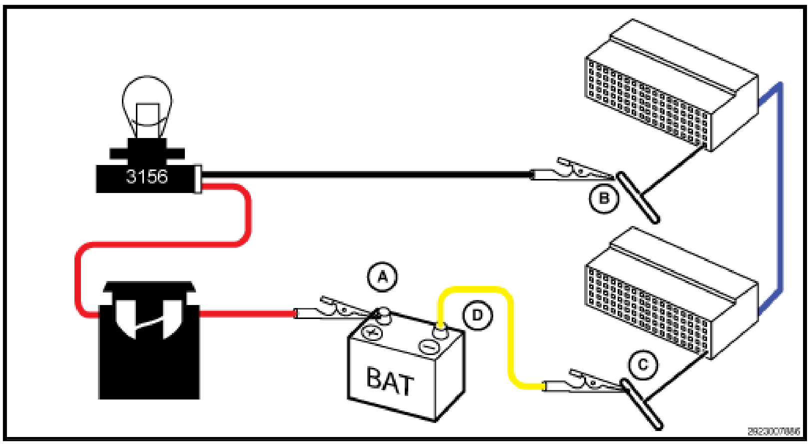
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
- **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



WARNING: **To avoid possible serious or fatal injury, DO NOT load test any air bag/restraint system components or circuits using the procedures listed here. Refer to the Service Information for proper air bag/restraint system testing procedures.**

CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 8

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **ACTUATE AND CHECK THE OPERATION OF THE VVT EXHAUST SOLENOID 2/2 DRIVER**
   1. Reconnect the PCM C2 harness connector.
   2. Turn the ignition on.
   3. Using a 12-volt test light connected to ground, probe the VVT Exhaust Solenoid 2/2 (K277) Control circuit in the VVT Exhaust Solenoid 2/2 harness connector.

NOTE: **The PCM will command the solenoid ON briefly after the ignition is turned on. This is a normal condition. The test light will illuminate briefly and then turn off and stay off if there is not a short to voltage.**

4. With the scan tool, actuate the VVT Exhaust Solenoid 2/2 Control to the highest duty cycle (80%) position.

   NOTE: **The test light should be illuminated and bright or illuminate with a steady pulse.**

   Is the test light illuminated and bright or illuminate with a steady pulse?

   Yes

   - Replace the VVT Exhaust Solenoid 2/2 in accordance with the Service Information. .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 9

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

   Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0031-O2 SENSOR 1/1 HEATER CIRCUIT LOW

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature**

Using the Scan Tool for Diagnostics:	
	will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to

Using the Scan Tool for Diagnostics:	
	ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

- Continuously with the O2 Sensor heater commanded on.
- Battery voltage between 10.5 and 15.75 volts.
- DTC P0032 is not active.

SET CONDITION

- The PCM detects that the O2 Sensor heater circuit resistance is below approximately 2.0 Ohms.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 1/1 HEATER CONTROL CIRCUIT SHORTED TO GROUND
O2 SENSOR 1/1 HEATER CONTROL CIRCUIT SHORTED TO THE O2 SENSOR GROUND CIRCUIT
OXYGEN (O2) SENSOR 1/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. With the scan tool, run a vehicle Scan Report or record the Environmental Data related to the DTCs.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the recorded Environmental Data and the When Monitored Conditions above, operate the vehicle in the conditions that set the DTC.

7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **ISOLATE AND CHECK THE O2 SENSOR 1/1 (K99) HEATER CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **ISOLATE AND CHECK THE O2 SENSOR 1/1 (K99) HEATER CONTROL CIRCUIT FOR A SHORT TO THE (Z910) GROUND CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.

3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE: **There should be no continuity between the circuits being tested.**

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **CHECK THE O2 SENSOR 1/1 (K99) HEATER CONTROL CIRCUIT**
   1. Reconnect the PCM harness connector.
   2. Turn the ignition on.
   3. With the scan tool, actuate the O2 Sensor 1/2 control to the maximum allowable percentage.
   4. Using a 12-volt test light connected to ground, probe the O2 Sensor 1/1 (K99) Heater Control circuit at the O2 Sensor 1/2 harness connector.

   NOTE: **The test light should be illuminated. The brightness will be dependant on the actuation percentage selected.**

   5. With the scan tool, actuate the O2 Sensor 1/2 control to the OFF (0%) position.

   NOTE: **The test light should not be illuminated.**

   Does the test light illuminate with the actuator ON and not illuminate with the actuator OFF?

   Yes

   - Replace the O2 Sensor 1/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5
5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.

2. Disconnect all PCM harness connectors.
3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0032-O2-SENSOR 1/1 HEATER CIRCUIT HIGH

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause

the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool.

NOTE:

When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance,

Using the Scan Tool for Diagnostics:	
	will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Continuously with the O2 Sensor heater commanded on.
- Battery voltage between 10.5 and 15.75 volts.
- DTC P0031 is not active.

SET CONDITION

- When the PCM detects that the O2 Sensor 1/1 Heater circuit resistance is above approximately 35.0 Ohms.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 1/1 HEATER CONTROL CIRCUIT SHORTED TO VOLTAGE
O2 SENSOR 1/1 HEATER CONTROL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
OXYGEN (O2) SENSOR 1/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. With the scan tool, run a vehicle Scan Report or record the Environmental Data related to the DTCs.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the recorded Environmental Data and the When Monitored Conditions above, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **CHECK THE (Z910) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Disconnect the component harness connector to isolate the ground circuit.
    2. Connect the positive lead of the load test tool to the positive side of the Battery.
    3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
    4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

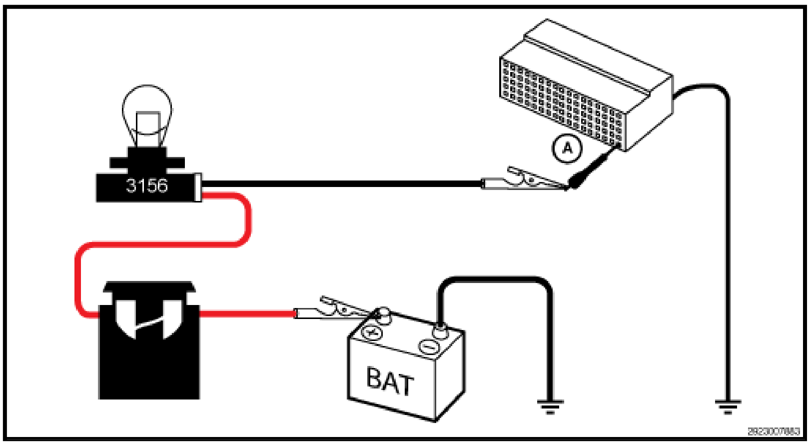
NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
- **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 4

   No

   - Repair the ground circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

4. **ISOLATE AND CHECK THE O2 SENSOR 1/1 (K99) HEATER CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
   4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

   Is there continuity between the circuit being tested and any other circuit?

   Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **ISOLATE AND CHECK THE O2 SENSOR 1/1 (K99) HEATER CONTROL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 6

    No

    - Repair the circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
6. **CHECK THE PCM HEATER CONTROL DRIVER FOR PROPER OPERATION**
    1. Turn the ignition off.
    2. Reconnect the PCM C2 harness connector.
    3. Turn the ignition on.
    4. Using a 12-volt test light connected to ground, probe the O2 Sensor 1/1 (K99) Heater Control circuit in the O2 Sensor 1/1 harness connector.
    5. With the scan tool, actuate the O2 Sensor 1/1 control to the maximum allowable percentage.

    NOTE: **The test light should be illuminated. The brightness will be dependant on the actuation percentage selected.**

6. With the scan tool, actuate the O2 Sensor 1/1 control to the OFF (0%) position.

   NOTE: The test light should not be illuminated.

   Does the test light illuminate with the actuator ON and not illuminated with the actuator OFF (0%)?

   Yes

   - Replace the O2 Sensor 1/1 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 7

7. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND**

INSTALLATION .

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0037-O2-SENSOR 1/2 HEATER CIRCUIT LOW

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool.**

Using the Scan Tool for Diagnostics:

	If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.

Using the Scan Tool for Diagnostics:	
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Battery voltage between 10.5 and 15.75 volts.
- The O2 Sensor Heater is commanded on.
- The O2 Sensor Heater circuit high fault is not active.

SET CONDITION

- The PCM detects that the O2 Sensor heater circuit resistance is below approximately 2.0 Ohms.

DEFAULT ACTION

- The MIL will illuminate.
- The PCM will disable the O2 Sensor Heater driver for the remainder of this ignition cycle.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 1/2 HEATER CONTROL CIRCUIT SHORTED TO GROUND
O2 SENSOR 1/2 HEATER CONTROL CIRCUIT SHORTED TO THE O2 SENSOR GROUND CIRCUIT
O2 SENSOR 1/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2

2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. With the scan tool, run a vehicle Scan Report or record the Environmental Data related to the DTCs.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the recorded Environmental Data and the When Monitored Conditions above, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **ISOLATE AND CHECK THE O2 SENSOR 1/2 (K299) HEATER CONTROL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

    NOTE: **There should be no continuity between ground and the circuit being tested.**

    Is there continuity between ground and the circuit being tested?

    Yes

    - Repair the O2 Sensor 1/2 (K299) Heater Control circuit for a short to chassis ground or the O2 Sensor (Z910) Ground circuit. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 4
4. **CHECK THE O2 SENSOR 1/2 (K299) HEATER CONTROL CIRCUIT OPERATION**
    1. Reconnect the PCM harness connector.
    2. Turn the ignition on.
    3. With the scan tool, actuate the O2 Sensor 1/2 control to the maximum allowable percentage.

4. Using a 12-volt test light connected to ground, probe the O2 Sensor 1/2 (K299) Heater Control circuit at the O2 Sensor 1/2 harness connector.

   NOTE: **The test light should be illuminated. The brightness will be dependant on the actuation percentage selected.**

5. With the scan tool, actuate the O2 Sensor 1/2 control to the OFF (0%) position.
6. Using a 12-volt test light connected to ground, probe the O2 Sensor 1/2 (K299) Heater Control circuit at the O2 Sensor 1/2 harness connector.

   NOTE: **The test light should not be illuminated.**

   Does the test light illuminate with the actuator ON and not illuminate with the actuator OFF?

   Yes

   - Replace the O2 Sensor 1/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.

11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0038-O2-SENSOR 1/2 HEATER CIRCUIT HIGH

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within

the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50**

	percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will

Using the Scan Tool for Diagnostics:	
(Return) Circuit Low Diagnosis:	switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Battery voltage between 10.5 and 15.75 volts.
- O2 Sensor Heater commanded on.
- The O2 Sensor Heater circuit low fault is not active.

SET CONDITION

- When the Powertrain Control Module (PCM) detects that the O2 Sensor 1/2 Heater circuit resistance is above approximately 35.0 Ohms.

DEFAULT ACTION

- The MIL will illuminate.
- The PCM will disable the O2 Sensor Heater driver for the remainder of this ignition cycle.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 1/2 HEATER CONTROL CIRCUIT SHORTED TO VOLTAGE
O2 SENSOR 1/2 HEATER CONTROL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
OXYGEN SENSOR 1/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

- Perform the applicable repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 2

2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 3

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK THE (Z910) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
   1. Disconnect the component harness connector to isolate the ground circuit.
   2. Connect the positive lead of the load test tool to the positive side of the Battery.
   3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
   4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

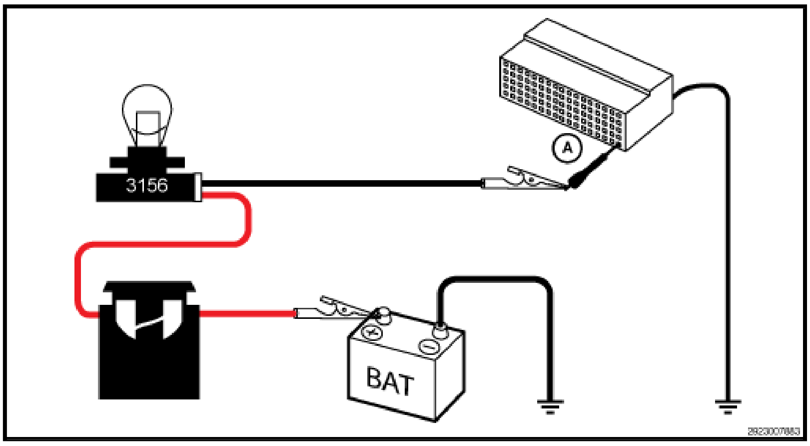
NOTE:	**Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**
NOTE:	**A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a**

circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 4

No

- Repair the ground circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE O2 SENSOR 1/2 (K299) HEATER CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

        NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

5. **ISOLATE AND LOAD TEST THE O2 SENSOR 1/2 (K299) HEATER CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
    3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
    4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at one of the component harness connectors (B).
    5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
    6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

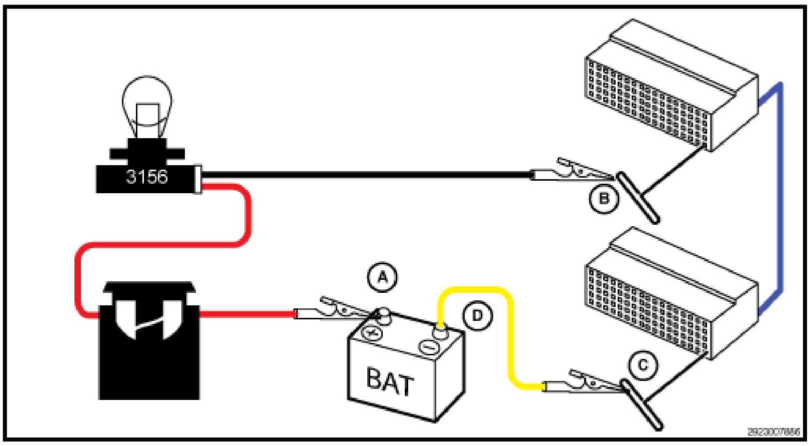
NOTE: Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .

NOTE: Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: Do not load test any circuits with components still connected to the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 6

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE O2 SENSOR 1/2 HEATER CONTROL DRIVER FOR PROPER OPERATION**
   1. Turn the ignition off.
   2. Connect the PCM C2 harness connector.
   3. Turn the ignition on.
   4. With the scan tool, actuate the O2 Sensor 1/2 control to the maximum allowable percentage.
   5. Using a 12-volt test light connected to ground, check the O2 Sensor 1/2 (K299) Heater Control circuit at the O2 Sensor 1/2 harness connector.

      NOTE: **The test light should be illuminated. The brightness will be dependant on the actuation percentage selected.**

   6. With the scan tool, actuate the O2 Sensor 1/2 control to the OFF (0%) position.

      NOTE: **The test light should not be illuminated.**

   Does the test light illuminate with the actuator ON and not illuminated with the actuator OFF (0%)?

   Yes

   - Replace the O2 Sensor 1/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 7

7. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.

2. Disconnect all PCM harness connectors.
3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0051-O2-SENSOR 2/1 HEATER CIRCUIT LOW

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause

the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool.

NOTE:

When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance,

Using the Scan Tool for Diagnostics:	
	will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

- Battery voltage between 10.5 and 15.75 volts.
- The O2 Sensor Heater is commanded on.
- The O2 Sensor Heater circuit high fault is not active.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the O2 Sensor heater circuit resistance is below approximately 2.0 Ohms.

DEFAULT ACTION

- The MIL will illuminate.
- The PCM will disable the O2 Sensor Heater driver for the remainder of this ignition cycle.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 2/1 HEATER CONTROL CIRCUIT SHORTED TO GROUND
O2 SENSOR 2/1 HEATER CONTROL CIRCUIT SHORTED TO THE O2 SENSOR GROUND CIRCUIT
O2 SENSOR 2/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To3

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **ISOLATE AND CHECK THE O2 SENSOR 2/1 (K199) HEATER CONTROL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the O2 Sensor 2/1 (K199) Heater Control circuit for a short to chassis ground or the O2 Sensor (Z910) Ground circuit. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **CHECK THE O2 SENSOR 2/1 HEATER CONTROL CIRCUIT**
    1. Turn the ignition off.
    2. Reconnect the PCM harness connector.
    3. Turn the ignition on.
    4. With the scan tool, actuate the O2 Sensor 2/1 control to the maximum allowable percentage.
    5. Using a 12-volt test light connected to ground, probe the O2 Sensor 2/1 (K199) Heater Control circuit at the O2 Sensor 2/1 harness connector.

    NOTE: **The test light should be illuminated. The brightness will be dependant on the actuation percentage selected.**

    6. With the scan tool, actuate the O2 Sensor 2/1 control to the OFF (0%) position.
    7. Using a 12-volt test light connected to ground, probe the O2 Sensor 2/1 (K199) Heater Control circuit at the O2 Sensor 2/1 harness connector.

    NOTE: **The test light should not be illuminated.**

    Does the test light illuminate with the actuator ON and not illuminate with the actuator OFF?

    Yes

    - Replace the O2 Sensor 2/1 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0052-O2-SENSOR 2/1 HEATER CIRCUIT HIGH

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any**

	issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

- Battery voltage between 10.5 and 15.75 volts.
- O2 Sensor Heater commanded on.
- The O2 Sensor Heater circuit low fault is not active.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the O2 Sensor 2/1 Heater circuit resistance is above approximately 35.0 Ohms.

DEFAULT ACTION

- The MIL will illuminate.
- The PCM will disable the O2 Sensor Heater driver for the remainder of this ignition cycle.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 2/1 HEATER CONTROL CIRCUIT SHORTED TO VOLTAGE
O2 SENSOR 2/1 HEATER CONTROL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 2/1 HEATER GROUND CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 2/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

        Are there any applicable Service Bulletins or Flash updates?

        Yes

        - Perform the applicable repair.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 3

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **CHECK THE (Z910) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
   1. Disconnect the component harness connector to isolate the ground circuit.
   2. Connect the positive lead of the load test tool to the positive side of the Battery.
   3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
   4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

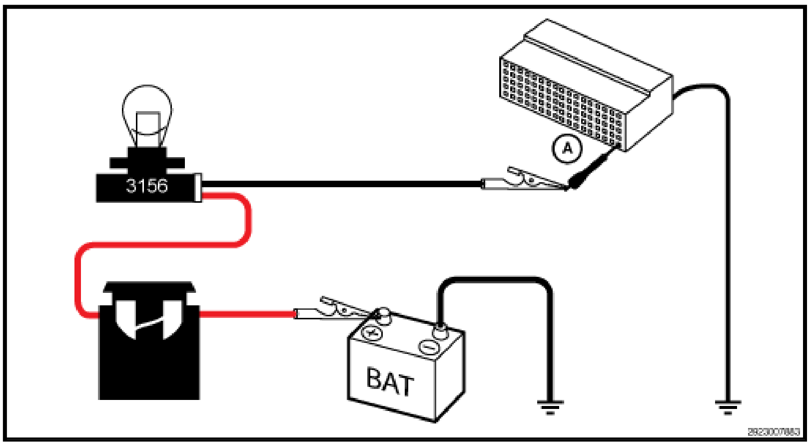
NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 4

No

- Repair the ground circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE O2 SENSOR 2/2 (K399) HEATER CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **ISOLATE AND LOAD TEST THE O2 SENSOR 2/2 (K399) HEATER CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
    3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
    4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at one of the component harness connectors (B).
    5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
    6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

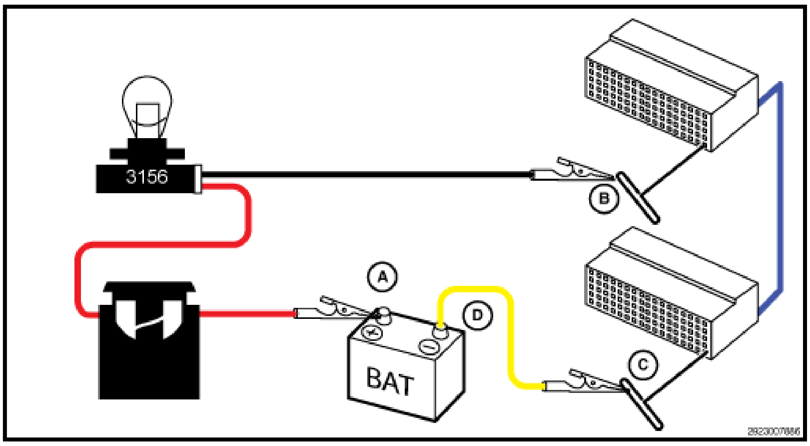
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**

2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 6

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE O2 SENSOR 2/2 HEATER CONTROL DRIVER FOR PROPER OPERATION**
    1. Turn the ignition off.
    2. Connect the PCM C2 harness connector.
    3. Turn the ignition on.
    4. With the scan tool, actuate the O2 Sensor 2/2 control to the maximum allowable percentage.
    5. Using a 12-volt test light connected to ground, check the O2 Sensor 2/2 (K399) Heater Control circuit at the O2 Sensor 2/2 harness connector.

        NOTE: **The test light should be illuminated. The brightness will be dependant on the actuation percentage selected.**

    6. With the scan tool, actuate the O2 Sensor 2/2 control to the OFF (0%) position.

        NOTE: **The test light should not be illuminated.**

        Does the test light illuminate with the actuator ON and not illuminated with the actuator OFF (0%)?

        Yes

        - Replace the O2 Sensor 2/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 7
7. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.

8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0057-O2 SENSOR 2/2 HEATER CIRCUIT LOW

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM.

Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.

- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool. NOTE: **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage**

	will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it

Using the Scan Tool for Diagnostics:	
	could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

- Battery voltage between 10.5 and 15.75 volts.
- The O2 Sensor Heater is commanded on.
- The O2 Sensor Heater circuit high fault is not active.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the O2 Sensor heater circuit resistance is below approximately 2.0 Ohms.

DEFAULT ACTION

- The MIL will illuminate.
- The PCM will disable the O2 Sensor Heater driver for the remainder of this ignition cycle.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 2/2 HEATER CONTROL CIRCUIT SHORTED TO GROUND
O2 SENSOR 2/2 HEATER CONTROL CIRCUIT SHORTED TO THE O2 SENSOR GROUND CIRCUIT
O2 SENSOR 2/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

Are there any applicable Service Bulletins or Flash updates?

Yes

- Perform the applicable repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 2

2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **ISOLATE AND CHECK THE O2 SENSOR 2/2 (K399) HEATER CONTROL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

    NOTE: **There should be no continuity between ground and the circuit being tested.**

    Is there continuity between ground and the circuit being tested?

    Yes

    - Repair the O2 Sensor 2/2 (K399) Heater Control circuit for a short to chassis ground or the O2 Sensor (Z910) Ground circuit.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **CHECK THE O2 SENSOR 2/2 HEATER CONTROL CIRCUIT**
    1. Turn the ignition off.
    2. Reconnect the PCM harness connector.
    3. Turn the ignition on.
    4. With the scan tool, actuate the O2 Sensor 2/2 control to the maximum allowable percentage.
    5. Using a 12-volt test light connected to ground, probe the O2 Sensor 2/2 (K399) Heater Control circuit at the O2 Sensor 2/2 harness connector.

       NOTE: **The test light should be illuminated. The brightness will be dependant on the actuation percentage selected.**

    6. With the scan tool, actuate the O2 Sensor 2/2 control to the OFF (0%) position.
    7. Using a 12-volt test light connected to ground, probe the O2 Sensor 2/2 (K399) Heater Control circuit at the O2 Sensor 2/2 harness connector.

       NOTE: **The test light should not be illuminated.**

    Does the test light illuminate with the actuator ON and not illuminate with the actuator OFF?

    Yes

    - Replace the O2 Sensor 2/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0058-O2-SENSOR 2/2 HEATER CIRCUIT HIGH

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to**

	operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor

Using the Scan Tool for Diagnostics:	
	return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Battery voltage between 10.5 and 15.75 volts.
- O2 Sensor Heater commanded on.
- The O2 Sensor Heater circuit low fault is not active.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the O2 Sensor 2/2 Heater circuit resistance is above approximately 35.0 Ohms.

DEFAULT ACTION

- The MIL will illuminate.
- The PCM will disable the O2 Sensor Heater driver for the remainder of this ignition cycle.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 2/2 HEATER CONTROL CIRCUIT SHORTED TO VOLTAGE
O2 SENSOR 2/2 HEATER CONTROL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 2/2 HEATER GROUND CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 2/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK THE (Z910) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Disconnect the component harness connector to isolate the ground circuit.
    2. Connect the positive lead of the load test tool to the positive side of the Battery.
    3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
    4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

NOTE:	**Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load**

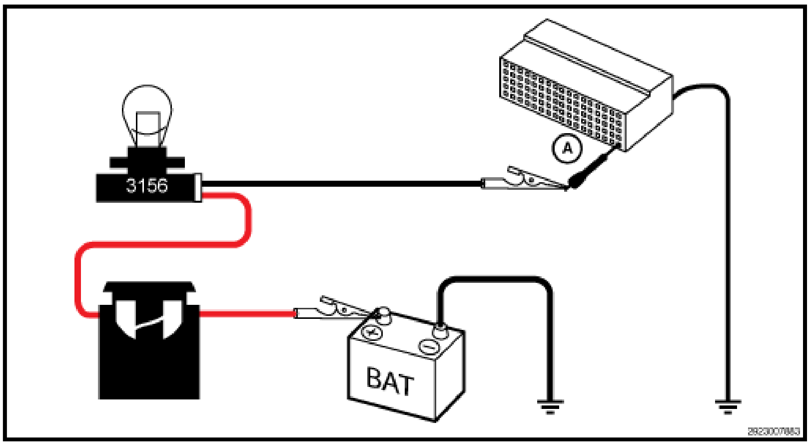
testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .

NOTE: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 4

No

- Repair the ground circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE O2 SENSOR 2/2 (K399) HEATER CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **ISOLATE AND LOAD TEST THE O2 SENSOR 2/2 (K399) HEATER CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
    3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.

4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at one of the component harness connectors (B).
5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

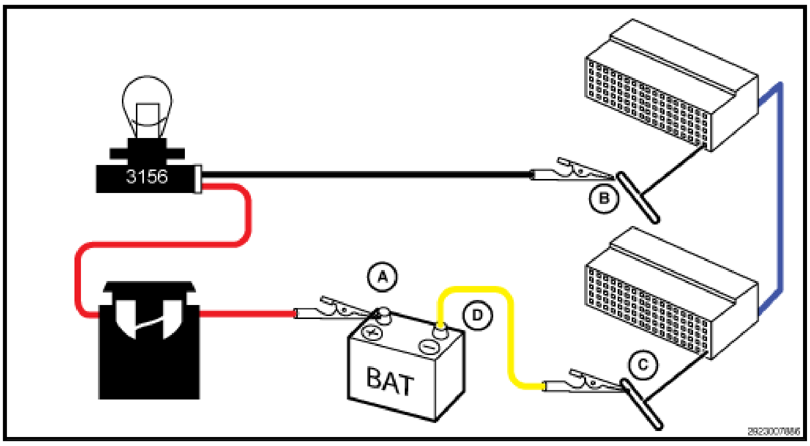
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 6

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE O2 SENSOR 2/2 HEATER CONTROL DRIVER FOR PROPER OPERATION**
   1. Turn the ignition off.
   2. Connect the PCM C2 harness connector.
   3. Turn the ignition on.
   4. With the scan tool, actuate the O2 Sensor 2/2 control to the maximum allowable percentage.
   5. Using a 12-volt test light connected to ground, check the O2 Sensor 2/2 (K399) Heater Control circuit at the O2 Sensor 2/2 harness connector.

   NOTE: **The test light should be illuminated. The brightness will be dependant on the actuation percentage selected.**

   6. With the scan tool, actuate the O2 Sensor 2/2 control to the OFF (0%) position.

   NOTE: **The test light should not be illuminated.**

Does the test light illuminate with the actuator ON and not illuminated with the actuator OFF (0%)?

Yes

- Replace the O2 Sensor 2/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0069-MANIFOLD PRESSURE/BAROMETRIC PRESSURE CORRELATION

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Ignition key is on.
- No Manifold Absolute Pressure Sensor (MAP) or Barometric Pressure Sensor (BARO) DTCs are present.
- Engine rollback protection is not active.

SET CONDITION

- Barometric pressure is greater than Manifold Absolute Pressure (plus a calibrated offset).

DEFAULT ACTION

- MIL will illuminate.
- ETC Lamp will illuminate.
- Engine speed is limited.
- Engine torque is limited.
- Transmission torque requests are disabled.

POSSIBLE CAUSES

Possible Causes
INTAKE OR EXHAUST SYSTEM RESTRICTION
MAP SENSOR
BAROMETRIC SENSOR INTERNAL TO THE POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any Crank Sensor, Cam Sensor, or sensor supply DTCs active or pending?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 3
3. **CHECK FOR INTAKE AND EXHAUST RESTRICTIONS**
    1. Check for an air intake system restriction and exhaust system restriction.

       Were any problems found?

       Yes

       - Repair the Intake or Exhaust System restriction.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 4
4. **CHECK FOR MAP AND BARO DTCS**
    1. Refer to the recorded DTCs.

       Are there any MAP sensor or BARO sensor DTCs active or pending?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 5
5. **CHECK THE MAP SENSOR OPERATION**
    1. Perform the CHECKING THE MAP SENSOR OPERATION procedure. Refer to the appropriate information.

       Were any problems found?

       Yes

       - Repair the MAP Sensor problem.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    5. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Repair the poor connections.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0071-AMBIENT AIR TEMPERATURE SENSOR PERFORMANCE

For a complete A/C CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

KNOWN VEHICLE ISSUES

Listed below are vehicles that have system issues that may cause an incorrect DTC to set which may lead to misdiagnosing the system.

1. **Heavy Duty Trucks** - Trucks that are equipped with a Drivers Door Module (DDM) may set the U110E-LOST AMBIENT TEMPERATURE MESSAGE fault when there is an open in the circuitry instead of the P0073-AAT SENSOR CIRCUIT HIGH fault. When diagnosing one of these vehicles with the U110E present, always diagnose the entire circuitry and sensor first.
2. **2018 - 2019 JL** - A short to ground in the AAT Sensor Signal will set the P0073-AAT SENSOR CIRCUIT HIGH DTC instead of the P0072-AAT SENSOR CIRCUIT LOW DTC.
3. **2019 KL** - May set the U110E-LOST AMBIENT TEMPERATURE MESSAGE fault when there is an open in the circuitry instead of the P0073-AAT SENSOR CIRCUIT HIGH fault. When diagnosing one of these vehicles with the U110E present, always diagnose the entire circuitry and sensor first.

DESCRIPTION AND OPERATION - AMBIENT AIR TEMP SENSOR

The AAT Sensor is typically located in the front of the vehicle near the grill. On some vehicles the AAT Sensor is located in the drivers side mirror housing. The sensor is normally hard-wired to the Body Control Module (BCM) or Totally Integrated Power Module (TIPM) depending on vehicle architecture. On vehicles that have the sensor mounted in the mirror, it may be hard-wired to the Drivers Door Module (DDM), if equipped. Refer to the wiring information for the specific vehicle being diagnosed to determine which module to test at. The analog AAT Sensor signal is converted to a digital signal and broadcast over the vehicle Bus. If hard-wired to the DDM, it is bussed to the BCM/TIPM. The BCM/TIPM broadcasts the AAT Sensor signal over the Can C Bus. The Powertrain Control Module (PCM) acquires the AAT Sensor signal from the Can C Bus.

NOTE: **While circuit high and low faults are monitored by both the PCM and BCM, only the PCM performs a rationality diagnostic of the AAT Sensor signal.**

The AAT Sensor rationality diagnostic runs on a cold start after a cold soak condition was present on the previous key off cycle. Following a start to run delay time, the PCM typically compares the signals from the AAT, Engine Coolant Temperature (ECT), and Intake Air Temperature (IAT) Sensors. If the ECT and IAT Sensors agree and the AAT Sensor does not agree, the AAT Sensor signal is declared as irrational. If declared irrational a second comparison will be done after a short drive cycle.

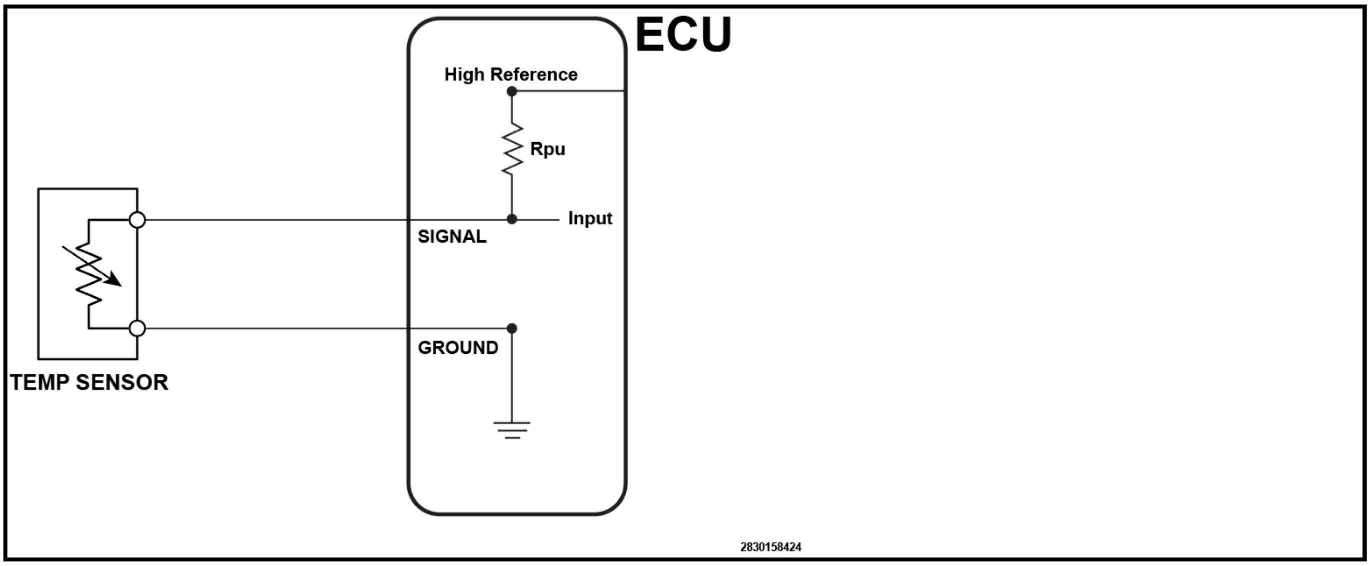
NOTE: **If a repair is performed to the AAT Sensor wiring, the sensor is replaced, or the BCM connector is disconnected during testing to correct an active DTC, the vehicle must be driven for a minimum of 5 minutes above 15 mph to update the AAT temp signal before the DTC will go stored and can be erased.**

COMPONENT FUNCTIONAL DESCRIPTION - TWO WIRE TEMP SENSOR

GENERAL OPERATION: Temperature sensors are typically a variable resistor that functions as a normal two wire, 5.0 volt sensor. An Electronic Control Unit (ECU) supplies the Temp Sensor with a 5.0 volt reference signal and a filtered ground (return) circuit. The pull up resistor (Rpu) inside the ECU is a fixed resistance. The resistance in the sensor will change in relation to temperature. The resistors are configured in a simple series circuit with the ECU internally monitoring the voltage on the signal circuit, which is converted into a digital temperature reading. As the resistance of the component increases, the voltage on the signal circuit will also increase. The increased voltage on the signal circuit can be interpreted by the ECU as the temperature increasing or decreasing depending on the temp sensor and ECU software design.

- **Circuit Fault Diagnostics:** On a normally functioning sensor with no circuit issues, the signal voltage should never read 5.0 volts or 0.0 volts. This allows the module the capability of diagnosing an open or short in the sensor or wiring. As a general rule, a voltage reading above approximately 4.9 volts would set a circuit high/open fault. A voltage below approximately 0.10 volts will set a circuit Low fault. Calibrated thresholds can vary slightly from module to module and vehicle to vehicle.

- **Performance Fault Diagnostics:** Since added resistance in the sensor or circuitry can cause an irrational reading and no circuit fault, the module will check the signal for a plausible reading in some cases. This can be done using different methods. One common way is by comparing the sensor reading to other temperature sensors. With this method the module will compare the sensors at a time when the readings should be within a calibrated threshold of each other (I.E. Ignition on after a cold soak). Another method could be to monitor for the temperature to increase or decrease when turning on or off a device that is being controlled by the ECU. In either case, an irrational reading can set a sensor performance fault.



ANALOG TO DIGITAL SIGNAL DESCRIPTION

Electronic Control Modules read analog signal voltages and convert them to digital counts. Each count is an equal percentage of the voltage. This can be seen when viewing the voltages of some sensors or switches on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts on most sensors to a battery voltage reference on switches.

- The resolution of the signal is determined by the required precision of the input by the ECU. Typically, sensor signals have a high resolution (Ex. a sensor signal may be divided into 4096 counts, or 5.0 volts divided by 4096). This allows the module to read small changes over a wide range in a variable resistance sensor signal used for a temperature, pressure, or position sensors.
- Switches will typically have a low resolution since they are usually only reporting a few switch states (Ex. a switch may typically be divided into only 15-20 counts, or Battery voltage divided by 15). The highest and lowest one or two counts will be used for detecting opens or shorts if the switch signal is being rationalized. The remaining counts are divided up between the states being detected.

TECHNICAL DATA - AMBIENT AIR TEMP SENSOR

Use the specification table below to check the Ambient Temperature Sensor. The values in the table show the approximate resistance values for the temperatures given. The actual resistance can vary +/- 10% form the values in the table. Typically, if the sensor is faulty the resistance value will be noticeably different from the specification in the table.

AMBIENT AIR TEMP SENSOR - TEMPERATURE TO RESISTANCE CHART			
Ambient Temp - Celsius	**Ambient Temp - Fahrenheit**	**Sensor Resistance**	**B**
-40B°C	-40B°F	345.26 kOhms	Lowest possible temperature reading
-10B°C	14B°F	53.38 kOhms	Logical temperature values
-5B°C	23B°F	40.89 kOhms	
0B°C	32B°F	31.56 kOhms	
5B°C	41B°F	24.55 kOhms	

AMBIENT AIR TEMP SENSOR - TEMPERATURE TO RESISTANCE CHART			
Ambient Temp - Celsius	**Ambient Temp - Fahrenheit**	**Sensor Resistance**	**B**
10B°C	50B°F	19.24 kOhms	
15B°C	59B°F	15.22 kOhms	
20B°C	68B°F	12.13 kOhms	
25B°C	77B°F	9720 Ohms	
30B°C	86B°F	7780 Ohms	
35B°C	95B°F	6370 Ohms	
40B°C	104B°F	5200 Ohms	
150B°C	302B°F	181 Ohms	Highest possible temperature reading

ENABLING CONDITIONS AND POSSIBLE CAUSES - AMBIENT AIR TEMP SENSOR

MONITORING CONDITIONS
Circuit Low/High Faults - With the ignition on, battery voltage above a calibrated threshold. **Performance Fault** - With the ignition on after an eight hour cold soak on the previous engine off cycle. Ambient Air, Intake Air, and Engine Coolant Temperature values are above -64B°C (-83B°F).

FAULT SETTING CRITERIA
Circuit Low Fault - The sensor signal voltage is below a calibrated threshold. The threshold is typically in the 0.1 volt range. **Circuit High Fault** - The sensor signal voltage is above a calibrated threshold. The threshold is typically in the 4.9 volt range. **Performance Fault** - The sensor signal voltage is irrational - typically not within 10B°C - 15B°C (18B°F - 27B°F) of the other engine temp sensors.

POSSIBLE CAUSES
TEMP SENSOR HARNESS CONNECTOR DAMAGED OR NOT CONNECTED COMPLETELY (CIRCUIT HIGH/PERFORMANCE FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT (CIRCUIT LOW FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH FAULT)
TEMP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH/PERFORMANCE FAULT)
TEMP SENSOR RETURN CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH/PERFORMANCE FAULT)
FAULTY TEMP SENSOR (OPEN, SHORTED OR DRIFTED OUT OF RANGE)
FAULTY ELECTRONIC CONTROL UNIT (ECU)

DIAGNOSTIC OVERVIEW

TEMP SENSOR ECU DIAGNOSTICS:

- **Circuit Fault Diagnostics:** With a normally functioning sensor that has no circuit issues, the signal voltage should never read 5.0 volts or 0.0 volts. This allows the module the capability of diagnosing an open or short in the sensor or wiring. As a general rule, a voltage reading above approximately 4.9 volts will typically set a circuit high/open fault. A voltage below approximately 0.10 volts will typically set a circuit Low fault. Calibrated thresholds can vary slightly from module to module and vehicle to vehicle.
- **Performance Fault Diagnostics:** Added resistance in the sensor or circuitry can cause an irrational reading and no circuit fault. The module will check the signal for a plausible reading in most cases. This can be done using different methods. One common way is by comparing the sensor reading to other

temperature sensors. With this method the module will compare the sensors at a time when the readings should be within a calibrated threshold of each other (Ex. Ignition on after a cold soak). Another method could be to monitor for the temperature to increase or decrease when turning on or off a device that is being controlled by the ECU. In either case, an irrational reading can set a sensor performance fault.

PRELIMINARY DIAGNOSTIC CHECKS

1. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the ECU. Low Battery voltage can cause a DTC.
3. Circuit faults should typically be diagnosed before rationality/performance faults.
4. Check the component harness connector(s) for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the component harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connections issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. Use the wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

Intermittent testing for a circuit low/high fault with the Mopar Scope:

1. Back probe and connect the scope lead to the temp sensor signal circuit.
2. Monitor the circuit voltage while wiggle testing the wiring harness.

3. If you are not able to monitor the scope signal voltage during wiggle testing, set up a trigger to catch an intermittent condition. Set the trigger for voltage above 4.9 volts for an intermittent circuit high fault or below 0.1 volts for a circuit low fault.

DIAGNOSTIC TEST - TWO WIRE TEMP SENSOR

NOTE: **If a repair is performed to the AAT Sensor wiring, the sensor is replaced, or the BCM connector is disconnected during testing to correct an active DTC, the vehicle must be driven for a minimum of 5 minutes above 15 mph to update the AAT temp signal before the DTC will go stored and can be erased.**

NOTE: **The AAT Sensor is an individually serviceable component. If the measured resistance from the AAT Sensor does not meet the values from the Technical Data information, then only the sensor should be replaced and not the entire mirror assembly.**

NOTE: **There are multiple test methods listed below. The first two tests are a complete system diagnostic of the wiring and sensor. The remaining tests are broken up by the failure modes. There can be advantages to using each method. All of the methods do not need to be performed. Pick the best test method based on accessibility, ease of testing, availability of test equipment. It is a good practice to perform a complete check of the wiring in case of calibration issues. Failure to perform a complete check of the wiring may lead to unnecessary replacement of the component or ECU. In some cases it may be beneficial to use parts of each method to test for different failure modes.**

COMPLETE CIRCUIT DIAGNOSTICS USING THE ELECTRICAL TEST LEAD KIT:

1. Check the ECU, signal and sensor ground circuits together to determine if the temp sensor is faulty. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the temp signal and sensor ground circuits at the temp sensor harness connector. Move the switch on the Electrical Test Lead Kit between the open and closed positions while monitoring the scan tool. If monitoring for faults, the circuit high fault should set when switched to the open position and the circuit low fault should set when switched to the closed position. If the sensor voltage is available on the scan tool, monitor the voltage readings. The voltage should be 5.0 volts when switched to the open position and 0.0 volts when switched to the closed position. Move the switch to adjust and use the tool to vary the resistance while monitoring the ECU signal voltage on the scan tool. **Pick the result from a, b, or c below that best matches the results.**

1. **If the faults set as described and the signal voltage is 5.0 volts and 0.0 volts** - the ECU and temp sensor circuits are testing good. The temp sensor is most likely faulty or has a poor connection at the harness connector. Check the temp sensor harness connector for pushed out, spread, corroded or dirty terminals before condemning the sensor. The internal resistance of the sensor can be measured and compared to the table (if available) to verify a faulty sensor.
2. **If the signal voltage is stuck low or only the circuit low fault sets** - the most likely cause is the temp sensor signal circuit shorted to chassis ground or the temp sensor ground circuit. Check the temp sensor signal circuit for a short to ground, or to the temp sensor ground circuit. If the signal circuit is not shorted, use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals before condemning an ECU. If no issues are found, the ECU is most likely faulty.
3. **If the signal voltage is stuck high or only the circuit high fault sets** - the most likely cause is an open or very high resistance in the temp sensor signal or temp sensor ground circuit. **Continue to step d.**
4. **If the signal reading on the scan tool shows voltage present when switched to closed** - remove the test lead from the sensor ground circuit and connect it to a good chassis ground while observing the voltage on the scan tool. If the voltage drops to 0.0 volts the resistance is in the temp sensor ground circuit. If the voltage is still present the resistance is in the temp sensor signal circuit. Check the appropriate circuit for high resistance. Typically, it should be less than 3.0 Ohms. If the circuits check good, **continue to step e.**
5. **If the circuits are checked and do not have excessive resistance** - use the wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the ECU. If no issues are found, replace the ECU in accordance with the service information.

COMPLETE CIRCUIT DIAGNOSTICS USING CONVENTIONAL VOLTAGE TESTING WITH A DVOM:

1. Verify the temp sensor and ECU harness connectors are connected and locked properly.
2. Turn the ignition on. Back probe and measure the voltage on the temp sensor signal circuit at the Fuel Pump harness connector. Pick the result below that best matches the voltage reading.
   1. **If the signal voltage is reading between 0.1 and 4.9 volts** - the temp sensor signal is most likely giving a legitimate reading. If the circuit fault is active and the voltage reading on the scan tool does not match the DVOM voltage reading, the ECU is likely faulty.
   2. **If the signal measures a constant 0.0 volts** - this indicates that the temp sensor signal circuit is shorted to ground or has an open between the ECU and temp sensor. If the circuit high fault is set, the most likely failure is an open in the temp sensor signal circuit. If the circuit low fault is set, the most likely failure is a short to ground in the temp sensor signal circuit or possibly a faulty sensor (disconnecting the temp sensor harness connector and checking for the circuit high fault to become active would indicate that the temp sensor is most likely faulty). **Continue to step 3.**
   3. **If the signal reading has a constant voltage above 6.0 volts** - this would indicate that the signal circuit is shorted to another voltage supply.
   4. **If the signal reading has a constant 5.0 volts** - this indicates an open further downstream in the circuitry. Most likely the temp sensor or the temp sensor ground circuit. **Continue to step 4.**
3. Disconnect the temp sensor and ECU harness connectors and check the temp sensor signal circuit for high resistance and short to ground. If the signal circuit checks good, check all connectors in the system for pushed out, spread, corroded or dirty terminals before condemning a ECU. If all of the connectors check good, replace the ECU in accordance with the service information.
4. To check the temp sensor, move the test lead over and back probe the temp sensor ground circuit at the temp sensor harness connector.

TYPICAL CIRCUIT LOW DIAGNOSTICS:

1. To quickly eliminate the temp sensor as a possible cause with an **active** circuit low fault, disconnect the temp sensor harness connector while monitoring for the circuit high fault to become active on the scan

tool.

1. If the circuit high fault becomes active when the sensor is disconnected, the temp sensor is most likely faulty.
2. If the circuit high fault does not become active, **continue to step 2.**

2. Disconnect the ECU harness connector to isolate the circuit. Check the temp signal circuit for continuity to both chassis ground and the sensor ground circuit.
   1. If there is continuity to either, repair the signal circuit for a short to ground or the sensor ground circuit.
   2. If the signal circuit is not shorted, replace the ECU in accordance with the service information.

TYPICAL CIRCUIT HIGH DIAGNOSTICS:

1. Disconnect the temp sensor harness connector and measure the temp sensor signal circuit voltage with the ignition on. The signal circuit voltage should be between 4.9 and 5.6 volts.
   1. If battery voltage is present, repair the sensor signal circuit for a short to another voltage supply circuit.
   2. If the voltage is correct, **continue to step 2.** .
2. With an active fault, monitor the scan tool and connect a jumper across the terminals with the ignition on. Typically, the temp sensor signal voltage should change to 0 volts on the scan tool with the jumper in place. If the voltage data read is not available, check for the circuit low fault to set with the jumper in place. If either result occurs, the temp sensor is faulty.
   1. If either result occurs, the temp sensor is faulty.
   2. If the voltage does not change to 0 volts or the circuit low fault is not present with the jumper in place, **continue to step 3.** .
3. Check the resistance of the temp sensor signal circuit and temp sensor ground circuit. Typically the circuit resistance should be less than 5.0 Ohms.
   1. If there is an open or high resistance in either circuit, repair the circuit.
   2. If the temp sensor signal and ground circuits test good, and the voltage is still reading high or only the circuit high fault is present, use the wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning ECU. If no issues are found, replace the ECU in accordance with the service information.

TYPICAL PERFORMANCE/RATIONALITY DIAGNOSTICS:

NOTE: **Temp sensor performance faults typically set due to resistance in one of the circuits or a sensor that is stuck or drifted out of range. The (special tool #2064100080, Kit, Electrical Test Lead) can be used with the scan tool to test the wiring and controller.**

1. Disconnect the temp sensor harness connector and connect the Electrical Test Kit leads to the temp sensor harness connector.
2. Move the switch on the tool to open. The signal should read 5.0 volts and a circuit high DTC should be active or pending on the scan tool.
3. Next flip the switch to the closed position. The signal should read 0 volts and a circuit low fault should be active or pending on the scan tool. If the scan tool reads as described in steps 2 and 3, it would indicate the wiring and ECU are good and the sensor is likely faulty. If there is voltage present between 0 and 5.0 volts with the test tool in the closed position it would indicate there is likely resistance in one of the circuits. **Continue to step a.**
   1. To determine which circuit has resistance, remove the test lead connected to the temp sensor ground circuit and connect it to a good chassis ground.
      - If the signal changes to 0 volts it would indicate the temp sensor ground has resistance. **Continue to step b.**

- If there is still voltage present it would indicate the temp sensor signal has resistance. **Continue to step b.**

2. Confirm the suspect circuit issue by isolating the suspect circuit and measuring the resistance of the circuit between the sensor and ECU harness connectors. If no resistance is measured, carefully check all connectors in the path of the circuit for spread or dirty/corroded terminals. If the circuits check good (no resistance), verify whether the issue is with the temp sensor or ECU. **Continue to step 4 or 5.**

4. **If a temp table is available** , the sensor and ECU can be verified in one of the following ways.
    1. Move the switch to adjust and connect an Ohmmeter to the test leads and dial the tool to a resistance value in the table. Connect both leads to the temp sensor harness connector with the ignition on and monitor the data in the scan tool for the proper reading. Use the tool to vary the resistance while monitoring the temp sensor signal temperature/voltage on the scan tool. If the reading matches the table, the temp sensor is likely faulty.
    2. If the temp sensor actual temperature can be acquired or reasonably estimated, measure the resistance across the terminals of the temp sensor and compare to the value in the table. If the resistance of the sensor is not in range of the table, the temp sensor is likely faulty.
5. **If a temp table is not available** for the sensor being tested, connect the Electrical Test Kit leads to the harness connector and flip the switch to adjust. With the ignition on, monitor the scan tool data and slowly adjust the resistance in the circuit. The temperature/voltage value should change with the resistance change. If the value changes as the resistance is varied it would indicate that the temp sensor is likely faulty.

VERIFYING AN ECU FAILURE: An ECU that is faulty and not able to properly read the signal can usually be determined when opening and shorting the circuits and monitoring the signal voltage and fault codes. If the expected voltage reads or DTCs do not occur when opening and jumping the connector, and the circuits are not shorted or open, it would indicate a faulty ECU. Before condemning and ECU, **always** carefully check all connectors in the path of the circuit for water intrusion, spread, pushed out, burnt or corroded terminals.

P0072-AMBIENT AIR TEMPERATURE SENSOR CIRCUIT LOW

For a complete A/C CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

KNOWN VEHICLE ISSUES

Listed below are vehicles that have system issues that may cause an incorrect DTC to set which may lead to misdiagnosing the system.

1. **Heavy Duty Trucks** - Trucks that are equipped with a Drivers Door Module (DDM) may set the U110E-LOST AMBIENT TEMPERATURE MESSAGE fault when there is an open in the circuitry instead of the P0073-AAT SENSOR CIRCUIT HIGH fault. When diagnosing one of these vehicles with the U110E present, always diagnose the entire circuitry and sensor first.
2. **2018 - 2019 JL** - A short to ground in the AAT Sensor Signal will set the P0073-AAT SENSOR CIRCUIT HIGH DTC instead of the P0072-AAT SENSOR CIRCUIT LOW DTC.
3. **2019 KL** - May set the U110E-LOST AMBIENT TEMPERATURE MESSAGE fault when there is an open in the circuitry instead of the P0073-AAT SENSOR CIRCUIT HIGH fault. When diagnosing one of these vehicles with the U110E present, always diagnose the entire circuitry and sensor first.

DESCRIPTION AND OPERATION - AMBIENT AIR TEMP SENSOR

The AAT Sensor is typically located in the front of the vehicle near the grill. On some vehicles the AAT Sensor is located in the drivers side mirror housing. The sensor is normally hard-wired to the Body Control Module (BCM) or Totally Integrated Power Module (TIPM) depending on vehicle architecture. On vehicles that have the sensor mounted in the mirror, it may be hard-wired to the Drivers Door Module (DDM), if equipped. Refer to the wiring information for the specific vehicle being diagnosed to determine which module to test at. The analog AAT Sensor signal is converted to a digital signal and broadcast over the vehicle Bus. If hard-wired to the DDM, it is bussed to the BCM/TIPM. The BCM/TIPM broadcasts the AAT Sensor signal over the Can C Bus. The Powertrain Control Module (PCM) acquires the AAT Sensor signal from the Can C Bus.

NOTE: **While circuit high and low faults are monitored by both the PCM and BCM, only the PCM performs a rationality diagnostic of the AAT Sensor signal.**

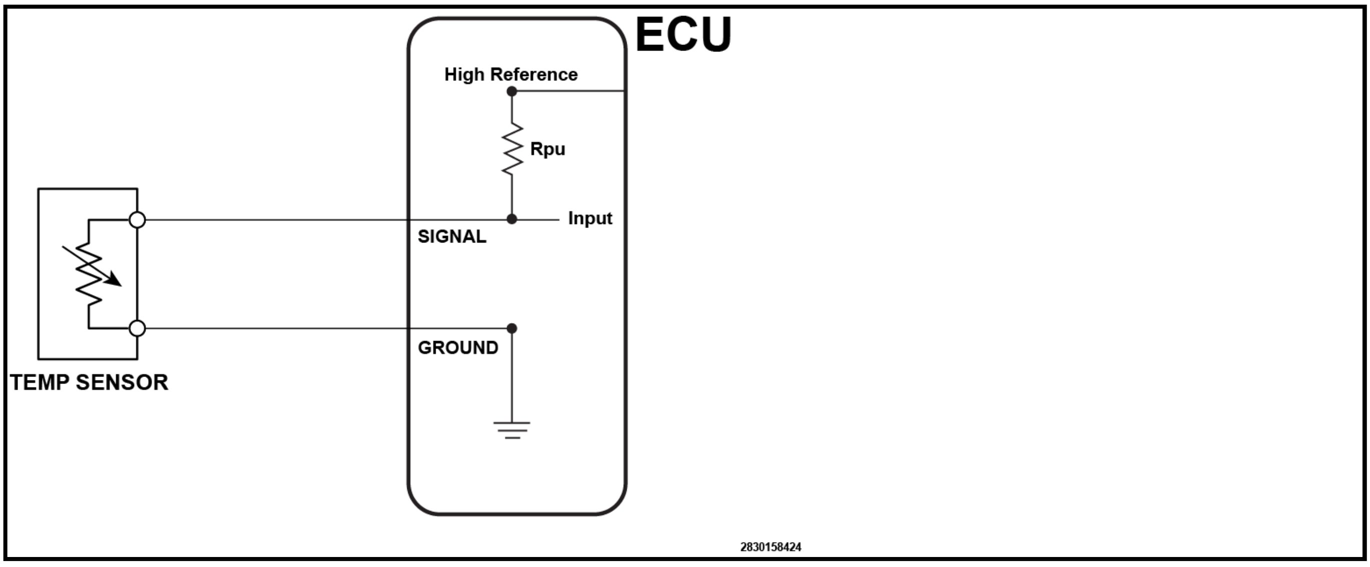
The AAT Sensor rationality diagnostic runs on a cold start after a cold soak condition was present on the previous key off cycle. Following a start to run delay time, the PCM typically compares the signals from the AAT, Engine Coolant Temperature (ECT), and Intake Air Temperature (IAT) Sensors. If the ECT and IAT Sensors agree and the AAT Sensor does not agree, the AAT Sensor signal is declared as irrational. If declared irrational a second comparison will be done after a short drive cycle.

NOTE: **If a repair is performed to the AAT Sensor wiring, the sensor is replaced, or the BCM connector is disconnected during testing to correct an active DTC, the vehicle must be driven for a minimum of 5 minutes above 15 mph to update the AAT temp signal before the DTC will go stored and can be erased.**

COMPONENT FUNCTIONAL DESCRIPTION - TWO WIRE TEMP SENSOR

GENERAL OPERATION: Temperature sensors are typically a variable resistor that functions as a normal two wire, 5.0 volt sensor. An Electronic Control Unit (ECU) supplies the Temp Sensor with a 5.0 volt reference signal and a filtered ground (return) circuit. The pull up resistor (Rpu) inside the ECU is a fixed resistance. The resistance in the sensor will change in relation to temperature. The resistors are configured in a simple series circuit with the ECU internally monitoring the voltage on the signal circuit, which is converted into a digital temperature reading. As the resistance of the component increases, the voltage on the signal circuit will also increase. The increased voltage on the signal circuit can be interpreted by the ECU as the temperature increasing or decreasing depending on the temp sensor and ECU software design.

- **Circuit Fault Diagnostics:** On a normally functioning sensor with no circuit issues, the signal voltage should never read 5.0 volts or 0.0 volts. This allows the module the capability of diagnosing an open or short in the sensor or wiring. As a general rule, a voltage reading above approximately 4.9 volts would set a circuit high/open fault. A voltage below approximately 0.10 volts will set a circuit Low fault. Calibrated thresholds can vary slightly from module to module and vehicle to vehicle.
- **Performance Fault Diagnostics:** Since added resistance in the sensor or circuitry can cause an irrational reading and no circuit fault, the module will check the signal for a plausible reading in some cases. This can be done using different methods. One common way is by comparing the sensor reading to other temperature sensors. With this method the module will compare the sensors at a time when the readings should be within a calibrated threshold of each other (I.E. Ignition on after a cold soak). Another method could be to monitor for the temperature to increase or decrease when turning on or off a device that is being controlled by the ECU. In either case, an irrational reading can set a sensor performance fault.



ANALOG TO DIGITAL SIGNAL DESCRIPTION

Electronic Control Modules read analog signal voltages and convert them to digital counts. Each count is an equal percentage of the voltage. This can be seen when viewing the voltages of some sensors or switches on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts on most sensors to a battery voltage reference on switches.

- The resolution of the signal is determined by the required precision of the input by the ECU. Typically, sensor signals have a high resolution (Ex. a sensor signal may be divided into 4096 counts, or 5.0 volts divided by 4096). This allows the module to read small changes over a wide range in a variable resistance sensor signal used for a temperature, pressure, or position sensors.
- Switches will typically have a low resolution since they are usually only reporting a few switch states (Ex. a switch may typically be divided into only 15-20 counts, or Battery voltage divided by 15). The highest and lowest one or two counts will be used for detecting opens or shorts if the switch signal is being rationalized. The remaining counts are divided up between the states being detected.

TECHNICAL DATA - AMBIENT AIR TEMP SENSOR

Use the specification table below to check the Ambient Temperature Sensor. The values in the table show the approximate resistance values for the temperatures given. The actual resistance can vary +/- 10% form the values in the table. Typically, if the sensor is faulty the resistance value will be noticeably different from the specification in the table.

AMBIENT AIR TEMP SENSOR - TEMPERATURE TO RESISTANCE CHART			
Ambient Temp - Celsius	**Ambient Temp - Fahrenheit**	**Sensor Resistance**	**B**
-40B°C	-40B°F	345.26 kOhms	Lowest possible temperature reading
-10B°C	14B°F	53.38 kOhms	Logical temperature values
-5B°C	23B°F	40.89 kOhms	
0B°C	32B°F	31.56 kOhms	
5B°C	41B°F	24.55 kOhms	
10B°C	50B°F	19.24 kOhms	
15B°C	59B°F	15.22 kOhms	
20B°C	68B°F	12.13 kOhms	
25B°C	77B°F	9720 Ohms	
30B°C	86B°F	7780 Ohms	
35B°C	95B°F	6370 Ohms	
40B°C	104B°F	5200 Ohms	
150B°C	302B°F	181 Ohms	Highest possible temperature reading

ENABLING CONDITIONS AND POSSIBLE CAUSES - AMBIENT AIR TEMP SENSOR

MONITORING CONDITIONS
Circuit Low/High Faults - With the ignition on, battery voltage above a calibrated threshold. **Performance Fault** - With the ignition on after an eight hour cold soak on the previous engine off cycle. Ambient Air, Intake Air, and Engine Coolant Temperature values are above -64B°C (-83B°F).

FAULT SETTING CRITERIA
Circuit Low Fault - The sensor signal voltage is below a calibrated threshold. The threshold is typically in the 0.1 volt range. **Circuit High Fault** - The sensor signal voltage is above a calibrated threshold. The threshold is typically in the 4.9 volt range. **Performance Fault** - The sensor signal voltage is irrational - typically not within 10B°C - 15B°C (18B°F - 27B°F) of the other engine temp sensors.

POSSIBLE CAUSES
TEMP SENSOR HARNESS CONNECTOR DAMAGED OR NOT CONNECTED COMPLETELY (CIRCUIT HIGH/PERFORMANCE FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT (CIRCUIT LOW FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH FAULT)
TEMP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH/PERFORMANCE FAULT)
TEMP SENSOR RETURN CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH/PERFORMANCE FAULT)
FAULTY TEMP SENSOR (OPEN, SHORTED OR DRIFTED OUT OF RANGE)
FAULTY ELECTRONIC CONTROL UNIT (ECU)

DIAGNOSTIC OVERVIEW

TEMP SENSOR ECU DIAGNOSTICS:

- **Circuit Fault Diagnostics:** With a normally functioning sensor that has no circuit issues, the signal voltage should never read 5.0 volts or 0.0 volts. This allows the module the capability of diagnosing an open or short in the sensor or wiring. As a general rule, a voltage reading above approximately 4.9 volts will typically set a circuit high/open fault. A voltage below approximately 0.10 volts will typically set a circuit Low fault. Calibrated thresholds can vary slightly from module to module and vehicle to vehicle.
- **Performance Fault Diagnostics:** Added resistance in the sensor or circuitry can cause an irrational reading and no circuit fault. The module will check the signal for a plausible reading in most cases. This can be done using different methods. One common way is by comparing the sensor reading to other temperature sensors. With this method the module will compare the sensors at a time when the readings should be within a calibrated threshold of each other (Ex. Ignition on after a cold soak). Another method could be to monitor for the temperature to increase or decrease when turning on or off a device that is being controlled by the ECU. In either case, an irrational reading can set a sensor performance fault.

PRELIMINARY DIAGNOSTIC CHECKS

1. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the ECU. Low Battery voltage can cause a DTC.
3. Circuit faults should typically be diagnosed before rationality/performance faults.
4. Check the component harness connector(s) for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the component harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not

be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.

2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connections issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. Use the wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

Intermittent testing for a circuit low/high fault with the Mopar Scope:

1. Back probe and connect the scope lead to the temp sensor signal circuit.
2. Monitor the circuit voltage while wiggle testing the wiring harness.
3. If you are not able to monitor the scope signal voltage during wiggle testing, set up a trigger to catch an intermittent condition. Set the trigger for voltage above 4.9 volts for an intermittent circuit high fault or below 0.1 volts for a circuit low fault.

DIAGNOSTIC TEST - TWO WIRE TEMP SENSOR

NOTE: **If a repair is performed to the AAT Sensor wiring, the sensor is replaced, or the BCM connector is disconnected during testing to correct an active DTC, the vehicle must be driven for a minimum of 5 minutes above 15 mph to update the AAT temp signal before the DTC will go stored and can be erased.**

NOTE: **The AAT Sensor is an individually serviceable component. If the measured resistance from the AAT Sensor does not meet the values from the Technical Data information, then only the sensor should be replaced and not the entire mirror assembly.**

NOTE: **There are multiple test methods listed below. The first two tests are a complete system diagnostic of the wiring and sensor. The remaining tests are broken up by the failure modes. There can be advantages to using each method. All of the methods do not need to be performed. Pick the best test method based on accessibility, ease of testing, availability of test equipment. It is a good practice to perform a complete check of the wiring in case of calibration issues. Failure to perform a complete check of the wiring may lead to unnecessary replacement of the component or ECU. In some cases it may be beneficial to use parts of each method to test for different failure modes.**

COMPLETE CIRCUIT DIAGNOSTICS USING THE ELECTRICAL TEST LEAD KIT:

1. Check the ECU, signal and sensor ground circuits together to determine if the temp sensor is faulty. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the temp signal and sensor ground

circuits at the temp sensor harness connector. Move the switch on the Electrical Test Lead Kit between the open and closed positions while monitoring the scan tool. If monitoring for faults, the circuit high fault should set when switched to the open position and the circuit low fault should set when switched to the closed position. If the sensor voltage is available on the scan tool, monitor the voltage readings. The voltage should be 5.0 volts when switched to the open position and 0.0 volts when switched to the closed position. Move the switch to adjust and use the tool to vary the resistance while monitoring the ECU signal voltage on the scan tool. **Pick the result from a, b, or c below that best matches the results.**

1. **If the faults set as described and the signal voltage is 5.0 volts and 0.0 volts** - the ECU and temp sensor circuits are testing good. The temp sensor is most likely faulty or has a poor connection at the harness connector. Check the temp sensor harness connector for pushed out, spread, corroded or dirty terminals before condemning the sensor. The internal resistance of the sensor can be measured and compared to the table (if available) to verify a faulty sensor.
2. **If the signal voltage is stuck low or only the circuit low fault sets** - the most likely cause is the temp sensor signal circuit shorted to chassis ground or the temp sensor ground circuit. Check the temp sensor signal circuit for a short to ground, or to the temp sensor ground circuit. If the signal circuit is not shorted, use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals before condemning an ECU. If no issues are found, the ECU is most likely faulty.
3. **If the signal voltage is stuck high or only the circuit high fault sets** - the most likely cause is an open or very high resistance in the temp sensor signal or temp sensor ground circuit. **Continue to step d.**
4. **If the signal reading on the scan tool shows voltage present when switched to closed** - remove the test lead from the sensor ground circuit and connect it to a good chassis ground while observing the voltage on the scan tool. If the voltage drops to 0.0 volts the resistance is in the temp sensor ground circuit. If the voltage is still present the resistance is in the temp sensor signal circuit. Check the appropriate circuit for high resistance. Typically, it should be less than 3.0 Ohms. If the circuits check good, **continue to step e.**
5. **If the circuits are checked and do not have excessive resistance** - use the wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the ECU. If no issues are found, replace the ECU in accordance with the service information.

COMPLETE CIRCUIT DIAGNOSTICS USING CONVENTIONAL VOLTAGE TESTING WITH A DVOM:

1. Verify the temp sensor and ECU harness connectors are connected and locked properly.

2. Turn the ignition on. Back probe and measure the voltage on the temp sensor signal circuit at the Fuel Pump harness connector. Pick the result below that best matches the voltage reading.
    1. **If the signal voltage is reading between 0.1 and 4.9 volts** - the temp sensor signal is most likely giving a legitimate reading. If the circuit fault is active and the voltage reading on the scan tool does not match the DVOM voltage reading, the ECU is likely faulty.
    2. **If the signal measures a constant 0.0 volts** - this indicates that the temp sensor signal circuit is shorted to ground or has an open between the ECU and temp sensor. If the circuit high fault is set, the most likely failure is an open in the temp sensor signal circuit. If the circuit low fault is set, the most likely failure is a short to ground in the temp sensor signal circuit or possibly a faulty sensor (disconnecting the temp sensor harness connector and checking for the circuit high fault to become active would indicate that the temp sensor is most likely faulty). **Continue to step 3.**
    3. **If the signal reading has a constant voltage above 6.0 volts** - this would indicate that the signal circuit is shorted to another voltage supply.
    4. **If the signal reading has a constant 5.0 volts** - this indicates an open further downstream in the circuitry. Most likely the temp sensor or the temp sensor ground circuit. **Continue to step 4.**
3. Disconnect the temp sensor and ECU harness connectors and check the temp sensor signal circuit for high resistance and short to ground. If the signal circuit checks good, check all connectors in the system for pushed out, spread, corroded or dirty terminals before condemning a ECU. If all of the connectors check good, replace the ECU in accordance with the service information.
4. To check the temp sensor, move the test lead over and back probe the temp sensor ground circuit at the temp sensor harness connector.

TYPICAL CIRCUIT LOW DIAGNOSTICS:

1. To quickly eliminate the temp sensor as a possible cause with an **active** circuit low fault, disconnect the temp sensor harness connector while monitoring for the circuit high fault to become active on the scan tool.
    1. If the circuit high fault becomes active when the sensor is disconnected, the temp sensor is most likely faulty.
    2. If the circuit high fault does not become active, **continue to step 2.**
2. Disconnect the ECU harness connector to isolate the circuit. Check the temp signal circuit for continuity to both chassis ground and the sensor ground circuit.
    1. If there is continuity to either, repair the signal circuit for a short to ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, replace the ECU in accordance with the service information.

TYPICAL CIRCUIT HIGH DIAGNOSTICS:

1. Disconnect the temp sensor harness connector and measure the temp sensor signal circuit voltage with the ignition on. The signal circuit voltage should be between 4.9 and 5.6 volts.
    1. If battery voltage is present, repair the sensor signal circuit for a short to another voltage supply circuit.
    2. If the voltage is correct, **continue to step 2.** .
2. With an active fault, monitor the scan tool and connect a jumper across the terminals with the ignition on. Typically, the temp sensor signal voltage should change to 0 volts on the scan tool with the jumper in place. If the voltage data read is not available, check for the circuit low fault to set with the jumper in place. If either result occurs, the temp sensor is faulty.
    1. If either result occurs, the temp sensor is faulty.
    2. If the voltage does not change to 0 volts or the circuit low fault is not present with the jumper in place, **continue to step 3.** .
3. Check the resistance of the temp sensor signal circuit and temp sensor ground circuit. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the circuit.

2. If the temp sensor signal and ground circuits test good, and the voltage is still reading high or only the circuit high fault is present, use the wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning ECU. If no issues are found, replace the ECU in accordance with the service information.

TYPICAL PERFORMANCE/RATIONALITY DIAGNOSTICS:

NOTE: Temp sensor performance faults typically set due to resistance in one of the circuits or a sensor that is stuck or drifted out of range. The (special tool #2064100080, Kit, Electrical Test Lead) can be used with the scan tool to test the wiring and controller.

1. Disconnect the temp sensor harness connector and connect the Electrical Test Kit leads to the temp sensor harness connector.
2. Move the switch on the tool to open. The signal should read 5.0 volts and a circuit high DTC should be active or pending on the scan tool.
3. Next flip the switch to the closed position. The signal should read 0 volts and a circuit low fault should be active or pending on the scan tool. If the scan tool reads as described in steps 2 and 3, it would indicate the wiring and ECU are good and the sensor is likely faulty. If there is voltage present between 0 and 5.0 volts with the test tool in the closed position it would indicate there is likely resistance in one of the circuits. **Continue to step a.**
    1. To determine which circuit has resistance, remove the test lead connected to the temp sensor ground circuit and connect it to a good chassis ground.
        - If the signal changes to 0 volts it would indicate the temp sensor ground has resistance. **Continue to step b.**
        - If there is still voltage present it would indicate the temp sensor signal has resistance. **Continue to step b.**
    2. Confirm the suspect circuit issue by isolating the suspect circuit and measuring the resistance of the circuit between the sensor and ECU harness connectors. If no resistance is measured, carefully check all connectors in the path of the circuit for spread or dirty/corroded terminals. If the circuits check good (no resistance), verify whether the issue is with the temp sensor or ECU. **Continue to step 4 or 5.**
4. **If a temp table is available** , the sensor and ECU can be verified in one of the following ways.
    1. Move the switch to adjust and connect an Ohmmeter to the test leads and dial the tool to a resistance value in the table. Connect both leads to the temp sensor harness connector with the ignition on and monitor the data in the scan tool for the proper reading. Use the tool to vary the resistance while monitoring the temp sensor signal temperature/voltage on the scan tool. If the reading matches the table, the temp sensor is likely faulty.
    2. If the temp sensor actual temperature can be acquired or reasonably estimated, measure the resistance across the terminals of the temp sensor and compare to the value in the table. If the resistance of the sensor is not in range of the table, the temp sensor is likely faulty.
5. **If a temp table is not available** for the sensor being tested, connect the Electrical Test Kit leads to the harness connector and flip the switch to adjust. With the ignition on, monitor the scan tool data and slowly adjust the resistance in the circuit. The temperature/voltage value should change with the resistance change. If the value changes as the resistance is varied it would indicate that the temp sensor is likely faulty.

VERIFYING AN ECU FAILURE: An ECU that is faulty and not able to properly read the signal can usually be determined when opening and shorting the circuits and monitoring the signal voltage and fault codes. If the expected voltage reads or DTCs do not occur when opening and jumping the connector, and the circuits are not shorted or open, it would indicate a faulty ECU. Before condemning and ECU, **always** carefully check all connectors in the path of the circuit for water intrusion, spread, pushed out, burnt or corroded terminals.

P0073-AMBIENT AIR TEMPERATURE SENSOR CIRCUIT HIGH

For a complete A/C CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

KNOWN VEHICLE ISSUES

Listed below are vehicles that have system issues that may cause an incorrect DTC to set which may lead to misdiagnosing the system.

1. **Heavy Duty Trucks** - Trucks that are equipped with a Drivers Door Module (DDM) may set the U110E-LOST AMBIENT TEMPERATURE MESSAGE fault when there is an open in the circuitry instead of the P0073-AAT SENSOR CIRCUIT HIGH fault. When diagnosing one of these vehicles with the U110E present, always diagnose the entire circuitry and sensor first.
2. **2018 - 2019 JL** - A short to ground in the AAT Sensor Signal will set the P0073-AAT SENSOR CIRCUIT HIGH DTC instead of the P0072-AAT SENSOR CIRCUIT LOW DTC.
3. **2019 KL** - May set the U110E-LOST AMBIENT TEMPERATURE MESSAGE fault when there is an open in the circuitry instead of the P0073-AAT SENSOR CIRCUIT HIGH fault. When diagnosing one of these vehicles with the U110E present, always diagnose the entire circuitry and sensor first.

DESCRIPTION AND OPERATION - AMBIENT AIR TEMP SENSOR

The AAT Sensor is typically located in the front of the vehicle near the grill. On some vehicles the AAT Sensor is located in the drivers side mirror housing. The sensor is normally hard-wired to the Body Control Module (BCM) or Totally Integrated Power Module (TIPM) depending on vehicle architecture. On vehicles that have the sensor mounted in the mirror, it may be hard-wired to the Drivers Door Module (DDM), if equipped. Refer to the wiring information for the specific vehicle being diagnosed to determine which module to test at. The analog AAT Sensor signal is converted to a digital signal and broadcast over the vehicle Bus. If hard-wired to the DDM, it is bussed to the BCM/TIPM. The BCM/TIPM broadcasts the AAT Sensor signal over the Can C Bus. The Powertrain Control Module (PCM) acquires the AAT Sensor signal from the Can C Bus.

NOTE:	**While circuit high and low faults are monitored by both the PCM and BCM, only the PCM performs a rationality diagnostic of the AAT Sensor signal.**

The AAT Sensor rationality diagnostic runs on a cold start after a cold soak condition was present on the previous key off cycle. Following a start to run delay time, the PCM typically compares the signals from the AAT, Engine Coolant Temperature (ECT), and Intake Air Temperature (IAT) Sensors. If the ECT and IAT Sensors agree and the AAT Sensor does not agree, the AAT Sensor signal is declared as irrational. If declared irrational a second comparison will be done after a short drive cycle.

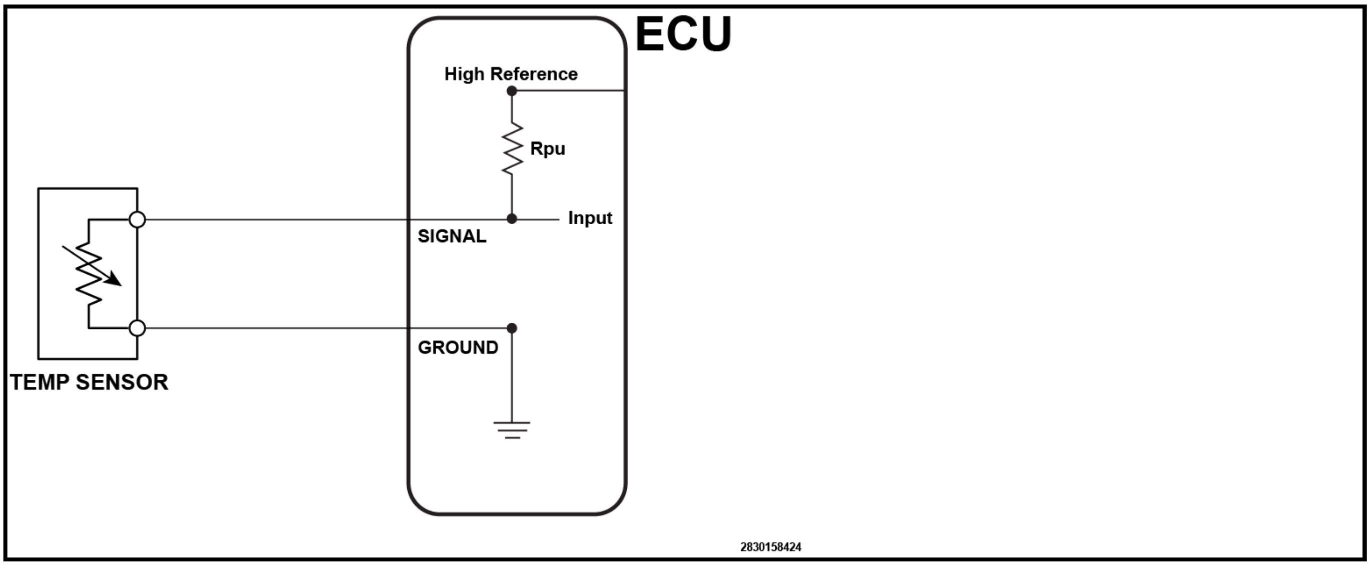
NOTE:	**If a repair is performed to the AAT Sensor wiring, the sensor is replaced, or the BCM connector is disconnected during testing to correct an active DTC, the vehicle must be driven for a minimum of 5 minutes above 15 mph to update the AAT temp signal before the DTC will go stored and can be erased.**

COMPONENT FUNCTIONAL DESCRIPTION - TWO WIRE TEMP SENSOR

GENERAL OPERATION: Temperature sensors are typically a variable resistor that functions as a normal two wire, 5.0 volt sensor. An Electronic Control Unit (ECU) supplies the Temp Sensor with a 5.0 volt reference signal and a filtered ground (return) circuit. The pull up resistor (Rpu) inside the ECU is a fixed resistance. The resistance in the sensor will change in relation to temperature. The resistors are configured in a simple series circuit with the ECU internally monitoring the voltage on the signal circuit, which is converted into a digital temperature reading. As the resistance of the component increases, the voltage on the signal circuit will also increase. The increased voltage on the signal circuit can be interpreted by the ECU as the temperature increasing or decreasing depending on the temp sensor and ECU software design.

- **Circuit Fault Diagnostics:** On a normally functioning sensor with no circuit issues, the signal voltage should never read 5.0 volts or 0.0 volts. This allows the module the capability of diagnosing an open or short in the sensor or wiring. As a general rule, a voltage reading above approximately 4.9 volts would set a circuit high/open fault. A voltage below approximately 0.10 volts will set a circuit Low fault. Calibrated thresholds can vary slightly from module to module and vehicle to vehicle.

- **Performance Fault Diagnostics:** Since added resistance in the sensor or circuitry can cause an irrational reading and no circuit fault, the module will check the signal for a plausible reading in some cases. This can be done using different methods. One common way is by comparing the sensor reading to other temperature sensors. With this method the module will compare the sensors at a time when the readings should be within a calibrated threshold of each other (I.E. Ignition on after a cold soak). Another method could be to monitor for the temperature to increase or decrease when turning on or off a device that is being controlled by the ECU. In either case, an irrational reading can set a sensor performance fault.



ANALOG TO DIGITAL SIGNAL DESCRIPTION

Electronic Control Modules read analog signal voltages and convert them to digital counts. Each count is an equal percentage of the voltage. This can be seen when viewing the voltages of some sensors or switches on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts on most sensors to a battery voltage reference on switches.

- The resolution of the signal is determined by the required precision of the input by the ECU. Typically, sensor signals have a high resolution (Ex. a sensor signal may be divided into 4096 counts, or 5.0 volts divided by 4096). This allows the module to read small changes over a wide range in a variable resistance sensor signal used for a temperature, pressure, or position sensors.
- Switches will typically have a low resolution since they are usually only reporting a few switch states (Ex. a switch may typically be divided into only 15-20 counts, or Battery voltage divided by 15). The highest and lowest one or two counts will be used for detecting opens or shorts if the switch signal is being rationalized. The remaining counts are divided up between the states being detected.

TECHNICAL DATA - AMBIENT AIR TEMP SENSOR

Use the specification table below to check the Ambient Temperature Sensor. The values in the table show the approximate resistance values for the temperatures given. The actual resistance can vary +/- 10% form the values in the table. Typically, if the sensor is faulty the resistance value will be noticeably different from the specification in the table.

AMBIENT AIR TEMP SENSOR - TEMPERATURE TO RESISTANCE CHART			
Ambient Temp - Celsius	**Ambient Temp - Fahrenheit**	**Sensor Resistance**	**B**
-40B°C	-40B°F	345.26 kOhms	Lowest possible temperature reading
-10B°C	14B°F	53.38 kOhms	Logical temperature values
-5B°C	23B°F	40.89 kOhms	
0B°C	32B°F	31.56 kOhms	
5B°C	41B°F	24.55 kOhms	

AMBIENT AIR TEMP SENSOR - TEMPERATURE TO RESISTANCE CHART			
Ambient Temp - Celsius	**Ambient Temp - Fahrenheit**	**Sensor Resistance**	**B**
10B°C	50B°F	19.24 kOhms	
15B°C	59B°F	15.22 kOhms	
20B°C	68B°F	12.13 kOhms	
25B°C	77B°F	9720 Ohms	
30B°C	86B°F	7780 Ohms	
35B°C	95B°F	6370 Ohms	
40B°C	104B°F	5200 Ohms	
150B°C	302B°F	181 Ohms	Highest possible temperature reading

ENABLING CONDITIONS AND POSSIBLE CAUSES - AMBIENT AIR TEMP SENSOR

MONITORING CONDITIONS
Circuit Low/High Faults - With the ignition on, battery voltage above a calibrated threshold. **Performance Fault** - With the ignition on after an eight hour cold soak on the previous engine off cycle. Ambient Air, Intake Air, and Engine Coolant Temperature values are above -64B°C (-83B°F).

FAULT SETTING CRITERIA
Circuit Low Fault - The sensor signal voltage is below a calibrated threshold. The threshold is typically in the 0.1 volt range. **Circuit High Fault** - The sensor signal voltage is above a calibrated threshold. The threshold is typically in the 4.9 volt range. **Performance Fault** - The sensor signal voltage is irrational - typically not within 10B°C - 15B°C (18B°F - 27B°F) of the other engine temp sensors.

POSSIBLE CAUSES
TEMP SENSOR HARNESS CONNECTOR DAMAGED OR NOT CONNECTED COMPLETELY (CIRCUIT HIGH/PERFORMANCE FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT (CIRCUIT LOW FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH FAULT)
TEMP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH/PERFORMANCE FAULT)
TEMP SENSOR RETURN CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH/PERFORMANCE FAULT)
FAULTY TEMP SENSOR (OPEN, SHORTED OR DRIFTED OUT OF RANGE)
FAULTY ELECTRONIC CONTROL UNIT (ECU)

DIAGNOSTIC OVERVIEW

TEMP SENSOR ECU DIAGNOSTICS:

- **Circuit Fault Diagnostics:** With a normally functioning sensor that has no circuit issues, the signal voltage should never read 5.0 volts or 0.0 volts. This allows the module the capability of diagnosing an open or short in the sensor or wiring. As a general rule, a voltage reading above approximately 4.9 volts will typically set a circuit high/open fault. A voltage below approximately 0.10 volts will typically set a circuit Low fault. Calibrated thresholds can vary slightly from module to module and vehicle to vehicle.
- **Performance Fault Diagnostics:** Added resistance in the sensor or circuitry can cause an irrational reading and no circuit fault. The module will check the signal for a plausible reading in most cases. This can be done using different methods. One common way is by comparing the sensor reading to other

temperature sensors. With this method the module will compare the sensors at a time when the readings should be within a calibrated threshold of each other (Ex. Ignition on after a cold soak). Another method could be to monitor for the temperature to increase or decrease when turning on or off a device that is being controlled by the ECU. In either case, an irrational reading can set a sensor performance fault.

PRELIMINARY DIAGNOSTIC CHECKS

1. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the ECU. Low Battery voltage can cause a DTC.
3. Circuit faults should typically be diagnosed before rationality/performance faults.
4. Check the component harness connector(s) for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the component harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connections issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. Use the wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

Intermittent testing for a circuit low/high fault with the Mopar Scope:

1. Back probe and connect the scope lead to the temp sensor signal circuit.
2. Monitor the circuit voltage while wiggle testing the wiring harness.

3. If you are not able to monitor the scope signal voltage during wiggle testing, set up a trigger to catch an intermittent condition. Set the trigger for voltage above 4.9 volts for an intermittent circuit high fault or below 0.1 volts for a circuit low fault.

DIAGNOSTIC TEST - TWO WIRE TEMP SENSOR

NOTE: **If a repair is performed to the AAT Sensor wiring, the sensor is replaced, or the BCM connector is disconnected during testing to correct an active DTC, the vehicle must be driven for a minimum of 5 minutes above 15 mph to update the AAT temp signal before the DTC will go stored and can be erased.**

NOTE: **The AAT Sensor is an individually serviceable component. If the measured resistance from the AAT Sensor does not meet the values from the Technical Data information, then only the sensor should be replaced and not the entire mirror assembly.**

NOTE: **There are multiple test methods listed below. The first two tests are a complete system diagnostic of the wiring and sensor. The remaining tests are broken up by the failure modes. There can be advantages to using each method. All of the methods do not need to be performed. Pick the best test method based on accessibility, ease of testing, availability of test equipment. It is a good practice to perform a complete check of the wiring in case of calibration issues. Failure to perform a complete check of the wiring may lead to unnecessary replacement of the component or ECU. In some cases it may be beneficial to use parts of each method to test for different failure modes.**

COMPLETE CIRCUIT DIAGNOSTICS USING THE ELECTRICAL TEST LEAD KIT:

1. Check the ECU, signal and sensor ground circuits together to determine if the temp sensor is faulty. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the temp signal and sensor ground circuits at the temp sensor harness connector. Move the switch on the Electrical Test Lead Kit between the open and closed positions while monitoring the scan tool. If monitoring for faults, the circuit high fault should set when switched to the open position and the circuit low fault should set when switched to the closed position. If the sensor voltage is available on the scan tool, monitor the voltage readings. The voltage should be 5.0 volts when switched to the open position and 0.0 volts when switched to the closed position. Move the switch to adjust and use the tool to vary the resistance while monitoring the ECU signal voltage on the scan tool. **Pick the result from a, b, or c below that best matches the results.**

1. **If the faults set as described and the signal voltage is 5.0 volts and 0.0 volts** - the ECU and temp sensor circuits are testing good. The temp sensor is most likely faulty or has a poor connection at the harness connector. Check the temp sensor harness connector for pushed out, spread, corroded or dirty terminals before condemning the sensor. The internal resistance of the sensor can be measured and compared to the table (if available) to verify a faulty sensor.
2. **If the signal voltage is stuck low or only the circuit low fault sets** - the most likely cause is the temp sensor signal circuit shorted to chassis ground or the temp sensor ground circuit. Check the temp sensor signal circuit for a short to ground, or to the temp sensor ground circuit. If the signal circuit is not shorted, use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals before condemning an ECU. If no issues are found, the ECU is most likely faulty.
3. **If the signal voltage is stuck high or only the circuit high fault sets** - the most likely cause is an open or very high resistance in the temp sensor signal or temp sensor ground circuit. **Continue to step d.**
4. **If the signal reading on the scan tool shows voltage present when switched to closed** - remove the test lead from the sensor ground circuit and connect it to a good chassis ground while observing the voltage on the scan tool. If the voltage drops to 0.0 volts the resistance is in the temp sensor ground circuit. If the voltage is still present the resistance is in the temp sensor signal circuit. Check the appropriate circuit for high resistance. Typically, it should be less than 3.0 Ohms. If the circuits check good, **continue to step e.**
5. **If the circuits are checked and do not have excessive resistance** - use the wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the ECU. If no issues are found, replace the ECU in accordance with the service information.

COMPLETE CIRCUIT DIAGNOSTICS USING CONVENTIONAL VOLTAGE TESTING WITH A DVOM:

1. Verify the temp sensor and ECU harness connectors are connected and locked properly.
2. Turn the ignition on. Back probe and measure the voltage on the temp sensor signal circuit at the Fuel Pump harness connector. Pick the result below that best matches the voltage reading.
    1. **If the signal voltage is reading between 0.1 and 4.9 volts** - the temp sensor signal is most likely giving a legitimate reading. If the circuit fault is active and the voltage reading on the scan tool does not match the DVOM voltage reading, the ECU is likely faulty.
    2. **If the signal measures a constant 0.0 volts** - this indicates that the temp sensor signal circuit is shorted to ground or has an open between the ECU and temp sensor. If the circuit high fault is set, the most likely failure is an open in the temp sensor signal circuit. If the circuit low fault is set, the most likely failure is a short to ground in the temp sensor signal circuit or possibly a faulty sensor (disconnecting the temp sensor harness connector and checking for the circuit high fault to become active would indicate that the temp sensor is most likely faulty). **Continue to step 3.**
    3. **If the signal reading has a constant voltage above 6.0 volts** - this would indicate that the signal circuit is shorted to another voltage supply.
    4. **If the signal reading has a constant 5.0 volts** - this indicates an open further downstream in the circuitry. Most likely the temp sensor or the temp sensor ground circuit. **Continue to step 4.**
3. Disconnect the temp sensor and ECU harness connectors and check the temp sensor signal circuit for high resistance and short to ground. If the signal circuit checks good, check all connectors in the system for pushed out, spread, corroded or dirty terminals before condemning a ECU. If all of the connectors check good, replace the ECU in accordance with the service information.
4. To check the temp sensor, move the test lead over and back probe the temp sensor ground circuit at the temp sensor harness connector.

TYPICAL CIRCUIT LOW DIAGNOSTICS:

1. To quickly eliminate the temp sensor as a possible cause with an **active** circuit low fault, disconnect the temp sensor harness connector while monitoring for the circuit high fault to become active on the scan

tool.

    1. If the circuit high fault becomes active when the sensor is disconnected, the temp sensor is most likely faulty.
    2. If the circuit high fault does not become active, **continue to step 2.**
2. Disconnect the ECU harness connector to isolate the circuit. Check the temp signal circuit for continuity to both chassis ground and the sensor ground circuit.
    1. If there is continuity to either, repair the signal circuit for a short to ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, replace the ECU in accordance with the service information.

TYPICAL CIRCUIT HIGH DIAGNOSTICS:

1. Disconnect the temp sensor harness connector and measure the temp sensor signal circuit voltage with the ignition on. The signal circuit voltage should be between 4.9 and 5.6 volts.
    1. If battery voltage is present, repair the sensor signal circuit for a short to another voltage supply circuit.
    2. If the voltage is correct, **continue to step 2.** .
2. With an active fault, monitor the scan tool and connect a jumper across the terminals with the ignition on. Typically, the temp sensor signal voltage should change to 0 volts on the scan tool with the jumper in place. If the voltage data read is not available, check for the circuit low fault to set with the jumper in place. If either result occurs, the temp sensor is faulty.
    1. If either result occurs, the temp sensor is faulty.
    2. If the voltage does not change to 0 volts or the circuit low fault is not present with the jumper in place, **continue to step 3.** .
3. Check the resistance of the temp sensor signal circuit and temp sensor ground circuit. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the circuit.
    2. If the temp sensor signal and ground circuits test good, and the voltage is still reading high or only the circuit high fault is present, use the wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning ECU. If no issues are found, replace the ECU in accordance with the service information.

TYPICAL PERFORMANCE/RATIONALITY DIAGNOSTICS:

NOTE: **Temp sensor performance faults typically set due to resistance in one of the circuits or a sensor that is stuck or drifted out of range. The (special tool #2064100080, Kit, Electrical Test Lead) can be used with the scan tool to test the wiring and controller.**

1. Disconnect the temp sensor harness connector and connect the Electrical Test Kit leads to the temp sensor harness connector.
2. Move the switch on the tool to open. The signal should read 5.0 volts and a circuit high DTC should be active or pending on the scan tool.
3. Next flip the switch to the closed position. The signal should read 0 volts and a circuit low fault should be active or pending on the scan tool. If the scan tool reads as described in steps 2 and 3, it would indicate the wiring and ECU are good and the sensor is likely faulty. If there is voltage present between 0 and 5.0 volts with the test tool in the closed position it would indicate there is likely resistance in one of the circuits. **Continue to step a.**
    1. To determine which circuit has resistance, remove the test lead connected to the temp sensor ground circuit and connect it to a good chassis ground.
        - If the signal changes to 0 volts it would indicate the temp sensor ground has resistance. **Continue to step b.**

- If there is still voltage present it would indicate the temp sensor signal has resistance. **Continue to step b.**

2. Confirm the suspect circuit issue by isolating the suspect circuit and measuring the resistance of the circuit between the sensor and ECU harness connectors. If no resistance is measured, carefully check all connectors in the path of the circuit for spread or dirty/corroded terminals. If the circuits check good (no resistance), verify whether the issue is with the temp sensor or ECU. **Continue to step 4 or 5.**

4. **If a temp table is available** , the sensor and ECU can be verified in one of the following ways.
   1. Move the switch to adjust and connect an Ohmmeter to the test leads and dial the tool to a resistance value in the table. Connect both leads to the temp sensor harness connector with the ignition on and monitor the data in the scan tool for the proper reading. Use the tool to vary the resistance while monitoring the temp sensor signal temperature/voltage on the scan tool. If the reading matches the table, the temp sensor is likely faulty.
   2. If the temp sensor actual temperature can be acquired or reasonably estimated, measure the resistance across the terminals of the temp sensor and compare to the value in the table. If the resistance of the sensor is not in range of the table, the temp sensor is likely faulty.
5. **If a temp table is not available** for the sensor being tested, connect the Electrical Test Kit leads to the harness connector and flip the switch to adjust. With the ignition on, monitor the scan tool data and slowly adjust the resistance in the circuit. The temperature/voltage value should change with the resistance change. If the value changes as the resistance is varied it would indicate that the temp sensor is likely faulty.

VERIFYING AN ECU FAILURE: An ECU that is faulty and not able to properly read the signal can usually be determined when opening and shorting the circuits and monitoring the signal voltage and fault codes. If the expected voltage reads or DTCs do not occur when opening and jumping the connector, and the circuits are not shorted or open, it would indicate a faulty ECU. Before condemning and ECU, **always** carefully check all connectors in the path of the circuit for water intrusion, spread, pushed out, burnt or corroded terminals.

P00FD-00-BATTERY B STATE OF CHARGE PERFORMANCE

For a complete STARTING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

NOTE: **The terminology of the relays in this procedure can be confusing. To add clarity the Power Control Relay is the relay that makes and breaks the connection between the two Batteries. The PCR Control Relay is in the PDC and is controlled by the Powertrain Control Module (PCM) using a Low Side Driver (LSD). The relay can be removable or a Printed Circuit Board (PCB) relay depending on vehicle configuration. The PCR Control Relay provides the power supply to operate the Power Control Relay.**

The Engine Stop/Start (ESS) system uses a **Power Control Relay (PCR)** and two Batteries to eliminate the voltage drop in the system voltage during an Auto-start event. This allows the consumer electronics and vehicle modules subsystems to continue to function in a normal manner. The Power Control Relay is connected in-line between the Main (Cranking) Battery and the Auxiliary (Vehicle) Battery. The Power Control Relay is normally closed when de-energized, connecting the two Batteries. When the Power Control Relay is energized, the relay opens and breaks the connection between the Batteries.

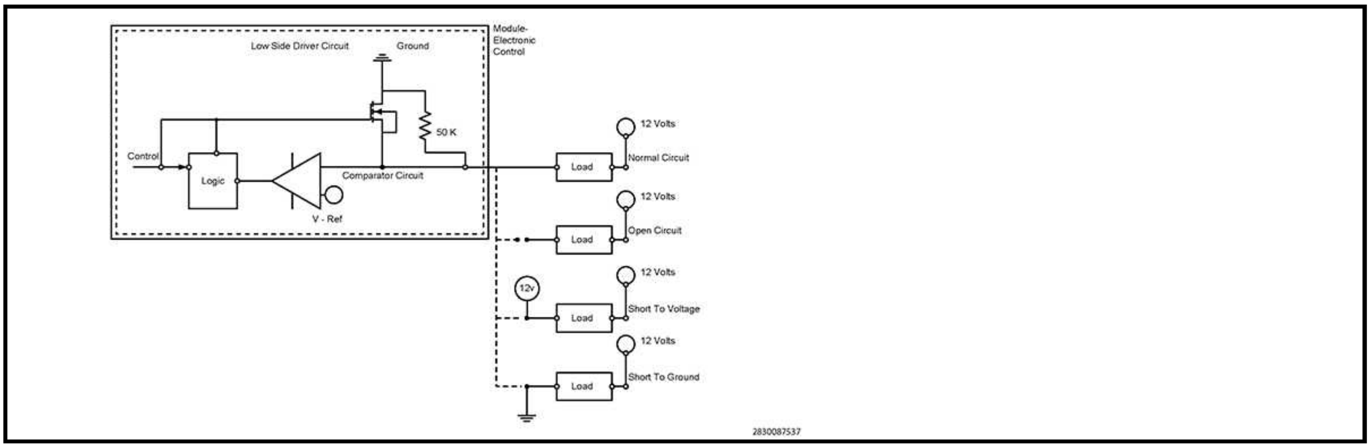
The engine starting and charging systems are connected directly to the Main Battery. When the Power Control Relay is closed (de-energized), the Auxiliary Battery is charged from the Main Battery. Therefore, if the Power Control Relay is stuck on (open), the Auxiliary Battery will not charge.

When ESS is active, and an **Auto-start crank event is initiated** , the **Power Control Relay** is temporarily energized when 12.0 volts is supplied from the output of the **PCR Control Relay in the PDC** . When the Power Control Relay is energized it breaks the connection and allows the Batteries to work independently. When this occurs, the Main Battery is used to crank and start the engine. The Auxiliary Battery, which is now solely connected to the PDC and is not affected by cranking, can maintain full Battery voltage to the rest of the vehicle modules and subsystems.

Typical Low Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver device. The PCM provides a ground to operate the device when switched on. The ground could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device, wiring and internal driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. For diagnostic purposes the PCM uses an internal pull down diagnostic resistor connected in series and a voltage reference (V-Ref) comparator for fault detection:

- **Circuit Open and Circuit Low Detection:** The PCM monitors for an **open circuit** and **short to ground** when the driver is switched off. When switched off, the available voltage passes through the device and the **internal pull down resistor** connected in series. The voltage at the **comparator circuit** should be close to Battery voltage since the majority of the voltage drop occurs through the diagnostic resistor. If the available voltage is less than the V-Ref, a fault is set. In this scenario the V-Ref would be slightly below Battery voltage. **An alternative method of fault detection for an open or short to ground** that is used is to monitor current draw when the internal driver is switched on. If the module does not detect any current draw it determines that the component or circuitry is open. Excessive current draw detected would indicate a short to ground.
- **Circuit High Detection:** The PCM monitors for a **short to voltage** when the driver is switched on. When the driver is switched on providing a path to ground through the transistor, the available voltage should be pulled low, near zero volts since the **comparator circuit** is monitoring the ground side of the device. If the voltage is greater than V-Ref, a fault is detected. In this scenario V-Ref would be slightly above zero volts.

NOTE: **A load that has a resistance that is below manufacturer specification, or a second load device shorted to the low side driver circuit can cause excessive current draw on the internal driver. The driver will be switched off to protect against overheating and damaging the driver. In this instance the Circuit High fault may be detected because the available voltage on the comparator circuit is above V-Ref.**



DIAGNOSTIC OVERVIEW - STOP/START SYSTEM AND AUXILIARY BATTERY STATE OF CHARGE (SOC)

PCM DIAGNOSTICS: It is important for the Power Control Relay to operate properly to allow the Auxiliary Battery to charge correctly with the engine running and be disconnected during an Engine Stop/Start (ESS) Auto-start event. The PCM runs continuous diagnostics to determine if the Power Control Relay is stuck in the On (open) or Off (closed) positions.

DIAGNOSTIC OVERVIEW OF SYSTEM:

- **Ignition Crank Sense Diagnostic:** The PCM monitors the Ignition Crank Sense circuit voltage when engine cranking is commanded. The Ignition Crank Sense circuit is connected to the Starter Solenoid Feed circuit inside the PDC. When engine cranking is commanded the PCM expects to see battery voltage at the Ignition Crank Sense circuit. If no voltage is detected a fault is set.

- If the engine is able to crank when the feedback circuit performance fault is active it eliminates the battery supply, Starter Relays and Starter as possible causes for the fault setting. If the engine does not crank when the feedback circuit performance fault is active the Ignition Crank Sense circuit is not the possible cause.

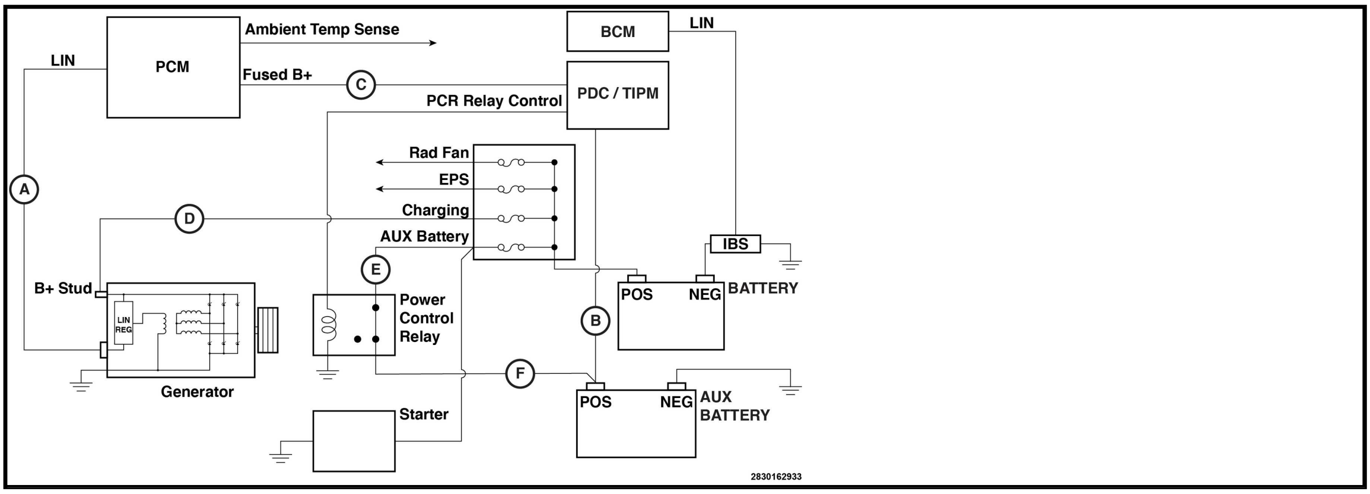
- **Stuck Starter Relay Diagnostic:** After the engine is initially started, the Powertrain Control Module (PCM) will command one of the Starter Relays closed and the other Starter Relay open and monitor the Ignition Crank Sense circuit for voltage. It will then open the closed relay and close the open relay and monitor the Ignition Crank Sense circuit for voltage. If there is voltage present on the feedback circuit during either of these tests, then the relay that was commanded off when voltage was detected is determined to be stuck closed and a performance fault is set against that relay.

POWER CONTROL RELAY DIAGNOSTIC: DISCLAIMER: The generic graphic below is used for reference to show how the components are configured in the system. It is not specific to any particular vehicle. Refer to the wiring and service information for the specific layout of the components for the vehicle that you are working on.

- **Diagnostic 1 - Auxiliary Battery Disconnected:** During an initial key start, the Power Control Relay is commanded on **(open)** and the Auxiliary Battery SOC is evaluated. If the Fused B+ voltage (C) to the Powertrain Control Module (PCM) is so low that the PCM experiences a reset during the initial key-on or engine crank event, the **PCM will set P00FD and ESS will be disabled.**

  NOTE: **This will cause a no crank condition. On the next key cycle the DTC will be active. The PCM will de-energize the Power Control Relay with an active DTC which will connect the Main Battery to the Auxiliary Battery, allowing the PCM to power up and allow engine cranking.**

- **Diagnostic 2 - Auxiliary Battery Depleted:** During an ESS Auto-start event, the Power Control Relay is temporarily commanded on (open) disconnecting the Main and Auxiliary Batteries from each other (E and F). This allows the Auxiliary Battery SOC to be separately monitored by the PCM. If the Auxiliary Battery voltage drops below a calibrated threshold (approximately 8.0 volts) during the ESS Auto-start event, the **PCM will set P00FD and ESS will be disabled.**
- **Diagnostic 3 - Auxiliary Battery is Depleting:** During the ESS Auto-start event, if the Auxiliary Battery voltage drops below a calibrated threshold the PCM will increment a counter by 1. ESS will be disabled for a short period to allow the Auxiliary Battery to charge before being re-enabled and tested again. If the voltage returns above a calibrated threshold on the next Auto-start event, the counter will decrement by 1. If the voltage is still below the calibrated threshold on the next Auto-start event, the counter will increment by 1 again. If the counter reaches 10 counts, the **PCM will set P00FD and ESS will be disabled.**
- **Diagnostic 4 - Power Control Relay Stuck Off:** During the ESS Auto-start event, if the PCM detects little or no difference (delta) between the Auxiliary Battery voltage and Main Battery voltage (C and IBS LIN feedback), the **PCM will set P2AF6 and ESS will be disabled.**
- **Diagnostic 5 - Auxiliary Battery Disconnected from Main Battery:** During normal engine operation, when the vehicle is not in an ESS Auto-start event, the Power Control Relay is commanded off (closed), connecting the Main and Auxiliary Batteries together (E and F) to allow the Auxiliary Battery to charge. If the difference (delta) between Auxiliary Battery voltage and Main Battery voltage (C and IBS LIN feedback) is more than a calibrated threshold, the **PCM will set P2AF5 and ESS will be disabled.**



SIMPLE DIAGNOSTIC STRATEGY:

- **The diagnostic for the P00FD fault** is basically designed to detect a discharging, discharged or disconnected Auxiliary Battery any time there is a disconnect between the two Batteries. It detects this if the Fused B+ voltage to the PCM drops low enough to cause a PCM reset when disconnected from the Main/Cranking Battery. This fault will detect a faulty Auxiliary Battery, or wiring issue between the Auxiliary Battery, PDC and Battery Supply circuit (B and C) and the PCM.
- **The P2AF5-Power Control Relay Stuck On description can be misleading.** Since the diagnostic is using a comparison of the voltage between the two Batteries as an indicator, it is more likely to have an issue in the wiring between either Battery and the Power Control Relay (E or F). The only way for the relay to be stuck on **(open)** would be if the internal contacts were physically stuck on, or the Fused B+ output from the PCR Control Relay were shorted to voltage. Both of these conditions are possible but not very likely. **A quick way to check for the Power Control Relay being stuck on (open)** would be to measure the voltage at each of the posts at the Power Control Relay with the engine running and the charging system active. If the Power Control Relay is stuck open the voltage on the Auxiliary Battery side will be lower than the voltage on the Main Battery side of the relay. If the voltage is the same on both sides, the relay is not open. If the voltage is equal to the charging system voltage at both terminals, the wiring issue is most likely on the Auxiliary Battery side of the relay. If the voltage is equal to the Auxiliary Battery voltage at both terminals, the wiring issue is most likely on the Main Battery side of the relay.
- **The P2AF6-Power Control Relay Stuck Off diagnostic** is checking for the disconnection between the Batteries to occur when the Power Control Relay is energized during an initial Auto-start event. **Anything that can cause the relay not to energize can set this fault,** including a wiring issue with either the Fused B+ output from the PCR Control Relay in the PDC or the Power Control Relay Ground circuit. These are the two circuits that control the Power Control Relay operation. They do not have separate control circuit faults associated with them. If there is an open or short in one of these circuits the stuck off rationality fault sets.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Ignition on.
- Power Control Relay (PCR) is commanded open.
- DTC P00FD is not already active.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Auxiliary Battery is disconnected at Key On before an Ignition Start event.
- The PCM detects that the Auxiliary Battery voltage is below 7.98 Volts when the PCR is commanded open.

- The PCM detects that the Auxiliary Battery voltage is below 10.30 Volts during an ESS Engine Start event.

DEFAULT ACTION

- This is a non-MIL DTC.
- Engine Start/Stop (ESS) events are disabled.

POSSIBLE CAUSES

Possible Causes
OPEN AUXILIARY BATTERY FUSE (150A) IN THE FUSE ARRAY
POOR CONNECTION AT THE PCR STUDS
POOR CONNECTION AT BATTERY POSITIVE OR NEGATIVE CABLE ENDS
HIGH RESISTANCE IN THE AUXILIARY BATTERY GROUND
HIGH RESISTANCE IN THE AUXILIARY BATTERY POSITIVE CABLE
PCR CONTROL RELAY OUTPUT CIRCUIT SHORTED TO VOLTAGE
PCR CONTROL RELAY (ON PCB INSIDE PDC) IS STUCK ON
POWER CONTROL RELAY (PCR) STUCK ON (OPEN)
FAULTY AUXILIARY BATTERY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding.

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
   1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

      Are there any applicable Service Bulletins or Flash updates?

      Yes

      - Perform the applicable repair.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 2
2. **CHECK FOR OTHER DTCS**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.

      Are there any PCR Control Relay Control circuit or Charging System DTCs present?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3

3. **CHECK RELEVANT CONNECTIONS AND FUSES**
    1. Check the Auxiliary Battery Fuse (150A) in the Fuse Array for an open condition.
    2. Check that the connections at both Main and Auxiliary Batteries are clean and tight.
    3. Check that the connections at the PCR studs are clean and tight.

    Were any issues found with the fuses or connections?

    Yes

    - Make the necessary repairs.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 4
4. **CHECK THE BATTERY STATE OF CHARGE FOR BOTH MAIN AND AUXILIARY BATTERIES**
    1. Disconnect the Negative Cable from the both Batteries.
    2. Use the (special tool #GR8-1220KIT-CHRY, AGM Battery Tester/Charger Station)or equivalent to load test both Batteries.

    Did both Batteries pass the load test?

    Yes

    - Go To 5

    No

    - Recharge or replace the Battery that failed and retest.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **CHECK THE POWER CONTROL RELAY FOR PROPER OPERATION**
    1. Turn the ignition off.
    2. Reconnect both Battery Negative Cables.
    3. Remove the C2 and C3 terminals from the Power Control Relay.

    NOTE: **These circuits are still connected to Battery voltage. Be careful to insulate and/or isolate the cable so that it cannot make contact with any engine ground.**

    4. Measure the voltage at both the C2 and C3 harness terminals.

    Is the voltage at or near battery voltage at both C2 and C3 terminals?

    Yes

    - Go To 6

    No

    - Repair the circuit for an open or high resistance. Be certain to verify that any applicable fuses and connections are in good condition.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE POWER CONTROL RELAY FOR PROPER RESISTANCE**
    1. Check the PCR relay output side for continuity by measuring the resistance between the studs for C2 and C3.

       Is the resistance below 3.0 ohms?

       Yes

       - A poor connection may have been the cause of the DTC. Reconnect all terminals, verifying that all connections are clean and tight.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 7
7. **CHECK THE PCR CONTROL CIRCUIT FOR VOLTAGE**

   NOTE: **The PCR should only be energized when commanded by the PCM during Auto Start events.**

    1. Remove the C1 harness connector from the PCR.
    2. Turn the ignition on.
    3. Measure the PCR Control Relay Output at the C1 harness connector.

       Is voltage present?

       Yes

       - Check the PCR Control Relay Output for a short to voltage and repair as necessary. If no short to voltage is found, replace the PDC in accordance with Service Information.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 8
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
8. **REPLACE THE POWER CONTROL RELAY AND RETEST FOR DTCS**
    1. Turn the ignition off.
    2. Replace the PCR in accordance with the Service Information.
    3. Connect all disconnected harness connectors.
    4. Turn the ignition on.
    5. With the scan tool, erase all DTCs.
    6. Turn the ignition off for a minimum of 10.0 seconds.
    7. Turn the ignition on.
    8. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    9. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

- Go To 9

No

- Replacing the faulty PCR repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0107-MANIFOLD ABSOLUTE PRESSURE SENSOR CIRCUIT LOW

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Manifold Absolute Pressure (MAP) Sensor is a transducer that varies resistance according to pressure changes in the Intake Manifold. The MAP Sensor signal provides the Powertrain Control Module (PCM) with an indication of the current air pressure within the Intake Manifold. The PCM uses this information to help calculate fuel delivery. The PCM supplies 5.0 volts to the MAP Sensor on a 5-Volt Reference circuit and provides a ground on a low reference circuit. The MAP Sensor provides a voltage signal to the PCM on a signal circuit relative to the pressure changes. The PCM receives the Barometric Pressure (BARO) Sensor reading from the MAP Sensor with the ignition on, before the engine is cranking or running.

NOTE: **Do not use shop air to clean out the MAP Sensor when diagnosing a MAP Sensor related fault as this will cause internal damage to the sensor.**

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Manifold Absolute Pressure (MAP) Sensor input voltage signal is below 0.10 - 0.15 volts for 0.08 seconds.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will flash.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED
5-VOLT SUPPLY CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
MAP SENSOR PRESSURE SIGNAL CIRCUIT SHORTED TO GROUND
MAP SENSOR PRESSURE SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read and record DTCs in all Electronic Control Units (ECUs) on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.

4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **ISOLATE AND CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 3

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **ISOLATE AND CHECK THE MAP SENSOR (K1) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as

a guide to follow the path of the circuit.

3. Connect the negative lead of the DVOM to a known good ground.
4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

No

- Go To 4

4. **ISOLATE AND CHECK THE MAP SENSOR (K1) PRESSURE SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 6

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND CHECK THE MAP SENSOR (K1) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO THE (K900) SENSOR GROUND CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between the circuits being tested.**

   Is there continuity between the circuits?

   Yes

   - Repair the short between the circuits.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6

6. **CONNECT A FUSED JUMPER BETWEEN THE MAP SENSOR (K1) PRESSURE SIGNAL CIRCUIT AND THE (F856) 5-VOLT SUPPLY CIRCUIT AT THE MAP SENSOR HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL CIRCUIT HIGH DTC**
   1. The Electronic Control Module (ECU) harness connectors must be connected to the ECU during this test step.
   2. Disconnect the sensor harness connector.
   3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the 5-Volt Supply circuit at the sensor harness connector.
   4. Turn the ignition on.
   5. With the scan tool, read DTCs.

Does the scan tool display the SENSOR SIGNAL CIRCUIT HIGH DTC with the jumper in place?

Yes

- Replace the MAP Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.
    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0108-MANIFOLD ABSOLUTE PRESSURE SENSOR CIRCUIT HIGH

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Manifold Absolute Pressure (MAP) Sensor is a transducer that varies resistance according to pressure changes in the Intake Manifold. The MAP Sensor signal provides the Powertrain Control Module (PCM) with an indication of the current air pressure within the Intake Manifold. The PCM uses this information to help calculate fuel delivery. The PCM supplies 5.0 volts to the MAP Sensor on a 5-Volt Reference circuit and provides a ground on a low reference circuit. The MAP Sensor provides a voltage signal to the PCM on a signal circuit relative to the pressure changes. The PCM receives the Barometric Pressure (BARO) Sensor reading from the MAP Sensor with the ignition on, before the engine is cranking or running.

NOTE: **Do not use shop air to clean out the MAP Sensor when diagnosing a MAP Sensor related fault as this will cause internal damage to the sensor.**

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on
- Battery voltage greater than 10.4 volts

SET CONDITION

- The PCM detects that the MAP Sensor input voltage is above 4.91 volts for 0.08 seconds.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will flash.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT SHORTED TO VOLTAGE
MAP SENSOR PRESSURE SIGNAL CIRCUIT SHORTED TO VOLTAGE
MAP SENSOR PRESSURE SIGNAL CIRCUIT SHORTED TO THE 5-VOLT SUPPLY CIRCUIT
MAP SENSOR PRESSURE SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to **PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .**

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 2

2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

NOTE:	**The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

    Is the voltage above 5.2 volts?

    Yes

    - Go To 4

    No

    - Go To 5
4. **ISOLATE AND CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors

connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.

3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 11

5. **CHECK THE MAP SENSOR (K1) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Measure the voltage on the (K1) MAP Signal circuit at the MAP Sensor harness connector.

   Is the voltage above 5.2 volts?

   Yes

   - Go To 6

   No

   - Go To 7

6. **ISOLATE AND CHECK THE MAP SENSOR (K1) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
   4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE: With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 11

7. **ISOLATE AND CHECK THE MAP SENSOR (K1) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO THE (F856) 5-VOLT SUPPLY CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: There should be no continuity between the circuits being tested.

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 8

8. **ISOLATE AND CHECK THE MAP SENSOR (K1) PRESSURE SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.

5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 9

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **ISOLATE AND CHECK THE (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 10

   No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CONNECT A FUSED JUMPER BETWEEN THE (K900) SENSOR GROUND CIRCUIT AND THE MAP SENSOR (K1) PRESSURE SIGNAL CIRCUIT AT THE MAP SENSOR HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL CIRCUIT LOW DTC**
    1. The Electronic Control Module (ECU) harness connectors must be connected to the ECU during this test step.
    2. Disconnect the sensor harness connector.
    3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the 5-Volt Supply circuit at the sensor harness connector.
    4. Turn the ignition on.
    5. With the scan tool, read DTCs.

    Does the scan tool display the SENSOR SIGNAL CIRCUIT LOW DTC with the jumper in place?

    Yes

    - Replace the faulty sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 11
11. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.

8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
    - Test complete.

P0111-INTAKE AIR TEMPERATURE SENSOR 1 PERFORMANCE

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Intake Air Temperature (IAT) Sensor rationality diagnostic looks at the outputs of three temperature sensors and compares them under cold start conditions. Following a start to run delay time the outputs of the Ambient Air Temperature (AAT) Sensor, Engine Coolant Temperature (ECT) Sensor, and Intake Air Temperature (IAT) Sensors will be compared. If the ECT and AAT Sensors agree and the IAT Sensor does not agree, the IAT Sensor is declared as irrational. If declared irrational a second comparison will be done after a short drive cycle.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- After an engine off time of greater than 480 minutes.
- At ignition on the:
  - Ambient temperature reading is greater than -64B°C (-83.2B°F).
  - Engine coolant temperature reading is greater than -64B°C (-83.2B°F).
  - Intake air temperature reading is greater than -64B°C (-83.2B°F).
- After the engine is started and the vehicle is driven above 48.3 kph (30 mph) for 30 seconds a determination is made.

SET CONDITION

- The PCM compares the Ambient Air Temperature (AAT), Engine Coolant Temperature (ECT), and Intake Air Temperature (IAT) Sensor values. If one of the sensor values is not within 15B°C (27B°F) of the other temperature sensors for two consecutive trips, a DTC will set.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
HIGH RESISTANCE IN THE IAT SENSOR TEMP SIGNAL CIRCUIT
HIGH RESISTANCE IN THE SENSOR GROUND CIRCUIT
INTAKE AIR TEMPERATURE (IAT) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE CONDITION**
    1. Turn the ignition off.
    2. Allow the vehicle to sit with the ignition off in an environment where the temperature is consistent and above -64B°C (83.2B°F) until the engine coolant temperature is equal to, or close to the environmental ambient temperature.
    3. Turn the ignition on.
    4. With a scan tool, compare the AAT, ECT, and IAT Sensor values.

    Is the Intake Air Temperature Sensor value within 15B°C (27B°F) of the other two sensor values?

    Yes

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

    No

    - Go To 2
2. **ISOLATE AND CHECK THE IAT SENSOR (K21) TEMP SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

    Is the resistance below 3.0 Ohms?

Yes

- Go To 3

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **ISOLATE AND CHECK THE (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 4

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE ABILITY OF THE PCM TO READ THE INTAKE AIR TEMPERATURE SENSOR SIGNAL**
    1. Connect the PCM C2 harness connector.
    2. Turn the ignition on.
    3. With the scan tool, read DTCs.

NOTE: **The P0113-INTAKE AIR TEMPERATURE SENSOR CIRCUIT HIGH DTC should display as active or pending with the Intake Air Temperature harness connector disconnected.**

4. Turn the ignition off.

5. Connect a jumper between the (K21) IAT Signal circuit and the (K900) Sensor Ground circuit at the Intake Air Temperature Sensor harness connector.
6. Turn the ignition on.
7. With the scan tool, read DTCs.

NOTE: **The P0112-INTAKE AIR TEMPERATURE SENSOR CIRCUIT LOW DTC should display as active or pending with the jumper in place.**

Do the DTCs display as described above?

Yes

- Replace the Intake Air Temperature Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.
   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

   Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0112-INTAKE AIR TEMPERATURE SENSOR 1 CIRCUIT LOW

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Intake Air Temperature (IAT) Sensor is a variable resistor that functions as a normal two wire, 5-Volt sensor. The Powertrain Control Module (PCM) supplies the IAT Sensor with a 5-Volt signal and a filtered ground (return) circuit. For the IAT Sensor diagnostic, the PCM internally monitors the voltage on the signal circuit, which is converted into a temperature reading. If the voltage reads above the high calibrated threshold, or below the low calibrated threshold, a circuit high or low fault is set.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Intake Air Temperature (IAT) Sensor input voltage is below 0.43 volt for 2.24 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
IAT SENSOR TEMP CIRCUIT SHORTED TO GROUND
IAT SENSOR TEMP CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
INTAKE AIR TEMPERATURE (IAT) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

Are there any applicable Service Bulletins or Flash updates?

Yes

- Perform the applicable repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 2

2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read and record DTCs in all Electronic Control Units (ECUs) on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **DISCONNECT THE IAT SENSOR HARNESS CONNECTOR AND VERIFY THE ABILITY OF THE PCM TO READ THE SENSOR SIGNAL HIGH DTC**
    1. The Electronic Control Unit (ECU) harness connectors must be connected to the ECU during this test step.
    2. With the ignition in the off position, disconnect the sensor harness connector.
    3. Turn the ignition on.
    4. With the scan tool, read DTCs.

    Does the scan tool display the SENSOR SIGNAL CIRCUIT HIGH DTC with the connector disconnected?

    Yes

    - Replace the faulty sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 4

4. **ISOLATE AND CHECK THE IAT SENSOR (K21) TEMP SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

        NOTE: **There should be no continuity between ground and the circuit being tested.**

        Is there continuity between ground and the circuit being tested?

        Yes

        - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 5
5. **ISOLATE AND CHECK THE IAT SENSOR (K21) TEMP SIGNAL CIRCUIT FOR A SHORT TO THE (K900) SENSOR GROUND CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

        NOTE: **There should be no continuity between the circuits being tested.**

        Is there continuity between the circuits?

        Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.
   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - The wiring or poor connection problem has been repaired.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

DIAGNOSIS AND TESTING

P0113-INTAKE AIR TEMPERATURE SENSOR 1 CIRCUIT HIGH

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Intake Air Temperature (IAT) Sensor is a variable resistor that functions as a normal two wire, 5-Volt sensor. The Powertrain Control Module (PCM) supplies the IAT Sensor with a 5-Volt signal and a filtered ground (return) circuit. For the IAT Sensor diagnostic, the PCM internally monitors the voltage on the signal circuit, which is converted into a temperature reading. If the voltage reads above the high calibrated threshold, or below the low calibrated threshold, a circuit high or low fault is set.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
- battery voltage greater than 10.4 volts.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Intake Air Temperature (IAT) Sensor input voltage is above 4.9 - 4.95 volts depending on calibration for 2.24 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

POSSIBLE CAUSES
IAT SENSOR TEMP SIGNAL CIRCUIT SHORTED TO VOLTAGE
IAT SENSOR TEMP SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
INTAKE AIR TEMPERATURE (IAT) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

  - Go To 2

2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
   1. With the scan tool, read and record DTCs in all Electronic Control Units (ECUs) on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 3

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **CHECK THE IAT SENSOR (K21) TEMP SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Turn the ignition on.
   4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

   NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

   Is the voltage above 5.2 volts?

   Yes

   - Go To 4

   No

   - Go To 5

4. **ISOLATE AND CHECK THE IAT SENSOR (K21) TEMP SIGNAL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Units (ECUs) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
   4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 8

5. **ISOLATE AND CHECK THE IAT SENSOR (K21) TEMP SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Units (ECUs) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 6

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND CHECK THE (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**

1. The ignition must be off when checking the continuity of a circuit.
2. Isolate the circuit by disconnecting the Electronic Control Units (ECUs) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 7

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CONNECT A FUSED JUMPER BETWEEN THE IAT SENSOR (K21) TEMP SIGNAL CIRCUIT AND THE (K900) SENSOR GROUND CIRCUIT AT THE IAT SENSOR HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL CIRCUIT LOW DTC**
   1. The Powertrain Control Module (PCM) harness connectors must be connected to the ECU during this test step.
   2. Disconnect the sensor harness connector.
   3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the sensor ground circuit at the sensor harness connector.
   4. Turn the ignition on.
   5. With the scan tool, read DTCs.

   Does the scan tool display the SENSOR SIGNAL CIRCUIT LOW DTC with the jumper in place?

   Yes

   - Replace the faulty sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

- Go To 8

8. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0116-ENGINE COOLANT TEMPERATURE SENSOR PERFORMANCE

For a complete COOLING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION - ENGINE COOLANT TEMPERATURE (ECT) SENSOR

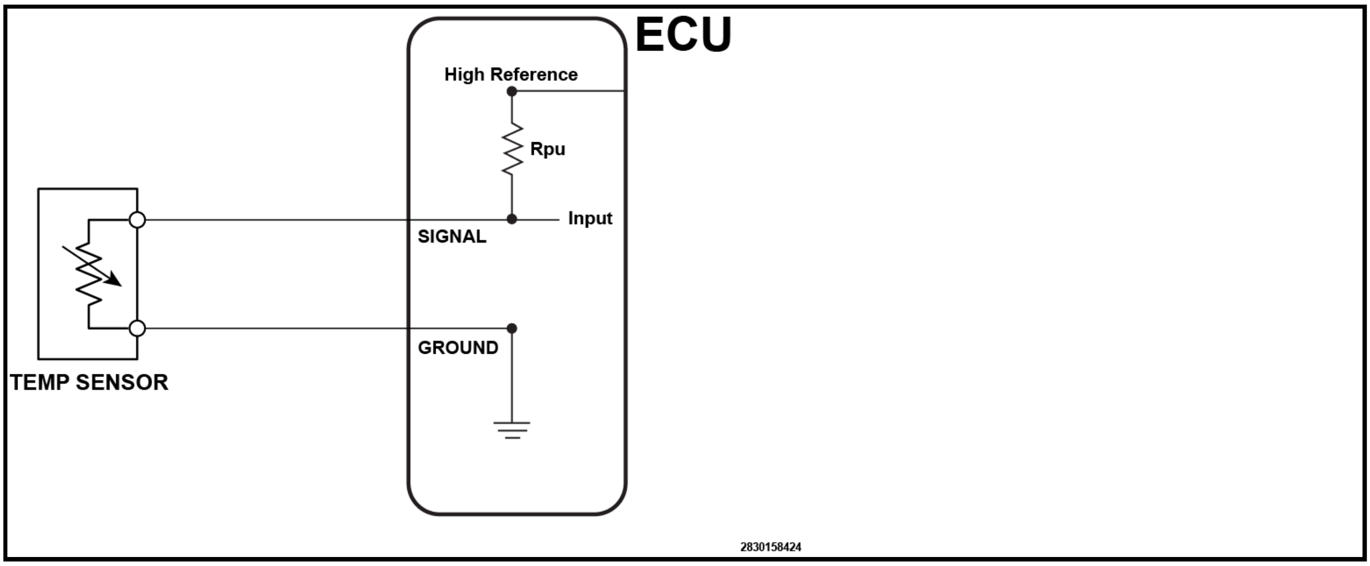
The Powertrain Control Module (PCM) monitors the ECT Sensor analog signal voltage. The ECT Sensor input signal is used with other sensor inputs in calculating fuel delivery and engine timing. The PCM also uses the ECT Sensor input for determining when to enable several OBD diagnostics. Each of these will impact emissions, which is why the ECT Sensor signal must be rationalized by the PCM.

The ECT Sensor rationality diagnostic looks at the outputs of three temperature sensors and compares them under cold start conditions. Following a start to run delay time the outputs of the Ambient Air Temperature (AAT) Sensor, Engine Coolant Temperature (ECT) Sensor, and Intake Air Temperature (IAT) Sensor will be compared. If the IAT and AAT Sensors agree and the coolant temperature does not agree, the ECT Sensor is declared as irrational. If declared irrational a second comparison will be done after a short drive cycle.

COMPONENT FUNCTIONAL DESCRIPTION - TWO WIRE TEMP SENSOR

GENERAL OPERATION: Temperature sensors are typically a variable resistor that functions as a normal two wire, 5.0 volt sensor. An Electronic Control Unit (ECU) supplies the Temp Sensor with a 5.0 volt reference signal and a filtered ground (return) circuit. The pull up resistor (Rpu) inside the ECU is a fixed resistance. The resistance in the sensor will change in relation to temperature. The resistors are configured in a simple series circuit with the ECU internally monitoring the voltage on the signal circuit, which is converted into a digital temperature reading. As the resistance of the component increases, the voltage on the signal circuit will also increase. The increased voltage on the signal circuit can be interpreted by the ECU as the temperature increasing or decreasing depending on the temp sensor and ECU software design.

- **Circuit Fault Diagnostics:** On a normally functioning sensor with no circuit issues, the signal voltage should never read 5.0 volts or 0.0 volts. This allows the module the capability of diagnosing an open or short in the sensor or wiring. As a general rule, a voltage reading above approximately 4.9 volts would set a circuit high/open fault. A voltage below approximately 0.10 volts will set a circuit Low fault. Calibrated thresholds can vary slightly from module to module and vehicle to vehicle.
- **Performance Fault Diagnostics:** Since added resistance in the sensor or circuitry can cause an irrational reading and no circuit fault, the module will check the signal for a plausible reading in some cases. This can be done using different methods. One common way is by comparing the sensor reading to other temperature sensors. With this method the module will compare the sensors at a time when the readings should be within a calibrated threshold of each other (I.E. Ignition on after a cold soak). Another method could be to monitor for the temperature to increase or decrease when turning on or off a device that is being controlled by the ECU. In either case, an irrational reading can set a sensor performance fault.



ANALOG TO DIGITAL SIGNAL DESCRIPTION

Electronic Control Modules read analog signal voltages and convert them to digital counts. Each count is an equal percentage of the voltage. This can be seen when viewing the voltages of some sensors or switches on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts on most sensors to a battery voltage reference on switches.

- The resolution of the signal is determined by the required precision of the input by the ECU. Typically, sensor signals have a high resolution (Ex. a sensor signal may be divided into 4096 counts, or 5.0 volts divided by 4096). This allows the module to read small changes over a wide range in a variable resistance sensor signal used for a temperature, pressure, or position sensors.
- Switches will typically have a low resolution since they are usually only reporting a few switch states (Ex. a switch may typically be divided into only 15-20 counts, or Battery voltage divided by 15). The highest and lowest one or two counts will be used for detecting opens or shorts if the switch signal is being rationalized. The remaining counts are divided up between the states being detected.

ENABLING CONDITIONS AND POSSIBLE CAUSES - ENGINE COOLANT TEMP SENSOR

MONITORING CONDITIONS
Circuit Low/High Faults - With the ignition on, battery voltage above a calibrated threshold. **Performance Fault** - With the ignition on after an eight hour cold soak on the previous engine off cycle. Ambient Air, Intake Air, Engine Oil and Engine Coolant Temperature values are above -64B°C (-83B°F).

FAULT SETTING CRITERIA
Circuit Low Fault - The sensor signal voltage is below a calibrated threshold. The threshold is typically in the 0.1 volt range. **Circuit High Fault** - The sensor signal voltage is above a calibrated threshold. The threshold is typically in the 4.9 volt range. **Performance Fault** - The sensor signal voltage is irrational - typically not within 10B°C - 15B°C (18B°F - 27B°F) of the other engine temp sensors. **NOTE:** **The fail values will increase if a block heater is detected.**

POSSIBLE CAUSES
TEMP SENSOR HARNESS CONNECTOR DAMAGED OR NOT CONNECTED COMPLETELY (CIRCUIT HIGH/PERFORMANCE FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT (CIRCUIT LOW FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH FAULT)
TEMP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH/PERFORMANCE FAULT)
TEMP SENSOR RETURN CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH/PERFORMANCE FAULT)
FAULTY TEMP SENSOR (OPEN, SHORTED OR DRIFTED OUT OF RANGE)
FAULTY POWERTRAIN CONTROL MODULE (PCM)

DIAGNOSTIC OVERVIEW

TEMP SENSOR ECU DIAGNOSTICS:

- **Circuit Fault Diagnostics:** With a normally functioning sensor that has no circuit issues, the signal voltage should never read 5.0 volts or 0.0 volts. This allows the module the capability of diagnosing an open or short in the sensor or wiring. As a general rule, a voltage reading above approximately 4.9 volts will typically set a circuit high/open fault. A voltage below approximately 0.10 volts will typically set a circuit Low fault. Calibrated thresholds can vary slightly from module to module and vehicle to vehicle.

- **Performance Fault Diagnostics:** Added resistance in the sensor or circuitry can cause an irrational reading and no circuit fault. The module will check the signal for a plausible reading in most cases. This can be done using different methods. One common way is by comparing the sensor reading to other temperature sensors. With this method the module will compare the sensors at a time when the readings should be within a calibrated threshold of each other (Ex. Ignition on after a cold soak). Another method could be to monitor for the temperature to increase or decrease when turning on or off a device that is being controlled by the ECU. In either case, an irrational reading can set a sensor performance fault.

PRELIMINARY DIAGNOSTIC CHECKS

1. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the ECU. Low Battery voltage can cause a DTC.
3. Circuit faults should typically be diagnosed before rationality/performance faults.
4. Check the component harness connector(s) for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the component harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connections issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

Intermittent testing for a circuit low/high fault with the Mopar Scope:

1. Back probe and connect the scope lead to the temp sensor signal circuit.
2. Monitor the circuit voltage while wiggle testing the wiring harness.
3. If you are not able to monitor the scope signal voltage during wiggle testing, set up a trigger to catch an intermittent condition. Set the trigger for voltage above 4.9 volts for an intermittent circuit high fault or below 0.1 volts for a circuit low fault.

DIAGNOSTIC TEST - TWO WIRE TEMP SENSOR

NOTE: **If a repair is performed to the AAT Sensor wiring, the sensor is replaced, or the BCM connector is disconnected during testing to correct an active DTC, the vehicle must be driven for a minimum of 5 minutes above 15 mph to update the AAT temp signal before the DTC will go stored and can be erased.**

NOTE: **The AAT Sensor is an individually serviceable component. If the measured resistance from the AAT Sensor does not meet the values from the Technical Data information, then only the sensor should be replaced and not the entire mirror assembly.**

NOTE: **There are multiple test methods listed below. The first two tests are a complete system diagnostic of the wiring and sensor. The remaining tests are broken up by the failure modes. There can be advantages to using each method. All of the methods do not need to be performed. Pick the best test method based on accessibility, ease of testing, availability of test equipment. It is a good practice to perform a complete check of the wiring in case of calibration issues. Failure to perform a complete check of the wiring may lead to unnecessary replacement of the component or ECU. In some cases it may be beneficial to use parts of each method to test for different failure modes.**

COMPLETE CIRCUIT DIAGNOSTICS USING THE ELECTRICAL TEST LEAD KIT:

1. Check the ECU, signal and sensor ground circuits together to determine if the temp sensor is faulty. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the temp signal and sensor ground circuits at the temp sensor harness connector. Move the switch on the Electrical Test Lead Kit between the open and closed positions while monitoring the scan tool. If monitoring for faults, the circuit high fault should set when switched to the open position and the circuit low fault should set when switched to the closed position. If the sensor voltage is available on the scan tool, monitor the voltage readings. The voltage should be 5.0 volts when switched to the open position and 0.0 volts when switched to the closed position. Move the switch to adjust and use the tool to vary the resistance while monitoring the ECU signal voltage on the scan tool. **Pick the result from a, b, or c below that best matches the results.**

1. **If the faults set as described and the signal voltage is 5.0 volts and 0.0 volts** - the ECU and temp sensor circuits are testing good. The temp sensor is most likely faulty or has a poor connection at the harness connector. Check the temp sensor harness connector for pushed out, spread, corroded or dirty terminals before condemning the sensor. The internal resistance of the sensor can be measured and compared to the table (if available) to verify a faulty sensor.
2. **If the signal voltage is stuck low or only the circuit low fault sets** - the most likely cause is the temp sensor signal circuit shorted to chassis ground or the temp sensor ground circuit. Check the temp sensor signal circuit for a short to ground, or to the temp sensor ground circuit. If the signal circuit is not shorted, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals before condemning an ECU. If no issues are found, the ECU is most likely faulty.
3. **If the signal voltage is stuck high or only the circuit high fault sets** - the most likely cause is an open or very high resistance in the temp sensor signal or temp sensor ground circuit. **Continue to step d.**
4. **If the signal reading on the scan tool shows voltage present when switched to closed** - remove the test lead from the sensor ground circuit and connect it to a good chassis ground while observing the voltage on the scan tool. If the voltage drops to 0.0 volts the resistance is in the temp sensor ground circuit. If the voltage is still present the resistance is in the temp sensor signal circuit. Check the appropriate circuit for high resistance. Typically, it should be less than 3.0 Ohms. If the circuits check good, **continue to step e.**
5. **If the circuits are checked and do not have excessive resistance** - Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the ECU. If no issues are found, replace the ECU in accordance with the service information.

COMPLETE CIRCUIT DIAGNOSTICS USING CONVENTIONAL VOLTAGE TESTING WITH A DVOM:

1. Verify the temp sensor and ECU harness connectors are connected and locked properly.
2. Turn the ignition on. Back probe and measure the voltage on the temp sensor signal circuit at the Fuel Pump harness connector. Pick the result below that best matches the voltage reading.
    1. **If the signal voltage is reading between 0.1 and 4.9 volts** - the temp sensor signal is most likely giving a legitimate reading. If the circuit fault is active and the voltage reading on the scan tool does not match the DVOM voltage reading, the ECU is likely faulty.
    2. **If the signal measures a constant 0.0 volts** - this indicates that the temp sensor signal circuit is shorted to ground or has an open between the ECU and temp sensor. If the circuit high fault is set, the most likely failure is an open in the temp sensor signal circuit. If the circuit low fault is set, the

most likely failure is a short to ground in the temp sensor signal circuit or possibly a faulty sensor (disconnecting the temp sensor harness connector and checking for the circuit high fault to become active would indicate that the temp sensor is most likely faulty). **Continue to step 3.**

  3. **If the signal reading has a constant voltage above 6.0 volts** - this would indicate that the signal circuit is shorted to another voltage supply.
  4. **If the signal reading has a constant 5.0 volts** - this indicates an open further downstream in the circuitry. Most likely the temp sensor or the temp sensor ground circuit. **Continue to step 4.**

3. Disconnect the temp sensor and ECU harness connectors and check the temp sensor signal circuit for high resistance and short to ground. If the signal circuit checks good, check all connectors in the system for pushed out, spread, corroded or dirty terminals before condemning a ECU. If all of the connectors check good, replace the ECU in accordance with the service information.
4. To check the temp sensor, move the test lead over and back probe the temp sensor ground circuit at the temp sensor harness connector.

TYPICAL CIRCUIT LOW DIAGNOSTICS:

1. To quickly eliminate the temp sensor as a possible cause with an **active** circuit low fault, disconnect the temp sensor harness connector while monitoring for the circuit high fault to become active on the scan tool.
   1. If the circuit high fault becomes active when the sensor is disconnected, the temp sensor is most likely faulty.
   2. If the circuit high fault does not become active, **continue to step 2.**
2. Disconnect the ECU harness connector to isolate the circuit. Check the temp signal circuit for continuity to both chassis ground and the sensor ground circuit.
   1. If there is continuity to either, repair the signal circuit for a short to ground or the sensor ground circuit.
   2. If the signal circuit is not shorted, replace the ECU in accordance with the service information.

TYPICAL CIRCUIT HIGH DIAGNOSTICS:

1. Disconnect the temp sensor harness connector and measure the temp sensor signal circuit voltage with the ignition on. The signal circuit voltage should be between 4.9 and 5.6 volts.
   1. If battery voltage is present, repair the sensor signal circuit for a short to another voltage supply circuit.
   2. If the voltage is correct, **continue to step 2.** .
2. With an active fault, monitor the scan tool and connect a jumper across the terminals with the ignition on. Typically, the temp sensor signal voltage should change to 0 volts on the scan tool with the jumper in place. If the voltage data read is not available, check for the circuit low fault to set with the jumper in place. If either result occurs, the temp sensor is faulty.
   1. If either result occurs, the temp sensor is faulty.
   2. If the voltage does not change to 0 volts or the circuit low fault is not present with the jumper in place, **continue to step 3.** .
3. Check the resistance of the temp sensor signal circuit and temp sensor ground circuit. Typically the circuit resistance should be less than 5.0 Ohms.
   1. If there is an open or high resistance in either circuit, repair the circuit.
   2. If the temp sensor signal and ground circuits test good, and the voltage is still reading high or only the circuit high fault is present, Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning ECU. If no issues are found, replace the ECU in accordance with the service information.

TYPICAL PERFORMANCE/RATIONALITY DIAGNOSTICS:

NOTE: Temp sensor performance faults typically set due to resistance in one of the circuits or a sensor that is stuck or drifted out of range. The (special tool #2064100080, Kit, Electrical Test Lead) can be used with the scan tool to test the wiring and controller.

1. Disconnect the temp sensor harness connector and connect the Electrical Test Kit leads to the temp sensor harness connector.
2. Move the switch on the tool to open. The signal should read 5.0 volts and a circuit high DTC should be active or pending on the scan tool.
3. Next flip the switch to the closed position. The signal should read 0 volts and a circuit low fault should be active or pending on the scan tool. If the scan tool reads as described in steps 2 and 3, it would indicate the wiring and ECU are good and the sensor is likely faulty. If there is voltage present between 0 and 5.0 volts with the test tool in the closed position it would indicate there is likely resistance in one of the circuits. **Continue to step a.**
    1. To determine which circuit has resistance, remove the test lead connected to the temp sensor ground circuit and connect it to a good chassis ground.
        - If the signal changes to 0 volts it would indicate the temp sensor ground has resistance. **Continue to step b.**
        - If there is still voltage present it would indicate the temp sensor signal has resistance. **Continue to step b.**
    2. Confirm the suspect circuit issue by isolating the suspect circuit and measuring the resistance of the circuit between the sensor and ECU harness connectors. If no resistance is measured, carefully check all connectors in the path of the circuit for spread or dirty/corroded terminals. If the circuits check good (no resistance), verify whether the issue is with the temp sensor or ECU. **Continue to step 4 or 5.**
4. **If a temp table is available** , the sensor and ECU can be verified in one of the following ways.
    1. Move the switch to adjust and connect an Ohmmeter to the test leads and dial the tool to a resistance value in the table. Connect both leads to the temp sensor harness connector with the ignition on and monitor the data in the scan tool for the proper reading. Use the tool to vary the resistance while monitoring the temp sensor signal temperature/voltage on the scan tool. If the reading matches the table, the temp sensor is likely faulty.
    2. If the temp sensor actual temperature can be acquired or reasonably estimated, measure the resistance across the terminals of the temp sensor and compare to the value in the table. If the resistance of the sensor is not in range of the table, the temp sensor is likely faulty.
5. **If a temp table is not available** for the sensor being tested, connect the Electrical Test Kit leads to the harness connector and flip the switch to adjust. With the ignition on, monitor the scan tool data and slowly adjust the resistance in the circuit. The temperature/voltage value should change with the resistance change. If the value changes as the resistance is varied it would indicate that the temp sensor is likely faulty.

VERIFYING AN ECU FAILURE: An ECU that is faulty and not able to properly read the signal can usually be determined when opening and shorting the circuits and monitoring the signal voltage and fault codes. If the expected voltage reads or DTCs do not occur when opening and jumping the connector, and the circuits are not shorted or open, it would indicate a faulty ECU. Before condemning and ECU, **always** carefully check all connectors in the path of the circuit for water intrusion, spread, pushed out, burnt or corroded terminals.

P0117-ENGINE COOLANT TEMPERATURE SENSOR CIRCUIT LOW

For a complete COOLING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION - ENGINE COOLANT TEMPERATURE (ECT) SENSOR

The Powertrain Control Module (PCM) monitors the ECT Sensor analog signal voltage. The ECT Sensor input signal is used with other sensor inputs in calculating fuel delivery and engine timing. The PCM also uses the

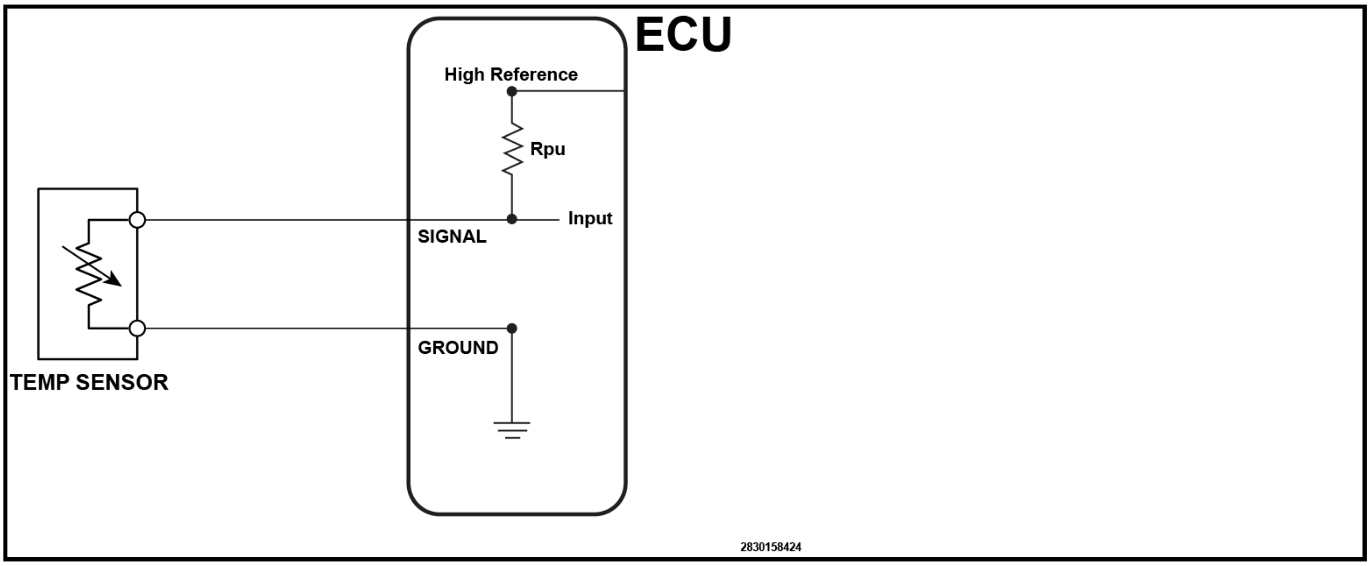
ECT Sensor input for determining when to enable several OBD diagnostics. Each of these will impact emissions, which is why the ECT Sensor signal must be rationalized by the PCM.

The ECT Sensor rationality diagnostic looks at the outputs of three temperature sensors and compares them under cold start conditions. Following a start to run delay time the outputs of the Ambient Air Temperature (AAT) Sensor, Engine Coolant Temperature (ECT) Sensor, and Intake Air Temperature (IAT) Sensor will be compared. If the IAT and AAT Sensors agree and the coolant temperature does not agree, the ECT Sensor is declared as irrational. If declared irrational a second comparison will be done after a short drive cycle.

COMPONENT FUNCTIONAL DESCRIPTION - TWO WIRE TEMP SENSOR

GENERAL OPERATION: Temperature sensors are typically a variable resistor that functions as a normal two wire, 5.0 volt sensor. An Electronic Control Unit (ECU) supplies the Temp Sensor with a 5.0 volt reference signal and a filtered ground (return) circuit. The pull up resistor (Rpu) inside the ECU is a fixed resistance. The resistance in the sensor will change in relation to temperature. The resistors are configured in a simple series circuit with the ECU internally monitoring the voltage on the signal circuit, which is converted into a digital temperature reading. As the resistance of the component increases, the voltage on the signal circuit will also increase. The increased voltage on the signal circuit can be interpreted by the ECU as the temperature increasing or decreasing depending on the temp sensor and ECU software design.

- **Circuit Fault Diagnostics:** On a normally functioning sensor with no circuit issues, the signal voltage should never read 5.0 volts or 0.0 volts. This allows the module the capability of diagnosing an open or short in the sensor or wiring. As a general rule, a voltage reading above approximately 4.9 volts would set a circuit high/open fault. A voltage below approximately 0.10 volts will set a circuit Low fault. Calibrated thresholds can vary slightly from module to module and vehicle to vehicle.
- **Performance Fault Diagnostics:** Since added resistance in the sensor or circuitry can cause an irrational reading and no circuit fault, the module will check the signal for a plausible reading in some cases. This can be done using different methods. One common way is by comparing the sensor reading to other temperature sensors. With this method the module will compare the sensors at a time when the readings should be within a calibrated threshold of each other (I.E. Ignition on after a cold soak). Another method could be to monitor for the temperature to increase or decrease when turning on or off a device that is being controlled by the ECU. In either case, an irrational reading can set a sensor performance fault.



ANALOG TO DIGITAL SIGNAL DESCRIPTION

Electronic Control Modules read analog signal voltages and convert them to digital counts. Each count is an equal percentage of the voltage. This can be seen when viewing the voltages of some sensors or switches on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts on most sensors to a battery voltage reference on switches.

- The resolution of the signal is determined by the required precision of the input by the ECU. Typically, sensor signals have a high resolution (Ex. a sensor signal may be divided into 4096 counts, or 5.0 volts divided by 4096). This allows the module to read small changes over a wide range in a variable resistance sensor signal used for a temperature, pressure, or position sensors.

- Switches will typically have a low resolution since they are usually only reporting a few switch states (Ex. a switch may typically be divided into only 15-20 counts, or Battery voltage divided by 15). The highest and lowest one or two counts will be used for detecting opens or shorts if the switch signal is being rationalized. The remaining counts are divided up between the states being detected.

ENABLING CONDITIONS AND POSSIBLE CAUSES - ENGINE COOLANT TEMP SENSOR

MONITORING CONDITIONS
Circuit Low/High Faults - With the ignition on, battery voltage above a calibrated threshold. **Performance Fault** - With the ignition on after an eight hour cold soak on the previous engine off cycle. Ambient Air, Intake Air, Engine Oil and Engine Coolant Temperature values are above -64B°C (-83B°F).

FAULT SETTING CRITERIA
Circuit Low Fault - The sensor signal voltage is below a calibrated threshold. The threshold is typically in the 0.1 volt range. **Circuit High Fault** - The sensor signal voltage is above a calibrated threshold. The threshold is typically in the 4.9 volt range. **Performance Fault** - The sensor signal voltage is irrational - typically not within 10B°C - 15B°C (18B°F - 27B°F) of the other engine temp sensors. **NOTE:** **The fail values will increase if a block heater is detected.**

POSSIBLE CAUSES
TEMP SENSOR HARNESS CONNECTOR DAMAGED OR NOT CONNECTED COMPLETELY (CIRCUIT HIGH/PERFORMANCE FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT (CIRCUIT LOW FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH FAULT)
TEMP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH/PERFORMANCE FAULT)
TEMP SENSOR RETURN CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH/PERFORMANCE FAULT)
FAULTY TEMP SENSOR (OPEN, SHORTED OR DRIFTED OUT OF RANGE)
FAULTY POWERTRAIN CONTROL MODULE (PCM)

DIAGNOSTIC OVERVIEW

TEMP SENSOR ECU DIAGNOSTICS:

- **Circuit Fault Diagnostics:** With a normally functioning sensor that has no circuit issues, the signal voltage should never read 5.0 volts or 0.0 volts. This allows the module the capability of diagnosing an open or short in the sensor or wiring. As a general rule, a voltage reading above approximately 4.9 volts will typically set a circuit high/open fault. A voltage below approximately 0.10 volts will typically set a circuit Low fault. Calibrated thresholds can vary slightly from module to module and vehicle to vehicle.
- **Performance Fault Diagnostics:** Added resistance in the sensor or circuitry can cause an irrational reading and no circuit fault. The module will check the signal for a plausible reading in most cases. This can be done using different methods. One common way is by comparing the sensor reading to other

temperature sensors. With this method the module will compare the sensors at a time when the readings should be within a calibrated threshold of each other (Ex. Ignition on after a cold soak). Another method could be to monitor for the temperature to increase or decrease when turning on or off a device that is being controlled by the ECU. In either case, an irrational reading can set a sensor performance fault.

PRELIMINARY DIAGNOSTIC CHECKS

1. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the ECU. Low Battery voltage can cause a DTC.
3. Circuit faults should typically be diagnosed before rationality/performance faults.
4. Check the component harness connector(s) for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the component harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connections issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

Intermittent testing for a circuit low/high fault with the Mopar Scope:

1. Back probe and connect the scope lead to the temp sensor signal circuit.
2. Monitor the circuit voltage while wiggle testing the wiring harness.

3. If you are not able to monitor the scope signal voltage during wiggle testing, set up a trigger to catch an intermittent condition. Set the trigger for voltage above 4.9 volts for an intermittent circuit high fault or below 0.1 volts for a circuit low fault.

DIAGNOSTIC TEST - TWO WIRE TEMP SENSOR

NOTE: **If a repair is performed to the AAT Sensor wiring, the sensor is replaced, or the BCM connector is disconnected during testing to correct an active DTC, the vehicle must be driven for a minimum of 5 minutes above 15 mph to update the AAT temp signal before the DTC will go stored and can be erased.**

NOTE: **The AAT Sensor is an individually serviceable component. If the measured resistance from the AAT Sensor does not meet the values from the Technical Data information, then only the sensor should be replaced and not the entire mirror assembly.**

NOTE: **There are multiple test methods listed below. The first two tests are a complete system diagnostic of the wiring and sensor. The remaining tests are broken up by the failure modes. There can be advantages to using each method. All of the methods do not need to be performed. Pick the best test method based on accessibility, ease of testing, availability of test equipment. It is a good practice to perform a complete check of the wiring in case of calibration issues. Failure to perform a complete check of the wiring may lead to unnecessary replacement of the component or ECU. In some cases it may be beneficial to use parts of each method to test for different failure modes.**

COMPLETE CIRCUIT DIAGNOSTICS USING THE ELECTRICAL TEST LEAD KIT:

1. Check the ECU, signal and sensor ground circuits together to determine if the temp sensor is faulty. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the temp signal and sensor ground circuits at the temp sensor harness connector. Move the switch on the Electrical Test Lead Kit between the open and closed positions while monitoring the scan tool. If monitoring for faults, the circuit high fault should set when switched to the open position and the circuit low fault should set when switched to the closed position. If the sensor voltage is available on the scan tool, monitor the voltage readings. The voltage should be 5.0 volts when switched to the open position and 0.0 volts when switched to the closed position. Move the switch to adjust and use the tool to vary the resistance while monitoring the ECU signal voltage on the scan tool. **Pick the result from a, b, or c below that best matches the results.**

1. **If the faults set as described and the signal voltage is 5.0 volts and 0.0 volts** - the ECU and temp sensor circuits are testing good. The temp sensor is most likely faulty or has a poor connection at the harness connector. Check the temp sensor harness connector for pushed out, spread, corroded or dirty terminals before condemning the sensor. The internal resistance of the sensor can be measured and compared to the table (if available) to verify a faulty sensor.
2. **If the signal voltage is stuck low or only the circuit low fault sets** - the most likely cause is the temp sensor signal circuit shorted to chassis ground or the temp sensor ground circuit. Check the temp sensor signal circuit for a short to ground, or to the temp sensor ground circuit. If the signal circuit is not shorted, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals before condemning an ECU. If no issues are found, the ECU is most likely faulty.
3. **If the signal voltage is stuck high or only the circuit high fault sets** - the most likely cause is an open or very high resistance in the temp sensor signal or temp sensor ground circuit. **Continue to step d.**
4. **If the signal reading on the scan tool shows voltage present when switched to closed** - remove the test lead from the sensor ground circuit and connect it to a good chassis ground while observing the voltage on the scan tool. If the voltage drops to 0.0 volts the resistance is in the temp sensor ground circuit. If the voltage is still present the resistance is in the temp sensor signal circuit. Check the appropriate circuit for high resistance. Typically, it should be less than 3.0 Ohms. If the circuits check good, **continue to step e.**
5. **If the circuits are checked and do not have excessive resistance** - Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the ECU. If no issues are found, replace the ECU in accordance with the service information.

COMPLETE CIRCUIT DIAGNOSTICS USING CONVENTIONAL VOLTAGE TESTING WITH A DVOM:

1. Verify the temp sensor and ECU harness connectors are connected and locked properly.
2. Turn the ignition on. Back probe and measure the voltage on the temp sensor signal circuit at the Fuel Pump harness connector. Pick the result below that best matches the voltage reading.
    1. **If the signal voltage is reading between 0.1 and 4.9 volts** - the temp sensor signal is most likely giving a legitimate reading. If the circuit fault is active and the voltage reading on the scan tool does not match the DVOM voltage reading, the ECU is likely faulty.
    2. **If the signal measures a constant 0.0 volts** - this indicates that the temp sensor signal circuit is shorted to ground or has an open between the ECU and temp sensor. If the circuit high fault is set, the most likely failure is an open in the temp sensor signal circuit. If the circuit low fault is set, the most likely failure is a short to ground in the temp sensor signal circuit or possibly a faulty sensor (disconnecting the temp sensor harness connector and checking for the circuit high fault to become active would indicate that the temp sensor is most likely faulty). **Continue to step 3.**
    3. **If the signal reading has a constant voltage above 6.0 volts** - this would indicate that the signal circuit is shorted to another voltage supply.
    4. **If the signal reading has a constant 5.0 volts** - this indicates an open further downstream in the circuitry. Most likely the temp sensor or the temp sensor ground circuit. **Continue to step 4.**
3. Disconnect the temp sensor and ECU harness connectors and check the temp sensor signal circuit for high resistance and short to ground. If the signal circuit checks good, check all connectors in the system for pushed out, spread, corroded or dirty terminals before condemning a ECU. If all of the connectors check good, replace the ECU in accordance with the service information.
4. To check the temp sensor, move the test lead over and back probe the temp sensor ground circuit at the temp sensor harness connector.

TYPICAL CIRCUIT LOW DIAGNOSTICS:

1. To quickly eliminate the temp sensor as a possible cause with an **active** circuit low fault, disconnect the temp sensor harness connector while monitoring for the circuit high fault to become active on the scan

tool.

    1. If the circuit high fault becomes active when the sensor is disconnected, the temp sensor is most likely faulty.
    2. If the circuit high fault does not become active, **continue to step 2.**
2. Disconnect the ECU harness connector to isolate the circuit. Check the temp signal circuit for continuity to both chassis ground and the sensor ground circuit.
    1. If there is continuity to either, repair the signal circuit for a short to ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, replace the ECU in accordance with the service information.

TYPICAL CIRCUIT HIGH DIAGNOSTICS:

1. Disconnect the temp sensor harness connector and measure the temp sensor signal circuit voltage with the ignition on. The signal circuit voltage should be between 4.9 and 5.6 volts.
    1. If battery voltage is present, repair the sensor signal circuit for a short to another voltage supply circuit.
    2. If the voltage is correct, **continue to step 2.** .
2. With an active fault, monitor the scan tool and connect a jumper across the terminals with the ignition on. Typically, the temp sensor signal voltage should change to 0 volts on the scan tool with the jumper in place. If the voltage data read is not available, check for the circuit low fault to set with the jumper in place. If either result occurs, the temp sensor is faulty.
    1. If either result occurs, the temp sensor is faulty.
    2. If the voltage does not change to 0 volts or the circuit low fault is not present with the jumper in place, **continue to step 3.** .
3. Check the resistance of the temp sensor signal circuit and temp sensor ground circuit. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the circuit.
    2. If the temp sensor signal and ground circuits test good, and the voltage is still reading high or only the circuit high fault is present, Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning ECU. If no issues are found, replace the ECU in accordance with the service information.

TYPICAL PERFORMANCE/RATIONALITY DIAGNOSTICS:

NOTE: **Temp sensor performance faults typically set due to resistance in one of the circuits or a sensor that is stuck or drifted out of range. The (special tool #2064100080, Kit, Electrical Test Lead) can be used with the scan tool to test the wiring and controller.**

1. Disconnect the temp sensor harness connector and connect the Electrical Test Kit leads to the temp sensor harness connector.
2. Move the switch on the tool to open. The signal should read 5.0 volts and a circuit high DTC should be active or pending on the scan tool.
3. Next flip the switch to the closed position. The signal should read 0 volts and a circuit low fault should be active or pending on the scan tool. If the scan tool reads as described in steps 2 and 3, it would indicate the wiring and ECU are good and the sensor is likely faulty. If there is voltage present between 0 and 5.0 volts with the test tool in the closed position it would indicate there is likely resistance in one of the circuits. **Continue to step a.**
    1. To determine which circuit has resistance, remove the test lead connected to the temp sensor ground circuit and connect it to a good chassis ground.
        - If the signal changes to 0 volts it would indicate the temp sensor ground has resistance. **Continue to step b.**

- If there is still voltage present it would indicate the temp sensor signal has resistance. **Continue to step b.**

2. Confirm the suspect circuit issue by isolating the suspect circuit and measuring the resistance of the circuit between the sensor and ECU harness connectors. If no resistance is measured, carefully check all connectors in the path of the circuit for spread or dirty/corroded terminals. If the circuits check good (no resistance), verify whether the issue is with the temp sensor or ECU. **Continue to step 4 or 5.**

4. **If a temp table is available** , the sensor and ECU can be verified in one of the following ways.
   1. Move the switch to adjust and connect an Ohmmeter to the test leads and dial the tool to a resistance value in the table. Connect both leads to the temp sensor harness connector with the ignition on and monitor the data in the scan tool for the proper reading. Use the tool to vary the resistance while monitoring the temp sensor signal temperature/voltage on the scan tool. If the reading matches the table, the temp sensor is likely faulty.
   2. If the temp sensor actual temperature can be acquired or reasonably estimated, measure the resistance across the terminals of the temp sensor and compare to the value in the table. If the resistance of the sensor is not in range of the table, the temp sensor is likely faulty.
5. **If a temp table is not available** for the sensor being tested, connect the Electrical Test Kit leads to the harness connector and flip the switch to adjust. With the ignition on, monitor the scan tool data and slowly adjust the resistance in the circuit. The temperature/voltage value should change with the resistance change. If the value changes as the resistance is varied it would indicate that the temp sensor is likely faulty.

VERIFYING AN ECU FAILURE: An ECU that is faulty and not able to properly read the signal can usually be determined when opening and shorting the circuits and monitoring the signal voltage and fault codes. If the expected voltage reads or DTCs do not occur when opening and jumping the connector, and the circuits are not shorted or open, it would indicate a faulty ECU. Before condemning and ECU, **always** carefully check all connectors in the path of the circuit for water intrusion, spread, pushed out, burnt or corroded terminals.

P0118-ENGINE COOLANT TEMPERATURE SENSOR CIRCUIT HIGH

For a complete COOLING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION - ENGINE COOLANT TEMPERATURE (ECT) SENSOR

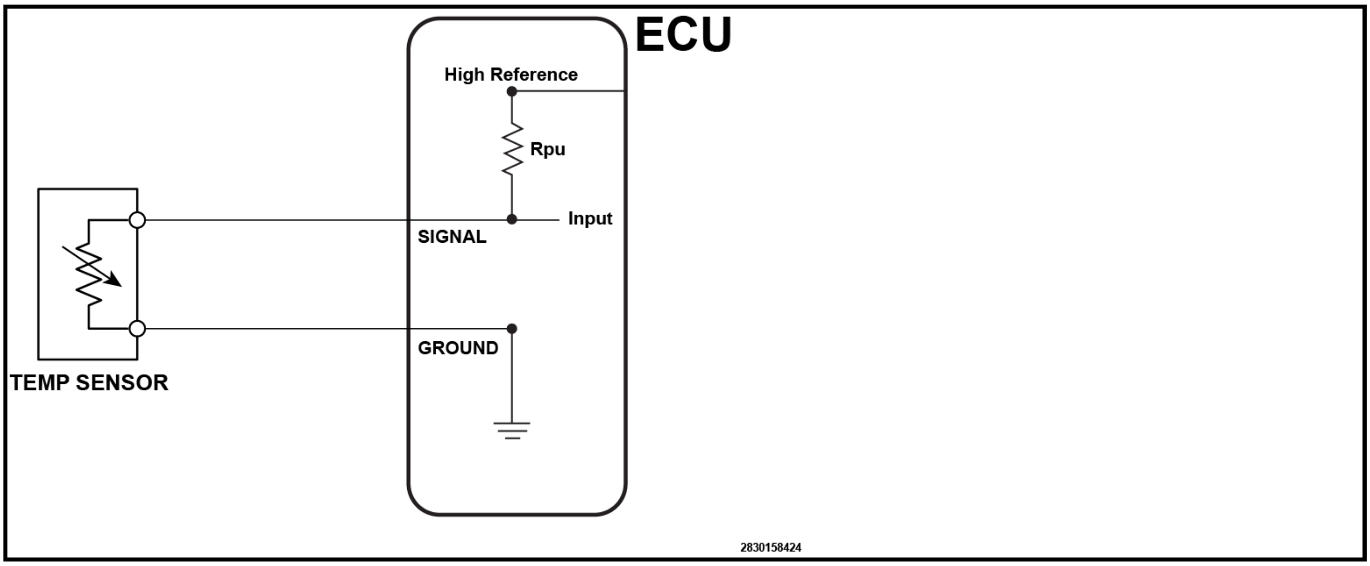
The Powertrain Control Module (PCM) monitors the ECT Sensor analog signal voltage. The ECT Sensor input signal is used with other sensor inputs in calculating fuel delivery and engine timing. The PCM also uses the ECT Sensor input for determining when to enable several OBD diagnostics. Each of these will impact emissions, which is why the ECT Sensor signal must be rationalized by the PCM.

The ECT Sensor rationality diagnostic looks at the outputs of three temperature sensors and compares them under cold start conditions. Following a start to run delay time the outputs of the Ambient Air Temperature (AAT) Sensor, Engine Coolant Temperature (ECT) Sensor, and Intake Air Temperature (IAT) Sensor will be compared. If the IAT and AAT Sensors agree and the coolant temperature does not agree, the ECT Sensor is declared as irrational. If declared irrational a second comparison will be done after a short drive cycle.

COMPONENT FUNCTIONAL DESCRIPTION - TWO WIRE TEMP SENSOR

GENERAL OPERATION: Temperature sensors are typically a variable resistor that functions as a normal two wire, 5.0 volt sensor. An Electronic Control Unit (ECU) supplies the Temp Sensor with a 5.0 volt reference signal and a filtered ground (return) circuit. The pull up resistor (Rpu) inside the ECU is a fixed resistance. The resistance in the sensor will change in relation to temperature. The resistors are configured in a simple series circuit with the ECU internally monitoring the voltage on the signal circuit, which is converted into a digital temperature reading. As the resistance of the component increases, the voltage on the signal circuit will also increase. The increased voltage on the signal circuit can be interpreted by the ECU as the temperature increasing or decreasing depending on the temp sensor and ECU software design.

- **Circuit Fault Diagnostics:** On a normally functioning sensor with no circuit issues, the signal voltage should never read 5.0 volts or 0.0 volts. This allows the module the capability of diagnosing an open or short in the sensor or wiring. As a general rule, a voltage reading above approximately 4.9 volts would set a circuit high/open fault. A voltage below approximately 0.10 volts will set a circuit Low fault. Calibrated thresholds can vary slightly from module to module and vehicle to vehicle.
- **Performance Fault Diagnostics:** Since added resistance in the sensor or circuitry can cause an irrational reading and no circuit fault, the module will check the signal for a plausible reading in some cases. This can be done using different methods. One common way is by comparing the sensor reading to other temperature sensors. With this method the module will compare the sensors at a time when the readings should be within a calibrated threshold of each other (I.E. Ignition on after a cold soak). Another method could be to monitor for the temperature to increase or decrease when turning on or off a device that is being controlled by the ECU. In either case, an irrational reading can set a sensor performance fault.



ANALOG TO DIGITAL SIGNAL DESCRIPTION

Electronic Control Modules read analog signal voltages and convert them to digital counts. Each count is an equal percentage of the voltage. This can be seen when viewing the voltages of some sensors or switches on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts on most sensors to a battery voltage reference on switches.

- The resolution of the signal is determined by the required precision of the input by the ECU. Typically, sensor signals have a high resolution (Ex. a sensor signal may be divided into 4096 counts, or 5.0 volts divided by 4096). This allows the module to read small changes over a wide range in a variable resistance sensor signal used for a temperature, pressure, or position sensors.
- Switches will typically have a low resolution since they are usually only reporting a few switch states (Ex. a switch may typically be divided into only 15-20 counts, or Battery voltage divided by 15). The highest and lowest one or two counts will be used for detecting opens or shorts if the switch signal is being rationalized. The remaining counts are divided up between the states being detected.

ENABLING CONDITIONS AND POSSIBLE CAUSES - ENGINE COOLANT TEMP SENSOR

MONITORING CONDITIONS
Circuit Low/High Faults - With the ignition on, battery voltage above a calibrated threshold. **Performance Fault** - With the ignition on after an eight hour cold soak on the previous engine off cycle. Ambient Air, Intake Air, Engine Oil and Engine Coolant Temperature values are above -64B°C (-83B°F).

FAULT SETTING CRITERIA
Circuit Low Fault - The sensor signal voltage is below a calibrated threshold. The threshold is typically in the 0.1 volt range.

FAULT SETTING CRITERIA
Circuit High Fault - The sensor signal voltage is above a calibrated threshold. The threshold is typically in the 4.9 volt range. **Performance Fault** - The sensor signal voltage is irrational - typically not within 10B°C - 15B°C (18B°F - 27B°F) of the other engine temp sensors. **NOTE:** **The fail values will increase if a block heater is detected.**

POSSIBLE CAUSES
TEMP SENSOR HARNESS CONNECTOR DAMAGED OR NOT CONNECTED COMPLETELY (CIRCUIT HIGH/PERFORMANCE FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT (CIRCUIT LOW FAULT)
TEMP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH FAULT)
TEMP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH/PERFORMANCE FAULT)
TEMP SENSOR RETURN CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH/PERFORMANCE FAULT)
FAULTY TEMP SENSOR (OPEN, SHORTED OR DRIFTED OUT OF RANGE)
FAULTY POWERTRAIN CONTROL MODULE (PCM)

DIAGNOSTIC OVERVIEW

TEMP SENSOR ECU DIAGNOSTICS:

- **Circuit Fault Diagnostics:** With a normally functioning sensor that has no circuit issues, the signal voltage should never read 5.0 volts or 0.0 volts. This allows the module the capability of diagnosing an open or short in the sensor or wiring. As a general rule, a voltage reading above approximately 4.9 volts will typically set a circuit high/open fault. A voltage below approximately 0.10 volts will typically set a circuit Low fault. Calibrated thresholds can vary slightly from module to module and vehicle to vehicle.
- **Performance Fault Diagnostics:** Added resistance in the sensor or circuitry can cause an irrational reading and no circuit fault. The module will check the signal for a plausible reading in most cases. This can be done using different methods. One common way is by comparing the sensor reading to other temperature sensors. With this method the module will compare the sensors at a time when the readings should be within a calibrated threshold of each other (Ex. Ignition on after a cold soak). Another method could be to monitor for the temperature to increase or decrease when turning on or off a device that is being controlled by the ECU. In either case, an irrational reading can set a sensor performance fault.

PRELIMINARY DIAGNOSTIC CHECKS

1. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the ECU. Low Battery voltage can cause a DTC.
3. Circuit faults should typically be diagnosed before rationality/performance faults.
4. Check the component harness connector(s) for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the component harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connections issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

Intermittent testing for a circuit low/high fault with the Mopar Scope:

1. Back probe and connect the scope lead to the temp sensor signal circuit.
2. Monitor the circuit voltage while wiggle testing the wiring harness.
3. If you are not able to monitor the scope signal voltage during wiggle testing, set up a trigger to catch an intermittent condition. Set the trigger for voltage above 4.9 volts for an intermittent circuit high fault or below 0.1 volts for a circuit low fault.

DIAGNOSTIC TEST - TWO WIRE TEMP SENSOR

NOTE: **If a repair is performed to the AAT Sensor wiring, the sensor is replaced, or the BCM connector is disconnected during testing to correct an active DTC, the vehicle must be driven for a minimum of 5 minutes above 15 mph to update the AAT temp signal before the DTC will go stored and can be erased.**

NOTE: **The AAT Sensor is an individually serviceable component. If the measured resistance from the AAT Sensor does not meet the values from the Technical Data information, then only the sensor should be replaced and not the entire mirror assembly.**

NOTE: **There are multiple test methods listed below. The first two tests are a complete system diagnostic of the wiring and sensor. The remaining tests are broken up by the failure modes. There can be advantages to using each method. All of the methods do not need to be performed. Pick the best test method based on accessibility, ease of testing, availability of test equipment. It is a good practice to perform a complete check of the wiring in case of calibration issues. Failure to perform a complete check of the wiring may lead to unnecessary replacement of the component or ECU. In some cases it may be beneficial to use parts of each method to test for different failure modes.**

COMPLETE CIRCUIT DIAGNOSTICS USING THE ELECTRICAL TEST LEAD KIT:

1. Check the ECU, signal and sensor ground circuits together to determine if the temp sensor is faulty. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the temp signal and sensor ground circuits at the temp sensor harness connector. Move the switch on the Electrical Test Lead Kit between the open and closed positions while monitoring the scan tool. If monitoring for faults, the circuit high fault should set when switched to the open position and the circuit low fault should set when switched to the closed position. If the sensor voltage is available on the scan tool, monitor the voltage readings. The voltage should be 5.0 volts when switched to the open position and 0.0 volts when switched to the closed position. Move the switch to adjust and use the tool to vary the resistance while monitoring the ECU signal voltage on the scan tool. **Pick the result from a, b, or c below that best matches the results.**

    1. **If the faults set as described and the signal voltage is 5.0 volts and 0.0 volts** - the ECU and temp sensor circuits are testing good. The temp sensor is most likely faulty or has a poor connection at the harness connector. Check the temp sensor harness connector for pushed out, spread, corroded or dirty terminals before condemning the sensor. The internal resistance of the sensor can be measured and compared to the table (if available) to verify a faulty sensor.
    2. **If the signal voltage is stuck low or only the circuit low fault sets** - the most likely cause is the temp sensor signal circuit shorted to chassis ground or the temp sensor ground circuit. Check the temp sensor signal circuit for a short to ground, or to the temp sensor ground circuit. If the signal circuit is not shorted, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals before condemning an ECU. If no issues are found, the ECU is most likely faulty.
    3. **If the signal voltage is stuck high or only the circuit high fault sets** - the most likely cause is an open or very high resistance in the temp sensor signal or temp sensor ground circuit. **Continue to step d.**
    4. **If the signal reading on the scan tool shows voltage present when switched to closed** - remove the test lead from the sensor ground circuit and connect it to a good chassis ground while observing

the voltage on the scan tool. If the voltage drops to 0.0 volts the resistance is in the temp sensor ground circuit. If the voltage is still present the resistance is in the temp sensor signal circuit. Check the appropriate circuit for high resistance. Typically, it should be less than 3.0 Ohms. If the circuits check good, **continue to step e.**

5. **If the circuits are checked and do not have excessive resistance** - Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the ECU. If no issues are found, replace the ECU in accordance with the service information.

COMPLETE CIRCUIT DIAGNOSTICS USING CONVENTIONAL VOLTAGE TESTING WITH A DVOM:

1. Verify the temp sensor and ECU harness connectors are connected and locked properly.
2. Turn the ignition on. Back probe and measure the voltage on the temp sensor signal circuit at the Fuel Pump harness connector. Pick the result below that best matches the voltage reading.
    1. **If the signal voltage is reading between 0.1 and 4.9 volts** - the temp sensor signal is most likely giving a legitimate reading. If the circuit fault is active and the voltage reading on the scan tool does not match the DVOM voltage reading, the ECU is likely faulty.
    2. **If the signal measures a constant 0.0 volts** - this indicates that the temp sensor signal circuit is shorted to ground or has an open between the ECU and temp sensor. If the circuit high fault is set, the most likely failure is an open in the temp sensor signal circuit. If the circuit low fault is set, the most likely failure is a short to ground in the temp sensor signal circuit or possibly a faulty sensor (disconnecting the temp sensor harness connector and checking for the circuit high fault to become active would indicate that the temp sensor is most likely faulty). **Continue to step 3.**
    3. **If the signal reading has a constant voltage above 6.0 volts** - this would indicate that the signal circuit is shorted to another voltage supply.
    4. **If the signal reading has a constant 5.0 volts** - this indicates an open further downstream in the circuitry. Most likely the temp sensor or the temp sensor ground circuit. **Continue to step 4.**
3. Disconnect the temp sensor and ECU harness connectors and check the temp sensor signal circuit for high resistance and short to ground. If the signal circuit checks good, check all connectors in the system for pushed out, spread, corroded or dirty terminals before condemning a ECU. If all of the connectors check good, replace the ECU in accordance with the service information.
4. To check the temp sensor, move the test lead over and back probe the temp sensor ground circuit at the temp sensor harness connector.

TYPICAL CIRCUIT LOW DIAGNOSTICS:

1. To quickly eliminate the temp sensor as a possible cause with an **active** circuit low fault, disconnect the temp sensor harness connector while monitoring for the circuit high fault to become active on the scan tool.
    1. If the circuit high fault becomes active when the sensor is disconnected, the temp sensor is most likely faulty.
    2. If the circuit high fault does not become active, **continue to step 2.**
2. Disconnect the ECU harness connector to isolate the circuit. Check the temp signal circuit for continuity to both chassis ground and the sensor ground circuit.
    1. If there is continuity to either, repair the signal circuit for a short to ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, replace the ECU in accordance with the service information.

TYPICAL CIRCUIT HIGH DIAGNOSTICS:

1. Disconnect the temp sensor harness connector and measure the temp sensor signal circuit voltage with the ignition on. The signal circuit voltage should be between 4.9 and 5.6 volts.

    1. If battery voltage is present, repair the sensor signal circuit for a short to another voltage supply circuit.
    2. If the voltage is correct, **continue to step 2.** .
2. With an active fault, monitor the scan tool and connect a jumper across the terminals with the ignition on. Typically, the temp sensor signal voltage should change to 0 volts on the scan tool with the jumper in place. If the voltage data read is not available, check for the circuit low fault to set with the jumper in place. If either result occurs, the temp sensor is faulty.
    1. If either result occurs, the temp sensor is faulty.
    2. If the voltage does not change to 0 volts or the circuit low fault is not present with the jumper in place, **continue to step 3.** .
3. Check the resistance of the temp sensor signal circuit and temp sensor ground circuit. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the circuit.
    2. If the temp sensor signal and ground circuits test good, and the voltage is still reading high or only the circuit high fault is present, Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning ECU. If no issues are found, replace the ECU in accordance with the service information.

TYPICAL PERFORMANCE/RATIONALITY DIAGNOSTICS:

NOTE: **Temp sensor performance faults typically set due to resistance in one of the circuits or a sensor that is stuck or drifted out of range. The (special tool #2064100080, Kit, Electrical Test Lead) can be used with the scan tool to test the wiring and controller.**

1. Disconnect the temp sensor harness connector and connect the Electrical Test Kit leads to the temp sensor harness connector.
2. Move the switch on the tool to open. The signal should read 5.0 volts and a circuit high DTC should be active or pending on the scan tool.
3. Next flip the switch to the closed position. The signal should read 0 volts and a circuit low fault should be active or pending on the scan tool. If the scan tool reads as described in steps 2 and 3, it would indicate the wiring and ECU are good and the sensor is likely faulty. If there is voltage present between 0 and 5.0 volts with the test tool in the closed position it would indicate there is likely resistance in one of the circuits. **Continue to step a.**
    1. To determine which circuit has resistance, remove the test lead connected to the temp sensor ground circuit and connect it to a good chassis ground.
        - If the signal changes to 0 volts it would indicate the temp sensor ground has resistance. **Continue to step b.**
        - If there is still voltage present it would indicate the temp sensor signal has resistance. **Continue to step b.**
    2. Confirm the suspect circuit issue by isolating the suspect circuit and measuring the resistance of the circuit between the sensor and ECU harness connectors. If no resistance is measured, carefully check all connectors in the path of the circuit for spread or dirty/corroded terminals. If the circuits check good (no resistance), verify whether the issue is with the temp sensor or ECU. **Continue to step 4 or 5.**
4. **If a temp table is available** , the sensor and ECU can be verified in one of the following ways.
    1. Move the switch to adjust and connect an Ohmmeter to the test leads and dial the tool to a resistance value in the table. Connect both leads to the temp sensor harness connector with the ignition on and monitor the data in the scan tool for the proper reading. Use the tool to vary the resistance while monitoring the temp sensor signal temperature/voltage on the scan tool. If the reading matches the table, the temp sensor is likely faulty.
    2. If the temp sensor actual temperature can be acquired or reasonably estimated, measure the resistance across the terminals of the temp sensor and compare to the value in the table. If the

resistance of the sensor is not in range of the table, the temp sensor is likely faulty.

5. **If a temp table is not available** for the sensor being tested, connect the Electrical Test Kit leads to the harness connector and flip the switch to adjust. With the ignition on, monitor the scan tool data and slowly adjust the resistance in the circuit. The temperature/voltage value should change with the resistance change. If the value changes as the resistance is varied it would indicate that the temp sensor is likely faulty.

VERIFYING AN ECU FAILURE: An ECU that is faulty and not able to properly read the signal can usually be determined when opening and shorting the circuits and monitoring the signal voltage and fault codes. If the expected voltage reads or DTCs do not occur when opening and jumping the connector, and the circuits are not shorted or open, it would indicate a faulty ECU. Before condemning and ECU, **always** carefully check all connectors in the path of the circuit for water intrusion, spread, pushed out, burnt or corroded terminals.

P0121-THROTTLE POSITION SENSOR 1 PERFORMANCE

For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Electronic Throttle Control (ETC) system uses two Throttle Position Sensors (TPS) to monitor the throttle blade position. TPS 1 and TPS 2 are located within the Throttle Body assembly. Each sensor has its own Signal circuit (TPS 1 or TPS 2). Both sensors share a common 5-Volt Reference circuit (Supply) and a common Sensor Ground. Each Signal circuit provides the Powertrain Control Module (PCM) with a signal voltage proportionate to throttle blade movement. Normally operating sensor signals are opposing to each other in the following manner:

- **TPS 1** voltage starts low, approximately 0.5 volts at **closed throttle,** and increases to approximately 4.5 volts at **wide open throttle** .
- **TPS 2** voltage starts high, approximately 4.3 volts at **closed throttle,** and decreases to approximately 0.7 volts at **wide open throttle** .

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- P2135 DTC is active.

SET CONDITION

- When fault P2135 is active, the Powertrain Control Module (PCM) looks at the difference between calculated Manifold Absolute Pressure (MAP) Sensor based on TPS 1 input and sensed MAP. The same is done for TPS 2. If the PCM determines that the TPS 1 error is larger than the TPS 2 error, this fault is set.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will illuminate.

POSSIBLE CAUSES

Possible Causes
TPS 1 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
THROTTLE BODY ASSEMBLY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

        Are there any applicable Service Bulletins or Flash updates?

        Yes

        - Perform the applicable repair.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any Throttle Body circuit, system voltage or 5-Volt Reference DTCs present?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 4

4. **ISOLATE AND CHECK THE THROTTLE BODY (K22) POSITION SIGNAL 1 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

       Is the resistance below 3.0 Ohms?

       Yes

       - Go To 5

       No

       - Repair the circuit for an open or high resistance.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **CHECK THE ABILITY OF THE PCM TO READ THE TPS 1 SIGNAL**
    1. Connect the PCM C2 harness connector.
    2. Connect a fused jumper between the Throttle Body (K22) Position Signal 1 circuit and the (F855) 5-Volt Supply circuit in the Throttle Body harness connector.
    3. Turn the ignition on.
    4. With the scan tool, read DTCs.

       NOTE: **The P0123-THROTTLE POSITION SENSOR 1 CIRCUIT HIGH DTC should be active or pending with the jumper in place.**

    5. Turn the ignition off.
    6. Connect a fused jumper between the Throttle Body (K22) Position Signal 1 circuit and the (K922) Sensor Ground circuit in the Throttle Body harness connector.
    7. Turn the ignition on.
    8. With the scan tool, read DTCs.

       NOTE: **The P0122-THROTTLE POSITION SENSOR 1 CIRCUIT LOW DTC should be active or pending with the jumper in place.**

       Does the scan tool display as described above?

Yes

- Replace the Throttle Body Assembly in accordance with the Service Information. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** . After installation is complete, with scan tool perform an ETC Learn procedure to calibrate the Throttle Body Assembly.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Remove the jumper before continuing.
- Go To 6

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0122-THROTTLE POSITION SENSOR 1 CIRCUIT LOW

For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Electronic Throttle Control (ETC) system uses two Throttle Position Sensors (TPS) to monitor the throttle blade position. TPS 1 and TPS 2 are located within the Throttle Body assembly. Each sensor has its own Signal circuit (TPS 1 or TPS 2). Both sensors share a common 5-Volt Reference circuit (Supply) and a common Sensor Ground. Each Signal circuit provides the Powertrain Control Module (PCM) with a signal voltage proportionate to throttle blade movement. Normally operating sensor signals are opposing to each other in the following manner:

- **TPS 1** voltage starts low, approximately 0.5 volts at **closed throttle,** and increases to approximately 4.5 volts at **wide open throttle** .
- **TPS 2** voltage starts high, approximately 4.3 volts at **closed throttle,** and decreases to approximately 0.7 volts at **wide open throttle** .

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The TPS 1 Sensor input voltage is below 0.25 - 0.40 volts depending on calibration for 0.07 seconds.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
TPS 1 SIGNAL CIRCUIT SHORTED TO GROUND
TPS 1 SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
THROTTLE BODY ASSEMBLY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to **PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .**

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

Are there any applicable Service Bulletins or Flash updates?

Yes

- Perform the applicable repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 2

2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read and record DTCs in all Electronic Control Units (ECUs) on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any system voltage or 5-Volt Reference DTCs active or pending?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 4
4. **ISOLATE AND CHECK THE THROTTLE BODY (K22) POSITION SIGNAL 1 CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Powertrain Control Module (PCM) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.

4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: There should be no continuity between ground and the circuit being tested.

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **ISOLATE AND CHECK THE THROTTLE BODY (K22) POSITION SIGNAL 1 CIRCUIT FOR A SHORT TO THE (K922) SENSOR GROUND CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Powertrain Control Module (PCM) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: There should be no continuity between the circuits being tested.

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK THE ABILITY OF THE PCM TO READ THE TPS 1 SIGNAL**
    1. The Powertrain Control Module (PCM) harness connectors must be connected to the PCM during this test step.
    2. Disconnect the sensor harness connector.
    3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the 5-Volt Supply circuit at the sensor harness connector.
    4. Turn the ignition on.
    5. With the scan tool, read DTCs.

    Does the scan tool display the SENSOR SIGNAL CIRCUIT HIGH DTC with the jumper in place?

    Yes

    - Replace the faulty sensor in accordance with the Service Information. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 7
7. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
- Test complete.

P0123-THROTTLE POSITION SENSOR 1 CIRCUIT HIGH

For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Electronic Throttle Control (ETC) system uses two Throttle Position Sensors (TPS) to monitor the throttle blade position. TPS 1 and TPS 2 are located within the Throttle Body assembly. Each sensor has its own Signal circuit (TPS 1 or TPS 2). Both sensors share a common 5-Volt Reference circuit (Supply) and a common Sensor Ground. Each Signal circuit provides the Powertrain Control Module (PCM) with a signal voltage proportionate to throttle blade movement. Normally operating sensor signals are opposing to each other in the following manner:

- **TPS 1** voltage starts low, approximately 0.5 volts at **closed throttle,** and increases to approximately 4.5 volts at **wide open throttle** .
- **TPS 2** voltage starts high, approximately 4.3 volts at **closed throttle,** and decreases to approximately 0.7 volts at **wide open throttle** .

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The TPS input voltage is above 4.65 - 4.9 volts depending on calibration for 0.07 seconds.

DEFAULT ACTION

- The MIL will illuminate.
- ETC light will flash.
- The Throttle input and vehicle speed are limited.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
TPS 1 SIGNAL CIRCUIT SHORTED TO ANOTHER VOLTAGE SUPPLY CIRCUIT
TPS 1 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE

Possible Causes
THROTTLE BODY ASSEMBLY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any system voltage or 5-Volt Reference DTCs active or pending?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

No

- Go To 4

4. **CHECK THE (F855) 5-VOLT SUPPLY CIRCUIT FOR VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

    NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

    Is the voltage between 4.8 and 5.2 volts?

    Yes

    - Go To 5

    No

    - Repair the (F855) 5-Volt Supply circuit for an open or short to ground.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK THE THROTTLE BODY (K22) POSITION SIGNAL 1 CIRCUIT FOR A SHORT TO ANOTHER VOLTAGE SUPPLY CIRCUIT**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

        NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

        Is there continuity between the circuit being tested and any other circuit?

        Yes

        - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **ISOLATE AND CHECK THE THROTTLE BODY (K22) POSITION SIGNAL 1 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 7

    No

    - Repair the circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **ISOLATE AND CHECK THE (K922) TPS SENSOR RETURN CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 8

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CONNECT A FUSED JUMPER BETWEEN THE THROTTLE BODY (K22) POSITION SIGNAL 1 CIRCUIT AND THE (K922) SENSOR GROUND CIRCUIT AT THE THROTTLE BODY HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL CIRCUIT LOW DTC**
   1. The Electronic Control Module (ECU) harness connectors must be connected to the ECU during this test step.
   2. Disconnect the sensor harness connector.
   3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the sensor ground circuit at the sensor harness connector.
   4. Turn the ignition on.
   5. With the scan tool, read DTCs.

   Does the scan tool display the SENSOR SIGNAL CIRCUIT LOW DTC with the jumper in place?

   Yes

   - Replace the faulty sensor in accordance with the Service Information. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 9

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).

- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
- Test complete.

P0125-INSUFFICIENT COOLANT TEMP FOR CLOSED-LOOP FUEL CONTROL

THEORY OF OPERATION

The purpose of this diagnostic is to verify that the engine coolant temperature has reached a certain value (pass temperature) within a calibrated amount of engine run time. Engine run time is based on the start-up coolant temperature; the lower the start-up temperature, the more time allowed for the Engine Coolant Temperature (ECT) Sensor value to reach the pass temperature. If the engine coolant temperature does not reach the calibrated pass temperature before the engine run time reaches the maximum time allowed for this diagnostic, a failure will occur.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- At initial engine start up.
- With battery voltage greater than 10.4 volts.

SET CONDITION

- The engine temperature does not go above 10B°C (50B°F). Failure time depends on start-up coolant temperature and ambient temperature.
  - Up to two minutes for a start temp of 1B°C (33.8B°F) or above.

- Up to five minutes for a vehicle with a start-up temp between 0B°C and -29B°C (32B°F and -20.2B°F).
- Up to 10 minutes for a vehicle with a start-up temp of -30B°C (-22B°F) or below.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
LOW COOLANT LEVEL
THERMOSTAT
ENGINE COOLANT TEMPERATURE (ECT) SENSOR READING IRRATIONAL
RESTRICTION IN THE RADIATOR/COOLING SYSTEM
ENGINE COOLANT TEMPERATURE (ECT) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK THE COOLING SYSTEM FOR PROPER LEVEL AND CONDITION**

   WARNING: **Never open the cooling system when the engine is hot. The system is under pressure. Extreme burns or scalding may result. Failure to follow these instructions can result in possible serious or fatal injury. Allow the engine to cool before opening the cooling system.**

   1. Inspect the cooling system for proper level and condition.

      Is the coolant level and condition OK?

      Yes

      - Go To 2

      No

      - Inspect the vehicle for a coolant leak, make the appropriate repairs and add the correct amount of coolant. Refer to COOLING SYSTEM .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .
2. **CHECK THE THERMOSTAT FOR PROPER OPERATION**

   NOTE: **For optimal test results, allow the vehicle to sit outside long enough to cool to ambient temperature in order to start the test with a totally cold soaked engine. With the scan tool, read the Engine Coolant Temperature degree value. If the engine was allowed to sit (cold soak), the temperature value should be a sensible value that is somewhere close to the ambient temperature.**

   1. Turn the ignition on.
   2. If engine coolant temperature is above 82B°C (180B°F), allow the engine to cool until it reaches at least 65B°C (150B°F) or cooler before continuing with this test.

3. Start the engine.
4. During engine warm-up monitor the Engine Coolant Temperature degree value on the scan tool. The temperature value change should be a smooth transition from start up to normal Thermostat opening temperature. Also monitor the actual coolant temperature with a digital thermometer at or near the ECT Sensor and Thermostat positions.

NOTE: **As the engine warms up to operating temperature, the actual coolant temperature (thermometer reading) and the scan tool Engine Coolant Temperature degree values should stay relatively close to each other. A discrepancy may indicate an inaccurate ECT Sensor signal to the PCM.**

5. As the engine warms to operating temperature, record the temperature at which the Thermostat opens.
6. Using the appropriate Service Information, determine the proper opening temperature of the thermostat.

   Did the thermostat open at the proper temperature?

   Yes

   - Go To 3

   No

   - Replace the Thermostat in accordance with the Service Information. Refer to **THERMOSTAT, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **CHECK THE ECT SENSOR FOR PROPER OPERATION**

   Was the digital thermometer readings relatively close to the scan tool reading for the ECT Sensor during warm up and when the Thermostat opened?

   Yes

   - Go To 4

   No

   - Replace the Engine Coolant Temperature (ECT) Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE RADIATOR FOR RESTRICTIONS**

   NOTE: **The engine must be running and the Thermostat open to perform this test.**

   1. Check and compare the temperatures at the inlet and outlet of the Radiator. Check for proper operation of the entire cooling system. Be certain to check the Radiator Cap, flow through the Radiator and anything that can cause a lack of system pressure or lack of coolant flow in the system.

   NOTE: **It is normal to see a lower temperature on the outlet of the Radiator, however a very large difference indicates a restriction in the Radiator core. This can cause this DTC to set due to the position on the ETC**

Sensor in the system. If necessary, compare the temperature difference with a similar vehicle.

Was the difference in the temperature readings relatively larger than expected?

Yes

- Replace the Radiator in accordance with the Service Information. Refer to **RADIATOR, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.
    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0128-THERMOSTAT RATIONALITY

THEORY OF OPERATION

The Thermostat is considered malfunctioning if the coolant temperature does not reach the temperature required to enable other diagnostics, or the coolant temperature does not reach a warmed up temperature within 11.0B°C (20B°F) of the Thermostat regulating temperature. The Powertrain Control Module (PCM) creates a model of the engine coolant temperature warm up cycle, based on the engine coolant temperature at start up, ambient temperature, vehicle speed and engine speed. The modeled engine coolant temperature is compared to the Engine Coolant Temperature (ECT) Sensor reading. If the engine actual temperature reaches the calibrated temperature threshold before the model, the diagnostic passes and completes.

If the model reaches the calibrated temperature threshold before the engine actual temperature, a pass/fail determination is made based on the difference between the model and actual values. The diagnostic is considered passing if the difference between the engine actual temperature and model is acceptable when the model is greater than the engine but represents the slowest possible warm-up for a "good" thermostat.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the engine running.
- Start up coolant temperature less than 65B°C (149B°F).
- Ambient temperature between -8B°C (17.6B°F) and 50B°C (122B°F).
- Average vehicle speed greater than 16 km/h (10 mph) until coolant temperature reaches 85B°C.
- Engine speed does not go above 5400 rpm for more than 32 seconds.
- The pass/fail determination point is reached when the coolant temp model reaches 88B°C (190.4B°F).

SET CONDITION

- The predicted coolant temperature reaches the target threshold before the actual coolant temperature and the PCM detects that the actual engine coolant temperature is too far below what is acceptable for a good thermostat.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
LOW COOLANT LEVEL
COOLING SYSTEM ISSUES - POOR FLOW DUE TO A RESTRICTION OR MECHANICAL ISSUE
FAULTY THERMOSTAT - OPENING TOO SOON

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR OTHER DTCS**
    1. Turn the ignition on.

2. With the scan tool, read and record DTCs.

   Are there any ECT or AAT DTCs active or pending?

   Yes

   - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

   No

   - Go To 2

2. **CHECK THE COOLANT LEVEL AND CONDITION**

WARNING: **Never open the cooling system when the engine is hot. The system is under pressure. Extreme burns or scalding may result. Failure to follow these instructions can result in possible serious or fatal injury. Allow the engine to cool before opening the cooling system.**

1. Inspect the Engine Coolant for proper level and condition. Refer to **COOLING SYSTEM** .

   Is the Engine Coolant at the proper level and condition?

   Yes

   - Go To 3

   No

   - Repair the Engine Coolant level or condition problem. Inspect the vehicle for coolant leaks and repair if necessary. Fill the Engine Coolant to the proper level and ensure the proper condition. Refer to **COOLING SYSTEM** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **CHECK THE THERMOSTAT OPERATION**

NOTE: **For optimal test results, allow the vehicle to sit outside long enough to cool to ambient temperature in order to start the test with a totally cold soaked engine. With the scan tool, read the Engine Coolant Temperature degree value. If the engine was allowed to sit (cold soak), the temperature value should be a sensible value that is somewhere close to the ambient temperature.**

1. Turn the ignition on.
2. If engine coolant temperature is above 82B°C (180B°F), allow the engine to cool until it reaches at least 65B°C (150B°F) or cooler before continuing with this test.
3. Start the engine.
4. During engine warm-up monitor the Engine Coolant Temperature degree value on the scan tool. The temperature value change should be a smooth transition from start up to Thermostat opening temperature. Also monitor the actual coolant temperature with a digital thermometer at or near the ECT Sensor and Thermostat positions.

   NOTE: **As the engine warms up to operating temperature, the actual coolant temperature (thermometer reading) and the scan tool Engine Coolant Temperature degree values should stay relatively close to each other. A discrepancy may indicate an inaccurate ECT Sensor signal to the PCM.**

5. As the engine warms to operating temperature, record the temperature at which the Thermostat opens.
6. Using the appropriate Service Information, determine the proper opening temperature of the Thermostat.

Did the Thermostat open at the proper temperature?

Yes

- Go To 4

No

- Replace the Thermostat in accordance with the Service Information. Refer to **THERMOSTAT, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE RADIATOR FOR RESTRICTIONS AND FLOW**

NOTE: **The engine must be running and the Thermostat open to perform this test.**

1. Check and compare the temperatures at the inlet and outlet of the Radiator. Check for proper operation of the entire cooling system. Be certain to check for proper operation of the Radiator Cap. Check for proper flow through the Radiator and anything that can cause a lack of system pressure or lack of coolant flow in the system which include air in the cooling system, proper operation of the Water Pump and drive belt, restricted Radiator core, collapsed hose restricting flow, etc.

NOTE: **It is normal to see a lower temperature on the outlet of the Radiator, however a very large difference could indicate a restriction in the Radiator. This condition can cause this DTC to set due to the position of the ETC Sensor in the coolant system. If necessary, compare the temperature difference with a similar vehicle.**

Was the difference in the temperature readings relatively larger than expected?

Yes

- Check the cooling system and Radiator for proper flow and repair as necessary.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Replace the Thermostat in accordance with the Service Information. Refer to **THERMOSTAT, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0129-BAROMETRIC PRESSURE OUT OF RANGE LOW

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) runs a diagnostic to check the Manifold Absolute Pressure Sensor (MAP) calibration and 5-Volt Supply circuit. It does this by reading the Barometric Pressure (BARO) when the engine is not running. The BARO reading with the engine off should fall within a predictable threshold. If the reading is below this threshold when the monitoring conditions are met, it is determined that the 5-Volt Supply was lost or the MAP Sensor is out of range.

NOTE: **Do not use shop air to clean out the MAP Sensor when diagnosing a MAP Sensor related fault as this will cause internal damage to the sensor.**

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
- After an engine off period of 12.0 seconds.
- Battery voltage greater than 10.4 volts.
- Engine speed less than 30 rpm.

SET CONDITION

- The voltage from the MAP Sensor is less than 2.28 volts, but above 0.10 volts.

DEFAULT ACTION

- ETC light will flash.
- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT OPEN
MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

NOTE: **Diagnose and repair any 5-Volt Reference DTCs before continuing with this test procedure.**

2. **CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT FOR PROPER VOLTAGE AT THE MAP SENSOR HARNESS CONNECTOR**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
    3. Turn the ignition on.
    4. Set the DVOM to measure DC voltage.
    5. Connect the negative lead of the DVOM to a known good ground.
    6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

NOTE: **Normal operating voltage should be between 4.8 and 5.2 volts.**

Does the circuit have the proper voltage present?

Yes

- Verify that there is good pin to terminal contact in the MAP Sensor and Powertrain Control Module connectors. If no problems are found, replace the MAP Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Repair the (F856) 5-Volt Supply circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0131-O2 SENSOR 1/1 CIRCUIT LOW

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other

	Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.**
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading

Using the Scan Tool for Diagnostics:	
	will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Battery voltage between 11.0 and 15.75 volts.
- With the engine running.

SET CONDITION

- The Oxygen Sensor 1/1 signal voltage is less than 0.0 volts for 9.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 1/1 SIGNAL CIRCUIT SHORTED TO GROUND

Possible Causes
O2 SENSOR 1/1 SIGNAL CIRCUIT SHORTED TO THE O2 SENSOR 1/1 HEATER GROUND CIRCUIT
O2 SENSOR 1/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **ISOLATE AND CHECK THE O2 SENSOR 1/1 (K41) SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.

4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, (special tool #10436, Adapter, GPEC Diagnostic) connect the to the appropriate PCM harness connector.

   NOTE: There should be no continuity between ground and the circuit being tested.

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **ISOLATE AND CHECK THE O2 SENSOR 1/1 (K41) SIGNAL CIRCUIT FOR A SHORT TO THE (Z910) GROUND CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   NOTE: There should be no continuity between the circuits being tested.

   Is there continuity between the circuits?

   Yes

   - Repair the short between the circuits.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **CHECK THE O2 SENSOR 1/1 (K41) SIGNAL CIRCUIT FOR PROPER VOLTAGE AT THE O2 SENSOR HARNESS CONNECTOR**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
    3. Turn the ignition on.
    4. Set the DVOM to measure DC voltage.
    5. Connect the negative lead of the DVOM to a known good ground.
    6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

    Is the O2 Sensor 1/1 voltage above 4.0 volts?

    Yes

    - Replace the O2 Sensor 1/1 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 6
6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.

11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information.. **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0132-O2 SENSOR 1/1 CIRCUIT HIGH

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within

the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50**

	percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will

Using the Scan Tool for Diagnostics:	
(Return) Circuit Low Diagnosis:	switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Battery voltage between 11.0 and 15.75 volts.
- With the engine running.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Oxygen Sensor 1/1 (0-1) differential signal voltage is above 1.2 volts for over 9.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 1/1 HEATER CONTROL CIRCUIT SHORTED TO VOLTAGE
O2 SENSOR 1/1 HEATER CONTROL CIRCUIT SHORTED TO GROUND
O2 SENSOR 1/1 HEATER CONTROL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 1/1 HEATER GROUND CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 1/1 SIGNAL CIRCUIT SHORTED TO VOLTAGE
O2 SENSOR 1/1 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 1/1 RETURN CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 1/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE CONDITION**
    1. Start the engine and allow it to idle for at least 60 seconds.

WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

2. With the scan tool, read the O2 Sensor 1/1 signal voltage.

   Is the voltage staying above 4.0 volts?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE O2 SENSOR 1/1 HEATER OPERATION**
   1. With the scan tool, check the O2 Sensor 1/1 duty cycle. Also monitor the O2 Sensor 1/1 heater temperature and compare to the other O2 Sensor heater temperatures.

   NOTE: **The duty cycle percentage and heater temperature should be relatively close to the other sensors. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably different than the other O2 Sensors.**

   Is the O2 Sensor heater operating properly?

   Yes

   - Go To 7

   No

   - Go To 3

3. **CHECK THE O2 SENSOR 1/1 (Z910) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
   1. Disconnect the component harness connector to isolate the ground circuit.
   2. Connect the positive lead of the load test tool to the positive side of the Battery.
   3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
   4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

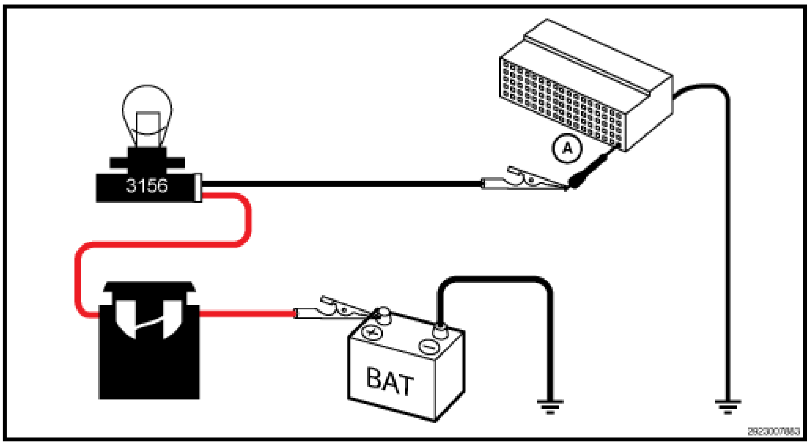
NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

   NOTE: Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.

   Is the load test bulb illuminated and bright?

Yes

- Go To 4

No

- Repair the ground circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE O2 SENSOR 1/1 (K99) HEATER CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

    NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

5. **ISOLATE AND CHECK THE O2 SENSOR 1/1 (K99) HEATER CONTROL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to**

pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

No

- Go To 6

6. **ISOLATE AND LOAD TEST THE O2 SENSOR 1/1 (K99) HEATER CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
    3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
    4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at one of the component harness connectors (B).
    5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
    6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

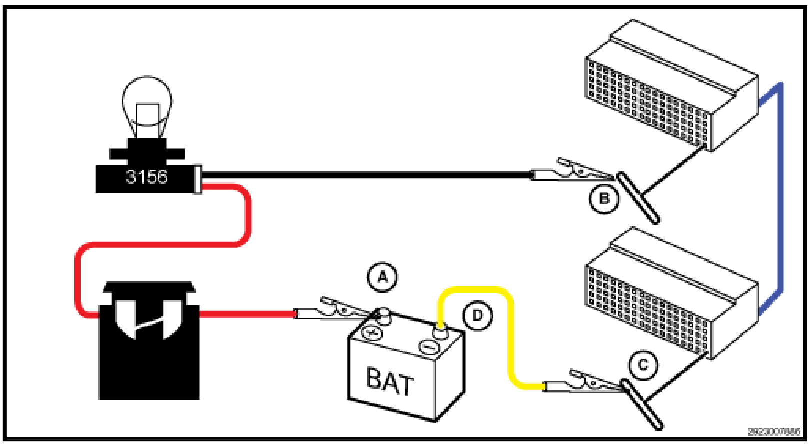
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage**

drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 10

   No

   - Repair the circuit for an open or high resistance.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK THE O2 SENSOR 1/1 (K41) SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

    NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

    Is the voltage above 5.2 volts?

    Yes

    - Repair the circuit for a short to voltage.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 8

8. **ISOLATE AND CHECK THE O2 SENSOR 1/1 (K41) SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

        NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

        Is the resistance below 3.0 Ohms?

        Yes

        - Go To 9

        No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **ISOLATE AND CHECK THE O2 SENSOR 1/1 (K902) RETURN CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 10

    No

    - Repair the circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **REPLACE THE O2 SENSOR 1/1 AND RETEST FOR DTC**
    1. Replace the O2 Sensor 1/1 in accordance with the Service Information. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** .
    2. Connect the O2 Sensor 1/1 and PCM harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the recorded Freeze Frame and the When Monitored conditions, operate the vehicle in the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 11

    No

    - Replacing the O2 Sensor repaired the fault.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
       - Proper connector installation.
       - Damaged connector locks.
       - Corrosion.
       - Other signs of water intrusion.
       - Weather seal damage (if equipped).
       - Bent terminals.
       - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
       - Terminals that have been pushed back into the connector cavity.
       - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0133-O2 SENSOR 1/1 SLOW RESPONSE

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Upstream Oxygen (O2) Sensor is usually placed close to the exhaust manifold to achieve fast light-off and provide immediate O2 feedback to allow the fuel system to enter closed loop fuel control.

The Upstream O2 Sensor is very important for emission control and engine performance since it can provide immediate air/fuel ratio feedback. Therefore, proper operation of this Upstream O2 Sensor is critical. An aged Upstream O2 Sensor tends to be less active and has a slower response rate to changes in the air/fuel ratio of exhaust gas. As a result, the quality of the Upstream O2 Sensor can be determined by observing the voltage activity from the sensor.

This monitor is triggered when the engine is running at certain MAP/RPM windows, airflow is relatively stable and steady O2 control is applied. The state change for Upstream O2 signal is captured in a calibrated time block (consisting of consecutive samples), such that even the slowest (but still considered as passing) O2 Sensor should accumulate enough state changes to pass the monitor.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Engine Coolant Temperature (ECT) Sensor value above 70B°C (158B°F).
- Engine speed between 1400 and 2300 rpm.
- Vehicle speed between 64 and 96 km/h (40 and 60 mph).
- Engine run time greater than three minutes.

SET CONDITION

- PCM detects that the oxygen sensor signal does not switch adequately during monitoring.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EXHAUST LEAK
O2 SENSOR 1/1 SIGNAL CIRCUIT
O2 SENSOR 1/1 RETURN CIRCUIT
OXYGEN (O2) SENSOR 1/1

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.

6. Using the When Monitored Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECKING THE EXHAUST SYSTEM FOR LEAKS**
    1. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

    Were any exhaust leaks found?

    Yes

    - Repair or replace the leaking exhaust parts as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 3

3. **CHECK THE O2 SENSOR 1/1 (K41) SIGNAL CIRCUIT FOR PROPER VOLTAGE AT THE O2 SENSOR HARNESS CONNECTOR**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
    3. Turn the ignition on.
    4. Set the DVOM to measure DC voltage.
    5. Connect the negative lead of the DVOM to a known good ground.
    6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **Normal operating voltage should be between 4.1 and 5.0 volts.**

Does the circuit have the proper voltage present?

Yes

- Go To 8

No

- Go To 4

4. **CHECK THE O2 SENSOR 1/1 (K41) SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

Is the voltage above 5.2 volts?

Yes

- Go To 5

No

- Go To 6

5. **ISOLATE AND CHECK THE O2 SENSOR 1/1 (K41) SIGNAL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

    NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 14

6. **ISOLATE AND CHECK THE O2 SENSOR 1/1 (K41) SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.

2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Connect the negative lead of the DVOM to a known good ground.
4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 7

7. **ISOLATE AND CHECK THE O2 SENSOR 1/1 (K41) SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 13

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK THE (K902) SENSOR RETURN CIRCUIT FOR PROPER VOLTAGE AT THE O2 SENSOR HARNESS CONNECTOR**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
    3. Turn the ignition on.
    4. Set the DVOM to measure DC voltage.
    5. Connect the negative lead of the DVOM to a known good ground.
    6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

    NOTE: **Normal operating voltage should be approximately 2.5 volts.**

    Does the circuit have the proper voltage present?

    Yes

    - Go To 13

    No

    - Go To 9

9. **CHECK THE (K902) SENSOR RETURN CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

    NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

    Is the voltage above 5.2 volts?

    Yes

    - Go To 10

    No

    - Go To 11

10. **ISOLATE AND CHECK THE (K902) SENSOR RETURN CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

    NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 14
11. **ISOLATE AND CHECK THE (K902) SENSOR RETURN CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

    NOTE: **There should be no continuity between ground and the circuit being tested.**

    Is there continuity between ground and the circuit being tested?

    Yes

    - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 12

12. **ISOLATE AND CHECK THE (K902) SENSOR RETURN CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

    Is the resistance below 3.0 Ohms?

    Yes

    - Repair the (K902) Sensor Return circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 13

13. **CHECK THE O2 SENSOR 1/1 WIRING AND CONNECTOR**

    NOTE: **Check for signs of contaminants that may have damaged the O2 Sensor, such as contaminated fuel, unapproved silicone, oil and coolant.**

    1. Using the wiring diagram/schematic as a guide, inspect the wiring and connectors between the O2 Sensor 1/1 and the Powertrain Control Module (PCM).
        - Look for any chafed, pierced, pinched, or partially broken wires.
        - Look for broken, bent, pushed out or corroded terminals.
        - Verify that there is good pin to terminal contact in the 1/1 O2 Sensor and Powertrain Control Module connectors.
        - Perform any Service Bulletins that may apply.

    Were any problems found?

    Yes

    - Repair as necessary.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Replace the O2 Sensor 1/1 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

14. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace the Powertrain Control Module (PCM) in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

- Test complete.

P0135-O2 SENSOR 1/1 HEATER PERFORMANCE

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The primary objective of the Oxygen (O2) Sensor Heater Control is to attain the fastest possible temperature rise, and to control the steady state temperature of the O2 Sensor. A Positive Temperature Coefficient (PTC) element inside the O2 Sensor heats up as current passes through it. This allows the system to enter Closed Loop quickly and meet the OBD II requirements for continuous monitoring and to deliver accurate readings. This is accomplished by the Powertrain Control Module (PCM) sending a Pulse Width Modulated (PWM) current to the O2 Sensors heater element. The PWM duty cycle is calculated, in response to the temperature measurements. The PCM uses the collected information to continually adjust the PWM to achieve a desired steady state temperature target.

The heater temperature is obtained by measuring the heater resistance and calculating the heater temperature using the resistance versus temperature characteristic. In order to measure the heater temperature, the transistor that controls the heater is momentarily disabled and current is passed through a precision sense resistor connected in series with the heater element. The voltage drop across the sense resistor provides the relationship to current which equates to a temperature value. Once the temperature is acquired, the sense current is turned off and normal operation is restored. The actual heater temperature is monitored continuously and the heating rate is adjusted to prevent damaging the heating element.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage between 11.0 and 15.75 volts.
- No Ambient Air Temperature Sensor faults set.
- And any one of the following is true:
  - Engine coolant temperature at start up is above 7B°C (44.6B°F).
  - Ambient temperature is above 7B°C (44.6B°F).
  - The difference between coolant temperature and ambient temperature is greater than 9B°C (16.2B°F) at engine start.
  - The O2 Sensor heater temperature is greater than 401B°C (753.8B°F) for more than 20.0 seconds.

SET CONDITION

- The PCM detects that the difference between the actual O2 Sensor Heater element resistance/temperature and the target resistance/temperature is not within a calibrated threshold with the O2 Sensor heater duty cycle above 89.8% for 90.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 1/1 HEATER CONTROL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 1/1 HEATER GROUND CIRCUIT OPEN/HIGH RESISTANCE
OXYGEN (O2) SENSOR 1/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **CHECK FOR AN ACTIVE CONDITION**
    1. Turn the ignition off.

       NOTE: **Wait a minimum of eight minutes to allow the sensor to cool down before continuing. The sensor voltage should stabilize between 2.47 and 2.52 volts.**

    2. Turn the ignition on.
    3. With a scan tool, actuate the O2 Sensor 1/1 heater control.
    4. With the scan tool, monitor the O2 Sensor 1/1 voltage for at least two minutes.

       Does the voltage stay above approximately 4.5 volts?

       Yes

       - Go To 3

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK FOR OTHER DTCS**
    1. With the scan tool, read and record DTCs on the repair order.

       Are there any other O2 Sensor Heater circuit DTCs active or pending?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 4
4. **CHECK THE O2 SENSOR 1/1 HEATER ELEMENT RESISTANCE**
    1. Turn the ignition off.

NOTE: **Allow the O2 Sensor heater a few minutes to cool down from the heater test performed with the scan tool.**

2. Disconnect the O2 Sensor 1/1 harness connector.
3. Measure the resistance of the O2 Sensor 1/1 Heater Element across the O2 Sensor, between the O2 Heater Control terminal and the Heater ground terminal (component side).

NOTE: **If possible, it's best to measure the O2 Sensor 1/1 Heater Element resistance value at approximately 20B°C (68B°F). The resistance value will vary with different temperature values. If the O2 Sensor is obviously warmer or cooler than the recommended temperature, use the table below to estimate what the resistance range should be. The MAXIMUM allowable resistance would be 12.5 Ohms at 1000B°C.**

Celsius	Fahrenheit	Resistance Range
0B°C	32B°F	3.1 - 4.2 Ohms
20B°C	68B°F	3.3 - 4.4 Ohms
100B°C	212B°F	3.85 - 5.1 Ohms

Is the O2 Sensor resistance within the acceptable range?

Yes

- Go To 5

No

- Verify that there is good pin to terminal contact in the O2 Sensor and PCM harness connectors. If no problems are found, replace the O2 Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND LOAD TEST THE O2 SENSOR 1/1 (K99) HEATER CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
   3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
   4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
   5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
   6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load**

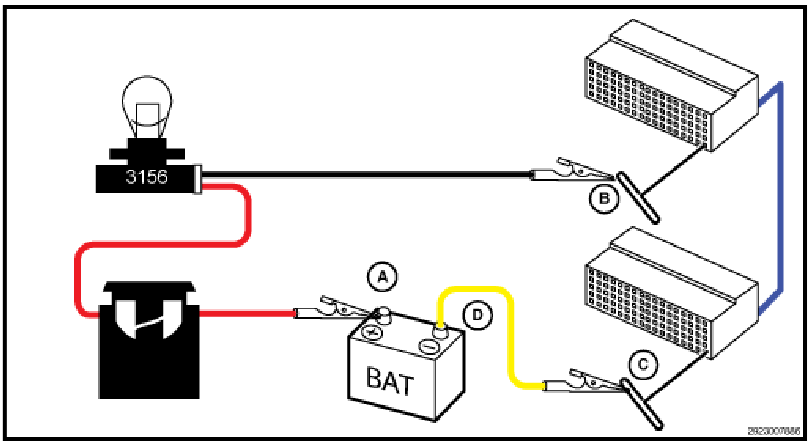
testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .

NOTE: Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

- 1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
- 2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
- 3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



WARNING: To avoid possible serious or fatal injury, DO NOT load test any air bag/restraint system components or circuits using the procedures listed here. Refer to the Service Information for proper air bag/restraint system testing procedures.

CAUTION: Do not load test any circuits with components still connected to the circuit.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to

pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE: **There should be no continuity between ground and the circuit being tested.**

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 6

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND LOAD TEST THE (Z910) GROUND CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
   3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
   4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
   5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
   6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

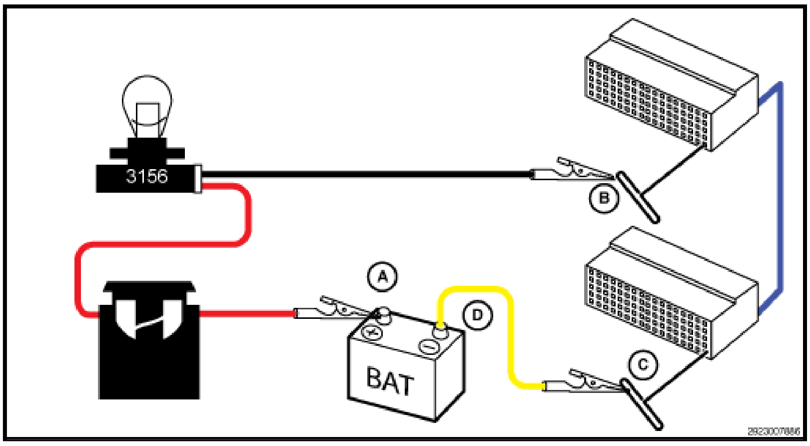
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load**

test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

- 1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
- 2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
- 3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



WARNING: To avoid possible serious or fatal injury, DO NOT load test any air bag/restraint system components or circuits using the procedures listed here. Refer to the Service Information for proper air bag/restraint system testing procedures.

CAUTION: Do not load test any circuits with components still connected to the circuit.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   NOTE: There should be no continuity between ground and the circuit being tested.

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 7

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0137-O2 SENSOR 1/2 CIRCUIT LOW

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the**

Using the Scan Tool for Diagnostics:	
	O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the

Using the Scan Tool for Diagnostics:	
(Return) Circuit High Diagnosis:	signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Battery voltage between 11.0 and 15.75 volts.
- With the engine running.

SET CONDITION

- The Oxygen Sensor 1/2 signal voltage is less than 0.0 volts for 9.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 1/2 SIGNAL CIRCUIT SHORTED TO GROUND
O2 SENSOR 1/2 SIGNAL CIRCUIT SHORTED TO THE O2 SENSOR 1/2 HEATER GROUND CIRCUIT
O2 SENSOR 1/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.

3. With the scan tool, erase all DTCs.
4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 3

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **ISOLATE AND CHECK THE O2 SENSOR 1/2 (K141) SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, (special tool #10436, Adapter, GPEC Diagnostic) connect the to the appropriate PCM harness connector.

    NOTE: **There should be no continuity between ground and the circuit being tested.**

    Is there continuity between ground and the circuit being tested?

    Yes

    - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 4

4. **ISOLATE AND CHECK THE O2 SENSOR 1/2 (K141) SIGNAL CIRCUIT FOR A SHORT TO THE (Z910) GROUND CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as

a guide to follow the path of the circuit.

3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   NOTE: There should be no continuity between the circuits being tested.

   Is there continuity between the circuits?

   Yes

   - Repair the short between the circuits.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **CHECK THE O2 SENSOR 1/2 (K141) SIGNAL CIRCUIT FOR PROPER VOLTAGE AT THE O2 SENSOR HARNESS CONNECTOR**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
   3. Turn the ignition on.
   4. Set the DVOM to measure DC voltage.
   5. Connect the negative lead of the DVOM to a known good ground.
   6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

   Is the O2 Sensor 1/2 voltage above 4.0 volts?

   Yes

   - Replace the O2 Sensor 1/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.

5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0138-O2 SENSOR 1/2 CIRCUIT HIGH

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A**

small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set. Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool.

NOTE:

When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably

	higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage between 11.0 volts and 15.8 volts.

SET CONDITION

- The PCM detects that Oxygen Sensor 1/2 signal voltage is greater than 1.20 volts.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 1/2 HEATER CONTROL CIRCUIT SHORTED TO VOLTAGE
O2 SENSOR 1/2 HEATER CONTROL CIRCUIT SHORTED TO GROUND
O2 SENSOR 1/2 HEATER CONTROL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 1/2 HEATER GROUND CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 1/2 SIGNAL CIRCUIT SHORTED TO VOLTAGE
O2 SENSOR 1/2 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 1/2 RETURN CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 1/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE CONDITION**
    1. Start the engine and allow it to idle for at least 60 seconds.

       WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

    2. With the scan tool, read the O2 Sensor 1/2 signal voltage.

       Is the voltage staying above 4.0 volts?

       Yes

       - Go To 2

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to INTERMITTENT CONDITION .
2. **CHECK THE O2 SENSOR 1/2 HEATER OPERATION**
    1. With the scan tool, check the O2 Sensor 1/2 duty cycle. Also monitor the O2 Sensor 1/2 heater temperature and compare to the other O2 Sensor heater temperatures.

       NOTE: **The duty cycle percentage and heater temperature should be relatively close to the other sensors. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably different than the other O2 Sensors.**

       Is the O2 Sensor heater operating properly?

       Yes

       - Go To 7

No

- Go To 3

3. **CHECK THE O2 SENSOR 1/2 (Z910) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Disconnect the component harness connector to isolate the ground circuit.
    2. Connect the positive lead of the load test tool to the positive side of the Battery.
    3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
    4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

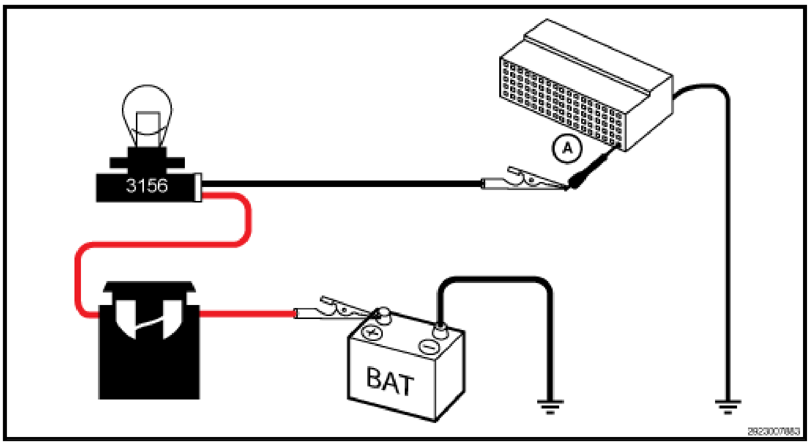
NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 4

   No

   - Repair the ground circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE O2 SENSOR 1/2 (K299) HEATER CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
   4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **ISOLATE AND CHECK THE O2 SENSOR 1/2 (K299) HEATER CONTROL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **ISOLATE AND LOAD TEST THE O2 SENSOR 1/2 (K299) HEATER CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.

3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at one of the component harness connectors (B).
5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

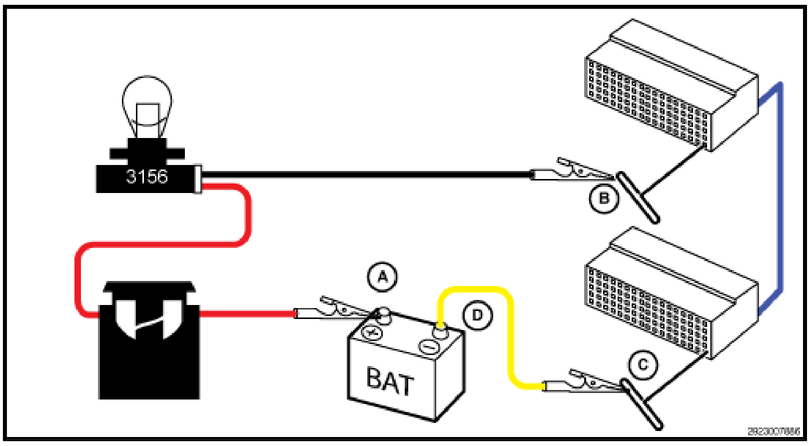
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 10

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK THE O2 SENSOR 1/2 (K141) SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Turn the ignition on.
   4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

Is the voltage above 5.2 volts?

Yes

- Repair the O2 Sensor 1/2 (K141) Signal circuit for a short to voltage.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 8

8. **ISOLATE AND CHECK THE O2 SENSOR 1/2 (K141) SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

      NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 9

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **ISOLATE AND CHECK THE O2 SENSOR 1/2 (K904) RETURN CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 10

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **REPLACE THE O2 SENSOR 1/2 AND RETEST FOR DTC**
    1. Replace the O2 Sensor 1/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. Connect the O2 Sensor 1/2 and PCM harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the recorded Freeze Frame and the When Monitored conditions, operate the vehicle in the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 11

    No

    - Replacing the O2 Sensor repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
11. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
       - Proper connector installation.
       - Damaged connector locks.
       - Corrosion.
       - Other signs of water intrusion.
       - Weather seal damage (if equipped).
       - Bent terminals.
       - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
       - Terminals that have been pushed back into the connector cavity.
       - Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0139-O2 SENSOR 1/2 SLOW RESPONSE

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

For an aged Oxygen (O2) Sensor, the response rate to the air/fuel change is slower than when it was new. The O2 Sensor tends to move less with the same air/fuel changes in a given time frame. Therefore by observing the activity of voltage readings from the O2 Sensor, the quality of the O2 Sensor can be detected.

The Downstream O2 Sensor is located in the exhaust path behind the Catalytic Converter, and is monitored for proper response to assure optimum Catalytic Converter efficiency. This occurs by monitoring the change in the Downstream O2 Sensor voltage over time, when the fuel is shut off during a decel condition after the enable conditions were met. If the slope of the Downstream O2 Sensor is too small, the monitor will fail indicating that the O2 Sensor is not reliable enough to monitor Catalytic Converter efficiency.

WHEN MONITORED

This diagnostic runs during a decel fuel shutoff event, after the following conditions were met:

- Vehicle speed above 96 km/h (60 mph).
- Throttle open for a minimum of 120 seconds.
- Coolant temperature greater than 70B°C (158B°F).
- Catalytic Converter temperature greater than 600B°C (1112B°F).

SET CONDITION

- If the PCM does not detect a rich to lean switch within a specific time during a Decel Fuel Shutoff Event, the monitor will fail.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
RESTRICTED INTAKE AIR FLOW (PLUGGED AIR FILTER)
LEAK IN THE EXHAUST SYSTEM
UPSTREAM AND DOWNSTREAM O2 SENSOR HARNESS CONNECTORS SWITCHED
O2 SENSOR 1/2 INSTALLED INCORRECTLY
O2 SENSOR 1/2
ENGINE MECHANICAL ISSUE CAUSING O2 SENSOR CONTAMINATION
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Go To 2

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

- Go To 3

3. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

    NOTE: **Any O2 Sensor heater or signal circuit DTCs should be diagnosed before continuing with this procedure.**

    Are there any O2 Sensor heater or signal circuit DTCs present?

    Yes

    - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

    No

    - Go To 4

4. **CHECK THE INTAKE SYSTEM AND AIR FILTER FOR RESTRICTIONS OR BLOCKAGE**
    1. Check for a blockage in the intake air system plumbing.
    2. Visually inspect the Air Filter for a restriction.

    NOTE: **Poor airflow due to a severely restricted Air Filter can cause this DTC to set.**

    Were any issues found?

    Yes

    - Replace the Air Filter or repair the blockage.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

5. **CHECK THE O2 SENSOR FOR PROPER MOUNTING**
    1. Check and verify that the Upstream O2 Sensor is mounted correctly into the exhaust. Verify the sensor is tight and not cross threaded.

    Is the O2 Sensor mounted correctly?

    Yes

    - Go To 6

    No

    - Mount the O2 Sensor correctly.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE ORIENTATION OF THE UPSTREAM AND DOWNSTREAM O2 SENSOR HARNESS CONNECTORS**
    1. Check and verify that the Upstream O2 Sensor and Downstream O2 Sensor harness connectors are properly connected to the correct sensors.

    Are the harness connectors reversed?

Yes

- Connect the harness connectors to the correct sensors.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **CHECK THE EXHAUST SYSTEM FOR LEAKS**
    1. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

    Were any exhaust leaks found?

    Yes

    - Repair or replace the leaking exhaust parts as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 8

8. **REPLACE THE O2 SENSOR 1/2 AND RETEST FOR DTC**

    NOTE: **Check for signs of contaminants that may have damaged the O2 Sensor, such as contaminated fuel, unapproved silicone, oil and coolant.**

    1. Replace the O2 Sensor 1/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. Connect the O2 Sensor 1/2 and PCM harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the recorded Freeze Frame and the When Monitored conditions, operate the vehicle in the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 9

    No

    - Replacing the O2 Sensor 1/2 repaired the fault. If the O2 Sensor was contaminated, also correct the engine mechanical condition that caused the contamination on the sensor.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.

5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0140-O2 SENSOR 1/2 NO ACTIVITY DETECTED

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Downstream Oxygen (O2) Sensor no activity diagnostic monitor is intended to diagnose a Downstream O2 Sensor that is not moving or is stuck in a voltage window. This diagnostic is intended to verify the Downstream O2 Sensors ability to respond to fuel adaption deviations during the Catalyst Monitor test. To pass this monitor, the sensor must output a voltage greater than a high calibrated voltage and less than a low calibrated voltage within a calibrated time period. The test includes a non-intrusive monitor and an intrusive fueling monitor. The intrusive monitor will only run if the non-intrusive test does not pass within the calibrated time period.

The intrusive fueling routine is used to 'jolt' the fuel feedback system to force the monitor to pass. A test failure occurs if the voltage pass values are not achieved after the total accumulated test time.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the engine running.
- Vehicle speed between 32 and 88 km/h (20 and 55 mph).
- Throttle open for a minimum of 120 seconds.
- Engine Coolant Temperature (ECT) Sensor value greater than 70B°C (158B°F).
- Catalytic Converter Temperature greater than 600B°C (1112B°F).
- EVAP Purge active.

SET CONDITION

- The Oxygen Sensor 1/2 signal switches from lean to rich less than 16 times within 20 seconds during monitoring.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EXHAUST LEAK
O2 SENSOR 1/2 SIGNAL CIRCUIT
O2 SENSOR 1/2 RETURN CIRCUIT
OXYGEN (O2) SENSOR 1/2

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECKING THE EXHAUST SYSTEM FOR LEAKS**
    1. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

       Were any exhaust leaks found?

       Yes

       - Perform the appropriate repairs.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 3

3. **CHECK THE O2 SENSOR 1/2 (K141) SIGNAL CIRCUIT FOR PROPER VOLTAGE AT THE O2 SENSOR 1/2 SIGNAL HARNESS CONNECTOR**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
    3. Turn the ignition on.
    4. Set the DVOM to measure DC voltage.
    5. Connect the negative lead of the DVOM to a known good ground.
    6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **Normal operating voltage should be between 4.1 and 5.0 volts.**

   Does the circuit have the proper voltage present?

   Yes

   - Go To 4

   No

   - Check the O2 Sensor 1/2 (K141) Signal circuit for a short to ground, open or short to voltage. If no problems are found, replace and program the PCM in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE (K904) SENSOR RETURN CIRCUIT FOR PROPER VOLTAGE AT THE O2 1/2 SENSOR HARNESS CONNECTOR**
    1. Turn the ignition off.

2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
3. Turn the ignition on.
4. Set the DVOM to measure DC voltage.
5. Connect the negative lead of the DVOM to a known good ground.
6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   NOTE: **Is the voltage at 2.5 volts?**

   Does the circuit have the proper voltage present?

   Yes

   - Go To 5

   No

   - Check the (K904) Sensor Return circuit for a short to ground, open or short to voltage. If no problems are found, replace and program the PCM in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK THE OXYGEN SENSOR FOR PROPER OPERATION**

NOTE: **Check for signs of contaminants that may have damaged the O2 Sensor 1/2, such as contaminated fuel, unapproved silicone, oil and coolant.**

1. Using the wiring diagram/schematic as a guide, inspect the wiring and connectors between the O2 Sensor 1/2 and the Powertrain Control Module (PCM).
2. Look for any chafed, pierced, pinched or partially broken wires.
3. Look for broken, bent, pushed out or corroded terminals.
4. Perform any Service Bulletins that may apply.

   Were any problems found?

   Yes

   - Repair as necessary.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Replace the Oxygen Sensor 1/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0141-O2 SENSOR 1/2 HEATER PERFORMANCE

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.

- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the**

	heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the

Using the Scan Tool for Diagnostics:	
	(0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the engine running.
- Battery voltage between 11.0 and 15.75 volts.
- No Ambient Air Temperature Sensor faults set.
- And any one of the following is true:
  - Engine coolant temperature at start up is above 7B°C (44.6B°F).
  - Ambient temperature is above 7B°C (44.6B°F).
  - The difference between engine coolant temperature and ambient temperature is greater than 9B°C (16.2B°F) at engine start.
  - The O2 Sensor heater temperature is greater than 401B°C (753.8B°F) for more than 20.0 seconds.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the difference between the actual O2 Sensor Heater element resistance/temperature and the target resistance/temperature is not within a calibrated threshold with the O2 Sensor heater duty cycle above 89.8% for 90.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 1/2 HEATER CONTROL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 1/2 HEATER GROUND CIRCUIT OPEN/HIGH RESISTANCE
OXYGEN (O2) SENSOR 1/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE CONDITION**
   1. Turn the ignition off.

      NOTE: **Wait a minimum of eight minutes to allow the sensor to cool down before continuing. The sensor voltage should stabilize between 2.47 and 2.52 volts.**

   2. Turn the ignition on.
   3. With a scan tool, actuate the Oxygen Sensor 1/2 heater control.
   4. With the scan tool, monitor the O2 Sensor 1/2 voltage for at least two minutes.

   Does the voltage stay above approximately 4.5 volts?

   Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
    1. With the scan tool, read and record DTCs on the repair order.

    Are there any other O2 Sensor Heater circuit DTCs active or pending?

    Yes

    - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

    No

    - Go To 3

3. **CHECK THE O2 SENSOR 1/2 HEATER ELEMENT RESISTANCE**
    1. Turn the ignition off.

    NOTE: **Allow the O2 Sensor heater a few minutes to cool down from the heater test performed with the scan tool.**

    2. Disconnect the O2 Sensor 1/2 harness connector.
    3. Measure the resistance of the O2 Sensor 1/2 Heater Element across the O2 Sensor, between the O2 Heater Control terminal and the Heater ground terminal (component side).

    NOTE: **If possible, it's best to measure the O2 Sensor 1/1 Heater Element resistance value at approximately 20B°C (68B°F). The resistance value will vary with different temperature values. If the O2 Sensor is obviously warmer or cooler than the recommended temperature, use the table below to estimate what the resistance range should be. The MAXIMUM allowable resistance would be 12.5 Ohms at 1000B°C.**

Celsius	Fahrenheit	Resistance Range
0B°C	32B°F	3.1 - 4.2 Ohms
20B°C	68B°F	3.3 - 4.4 Ohms
100B°C	212B°F	3.85 - 5.1 Ohms

    Is the O2 Sensor resistance within the acceptable range?

    Yes

    - Go To 4

    No

    - Verify that there is good pin to terminal contact in the Sensor and Control Module connectors. If no problems are found, replace the O2 Sensor. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND LOAD TEST THE O2 SENSOR 1/2 (K299) HEATER CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**

1. The ignition must be off when performing a load test on a circuit.
2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

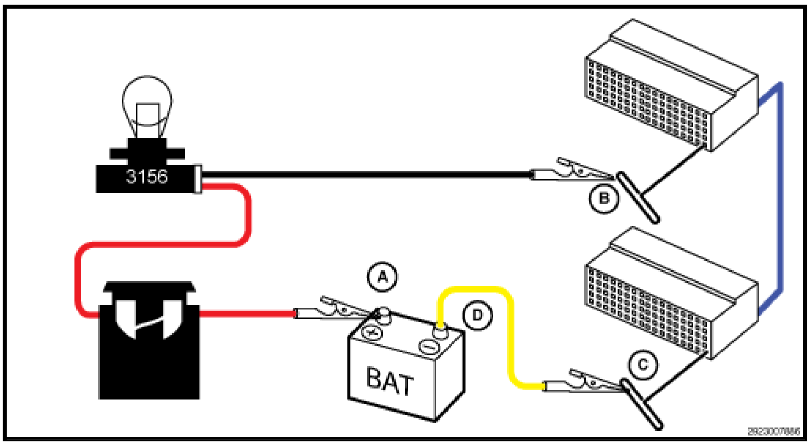
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
- **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



WARNING: **To avoid possible serious or fatal injury, DO NOT load test any air bag/restraint system components or circuits using the procedures listed here. Refer to the Service Information for proper air bag/restraint system testing procedures.**

CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 5

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND LOAD TEST THE (Z910) GROUND CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.

3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

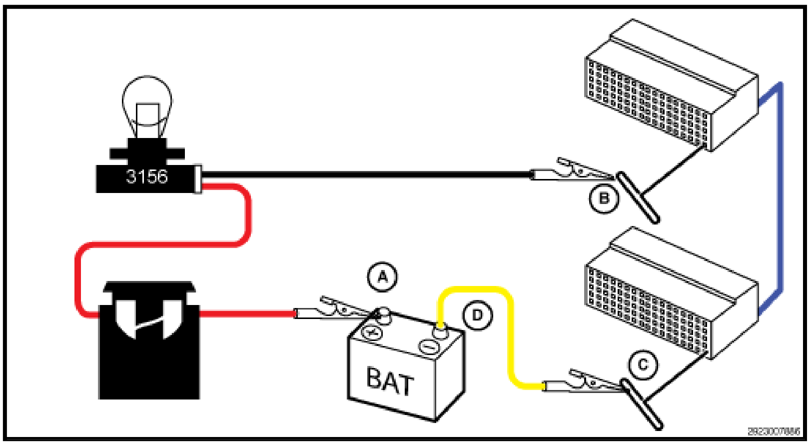
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
- **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



WARNING: **To avoid possible serious or fatal injury, DO NOT load test any air bag/restraint system components or circuits using the procedures listed here. Refer to the Service Information for proper air bag/restraint system testing procedures.**

CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 6

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK RELATED HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.

- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0151-O2 SENSOR 2/1 CIRCUIT LOW

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms

	resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.**
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts**

Using the Scan Tool for Diagnostics:	
	and increase toward 0.0 volts as the sensor heats up. When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Battery voltage between 11.0 and 15.75 volts.
- With the engine running.

SET CONDITION

- The Oxygen Sensor 2/1 signal voltage is less than 0.0 volts for 9.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 2/1 SIGNAL CIRCUIT SHORTED TO GROUND
O2 SENSOR 2/1 SIGNAL CIRCUIT SHORTED TO THE O2 SENSOR 2/1 HEATER GROUND CIRCUIT
O2 SENSOR 2/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **ISOLATE AND CHECK THE O2 SENSOR 2/1 (K43) SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.

3. Connect the negative lead of the DVOM to a known good ground.
4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, (special tool #10436, Adapter, GPEC Diagnostic) connect the to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **ISOLATE AND CHECK THE O2 SENSOR 2/1 (K43) SIGNAL CIRCUIT FOR A SHORT TO THE (Z910) GROUND CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between the circuits being tested.**

   Is there continuity between the circuits?

   Yes

   - Repair the short between the circuits.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

- Go To 5

5. **CHECK THE O2 SENSOR 2/1 (K43) SIGNAL CIRCUIT FOR PROPER VOLTAGE AT THE O2 SENSOR HARNESS CONNECTOR**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
    3. Turn the ignition on.
    4. Set the DVOM to measure DC voltage.
    5. Connect the negative lead of the DVOM to a known good ground.
    6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

    Is the O2 Sensor 2/1 voltage above 4.0 volts?

    Yes

    - Replace the O2 Sensor 2/1 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 6

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.

10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0152-O2 SENSOR 2/1 CIRCUIT HIGH

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.

- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between**

	approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.

Using the Scan Tool for Diagnostics:	
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage is between 11.0 volts and 15.8 volts.

SET CONDITION

- The PCM detects that Oxygen Sensor 2/1 signal voltage is greater than 1.20 volts.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 2/1 HEATER CONTROL CIRCUIT SHORTED TO VOLTAGE
O2 SENSOR 2/1 HEATER CONTROL CIRCUIT SHORTED TO GROUND
O2 SENSOR 2/1 HEATER CONTROL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 2/1 HEATER GROUND CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 2/1 SIGNAL CIRCUIT SHORTED TO VOLTAGE
O2 SENSOR 2/1 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 2/1 RETURN CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 2/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE CONDITION**
    1. Start the engine and allow it to idle for at least 60 seconds.

WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

2. With the scan tool, read the O2 Sensor 2/1 signal voltage.

   Is the voltage staying above 4.0 volts?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE O2 SENSOR 2/1 HEATER OPERATION**
   1. With the scan tool, check the O2 Sensor 2/1 duty cycle. Also monitor the O2 Sensor 2/1 heater temperature and compare to the other O2 Sensor heater temperatures.

   NOTE: **The duty cycle percentage and heater temperature should be relatively close to the other sensors. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably different than the other O2 Sensors.**

   Is the O2 Sensor heater operating properly?

   Yes

   - Go To 7

   No

   - Go To 3

3. **CHECK THE O2 SENSOR 2/1 (Z910) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
   1. Disconnect the component harness connector to isolate the ground circuit.
   2. Connect the positive lead of the load test tool to the positive side of the Battery.
   3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
   4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

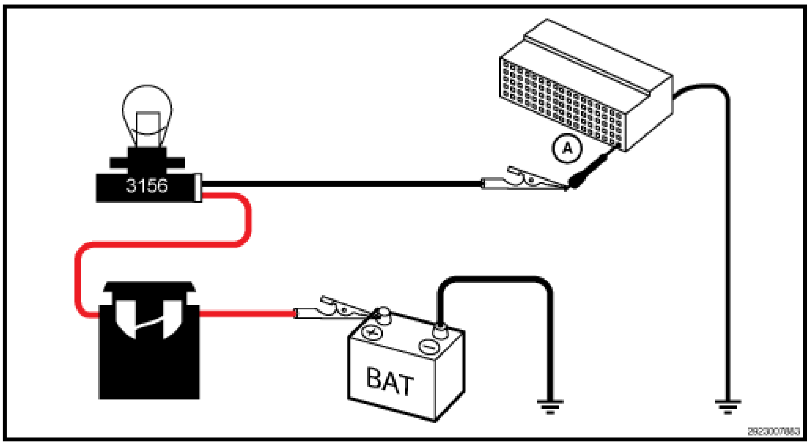
NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

   NOTE: Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.

   Is the load test bulb illuminated and bright?

Yes

- Go To 4

No

- Repair the ground circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE O2 SENSOR 2/1 (K199) HEATER CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
   4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

   Is there continuity between the circuit being tested and any other circuit?

   Yes

   - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **ISOLATE AND CHECK THE O2 SENSOR 2/1 (K199) HEATER CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to**

pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

No

- Go To 6

6. **ISOLATE AND LOAD TEST THE O2 SENSOR 2/1 (K199) HEATER CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
   3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
   4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at one of the component harness connectors (B).
   5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
   6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

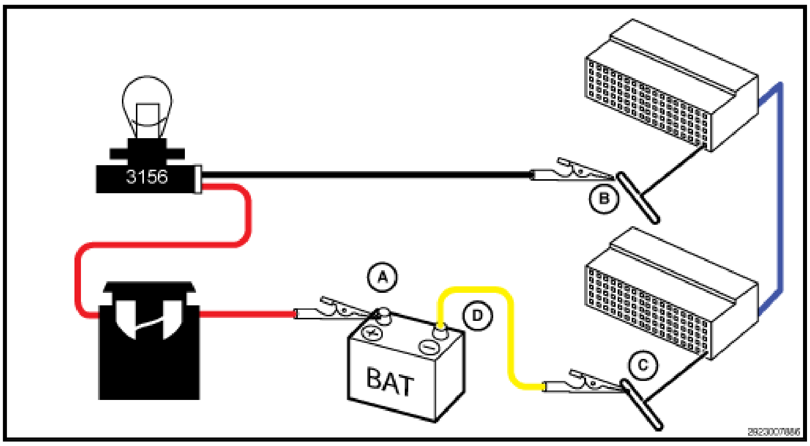
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage**

drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: Do not load test any circuits with components still connected to the circuit.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

NOTE: Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.

Is the load test bulb illuminated and bright?

Yes

- Go To 10

No

- Repair the circuit for an open or high resistance.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK THE O2 SENSOR 2/1 (K43) SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

    NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

    Is the voltage above 5.2 volts?

    Yes

    - Repair the (K43) O2 Sensor 2/1 Signal circuit for a short to voltage.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 8

8. **ISOLATE AND CHECK THE O2 SENSOR 2/1 (K43) SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

        NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

        Is the resistance below 3.0 Ohms?

        Yes

        - Go To 9

        No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **ISOLATE AND CHECK THE O2 SENSOR 2/1 (K902) RETURN CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 10

    No

    - Repair the circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **REPLACE THE O2 SENSOR 2/1 AND RETEST FOR DTC**
    1. Replace the O2 Sensor 2/1 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. Connect the O2 Sensor 2/1 and PCM harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the recorded Freeze Frame and the When Monitored conditions, operate the vehicle in the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 11

    No

    - Replacing the O2 Sensor repaired the fault.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0153-O2 SENSOR 2/1 SLOW RESPONSE

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Upstream Oxygen (O2) Sensor is usually placed close to the exhaust manifold to achieve fast light-off and provide immediate O2 feedback to allow the fuel system to enter closed loop fuel control.

The Upstream O2 Sensor is very important for emission control and engine performance since it can provide immediate air/fuel ratio feedback. Therefore, proper operation of this Upstream O2 Sensor is critical. An aged Upstream O2 Sensor tends to be less active and has a slower response rate to changes in the air/fuel ratio of exhaust gas. As a result, the quality of the Upstream O2 Sensor can be determined by observing the voltage activity from the sensor.

This monitor is triggered when the engine is running at certain MAP/RPM windows, airflow is relatively stable and steady O2 control is applied. The state change for Upstream O2 signal is captured in a calibrated time block (consisting of consecutive samples), such that even the slowest (but still considered as passing) O2 Sensor should accumulate enough state changes to pass the monitor.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Engine Coolant Temperature (ECT) Sensor value is above 70 B°C (158 B°F).
- Engine speed between 1400 and 2300 rpm.
- Vehicle speed between 64 and 96 km/h (40 and 60 mph).
- Engine run time greater than three minutes.

SET CONDITION

- PCM detects that the Oxygen Sensor signal does not switch adequately during monitoring.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EXHAUST LEAK
O2 SENSOR 2/1 SIGNAL CIRCUIT
O2 SENSOR 2/1 RETURN CIRCUIT
OXYGEN (O2) SENSOR 2/1

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.

7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECKING THE EXHAUST SYSTEM FOR LEAKS**
    1. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

    Were any exhaust leaks found?

    Yes

    - Repair or replace the leaking exhaust parts as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 3

3. **CHECK THE O2 SENSOR 2/1 (K43) SIGNAL CIRCUIT FOR PROPER VOLTAGE AT THE O2 SENSOR HARNESS CONNECTOR**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
    3. Turn the ignition on.
    4. Set the DVOM to measure DC voltage.
    5. Connect the negative lead of the DVOM to a known good ground.
    6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **Normal operating voltage should be between 4.1 and 5.0 volts.**

Does the circuit have the proper voltage present?

Yes

- Go To 8

No

- Go To 4

4. **CHECK THE O2 SENSOR 2/1 (K43) SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

    NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

    Is the voltage above 5.2 volts?

    Yes

    - Go To 5

    No

    - Go To 6

5. **ISOLATE AND CHECK THE O2 SENSOR 2/1 (K43) SIGNAL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

        NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

        Is there continuity between the circuit being tested and any other circuit?

        Yes

        - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 14

6. **ISOLATE AND CHECK THE O2 SENSOR 2/1 (K43) SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.

3. Connect the negative lead of the DVOM to a known good ground.
4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 7

7. **ISOLATE AND CHECK THE O2 SENSOR 2/1 (K43) SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 13

   No

   - Repair the circuit for an open or high resistance.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK THE (K902) SENSOR RETURN UPSTREAM CIRCUIT FOR PROPER VOLTAGE AT THE O2 SENSOR HARNESS CONNECTOR**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
    3. Turn the ignition on.
    4. Set the DVOM to measure DC voltage.
    5. Connect the negative lead of the DVOM to a known good ground.
    6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

        NOTE: **Normal operating voltage should be approximately 2.5 volts.**

        Does the circuit have the proper voltage present?

        Yes

        - Go To 13

        No

        - Go To 9

9. **CHECK THE (K902) SENSOR RETURN UPSTREAM CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

    NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

    Is the voltage above 5.2 volts?

    Yes

    - Go To 10

    No

    - Go To 11

10. **ISOLATE AND CHECK THE (K902) SENSOR RETURN UPSTREAM CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**

1. The ignition must be off when performing a resistance check to find a short between circuits.
2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 14

11. **ISOLATE AND CHECK THE (K902) SENSOR RETURN UPSTREAM CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 12

12. **ISOLATE AND CHECK THE (K902) SENSOR RETURN UPSTREAM CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Repair the (K902) O2 Return Upstream circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 13

13. **CHECK THE O2 SENSOR 2/1 WIRING AND CONNECTOR**

NOTE: **Check for signs of contaminants that may have damaged the O2 Sensor, such as contaminated fuel, unapproved silicone, oil and coolant.**

1. Using the wiring diagram/schematic as a guide, inspect the wiring and connectors between the O2 Sensor 2/1 and the Powertrain Control Module (PCM).
   - Look for any chafed, pierced, pinched, or partially broken wires.
   - Look for broken, bent, pushed out or corroded terminals.
   - Verify that there is good pin to terminal contact in the O2 Sensor 2/1 and Powertrain Control Module connectors.
   - Perform any Service Bulletins that may apply.

   Were any problems found?

   Yes

   - Repair as necessary.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Replace the O2 Sensor 2/1 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

14. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace the Powertrain Control Module (PCM) in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

- Test complete.

P0155-O2 SENSOR 2/1 HEATER PERFORMANCE

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.

- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver**

	and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Engine coolant temperature at start up and Ambient temperature are greater than 7B°C (45B°F).
- The difference between coolant temperature at engine start and ambient temperature is greater than 9B°C (48B°F).
- The O2 Heater temperature is greater than 401B°C (754B°F).
- Battery voltage is between 11.0 volts and 15.8 volts.

SET CONDITION

- No temperature change is detected in the O2 Sensor 2/1 Heater element when the heater circuit is active.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 2/1 HEATER CONTROL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 2/1 HEATER GROUND CIRCUIT OPEN/HIGH RESISTANCE
OXYGEN (O2) SENSOR 2/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE CONDITION**
    1. Turn the ignition off.

       NOTE: **Wait a minimum of eight minutes to allow the sensor to cool down before continuing. The sensor voltage should stabilize between 2.47 and 2.52 volts.**

    2. Turn the ignition on.
    3. With a scan tool, actuate the Oxygen Sensor 2/1 heater control.
    4. With the scan tool, monitor the O2 Sensor 2/1 voltage for at least two minutes.

       Does the voltage stay above approximately 4.5 volts?

       Yes

       - Go To 2

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. With the scan tool, read and record DTCs on the repair order.

       Are there any other O2 Sensor Heater circuit DTCs active or pending?

Yes

- Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

No

- Go To 3

3. **CHECK THE O2 SENSOR 2/1 HEATER ELEMENT RESISTANCE**
    1. Turn the ignition off.
    2. Disconnect the O2 Sensor 2/1 harness connector.
    3. Measure the resistance of the O2 Sensor 2/1 Heater Element across the O2 Sensor, between the O2 Heater Control terminal and the Heater ground terminal (component side).

    NOTE: **If possible, it's best to measure the O2 Sensor 1/1 Heater Element resistance value at approximately 20B°C (68B°F). The resistance value will vary with different temperature values. If the O2 Sensor is obviously warmer or cooler than the recommended temperature, use the table below to estimate what the resistance range should be. The MAXIMUM allowable resistance would be 12.5 Ohms at 1000B°C.**

Celsius	Fahrenheit	Resistance Range
0B°C	32B°F	3.1 - 4.2 Ohms
20B°C	68B°F	3.3 - 4.4 Ohms
100B°C	212B°F	3.85 - 5.1 Ohms

    Is the O2 Sensor resistance within the acceptable range?

    Yes

    - Go To 4

    No

    - Verify that there is good pin to terminal contact in the Sensor and Control Module connectors. If no problems are found, replace the O2 Sensor. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
4. **ISOLATE AND LOAD TEST THE O2 SENSOR 2/1 (K199) HEATER CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
    3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
    4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
    5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
    6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

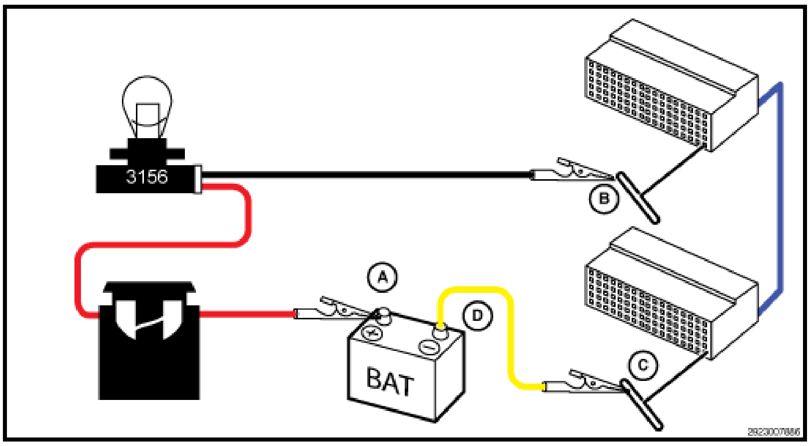
NOTE: Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .

NOTE: Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

- 1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
- 2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
- 3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



WARNING: To avoid possible serious or fatal injury, DO NOT load test any air bag/restraint system components or circuits using the procedures listed here. Refer to the Service Information for proper air bag/restraint system testing procedures.

CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 5

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND LOAD TEST THE (Z910) GROUND CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
   3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
   4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
   5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
   6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

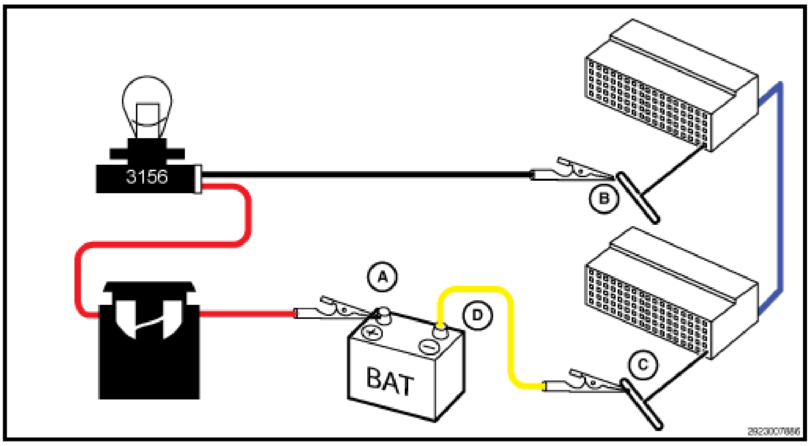
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

- 1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
- 2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
- 3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



WARNING: To avoid possible serious or fatal injury, DO NOT load test any air bag/restraint system components or circuits using the procedures listed here. Refer to the Service Information for proper air bag/restraint system testing procedures.

CAUTION: Do not load test any circuits with components still connected to the circuit.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 6

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK RELATED HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. With the scan tool, erase DTCs.
   9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   10. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0157-O2 SENSOR 2/2 CIRCUIT LOW

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this

case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between**

	approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will

Using the Scan Tool for Diagnostics:	
	cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Battery voltage between 11.0 and 15.75 volts.
- With the engine running.

SET CONDITION

- The Oxygen Sensor 2/2 signal voltage is less than 0.0 volts for 9.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 2/2 SIGNAL CIRCUIT SHORTED TO GROUND
O2 SENSOR 2/2 SIGNAL CIRCUIT SHORTED TO THE O2 SENSOR 2/2 HEATER GROUND CIRCUIT
O2 SENSOR 2/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2

2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **ISOLATE AND CHECK THE O2 SENSOR (K243) 2/2 SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, (special tool #10436, Adapter, GPEC Diagnostic) connect the to the appropriate PCM harness connector.

        NOTE: **There should be no continuity between ground and the circuit being tested.**

        Is there continuity between ground and the circuit being tested?

        Yes

        - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

- Go To 4

4. **ISOLATE AND CHECK THE O2 SENSOR (K243) 2/2 SIGNAL CIRCUIT FOR A SHORT TO THE (Z910) GROUND CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

    NOTE: **There should be no continuity between the circuits being tested.**

    Is there continuity between the circuits?

    Yes

    - Repair the short between the circuits.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

5. **CHECK THE O2 SENSOR (K243) 2/2 SIGNAL CIRCUIT FOR PROPER VOLTAGE AT THE O2 SENSOR HARNESS CONNECTOR**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
    3. Turn the ignition on.
    4. Set the DVOM to measure DC voltage.
    5. Connect the negative lead of the DVOM to a known good ground.
    6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

Is the O2 Sensor 2/2 voltage above 4.0 volts?

Yes

- Replace the O2 Sensor 2/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0158-O2 SENSOR 2/2 CIRCUIT HIGH

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and

heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool.

NOTE:

When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even

Using the Scan Tool for Diagnostics:	
	a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.

- Battery voltage between 11.0 volts and 15.8 volts.

SET CONDITION

- The PCM detects that Oxygen Sensor 2/2 signal voltage is greater than 1.20 volts.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 2/2 HEATER CONTROL CIRCUIT SHORTED TO VOLTAGE
O2 SENSOR 2/2 HEATER CONTROL CIRCUIT SHORTED TO GROUND
O2 SENSOR 2/2 HEATER CONTROL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 2/2 HEATER GROUND CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 2/2 SIGNAL CIRCUIT SHORTED TO VOLTAGE
O2 SENSOR 2/2 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 2/2 RETURN CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 2/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE CONDITION**
    1. Start the engine and allow it to idle for at least 60 seconds.

       WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

    2. With the scan tool, read the O2 Sensor 2/2 signal voltage.

       Is the voltage staying above 4.0 volts?

       Yes

       - Go To 2

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE O2 SENSOR 2/2 HEATER OPERATION**
    1. With the scan tool, check the O2 Sensor 2/2 duty cycle. Also monitor the O2 Sensor 2/2 heater temperature and compare to the other O2 Sensor heater temperatures.

       NOTE: **The duty cycle percentage and heater temperature should be relatively close to the other sensors. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry,**

even a small amount of resistance, will cause the temperature reading to be noticeably different than the other O2 Sensors.

Is the O2 Sensor heater operating properly?

Yes

- Go To 7

No

- Go To 3

3. **CHECK THE O2 SENSOR 2/2 (Z910) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Disconnect the component harness connector to isolate the ground circuit.
    2. Connect the positive lead of the load test tool to the positive side of the Battery.
    3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
    4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

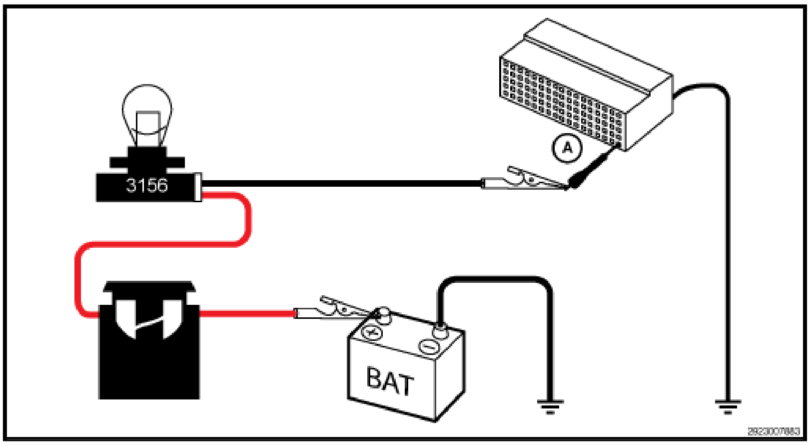
NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and

alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 4

   No

   - Repair the ground circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE O2 SENSOR 2/2 (K399) HEATER CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
   4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

   Is there continuity between the circuit being tested and any other circuit?

   Yes

   - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **ISOLATE AND CHECK THE O2 SENSOR 2/2 (K399) HEATER CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6

6. **ISOLATE AND LOAD TEST THE O2 SENSOR 2/2 (K399) HEATER CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.

2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at one of the component harness connectors (B).
5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

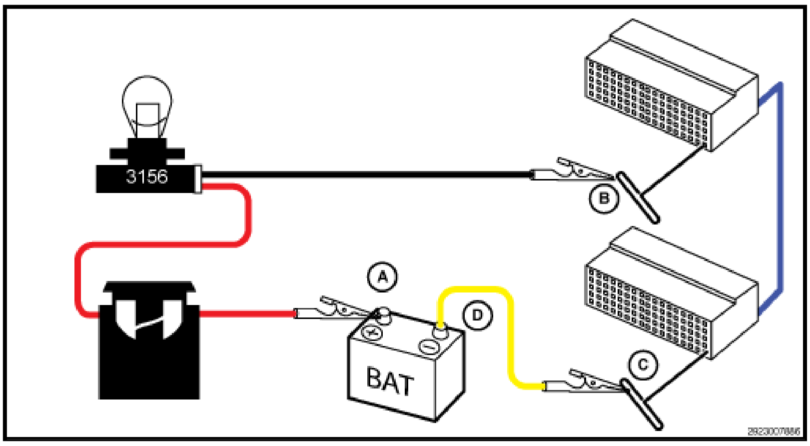
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 10

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK THE O2 SENSOR 2/2 (K243) SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Turn the ignition on.
   4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

Is the voltage above 5.2 volts?

Yes

- Repair the O2 Sensor 2/2 (K141) Signal circuit for a short to voltage.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 8

8. **ISOLATE AND CHECK THE O2 SENSOR 2/2 (K243) SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 9

    No

    - Repair the circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **ISOLATE AND CHECK THE O2 SENSOR 2/2 (K904) RETURN CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 10

    No

    - Repair the circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **REPLACE THE O2 SENSOR 2/2 AND RETEST FOR DTC**
    1. Replace the O2 Sensor 2/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. Connect the O2 Sensor 2/2 and PCM harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the recorded Freeze Frame and the When Monitored conditions, operate the vehicle in the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 11

    No

    - Replacing the O2 Sensor repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0159-O2 SENSOR 2/2 SLOW RESPONSE

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

For an aged Oxygen (O2) Sensor, the response rate to the air/fuel change is slower than when it was new. The O2 Sensor tends to move less with the same air/fuel changes in a given time frame. Therefore by observing the activity of voltage readings from the O2 Sensor, the quality of the O2 Sensor can be detected.

The Downstream O2 Sensor is located in the exhaust path behind the Catalytic Converter, and is monitored for proper response to assure optimum Catalytic Converter efficiency. This occurs by monitoring the change in the Downstream O2 Sensor voltage over time, when the fuel is shut off during a decel condition after the enable conditions were met. If the slope of the Downstream O2 Sensor is too small, the monitor will fail indicating that the O2 Sensor is not reliable enough to monitor Catalytic Converter efficiency.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the engine running.
- Vehicle speed above 96 km/h (60 mph).
- Engine Coolant Temperature (ECT) Sensor value greater than 70B°C (158B°F).
- Throttle open for a minimum of 120 seconds.
- Catalytic Converter temperature greater than 600B°C (1112B°F).
- Downstream O2 Sensor in a rich state.

- During a Decel Fuel Shutoff Event, the Downstream Oxygen Sensor should switch from rich to lean within a specific time.

SET CONDITION

- If the PCM does not detect a rich to lean switch within a specific time during a decel fuel shutoff event, the monitor will fail.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EXHAUST LEAK
O2 SENSOR 2/2 SIGNAL CIRCUIT
O2 SENSOR 2/2 RETURN CIRCUIT
OXYGEN (O2) SENSOR 2/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECKING THE EXHAUST SYSTEM FOR LEAKS**
   1. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

      Were any exhaust leaks found?

      Yes

- Repair or replace the leaking exhaust parts as necessary.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **CHECK THE O2 SENSOR 2/2 (K243) SIGNAL CIRCUIT FOR PROPER VOLTAGE AT THE O2 SENSOR HARNESS CONNECTOR**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
   3. Turn the ignition on.
   4. Set the DVOM to measure DC voltage.
   5. Connect the negative lead of the DVOM to a known good ground.
   6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **Normal operating voltage should be between 4.1 and 5.0 volts.**

   Does the circuit have the proper voltage present?

   Yes

   - Go To 8

   No

   - Go To 4

4. **CHECK THE O2 SENSOR 2/2 (K243) SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Turn the ignition on.
   4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

Is the voltage above 5.2 volts?

Yes

- Go To 5

No

- Go To 6

5. **ISOLATE AND CHECK THE O2 SENSOR 2/2 (K243) SIGNAL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

    NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 14
6. **ISOLATE AND CHECK THE O2 SENSOR 2/2 (K243) SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **ISOLATE AND CHECK THE O2 SENSOR 2/2 (K243) SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 13

    No

    - Repair the circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK THE (K904) SENSOR RETURN DOWNSTREAM CIRCUIT FOR PROPER VOLTAGE AT THE O2 SENSOR HARNESS CONNECTOR**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
    3. Turn the ignition on.
    4. Set the DVOM to measure DC voltage.
    5. Connect the negative lead of the DVOM to a known good ground.
    6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to**

pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

NOTE: **Normal operating voltage should be approximately 2.5 volts.**

Does the circuit have the proper voltage present?

Yes

- Go To 13

No

- Go To 9

9. **CHECK THE (K904) SENSOR RETURN DOWNSTREAM CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Turn the ignition on.
   4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

   Is the voltage above 5.2 volts?

   Yes

   - Go To 10

   No

   - Go To 11
10. **ISOLATE AND CHECK THE (K904) SENSOR RETURN DOWNSTREAM CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

    NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 14

11. **ISOLATE AND CHECK THE (K904) SENSOR RETURN DOWNSTREAM CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 12

12. **ISOLATE AND CHECK THE (K904) SENSOR RETURN DOWNSTREAM CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   Is the resistance below 3.0 Ohms?

   Yes

   - Repair the (K904) O2 Sensor Downstream Return circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 13

13. **CHECK THE O2 SENSOR 2/2 WIRING AND CONNECTOR**

   NOTE: **Check for signs of contaminants that may have damaged the O2 Sensor, such as contaminated fuel, unapproved silicone, oil and coolant.**

   1. Using the wiring diagram/schematic as a guide, inspect the wiring and connectors between the O2 Sensor 1/1 and the Powertrain Control Module (PCM).
      - Look for any chafed, pierced, pinched, or partially broken wires.
      - Look for broken, bent, pushed out or corroded terminals.
      - Verify that there is good pin to terminal contact in the 2/2 O2 Sensor and Powertrain Control Module connectors.
      - Perform any Service Bulletins that may apply.

      Were any problems found?

      Yes

      - Repair as necessary.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Replace the O2 Sensor 2/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

14. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).

- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace the Powertrain Control Module (PCM) in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
- Test complete.

P0160-O2 SENSOR 2/2 NO ACTIVITY DETECTED

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Downstream Oxygen (O2) Sensor no activity diagnostic monitor is intended to diagnose a Downstream O2 Sensor that is not moving or is stuck in a voltage window. This diagnostic is intended to verify the Downstream O2 Sensors ability to respond to fuel adaption deviations during the Catalyst Monitor test. To pass this monitor, the sensor must output a voltage greater than a high calibrated voltage and less than a low calibrated voltage within a calibrated time period. The test includes a non-intrusive monitor and an intrusive fueling monitor. The intrusive monitor will only run if the non-intrusive test does not pass within the calibrated time period.

The intrusive fueling routine is used to 'jolt' the fuel feedback system to force the monitor to pass. A test failure occurs if the voltage pass values are not achieved after the total accumulated test time.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Vehicle speed between 32 and 88.5 km/h (20 and 55 mph).
- Throttle open for a minimum of 120 seconds.

- Coolant temperature greater than 70B°C (158B°F).
- Catalytic Converter Temperature greater than 600B° C (1112B°F).
- EVAP Purge is active.

SET CONDITION

- The Oxygen Sensor signal voltage switches less than 16 times from lean to rich within 20 seconds during monitoring.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EXHAUST LEAK
O2 SENSOR 2/2 SIGNAL CIRCUIT
O2 SENSOR 2/2 RETURN CIRCUIT
OXYGEN (O2) SENSOR 2/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECKING THE EXHAUST SYSTEM FOR LEAKS**
    1. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

        Were any exhaust leaks found?

Yes

- Perform the appropriate repairs.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **CHECK THE O2 SENSOR 2/2 (K243) SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

    NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

    Is the voltage above 5.2 volts?

    Yes

    - Go To 4

    No

    - Go To 5

4. **ISOLATE AND CHECK THE O2 SENSOR 2/2 (K243) SIGNAL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

- Go To 8

5. **CHECK THE (K904) SENSOR RETURN CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

    NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

    Is the voltage above 5.2 volts?

    Yes

    - Go To 6

    No

    - Go To 7
6. **ISOLATE AND CHECK THE (K904) SENSOR RETURN CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

        NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

        Is there continuity between the circuit being tested and any other circuit?

        Yes

        - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 8
7. **CHECK THE OXYGEN SENSOR FOR PROPER OPERATION**

    NOTE: **Check for signs of contaminants that may have damaged the O2 Sensor, such as contaminated fuel, unapproved silicone, oil and coolant.**

1. Using the wiring diagram/schematic as a guide, inspect the wiring and connectors between the Oxygen Sensor 2/2 and the Powertrain Control Module (PCM).
2. Look for any chafed, pierced, pinched or partially broken wires.
3. Look for broken, bent, pushed out or corroded terminals.
4. Perform any Service Bulletins that may apply.

   Were any problems found?

   Yes

   - Repair as necessary.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Replace the Oxygen Sensor 2/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK RELATED HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. With the scan tool, erase DTCs.
   9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   10. With the scan tool, read DTCs.

      Did the DTC return?

      Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0161-O2 SENSOR 2/2 HEATER PERFORMANCE

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperature. A resistive heater element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heater resistance is directly proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a calculation to determine the heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater temperature is determined using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (PWM) to prevent damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating temperature range. The output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected in a comparison chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/fuel mixture) it produces a higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negative voltage to be read, each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnostics for O2 Sensors are algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 Sensor circuits. Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits originate from a single source within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sensors.
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s). The PCM performs individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return circuits are separate within the PCM. In this

case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heater will remain disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that ignition cycle. Any of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output of sensor signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (usually stays above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Control Circuit High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistance (3-4 Ohms) may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High DTC to set.** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can help in diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on the scan tool for the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 Ohms can increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between**

	approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is cold, will show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward 0.0 volts as the sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will both read near 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltage signals** to read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) Voltage Circuit Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heater circuitry** can cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the affected sensor to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit will cause the biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affected sensor or sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sensors are both affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the shared return circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt instead of 2.5-3.5 volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in the **O2 Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor return low for all shared sensors after the sensor warms up. However, this will

Using the Scan Tool for Diagnostics:	
	cause the voltage reading on the sensor that has the shorted signal to read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors will read 5.0 volts on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and return circuit voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condition and scan tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, the (0-1) raw voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Battery voltage between 11.0 volts and 15.8 volts.
- Engine coolant temperature at start up and Ambient temperature are greater than 7B°C (45B°F).
- The difference between coolant temperature at engine start and ambient temperature are greater than 9B°C (48B°F).
- The O2 Sensor heater temperature is greater than 401B°C (754B°F).

SET CONDITION

- No temperature change is detected in the O2 Sensor 2/2 Heater element when the heater circuit is active

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
O2 SENSOR 2/2 HEATER CONTROL CIRCUIT OPEN/HIGH RESISTANCE
O2 SENSOR 2/2 HEATER GROUND CIRCUIT OPEN/HIGH RESISTANCE
OXYGEN (O2) SENSOR 2/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
   1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

      Are there any applicable Service Bulletins or Flash updates?

      Yes

      - Perform the applicable repair.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

      No

- Go To 2

2. **CHECK FOR AN ACTIVE CONDITION**
    1. Turn the ignition off.

    NOTE: **Wait a minimum of eight minutes to allow the sensor to cool down before continuing. The sensor voltage should stabilize between 2.47 and 2.52 volts.**

    2. Turn the ignition on.
    3. With a scan tool, actuate the Oxygen Sensor 2/2 heater control.
    4. With the scan tool, monitor the O2 Sensor 2/2 voltage for at least two minutes.

    Does the voltage stay above approximately 4.5 volts?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **CHECK FOR OTHER DTCS**
    1. With the scan tool, read and record DTCs on the repair order.

    Are there any other O2 Sensor Heater circuit DTCs active or pending?

    Yes

    - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

    No

    - Go To 4

4. **CHECK THE O2 SENSOR 2/2 HEATER ELEMENT RESISTANCE VALUE**
    1. Turn the ignition off.

    NOTE: **Allow the O2 Sensor heater a few minutes to cool down from the heater test performed with the scan tool.**

    2. Disconnect the O2 Sensor 2/2 harness connector.
    3. Measure the resistance of the O2 Sensor Heater Element inside the O2 Sensor. Measure between the O2 Heater Control circuit terminal and the O2 Heater ground circuit terminal.

    NOTE: **If possible, it's best to measure the O2 Sensor 1/1 Heater Element resistance value at approximately 20B°C (68B°F). The resistance value will vary with different temperature values. If the O2 Sensor is obviously warmer or cooler than the recommended temperature, use the table below to estimate what the resistance range should be. The MAXIMUM allowable resistance would be 12.5 Ohms at 1000B°C.**

Celsius	Fahrenheit	Resistance Range
0B°C	32B°F	3.1 - 4.2 Ohms
20B°C	68B°F	3.3 - 4.4 Ohms

Celsius	Fahrenheit	Resistance Range
100B°C	212B°F	3.85 - 5.1 Ohms

Is the O2 Sensor resistance within the acceptable range?

Yes

- Go To 5

No

- Verify that there is good pin to terminal contact in the O2 Sensor 2/2 and Powertrain Control Module connectors. If OK, replace the O2 Sensor 2/2. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND LOAD TEST THE O2 SENSOR 2/2 (K399) HEATER CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
    3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
    4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
    5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
    6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

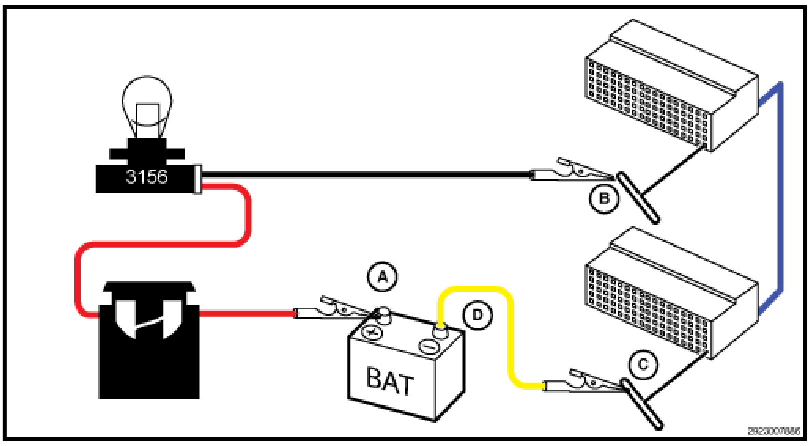
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**

- 2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
- 3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



WARNING: **To avoid possible serious or fatal injury, DO NOT load test any air bag/restraint system components or circuits using the procedures listed here. Refer to the Service Information for proper air bag/restraint system testing procedures.**

CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

- Go To 6

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND LOAD TEST THE (Z910) GROUND CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
    3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
    4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
    5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
    6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

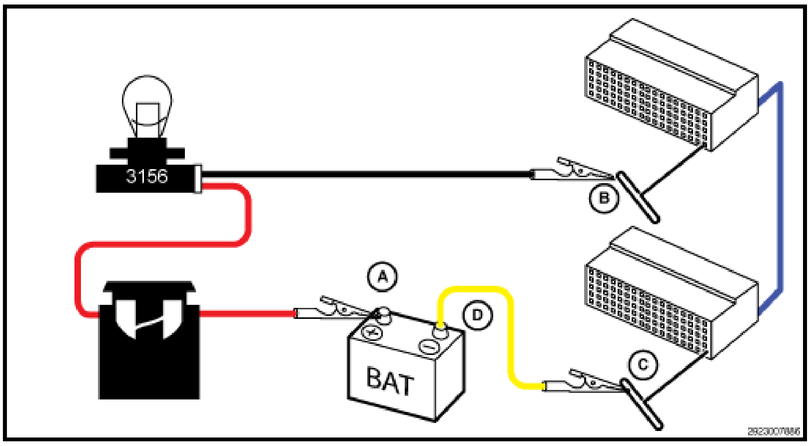
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
- **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit

makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



WARNING: **To avoid possible serious or fatal injury, DO NOT load test any air bag/restraint system components or circuits using the procedures listed here. Refer to the Service Information for proper air bag/restraint system testing procedures.**

CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 7

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

7. **CHECK RELATED HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.

4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

DIAGNOSIS AND TESTING

P0304-CYLINDER 4 MISFIRE

THEORY OF OPERATION

The PCM uses the Crankshaft Position (CKP) Sensor to detect and monitor the Crankshaft rotational speed. Normally, the Crankshaft rotational speed is fairly stable from cylinder to cylinder. When a misfire occurs in a cylinder, the Crankshaft speed changes abruptly for that cylinder. Therefore, anything that causes a sudden change in Crankshaft speed detected for a single cylinder is determined to be an engine misfire event. A misfire fault will usually occur due to poor fuel quality or metering, lack of spark, engine timing, low engine compression due to engine mechanical or valvetrain issues, a vacuum leak or coolant leak entering the engine intake air system. Though not as common, other factors such as severe wheel balance or braking vibration, a worn serpentine belt or belt driven accessory binding should also be considered when diagnosing a misfire fault.

Depending on the engine involved, there can be several systems and components that can contribute to a misfire. **In many cases, but not always, there will be other DTCs set related to these systems. If that is the case, the focus should be on following the diagnostics for the system that has DTCs set against it.** The different components or systems will affect misfire in different ways. Factors to consider when diagnosing a misfire are whether the misfire is a single cylinder or multiple cylinder misfire, and when does the misfire occur (idle, vehicle and engine speed, heavy engine load conditions, etc.). These factors can help in determining what components or systems should be focused on during diagnostics. **Typically a multiple cylinder misfire is an indication of timing, oil or coolant consumption, air handling, fuel supply or poor fuel quality issue that can affect multiple cylinders and not a single cylinder component such as a Fuel Injector, Ignition Coil or Spark Plug.**

NOTE: **The effects that the components and systems have on misfire detection are described in more detail in the individual test steps below.**

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Fuel level above 12%.
- Battery voltage above 10.9 volts.
- The adaptive numerator has been successfully learned.
- Ambient temperature above -23B°C (-9.4B°F).
- Coolant temperature at engine start is above -7B°C (19.4B°F). If start engine temperature is below threshold, enable monitor when engine temperature reaches 21B°C (69.8B°F).
- Engine speed between approximately 400 rpm and 6200 rpm.
    - Misfire monitor is disabled during a Decel Fuel Shutoff Event (DFSO).

SET CONDITION

- The variation in crankshaft speed between cylinders exceeds a calibrated value, based on engine speed and load.

DEFAULT ACTION

- The MIL light will illuminate or flash depending on severity of the misfire.
- During a severe misfire (MIL Light flashing) the PCM will disable the Fuel Injector of the affected cylinder(s) for a calibrated number of engine revolutions to prevent damage to the Catalytic Converter.

When the engine rev counter has reached the calculated threshold the Fuel Injector is turned back on. If a misfire is still occurring, the injector is disabled again. This cycle will continue until the misfire has stopped.

- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
ENGINE VACUUM LEAK
FAULTY FUEL INJECTOR
FAULTY IGNITION COIL OR SPARK PLUG
CRANKSHAFT POSITION SENSOR (CKP) OR TONE WHEEL ISSUES
EXCESSIVE CARBON BUILD-UP OR VALVETRAIN ISSUE
VARIABLE VALVE LIFT (VVL) SYSTEM ISSUES (IF EQUIPPED)
COOLANT LEAKING INTO A CYLINDER
ENGINE MECHANICAL SYSTEM
WORN CAMSHAFT LOBES, SPRINGS OR ROCKER ARMS
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE CONDITION**
    1. Turn the ignition on.
    2. With the scan tool, read and record all DTCs and Freeze Frame information.
    3. Operate the vehicle under conditions recorded in the Freeze Frame information when the DTC was set.

        NOTE: **During the test drive of the vehicle, note when the misfire condition is present for use later in this diagnostic test. Also monitor the Downstream O2 Sensor(s) when the misfire is occurring. O2 Sensor voltage readings that are consistently on the low side of the scale would indicate a lean condition. This could indicate a lack of fuel due to a plugged Fuel Injector or fuel system issue. O2 Sensor voltage readings that are consistently on the high side of the scale would indicate a rich condition. This could be caused by a lack of spark or a possible leaky Fuel Injector.**

        NOTE: **Keep in mind that during a severe misfire (MIL Light flashing) the PCM will disable the Fuel Injector of the affected cylinder(s) for a calibrated number of engine revolutions to prevent damage to the Catalytic Converter. This can cause a misfire that occurs only at high engine speed or heavy engine load to appear to continue when returning to idle. However this could be due to the Fuel Injector being disabled until the rev counter resets.**

    4. With the scan tool, view the Misfire Monitor to see which cylinders are effected.

        Are there excessive misfires shown for this cylinder at this time?

        Yes

        - Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

   Are there any Service Bulletins or fuel system, ignition system component, air handling component, VVL system (if equipped), or VVT system DTCs active or pending?

   Yes

   - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

   No

   - Go To 3

3. **CHECK FOR MECHANICAL CONDITIONS THAT COULD CAUSE A MISFIRE**

   NOTE: **Each of the following conditions can cause a misfire during most operating conditions with the exception of the out of balance tires or warped brake rotors.**

   1. Visually inspect the engine for any of the following conditions:
      - Worn, loose or slipping serpentine belt.
      - Binding or misaligned engine driven accessories: A/C Compressor, P/S Pump, Water pump, etc.
      - Improper mounting of the CKP Sensor or damaged target wheel.
      - Harmonic Balancer out of balance.
      - Extremely out of balance tires or warped brake rotors.

   Were any of the above conditions present?

   Yes

   - Repair as necessary.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **CHECK THE ENGINE OIL LEVEL AND CONDITION**

   NOTE: **The oil level being low or the wrong oil filter or viscosity being used can cause Variable Valve Timing system operating issues. This could lead to a misfire condition.**

   NOTE: **The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.**

   - **ENGINE MECHANICAL TOLERANCES OUT OF SPECIFICATION**
   - **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
   - **LOW ENGINE OIL LEVEL**

- **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**
- **DETERIORATED OR DIRTY OIL**
- **CONTAMINATED ENGINE OIL**
- **INCORRECT ENGINE OIL VISCOSITY**
- **AERATED ENGINE OIL**

1. If any of the above conditions are found, repair as necessary.

   Were any of the above conditions present?

   Yes

   - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **CHECK THE INTAKE SYSTEM FOR LEAKS**
   1. Check the engine and Intake Manifold for vacuum leaks.

   NOTE: **A vacuum leak can affect one or more cylinders depending on the location of the leak.**

   Were any leaks found with the intake system?

   Yes

   - Repair the leak in the intake system.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6

6. **CHECK THE FUEL QUALITY**
   1. Check the fuel for the following:
      - Water in fuel
      - Correct type of fuel
      - Old or contaminated fuel
      - Low fuel
      - Perform the CHECK FOR PROPER ETHANOL LEVEL IN THE GASOLINE procedure. Refer to **CHECKING FOR PROPER ETHANOL LEVEL IN THE GASOLINE** .

   Were any problems found with the fuel?

   Yes

   - Replace the fuel and, if necessary, flush and clean the fuel system.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **CHECK FOR A CLOGGED OR LEAKING FUEL INJECTOR**

NOTE: **A Fuel Injector that is plugged and spraying too little fuel, or fouled and spraying too much fuel, will generally cause a misfire during any operating condition. One faulty Fuel Injector will usually cause a single cylinder misfire. However if the injector is spraying an excessive amount of fuel, the excess fuel could also affect the adjoining cylinders. In most cases there will be far more misfire counts on the cylinder with the faulty Fuel Injector than on the other affected cylinders.**

WARNING: **The fuel system is under a constant pressure (even with the engine off). Before testing or servicing any fuel system hose, fitting or line, the fuel system pressure must be released. Failure to follow these instructions can result in possible serious or fatal injury.**

1. Install the Fuel Pressure Decay Tester (special tool #8978A, Decay Tool, Fuel) to the fuel rail.
2. Turn the ignition on and allow the fuel pressure to reach maximum pressure and stabilize.

   NOTE: **The ignition may need to be cycled off and on a couple times to reach maximum fuel pressure in the rail.**

3. Once the pressure reading has stabilized, record the fuel pressure. This is known as the "starting pressure".
4. With the scan tool, actuate the Fuel Injector for the cylinder that indicated the misfire while monitoring the fuel pressure gauge.
5. Record the fuel pressure. This is known as the "ending pressure."

   CAUTION: **After each Fuel Injector actuation, start the engine to clean the cylinder of fuel. Failure to do so could cause engine damage.**

6. Repeat sub-steps two through five with several other Fuel Injectors on cylinders that do not have a misfire. Make sure to start the Fuel Injector actuation at the same starting pressure for each injector. Compare the ending pressures of the known good cylinders to the cylinder with the misfire condition.

   Are the ending pressures about the same for all of the tested injectors?

   Yes

   - Go To 8

   No, the injector from the cylinder with the misfire stood out from the rest.

   - If the pressure drop is too small, check for debris in the Fuel Rail or Fuel Injector and repair as necessary. If the pressure drop is too large, suspect a faulty or fouled Fuel Injector as the issue.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK THE VARIABLE VALVE LIFT (VVL) SYSTEM (IF EQUIPPED)**

NOTE: **The 3.6L Upgrade engine is equipped with the VVL System. The classic engine is not. If this vehicle is not equipped with the VVL system skip this test step.**

NOTE: **A Rocker Arm or arms can get stuck due to an oil pressure issue, or a mechanical failure of a VVL Solenoid (including O-rings) or Rocker Arm. A single Rocker Arm that is stuck in low lift will not be detected and the system will continue to operate normally, however some misfire and engine roughness may be felt. One Rocker Arm stuck in Low Lift mode will cause a misfire at higher engine speeds (above approximately 4000 rpm). Two or more Rocker Arms stuck in Low Lift mode can cause a misfire at any engine speed, including idle. A Rocker Arm stuck in high lift mode typically misfires at idle.**

NOTE: **The two rear cylinders are controlled by the rear solenoid on each bank. Therefore, a VVL issue that affects both rear cylinders on a bank is most likely a common issue for both cylinders. These would include a damaged or missing O-ring, faulty solenoid, oil supply or control circuit issue. A VVL issue that only affects one of the rear cylinders is more likely going to be a failure of a Rocker Arm or pin for that cylinder.**

NOTE: **The front VVL Solenoids control the operation of the Rocker Arms for the front cylinder only on each bank. The rear VVL Solenoids control the operation of the Rocker Arms for the back two cylinders on each bank.**

1. Turn the ignition on.
2. With the scan tool, navigate to Systems Tests, perform the VVL System Diagnostic test and follow the on screen directions. for further VVL system functionality and scan tool routine information.

   NOTE: **Do not erase the DTC before running the routine.**

3. When the test is complete, compare the results to the table below for the probable failure conditions.

   Does the scan tool results show that the misfire is being caused by the VVL system?

   Yes

   - Compare the results from the routine to the table below
   -

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
Low misfire percentage on (1) Rocker Stuck Low test, (2) Rocker Stuck High, Low RPM test, and (3) Rocker Stuck High, High RPM test	No VVL issue detected	The misfire condition being detected is not caused by the VVL System. Another system is likely causing the misfire
High misfire percentage on (1) Rocker Stuck Low test, (2) Rocker Stuck High, Low RPM test, and (3) Rocker Stuck High, High RPM test	No VVL issue detected	The misfire condition being detected is not caused by the VVL System. Another system is likely causing the misfire
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 1	• VVL Solenoid 1/1 stuck on/open • VVL Solenoid 1/1 control circuit shorted to 12 volts	• Verify that the VVL Solenoid 1/1 control circuit is not shorted to 12 volts

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	• VVL Solenoid 1/1 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Cylinder 1 rocker arm lash adjuster issue (stuck or broken) • Cylinder 1 rocker arm lock pin stuck retracted • Oil pressure leakage from the supply oil passage to the front control oil passage in the Cylinder Head.	• Check operation of VVL Solenoid 1/1 for a stuck on/open condition, damaged or missing supply O-ring • Check for broken or stuck Cylinder 1 rocker arms or lock pins • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head.
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 2	• VVL Solenoid 2/1 stuck on/open • VVL Solenoid 2/1 control circuit shorted to 12 volts • VVL Solenoid 2/1 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Cylinder 2 rocker arm lash adjuster issue (stuck or broken) • Cylinder 2 rocker arm lock pin stuck retracted • Oil pressure leakage from the supply oil passage to the front control oil passage in the Cylinder Head.	• Verify that the VVL Solenoid 2/1 control circuit is not shorted to 12 volts • Check operation of VVL Solenoid 2/1 for a stuck on/open condition, damaged or missing supply O-ring • Check for broken or stuck Cylinder 2 rocker arms or lock pins • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9.
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 3	• Cylinder 3 rocker arm lash adjuster issue (stuck or broken) • Cylinder 3 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 3 rocker arms or lock pins
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 4	• Cylinder 4 rocker arm lash adjuster issue (stuck or broken)	• Check for broken or stuck Cylinder 4 rocker arms or lock pins

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	• Cylinder 4 rocker arm lock pin stuck retracted	
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 5	• Cylinder 5 rocker arm lash adjuster issue (stuck or broken) • Cylinder 5 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 5 rocker arms or lock pins
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 6	• Cylinder 6 rocker arm lash adjuster issue (stuck or broken) • Cylinder 6 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 6 rocker arms or lock pins
(1) Rocker Stuck Low test - high misfire percentage on Cylinder 3 and Cylinder 5	• VVL Solenoid 1/2 stuck on/open • VVL Solenoid 1/2 control circuit shorted to 12 volts • VVL Solenoid 1/2 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Oil pressure leakage from the supply oil passage to the rear control oil passage in the Cylinder Head. **NOTE:** **It's less likely but possible for a rocker arm lash adjuster failure (stuck or broken) or lock pin stuck retracted on both Cylinder 3 and Cylinder 5**	• Check the VVL Solenoid 1/2 control circuit for a short to 12 volts condition • Check operation of VVL Solenoid 1/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head.
(1) Rocker Stuck Low test - high misfire percentage on Cylinder 4 and Cylinder 6	• VVL Solenoid 2/2 stuck on/open • VVL Solenoid 2/2 control circuit shorted to 12 volts	• Check the VVL Solenoid 2/2 control circuit for a short to 12 volts condition

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	• VVL Solenoid 2/2 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Oil pressure leakage from the supply oil passage to the rear control oil passage in the Cylinder Head. **NOTE:** **It's less likely but possible for a rocker arm lash adjuster failure (stuck or broken) or lock pin stuck retracted on both Cylinder 4 and Cylinder 6**	• Check operation of VVL Solenoid 2/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9.
(1) Rocker Stuck Low test - high misfire percentage Cylinder 1, Cylinder 3, and Cylinder 5	• Both bank 1 solenoids have missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage for both bank 1 solenoids • Oil pressure leakage from the supply oil passage to the front and rear control oil passages in the Cylinder Head.	• Check operation of VVL Solenoid 1/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9.
(1) Rocker Stuck Low test - high misfire percentage Cylinder 2, Cylinder 4, and Cylinder 6	• Both bank 2 solenoids have missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control	• Check operation of VVL Solenoid 2/2 for a stuck on/open condition, damaged or missing supply O-ring

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	oil passage for both bank 2 solenoids • Oil pressure leakage from the supply oil passage to the front and rear control oil passages in the Cylinder Head.	• It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9.
(1) Rocker Stuck Low test - high misfire percentage for all Cylinders (1 - 6)	• Missing or damaged supply O-rings causing oil pressure leakage from the supply oil passage to the control oil passage for front and rear solenoids on bank 1 and bank 2 • Oil pressure leakage from the supply oil passage to the front and rear control oil passages in both Cylinder Heads.	• Check operation of all VVL Solenoids for a stuck on/open condition, damaged or missing supply O-rings • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace both Cylinder Heads.
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 1	• VVL Solenoid 1/1 control circuit open or shorted to ground • VVL Solenoid 1/1 stuck closed/off • VVL Solenoid 1/1 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted • Cylinder 1 lash adjuster plugged • Cylinder 1 rocker arm lash adjuster issue (stuck or broken) • Cylinder 1 rocker arm lock pin stuck extended	• Check the VVL Solenoid 1/1 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 1/1 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 1/1 operation. Check for debris on screen • Cylinder 1 lash adjuster plugged • Cylinder 1 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High	• VVL Solenoid 2/1 stuck closed/off	• Check the VVL Solenoid 2/1 control circuit for an

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
RPM test - high misfire percentage Cylinder 2	• VVL Solenoid 2/1 control circuit open or shorted to ground • VVL Solenoid 2/1 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted • Cylinder 2 lash adjuster plugged • Cylinder 2 rocker arm lash adjuster issue (stuck or broken) • Cylinder 2 rocker arm lock pin stuck extended	open or shorted to ground condition • Check the VVL Solenoid 2/1 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 2/1 operation. Check for debris on screen • Cylinder 2 lash adjuster plugged • Cylinder 2 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 3	• Cylinder 3 lash adjuster plugged • Cylinder 3 rocker arm lash adjuster issue (stuck or broken) • Cylinder 3 rocker arm lock pin stuck extended	• Cylinder 3 lash adjuster plugged • Cylinder 3 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 4	• Cylinder 4 lash adjuster plugged • Cylinder 4 rocker arm lash adjuster issue (stuck or broken) • Cylinder 4 rocker arm lock pin stuck extended	• Cylinder 4 lash adjuster plugged • Cylinder 4 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 5	• Cylinder 5 lash adjuster plugged • Cylinder 5 rocker arm lash adjuster issue (stuck or broken) • Cylinder 5 rocker arm lock pin stuck extended	• Cylinder 5 lash adjuster plugged • Cylinder 5 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 6	• Cylinder 6 lash adjuster plugged • Cylinder 6 rocker arm lash adjuster issue (stuck or broken) • Cylinder 6 rocker arm lock pin stuck extended	• Cylinder 6 lash adjuster plugged • Cylinder 6 rocker arm stuck failure or lock pin stuck extended

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 3 and Cylinder 5	• VVL Solenoid 1/2 stuck closed/off • VVL Solenoid 1/2 control circuit open or shorted to ground • VVL Solenoid 1/2 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted **NOTE:** **It's less likely but possible for a rocker arm lash adjuster issue (stuck or broken) or lock pin stuck retracted on Cylinder 3 and Cylinder 5**	• Check the VVL Solenoid 1/2 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 1/2 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 1/2 operation. Check for debris on screen • Cylinder 3 or 5 lash adjuster plugged • Cylinder 3 or 5 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 4 and Cylinder 6	• VVL Solenoid 2/2 stuck closed/off • VVL Solenoid 2/2 control circuit open or shorted to ground • VVL Solenoid 2/2 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted **NOTE:** **It's less likely but possible for a rocker arm lash adjuster issue (stuck**	• Check the VVL Solenoid 2/2 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 2/2 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 2/2 operation. Check for debris on screen • Cylinder 4 or 6 lash adjuster plugged • Cylinder 4 or 6 rocker arm stuck failure or lock pin stuck extended

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	or broken) or lock pin stuck retracted on Cylinder 4 and Cylinder 6	
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 1, Cylinder 3 and Cylinder 5	• VVL Solenoid 1/1 and 1/2 have missing or damaged control O-rings causing oil pressure leakage from the control oil passage to the exhaust oil passage • Bank 1 oil supply passage blockage or restriction to front and rear oil feeds in the bank 1 Cylinder Head • Large internal leakage in bank 1 Cylinder Head affecting the front and rear oil feeds	• Check the control O-rings on the front and rear bank 1 VVL Solenoids for damage • Check for proper oil pressure at the front and rear bank 1 VVL Solenoids. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9. It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if the oil pressure is low to both solenoids and all other possible causes are exhausted, replace the Cylinder Head **NOTE:** **Low oil pressure in the Cylinder Head will likely also cause issues/faults for the VVT system**
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 2, Cylinder 4 and Cylinder 6	• VVL Solenoid 2/1 and 2/2 have missing or damaged control O-rings causing oil pressure leakage from the control oil passage to the exhaust oil passage • Bank 2 oil supply passage blockage or restriction to front and rear oil feeds in the bank 2 Cylinder Head	• Check the control O-rings on the front and rear bank 2 VVL Solenoids for damage • Check for proper oil pressure at the front and rear bank VVL Solenoids. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9. It is a very low

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	• Large internal leakage in bank 2 Cylinder Head affecting the front and rear oil feeds	percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if the oil pressure is low to both solenoids and all other possible causes are exhausted, replace the Cylinder Head **NOTE:** **Low oil pressure in the Cylinder Head will likely also cause issues/faults for the VVT system**
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage for all Cylinders (1 - 6)	Engine oil pressure too low to both Cylinder Heads due to: • Oil level low • Wrong viscosity oil • Oil Filter restriction • Engine mechanical failure (damaged bearings, pick-up tube or seal, engine block, etc.) • Faulty Oil Pump	• Check for proper oil level, filter and viscosity before checking engine oil pressure • If the engine oil pressure is low check for any mechanical issue that could cause low oil pressure. If there are no issues with the bearings, pick-up tube and engine block replace the Engine Oil Pump Assembly **NOTE:** **Low engine oil pressure will likely also cause issues/faults for the VVT system**

- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

No

- Go To 10

9. **CHECK THE ACTUAL OIL PRESSURE TO THE VVL SOLENOID IN THE CYLINDER HEAD**
    1. Turn the ignition off.
    2. Remove the appropriate VVL Solenoid called out by the scan tool.

3. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the VVL Solenoid.
4. Start the engine and allow it to idle.
5. With the scan tool, monitor the Dual Oil Pump mode.

NOTE: **Let the engine run long enough for the pump to switch to low pump mode.**

6. Read and record the oil pressure reading on the oil pressure gauge. Compare the reading to the main engine oil pressure reading from the Engine Oil Pressure Sensor reading on the scan tool.

NOTE: **The Cylinder Head oil pressure should be within 5.0 psi of main engine oil pressure reading.**

Is the Cylinder Head oil pressure should be within 5.0 psi of main engine oil pressure?

Yes

- Remove and inspect the screen on the VVL Solenoid for debris that can block oil flow through the solenoid. Check the seals on the VVL Solenoid for damage and proper installation. If no debris is found, and the seals appear good replace the VVL Solenoid in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Diagnose and repair the lack of oil pressure to the VVL Solenoid.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CHECK FOR PROPER SPARK AT THE IGNITION COIL**
    1. Turn the ignition off and remove the Fuel Pressure Decay Tester and connect the fuel lines before continuing.

NOTE: **A faulty Ignition Coil or Spark Plug can cause a misfire at idle but could also misfire only under a heavy load on the engine. One faulty Ignition Coil or Spark Plug will usually cause a single cylinder misfire.**

2. Remove the Ignition Coil from the cylinder that is misfiring.
3. Connect the Ignition Coil harness connector.
4. Disconnect the Fuel Injector harness connector of the cylinder being tested.
5. Install a spark tester on the Ignition Coil.
6. While cranking the engine observe the spark coming from the spark tester.

Is a crisp blue spark present?

Yes

- Go To 11

No

- Go To 16

11. **INSPECT THE SPARK PLUG AND CYLINDER**
    1. Turn the ignition off.

2. Remove the Spark Plug in accordance with the Service Information.
3. Inspect the Spark Plug for the following conditions:
   - Cracks
   - Carbon Tracking
   - Fouling due to oil, coolant or excess fuel in the cylinder
   - Gap size out of specifications
   - Loose or broken electrode
4. Check for signs of oil or coolant in the cylinder.

   Were any of the above conditions present?

   Yes

   - Replace the Spark Plug. If oil or coolant were found in the cylinder or on the Spark Plug, diagnose and repair the cause.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 12

12. **CHECK THE ENGINE COMPRESSION TO CHECK FOR VALVETRAIN OR COMBUSTION CHAMBER ISSUES**

NOTE: **A cylinder compression or valvetrain issue will cause a misfire during all operating conditions. These types of failures will normally affect a single cylinder. However, depending on the type of failure incurred, other cylinders can also be affected and show misfires. In most cases there will be far more misfire counts on the cylinder with the issue than on the other affected cylinders.**

1. Perform a cylinder compression test on several cylinders and compare the known good cylinders to the cylinder that was misfiring. Refer to **CYLINDER COMPRESSION TEST** .

   Is the cylinder compression within specification?

   Yes

   - Go To 13

   No

   - Perform a Cylinder Leak Down Test to determine if the cause is from the valvetrain or combustion chamber and repair as necessary.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **EXCHANGE SPARK PLUG AND CHECK FOR MISFIRE TO FOLLOW THE SPARK PLUG**
1. Exchange the Spark Plug with a known good cylinder that was not indicating a misfire or replace the Spark Plug if it is difficult to access.
2. Start the engine and monitor the misfire monitor screen.

   Did the misfire switch to the previously good cylinder or go away if the Spark Plug was replaced?

   Yes

- Repair is complete if Spark Plug was replaced and misfire is gone, or replace the Spark Plug if it moved to the known good cylinder.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 14

14. **CLEAN THE CARBON FROM THE VALVETRAIN AND COMBUSTION CHAMBERS**

NOTE: **Carbon build up on the engine valves and guides can cause a misfire during all operating conditions but is usually more noticeable during cruising speeds or heavy engine load conditions. If carbon build up is becoming an issue it could set only a single cylinder misfire but usually will affect more than one cylinder and set multiple cylinder misfire as well.**

1. Using Mopar Combustion cleaner, de-carbon the engine.
2. After driving and clearing the combustion cleaner from the engine, erase DTCs with the scan tool.
3. Test drive the vehicle in accordance with the Freeze Frame data.
4. With the scan tool, view the Misfire Monitor.

Did the misfire return?

Yes

- Go To 15

No

- Cleaning the valves and combustion chambers repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

15. **CHECK THE CAMSHAFT LOBES, ROCKER ARMS AND SPRINGS**

NOTE: **Worn Camshaft Lobes, worn or broken Rocker Arms or springs may sometimes but not always be detected during a compression test. The misfire can occur at different operating conditions depending on which component is worn and the severity of the wear on the component.**

1. Visually inspect the Camshaft, Rocker Arms or springs for excessive wear or broken parts.

Were any issues found with the Camshaft, Rocker Arms or springs?

Yes

- Perform the appropriate repair in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 20

16. **CHECK THE ASD RELAY OUTPUT CIRCUIT**

1. Turn the ignition off.
2. Disconnect the Ignition Coil harness connector.

3. Turn the ignition on.
4. With a scan tool, actuate the ASD Relay.
5. Using a 12-volt test light connected to ground, probe the ASD Relay Output circuit at the Ignition Coil harness connector.

   Does the test light illuminate brightly?

   Yes

   - Go To 17

   No

   - Stop all scan tool actuations and repair the open or short to ground in the ASD Relay Output circuit between the PDC and Ignition Coil harness connector.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

17. **CHECK THE IGNITION COIL CONTROL CIRCUIT**

WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

1. Using a 12-volt test light connected to a 12 volt source, back probe the Coil Control circuit at the Ignition Coil harness connector.
2. Crank the engine for 5 seconds while observing the test light.

   What was the condition of the test light while cranking the engine?

   Blinking brightly

   - Replace the Ignition Coil in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   ON constantly

   - Go To 18

   OFF constantly

   - Go To 19

18. **CHECK THE COIL CONTROL CIRCUIT FOR A SHORT TO GROUND**

1. Turn the ignition off.
2. Disconnect the PCM C2 harness connector.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

3. Connect the (special tool #10436, Adapter, GPEC Diagnostic) to the engine harness side of the PCM C2 harness connector.
4. Check for continuity between ground and the Coil Control circuit at the Ignition Coil harness connector.

Is there continuity between ground and the Coil Control circuit?

Yes

- Repair the Coil Control circuit for a short to ground.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 20

19. **CHECK THE COIL CONTROL CIRCUIT FOR AN OPEN**
    1. Turn the ignition off.
    2. Measure the resistance of the Coil Control circuit between the Ignition Coil harness connector and the GPEC Adaptor.

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 20

    No

    - Repair the Coil Control circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
20. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.

9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0305-CYLINDER 5 MISFIRE

THEORY OF OPERATION

The PCM uses the Crankshaft Position (CKP) Sensor to detect and monitor the Crankshaft rotational speed. Normally, the Crankshaft rotational speed is fairly stable from cylinder to cylinder. When a misfire occurs in a cylinder, the Crankshaft speed changes abruptly for that cylinder. Therefore, anything that causes a sudden change in Crankshaft speed detected for a single cylinder is determined to be an engine misfire event. A misfire fault will usually occur due to poor fuel quality or metering, lack of spark, engine timing, low engine compression due to engine mechanical or valvetrain issues, a vacuum leak or coolant leak entering the engine intake air system. Though not as common, other factors such as severe wheel balance or braking vibration, a worn serpentine belt or belt driven accessory binding should also be considered when diagnosing a misfire fault.

Depending on the engine involved, there can be several systems and components that can contribute to a misfire. **In many cases, but not always, there will be other DTCs set related to these systems. If that is the case, the focus should be on following the diagnostics for the system that has DTCs set against it.** The different components or systems will affect misfire in different ways. Factors to consider when diagnosing a misfire are whether the misfire is a single cylinder or multiple cylinder misfire, and when does the misfire occur (idle, vehicle and engine speed, heavy engine load conditions, etc.). These factors can help in determining what components or systems should be focused on during diagnostics. **Typically a multiple cylinder misfire is an indication of timing, oil or coolant consumption, air handling, fuel supply or poor fuel quality issue that can affect multiple cylinders and not a single cylinder component such as a Fuel Injector, Ignition Coil or Spark Plug.**

NOTE: **The effects that the components and systems have on misfire detection are described in more detail in the individual test steps below.**

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Fuel level above 12%.
- Battery voltage above 10.9 volts.
- The adaptive numerator has been successfully learned.
- Ambient temperature above -23B°C (-9.4B°F).
- Coolant temperature at engine start is above -7B°C (19.4B°F). If start engine temperature is below threshold, enable monitor when engine temperature reaches 21B°C (69.8B°F).

- Engine speed between approximately 400 rpm and 6200 rpm.
  - Misfire monitor is disabled during a Decel Fuel Shutoff Event (DFSO).

SET CONDITION

- The variation in crankshaft speed between cylinders exceeds a calibrated value, based on engine speed and load.

DEFAULT ACTION

- The MIL light will illuminate or flash depending on severity of the misfire.
- During a severe misfire (MIL Light flashing) the PCM will disable the Fuel Injector of the affected cylinder(s) for a calibrated number of engine revolutions to prevent damage to the Catalytic Converter. When the engine rev counter has reached the calculated threshold the Fuel Injector is turned back on. If a misfire is still occurring, the injector is disabled again. This cycle will continue until the misfire has stopped.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
ENGINE VACUUM LEAK
EXCESSIVE CARBON BUILD-UP IN CYLINDER HEAD OR COMBUSTION CHAMBER
FAULTY FUEL INJECTOR
POOR FUEL QUALITY OR HIGH ETHANOL LEVEL
CRANKSHAFT POSITION SENSOR (CKP) OR TONE WHEEL ISSUES
FAULTY IGNITION COIL OR SPARK PLUG
VARIABLE VALVE LIFT (VVL) SYSTEM ISSUES (IF EQUIPPED)
COOLANT LEAKING INTO A CYLINDER
FAULTY CYLINDER HEAD GASKET
ENGINE MECHANICAL/LOW COMPRESSION
WORN CAMSHAFT LOBES, SPRINGS OR ROCKER ARMS
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE CONDITION**
   1. Turn the ignition on.
   2. With the scan tool, read and record all DTCs and Freeze Frame information.
   3. Operate the vehicle under conditions recorded in the Freeze Frame information when the DTC was set.

      NOTE: **During the test drive of the vehicle, note when the misfire condition is present for use later in this diagnostic test. Also monitor the Downstream O2 Sensor(s) when the misfire is occurring. O2 Sensor voltage readings that are consistently on the low side of the scale would indicate a lean condition. This could indicate a lack of fuel due to a plugged Fuel Injector or fuel system issue. O2 Sensor voltage readings that are consistently on the high side of the scale would indicate a rich condition. This could be caused by a lack of spark or a possible leaky Fuel Injector.**

NOTE: **Keep in mind that during a severe misfire (MIL Light flashing) the PCM will disable the Fuel Injector of the affected cylinder(s) for a calibrated number of engine revolutions to prevent damage to the Catalytic Converter. This can cause a misfire that occurs only at high engine speed or heavy engine load to appear to continue when returning to idle. However this could be due to the Fuel Injector being disabled until the rev counter resets.**

4. With the scan tool, view the Misfire Monitor to see which cylinders are effected.

   Are there excessive misfires shown for this cylinder at this time?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any Service Bulletins or fuel system, ignition system component, air handling component, VVL system (if equipped), or VVT system DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3

3. **CHECK FOR MECHANICAL CONDITIONS THAT COULD CAUSE A MISFIRE**

   NOTE: **Each of the following conditions can cause a misfire during most operating conditions with the exception of the out of balance tires or warped brake rotors.**

   1. Visually inspect the engine for any of the following conditions:
      - Worn, loose or slipping serpentine belt.
      - Binding or misaligned engine driven accessories: A/C Compressor, P/S Pump, Water pump, etc.
      - Improper mounting of the CKP Sensor or damaged target wheel.
      - Harmonic Balancer out of balance.
      - Extremely out of balance tires or warped brake rotors.

      Were any of the above conditions present?

      Yes

      - Repair as necessary.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

- Go To 4

4. **CHECK THE ENGINE OIL LEVEL AND CONDITION**

NOTE: **The oil level being low or the wrong oil filter or viscosity being used can cause Variable Valve Timing system operating issues. This could lead to a misfire condition.**

NOTE: **The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.**

- **ENGINE MECHANICAL TOLERANCES OUT OF SPECIFICATION**
- **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
- **LOW ENGINE OIL LEVEL**
- **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**
- **DETERIORATED OR DIRTY OIL**
- **CONTAMINATED ENGINE OIL**
- **INCORRECT ENGINE OIL VISCOSITY**
- **AERATED ENGINE OIL**

1. If any of the above conditions are found, repair as necessary.

Were any of the above conditions present?

Yes

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK THE INTAKE SYSTEM FOR LEAKS**

1. Check the engine and Intake Manifold for vacuum leaks.

NOTE: **A vacuum leak can affect one or more cylinders depending on the location of the leak.**

Were any leaks found with the intake system?

Yes

- Repair the leak in the intake system.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK THE FUEL QUALITY**

1. Check the fuel for the following:
   - Water in fuel

- Correct type of fuel
- Old or contaminated fuel
- Low fuel
- Perform the CHECK FOR PROPER ETHANOL LEVEL IN THE GASOLINE procedure. Refer to **CHECKING FOR PROPER ETHANOL LEVEL IN THE GASOLINE** .

Were any problems found with the fuel?

Yes

- Replace the fuel and, if necessary, flush and clean the fuel system.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **CHECK FOR A CLOGGED OR LEAKING FUEL INJECTOR**

NOTE: **A Fuel Injector that is plugged and spraying too little fuel, or fouled and spraying too much fuel, will generally cause a misfire during any operating condition. One faulty Fuel Injector will usually cause a single cylinder misfire. However if the injector is spraying an excessive amount of fuel, the excess fuel could also affect the adjoining cylinders. In most cases there will be far more misfire counts on the cylinder with the faulty Fuel Injector than on the other affected cylinders.**

WARNING: **The fuel system is under a constant pressure (even with the engine off). Before testing or servicing any fuel system hose, fitting or line, the fuel system pressure must be released. Failure to follow these instructions can result in possible serious or fatal injury.**

1. Install the Fuel Pressure Decay Tester (special tool #8978A, Decay Tool, Fuel) to the fuel rail.
2. Turn the ignition on and allow the fuel pressure to reach maximum pressure and stabilize.

NOTE: **The ignition may need to be cycled off and on a couple times to reach maximum fuel pressure in the rail.**

3. Once the pressure reading has stabilized, record the fuel pressure. This is known as the "starting pressure".
4. With the scan tool, actuate the Fuel Injector for the cylinder that indicated the misfire while monitoring the fuel pressure gauge.
5. Record the fuel pressure. This is known as the "ending pressure."

CAUTION: **After each Fuel Injector actuation, start the engine to clean the cylinder of fuel. Failure to do so could cause engine damage.**

6. Repeat sub-steps two through five with several other Fuel Injectors on cylinders that do not have a misfire. Make sure to start the Fuel Injector actuation at the same starting pressure for each injector. Compare the ending pressures of the known good cylinders to the cylinder with the misfire condition.

Are the ending pressures about the same for all of the tested injectors?

Yes

- Go To 8

No, the injector from the cylinder with the misfire stood out from the rest.

- If the pressure drop is too small, check for debris in the Fuel Rail or Fuel Injector and repair as necessary. If the pressure drop is too large, suspect a faulty or fouled Fuel Injector as the issue.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK THE VARIABLE VALVE LIFT (VVL) SYSTEM (IF EQUIPPED)**

NOTE: **The 3.6L Upgrade engine is equipped with the VVL System. The classic engine is not. If this vehicle is not equipped with the VVL system skip this test step.**

NOTE: **A Rocker Arm or arms can get stuck due to an oil pressure issue, or a mechanical failure of a VVL Solenoid (including O-rings) or Rocker Arm. A single Rocker Arm that is stuck in low lift will not be detected and the system will continue to operate normally, however some misfire and engine roughness may be felt. One Rocker Arm stuck in Low Lift mode will cause a misfire at higher engine speeds (above approximately 4000 rpm). Two or more Rocker Arms stuck in Low Lift mode can cause a misfire at any engine speed, including idle. A Rocker Arm stuck in high lift mode typically misfires at idle.**

NOTE: **The two rear cylinders are controlled by the rear solenoid on each bank. Therefore, a VVL issue that affects both rear cylinders on a bank is most likely a common issue for both cylinders. These would include a damaged or missing O-ring, faulty solenoid, oil supply or control circuit issue. A VVL issue that only affects one of the rear cylinders is more likely going to be a failure of a Rocker Arm or pin for that cylinder.**

NOTE: **The front VVL Solenoids control the operation of the Rocker Arms for the front cylinder only on each bank. The rear VVL Solenoids control the operation of the Rocker Arms for the back two cylinders on each bank.**

1. Turn the ignition on.
2. With the scan tool, navigate to Systems Tests, perform the VVL System Diagnostic test and follow the on screen directions. for further VVL system functionality and scan tool routine information. Refer to **VALVE TIMING, DESCRIPTION AND OPERATION** .

   NOTE: **Do not erase the DTC before running the routine.**

3. When the test is complete, compare the results to the table below for the probable failure conditions.

   Does the scan tool results show that the misfire is being caused by the VVL system?

   Yes

   - Compare the results from the routine to the table below

•

<table>
<tr><th>SCAN TOOL INTRUSIVE VVL TEST RESULT</th><th>PROBABLE CAUSES</th><th>REPAIR ACTIONS</th></tr>
<tr><td>Low misfire percentage on (1) Rocker Stuck Low test, (2) Rocker Stuck High, Low RPM test, and (3) Rocker Stuck High, High RPM test</td><td>No VVL issue detected</td><td>The misfire condition being detected is not caused by the VVL System. Another system is likely causing the misfire</td></tr>
<tr><td>High misfire percentage on (1) Rocker Stuck Low test, (2) Rocker Stuck High, Low RPM test, and (3) Rocker Stuck High, High RPM test</td><td>No VVL issue detected</td><td>The misfire condition being detected is not caused by the VVL System. Another system is likely causing the misfire</td></tr>
<tr><td>(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 1</td><td>VVL Solenoid 1/1 stuck on/open
VVL Solenoid 1/1 control circuit shorted to 12 volts
VVL Solenoid 1/1 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage
Cylinder 1 rocker arm lash adjuster issue (stuck or broken)
Cylinder 1 rocker arm lock pin stuck retracted
Oil pressure leakage from the supply oil passage to the front control oil passage in the Cylinder Head.</td><td>Verify that the VVL Solenoid 1/1 control circuit is not shorted to 12 volts
Check operation of VVL Solenoid 1/1 for a stuck on/open condition, damaged or missing supply O-ring
Check for broken or stuck Cylinder 1 rocker arms or lock pins
It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head.</td></tr>
<tr><td>(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 2</td><td>VVL Solenoid 2/1 stuck on/open
VVL Solenoid 2/1 control circuit shorted to 12 volts
VVL Solenoid 2/1 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage
Cylinder 2 rocker arm lash adjuster issue (stuck or broken)</td><td>Verify that the VVL Solenoid 2/1 control circuit is not shorted to 12 volts
Check operation of VVL Solenoid 2/1 for a stuck on/open condition, damaged or missing supply O-ring
Check for broken or stuck Cylinder 2 rocker arms or lock pins
It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue.</td></tr>
</table>

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	• Cylinder 2 rocker arm lock pin stuck retracted • Oil pressure leakage from the supply oil passage to the front control oil passage in the Cylinder Head.	However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9.
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 3	• Cylinder 3 rocker arm lash adjuster issue (stuck or broken) • Cylinder 3 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 3 rocker arms or lock pins
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 4	• Cylinder 4 rocker arm lash adjuster issue (stuck or broken) • Cylinder 4 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 4 rocker arms or lock pins
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 5	• Cylinder 5 rocker arm lash adjuster issue (stuck or broken) • Cylinder 5 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 5 rocker arms or lock pins
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 6	• Cylinder 6 rocker arm lash adjuster issue (stuck or broken) • Cylinder 6 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 6 rocker arms or lock pins
(1) Rocker Stuck Low test - high misfire percentage on Cylinder 3 and Cylinder 5	• VVL Solenoid 1/2 stuck on/open • VVL Solenoid 1/2 control circuit shorted to 12 volts • VVL Solenoid 1/2 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Oil pressure leakage from the supply oil passage to the rear control oil passage in the Cylinder Head. **NOTE:** **It's less likely but**	• Check the VVL Solenoid 1/2 control circuit for a short to 12 volts condition • Check operation of VVL Solenoid 1/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head.

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	possible for a rocker arm lash adjuster failure (stuck or broken) or lock pin stuck retracted on both Cylinder 3 and Cylinder 5	
(1) Rocker Stuck Low test - high misfire percentage on Cylinder 4 and Cylinder 6	• VVL Solenoid 2/2 stuck on/open • VVL Solenoid 2/2 control circuit shorted to 12 volts • VVL Solenoid 2/2 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Oil pressure leakage from the supply oil passage to the rear control oil passage in the Cylinder Head. **NOTE:** **It's less likely but possible for a rocker arm lash adjuster failure (stuck or broken) or lock pin stuck retracted on both Cylinder 4 and Cylinder 6**	• Check the VVL Solenoid 2/2 control circuit for a short to 12 volts condition • Check operation of VVL Solenoid 2/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9.
(1) Rocker Stuck Low test - high misfire percentage Cylinder 1, Cylinder 3, and Cylinder 5	• Both bank 1 solenoids have missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control	• Check operation of VVL Solenoid 1/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	oil passage for both bank 1 solenoids • Oil pressure leakage from the supply oil passage to the front and rear control oil passages in the Cylinder Head.	that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9.
(1) Rocker Stuck Low test - high misfire percentage Cylinder 2, Cylinder 4, and Cylinder 6	• Both bank 2 solenoids have missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage for both bank 2 solenoids • Oil pressure leakage from the supply oil passage to the front and rear control oil passages in the Cylinder Head.	• Check operation of VVL Solenoid 2/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9.
(1) Rocker Stuck Low test - high misfire percentage for all Cylinders (1 - 6)	• Missing or damaged supply O-rings causing oil pressure leakage from the supply oil passage to the control oil passage for front and rear solenoids on bank 1 and bank 2 • Oil pressure leakage from the supply oil passage to the front and rear control oil passages in both Cylinder Heads.	• Check operation of all VVL Solenoids for a stuck on/open condition, damaged or missing supply O-rings • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace both Cylinder Heads.
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 1	• VVL Solenoid 1/1 control circuit open or shorted to ground • VVL Solenoid 1/1 stuck closed/off • VVL Solenoid 1/1 has missing or damaged control O-ring causing	• Check the VVL Solenoid 1/1 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 1/1 for a missing or damaged control O-ring

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted • Cylinder 1 lash adjuster plugged • Cylinder 1 rocker arm lash adjuster issue (stuck or broken) • Cylinder 1 rocker arm lock pin stuck extended	• Actuate and check the VVL Solenoid 1/1 operation. Check for debris on screen • Cylinder 1 lash adjuster plugged • Cylinder 1 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 2	• VVL Solenoid 2/1 stuck closed/off • VVL Solenoid 2/1 control circuit open or shorted to ground • VVL Solenoid 2/1 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted • Cylinder 2 lash adjuster plugged • Cylinder 2 rocker arm lash adjuster issue (stuck or broken) • Cylinder 2 rocker arm lock pin stuck extended	• Check the VVL Solenoid 2/1 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 2/1 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 2/1 operation. Check for debris on screen • Cylinder 2 lash adjuster plugged • Cylinder 2 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 3	• Cylinder 3 lash adjuster plugged • Cylinder 3 rocker arm lash adjuster issue (stuck or broken) • Cylinder 3 rocker arm lock pin stuck extended	• Cylinder 3 lash adjuster plugged • Cylinder 3 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 4	• Cylinder 4 lash adjuster plugged • Cylinder 4 rocker arm lash adjuster issue (stuck or broken) • Cylinder 4 rocker arm lock pin stuck extended	• Cylinder 4 lash adjuster plugged • Cylinder 4 rocker arm stuck failure or lock pin stuck extended

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 5	• Cylinder 5 lash adjuster plugged • Cylinder 5 rocker arm lash adjuster issue (stuck or broken) • Cylinder 5 rocker arm lock pin stuck extended	• Cylinder 5 lash adjuster plugged • Cylinder 5 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 6	• Cylinder 6 lash adjuster plugged • Cylinder 6 rocker arm lash adjuster issue (stuck or broken) • Cylinder 6 rocker arm lock pin stuck extended	• Cylinder 6 lash adjuster plugged • Cylinder 6 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 3 and Cylinder 5	• VVL Solenoid 1/2 stuck closed/off • VVL Solenoid 1/2 control circuit open or shorted to ground • VVL Solenoid 1/2 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted **NOTE:** **It's less likely but possible for a rocker arm lash adjuster issue (stuck or broken) or lock pin stuck retracted on Cylinder 3 and Cylinder 5**	• Check the VVL Solenoid 1/2 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 1/2 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 1/2 operation. Check for debris on screen • Cylinder 3 or 5 lash adjuster plugged • Cylinder 3 or 5 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 4 and Cylinder 6	• VVL Solenoid 2/2 stuck closed/off • VVL Solenoid 2/2 control circuit open or shorted to ground	• Check the VVL Solenoid 2/2 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 2/2 for a missing or damaged control O-ring

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	• VVL Solenoid 2/2 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted **NOTE:** **It's less likely but possible for a rocker arm lash adjuster issue (stuck or broken) or lock pin stuck retracted on Cylinder 4 and Cylinder 6**	• Actuate and check the VVL Solenoid 2/2 operation. Check for debris on screen • Cylinder 4 or 6 lash adjuster plugged • Cylinder 4 or 6 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 1, Cylinder 3 and Cylinder 5	• VVL Solenoid 1/1 and 1/2 have missing or damaged control O-rings causing oil pressure leakage from the control oil passage to the exhaust oil passage • Bank 1 oil supply passage blockage or restriction to front and rear oil feeds in the bank 1 Cylinder Head • Large internal leakage in bank 1 Cylinder Head affecting the front and rear oil feeds	• Check the control O-rings on the front and rear bank 1 VVL Solenoids for damage • Check for proper oil pressure at the front and rear bank 1 VVL Solenoids. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9. It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if the oil pressure is low to both solenoids and all other possible causes are exhausted, replace the Cylinder Head **NOTE:** **Low oil pressure in the Cylinder Head will likely also**

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
		cause issues/faults for the VVT system
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 2, Cylinder 4 and Cylinder 6	• VVL Solenoid 2/1 and 2/2 have missing or damaged control O-rings causing oil pressure leakage from the control oil passage to the exhaust oil passage • Bank 2 oil supply passage blockage or restriction to front and rear oil feeds in the bank 2 Cylinder Head • Large internal leakage in bank 2 Cylinder Head affecting the front and rear oil feeds	• Check the control O-rings on the front and rear bank 2 VVL Solenoids for damage • Check for proper oil pressure at the front and rear bank VVL Solenoids. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9. It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if the oil pressure is low to both solenoids and all other possible causes are exhausted, replace the Cylinder Head **NOTE:** **Low oil pressure in the Cylinder Head will likely also cause issues/faults for the VVT system**
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage for all Cylinders (1 - 6)	Engine oil pressure too low to both Cylinder Heads due to: • Oil level low • Wrong viscosity oil • Oil Filter restriction • Engine mechanical failure (damaged bearings, pick-up tube or seal, engine block, etc.) • Faulty Oil Pump	• Check for proper oil level, filter and viscosity before checking engine oil pressure • If the engine oil pressure is low check for any mechanical issue that could cause low oil pressure. If there are no issues with the bearings, pick-up tube and engine block replace the Engine Oil Pump Assembly **NOTE:**

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
		Low engine oil pressure will likely also cause issues/faults for the VVT system

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 10

9. **CHECK THE ACTUAL OIL PRESSURE TO THE VVL SOLENOID IN THE CYLINDER HEAD**
    1. Turn the ignition off.
    2. Remove the appropriate VVL Solenoid called out by the scan tool.
    3. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the VVL Solenoid.
    4. Start the engine and allow it to idle.
    5. With the scan tool, monitor the Dual Oil Pump mode.

    NOTE: **Let the engine run long enough for the pump to switch to low pump mode.**

    6. Read and record the oil pressure reading on the oil pressure gauge. Compare the reading to the main engine oil pressure reading from the Engine Oil Pressure Sensor reading on the scan tool.

    NOTE: **The Cylinder Head oil pressure should be within 5.0 psi of main engine oil pressure reading.**

    Is the Cylinder Head oil pressure should be within 5.0 psi of main engine oil pressure?

    Yes

    - Remove and inspect the screen on the VVL Solenoid for debris that can block oil flow through the solenoid. Check the seals on the VVL Solenoid for damage and proper installation. If no debris is found, and the seals appear good replace the VVL Solenoid in accordance with the Service Information.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Diagnose and repair the lack of oil pressure to the VVL Solenoid.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
10. **CHECK FOR PROPER SPARK AT THE IGNITION COIL**
    1. Turn the ignition off and remove the Fuel Pressure Decay Tester and connect the fuel lines before continuing.

    NOTE: **A faulty Ignition Coil or Spark Plug can cause a misfire at idle but could also misfire only under a heavy load on the engine. One faulty**

Ignition Coil or Spark Plug will usually cause a single cylinder misfire.

2. Remove the Ignition Coil from the cylinder that is misfiring.
3. Connect the Ignition Coil harness connector.
4. Disconnect the Fuel Injector harness connector of the cylinder being tested.
5. Install a spark tester on the Ignition Coil.
6. While cranking the engine observe the spark coming from the spark tester.

Is a crisp blue spark present?

Yes

- Go To 11

No

- Go To 16

11. **INSPECT THE SPARK PLUG AND CYLINDER**
    1. Turn the ignition off.
    2. Remove the Spark Plug in accordance with the Service Information.
    3. Inspect the Spark Plug for the following conditions:
       - Cracks
       - Carbon Tracking
       - Fouling due to oil, coolant or excess fuel in the cylinder
       - Gap size out of specifications
       - Loose or broken electrode
    4. Check for signs of oil or coolant in the cylinder.

    Were any of the above conditions present?

    Yes

    - Replace the Spark Plug. If oil or coolant were found in the cylinder or on the Spark Plug, diagnose and repair the cause.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 12

12. **CHECK THE ENGINE COMPRESSION TO CHECK FOR VALVETRAIN OR COMBUSTION CHAMBER ISSUES**

    NOTE: **A cylinder compression or valvetrain issue will cause a misfire during all operating conditions. These types of failures will normally affect a single cylinder. However, depending on the type of failure incurred, other cylinders can also be affected and show misfires. In most cases there will be far more misfire counts on the cylinder with the issue than on the other affected cylinders.**

    1. Perform a cylinder compression test on several cylinders and compare the known good cylinders to the cylinder that was misfiring. Refer to **CYLINDER COMPRESSION TEST** .

    Is the cylinder compression within specification?

Yes

- Go To 13

No

- Perform a Cylinder Leak Down Test to determine if the cause is from the valvetrain or combustion chamber and repair as necessary.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **EXCHANGE SPARK PLUG AND CHECK FOR MISFIRE TO FOLLOW THE SPARK PLUG**
    1. Exchange the Spark Plug with a known good cylinder that was not indicating a misfire or replace the Spark Plug if it is difficult to access.
    2. Start the engine and monitor the misfire monitor screen.

    Did the misfire switch to the previously good cylinder or go away if the Spark Plug was replaced?

    Yes

    - Repair is complete if Spark Plug was replaced and misfire is gone, or replace the Spark Plug if it moved to the known good cylinder.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 14

14. **CLEAN THE CARBON FROM THE VALVETRAIN AND COMBUSTION CHAMBERS**

    NOTE: Carbon build up on the engine valves and guides can cause a misfire during all operating conditions but is usually more noticeable during cruising speeds or heavy engine load conditions. If carbon build up is becoming an issue it could set only a single cylinder misfire but usually will affect more than one cylinder and set multiple cylinder misfire as well.

    1. Using Mopar Combustion cleaner, de-carbon the engine.
    2. After driving and clearing the combustion cleaner from the engine, erase DTCs with the scan tool.
    3. Test drive the vehicle in accordance with the Freeze Frame data.
    4. With the scan tool, view the Misfire Monitor.

    Did the misfire return?

    Yes

    - Go To 15

    No

    - Cleaning the valves and combustion chambers repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

15. **CHECK THE CAMSHAFT LOBES, ROCKER ARMS AND SPRINGS**

    NOTE: Worn Camshaft Lobes, worn or broken Rocker Arms or springs may sometimes but not always be detected during a compression test. The

misfire can occur at different operating conditions depending on which component is worn and the severity of the wear on the component.

1. Visually inspect the Camshaft, Rocker Arms or springs for excessive wear or broken parts.

   Were any issues found with the Camshaft, Rocker Arms or springs?

   Yes

   - Perform the appropriate repair in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 20

16. **CHECK THE ASD RELAY OUTPUT CIRCUIT**
    1. Turn the ignition off.
    2. Disconnect the Ignition Coil harness connector.
    3. Turn the ignition on.
    4. With a scan tool, actuate the ASD Relay.
    5. Using a 12-volt test light connected to ground, probe the ASD Relay Output circuit at the Ignition Coil harness connector.

       Does the test light illuminate brightly?

       Yes

       - Go To 17

       No

       - Stop all scan tool actuations and repair the open or short to ground in the ASD Relay Output circuit between the PDC and Ignition Coil harness connector.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
17. **CHECK THE IGNITION COIL CONTROL CIRCUIT**

    WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

    1. Using a 12-volt test light connected to a 12 volt source, back probe the Coil Control circuit at the Ignition Coil harness connector.
    2. Crank the engine for 5 seconds while observing the test light.

       What was the condition of the test light while cranking the engine?

       Blinking brightly

       - Replace the Ignition Coil in accordance with the Service Information.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       ON constantly

- Go To 18

OFF constantly

- Go To 19

18. **CHECK THE COIL CONTROL CIRCUIT FOR A SHORT TO GROUND**
    1. Turn the ignition off.
    2. Disconnect the PCM C2 harness connector.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    3. Connect the (special tool #10436, Adapter, GPEC Diagnostic) to the engine harness side of the PCM C2 harness connector.
    4. Check for continuity between ground and the Coil Control circuit at the Ignition Coil harness connector.

    Is there continuity between ground and the Coil Control circuit?

    Yes

    - Repair the Coil Control circuit for a short to ground.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 20

19. **CHECK THE COIL CONTROL CIRCUIT FOR AN OPEN**
    1. Turn the ignition off.
    2. Measure the resistance of the Coil Control circuit between the Ignition Coil harness connector and the GPEC Adaptor.

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 20

    No

    - Repair the Coil Control circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

20. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.

- Corrosion.
- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0306-CYLINDER 6 MISFIRE

THEORY OF OPERATION

The PCM uses the Crankshaft Position (CKP) Sensor to detect and monitor the Crankshaft rotational speed. Normally, the Crankshaft rotational speed is fairly stable from cylinder to cylinder. When a misfire occurs in a cylinder, the Crankshaft speed changes abruptly for that cylinder. Therefore, anything that causes a sudden change in Crankshaft speed detected for a single cylinder is determined to be an engine misfire event. A misfire fault will usually occur due to poor fuel quality or metering, lack of spark, engine timing, low engine compression due to engine mechanical or valvetrain issues, a vacuum leak or coolant leak entering the engine intake air system. Though not as common, other factors such as severe wheel balance or braking vibration, a worn serpentine belt or belt driven accessory binding should also be considered when diagnosing a misfire fault.

Depending on the engine involved, there can be several systems and components that can contribute to a misfire. **In many cases, but not always, there will be other DTCs set related to these systems. If that is the case, the focus should be on following the diagnostics for the system that has DTCs set against it.** The different components or systems will affect misfire in different ways. Factors to consider when diagnosing a misfire are whether the misfire is a single cylinder or multiple cylinder misfire, and when does the misfire occur (idle, vehicle and engine speed, heavy engine load conditions, etc.). These factors can help in determining what components or systems should be focused on during diagnostics. **Typically a multiple cylinder misfire is an indication of timing, oil or coolant consumption, air handling, fuel supply or poor fuel quality issue that can affect multiple cylinders and not a single cylinder component such as a Fuel Injector, Ignition Coil or Spark Plug.**

NOTE: **The effects that the components and systems have on misfire detection are described in more detail in the individual test steps below.**

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Fuel level above 12%.
- Battery voltage above 10.9 volts.
- The adaptive numerator has been successfully learned.
- Ambient temperature above -23B°C (-9.4B°F).
- Coolant temperature at engine start is above -7B°C (19.4B°F). If start engine temperature is below threshold, enable monitor when engine temperature reaches 21B°C (69.8B°F).
- Engine speed between approximately 400 rpm and 6200 rpm.
    - Misfire monitor is disabled during a Decel Fuel Shutoff Event (DFSO).

SET CONDITION

- The variation in crankshaft speed between cylinders exceeds a calibrated value, based on engine speed and load.

DEFAULT ACTION

- The MIL light will illuminate or flash depending on severity of the misfire.
- During a severe misfire (MIL Light flashing) the PCM will disable the Fuel Injector of the affected cylinder(s) for a calibrated number of engine revolutions to prevent damage to the Catalytic Converter. When the engine rev counter has reached the calculated threshold the Fuel Injector is turned back on. If a misfire is still occurring, the injector is disabled again. This cycle will continue until the misfire has stopped.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
ENGINE VACUUM LEAK
EXCESSIVE CARBON BUILD-UP IN CYLINDER HEAD OR COMBUSTION CHAMBER
FAULTY FUEL INJECTOR
POOR FUEL QUALITY OR HIGH ETHANOL LEVEL
CRANKSHAFT POSITION SENSOR (CKP) OR TONE WHEEL ISSUES
FAULTY IGNITION COIL OR SPARK PLUG
VARIABLE VALVE LIFT (VVL) SYSTEM ISSUES (IF EQUIPPED)
COOLANT LEAKING INTO A CYLINDER
FAULTY CYLINDER HEAD GASKET
ENGINE MECHANICAL/LOW COMPRESSION
WORN CAMSHAFT LOBES, SPRINGS OR ROCKER ARMS
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. **Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .**

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE CONDITION**
    1. Turn the ignition on.
    2. With the scan tool, read and record all DTCs and Freeze Frame information.
    3. Operate the vehicle under conditions recorded in the Freeze Frame information when the DTC was set.

        NOTE: **During the test drive of the vehicle, note when the misfire condition is present for use later in this diagnostic test. Also monitor the Downstream O2 Sensor(s) when the misfire is occurring. O2 Sensor voltage readings that are consistently on the low side of the scale would indicate a lean condition. This could indicate a lack of fuel due to a plugged Fuel Injector or fuel system issue. O2 Sensor voltage readings that are consistently on the high side of the scale would indicate a rich condition. This could be caused by a lack of spark or a possible leaky Fuel Injector.**

        NOTE: **Keep in mind that during a severe misfire (MIL Light flashing) the PCM will disable the Fuel Injector of the affected cylinder(s) for a calibrated number of engine revolutions to prevent damage to the Catalytic Converter. This can cause a misfire that occurs only at high engine speed or heavy engine load to appear to continue when returning to idle. However this could be due to the Fuel Injector being disabled until the rev counter resets.**

    4. With the scan tool, view the Misfire Monitor to see which cylinders are effected.

        Are there excessive misfires shown for this cylinder at this time?

        Yes

        - Go To 2

        No

        - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any Service Bulletins or fuel system, ignition system component, air handling component, VVL system (if equipped), or VVT system DTCs active or pending?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **CHECK FOR MECHANICAL CONDITIONS THAT COULD CAUSE A MISFIRE**

    NOTE: **Each of the following conditions can cause a misfire during most operating conditions with the exception of the out of balance tires or warped brake rotors.**

1. Visually inspect the engine for any of the following conditions:
    - Worn, loose or slipping serpentine belt.
    - Binding or misaligned engine driven accessories: A/C Compressor, P/S Pump, Water pump, etc.
    - Improper mounting of the CKP Sensor or damaged target wheel.
    - Harmonic Balancer out of balance.
    - Extremely out of balance tires or warped brake rotors.

   Were any of the above conditions present?

   Yes

    - Repair as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

    - Go To 4

4. **CHECK THE ENGINE OIL LEVEL AND CONDITION**

NOTE: **The oil level being low or the wrong oil filter or viscosity being used can cause Variable Valve Timing system operating issues. This could lead to a misfire condition.**

NOTE: **The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.**

- **ENGINE MECHANICAL TOLERANCES OUT OF SPECIFICATION**
- **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
- **LOW ENGINE OIL LEVEL**
- **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**
- **DETERIORATED OR DIRTY OIL**
- **CONTAMINATED ENGINE OIL**
- **INCORRECT ENGINE OIL VISCOSITY**
- **AERATED ENGINE OIL**

1. If any of the above conditions are found, repair as necessary.

   Were any of the above conditions present?

   Yes

    - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

    - Go To 5

5. **CHECK THE INTAKE SYSTEM FOR LEAKS**

1. Check the engine and Intake Manifold for vacuum leaks.

   NOTE: **A vacuum leak can affect one or more cylinders depending on the location of the leak.**

   Were any leaks found with the intake system?

   Yes

   - Repair the leak in the intake system.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6

6. **CHECK THE FUEL QUALITY**
   1. Check the fuel for the following:
      - Water in fuel
      - Correct type of fuel
      - Old or contaminated fuel
      - Low fuel
      - Perform the CHECK FOR PROPER ETHANOL LEVEL IN THE GASOLINE procedure. Refer to **CHECKING FOR PROPER ETHANOL LEVEL IN THE GASOLINE** .

   Were any problems found with the fuel?

   Yes

   - Replace the fuel and, if necessary, flush and clean the fuel system.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 7

7. **CHECK FOR A CLOGGED OR LEAKING FUEL INJECTOR**

   NOTE: **A Fuel Injector that is plugged and spraying too little fuel, or fouled and spraying too much fuel, will generally cause a misfire during any operating condition. One faulty Fuel Injector will usually cause a single cylinder misfire. However if the injector is spraying an excessive amount of fuel, the excess fuel could also affect the adjoining cylinders. In most cases there will be far more misfire counts on the cylinder with the faulty Fuel Injector than on the other affected cylinders.**

   WARNING: **The fuel system is under a constant pressure (even with the engine off). Before testing or servicing any fuel system hose, fitting or line, the fuel system pressure must be released. Failure to follow these instructions can result in possible serious or fatal injury.**

   1. Install the Fuel Pressure Decay Tester (special tool #8978A, Decay Tool, Fuel) to the fuel rail.
   2. Turn the ignition on and allow the fuel pressure to reach maximum pressure and stabilize.

NOTE: **The ignition may need to be cycled off and on a couple times to reach maximum fuel pressure in the rail.**

3. Once the pressure reading has stabilized, record the fuel pressure. This is known as the "starting pressure".
4. With the scan tool, actuate the Fuel Injector for the cylinder that indicated the misfire while monitoring the fuel pressure gauge.
5. Record the fuel pressure. This is known as the "ending pressure."

CAUTION: **After each Fuel Injector actuation, start the engine to clean the cylinder of fuel. Failure to do so could cause engine damage.**

6. Repeat sub-steps two through five with several other Fuel Injectors on cylinders that do not have a misfire. Make sure to start the Fuel Injector actuation at the same starting pressure for each injector. Compare the ending pressures of the known good cylinders to the cylinder with the misfire condition.

   Are the ending pressures about the same for all of the tested injectors?

   Yes

   - Go To 8

   No, the injector from the cylinder with the misfire stood out from the rest.

   - If the pressure drop is too small, check for debris in the Fuel Rail or Fuel Injector and repair as necessary. If the pressure drop is too large, suspect a faulty or fouled Fuel Injector as the issue.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK THE VARIABLE VALVE LIFT (VVL) SYSTEM (IF EQUIPPED)**

NOTE: **The 3.6L Upgrade engine is equipped with the VVL System. The classic engine is not. If this vehicle is not equipped with the VVL system skip this test step.**

NOTE: **A Rocker Arm or arms can get stuck due to an oil pressure issue, or a mechanical failure of a VVL Solenoid (including O-rings) or Rocker Arm. A single Rocker Arm that is stuck in low lift will not be detected and the system will continue to operate normally, however some misfire and engine roughness may be felt. One Rocker Arm stuck in Low Lift mode will cause a misfire at higher engine speeds (above approximately 4000 rpm). Two or more Rocker Arms stuck in Low Lift mode can cause a misfire at any engine speed, including idle. A Rocker Arm stuck in high lift mode typically misfires at idle.**

NOTE: **The two rear cylinders are controlled by the rear solenoid on each bank. Therefore, a VVL issue that affects both rear cylinders on a bank is most likely a common issue for both cylinders. These would include a damaged or missing O-ring, faulty solenoid, oil supply or control circuit issue. A VVL issue that only affects one of the rear cylinders is more likely going to be a failure of a Rocker Arm or pin for that cylinder.**

NOTE: **The front VVL Solenoids control the operation of the Rocker Arms for the front cylinder only on each bank. The rear VVL Solenoids control the operation of the Rocker Arms for the back two cylinders on each bank.**

1. Turn the ignition on.
2. With the scan tool, navigate to Systems Tests, perform the VVL System Diagnostic test and follow the on screen directions. for further VVL system functionality and scan tool routine information. Refer to VALVE TIMING, DESCRIPTION AND OPERATION .

NOTE: **Do not erase the DTC before running the routine.**

3. When the test is complete, compare the results to the table below for the probable failure conditions.

Does the scan tool results show that the misfire is being caused by the VVL system?

Yes

- Compare the results from the routine to the table below
-

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
Low misfire percentage on (1) Rocker Stuck Low test, (2) Rocker Stuck High, Low RPM test, and (3) Rocker Stuck High, High RPM test	No VVL issue detected	The misfire condition being detected is not caused by the VVL System. Another system is likely causing the misfire
High misfire percentage on (1) Rocker Stuck Low test, (2) Rocker Stuck High, Low RPM test, and (3) Rocker Stuck High, High RPM test	No VVL issue detected	The misfire condition being detected is not caused by the VVL System. Another system is likely causing the misfire
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 1	• VVL Solenoid 1/1 stuck on/open • VVL Solenoid 1/1 control circuit shorted to 12 volts • VVL Solenoid 1/1 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Cylinder 1 rocker arm lash adjuster issue (stuck or broken) • Cylinder 1 rocker arm lock pin stuck retracted • Oil pressure leakage from the supply oil passage to the front control oil passage in the Cylinder Head.	• Verify that the VVL Solenoid 1/1 control circuit is not shorted to 12 volts • Check operation of VVL Solenoid 1/1 for a stuck on/open condition, damaged or missing supply O-ring • Check for broken or stuck Cylinder 1 rocker arms or lock pins • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head.

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 2	• VVL Solenoid 2/1 stuck on/open • VVL Solenoid 2/1 control circuit shorted to 12 volts • VVL Solenoid 2/1 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Cylinder 2 rocker arm lash adjuster issue (stuck or broken) • Cylinder 2 rocker arm lock pin stuck retracted • Oil pressure leakage from the supply oil passage to the front control oil passage in the Cylinder Head.	• Verify that the VVL Solenoid 2/1 control circuit is not shorted to 12 volts • Check operation of VVL Solenoid 2/1 for a stuck on/open condition, damaged or missing supply O-ring • Check for broken or stuck Cylinder 2 rocker arms or lock pins • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9.
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 3	• Cylinder 3 rocker arm lash adjuster issue (stuck or broken) • Cylinder 3 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 3 rocker arms or lock pins
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 4	• Cylinder 4 rocker arm lash adjuster issue (stuck or broken) • Cylinder 4 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 4 rocker arms or lock pins
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 5	• Cylinder 5 rocker arm lash adjuster issue (stuck or broken) • Cylinder 5 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 5 rocker arms or lock pins
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 6	• Cylinder 6 rocker arm lash adjuster issue (stuck or broken) • Cylinder 6 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 6 rocker arms or lock pins
(1) Rocker Stuck Low test - high misfire percentage on Cylinder 3 and Cylinder 5	• VVL Solenoid 1/2 stuck on/open	• Check the VVL Solenoid 1/2 control circuit for a short to 12 volts condition

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	• VVL Solenoid 1/2 control circuit shorted to 12 volts • VVL Solenoid 1/2 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Oil pressure leakage from the supply oil passage to the rear control oil passage in the Cylinder Head. **NOTE:** **It's less likely but possible for a rocker arm lash adjuster failure (stuck or broken) or lock pin stuck retracted on both Cylinder 3 and Cylinder 5**	• Check operation of VVL Solenoid 1/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head.
(1) Rocker Stuck Low test - high misfire percentage on Cylinder 4 and Cylinder 6	• VVL Solenoid 2/2 stuck on/open • VVL Solenoid 2/2 control circuit shorted to 12 volts • VVL Solenoid 2/2 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Oil pressure leakage from the supply oil passage to the rear control oil passage in the Cylinder Head. **NOTE:** **It's less likely but**	• Check the VVL Solenoid 2/2 control circuit for a short to 12 volts condition • Check operation of VVL Solenoid 2/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	possible for a rocker arm lash adjuster failure (stuck or broken) or lock pin stuck retracted on both Cylinder 4 and Cylinder 6	Cylinder Head. Refer to 9.
(1) Rocker Stuck Low test - high misfire percentage Cylinder 1, Cylinder 3, and Cylinder 5	• Both bank 1 solenoids have missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage for both bank 1 solenoids • Oil pressure leakage from the supply oil passage to the front and rear control oil passages in the Cylinder Head.	• Check operation of VVL Solenoid 1/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9.
(1) Rocker Stuck Low test - high misfire percentage Cylinder 2, Cylinder 4, and Cylinder 6	• Both bank 2 solenoids have missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage for both bank 2 solenoids • Oil pressure leakage from the supply oil passage to the front and rear control oil passages in the Cylinder Head.	• Check operation of VVL Solenoid 2/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9.
(1) Rocker Stuck Low test - high misfire percentage for all Cylinders (1 - 6)	• Missing or damaged supply O-rings causing oil pressure leakage from the supply oil	• Check operation of all VVL Solenoids for a stuck on/open condition,

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	passage to the control oil passage for front and rear solenoids on bank 1 and bank 2 • Oil pressure leakage from the supply oil passage to the front and rear control oil passages in both Cylinder Heads.	damaged or missing supply O-rings • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace both Cylinder Heads.
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 1	• VVL Solenoid 1/1 control circuit open or shorted to ground • VVL Solenoid 1/1 stuck closed/off • VVL Solenoid 1/1 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted • Cylinder 1 lash adjuster plugged • Cylinder 1 rocker arm lash adjuster issue (stuck or broken) • Cylinder 1 rocker arm lock pin stuck extended	• Check the VVL Solenoid 1/1 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 1/1 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 1/1 operation. Check for debris on screen • Cylinder 1 lash adjuster plugged • Cylinder 1 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 2	• VVL Solenoid 2/1 stuck closed/off • VVL Solenoid 2/1 control circuit open or shorted to ground • VVL Solenoid 2/1 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted • Cylinder 2 lash adjuster plugged • Cylinder 2 rocker arm lash adjuster issue (stuck	• Check the VVL Solenoid 2/1 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 2/1 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 2/1 operation. Check for debris on screen • Cylinder 2 lash adjuster plugged • Cylinder 2 rocker arm stuck failure or lock pin stuck extended

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	or broken) • Cylinder 2 rocker arm lock pin stuck extended	
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 3	• Cylinder 3 lash adjuster plugged • Cylinder 3 rocker arm lash adjuster issue (stuck or broken) • Cylinder 3 rocker arm lock pin stuck extended	• Cylinder 3 lash adjuster plugged • Cylinder 3 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 4	• Cylinder 4 lash adjuster plugged • Cylinder 4 rocker arm lash adjuster issue (stuck or broken) • Cylinder 4 rocker arm lock pin stuck extended	• Cylinder 4 lash adjuster plugged • Cylinder 4 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 5	• Cylinder 5 lash adjuster plugged • Cylinder 5 rocker arm lash adjuster issue (stuck or broken) • Cylinder 5 rocker arm lock pin stuck extended	• Cylinder 5 lash adjuster plugged • Cylinder 5 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 6	• Cylinder 6 lash adjuster plugged • Cylinder 6 rocker arm lash adjuster issue (stuck or broken) • Cylinder 6 rocker arm lock pin stuck extended	• Cylinder 6 lash adjuster plugged • Cylinder 6 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 3 and Cylinder 5	• VVL Solenoid 1/2 stuck closed/off • VVL Solenoid 1/2 control circuit open or shorted to ground • VVL Solenoid 1/2 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted **NOTE:**	• Check the VVL Solenoid 1/2 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 1/2 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 1/2 operation. Check for debris on screen • Cylinder 3 or 5 lash adjuster plugged • Cylinder 3 or 5 rocker arm stuck failure or lock pin stuck extended

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	It's less likely but possible for a rocker arm lash adjuster issue (stuck or broken) or lock pin stuck retracted on Cylinder 3 and Cylinder 5	
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 4 and Cylinder 6	• VVL Solenoid 2/2 stuck closed/off • VVL Solenoid 2/2 control circuit open or shorted to ground • VVL Solenoid 2/2 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted **NOTE:** **It's less likely but possible for a rocker arm lash adjuster issue (stuck or broken) or lock pin stuck retracted on Cylinder 4 and Cylinder 6**	• Check the VVL Solenoid 2/2 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 2/2 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 2/2 operation. Check for debris on screen • Cylinder 4 or 6 lash adjuster plugged • Cylinder 4 or 6 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 1, Cylinder 3 and Cylinder 5	• VVL Solenoid 1/1 and 1/2 have missing or damaged control O-rings causing oil pressure leakage from the control oil passage to the exhaust oil passage • Bank 1 oil supply passage blockage or restriction to front and	• Check the control O-rings on the front and rear bank 1 VVL Solenoids for damage • Check for proper oil pressure at the front and rear bank 1 VVL Solenoids. Proceed to step below to check the oil pressure in the

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	rear oil feeds in the bank 1 Cylinder Head • Large internal leakage in bank 1 Cylinder Head affecting the front and rear oil feeds	Cylinder Head. Refer to 9. It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if the oil pressure is low to both solenoids and all other possible causes are exhausted, replace the Cylinder Head **NOTE:** **Low oil pressure in the Cylinder Head will likely also cause issues/faults for the VVT system**
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 2, Cylinder 4 and Cylinder 6	• VVL Solenoid 2/1 and 2/2 have missing or damaged control O-rings causing oil pressure leakage from the control oil passage to the exhaust oil passage • Bank 2 oil supply passage blockage or restriction to front and rear oil feeds in the bank 2 Cylinder Head • Large internal leakage in bank 2 Cylinder Head affecting the front and rear oil feeds	• Check the control O-rings on the front and rear bank 2 VVL Solenoids for damage • Check for proper oil pressure at the front and rear bank VVL Solenoids. Proceed to step below to check the oil pressure in the Cylinder Head. Refer to 9. It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if the oil pressure is low to both solenoids and all other possible causes are exhausted, replace the Cylinder Head **NOTE:** **Low oil pressure in the Cylinder Head will likely also cause**

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
		issues/faults for the VVT system
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage for all Cylinders (1 - 6)	Engine oil pressure too low to both Cylinder Heads due to: • Oil level low • Wrong viscosity oil • Oil Filter restriction • Engine mechanical failure (damaged bearings, pick-up tube or seal, engine block, etc.) • Faulty Oil Pump	• Check for proper oil level, filter and viscosity before checking engine oil pressure • If the engine oil pressure is low check for any mechanical issue that could cause low oil pressure. If there are no issues with the bearings, pick-up tube and engine block replace the Engine Oil Pump Assembly **NOTE:** **Low engine oil pressure will likely also cause issues/faults for the VVT system**

- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

No

- Go To 10

9. **CHECK THE ACTUAL OIL PRESSURE TO THE VVL SOLENOID IN THE CYLINDER HEAD**
    1. Turn the ignition off.
    2. Remove the appropriate VVL Solenoid called out by the scan tool.
    3. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the VVL Solenoid.
    4. Start the engine and allow it to idle.
    5. With the scan tool, monitor the Dual Oil Pump mode.

    NOTE: **Let the engine run long enough for the pump to switch to low pump mode.**

    6. Read and record the oil pressure reading on the oil pressure gauge. Compare the reading to the main engine oil pressure reading from the Engine Oil Pressure Sensor reading on the scan tool.

    NOTE: **The Cylinder Head oil pressure should be within 5.0 psi of main engine oil pressure reading.**

    Is the Cylinder Head oil pressure should be within 5.0 psi of main engine oil pressure?

    Yes

- Remove and inspect the screen on the VVL Solenoid for debris that can block oil flow through the solenoid. Check the seals on the VVL Solenoid for damage and proper installation. If no debris is found, and the seals appear good replace the VVL Solenoid in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Diagnose and repair the lack of oil pressure to the VVL Solenoid.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CHECK FOR PROPER SPARK AT THE IGNITION COIL**
    1. Turn the ignition off and remove the Fuel Pressure Decay Tester and connect the fuel lines before continuing.

       NOTE: **A faulty Ignition Coil or Spark Plug can cause a misfire at idle but could also misfire only under a heavy load on the engine. One faulty Ignition Coil or Spark Plug will usually cause a single cylinder misfire.**

    2. Remove the Ignition Coil from the cylinder that is misfiring.
    3. Connect the Ignition Coil harness connector.
    4. Disconnect the Fuel Injector harness connector of the cylinder being tested.
    5. Install a spark tester on the Ignition Coil.
    6. While cranking the engine observe the spark coming from the spark tester.

    Is a crisp blue spark present?

    Yes

    - Go To 11

    No

    - Go To 16

11. **INSPECT THE SPARK PLUG AND CYLINDER**
    1. Turn the ignition off.
    2. Remove the Spark Plug in accordance with the Service Information.
    3. Inspect the Spark Plug for the following conditions:
       - Cracks
       - Carbon Tracking
       - Fouling due to oil, coolant or excess fuel in the cylinder
       - Gap size out of specifications
       - Loose or broken electrode
    4. Check for signs of oil or coolant in the cylinder.

    Were any of the above conditions present?

    Yes

    - Replace the Spark Plug. If oil or coolant were found in the cylinder or on the Spark Plug, diagnose and repair the cause.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 12

12. **CHECK THE ENGINE COMPRESSION TO CHECK FOR VALVETRAIN OR COMBUSTION CHAMBER ISSUES**

    NOTE: **A cylinder compression or valvetrain issue will cause a misfire during all operating conditions. These types of failures will normally affect a single cylinder. However, depending on the type of failure incurred, other cylinders can also be affected and show misfires. In most cases there will be far more misfire counts on the cylinder with the issue than on the other affected cylinders.**

    1. Perform a cylinder compression test on several cylinders and compare the known good cylinders to the cylinder that was misfiring. Refer to **CYLINDER COMPRESSION TEST** .

       Is the cylinder compression within specification?

       Yes

       - Go To 13

       No

       - Perform a Cylinder Leak Down Test to determine if the cause is from the valvetrain or combustion chamber and repair as necessary.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **EXCHANGE SPARK PLUG AND CHECK FOR MISFIRE TO FOLLOW THE SPARK PLUG**
    1. Exchange the Spark Plug with a known good cylinder that was not indicating a misfire or replace the Spark Plug if it is difficult to access.
    2. Start the engine and monitor the misfire monitor screen.

       Did the misfire switch to the previously good cylinder or go away if the Spark Plug was replaced?

       Yes

       - Repair is complete if Spark Plug was replaced and misfire is gone, or replace the Spark Plug if it moved to the known good cylinder.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 14

14. **CLEAN THE CARBON FROM THE VALVETRAIN AND COMBUSTION CHAMBERS**

    NOTE: **Carbon build up on the engine valves and guides can cause a misfire during all operating conditions but is usually more noticeable during cruising speeds or heavy engine load conditions. If carbon build up is becoming an issue it could set only a single cylinder misfire but usually will affect more than one cylinder and set multiple cylinder misfire as well.**

    1. Using Mopar Combustion cleaner, de-carbon the engine.

2. After driving and clearing the combustion cleaner from the engine, erase DTCs with the scan tool.
3. Test drive the vehicle in accordance with the Freeze Frame data.
4. With the scan tool, view the Misfire Monitor.

   Did the misfire return?

   Yes

   - Go To 15

   No

   - Cleaning the valves and combustion chambers repaired the fault.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

15. **CHECK THE CAMSHAFT LOBES, ROCKER ARMS AND SPRINGS**

NOTE: **Worn Camshaft Lobes, worn or broken Rocker Arms or springs may sometimes but not always be detected during a compression test. The misfire can occur at different operating conditions depending on which component is worn and the severity of the wear on the component.**

1. Visually inspect the Camshaft, Rocker Arms or springs for excessive wear or broken parts.

   Were any issues found with the Camshaft, Rocker Arms or springs?

   Yes

   - Perform the appropriate repair in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 20

16. **CHECK THE ASD RELAY OUTPUT CIRCUIT**

1. Turn the ignition off.
2. Disconnect the Ignition Coil harness connector.
3. Turn the ignition on.
4. With a scan tool, actuate the ASD Relay.
5. Using a 12-volt test light connected to ground, probe the ASD Relay Output circuit at the Ignition Coil harness connector.

   Does the test light illuminate brightly?

   Yes

   - Go To 17

   No

   - Stop all scan tool actuations and repair the open or short to ground in the ASD Relay Output circuit between the PDC and Ignition Coil harness connector.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

17. **CHECK THE IGNITION COIL CONTROL CIRCUIT**

WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

1. Using a 12-volt test light connected to a 12 volt source, back probe the Coil Control circuit at the Ignition Coil harness connector.
2. Crank the engine for 5 seconds while observing the test light.

   What was the condition of the test light while cranking the engine?

   Blinking brightly

   - Replace the Ignition Coil in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   ON constantly

   - Go To 18

   OFF constantly

   - Go To 19

18. **CHECK THE COIL CONTROL CIRCUIT FOR A SHORT TO GROUND**
    1. Turn the ignition off.
    2. Disconnect the PCM C2 harness connector.

       CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    3. Connect the (special tool #10436, Adapter, GPEC Diagnostic) to the engine harness side of the PCM C2 harness connector.
    4. Check for continuity between ground and the Coil Control circuit at the Ignition Coil harness connector.

       Is there continuity between ground and the Coil Control circuit?

       Yes

       - Repair the Coil Control circuit for a short to ground.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 20

19. **CHECK THE COIL CONTROL CIRCUIT FOR AN OPEN**
    1. Turn the ignition off.
    2. Measure the resistance of the Coil Control circuit between the Ignition Coil harness connector and the GPEC Adaptor.

       Is the resistance below 3.0 Ohms?

Yes

- Go To 20

No

- Repair the Coil Control circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

20. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.

    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0325-KNOCK SENSOR 1 CIRCUIT

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Knock is the spontaneous auto-ignition of the remaining fuel/air mixture in the engine combustion chamber that occurs after normal combustion has started. It can occur under extreme vehicle operating conditions such as;

- excessive spark advance for the given engine operating conditions.
- high engine temperature.
- high Manifold Absolute Pressure (MAP) Sensor value.
- low humidity and heavy loads to the engine.

Severe, continuous knock may be caused by any of the following, but not limited to;

- carbon deposits.
- bad gasoline and/or low octane fuel.

Engine power is maximized when the spark advance is calibrated to the maximum torque point or the knock limited point. In order to calibrate spark advance as close as possible to its optimum point, a knock feedback system is used to protect the engine from damage.

The analog output voltage of the Knock Sensor represents the strength of the engine knock. If the engine is running, Knock Sensor voltage will not be at zero, even when knock is not present. This is due to the background noise of the engine. Background noise varies from engine to engine depending upon;

- age.
- temperature.
- speed.
- load.
- and other engine operating conditions.

An adaptive background noise curve is established by learning the knock voltage versus engine speed under non-knock conditions. When the engine is operated under high load conditions where knock is possible, the knock voltage is tested to decide if it exceeds the knock voltage threshold. Knock has occurred when the knock voltage is at or above this calibrated voltage threshold.

When knock is detected, short term spark advance is reduced by a calculated amount. The amount of spark advance reduction is based off a calibrated severity of the knock event. This reduction in spark advance is used in the next ignition event to prevent further knock events. If the knock continues, an additional reduction in short term spark advance occurs. When the knock stops, the short term reduction in spark advance is ceased. Once ceased, the long term knock compensation is reduced by a calibrated amount to recover some of the reduction in spark advance. This decreases the amount of short term spark advance reduction to optimize engine performance.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Engine speed above 2000 rpm.
- Battery voltage between 7.5 volts and 15.8 volts.
- Barometric pressure is above 75.2 kPa.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Knock Sensor input voltage is either:

- above 4.8 volts.
- less than 0.2 volts when engine speed is above 2000 rpm.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
KNOCK SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE
KNOCK SENSOR SIGNAL CIRCUIT OPEN
KNOCK SENSOR RETURN CIRCUIT OPEN
KNOCK SENSOR SIGNAL CIRCUIT SHORTED TO THE KNOCK SENSOR RETURN CIRCUIT
KNOCK SENSOR SIGNAL CIRCUIT SHORTED TO GROUND
KNOCK SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to INTERMITTENT CONDITION .
2. **CHECK THE KNOCK SENSOR 1 (K42) SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

Is the voltage above 5.2 volts?

Yes

- Go To 3

No

- Go To 4

3. **ISOLATE AND CHECK THE KNOCK SENSOR 1 (K42) SIGNAL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 9

4. **ISOLATE AND CHECK THE KNOCK SENSOR 1 (K42) SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to**

pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 5

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND CHECK THE KNOCK SENSOR 1 (K942) RETURN CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 6

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND CHECK THE KNOCK SENSOR 1 (K42) SIGNAL CIRCUIT FOR A SHORT TO THE KNOCK SENSOR 1 (K942) RETURN CIRCUIT**

1. The ignition must be off when checking for a short between circuits.
2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between the circuits being tested.**

   Is there continuity between the circuits?

   Yes

   - Repair the short between the circuits.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 7

7. **ISOLATE AND CHECK THE KNOCK SENSOR 1 (K42) SIGNAL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.

        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

        - Go To 8

8. **REPLACE KNOCK SENSOR 1 AND RETEST FOR DTCS**
    1. Replace the component in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. Connect the component and Electronic Control Unit (ECU) harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 9

    No

    - Replacing the faulty component repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.

8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0327-KNOCK SENSOR 1 CIRCUIT LOW

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Knock is the spontaneous auto-ignition of the remaining fuel/air mixture in the engine combustion chamber that occurs after normal combustion has started. It can occur under extreme vehicle operating conditions such as;

- excessive spark advance for the given engine operating conditions.
- high engine temperature.
- high Manifold Absolute Pressure (MAP) Sensor value.
- low humidity and heavy loads to the engine.

Severe, continuous knock may be caused by any of the following, but not limited to;

- carbon deposits.
- bad gasoline and/or low octane fuel.

Engine power is maximized when the spark advance is calibrated to the maximum torque point or the knock limited point. In order to calibrate spark advance as close as possible to its optimum point, a knock feedback system is used to protect the engine from damage.

The analog output voltage of the Knock Sensor represents the strength of the engine knock. If the engine is running, Knock Sensor voltage will not be at zero, even when knock is not present. This is due to the background noise of the engine. Background noise varies from engine to engine depending upon;

- age.
- temperature.
- speed.
- load.
- and other engine operating conditions.

An adaptive background noise curve is established by learning the knock voltage versus engine speed under non-knock conditions. When the engine is operated under high load conditions where knock is possible, the knock voltage is tested to decide if it exceeds the knock voltage threshold. Knock has occurred when the knock voltage is at or above this calibrated voltage threshold.

When knock is detected, short term spark advance is reduced by a calculated amount. The amount of spark advance reduction is based off a calibrated severity of the knock event. This reduction in spark advance is used in the next ignition event to prevent further knock events. If the knock continues, an additional reduction in short term spark advance occurs. When the knock stops, the short term reduction in spark advance is ceased. Once ceased, the long term knock compensation is reduced by a calibrated amount to recover some of the reduction in spark advance. This decreases the amount of short term spark advance reduction to optimize engine performance.

WHEN MONITORED

- This diagnostic runs if the engine speed is less than or equal to 0 rpm.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Knock Sensor 1 input voltage is less than or equal to 1.0 volt with engine speed at or less than 0 rpm.

DEFAULT ACTION

- MIL light will illuminate.

POSSIBLE CAUSES

Possible Causes
KNOCK SENSOR 1 SIGNAL CIRCUIT SHORTED TO THE KNOCK SENSOR RETURN CIRCUIT
KNOCK SENSOR 1 SIGNAL CIRCUIT SHORTED TO GROUND
KNOCK SENSOR 1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **ISOLATE AND CHECK THE KNOCK SENSOR 1 (K42) SIGNAL CIRCUIT FOR A SHORT TO THE (K942) SENSOR GROUND CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **There should be no continuity between the circuits being tested.**

    Is there continuity between the circuits?

    Yes

    - Repair the short between the circuits.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 3

3. **ISOLATE AND CHECK THE KNOCK SENSOR 1 (K42) SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **REPLACE THE KNOCK SENSOR**
    1. Verify that there is good pin to terminal contact at the Knock Sensor and the Powertrain Control Module harness connector.
    2. If no problems were found in the connectors, replace the Knock Sensor 1. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    3. Reconnect the PCM C2 harness connector.
    4. Turn the ignition on.
    5. With the scan tool, erase DTCs.
    6. Start the engine and allow it to reach normal operating temperature.

WARNING:	**When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

NOTE:	**It may be necessary to test drive the vehicle within the DTC monitoring conditions in order for this DTC to reset.**

    7. With the scan tool, read DTCs.

    Is the DTC active or pending?

    Yes

    - Go To 5

    No

    - Test complete.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Repair the poor connections.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0328-KNOCK SENSOR 1 CIRCUIT HIGH

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Knock is the spontaneous auto-ignition of the remaining fuel/air mixture in the engine combustion chamber that occurs after normal combustion has started. It can occur under extreme vehicle operating conditions such as;

- excessive spark advance for the given engine operating conditions.
- high engine temperature.
- high Manifold Absolute Pressure (MAP) Sensor value.
- low humidity and heavy loads to the engine.

Severe, continuous knock may be caused by any of the following, but not limited to;

- carbon deposits.
- bad gasoline and/or low octane fuel.

Engine power is maximized when the spark advance is calibrated to the maximum torque point or the knock limited point. In order to calibrate spark advance as close as possible to its optimum point, a knock feedback system is used to protect the engine from damage.

The analog output voltage of the Knock Sensor represents the strength of the engine knock. If the engine is running, Knock Sensor voltage will not be at zero, even when knock is not present. This is due to the background noise of the engine. Background noise varies from engine to engine depending upon;

- age.
- temperature.
- speed.

- load.
- and other engine operating conditions.

An adaptive background noise curve is established by learning the knock voltage versus engine speed under non-knock conditions. When the engine is operated under high load conditions where knock is possible, the knock voltage is tested to decide if it exceeds the knock voltage threshold. Knock has occurred when the knock voltage is at or above this calibrated voltage threshold.

When knock is detected, short term spark advance is reduced by a calculated amount. The amount of spark advance reduction is based off a calibrated severity of the knock event. This reduction in spark advance is used in the next ignition event to prevent further knock events. If the knock continues, an additional reduction in short term spark advance occurs. When the knock stops, the short term reduction in spark advance is ceased. Once ceased, the long term knock compensation is reduced by a calibrated amount to recover some of the reduction in spark advance. This decreases the amount of short term spark advance reduction to optimize engine performance.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running
- Battery voltage is between 10.0 volts and 16.0 volts.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Knock Sensor 1 Signal circuit is shorted high.

DEFAULT ACTION

- The MIL light will illuminate.

POSSIBLE CAUSES

Possible Causes
KNOCK SENSOR 1 SIGNAL CIRCUIT SHORTED TO VOLTAGE
KNOCK SENSOR 1 RETURN CIRCUIT OPEN
KNOCK SENSOR 1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE KNOCK SENSOR 1 (K42) SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

Is there any voltage present?

Yes

- Repair the circuit for a short to voltage.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **ISOLATE AND CHECK THE KNOCK SENSOR 1 (K942) RETURN CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

    Is the resistance below 3.0 Ohms?

    Yes

- Go To 4

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE KNOCK SENSOR FOR PROPER OPERATION**
    1. Turn the ignition off.
    2. Verify that there is good pin to terminal contact at the Knock Sensor and the Powertrain Control Module harness connectors.
    3. If no problems were found in the connectors, replace the Knock Sensor. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    4. Connect the Powertrain Control Module (PCM) harness connector.
    5. Turn the ignition on.
    6. With the scan tool, erase DTCs.
    7. Start the engine and allow it to reach normal operating temperature.

    WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

    NOTE: **It may be necessary to test drive the vehicle within the DTC monitoring conditions in order for this DTC to reset.**

    8. With the scan tool, read DTCs.

    Is the DTC active or pending?

    Yes

    - Go To 5

    No

    - Test complete.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.

- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Repair the poor connections.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P032F-COMBUSTION ENGINE PRODUCING INSUFFICIENT TORQUE

THEORY OF OPERATION

The Powertrain Control Module (PCM) is able to detect an engine stall event after the engine is started and certain parameters are met. The PCM will set a DTC but will not set the Malfunction Indicator Light (MIL). This allows the PCM to retain engine data from the time of the event. The DTC and saved data serves two purposes:

1. For technicians the DTC verifies that there was a stall event that was not related to an ESS system Auto-stop issue. The data saved with the DTC can be used along with any other PCM related DTCs to attempt to narrow down which system or components to focus on when diagnosing the stall event.
2. The data is automatically uploaded to an FCA database. Engineering is able to review this data to help in determining the issues that are causing the stall events and possibly aid in finding a root cause and solution. If a solution is determined for the issue, likely a Service Bulletin or Star On-line Case will be provided describing the issue, possible related symptoms and repair action.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- PCM must see engine speed over 400 RPM for minimum time of 10 seconds. This prevents a fault on an engine start/stall condition.

- Fuel level is greater then 5%.
- The PCM did not request an ESS Auto-stop event.

SET CONDITION

- The PCM detects an engine stall condition with the Immobilizer not active.

DEFAULT ACTION

- The MIL will not illuminate.

POSSIBLE CAUSES

Possible Causes
ANY CONDITION THAT CAN CAUSE AN ENGINE STALL EVENT

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR POWERTRAIN CONTROL MODULE (PCM) DTCS**
    1. With the scan tool, read PCM DTCs.

       Are there any other PCM DTCs present?

       Yes

       - Perform the applicable diagnostic procedure(s) for the other PCM DTC(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins, Star On-line Cases or Flash updates related to the DTC or stall condition.

       Are there any applicable Service Bulletins, Star On-line Cases or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Perform the START AND STALL CONDITION test procedure. Refer to **START AND STALL CONDITION** . The START AND STALL CONDITION test procedure lists several possible causes for a stall condition. This is a general list to help give direction where to look for an issue that can cause a stall. If the vehicle is setting this DTC alone with no other faults do not overlook possible intermittent circuit issues for any component or system that can cause an engine to intermittently stall. An intermittent stall event is most likely not going to be caused by an engine mechanical part issue affecting the engine combustion. Focus on electrical issues for components that can affect spark or fueling and perform the

INTERMITTENT CONDITION test procedure. Refer to **INTERMITTENT CONDITION** .

P0330-KNOCK SENSOR 2 CIRCUIT

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Knock is the spontaneous auto-ignition of the remaining fuel/air mixture in the engine combustion chamber that occurs after normal combustion has started. It can occur under extreme vehicle operating conditions such as;

- excessive spark advance for the given engine operating conditions.
- high engine temperature.
- high Manifold Absolute Pressure (MAP) Sensor value.
- low humidity and heavy loads to the engine.

Severe, continuous knock may be caused by any of the following, but not limited to;

- carbon deposits.
- bad gasoline and/or low octane fuel.

Engine power is maximized when the spark advance is calibrated to the maximum torque point or the knock limited point. In order to calibrate spark advance as close as possible to its optimum point, a knock feedback system is used to protect the engine from damage.

The analog output voltage of the Knock Sensor represents the strength of the engine knock. If the engine is running, Knock Sensor voltage will not be at zero, even when knock is not present. This is due to the background noise of the engine. Background noise varies from engine to engine depending upon;

- age.
- temperature.
- speed.
- load.
- and other engine operating conditions.

An adaptive background noise curve is established by learning the knock voltage versus engine speed under non-knock conditions. When the engine is operated under high load conditions where knock is possible, the knock voltage is tested to decide if it exceeds the knock voltage threshold. Knock has occurred when the knock voltage is at or above this calibrated voltage threshold.

When knock is detected, short term spark advance is reduced by a calculated amount. The amount of spark advance reduction is based off a calibrated severity of the knock event. This reduction in spark advance is used in the next ignition event to prevent further knock events. If the knock continues, an additional reduction in short term spark advance occurs. When the knock stops, the short term reduction in spark advance is ceased. Once ceased, the long term knock compensation is reduced by a calibrated amount to recover some of the reduction in spark advance. This decreases the amount of short term spark advance reduction to optimize engine performance.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Engine speed above 2000 rpm.
- Battery voltage between 7.5 volts and 15.8 volts.
- Barometric pressure is above 75.2 kPa.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Knock Sensor input voltage is either:
  - Above 4.8 volts.
  - Less than 0.2 volts when engine speed is above 2000 rpm.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
KNOCK SENSOR 2 SIGNAL CIRCUIT SHORTED TO VOLTAGE
KNOCK SENSOR 2 SIGNAL CIRCUIT OPEN
KNOCK SENSOR 2 RETURN CIRCUIT OPEN
KNOCK SENSOR 2 SIGNAL CIRCUIT SHORTED TO THE KNOCK SENSOR 2 RETURN CIRCUIT
KNOCK SENSOR 2 SIGNAL CIRCUIT SHORTED TO GROUND
KNOCK SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE KNOCK SENSOR 2 (K242) SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Turn the ignition on.

4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

Is the voltage above 5.2 volts?

Yes

- Go To 3

No

- Go To 4

3. **ISOLATE AND CHECK THE KNOCK SENSOR 2 (K242) SIGNAL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
   4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

   Is there continuity between the circuit being tested and any other circuit?

   Yes

   - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 9

4. **ISOLATE AND CHECK THE KNOCK SENSOR 2 (K242) SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 5

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND CHECK THE KNOCK SENSOR 2 (K924) RETURN CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 6

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND CHECK THE KNOCK SENSOR 2 (K242) SIGNAL CIRCUIT FOR A SHORT TO THE KNOCK SENSOR 2 (K924) RETURN CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

    CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: There should be no continuity between the circuits being tested.

    Is there continuity between the circuits?

    Yes

    - Repair the short between the circuits.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

    No

    - Go To 7
7. **ISOLATE AND CHECK THE KNOCK SENSOR 2 (K242) SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

    CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: There should be no continuity between ground and the circuit being tested.

    Is there continuity between ground and the circuit being tested?

    Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 8

8. **REPLACE KNOCK SENSOR 2 AND RETEST FOR DTCS**
    1. Replace the component in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. Connect the component and Electronic Control Unit (ECU) harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 9

    No

    - Replacing the faulty component repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.

7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
    - Test complete.

P0332-KNOCK SENSOR 2 CIRCUIT LOW

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Knock is the spontaneous auto-ignition of the remaining fuel/air mixture in the engine combustion chamber that occurs after normal combustion has started. It can occur under extreme vehicle operating conditions such as;

- excessive spark advance for the given engine operating conditions.
- high engine temperature.
- high Manifold Absolute Pressure (MAP) Sensor value.
- low humidity and heavy loads to the engine.

Severe, continuous knock may be caused by any of the following, but not limited to;

- carbon deposits.
- bad gasoline and/or low octane fuel.

Engine power is maximized when the spark advance is calibrated to the maximum torque point or the knock limited point. In order to calibrate spark advance as close as possible to its optimum point, a knock feedback system is used to protect the engine from damage.

The analog output voltage of the Knock Sensor represents the strength of the engine knock. If the engine is running, Knock Sensor voltage will not be at zero, even when knock is not present. This is due to the background noise of the engine. Background noise varies from engine to engine depending upon;

- age.
- temperature.
- speed.
- load.
- and other engine operating conditions.

An adaptive background noise curve is established by learning the knock voltage versus engine speed under non-knock conditions. When the engine is operated under high load conditions where knock is possible, the knock voltage is tested to decide if it exceeds the knock voltage threshold. Knock has occurred when the knock voltage is at or above this calibrated voltage threshold.

When knock is detected, short term spark advance is reduced by a calculated amount. The amount of spark advance reduction is based off a calibrated severity of the knock event. This reduction in spark advance is used in the next ignition event to prevent further knock events. If the knock continues, an additional reduction in short term spark advance occurs. When the knock stops, the short term reduction in spark advance is ceased. Once ceased, the long term knock compensation is reduced by a calibrated amount to recover some of the reduction in spark advance. This decreases the amount of short term spark advance reduction to optimize engine performance.

WHEN MONITORED

- This diagnostic runs if the engine speed is less than or equal to 0 rpm.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Knock Sensor 2 input voltage is less than or equal to 1.0 volt with engine speed at or less than 0 rpm.

DEFAULT ACTION

- MIL light will illuminate.

POSSIBLE CAUSES

Possible Causes
KNOCK SENSOR SIGNAL 2 CIRCUIT SHORTED TO THE KNOCK SENSOR RETURN CIRCUIT
KNOCK SENSOR SIGNAL 2 CIRCUIT SHORTED TO GROUND
KNOCK SENSOR 2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **ISOLATE AND CHECK THE KNOCK SENSOR 2 (K242) SIGNAL CIRCUIT FOR A SHORT TO THE (K924) SENSOR GROUND CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between the circuits being tested.**

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **ISOLATE AND CHECK THE KNOCK SENSOR 2 (K242) SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **REPLACE THE KNOCK SENSOR**
    1. Verify that there is good pin to terminal contact at the Knock Sensor and the Powertrain Control Module harness connector.
    2. If no problems were found in the connectors, replace the Knock Sensor 2. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    3. Reconnect the PCM C2 harness connector.
    4. Turn the ignition on.
    5. With the scan tool, erase DTCs.
    6. Start the engine and allow it to reach normal operating temperature.

    WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

    NOTE: **It may be necessary to test drive the vehicle within the DTC monitoring conditions in order for this DTC to reset.**

    7. With the scan tool, read DTCs.

    Is the DTC active or pending?

    Yes

    - Go To 5

    No

    - Test complete.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Repair the poor connections.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0333-KNOCK SENSOR 2 CIRCUIT HIGH

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Knock is the spontaneous auto-ignition of the remaining fuel/air mixture in the engine combustion chamber that occurs after normal combustion has started. It can occur under extreme vehicle operating conditions such as;

- excessive spark advance for the given engine operating conditions.
- high engine temperature.
- high Manifold Absolute Pressure (MAP) Sensor value.
- low humidity and heavy loads to the engine.

Severe, continuous knock may be caused by any of the following, but not limited to;

- carbon deposits.
- bad gasoline and/or low octane fuel.

Engine power is maximized when the spark advance is calibrated to the maximum torque point or the knock limited point. In order to calibrate spark advance as close as possible to its optimum point, a knock feedback system is used to protect the engine from damage.

The analog output voltage of the Knock Sensor represents the strength of the engine knock. If the engine is running, Knock Sensor voltage will not be at zero, even when knock is not present. This is due to the background noise of the engine. Background noise varies from engine to engine depending upon;

- age.
- temperature.
- speed.

- load.
- and other engine operating conditions.

An adaptive background noise curve is established by learning the knock voltage versus engine speed under non-knock conditions. When the engine is operated under high load conditions where knock is possible, the knock voltage is tested to decide if it exceeds the knock voltage threshold. Knock has occurred when the knock voltage is at or above this calibrated voltage threshold.

When knock is detected, short term spark advance is reduced by a calculated amount. The amount of spark advance reduction is based off a calibrated severity of the knock event. This reduction in spark advance is used in the next ignition event to prevent further knock events. If the knock continues, an additional reduction in short term spark advance occurs. When the knock stops, the short term reduction in spark advance is ceased. Once ceased, the long term knock compensation is reduced by a calibrated amount to recover some of the reduction in spark advance. This decreases the amount of short term spark advance reduction to optimize engine performance.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running
- Battery voltage is between 10.0 volts and 16.0 volts.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Knock Sensor 2 Signal circuit is shorted high.

DEFAULT ACTION

- The MIL light will illuminate.

POSSIBLE CAUSES

Possible Causes
KNOCK SENSOR SIGNAL 2 CIRCUIT SHORTED TO VOLTAGE
KNOCK SENSOR RETURN 2 CIRCUIT OPEN
KNOCK SENSOR 2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE KNOCK SENSOR 2 (K242) SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Turn the ignition on.
   4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

   Is there any voltage present?

   Yes

   - Repair the circuit for a short to voltage.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 3

3. **ISOLATE AND CHECK THE KNOCK SENSOR 2 (K924) RETURN CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

      NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

      Is the resistance below 3.0 Ohms?

      Yes

- Go To 4

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE KNOCK SENSOR FOR PROPER OPERATION**
   1. Turn the ignition off.
   2. Verify that there is good pin to terminal contact at the Knock Sensor and the Powertrain Control Module harness connectors.
   3. If no problems were found in the connectors, replace the Knock Sensor 2. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   4. Connect the Powertrain Control Module (PCM) harness connector.
   5. Turn the ignition on.
   6. With the scan tool, erase DTCs.
   7. Start the engine and allow it to reach normal operating temperature.

      WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

      NOTE: **It may be necessary to test drive the vehicle within the DTC monitoring conditions in order for this DTC to reset.**

   8. With the scan tool, read DTCs.

   Is the DTC active or pending?

   Yes

   - Go To 5

   No

   - Test complete.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.

- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Repair the poor connections.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0335-CRANKSHAFT POSITION SENSOR CIRCUIT

For a complete IGNITION SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) uses the Crankshaft Position (CKP) Sensor signal and the Camshaft Position (CMP) Sensor signal together to identify engine timing/firing order. This process is done by recognizing the patterns of each signal. From those patterns an engine position can be determined. This process is described as engine synchronization.

- The CKP Sensor contains an Integrated Circuit (IC) and a magnet. The sensor outputs a digital signal based on the magnetic flux changes of the magnet created from the teeth and valleys of the tone wheel located on the Crankshaft or Flex Plate depending on engine. The PCM identifies the Crankshaft position angle by recognizing the reference tooth/gap. The reference tooth or gap is the largest feature of the tone wheel. This identification process is said to "lock" the crank signal.
- The PCM determines the Camshaft position angle in a similar way. By recognizing unique but successive features on the Camshaft tone wheel, the PCM can identify the particular angle at which the camshaft signal is indicating. Upon recognition of the Camshaft signal pattern sequence, it is also said to be "locked".

When both locked conditions have been met, the engine is said to be synchronized. At this time, sequencing the ignition timing and fuel injection events for the engine can begin. From the CKP signal, engine speed and misfire detection are also determined. When the PCM loses pattern recognition of the CKP signal, it is said to be "unlocked". The PCM will try to re-establish pattern recognition. If the PCM fails to achieve the pattern recognition, or if the CKP Signal unlocks more than a calibrated number of times within a calibrated threshold of time, a code is set.

NOTE: **The engine may still start even if either the CKP or CMP fails. The PCM eventually sorts out engine position and can start the vehicle on just one of these two inputs. However, there is a delay in starting until the PCM can establish sync. A DTC is set and the MIL illuminates if either of the CKP or CMP Sensor signals are not present during engine cranking.**

WHEN MONITORED

- This diagnostic runs continuously with the engine cranking and with the engine running.

SET CONDITION

There are two conditions in which this DTC can set:

- **During cranking:** The CKP Sensor signal is unable to be locked for more than approximately 2.5 seconds after the CMP Sensor signal is locked.
- **Engine running:** The PCM loses the CKP position (unlocks) and fails to re-lock within approximately 0.15 seconds.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT SHORTED TO VOLTAGE
5-VOLT SUPPLY CIRCUIT SHORTED TO GROUND
CRANKSHAFT POSITION SENSOR MOUNTED INCORRECTLY OR MOUNTING SURFACE DAMAGED
5-VOLT SUPPLY CIRCUIT OPEN/HIGH RESISTANCE
CKP SENSOR POSITION SIGNAL CIRCUIT SHORTED TO VOLTAGE
CKP SENSOR POSITION SIGNAL CIRCUIT SHORTED TO GROUND
CKP SENSOR POSITION SIGNAL CIRCUIT SHORTED TO THE CKP SENSOR GROUND CIRCUIT
CKP SENSOR POSITION SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
CKP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
CRANKSHAFT POSITION SENSOR
TONE WHEEL/PULSE RING
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

Yes

- Perform the applicable repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 2

2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 5

    No

    - Go To 3

3. **WIRE HARNESS/CKP SENSOR INSPECTION**
    1. Turn the ignition off.
    2. Verify that the CKP Sensor harness connector is fully seated and the primary lock is engaged at the sensor before disconnecting.
    3. Start the engine and wiggle test the wiring harness and connectors in attempt to duplicate the problem.
    4. Turn the ignition off.
    5. Disconnect the harness connectors at the PCM and Crank Sensor and inspect for wire chaffing or rub conditions, terminals pushed out on the wiring connector, bent terminals at the PCM and Crank Sensor, water in the connector cavities, presence of corrosion on the terminals of the connectors or components.
    6. Visually inspect the mounting area of Crank Sensor for debris/damage or a loose sensor.

    Were any problems found?

    Yes

    - Perform the appropriate repair.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 4

4. **CHECK THE VEHICLES REPAIR HISTORY**
    1. Check the history of the vehicle for previous Crank Sensor related DTCs within the past 90 days. Verify if the Crank Sensor was replaced during the previous visit.

       Did the repair history show that the vehicle was serviced for a crank sensor fault within the past 30 days?

       Yes, and the Crank Sensor was replaced on previous visit

       - Wiggle test the wiring harness and connectors again and try to duplicate the issue. If unable to duplicate, remove the Crank Sensor and visually inspect the sensor mounting location for damage or foreign material.
       - Inspect the target wheel for any signs of damage by placing a bore scope into the CKP Sensor bore and manually rotate the engine slowly using a wrench on the crank damper bolt. For stamped steel targets, pay close attention to the light reflection of the bore scope light on each tooth. If a tooth is bent, the reflection (bright spot) will move in relation to the reflection of the other teeth that are not bent. The light reflection will remain in the same location on each tooth if none of the teeth are bent. For powder metal targets, look for any tooth that is dull or does not shine as compared to the other teeth. The rough surface that remains from a tooth that has broken off appears to be dull/non-reflective.
       - Repair as necessary. With the scan tool, perform the Cam/Crank Relearn Procedure. The Cam/Crank Relearn Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       Yes, and the Crank Sensor was not replaced on the last visit

       - Replace the Crank Sensor in accordance with the Service Information. With the scan tool, perform the Cam/Crank Relearn Procedure. The Cam/Crank Relearn Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Test complete. Reconnect the harness connectors and erase the DTC. The most likely cause was a poor connection at one of the harness connectors.
5. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any 5-Volt Reference DTCs present?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 6
6. **CHECK THE (F855) 5-VOLT SUPPLY CIRCUIT VOLTAGE**
    1. Turn the ignition off.

2. Disconnect the CKP Sensor harness connector.
3. Turn the ignition on.
4. Measure the voltage on the (F855) 5-Volt Supply circuit at the CKP Sensor harness connector.

   Is the voltage between 4.8 and 5.2 volts?

   Yes

   - Go To 7

   No, voltage is below 4.8 volts:

   - Repair the 5-Volt Supply circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No, voltage is above 5.2 volts:

   - Repair the 5-Volt Supply circuit for a short to voltage.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK THE CKP (K24) SIGNAL CIRCUIT VOLTAGE**
   1. Measure the voltage on the CKP (K24) Signal circuit at the CKP Sensor harness connector.

      Is the voltage between 4.8 and 5.2 volts?

      Yes

      - Go To 8

      No

      - Go To 10
8. **CHECK THE (K925) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. Turn the ignition off.
   2. Disconnect the PCM C2 harness connector.
   3. Measure the resistance of the (K925) Sensor Ground circuit between the CKP Sensor harness connector and the PCM C2 harness connector.

      Is the resistance below 3.0 Ohms?

      Yes

      - Go To 9

      No

      - Repair the (K925) Sensor Ground circuit for an open or high resistance.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
9. **VISUALLY INSPECT THE TARGET WHEEL/PULSE RING FOR DAMAGE OR EXCESSIVE RUNOUT**
   1. Disconnect the battery ground cable.
   2. Remove the CKP Sensor.
   3. Visually inspect the sensor mounting location for damage, foreign material.

4. Rotate the engine and if possible inspect the Target Wheel for any signs of damage.
5. Inspect the target wheel for any signs of damage by placing a bore scope into the CKP Sensor bore and manually rotate the engine slowly using a wrench on the crank damper bolt. For stamped steel targets, pay close attention to the light reflection of the bore scope light on each tooth. If a tooth is bent, the reflection (bright spot) will move in relation to the reflection of the other teeth that are not bent. The light reflection will remain in the same location on each tooth if none of the teeth are bent. For powder metal targets, look for any tooth that is dull or does not shine as compared to the other teeth. The rough surface that remains from a tooth that has broken off appears to be dull/non-reflective.

   Were any problems found?

   Yes

   - Repair Issues in mounting location, or repair or replace the Target Wheel/Pulse Ring as necessary. With the scan tool, perform the Cam/Crank Relearn Procedure. The Cam/Crank Relearn Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Replace the Crank Position Sensor in accordance with the Service Information. With the scan tool, perform the Cam/Crank Relearn Procedure. The Cam/Crank Relearn Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CHECK THE CKP (K24) SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. Turn the ignition off.
    2. Disconnect the PCM C2 harness connector.
    3. Check for continuity between ground and the CKP (K24) Signal circuit at the CKP Sensor harness connector.

       Is there continuity between ground and the CKP (K24) Signal circuit?

       Yes

       - Repair the CKP (K24) Signal circuit for a short to ground.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 11
11. **CHECK THE CKP (K24) SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. Measure the resistance of the CKP (K24) Signal circuit between the CKP Sensor harness connector and the PCM C2 harness connector.

       Is the resistance below 3.0 Ohms?

       Yes

- Go To 12

No

- Repair the CKP (K24) Signal circuit for an open circuit or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

12. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0339-CRANKSHAFT POSITION SENSOR INTERMITTENT

For a complete IGNITION SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) uses the Crankshaft Position (CKP) Sensor signal and the Camshaft Position (CMP) Sensor signal together to identify engine timing/firing order. This process is done by recognizing the patterns of each signal. From those patterns an engine position can be determined. This process is described as engine synchronization.

- The CKP Sensor contains an Integrated Circuit (IC) and a magnet. The sensor outputs a digital signal based on the magnetic flux changes of the magnet created from the teeth and valleys of the tone wheel located on the Crankshaft or Flex Plate depending on engine. The PCM identifies the Crankshaft position angle by recognizing the reference tooth/gap. The reference tooth or gap is the largest feature of the tone wheel. This identification process is said to "lock" the crank signal.
- The PCM determines the Camshaft position angle in a similar way. By recognizing unique but successive features on the Camshaft tone wheel, the PCM can identify the particular angle at which the camshaft signal is indicating. Upon recognition of the Camshaft signal pattern sequence, it is also said to be "locked".

When both locked conditions have been met, the engine is said to be synchronized. At this time, sequencing the ignition timing and fuel injection events for the engine can begin. From the CKP signal, engine speed and misfire detection are also determined. When the PCM loses pattern recognition of the CKP signal, it is said to be "unlocked". The PCM will try to re-establish pattern recognition. If the PCM fails to achieve the pattern recognition, or if the CKP Signal unlocks more than a calibrated number of times within a calibrated threshold of time, a code is set.

NOTE: **The engine may still start even if either the CKP or CMP fails. The PCM eventually sorts out engine position and can start the vehicle on just one of these two inputs. However, there is a delay in starting until the PCM can establish sync. A DTC is set and the MIL illuminates if either of the CKP or CMP Sensor signals are not present during engine cranking.**

WHEN MONITORED

- This diagnostic runs continuously with the engine cranking and with the engine running.

SET CONDITION

- The PCM detects a calibrated number of "unlock" events of the CKP Sensor signal within a calibrated threshold of test time.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT SHORTED TO VOLTAGE
5-VOLT SUPPLY CIRCUIT SHORTED TO GROUND
5-VOLT SUPPLY CIRCUIT SHORTED TO THE CKP SENSOR GROUND CIRCUIT
5-VOLT SUPPLY CIRCUIT OPEN/HIGH RESISTANCE
CKP SENSOR POSITION SIGNAL CIRCUIT SHORTED TO VOLTAGE
CKP SENSOR POSITION SIGNAL CIRCUIT SHORTED TO GROUND
CKP SENSOR POSITION SIGNAL CIRCUIT SHORTED TO THE CKP SENSOR GROUND CIRCUIT

Possible Causes
CKP SENSOR POSITION SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
CKP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
CRANKSHAFT POSITION SENSOR MOUNTED INCORRECTLY OR MOUNTING SURFACE DAMAGED
TARGET WHEEL/PULSE RING BENT / BROKEN / MISSING TEETH / EXCESSIVE RUNOUT
CRANKSHAFT POSITION SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Go To 5

       No

       - Go To 3
3. **WIRE HARNESS/CKP SENSOR INSPECTION**
    1. Turn the ignition off.
    2. Verify that the CKP Sensor harness connector is fully seated and the primary lock is engaged at the sensor before disconnecting.

3. Start the engine and wiggle test the wiring harness and connectors in attempt to duplicate the problem.
4. Turn the ignition off.
5. Disconnect the harness connectors at the PCM and Crank Sensor and inspect for wire chaffing or rub conditions, terminals pushed out on the wiring connector, bent terminals at the PCM and Crank Sensor, water in the connector cavities, presence of corrosion on the terminals of the connectors or components.
6. Visually inspect the mounting area of Crank Sensor for debris/damage or a loose sensor.

   Were any problems found?

   Yes

   - Perform the appropriate repair.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **CHECK THE VEHICLES REPAIR HISTORY**
   1. Check the history of the vehicle for previous Crank Sensor related DTCs within the past 30 days. Verify if the Crank Sensor was replaced during the visit.

      Did the repair history show that the vehicle was in dealership for a crank sensor fault within the past 30 days?

      Yes, and the Crank Sensor was replaced on previous visit

      - Wiggle test the wiring harness and connectors again and try to duplicate the issue. If not able to duplicate, remove the Crank Sensor, and visually inspect the sensor mounting location for damage, foreign material.
      - Inspect the target wheel for any signs of damage by placing a bore scope into the CKP Sensor bore and manually rotate the engine slowly using a wrench on the crank damper bolt. For stamped steel targets, pay close attention to the light reflection of the bore scope light on each tooth. If a tooth is bent, the reflection (bright spot) will move in relation to the reflection of the other teeth that are not bent. The light reflection will remain in the same location on each tooth if none of the teeth are bent. For powder metal targets, look for any tooth that is dull or does not shine as compared to the other teeth. The rough surface that remains from a tooth that has broken off appears to be dull/non-reflective.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      Yes, and the Crank Sensor was not replaced on the last visit

      - Replace the Crank Sensor in accordance with the Service Information. With the scan tool, perform the Cam/Crank Relearn Procedure. The Cam/Crank Relearn Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

- Test complete. Reconnect the harness connectors and erase the DTC. The most likely cause was a poor connection at one of the harness connectors.

5. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

    Are there any 5-Volt Reference DTCs present?

    Yes

    - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

    No

    - Go To 6

6. **CHECK THE (F855) 5-VOLT SUPPLY CIRCUIT VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the CKP Sensor harness connector.
    3. Turn the ignition on.
    4. Measure the voltage on the (F855) 5-Volt Supply circuit at the CKP Sensor harness connector.

    Is the voltage between 4.8 and 5.2 volts?

    Yes

    - Go To 7

    No, voltage is below 4.8 volts:

    - Repair the 5-Volt Supply circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No, voltage is above 5.2 volts:

    - Repair the 5-Volt Supply circuit for a short to voltage.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK THE CKP (K24) SIGNAL CIRCUIT VOLTAGE**
    1. Measure the voltage on the CKP (K24) Signal circuit at the CKP Sensor harness connector.

    Is the voltage between 4.8 and 5.2 volts?

    Yes

    - Go To 8

    No, voltage is below 5.2 volts:

    - Go To 10

    No, voltage is above 5.2 volts:

    - Repair the 5-Volt Supply circuit for a short to voltage.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK THE (K925) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. Turn the ignition off.
    2. Disconnect the PCM C2 harness connector.
    3. Measure the resistance of the (K925) Sensor Ground circuit between the CKP Sensor harness connector and the PCM C2 harness connector.

       Is the resistance below 3.0 Ohms?

       Yes

       - Go To 9

       No

       - Repair the (K925) Sensor Ground circuit for an open or high resistance.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
9. **VISUALLY INSPECT THE TARGET WHEEL/PULSE RING FOR DAMAGE OR EXCESSIVE RUNOUT**
    1. Disconnect the battery ground cable.
    2. Remove the CKP Sensor.
    3. Visually inspect the sensor mounting location for damage, foreign material.
    4. Rotate the engine and if possible inspect the Target Wheel for any signs of damage.
    5. Inspect the target wheel for any signs of damage by placing a bore scope into the CKP Sensor bore and manually rotate the engine slowly using a wrench on the crank damper bolt. For stamped steel targets, pay close attention to the light reflection of the bore scope light on each tooth. If a tooth is bent, the reflection (bright spot) will move in relation to the reflection of the other teeth that are not bent. The light reflection will remain in the same location on each tooth if none of the teeth are bent. For powder metal targets, look for any tooth that is dull or does not shine as compared to the other teeth. The rough surface that remains from a tooth that has broken off appears to be dull/non-reflective.

       Were any problems found?

       Yes

       - Repair Issues in mounting location, or repair or replace the Target Wheel / Pulse Ring as necessary. With the scan tool, perform the Cam/Crank Relearn Procedure. The Cam/Crank Relearn Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Replace the Crank Position Sensor in accordance with the Service Information. With the scan tool, perform the Cam/Crank Relearn Procedure. The Cam/Crank Relearn Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
10. **CHECK THE CKP (K24) SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. Turn the ignition off.

2. Disconnect the PCM C2 harness connector.
3. Check for continuity between ground and the CKP (K24) Signal circuit at the CKP Sensor harness connector.

   Is there continuity between ground and the CKP (K24) Signal circuit?

   Yes

   - Repair the CKP (K24) Signal circuit for a short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 11

11. **CHECK THE CKP (K24) SIGNAL CIRCUIT FOR A SHORT TO THE (K925) SENSOR GROUND**
    1. Check for continuity between the CKP (K24) Signal circuit and the (K925) Sensor Ground circuit at the CKP Sensor harness connector.

       Is there continuity between the CKP (K24) Signal circuit and the (K925) Sensor Ground circuit?

       Yes

       - Repair the short between the CKP (K24) Signal circuit and the (K925) Sensor Ground circuit.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 12
12. **CHECK THE CKP (K24) SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. Measure the resistance of the CKP (K24) Signal circuit between the CKP Sensor harness connector and the PCM C2 harness connector.

       Is the resistance below 3.0 Ohms?

       Yes

       - Go To 13

       No

       - Repair the CKP (K24) Signal circuit for an open circuit or high resistance.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
13. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
       - Proper connector installation.

- Damaged connector locks.
- Corrosion.
- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0340-CAMSHAFT POSITION SENSOR CIRCUIT - BANK 1 SENSOR 1

For a complete IGNITION SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

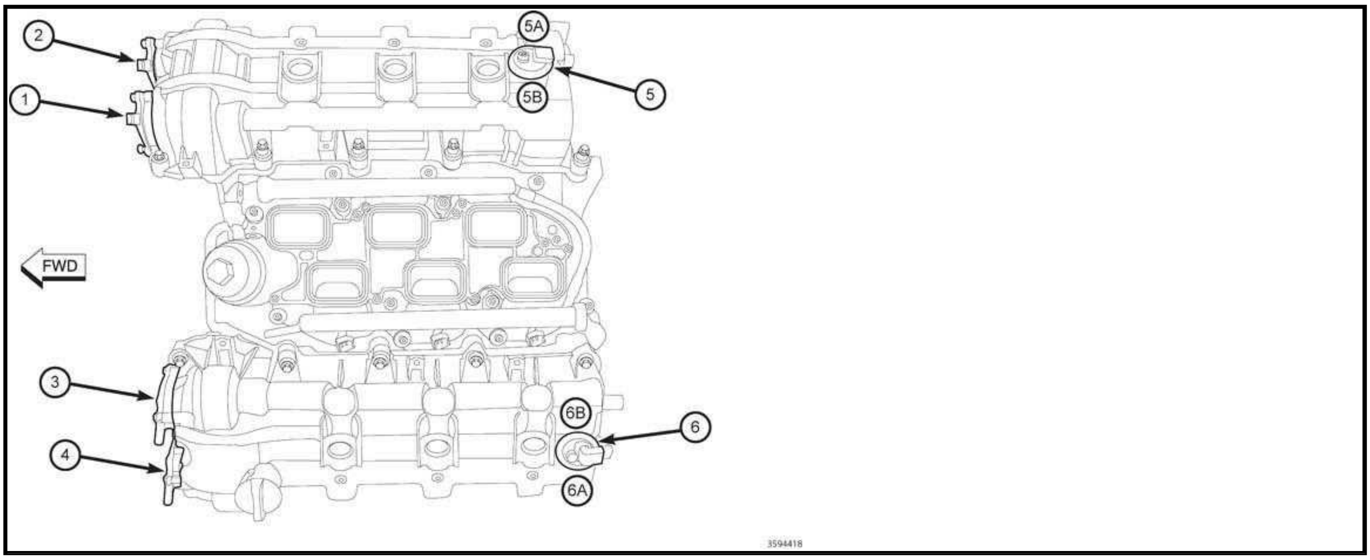
The Camshaft Position (CMP) Sensor circuits consist of a Powertrain Control Module (PCM) supplied 5-Volt reference circuit, low reference circuit, and an output signal circuit. The CMP Sensor detects magnetic flux from the peaks and valleys between the magnets of the tone wheel attached to the camshaft. As each magnet rotates past the CMP Sensor, the resulting change in the magnetic field is used by the sensor electronics to produce a digital output pulse. The sensor returns a digital ON/OFF DC voltage pulse of varying frequency output pulses per Camshaft revolution that represent an image of the camshaft tone wheel. The frequency of the CMP Sensor output depends on the velocity of the camshaft. The PCM decodes the tooth pattern to identify camshaft position. This information is then used to sequence the ignition timing and fuel injection events for the engine. The PCM also uses CMP Sensor output information to determine the camshaft relative position to the Crankshaft, to control the CMP Actuator operation if equipped.

NOTE: **The engine may still start even if either the Crankshaft Position (CKP) Sensor or CMP fails. The PCM eventually sorts out engine position and starts the vehicle on just one of these two inputs. However, there is a slight delay in starting until the PCM can establish sync. A DTC is set and the MIL illuminates if either of the CKP or CMP Sensor signals are not present during engine cranking.**

There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and tables below indicating the CMP Sensor, Position Solenoid/Phaser and DTC orientation).

3.2L / 3.6L DTCs RELATED TO EACH CAMSHAFT					
CAMSHAFT LOCATIONS	CALLOUT #	RELATED CAM SENSOR DTCS	PHASER/ACTUATOR DTCS	MISALIGNMENT DTCS	COLD START PERFORMANCE DTCS
Bank 1 Intake Camshaft	1	P0365, P0369	P000A, P0010	P0017	P052A, P052B
Bank 1 Exhaust Camshaft	2	P0340, P0344	P000B, P0013	P0016	P054A, P054B
Bank 2 Intake Camshaft	3	P0390, P0394	P000C, P0020	P0019	P052C, P052D
Bank 2 Exhaust Camshaft	4	P0345, P0349	P000D, P0023	P0018	P054C, P054D

3.2L / 3.6L VVT Component Locations			
CALLOUT	DESCRIPTION	CALLOUT	DESCRIPTION
1	CMP Position Solenoid - Bank 1 Position 1 (INTAKE)	5A	CMP Sensor - Bank 1 Sensor 1 (EXHAUST)
2	CMP Position Solenoid - Bank 1 Position 2 (EXHAUST)	5B	CMP Sensor - Bank 1 Sensor 2 (INTAKE)
3	CMP Position Solenoid - Bank 2 Position 1 (INTAKE)	6	Bank 2 Camshaft Sensor
4	CMP Position Solenoid - Bank 2 Position 2 (EXHAUST)	6A	CMP Sensor - Bank 2 Sensor 1 (EXHAUST)
5	Bank 1 Camshaft Sensor	6B	CMP Sensor - Bank 2 Sensor 2 (INTAKE)



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Battery voltage is above approximately 11.0 volts.
- With the engine cranking and with the engine running.

SET CONDITION

- During cranking, at least 2.5 seconds have elapsed with a Crankshaft Position Sensor signal present but no Camshaft Position Sensor signal.
- With the engine running, the Camshaft Position Sensor signal is lost for at least 0.4 seconds with a Crankshaft Position Sensor signal present.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
LOW ENGINE OIL LEVEL
5-VOLT SUPPLY CIRCUIT SHORTED TO VOLTAGE
5-VOLT SUPPLY CIRCUIT OPEN
5-VOLT SUPPLY CIRCUIT SHORTED TO GROUND
5-VOLT SUPPLY CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 1/1 SIGNAL CIRCUIT SHORTED TO VOLTAGE
CMP 1/1 SIGNAL CIRCUIT SHORTED TO GROUND
CMP 1/1 SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 1/1 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
CAMSHAFT POSITION SENSOR 1
TONE WHEEL LOOSE OR DAMAGED
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK THE ENGINE OIL LEVEL AND CONDITION**
    1. Turn the ignition off.

NOTE: **The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.**

- **LOW ENGINE OIL LEVEL**
- **CONTAMINATED, DIRTY, AERATED OR DETERIORATED ENGINE OIL**
- **INCORRECT ENGINE OIL VISCOSITY**
- **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
- **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**

Were any of the above conditions present?

Yes

- Repair as necessary. If the engine oil was not at the proper level, top off the engine oil to the proper specification. Start the engine and allow it to idle for 2 - 3 minutes. Turn the engine off, ignition on, and using the scan tool, erase the DTC. Start the engine and drive the vehicle to verify repair. If the DTC does not return, repair is complete.
- If the DTC returns, Go To 3

No

- Go To 2

2. **CHECK FOR AN ACTIVE DTC**
   1. Turn the ignition on.
   2. With the scan tool, read DTCs and record on the repair order. Copy DTC and Freeze Frame information.
   3. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.

      WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

   4. With the scan tool, read DTCs.

      Is the DTC active or pending?

      Yes

      - Go To 3

      No

      - Go To 27
3. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any 5-Volt Reference, Dual Stage Oil Pump or Oil Pressure related DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s) before continuing with this test procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 4
4. **CHECK FOR RELATED CAM SENSOR DTCS**

   Is the P0365 or P0369 DTC also active at this time?

   Yes

   - Go To 5

   No

- Go To 8

5. **CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT VOLTAGE**

   NOTE: **Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.**

   1. Turn the ignition off.
   2. Disconnect the CMP Sensor 1 harness connector.
   3. Turn the ignition on.
   4. Measure the voltage on the (F856) 5-Volt Supply circuit at the CMP Sensor 1 harness connector.

      Is the voltage between 4.8 and 5.2 volts?

      Yes

      - Go To 6

      No

      - Repair the (F856) 5-Volt Supply circuit for an open or shorted circuit.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE CMP SENSOR 1 (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. Turn the ignition off.
   2. Disconnect the PCM C2 harness connector.

      CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
   4. Measure the resistance of the CMP Sensor 1 (K900) Sensor Ground circuit between the CMP Sensor 1 harness connector and the GPEC Adaptor.

      Is the resistance below 3.0 Ohms?

      Yes

      - Go To 7

      No

      - Repair the CMP Sensor 1 (K900) Sensor Ground circuit for an open or high resistance.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
   1. Remove and exchange the CMP Sensor 1 with the CMP Sensor on the opposite bank.

      NOTE: **Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed**

every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.

2. Reconnect the PCM C2 and CMP Sensor harness connectors.
3. Turn the ignition on,
4. With the scan tool, erase DTCs.
5. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.
6. With the scan tool, read DTCs.

   Did the CMP Sensor DTCs for the opposite bank set?

   Yes

   - Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 22

8. **CHECK THE CMP SENSOR 1 (K44) POSITION SIGNAL 1 CIRCUIT FOR A SHORT TO VOLTAGE**

   NOTE: **Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.**

   1. Disconnect the CMP Sensor 1 harness connector.
   2. Measure the voltage on the CMP Sensor 1 (K44) Position Signal 1 circuit in the CMP Sensor 1 harness connector.

      Is the voltage above 5.2 volts?

      Yes

      - Repair the CMP Sensor 1 (K44) Position Signal 1 circuit for a short to voltage.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 9

9. **CHECK THE CMP SENSOR 1 (K44) POSITION SIGNAL 1 CIRCUIT FOR A SHORT TO GROUND**
   1. Turn the ignition off.
   2. Disconnect the PCM C2 harness connector.
   3. Check for continuity between ground and the CMP Sensor 1 (K44) Position Signal 1 circuit at the CMP Sensor 1 harness connector.

Is there continuity between ground and the CMP Sensor 1 (K44) Position Signal 1 circuit?

Yes

- Repair the CMP Sensor 1 (K44) Position Signal 1 circuit for a short to ground.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 10

10. **CHECK FOR THE CMP SENSOR 1 (K44) POSITION SIGNAL 1 CIRCUIT SHORTED TO THE CMP SENSOR 1 (K900) SENSOR GROUND CIRCUIT**
    1. Check for continuity between the CMP Sensor 1 (K44) Position Signal 1 circuit and the CMP Sensor 1 (K900) Sensor Ground circuit at the CMP Sensor 1 harness connector.

       Is there continuity between ground and the CMP Sensor 1 (K44) Position Signal 1 circuit and the CMP Sensor 1 (K900) Sensor Ground circuit?

       Yes

       - Repair the short between the CMP Sensor 1 (K44) Position Signal 1 circuit and the CMP Sensor 1 (K900) Sensor Ground circuit.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 11

11. **CHECK THE CMP SENSOR 1 (K44) POSITION SIGNAL 1 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
    2. Measure the resistance of the CMP Sensor 1 (K44) Position Signal 1 circuit between the CMP Sensor 1 harness connector and the GPEC Adaptor.

       Is the resistance below 3.0 Ohms?

       Yes

       - Go To 12

       No

       - Repair the CMP Sensor 1 (K44) Position Signal 1 circuit for an open or high resistance.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

12. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

    NOTE: **During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure**

with the adaptor tool and a gauge on the later model engines where the adaptor can be used.

1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

NOTE: **If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.**

Is the oil pressure reading stable and above 16.0 psi?

Yes

- Go To 13

No

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**
    1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
    2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
    3. Start the engine and allow it to idle.
    4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

NOTE: **The oil pressure reading at the Cylinder Head should be above 14.0 psi.**

Is the oil pressure reading stable and above 14.0 psi?

Yes

- Go To 14

No

- Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

14. **CHECK THE CAMSHAFT 1/2 OIL CONTROL VALVE OPERATION**
    1. Turn the ignition off.
    2. Remove the VVT Exhaust Solenoid 1/2.
    3. Inspect the spring loaded spool valve on the Oil Control Valve.

       NOTE: **The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.**

    4. Push and release the spring loaded spool valve against the return spring with a small punch.

       NOTE: **The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.**

    Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

    Yes

    - Go To 15

    No

    - Replace the Camshaft 1/2 Oil Control Valve in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

15. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
    1. Remove and exchange the CMP Sensor 1 with the CMP Sensor on the opposite bank.

       NOTE: **Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.**

    2. Reconnect the PCM C2 and Cam Sensor harness connectors.
    3. Turn the ignition on,
    4. With the scan tool, erase DTCs.
    5. Start the engine and allow it to idle or crank the engine if it will not start.
    6. With the scan tool, read DTCs.

    Did the CMP Sensor DTCs for the opposite bank set as active?

    Yes

    - Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank**

Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

    - Go To 16

16. **INSPECT CAMSHAFT SENSOR TONE WHEEL FOR DAMAGE OR LOOSENESS**
    1. Remove the Cylinder Head Cover and inspect the Camshaft Sensor Tone Wheel for any looseness or signs of damage.
    2. Using the (special tool #2027902090, Check Tool, Tone Wheel Right) check the alignment of the CMP Sensor Tone Wheel in accordance with the service information.

    Were any issues found with the CMP Sensor Tone Wheel?

    Yes

    - Replace the Camshaft Assembly in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 17

17. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain and tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 18

18. **CHECK THE CAM PHASER AND CAMSHAFT ASSEMBLY**
    1. Check the Cam Phaser to verify it has returned to lock pin.

2. Put a wrench on the flat of the Camshaft behind the phaser and attempt to move the Camshaft back and forth.

   NOTE: **The Cam Phaser should always return to lock pin when the engine is turned off. If the Cam Phaser is not at lock pin, there will be movement felt between the Camshaft and the Cam Phaser.**

   Is there movement between the Camshaft and Cam Phaser?

   Yes

   - Replace the Cam Phaser in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
   - Go To 19

   No

   - Replace the Cam Phaser and Camshaft in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
   - Go To 19

19. **VERIFY THE REPAIR**
   1. With the scan tool, erase DTCs.
   2. Test drive the vehicle in accordance with the Freeze Frame data collected.

   Did the DTC return?

   Yes

   - Go To 20

   No

   - Repair is complete.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

20. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.

- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 21

No

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
- Test complete.

21. **REPLACE THE PCM AND RETEST FOR DTC**
    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

    Did the CMP Sensor DTC return?

    Yes

    - Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Repair is complete.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

22. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

NOTE: **During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.**

1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

   NOTE: **If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.**

   Is the oil pressure reading stable and above 16.0 psi?

   Yes

   - Go To 23

   No

   - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

23. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**
    1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
    2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
    3. Start the engine and allow it to idle.
    4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

    NOTE: **The oil pressure reading at the Cylinder Head should be above 14.0 psi.**

    Is the oil pressure reading stable and above 14.0 psi?

    Yes

    - Go To 24

    No

    - Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or

CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
 - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

24. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 25
25. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.

9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 26

    No

    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
    - Test complete.

26. **REPLACE THE PCM AND RETEST FOR DTC**
    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

       Did the CMP Sensor DTC return?

       Yes

       - Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Replacing the PCM repaired the fault.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

27. **WIRE HARNESS/CKP SENSOR INSPECTION**
    1. Turn the ignition off.
    2. Disconnect the harness connectors at the PCM and Cam Sensor. Inspect for wire chaffing or rub conditions, spread terminals, terminals pushed out of the wiring connector, bent terminals at the PCM and Cam Sensor, water in the connector cavities, presence of corrosion on the terminals of the connectors or components.
    3. Visually inspect the mounting area of Cam Sensor for debris/damage or a loose sensor. Remove the Cam Sensor and inspect the end of the sensor for signs of damage or debris. Rotate the engine and if possible, inspect the tone wheel for any signs of damage. Reinstall the Cam Sensor and ensure that the sensor is properly installed and torqued to proper specification.

NOTE:	**Due to the fact that this DTC is set by an intermittent loss of the signal, the DTC may be caused by a poor connection at the Cam Sensor or PCM terminals, or a poor signal between the Cam Sensor**

and tone wheel. Because of this, unplugging and reconnecting the harness connectors, or repositioning the Cam Sensor will often repair the condition that set the DTC.

Were any problems found?

Yes

- Perform the appropriate repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 28

28. **CHECK THE VEHICLE'S REPAIR HISTORY**
    1. Check the history of the vehicle for previous Cam Sensor related DTCs.

    Did the repair history show that the vehicle was previously in the dealership with a Cam Sensor fault?

    Yes

    - If the current DTC being diagnosed is for the **same** engine bank as the DTC that set on the previous visit, perform the diagnostics starting at test step #12 in this diagnostic procedure.
    - If the current DTC being diagnosed is for the **opposite** engine bank as the DTC that set on the previous visit, replace the Cam Sensor in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Swap the Cam Sensor with the Cam Sensor on the opposite bank and clear DTCs. The cause may have been a poor connection at one of the harness connectors. Unplugging and reconnecting the harness connector may resolve the issue. Verify the DTC does not return.

    NOTE: **The sensors must be exchanged to aid in determining the possible failure if the vehicle returns to the dealership in the future with another Cam Sensor related DTC.**

    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0344-CAMSHAFT POSITION SENSOR INTERMITTENT - BANK 1 SENSOR 1

For a complete IGNITION SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

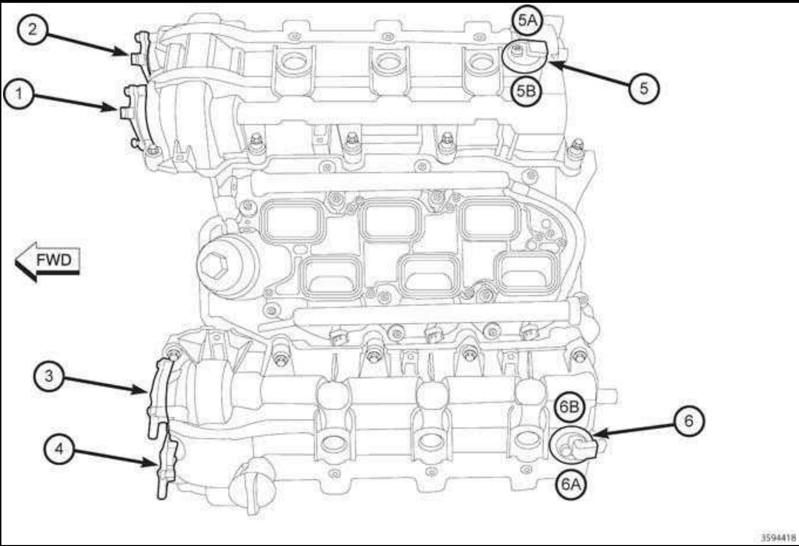
The Camshaft Position (CMP) Sensor circuits consist of a Powertrain Control Module (PCM) supplied 5-Volt reference circuit, low reference circuit, and an output signal circuit. The CMP Sensor detects magnetic flux from the peaks and valleys between the magnets of the tone wheel attached to the camshaft. As each magnet rotates past the CMP Sensor, the resulting change in the magnetic field is used by the sensor electronics to produce a digital output pulse. The sensor returns a digital ON/OFF DC voltage pulse of varying frequency output pulses per Camshaft revolution that represent an image of the camshaft tone wheel. The frequency of the CMP Sensor output depends on the velocity of the camshaft. The PCM decodes the tooth pattern to identify camshaft position. This information is then used to sequence the ignition timing and fuel injection events for the engine. The PCM also uses CMP Sensor output information to determine the camshaft relative position to the Crankshaft, to control the CMP Actuator operation if equipped.

NOTE: **The engine may still start even if either the Crankshaft Position (CKP) Sensor or CMP fails. The PCM eventually sorts out engine position and starts the vehicle on just one of these two inputs. However, there is a slight delay in starting until the PCM can establish sync. A DTC is set and the MIL illuminates if either of the CKP or CMP Sensor signals are not present during engine cranking.**

There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and tables below indicating the CMP Sensor, Position Solenoid/Phaser and DTC orientation).

3.2L / 3.6L DTCs RELATED TO EACH CAMSHAFT					
CAMSHAFT LOCATIONS	**CALLOUT #**	**RELATED CAM SENSOR DTCS**	**PHASER/ACTUATOR DTCS**	**MISALIGNMENT DTCS**	**COLD START PERFORMANCE DTCS**
Bank 1 Intake Camshaft	1	P0365, P0369	P000A, P0010	P0017	P052A, P052B
Bank 1 Exhaust Camshaft	2	P0340, P0344	P000B, P0013	P0016	P054A, P054B
Bank 2 Intake Camshaft	3	P0390, P0394	P000C, P0020	P0019	P052C, P052D
Bank 2 Exhaust Camshaft	4	P0345, P0349	P000D, P0023	P0018	P054C, P054D

3.2L / 3.6L VVT Component Locations			
CALLOUT	**DESCRIPTION**	**CALLOUT**	**DESCRIPTION**
1	CMP Position Solenoid - Bank 1 Position 1 (INTAKE)	5A	CMP Sensor - Bank 1 Sensor 1 (EXHAUST)
2	CMP Position Solenoid - Bank 1 Position 2 (EXHAUST)	5B	CMP Sensor - Bank 1 Sensor 2 (INTAKE)
3	CMP Position Solenoid - Bank 2 Position 1 (INTAKE)	6	Bank 2 Camshaft Sensor
4	CMP Position Solenoid - Bank 2 Position 2 (EXHAUST)	6A	CMP Sensor - Bank 2 Sensor 1 (EXHAUST)
5	Bank 1 Camshaft Sensor	6B	CMP Sensor - Bank 2 Sensor 2 (INTAKE)



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage is above approximately 11.0 volts.

SET CONDITION

- With the engine running, the Powertrain Control Module (PCM) acquires and locks in on a pattern for the Camshaft Position (CMP) Sensor signal. If the CMP Sensor signal pattern changes between unlock and lock at least four times during a period of eight Crankshaft revolutions, a fault is set.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
LOW ENGINE OIL LEVEL
ENGINE OIL AERATED OR CONTAMINATED
INCORRECT ENGINE OIL FILTER
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
5-VOLT SUPPLY CIRCUIT SHORTED TO VOLTAGE
5-VOLT SUPPLY CIRCUIT OPEN
5-VOLT SUPPLY CIRCUIT SHORTED TO GROUND
5-VOLT SUPPLY CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 1/1 SIGNAL CIRCUIT SHORTED TO VOLTAGE
CMP 1/1 SIGNAL CIRCUIT SHORTED TO GROUND
CMP 1/1 SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 1/1 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
CAMSHAFT POSITION SENSOR 1
CAMSHAFT TONE WHEEL LOOSE/DAMAGED OR MISALIGNED
CAMSHAFT 1/2 OIL CONTROL VALVE FAULTY OR INTERMITTENTLY BINDING/STICKING SPOOL VALVE
CAMSHAFT 1/2 PHASER FAULTY OR INTERMITTENTLY BINDING/STICKING
POWERTRAIN CONTROL MODULE (PCM)

Possible Causes
OIL PRESSURE ISSUE IN CYLINDER HEAD

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK THE ENGINE OIL LEVEL AND CONDITION**
    1. Turn the ignition off.

    NOTE: **The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.**

    - **LOW ENGINE OIL LEVEL**
    - **CONTAMINATED, DIRTY, AERATED OR DETERIORATED ENGINE OIL**
    - **INCORRECT ENGINE OIL VISCOSITY**
    - **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
    - **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**

    Were any of the above conditions present?

    Yes

    - Repair as necessary. If the engine oil was not at the proper level, top off the engine oil to the proper specification. Start the engine and allow it to idle for 2 - 3 minutes. Turn the engine off, ignition on, and using the scan tool, erase the DTC. Start the engine and drive the vehicle to verify repair. If the DTC does not return, repair is complete.
    - If the DTC returns, Go To 3

    No

    - Go To 2
2. **CHECK FOR AN ACTIVE DTC**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs and record on the repair order. Copy DTC and Freeze Frame information.
    3. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.

    WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

    4. With the scan tool, read DTCs.

    Is the DTC active or pending?

    Yes

    - Go To 3

No

- Go To 27

3. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any 5-Volt Reference, Dual Stage Oil Pump or Oil Pressure related DTCs active or pending?

        Yes

        - Perform the applicable diagnostic procedure(s) before continuing with this test procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 4

4. **CHECK FOR RELATED CAM SENSOR DTCS**

    Is the P0365 or P0369 DTC also active at this time?

    Yes

    - Go To 5

    No

    - Go To 8

5. **CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT VOLTAGE**

    NOTE: **Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.**

    1. Turn the ignition off.
    2. Disconnect the CMP Sensor 1 harness connector.
    3. Turn the ignition on.
    4. Measure the voltage on the (F856) 5-Volt Supply circuit at the CMP Sensor 1 harness connector.

        Is the voltage between 4.8 and 5.2 volts?

        Yes

        - Go To 6

        No

        - Repair the (F856) 5-Volt Supply circuit for an open or shorted circuit.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE CMP SENSOR 1 (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. Turn the ignition off.
    2. Disconnect the PCM C2 harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
4. Measure the resistance of the (K900) Sensor Ground circuit between the CMP Sensor 1 harness connector and the GPEC Adaptor.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 7

   No

   - Repair the (K900) Sensor Ground circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
   1. Remove and exchange the CMP Sensor 1 with the CMP Sensor on the opposite bank.

      NOTE: **Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.**

   2. Reconnect the PCM C2 and CMP Sensor harness connectors.
   3. Turn the ignition on,
   4. With the scan tool, erase DTCs.
   5. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.
   6. With the scan tool, read DTCs.

   Did the CMP Sensor DTCs for the opposite bank set?

   Yes

   - Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 22

8. **CHECK THE CMP SENSOR 1 (K44) POSITION SIGNAL 1 CIRCUIT FOR A SHORT TO VOLTAGE**

   NOTE: **Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.**

   1. Disconnect the CMP Sensor 1 harness connector.
   2. Measure the voltage on the CMP Sensor 1 (K44) Position Signal 1 circuit in the CMP Sensor 1 harness connector.

      Is the voltage above 5.2 volts?

      Yes

      - Repair the CMP Sensor 1 (K44) Position Signal 1 circuit for a short to voltage.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 9
9. **CHECK THE CMP SENSOR 1 (K44) POSITION SIGNAL 1 CIRCUIT FOR A SHORT TO GROUND**
   1. Turn the ignition off.
   2. Disconnect the PCM C2 harness connector.
   3. Check for continuity between ground and the CMP Sensor 1 (K44) Position Signal 1 circuit at the CMP Sensor 1 harness connector.

      Is there continuity between ground and the CMP Sensor 1 (K44) Position Signal 1 circuit?

      Yes

      - Repair the CMP Sensor 1 (K44) Position Signal 1 circuit for a short to ground.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 10
10. **CHECK FOR THE CMP SENSOR 1 (K44) POSITION SIGNAL 1 CIRCUIT SHORTED TO THE CMP SENSOR 1 (K900) SENSOR GROUND CIRCUIT**
    1. Check for continuity between the CMP Sensor 1 (K44) Position Signal 1 circuit and the CMP Sensor 1 (K900) Sensor Ground circuit at the CMP Sensor 1 harness connector.

       Is there continuity between ground and the CMP Sensor 1 (K44) Position Signal 1 circuit and the CMP Sensor 1 (K900) Sensor Ground circuit?

       Yes

       - Repair the short between the CMP Sensor 1 (K44) Position Signal 1 circuit and the CMP Sensor 1 (K900) Sensor Ground circuit.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

- Go To 11

11. **CHECK THE CMP SENSOR 1 (K44) POSITION SIGNAL 1 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
    2. Measure the resistance of the CMP Sensor 1 (K44) Position Signal 1 circuit between the CMP Sensor 1 harness connector and the GPEC Adaptor.

       Is the resistance below 3.0 Ohms?

       Yes

       - Go To 12

       No

       - Repair the CMP Sensor 1 (K44) Position Signal 1 circuit for an open or high resistance.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

12. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

    NOTE: **During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.**

    1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
    2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
    3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
    4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
    5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

       NOTE: **If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.**

       Is the oil pressure reading stable and above 16.0 psi?

       Yes

       - Go To 13

       No

       - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**
    1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
    2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
    3. Start the engine and allow it to idle.
    4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

    NOTE: **The oil pressure reading at the Cylinder Head should be above 14.0 psi.**

    Is the oil pressure reading stable and above 14.0 psi?

    Yes

    - Go To 14

    No

    - Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

14. **CHECK THE CAMSHAFT 1/2 OIL CONTROL VALVE OPERATION**
    1. Turn the ignition off.
    2. Remove the VVT Intake Solenoid 1/2.
    3. Inspect the spring loaded spool valve on the Oil Control Valve.

    NOTE: **The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.**

    4. Push and release the spring loaded spool valve against the return spring with a small punch.

    NOTE: **The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.**

    Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

    Yes

    - Go To 15

    No

    - Replace the Camshaft 1/2 Oil Control Valve in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing

chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

15. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
    1. Remove and exchange the CMP Sensor 1 with the CMP Sensor on the opposite bank.

       NOTE: **Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.**

    2. Reconnect the PCM C2 and Cam Sensor harness connectors.
    3. Turn the ignition on,
    4. With the scan tool, erase DTCs.
    5. Start the engine and allow it to idle or crank the engine if it will not start.
    6. With the scan tool, read DTCs.

    Did the CMP Sensor DTCs for the opposite bank set as active?

    Yes

    - Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 16

16. **INSPECT CAMSHAFT SENSOR TONE WHEEL FOR DAMAGE OR LOOSENESS**
    1. Remove the Cylinder Head Cover and inspect the Camshaft Sensor Tone Wheel for any looseness or signs of damage.
    2. Using the (special tool #2027902090, Check Tool, Tone Wheel Right) check the alignment of the CMP Sensor Tone Wheel in accordance with the service information.

    Were any issues found with the CMP Sensor Tone Wheel?

    Yes

    - Replace the Camshaft Assembly in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 17

17. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 18

18. **CHECK THE CAM PHASER AND CAMSHAFT ASSEMBLY**
    1. Check the Cam Phaser to verify it has returned to lock pin.
    2. Put a wrench on the flat of the Camshaft behind the phaser and attempt to move the Camshaft back and forth.

    NOTE: **The Cam Phaser should always return to lock pin when the engine is turned off. If the Cam Phaser is not at lock pin, there will be movement felt between the Camshaft and the Cam Phaser.**

    Is there movement between the Camshaft and Cam Phaser?

    Yes

    - Replace the Cam Phaser in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Go To 19

    No

    - Replace the Cam Phaser and Camshaft in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Go To 19

19. **VERIFY THE REPAIR**
    1. With the scan tool, erase DTCs.

2. Test drive the vehicle in accordance with the Freeze Frame data collected.

   Did the DTC return?

   Yes

   - Go To 20

   No

   - Repair is complete.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

20. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
       - Proper connector installation.
       - Damaged connector locks.
       - Corrosion.
       - Other signs of water intrusion.
       - Weather seal damage (if equipped).
       - Bent terminals.
       - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
       - Terminals that have been pushed back into the connector cavity.
       - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Go To 21

        No

        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

- Test complete.

21. **REPLACE THE PCM AND RETEST FOR DTC**
    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

    Did the CMP Sensor DTC return?

    Yes

    - Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Repair is complete.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

22. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

    NOTE: During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.

    1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
    2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
    3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
    4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
    5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

       NOTE: If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.

    Is the oil pressure reading stable and above 16.0 psi?

    Yes

    - Go To 23

No

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

23. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**
    1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
    2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
    3. Start the engine and allow it to idle.
    4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

    NOTE: **The oil pressure reading at the Cylinder Head should be above 14.0 psi.**

    Is the oil pressure reading stable and above 14.0 psi?

    Yes

    - Go To 24

    No

    - Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

24. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 25

25. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Go To 26

        No

        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
        - Test complete.
26. **REPLACE THE PCM AND RETEST FOR DTC**
    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

       Did the CMP Sensor DTC return?

Yes

- Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Repair is complete.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

27. **WIRE HARNESS/CKP SENSOR INSPECTION**
    1. Turn the ignition off.
    2. Disconnect the harness connectors at the PCM and Cam Sensor. Inspect for wire chaffing or rub conditions, spread terminals, terminals pushed out of the wiring connector, bent terminals at the PCM and Cam Sensor, water in the connector cavities, presence of corrosion on the terminals of the connectors or components.
    3. Visually inspect the mounting area of Cam Sensor for debris/damage or a loose sensor. Remove the Cam Sensor and inspect the end of the sensor for signs of damage or debris. Rotate the engine and if possible, inspect the tone wheel for any signs of damage. Reinstall the Cam Sensor and ensure that the sensor is properly installed and torqued to proper specification.

    NOTE: **Due to the fact that this DTC is set by an intermittent loss of the signal, the DTC may be caused by a poor connection at the Cam Sensor or PCM terminals, or a poor signal between the Cam Sensor and tone wheel. Because of this, unplugging and reconnecting the harness connectors, or repositioning the Cam Sensor will often repair the condition that set the DTC.**

    Were any problems found?

    Yes

    - Perform the appropriate repair.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 28
28. **CHECK THE VEHICLE'S REPAIR HISTORY**
    1. Check the history of the vehicle for previous Cam Sensor related DTCs.

    Did the repair history show that the vehicle was previously in the dealership with a Cam Sensor fault?

    Yes

    - If the current DTC being diagnosed is for the **same** engine bank as the DTC that set on the previous visit, perform the diagnostics starting at test step #12 in this diagnostic procedure.
    - If the current DTC being diagnosed is for the **opposite** engine bank as the DTC that set on the previous visit, replace the Cam Sensor in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing

chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Swap the Cam Sensor with the Cam Sensor on the opposite bank and clear DTCs. The cause may have been a poor connection at one of the harness connectors. Unplugging and reconnecting the harness connector may resolve the issue. Verify the DTC does not return.

NOTE: **The sensors must be exchanged to aid in determining the possible failure if the vehicle returns to the dealership in the future with another Cam Sensor related DTC.**

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0345-CAMSHAFT POSITION SENSOR CIRCUIT - BANK 2 SENSOR 1

For a complete IGNITION SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Camshaft Position (CMP) Sensor circuits consist of a Powertrain Control Module (PCM) supplied 5-Volt reference circuit, low reference circuit, and an output signal circuit. The CMP Sensor detects magnetic flux from the peaks and valleys between the magnets of the tone wheel attached to the camshaft. As each magnet rotates past the CMP Sensor, the resulting change in the magnetic field is used by the sensor electronics to produce a digital output pulse. The sensor returns a digital ON/OFF DC voltage pulse of varying frequency output pulses per Camshaft revolution that represent an image of the camshaft tone wheel. The frequency of the CMP Sensor output depends on the velocity of the camshaft. The PCM decodes the tooth pattern to identify camshaft position. This information is then used to sequence the ignition timing and fuel injection events for the engine. The PCM also uses CMP Sensor output information to determine the camshaft relative position to the Crankshaft, to control the CMP Actuator operation if equipped.

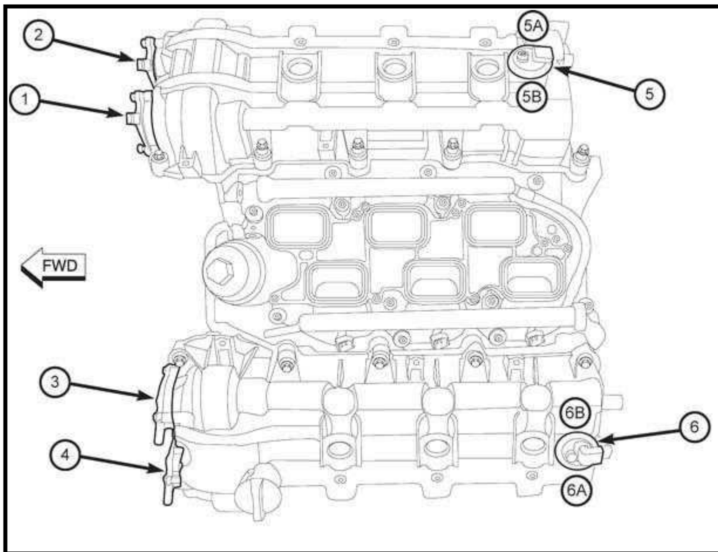
NOTE: **The engine may still start even if either the Crankshaft Position (CKP) Sensor or CMP fails. The PCM eventually sorts out engine position and starts the vehicle on just one of these two inputs. However, there is a slight delay in starting until the PCM can establish sync. A DTC is set and the MIL illuminates if either of the CKP or CMP Sensor signals are not present during engine cranking.**

There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and tables below indicating the CMP Sensor, Position Solenoid/Phaser and DTC orientation).

3.2L / 3.6L DTCs RELATED TO EACH CAMSHAFT					
CAMSHAFT LOCATIONS	CALLOUT #	RELATED CAM SENSOR DTCS	PHASER/ACTUATOR DTCS	MISALIGNMENT DTCS	COLD START PERFORMANCE DTCS
Bank 1 Intake Camshaft	1	P0365, P0369	P000A, P0010	P0017	P052A, P052B
Bank 1 Exhaust Camshaft	2	P0340, P0344	P000B, P0013	P0016	P054A, P054B

3.2L / 3.6L DTCs RELATED TO EACH CAMSHAFT					
CAMSHAFT LOCATIONS	**CALLOUT #**	**RELATED CAM SENSOR DTCS**	**PHASER/ACTUATOR DTCS**	**MISALIGNMENT DTCS**	**COLD START PERFORMANCE DTCS**
Bank 2 Intake Camshaft	3	P0390, P0394	P000C, P0020	P0019	P052C, P052D
Bank 2 Exhaust Camshaft	4	P0345, P0349	P000D, P0023	P0018	P054C, P054D

3.2L / 3.6L VVT Component Locations			
CALLOUT	**DESCRIPTION**	**CALLOUT**	**DESCRIPTION**
1	CMP Position Solenoid - Bank 1 Position 1 (INTAKE)	5A	CMP Sensor - Bank 1 Sensor 1 (EXHAUST)
2	CMP Position Solenoid - Bank 1 Position 2 (EXHAUST)	5B	CMP Sensor - Bank 1 Sensor 2 (INTAKE)
3	CMP Position Solenoid - Bank 2 Position 1 (INTAKE)	6	Bank 2 Camshaft Sensor
4	CMP Position Solenoid - Bank 2 Position 2 (EXHAUST)	6A	CMP Sensor - Bank 2 Sensor 1 (EXHAUST)
5	Bank 1 Camshaft Sensor	6B	CMP Sensor - Bank 2 Sensor 2 (INTAKE)



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine cranking and with the engine running.
- Battery voltage is above approximately 11.0 volts.

SET CONDITION

- During cranking, at least 2.5 seconds have elapsed with a Crankshaft Position Sensor signal present but no Camshaft Position Sensor signal.
- With the engine running, the Camshaft Position Sensor signal is lost for at least 0.4 seconds with a Crankshaft Position Sensor signal present.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
LOW ENGINE OIL LEVEL
ENGINE OIL AERATED OR CONTAMINATED
INCORRECT ENGINE OIL FILTER
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
5-VOLT SUPPLY CIRCUIT SHORTED TO VOLTAGE
5-VOLT SUPPLY CIRCUIT OPEN
5-VOLT SUPPLY CIRCUIT SHORTED TO GROUND
5-VOLT SUPPLY CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 2/1 SIGNAL CIRCUIT SHORTED TO VOLTAGE
CMP 2/1 SIGNAL CIRCUIT SHORTED TO GROUND
CMP 2/1 SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 2/1 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
CAMSHAFT POSITION SENSOR 2
CAMSHAFT TONE WHEEL LOOSE/DAMAGED OR MISALIGNED
CAMSHAFT 2/2 OIL CONTROL VALVE FAULTY OR INTERMITTENTLY BINDING/STICKING SPOOL VALVE
CAMSHAFT 2/2 PHASER FAULTY OR INTERMITTENTLY BINDING/STICKING
POWERTRAIN CONTROL MODULE (PCM)
OIL PRESSURE ISSUE IN CYLINDER HEAD

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK THE ENGINE OIL LEVEL AND CONDITION**
    1. Turn the ignition off.

    NOTE: **The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.**

    - **LOW ENGINE OIL LEVEL**
    - **CONTAMINATED, DIRTY, AERATED OR DETERIORATED ENGINE OIL**
    - **INCORRECT ENGINE OIL VISCOSITY**
    - **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
    - **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**

    Were any of the above conditions present?

    Yes

    - Repair as necessary. If the engine oil was not at the proper level, top off the engine oil to the proper specification. Start the engine and allow it to idle for 2 - 3 minutes. Turn the engine off, ignition on, and using the scan tool, erase the DTC. Start the engine and drive the vehicle to verify repair. If the DTC does not return, repair is complete.

- If the DTC returns, Go To 3

No

- Go To 2

2. **CHECK FOR AN ACTIVE DTC**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs and record on the repair order. Copy DTC and Freeze Frame information.
    3. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.

    WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

    4. With the scan tool, read DTCs.

    Is the DTC active or pending?

    Yes

    - Go To 3

    No

    - Go To 27
3. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

    Are there any 5-Volt Reference, Dual Stage Oil Pump or Oil Pressure related DTCs active or pending?

    Yes

    - Perform the applicable diagnostic procedure(s) before continuing with this test procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

    No

    - Go To 4
4. **CHECK FOR RELATED CAM SENSOR DTCS**

    Is the P0390 or P0394 DTC also active at this time?

    Yes

    - Go To 5

    No

    - Go To 8
5. **CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT**

NOTE: **Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.**

1. Turn the ignition off.
2. Disconnect the CMP Sensor 2 harness connector.
3. Turn the ignition on.
4. Measure the voltage on the (F856) 5-Volt Supply circuit at the CMP Sensor 2 harness connector.

   Is the voltage between 4.8 and 5.2 volts?

   Yes

   - Go To 6

   No

   - Repair the (F856) 5-Volt Supply circuit for an open or shorted circuit.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE CMP SENSOR 2 (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. Turn the ignition off.
   2. Disconnect the PCM C2 harness connector.

      CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
   4. Measure the resistance of the CMP Sensor 2 (K900) Sensor Ground circuit between the CMP Sensor 2 harness connector and the GPEC Adaptor.

      Is the resistance below 3.0 Ohms?

      Yes

      - Go To 7

      No

      - Repair the CMP Sensor 2 (K900) Sensor Ground circuit for an open or high resistance.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
   1. Remove and exchange the CMP Sensor 2 with the CMP Sensor on the opposite bank.

      NOTE: **Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or**

gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.

2. Reconnect the PCM C2 and CMP Sensor harness connectors.
3. Turn the ignition on,
4. With the scan tool, erase DTCs.
5. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.
6. With the scan tool, read DTCs.

Did the CMP Sensor DTCs for the opposite bank set?

Yes

- Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 22

8. **CHECK THE CMP SENSOR 2 (K444) SIGNAL 1 CIRCUIT FOR A SHORT TO VOLTAGE**

NOTE: Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.

1. Disconnect the CMP Sensor 2 harness connector.
2. Measure the voltage on the CMP Sensor 2 (K444) Signal 1 circuit in the CMP Sensor 2 harness connector.

Is the voltage above 5.2 volts?

Yes

- Repair the CMP Sensor 2 (K444) Signal 1 circuit for a short to voltage.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 9

9. **CHECK THE CMP SENSOR 2 (K444) SIGNAL 1 CIRCUIT FOR A SHORT TO GROUND**

1. Turn the ignition off.
2. Disconnect the PCM C2 harness connector.
3. Check for continuity between ground and the CMP Sensor 2 (K444) Signal 1 circuit at the CMP Sensor 2 harness connector.

Is there continuity between ground and the CMP Sensor 2 (K444) Signal 1 circuit?

Yes

- Repair the CMP Sensor 2 (K444) Signal 1 circuit for a short to ground.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 10

10. **CHECK FOR THE CMP SENSOR 2 (K444) SIGNAL 1 CIRCUIT SHORTED TO THE CMP SENSOR 2 (K900) SENSOR GROUND CIRCUIT**
    1. Check for continuity between the CMP Sensor 2 (K444) Signal 1 circuit and the CMP Sensor 2 (K900) Sensor Ground circuit at the CMP Sensor 2 harness connector.

    Is there continuity between ground and the CMP Sensor 2 (K444) Signal 1 circuit and the CMP Sensor 2 (K900) Sensor Ground circuit?

    Yes

    - Repair the short between the CMP Sensor 2 (K444) Signal 1 circuit and the CMP Sensor 2 (K900) Sensor Ground circuit.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 11

11. **CHECK THE CMP SENSOR 2 (K444) SIGNAL 1 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
    2. Measure the resistance of the CMP Sensor 2 (K444) Signal 1 circuit between the CMP Sensor 2 harness connector and the GPEC Adaptor.

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 12

    No

    - Repair the CMP Sensor 2 (K444) Signal 1 circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

12. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

    NOTE: **During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.**

1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

NOTE: **If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.**

Is the oil pressure reading stable and above 16.0 psi?

Yes

- Go To 13

No

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**
    1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
    2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
    3. Start the engine and allow it to idle.
    4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

NOTE: **The oil pressure reading at the Cylinder Head should be within above 14.0 psi.**

Is the oil pressure reading stable and above 14.0 psi?

Yes

- Go To 14

No

- Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

14. **CHECK THE CAMSHAFT 2/2 OIL CONTROL VALVE OPERATION**

1. Turn the ignition off.
2. Remove the Camshaft Position Solenoid 2/2.
3. Inspect the spring loaded spool valve on the Oil Control Valve.

   NOTE: The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.

4. Push and release the spring loaded spool valve against the return spring with a small punch.

   NOTE: The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.

   Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

   Yes

   - Go To 15

   No

   - Replace the Camshaft 2/2 Oil Control Valve in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

15. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
    1. Remove and exchange the CMP Sensor 2 with the CMP Sensor on the opposite bank.

       NOTE: Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.

    2. Reconnect the PCM C2 and Cam Sensor harness connectors.
    3. Turn the ignition on,
    4. With the scan tool, erase DTCs.
    5. Start the engine and allow it to idle or crank the engine if it will not start.
    6. With the scan tool, read DTCs.

    Did the CMP Sensor DTCs for the opposite bank set as active?

    Yes

    - Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears.

Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 16

16. **INSPECT CAMSHAFT SENSOR TONE WHEEL FOR DAMAGE OR LOOSENESS**
    1. Remove the Cylinder Head Cover and inspect the Camshaft Sensor Tone Wheel for any looseness or signs of damage.
    2. Using the (special tool #2027902090, Check Tool, Tone Wheel Right) check the alignment of the CMP Sensor Tone Wheel in accordance with the service information.

    Were any issues found with the CMP Sensor Tone Wheel?

    Yes

    - Replace the Camshaft Assembly in accordance with the Service Information. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 17

17. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 18

18. **CHECK THE CAM PHASER AND CAMSHAFT ASSEMBLY**
    1. Check the Cam Phaser to verify it has returned to lock pin.

2. Put a wrench on the flat of the Camshaft behind the phaser and attempt to move the Camshaft back and forth.

   NOTE: **The Cam Phaser should always return to lock pin when the engine is turned off. If the Cam Phaser is not at lock pin, there will be movement felt between the Camshaft and the Cam Phaser.**

   Is there movement between the Camshaft and Cam Phaser?

   Yes

   - Replace the Cam Phaser in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
   - Go To 19

   No

   - Replace the Cam Phaser and Camshaft in accordance with the Service Information. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
   - Go To 19

19. **VERIFY THE REPAIR**
   1. With the scan tool, erase DTCs.
   2. Test drive the vehicle in accordance with the Freeze Frame data collected.

   Did the DTC return?

   Yes

   - Go To 20

   No

   - Repair is complete.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

20. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.

- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 21

No

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
- Test complete.

21. **REPLACE THE PCM AND RETEST FOR DTC**
    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

    Did the CMP Sensor DTC return?

    Yes

    - Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Repair is complete.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

22. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

    NOTE: During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.

    1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
    2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
    3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
    4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
    5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

       NOTE: If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.

    Is the oil pressure reading stable and above 16.0 psi?

    Yes

    - Go To 23

    No

    - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

23. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**
    1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
    2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
    3. Start the engine and allow it to idle.
    4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

       NOTE: The oil pressure reading at the Cylinder Head should be above 14.0 psi.

    Is the oil pressure reading stable and above 14.0 psi?

    Yes

    - Go To 24

    No

    - Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

24. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 25
25. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.

7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 26

    No

    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
    - Test complete.

26. **REPLACE THE PCM AND RETEST FOR DTC**
    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

       Did the CMP Sensor DTC return?

       Yes

       - Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Repair is complete.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

27. **WIRE HARNESS/CKP SENSOR INSPECTION**
    1. Turn the ignition off.
    2. Disconnect the harness connectors at the PCM and Cam Sensor. Inspect for wire chaffing or rub conditions, spread terminals, terminals pushed out of the wiring connector, bent terminals at the PCM and Cam Sensor, water in the connector cavities, presence of corrosion on the terminals of the connectors or components.
    3. Visually inspect the mounting area of Cam Sensor for debris/damage or a loose sensor. Remove the Cam Sensor and inspect the end of the sensor for signs of damage or debris. Rotate the engine and

if possible, inspect the tone wheel for any signs of damage. Reinstall the Cam Sensor and ensure that the sensor is properly installed and torqued to proper specification.

NOTE: **Due to the fact that this DTC is set by an intermittent loss of the signal, the DTC may be caused by a poor connection at the Cam Sensor or PCM terminals, or a poor signal between the Cam Sensor and tone wheel. Because of this, unplugging and reconnecting the harness connectors, or repositioning the Cam Sensor will often repair the condition that set the DTC.**

Were any problems found?

Yes

- Perform the appropriate repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 28

28. **CHECK THE VEHICLE'S REPAIR HISTORY**
    1. Check the history of the vehicle for previous Cam Sensor related DTCs.

    Did the repair history show that the vehicle was previously in the dealership with a Cam Sensor fault?

    Yes

    - If the current DTC being diagnosed is for the **same** engine bank as the DTC that set on the previous visit, perform the diagnostics starting at test step #12 in this diagnostic procedure.
    - If the current DTC being diagnosed is for the **opposite** engine bank as the DTC that set on the previous visit, replace the Cam Sensor in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Swap the Cam Sensor with the Cam Sensor on the opposite bank and clear DTCs. The cause may have been a poor connection at one of the harness connectors. Unplugging and reconnecting the harness connector may resolve the issue. Verify the DTC does not return.

      NOTE: **The sensors must be exchanged to aid in determining the possible failure if the vehicle returns to the dealership in the future with another Cam Sensor related DTC.**

    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0349-CAMSHAFT POSITION SENSOR INTERMITTENT - BANK 2 SENSOR 1

For a complete IGNITION SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

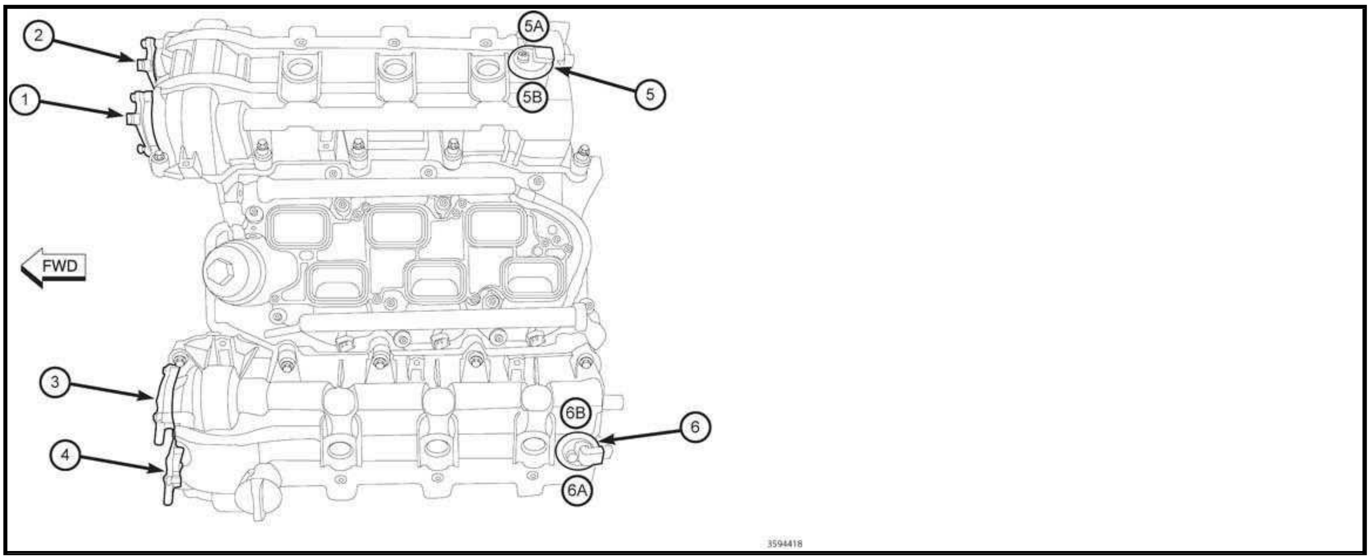
The Camshaft Position (CMP) Sensor circuits consist of a Powertrain Control Module (PCM) supplied 5-Volt reference circuit, low reference circuit, and an output signal circuit. The CMP Sensor detects magnetic flux from the peaks and valleys between the magnets of the tone wheel attached to the camshaft. As each magnet rotates past the CMP Sensor, the resulting change in the magnetic field is used by the sensor electronics to produce a digital output pulse. The sensor returns a digital ON/OFF DC voltage pulse of varying frequency output pulses per Camshaft revolution that represent an image of the camshaft tone wheel. The frequency of the CMP Sensor output depends on the velocity of the camshaft. The PCM decodes the tooth pattern to identify camshaft position. This information is then used to sequence the ignition timing and fuel injection events for the engine. The PCM also uses CMP Sensor output information to determine the camshaft relative position to the Crankshaft, to control the CMP Actuator operation if equipped.

NOTE: **The engine may still start even if either the Crankshaft Position (CKP) Sensor or CMP fails. The PCM eventually sorts out engine position and starts the vehicle on just one of these two inputs. However, there is a slight delay in starting until the PCM can establish sync. A DTC is set and the MIL illuminates if either of the CKP or CMP Sensor signals are not present during engine cranking.**

There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and tables below indicating the CMP Sensor, Position Solenoid/Phaser and DTC orientation).

3.2L / 3.6L DTCs RELATED TO EACH CAMSHAFT					
CAMSHAFT LOCATIONS	CALLOUT #	RELATED CAM SENSOR DTCS	PHASER/ACTUATOR DTCS	MISALIGNMENT DTCS	COLD START PERFORMANCE DTCS
Bank 1 Intake Camshaft	1	P0365, P0369	P000A, P0010	P0017	P052A, P052B
Bank 1 Exhaust Camshaft	2	P0340, P0344	P000B, P0013	P0016	P054A, P054B
Bank 2 Intake Camshaft	3	P0390, P0394	P000C, P0020	P0019	P052C, P052D
Bank 2 Exhaust Camshaft	4	P0345, P0349	P000D, P0023	P0018	P054C, P054D

3.2L / 3.6L VVT Component Locations			
CALLOUT	DESCRIPTION	CALLOUT	DESCRIPTION
1	CMP Position Solenoid - Bank 1 Position 1 (INTAKE)	5A	CMP Sensor - Bank 1 Sensor 1 (EXHAUST)
2	CMP Position Solenoid - Bank 1 Position 2 (EXHAUST)	5B	CMP Sensor - Bank 1 Sensor 2 (INTAKE)
3	CMP Position Solenoid - Bank 2 Position 1 (INTAKE)	6	Bank 2 Camshaft Sensor
4	CMP Position Solenoid - Bank 2 Position 2 (EXHAUST)	6A	CMP Sensor - Bank 2 Sensor 1 (EXHAUST)
5	Bank 1 Camshaft Sensor	6B	CMP Sensor - Bank 2 Sensor 2 (INTAKE)



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage is above approximately 11.0 volts.

SET CONDITION

- With the engine running, the Powertrain Control Module (PCM) acquires and locks in on a pattern for the Camshaft Position (CMP) Sensor signal. If the CMP Sensor signal pattern changes between unlock and lock at least four times during a period of eight Crankshaft revolutions, a fault is set.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
LOW ENGINE OIL LEVEL
ENGINE OIL AERATED OR CONTAMINATED
INCORRECT ENGINE OIL FILTER
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
5-VOLT SUPPLY CIRCUIT SHORTED TO VOLTAGE
5-VOLT SUPPLY CIRCUIT OPEN
5-VOLT SUPPLY CIRCUIT SHORTED TO GROUND
5-VOLT SUPPLY CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 2/1 SIGNAL CIRCUIT SHORTED TO VOLTAGE
CMP 2/1 SIGNAL CIRCUIT SHORTED TO GROUND
CMP 2/1 SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 2/1 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
CAMSHAFT POSITION SENSOR 2
CAMSHAFT TONE WHEEL LOOSE/DAMAGED OR MISALIGNED
CAMSHAFT 2/2 OIL CONTROL VALVE FAULTY OR INTERMITTENTLY BINDING/STICKING SPOOL VALVE
CAMSHAFT 2/2 PHASER FAULTY OR INTERMITTENTLY BINDING/STICKING

Possible Causes
POWERTRAIN CONTROL MODULE (PCM)
OIL PRESSURE ISSUE IN CYLINDER HEAD

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK THE ENGINE OIL LEVEL AND CONDITION**
    1. Turn the ignition off.

    NOTE: **The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.**

    - **LOW ENGINE OIL LEVEL**
    - **CONTAMINATED, DIRTY, AERATED OR DETERIORATED ENGINE OIL**
    - **INCORRECT ENGINE OIL VISCOSITY**
    - **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
    - **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**

    Were any of the above conditions present?

    Yes

    - Repair as necessary. If the engine oil was not at the proper level, top off the engine oil to the proper specification. Start the engine and allow it to idle for 2 - 3 minutes. Turn the engine off, ignition on, and using the scan tool, erase the DTC. Start the engine and drive the vehicle to verify repair. If the DTC does not return, repair is complete.
    - If the DTC returns, Go To 3

    No

    - Go To 2
2. **CHECK FOR AN ACTIVE DTC**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs and record on the repair order. Copy DTC and Freeze Frame information.
    3. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.

    WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

    4. With the scan tool, read DTCs.

    Is the DTC active or pending?

    Yes

    - Go To 3

No

- Go To 27

3. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any 5-Volt Reference, Dual Stage Oil Pump or Oil Pressure related DTCs active or pending?

       Yes

       - Perform the applicable diagnostic procedure(s) before continuing with this test procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 4
4. **CHECK FOR RELATED CAM SENSOR DTCS**

    Is the P0390 or P0394 DTC also active at this time?

    Yes

    - Go To 5

    No

    - Go To 8
5. **CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT**

    NOTE: **Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.**

    1. Turn the ignition off.
    2. Disconnect the CMP Sensor 2 harness connector.
    3. Turn the ignition on.
    4. Measure the voltage on the (F856) 5-Volt Supply circuit at the CMP Sensor 2 harness connector.

       Is the voltage between 4.8 and 5.2 volts?

       Yes

       - Go To 6

       No

       - Repair the (F856) 5-Volt Supply circuit for an open or shorted circuit.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
6. **CHECK THE CMP SENSOR 2 (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. Turn the ignition off.
    2. Disconnect the PCM C2 harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
4. Measure the resistance of the CMP Sensor 2 (K900) Sensor Ground circuit between the CMP Sensor 2 harness connector and the GPEC Adaptor.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 7

   No

   - Repair the CMP Sensor 2 (K900) Sensor Ground circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
   1. Remove and exchange the CMP Sensor 2 with the CMP Sensor on the opposite bank.

   NOTE: **Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.**

   2. Reconnect the PCM C2 and CMP Sensor harness connectors.
   3. Turn the ignition on,
   4. With the scan tool, erase DTCs.
   5. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.
   6. With the scan tool, read DTCs.

   Did the CMP Sensor DTCs for the opposite bank set?

   Yes

   - Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 22

8. **CHECK THE CMP SENSOR 2 (K444) SIGNAL 1 CIRCUIT FOR A SHORT TO VOLTAGE**

NOTE: **Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.**

1. Disconnect the CMP Sensor 2 harness connector.
2. Measure the voltage on the CMP Sensor 2 (K444) Signal 1 circuit in the CMP Sensor 2 harness connector.

   Is the voltage above 5.2 volts?

   Yes

   - Repair the CMP Sensor 2 (K444) Signal 1 circuit for a short to voltage.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 9

9. **CHECK THE CMP SENSOR 2 (K444) SIGNAL 1 CIRCUIT FOR A SHORT TO GROUND**
   1. Turn the ignition off.
   2. Disconnect the PCM C2 harness connector.
   3. Check for continuity between ground and the CMP Sensor 2 (K444) Signal 1 circuit at the CMP Sensor 2 harness connector.

      Is there continuity between ground and the CMP Sensor 2 (K444) Signal 1 circuit?

      Yes

      - Repair the CMP Sensor 2 (K444) Signal 1 circuit for a short to ground.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 10

10. **CHECK FOR THE CMP SENSOR 2 (K444) SIGNAL 1 CIRCUIT SHORTED TO THE CMP SENSOR 2 (K900) SENSOR GROUND CIRCUIT**
    1. Check for continuity between the CMP Sensor 2 (K444) Signal 1 circuit and the CMP Sensor 1 (K900) Sensor Ground circuit at the CMP Sensor 2 harness connector.

       Is there continuity between ground and the CMP Sensor 2 (K444) Signal 1 circuit and the CMP Sensor 1 (K900) Sensor Ground circuit?

       Yes

       - Repair the short between the CMP Sensor 2 (K444) Signal 1 circuit and the CMP Sensor 1 (K900) Sensor Ground circuit.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 11

11. **CHECK THE CMP SENSOR 2 (K444) SIGNAL 1 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
2. Measure the resistance of the CMP Sensor 2 (K444) Signal 1 circuit between the CMP Sensor 2 harness connector and the GPEC Adaptor.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 12

   No

   - Repair the CMP Sensor 2 (K444) Signal 1 circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

12. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

NOTE: During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.

1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

   NOTE: If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.

   Is the oil pressure reading stable and above 16.0 psi?

   Yes

   - Go To 13

   No

   - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**

1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
3. Start the engine and allow it to idle.
4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

NOTE: The oil pressure reading at the Cylinder Head should be within above 14.0 psi.

Is the oil pressure reading stable and above 14.0 psi?

Yes

- Go To 14

No

- Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

14. **CHECK THE CAMSHAFT 2/2 OIL CONTROL VALVE OPERATION**
    1. Turn the ignition off.
    2. Remove the Camshaft Position Solenoid 2/2.
    3. Inspect the spring loaded spool valve on the Oil Control Valve.

    NOTE: The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.

    4. Push and release the spring loaded spool valve against the return spring with a small punch.

    NOTE: The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.

    Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

    Yes

    - Go To 15

    No

    - Replace the Camshaft 2/2 Oil Control Valve in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

15. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
    1. Remove and exchange the CMP Sensor 2 with the CMP Sensor on the opposite bank.

       NOTE: **Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.**

    2. Reconnect the PCM C2 and Cam Sensor harness connectors.
    3. Turn the ignition on,
    4. With the scan tool, erase DTCs.
    5. Start the engine and allow it to idle or crank the engine if it will not start.
    6. With the scan tool, read DTCs.

    Did the CMP Sensor DTCs for the opposite bank set as active?

    Yes

    - Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 16

16. **INSPECT CAMSHAFT SENSOR TONE WHEEL FOR DAMAGE OR LOOSENESS**
    1. Remove the Cylinder Head Cover and inspect the Camshaft Sensor Tone Wheel for any looseness or signs of damage.
    2. Using the (special tool #2027902090, Check Tool, Tone Wheel Right) check the alignment of the CMP Sensor Tone Wheel in accordance with the service information.

    Were any issues found with the CMP Sensor Tone Wheel?

    Yes

    - Replace the Camshaft Assembly in accordance with the Service Information. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 17

17. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 18

18. **CHECK THE CAM PHASER AND CAMSHAFT ASSEMBLY**
    1. Check the Cam Phaser to verify it has returned to lock pin.
    2. Put a wrench on the flat of the Camshaft behind the phaser and attempt to move the Camshaft back and forth.

    NOTE: **The Cam Phaser should always return to lock pin when the engine is turned off. If the Cam Phaser is not at lock pin, there will be movement felt between the Camshaft and the Cam Phaser.**

    Is there movement between the Camshaft and Cam Phaser?

    Yes

    - Replace the Cam Phaser in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Go To 19

    No

    - Replace the Cam Phaser and Camshaft in accordance with the Service Information. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Go To 19

19. **VERIFY THE REPAIR**

1. With the scan tool, erase DTCs.
2. Test drive the vehicle in accordance with the Freeze Frame data collected.

   Did the DTC return?

   Yes

   - Go To 20

   No

   - Repair is complete.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

20. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
       - Proper connector installation.
       - Damaged connector locks.
       - Corrosion.
       - Other signs of water intrusion.
       - Weather seal damage (if equipped).
       - Bent terminals.
       - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
       - Terminals that have been pushed back into the connector cavity.
       - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Go To 21

        No

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
- Test complete.

21. **REPLACE THE PCM AND RETEST FOR DTC**
    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

    Did the CMP Sensor DTC return?

    Yes

    - Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Repair is complete.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

22. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

    NOTE: **During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.**

    1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
    2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
    3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
    4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
    5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

       NOTE: **If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.**

    Is the oil pressure reading stable and above 16.0 psi?

    Yes

- Go To 23

No

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

23. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**
    1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
    2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
    3. Start the engine and allow it to idle.
    4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

    NOTE: **The oil pressure reading at the Cylinder Head should be above 14.0 psi.**

    Is the oil pressure reading stable and above 14.0 psi?

    Yes

    - Go To 24

    No

    - Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

24. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

- Go To 25

25. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Go To 26

        No

        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
        - Test complete.

26. **REPLACE THE PCM AND RETEST FOR DTC**
    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

       Did the CMP Sensor DTC return?

Yes

- Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Repair is complete.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

27. **WIRE HARNESS/CKP SENSOR INSPECTION**
    1. Turn the ignition off.
    2. Disconnect the harness connectors at the PCM and Cam Sensor. Inspect for wire chaffing or rub conditions, spread terminals, terminals pushed out of the wiring connector, bent terminals at the PCM and Cam Sensor, water in the connector cavities, presence of corrosion on the terminals of the connectors or components.
    3. Visually inspect the mounting area of Cam Sensor for debris/damage or a loose sensor. Remove the Cam Sensor and inspect the end of the sensor for signs of damage or debris. Rotate the engine and if possible, inspect the tone wheel for any signs of damage. Reinstall the Cam Sensor and ensure that the sensor is properly installed and torqued to proper specification.

    NOTE: **Due to the fact that this DTC is set by an intermittent loss of the signal, the DTC may be caused by a poor connection at the Cam Sensor or PCM terminals, or a poor signal between the Cam Sensor and tone wheel. Because of this, unplugging and reconnecting the harness connectors, or repositioning the Cam Sensor will often repair the condition that set the DTC.**

    Were any problems found?

    Yes

    - Perform the appropriate repair.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 28

28. **CHECK THE VEHICLE'S REPAIR HISTORY**
    1. Check the history of the vehicle for previous Cam Sensor related DTCs.

    Did the repair history show that the vehicle was previously in the dealership with a Cam Sensor fault?

    Yes

    - If the current DTC being diagnosed is for the **same** engine bank as the DTC that set on the previous visit, perform the diagnostics starting at test step #12 in this diagnostic procedure.

- If the current DTC being diagnosed is for the **opposite** engine bank as the DTC that set on the previous visit, replace the Cam Sensor in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

No

- Swap the Cam Sensor with the Cam Sensor on the opposite bank and clear DTCs. The cause may have been a poor connection at one of the harness connectors. Unplugging and reconnecting the harness connector may resolve the issue. Verify the DTC does not return.

NOTE: **The sensors must be exchanged to aid in determining the possible failure if the vehicle returns to the dealership in the future with another Cam Sensor related DTC.**

- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

P0351-IGNITION COIL 1 PRIMARY CIRCUIT

WHEN MONITORED

- This diagnostic runs continuously with ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Ignition Coil 1 Signal circuit current is less than, or equal to, 0.0 amps for at least 1.2 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
FUSED OUTPUT RELAY CIRCUIT OPEN/HIGH RESISTANCE
IGNITION COIL 1 CONTROL CIRCUIT OPEN/HIGH RESISTANCE
IGNITION COIL 1 CONTROL CIRCUIT SHORTED TO GROUND
IGNITION COIL 1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.

3. With the scan tool, erase all DTCs.
4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any ASD DTCs present?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3

3. **CHECK THE RELAY (F343) OUTPUT CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
   1. Disconnect the component harness connector to isolate the 12.0 volt supply circuit.
   2. Connect the positive lead of the load test tool to the 12.0 volt supply circuit at the component harness connector (A). **Note:** refer to the diagram below.
   3. Connect the negative lead of the load test tool to the ground circuit of the Battery or a good chassis ground.
   4. Ensure that the circuit being tested is being powered on. If the 12.0 volt circuit being tested is an ignition feed for example, the ignition must be on. If testing an output from a relay, verify that the relay is energized and on.
   5. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

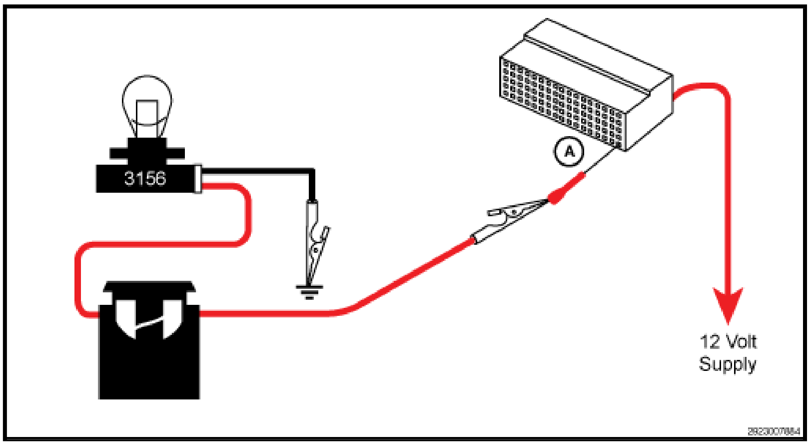
NOTE:	**Why perform a Voltage Drop Test? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**
NOTE:	**A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many**

high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

- Go To 4

No

- Repair the 12.0 volt circuit for an open or high resistance. If the fuse is found to be open, check the circuit for a short to ground.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE IGNITION COIL CONTROL CIRCUIT OPERATION**

WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

   1. Using a 12-volt test light connected to a 12.0 volt source, probe the Coil 1 (K19) Control circuit at the Ignition Coil harness connector.
   2. Crank the engine for 5.0 seconds while observing the test light.

   What is the condition of the test light while cranking the engine?

   Brightly blinking

   - Go To 5

   ON constantly

   - Go To 6

   OFF constantly

   - Go To 7

5. **CHECK THE CONDITION OF THE SPARK PLUG**
   1. Turn the ignition off.
   2. Remove the Spark Plug(s) in accordance with the Service Information.
   3. Inspect the Spark Plug(s) for the following conditions:
      - Cracks
      - Carbon Tracking
      - Foreign Material
      - Gap size out of specifications
      - Loose or broken electrode

   Were any of the above conditions present?

   Yes

   - Replace the Spark Plug in accordance with the Service Information.

     NOTE: **If carbon tracking is found on the Spark Plug, inspect the boot on the Ignition Coil for signs of damage and replace if necessary.**

   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Replace the Ignition Coil and Spark Plug in accordance with the Service Information. Refer to **COIL, IGNITION, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND CHECK THE IGNITION COIL 1 (K19) CONTROL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

    NOTE: **There should be no continuity between ground and the circuit being tested.**

    Is there continuity between ground and the circuit being tested?

    Yes

    - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 8
7. **ISOLATE AND CHECK THE IGNITION COIL 1 (K19) CONTROL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

        NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 8

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **DETERMINE IF THE IGNITION COIL IS THE CAUSE OF THE PCM DRIVER FAILURE**

   NOTE: **An internally shorted or damaged secondary coil circuit may be the cause of the PCM coil driver failure. Do not replace the PCM without first determining if the Ignition Coil is the cause of the failure.**

   1. Remove the Ignition Coil that is controlled by the coil driver setting the DTC.
   2. Install the Ignition Coil onto another coil location that did not have a DTC set against it.
   3. Turn the ignition on.
   4. With the scan tool, erase DTCs.
   5. Start and run the engine for up to one minute.

      NOTE: **If the engine will not start, crank the engine three times for 10 seconds.**

   6. With a scan tool, read DTCs.

   Did a correlating fault set for the new coil location?

   Yes

   - Replace the Ignition Coil in accordance with the Service Information. Refer to **COIL, IGNITION, REMOVAL AND INSTALLATION** .
   - Replace and program the Powertrain Control Module in accordance with the Service Information.

     Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .

   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 9

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.

- Damaged connector locks.
- Corrosion.
- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

   Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0352-IGNITION COIL 2 PRIMARY CIRCUIT

WHEN MONITORED

- This diagnostic runs continuously with ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Ignition Coil 2 Signal circuit current is less than, or equal to, 0.0 amps for at least 1.2 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
FUSED OUTPUT RELAY CIRCUIT OPEN/HIGH RESISTANCE
IGNITION COIL 2 CONTROL CIRCUIT OPEN/HIGH RESISTANCE
IGNITION COIL 2 CONTROL CIRCUIT SHORTED TO GROUND
IGNITION COIL 2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any ASD DTCs present?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **CHECK THE RELAY (F343) OUTPUT CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Disconnect the component harness connector to isolate the 12.0 volt supply circuit.
    2. Connect the positive lead of the load test tool to the 12.0 volt supply circuit at the component harness connector (A). **Note:** refer to the diagram below.

3. Connect the negative lead of the load test tool to the ground circuit of the Battery or a good chassis ground.
4. Ensure that the circuit being tested is being powered on. If the 12.0 volt circuit being tested is an ignition feed for example, the ignition must be on. If testing an output from a relay, verify that the relay is energized and on.
5. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

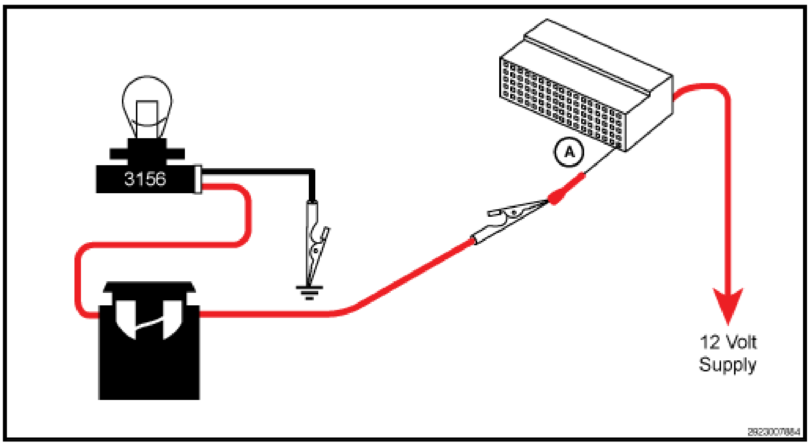
NOTE: **Why perform a Voltage Drop Test? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to** **CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES .**



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 4

   No

   - Repair the 12.0 volt circuit for an open or high resistance. If the fuse is found to be open, check the circuit for a short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE IGNITION COIL CONTROL CIRCUIT OPERATION**

WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

1. Using a 12-volt test light connected to a 12.0 volt source, probe the Coil 2 (K17) Control circuit at the Ignition Coil harness connector.
2. Crank the engine for 5.0 seconds while observing the test light.

   What is the condition of the test light while cranking the engine?

   Brightly blinking

   - Go To 5

   ON constantly

- Go To 6

OFF constantly

- Go To 7

5. **CHECK THE CONDITION OF THE SPARK PLUG**
   1. Turn the ignition off.
   2. Remove the Spark Plug(s) in accordance with the Service Information.
   3. Inspect the Spark Plug(s) for the following conditions:
      - Cracks
      - Carbon Tracking
      - Foreign Material
      - Gap size out of specifications
      - Loose or broken electrode

   Were any of the above conditions present?

   Yes

   - Replace the Spark Plug in accordance with the Service Information.

     NOTE: **If carbon tracking is found on the Spark Plug, inspect the boot on the Ignition Coil for signs of damage and replace if necessary.**

   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Replace the Ignition Coil and Spark Plug in accordance with the Service Information. Refer to **COIL, IGNITION, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
6. **ISOLATE AND CHECK THE IGNITION COIL 2 (K17) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 8

7. **ISOLATE AND CHECK THE IGNITION COIL 2 (K17) CONTROL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

      NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 8

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
8. **DETERMINE IF THE IGNITION COIL IS THE CAUSE OF THE PCM DRIVER FAILURE**

   NOTE: **An internally shorted or damaged secondary coil circuit may be the cause of the PCM coil driver failure. Do not replace the PCM without first determining if the Ignition Coil is the cause of the failure.**

   1. Remove the Ignition Coil that is controlled by the coil driver setting the DTC.
   2. Install the Ignition Coil onto another coil location that did not have a DTC set against it.
   3. Turn the ignition on.
   4. With the scan tool, erase DTCs.
   5. Start and run the engine for up to one minute.

      NOTE: **If the engine will not start, crank the engine three times for 10 seconds.**

6. With a scan tool, read DTCs.

   Did a correlating fault set for the new coil location?

   Yes

   - Replace the Ignition Coil in accordance with the Service Information. Refer to **COIL, IGNITION, REMOVAL AND INSTALLATION** .
   - Replace and program the Powertrain Control Module in accordance with the Service Information.

     Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .

   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 9

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0353-IGNITION COIL 3 PRIMARY CIRCUIT

WHEN MONITORED

- This diagnostic runs continuously with ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Ignition Coil 3 Signal circuit current is less than, or equal to, 0.0 amps for at least 1.2 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
FUSED OUTPUT RELAY CIRCUIT OPEN/HIGH RESISTANCE
IGNITION COIL 3 CONTROL CIRCUIT OPEN/HIGH RESISTANCE
IGNITION COIL 3 CONTROL CIRCUIT SHORTED TO GROUND
IGNITION COIL 3
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any ASD DTCs present?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3
3. **CHECK THE RELAY (F343) OUTPUT CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
   1. Disconnect the component harness connector to isolate the 12.0 volt supply circuit.
   2. Connect the positive lead of the load test tool to the 12.0 volt supply circuit at the component harness connector (A). **Note:** refer to the diagram below.
   3. Connect the negative lead of the load test tool to the ground circuit of the Battery or a good chassis ground.
   4. Ensure that the circuit being tested is being powered on. If the 12.0 volt circuit being tested is an ignition feed for example, the ignition must be on. If testing an output from a relay, verify that the relay is energized and on.
   5. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

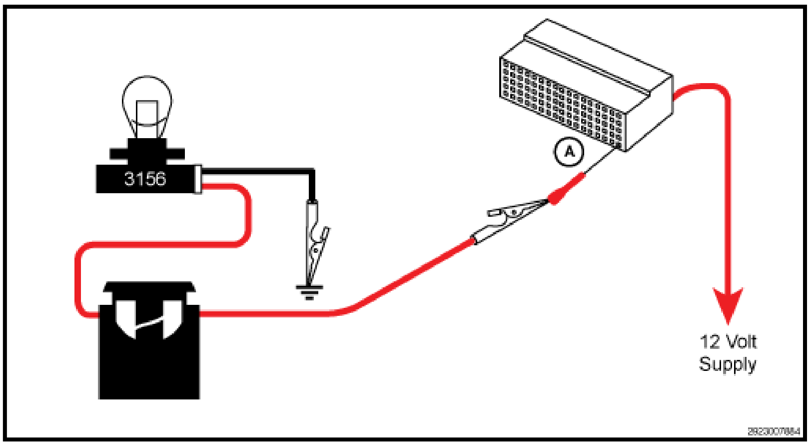
NOTE: **Why perform a Voltage Drop Test? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 4

   No

   - Repair the 12.0 volt circuit for an open or high resistance. If the fuse is found to be open, check the circuit for a short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE IGNITION COIL CONTROL CIRCUIT OPERATION**

WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

1. Using a 12-volt test light connected to a 12.0 volt source, probe the Coil 3 (K18) Control circuit at the Ignition Coil harness connector.
2. Crank the engine for 5.0 seconds while observing the test light.

What is the condition of the test light while cranking the engine?

Brightly blinking

- Go To 5

ON constantly

- Go To 6

OFF constantly

- Go To 7

5. **CHECK THE CONDITION OF THE SPARK PLUG**
1. Turn the ignition off.
2. Remove the Spark Plug(s) in accordance with the Service Information.
3. Inspect the Spark Plug(s) for the following conditions:
   - Cracks
   - Carbon Tracking
   - Foreign Material
   - Gap size out of specifications
   - Loose or broken electrode

Were any of the above conditions present?

Yes

- Replace the Spark Plug in accordance with the Service Information.

NOTE: **If carbon tracking is found on the Spark Plug, inspect the boot on the Ignition Coil for signs of damage and replace if necessary.**

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Replace the Ignition Coil and Spark Plug in accordance with the Service Information. Refer to **COIL, IGNITION, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND CHECK THE IGNITION COIL 3 (K18) CONTROL CIRCUIT FOR A SHORT TO GROUND**

1. The ignition must be off when checking a circuit for continuity to ground.
2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Connect the negative lead of the DVOM to a known good ground.
4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 8

7. **ISOLATE AND CHECK THE IGNITION COIL 3 (K18) CONTROL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 8

No

- Repair the circuit for an open or high resistance.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **DETERMINE IF THE IGNITION COIL IS THE CAUSE OF THE PCM DRIVER FAILURE**

   NOTE: **An internally shorted or damaged secondary coil circuit may be the cause of the PCM coil driver failure. Do not replace the PCM without first determining if the Ignition Coil is the cause of the failure.**

   1. Remove the Ignition Coil that is controlled by the coil driver setting the DTC.
   2. Install the Ignition Coil onto another coil location that did not have a DTC set against it.
   3. Turn the ignition on.
   4. With the scan tool, erase DTCs.
   5. Start and run the engine for up to one minute.

      NOTE: **If the engine will not start, crank the engine three times for 10 seconds.**

   6. With a scan tool, read DTCs.

   Did a correlating fault set for the new coil location?

   Yes

   - Replace the Ignition Coil in accordance with the Service Information. Refer to **COIL, IGNITION, REMOVAL AND INSTALLATION** .
   - Replace and program the Powertrain Control Module in accordance with the Service Information.

     Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 9

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.

- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0354-IGNITION COIL 4 PRIMARY CIRCUIT

WHEN MONITORED

- This diagnostic runs continuously with ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Ignition Coil 4 Signal circuit current is less than, or equal to, 0.0 amps for at least 1.2 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
FUSED OUTPUT RELAY CIRCUIT OPEN/HIGH RESISTANCE
IGNITION COIL 4 CONTROL CIRCUIT OPEN/HIGH RESISTANCE
IGNITION COIL 4 CONTROL CIRCUIT SHORTED TO GROUND
IGNITION COIL 4
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any ASD DTCs present?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **CHECK THE RELAY (F343) OUTPUT CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Disconnect the component harness connector to isolate the 12.0 volt supply circuit.
    2. Connect the positive lead of the load test tool to the 12.0 volt supply circuit at the component harness connector (A). **Note:** refer to the diagram below.
    3. Connect the negative lead of the load test tool to the ground circuit of the Battery or a good chassis ground.
    4. Ensure that the circuit being tested is being powered on. If the 12.0 volt circuit being tested is an ignition feed for example, the ignition must be on. If testing an output from a relay, verify that the relay is energized and on.
    5. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

NOTE: **Why perform a Voltage Drop Test? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps**

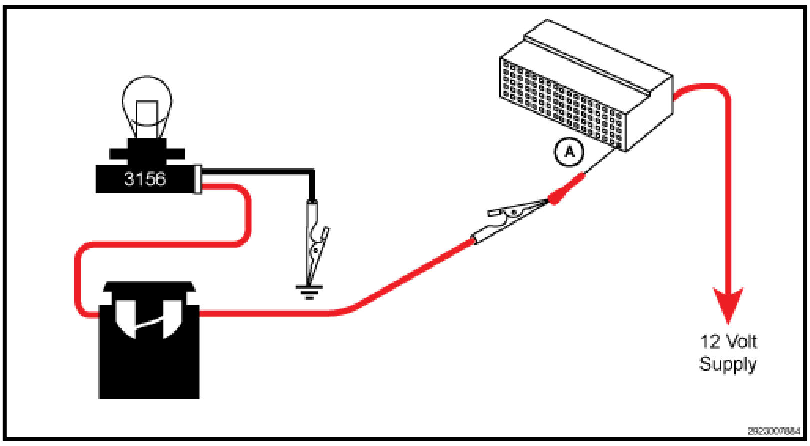
of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .

NOTE: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 4

No

- Repair the 12.0 volt circuit for an open or high resistance. If the fuse is found to be open, check the circuit for a short to ground.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE IGNITION COIL CONTROL CIRCUIT OPERATION**

WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

1. Using a 12-volt test light connected to a 12.0 volt source, probe the Coil 4 (K15) Control circuit at the Ignition Coil harness connector.
2. Crank the engine for 5.0 seconds while observing the test light.

What is the condition of the test light while cranking the engine?

Brightly blinking

- Go To 5

ON constantly

- Go To 6

OFF constantly

- Go To 7

5. **CHECK THE CONDITION OF THE SPARK PLUG**
   1. Turn the ignition off.
   2. Remove the Spark Plug(s) in accordance with the Service Information.
   3. Inspect the Spark Plug(s) for the following conditions:
      - Cracks
      - Carbon Tracking
      - Foreign Material
      - Gap size out of specifications
      - Loose or broken electrode

Were any of the above conditions present?

Yes

- Replace the Spark Plug in accordance with the Service Information.

NOTE: **If carbon tracking is found on the Spark Plug, inspect the boot on the Ignition Coil for signs of damage and replace if necessary.**

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Replace the Ignition Coil and Spark Plug in accordance with the Service Information. Refer to **COIL, IGNITION, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND CHECK THE IGNITION COIL 4 (K15) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 8
7. **ISOLATE AND CHECK THE IGNITION COIL 4 (K15) CONTROL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 8

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **DETERMINE IF THE IGNITION COIL IS THE CAUSE OF THE PCM DRIVER FAILURE**

   NOTE: An internally shorted or damaged secondary coil circuit may be the cause of the PCM coil driver failure. Do not replace the PCM without first determining if the Ignition Coil is the cause of the failure.

   1. Remove the Ignition Coil that is controlled by the coil driver setting the DTC.
   2. Install the Ignition Coil onto another coil location that did not have a DTC set against it.
   3. Turn the ignition on.
   4. With the scan tool, erase DTCs.
   5. Start and run the engine for up to one minute.

      NOTE: If the engine will not start, crank the engine three times for 10 seconds.

   6. With a scan tool, read DTCs.

      Did a correlating fault set for the new coil location?

      Yes

      - Replace the Ignition Coil in accordance with the Service Information. Refer to **COIL, IGNITION, REMOVAL AND INSTALLATION** .
      - Replace and program the Powertrain Control Module in accordance with the Service Information.

        Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .

      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 9

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.

3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
   - Proper connector installation.
   - Damaged connector locks.
   - Corrosion.
   - Other signs of water intrusion.
   - Weather seal damage (if equipped).
   - Bent terminals.
   - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
   - Terminals that have been pushed back into the connector cavity.
   - Check for spread terminals and verify proper terminal tension.

   Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0355-IGNITION COIL 5 PRIMARY CIRCUIT

WHEN MONITORED

- This diagnostic runs continuously with ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Ignition Coil 5 Signal circuit current is less than, or equal to, 0.0 amps for at least 1.2 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
FUSED OUTPUT RELAY CIRCUIT OPEN/HIGH RESISTANCE
IGNITION COIL 5 CONTROL CIRCUIT OPEN/HIGH RESISTANCE
IGNITION COIL 5 CONTROL CIRCUIT SHORTED TO GROUND
IGNITION COIL 5
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any ASD DTCs present?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **CHECK THE RELAY (F343) OUTPUT CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**

1. Disconnect the component harness connector to isolate the 12.0 volt supply circuit.
2. Connect the positive lead of the load test tool to the 12.0 volt supply circuit at the component harness connector (A). **Note:** refer to the diagram below.
3. Connect the negative lead of the load test tool to the ground circuit of the Battery or a good chassis ground.
4. Ensure that the circuit being tested is being powered on. If the 12.0 volt circuit being tested is an ignition feed for example, the ignition must be on. If testing an output from a relay, verify that the relay is energized and on.
5. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

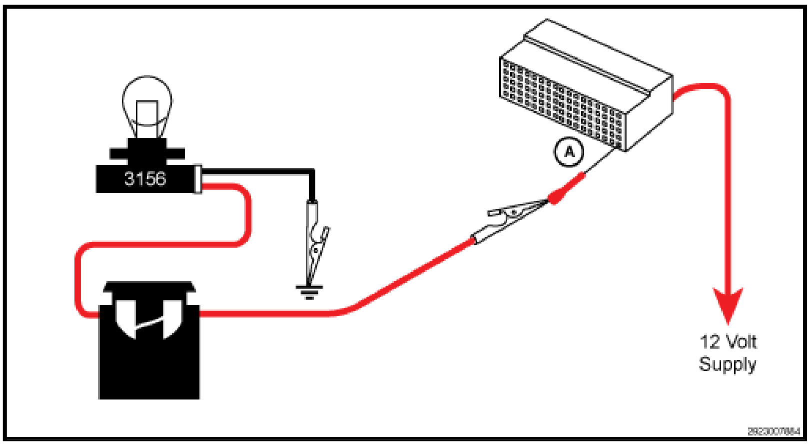
NOTE: **Why perform a Voltage Drop Test? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to** **CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES .**



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 4

   No

   - Repair the 12.0 volt circuit for an open or high resistance. If the fuse is found to be open, check the circuit for a short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE IGNITION COIL CONTROL CIRCUIT OPERATION**

WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

1. Using a 12-volt test light connected to a 12.0 volt source, probe the Coil 5 (K16) Control circuit at the Ignition Coil harness connector.
2. Crank the engine for 5.0 seconds while observing the test light.

   What is the condition of the test light while cranking the engine?

   Brightly blinking

   - Go To 5

   ON constantly

- Go To 6

OFF constantly

- Go To 7

5. **CHECK THE CONDITION OF THE SPARK PLUG**
    1. Turn the ignition off.
    2. Remove the Spark Plug(s) in accordance with the Service Information.
    3. Inspect the Spark Plug(s) for the following conditions:
        - Cracks
        - Carbon Tracking
        - Foreign Material
        - Gap size out of specifications
        - Loose or broken electrode

    Were any of the above conditions present?

    Yes

    - Replace the Spark Plug in accordance with the Service Information.

NOTE:	If carbon tracking is found on the Spark Plug, inspect the boot on the Ignition Coil for signs of damage and replace if necessary.

    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Replace the Ignition Coil and Spark Plug in accordance with the Service Information. Refer to **COIL, IGNITION, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
6. **ISOLATE AND CHECK THE IGNITION COIL 5 (K16) CONTROL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

NOTE:	There should be no continuity between ground and the circuit being tested.

    Is there continuity between ground and the circuit being tested?

    Yes

    - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 8

7. **ISOLATE AND CHECK THE IGNITION COIL 5 (K16) CONTROL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 8

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **DETERMINE IF THE IGNITION COIL IS THE CAUSE OF THE PCM DRIVER FAILURE**

NOTE: **An internally shorted or damaged secondary coil circuit may be the cause of the PCM coil driver failure. Do not replace the PCM without first determining if the Ignition Coil is the cause of the failure.**

1. Remove the Ignition Coil that is controlled by the coil driver setting the DTC.
2. Install the Ignition Coil onto another coil location that did not have a DTC set against it.
3. Turn the ignition on.
4. With the scan tool, erase DTCs.
5. Start and run the engine for up to one minute.

NOTE: **If the engine will not start, crank the engine three times for 10 seconds.**

6. With a scan tool, read DTCs.

   Did a correlating fault set for the new coil location?

   Yes

   - Replace the Ignition Coil in accordance with the Service Information. Refer to **COIL, IGNITION, REMOVAL AND INSTALLATION** .
   - Replace and program the Powertrain Control Module in accordance with the Service Information.

     Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .

   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 9

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0356-IGNITION COIL 6 PRIMARY CIRCUIT

WHEN MONITORED

- This diagnostic runs continuously with ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Ignition Coil 6 Signal circuit current is less than, or equal to, 0.0 amps for at least 1.2 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
FUSED OUTPUT RELAY CIRCUIT OPEN/HIGH RESISTANCE
IGNITION COIL 6 CONTROL CIRCUIT OPEN/HIGH RESISTANCE
IGNITION COIL 6 CONTROL CIRCUIT SHORTED TO GROUND
IGNITION COIL 6
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any ASD DTCs present?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 3

3. **CHECK THE RELAY (F343) OUTPUT CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Disconnect the component harness connector to isolate the 12.0 volt supply circuit.
    2. Connect the positive lead of the load test tool to the 12.0 volt supply circuit at the component harness connector (A). **Note:** refer to the diagram below.
    3. Connect the negative lead of the load test tool to the ground circuit of the Battery or a good chassis ground.
    4. Ensure that the circuit being tested is being powered on. If the 12.0 volt circuit being tested is an ignition feed for example, the ignition must be on. If testing an output from a relay, verify that the relay is energized and on.
    5. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

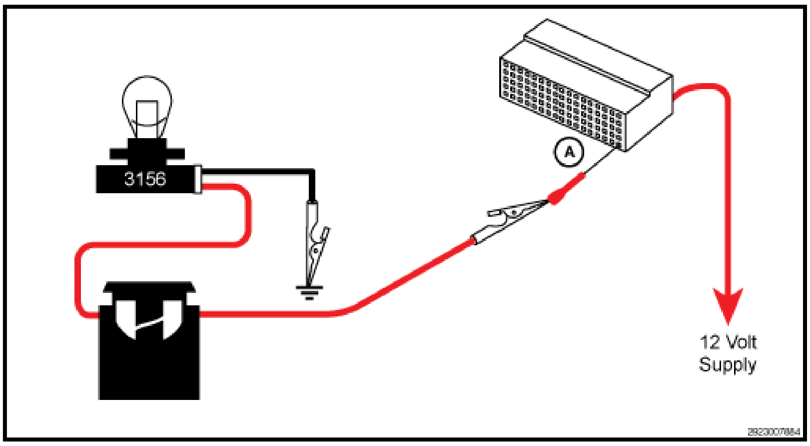
NOTE:	**Why perform a Voltage Drop Test? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE:	**A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE:	**Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 4

   No

   - Repair the 12.0 volt circuit for an open or high resistance. If the fuse is found to be open, check the circuit for a short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

4. **CHECK THE IGNITION COIL CONTROL CIRCUIT OPERATION**

WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

   1. Using a 12-volt test light connected to a 12.0 volt source, probe the Coil 6 (K10) Control circuit at the Ignition Coil harness connector.
   2. Crank the engine for 5.0 seconds while observing the test light.

   What is the condition of the test light while cranking the engine?

   Brightly blinking

   - Go To 5

   ON constantly

   - Go To 6

   OFF constantly

   - Go To 7

5. **CHECK THE CONDITION OF THE SPARK PLUG**
   1. Turn the ignition off.
   2. Remove the Spark Plug(s) in accordance with the Service Information.
   3. Inspect the Spark Plug(s) for the following conditions:
      - Cracks
      - Carbon Tracking
      - Foreign Material
      - Gap size out of specifications
      - Loose or broken electrode

   Were any of the above conditions present?

   Yes

   - Replace the Spark Plug in accordance with the Service Information.

     NOTE: **If carbon tracking is found on the Spark Plug, inspect the boot on the Ignition Coil for signs of damage and replace if necessary.**

   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Replace the Ignition Coil and Spark Plug in accordance with the Service Information. Refer to **COIL, IGNITION, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND CHECK THE IGNITION COIL 6 (K10) CONTROL CIRCUIT FOR A SHORT TO GROUND**

1. The ignition must be off when checking a circuit for continuity to ground.
2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Connect the negative lead of the DVOM to a known good ground.
4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 8

7. **ISOLATE AND CHECK THE IGNITION COIL 6 (K10) CONTROL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 8

   No

   - Repair the circuit for an open or high resistance.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **DETERMINE IF THE IGNITION COIL IS THE CAUSE OF THE PCM DRIVER FAILURE**

    NOTE: **An internally shorted or damaged secondary coil circuit may be the cause of the PCM coil driver failure. Do not replace the PCM without first determining if the Ignition Coil is the cause of the failure.**

    1. Remove the Ignition Coil that is controlled by the coil driver setting the DTC.
    2. Install the Ignition Coil onto another coil location that did not have a DTC set against it.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Start and run the engine for up to one minute.

        NOTE: **If the engine will not start, crank the engine three times for 10 seconds.**

    6. With a scan tool, read DTCs.

    Did a correlating fault set for the new coil location?

    Yes

    - Replace the Ignition Coil in accordance with the Service Information. Refer to **COIL, IGNITION, REMOVAL AND INSTALLATION** .
    - Replace and program the Powertrain Control Module in accordance with the Service Information.

        Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .

    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 9

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.

- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0365-CAMSHAFT POSITION SENSOR CIRCUIT - BANK 1 SENSOR 2

For a complete IGNITION SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

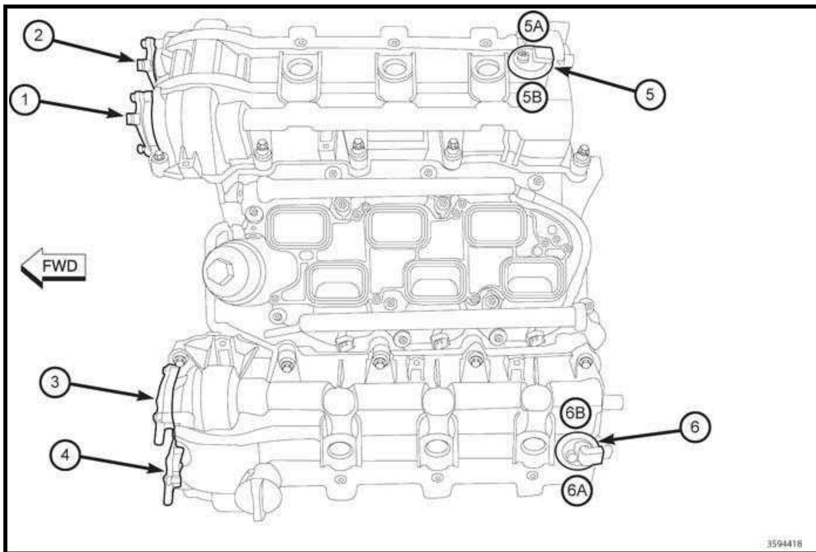
The Camshaft Position (CMP) Sensor circuits consist of a Powertrain Control Module (PCM) supplied 5-Volt reference circuit, low reference circuit, and an output signal circuit. The CMP Sensor detects magnetic flux from the peaks and valleys between the magnets of the tone wheel attached to the camshaft. As each magnet rotates past the CMP Sensor, the resulting change in the magnetic field is used by the sensor electronics to produce a digital output pulse. The sensor returns a digital ON/OFF DC voltage pulse of varying frequency output pulses per Camshaft revolution that represent an image of the camshaft tone wheel. The frequency of the CMP Sensor output depends on the velocity of the camshaft. The PCM decodes the tooth pattern to identify camshaft position. This information is then used to sequence the ignition timing and fuel injection events for the engine. The PCM also uses CMP Sensor output information to determine the camshaft relative position to the Crankshaft, to control the CMP Actuator operation if equipped.

NOTE: **The engine may still start even if either the Crankshaft Position (CKP) Sensor or CMP fails. The PCM eventually sorts out engine position and starts the vehicle on just one of these two inputs. However, there is a slight delay in starting until the PCM can establish sync. A DTC is set and the MIL illuminates if either of the CKP or CMP Sensor signals are not present during engine cranking.**

There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and tables below indicating the CMP Sensor, Position Solenoid/Phaser and DTC orientation).

3.2L / 3.6L DTCs RELATED TO EACH CAMSHAFT					
CAMSHAFT LOCATIONS	**CALLOUT #**	**RELATED CAM SENSOR DTCS**	**PHASER/ACTUATOR DTCS**	**MISALIGNMENT DTCS**	**COLD START PERFORMANCE DTCS**
Bank 1 Intake Camshaft	1	P0365, P0369	P000A, P0010	P0017	P052A, P052B
Bank 1 Exhaust Camshaft	2	P0340, P0344	P000B, P0013	P0016	P054A, P054B
Bank 2 Intake Camshaft	3	P0390, P0394	P000C, P0020	P0019	P052C, P052D
Bank 2 Exhaust Camshaft	4	P0345, P0349	P000D, P0023	P0018	P054C, P054D

3.2L / 3.6L VVT Component Locations			
CALLOUT	**DESCRIPTION**	**CALLOUT**	**DESCRIPTION**
1	CMP Position Solenoid - Bank 1 Position 1 (INTAKE)	5A	CMP Sensor - Bank 1 Sensor 1 (EXHAUST)
2	CMP Position Solenoid - Bank 1 Position 2 (EXHAUST)	5B	CMP Sensor - Bank 1 Sensor 2 (INTAKE)
3	CMP Position Solenoid - Bank 2 Position 1 (INTAKE)	6	Bank 2 Camshaft Sensor
4	CMP Position Solenoid - Bank 2 Position 2 (EXHAUST)	6A	CMP Sensor - Bank 2 Sensor 1 (EXHAUST)
5	Bank 1 Camshaft Sensor	6B	CMP Sensor - Bank 2 Sensor 2 (INTAKE)



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine cranking and with the engine running.
- Battery voltage is above approximately 11.0 volts.

SET CONDITION

- During cranking, at least 2.5 seconds have elapsed with a Crankshaft Position Sensor signal present but no Camshaft Position Sensor signal.

- With the engine running, the Camshaft Position Sensor signal is lost for at least 0.4 seconds with a Crankshaft Position Sensor signal present.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
LOW ENGINE OIL LEVEL
ENGINE OIL AERATED OR CONTAMINATED
INCORRECT ENGINE OIL FILTER
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
5-VOLT SUPPLY CIRCUIT SHORTED TO VOLTAGE
5-VOLT SUPPLY CIRCUIT OPEN
5-VOLT SUPPLY CIRCUIT SHORTED TO GROUND
5-VOLT SUPPLY CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 1/2 SIGNAL CIRCUIT SHORTED TO VOLTAGE
CMP 1/2 SIGNAL CIRCUIT SHORTED TO GROUND
CMP 1/2 SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 1/2 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
CAMSHAFT POSITION SENSOR 1
CAMSHAFT TONE WHEEL LOOSE/DAMAGED OR MISALIGNED
CAMSHAFT PHASER 1/1 OIL CONTROL VALVE FAULTY OR INTERMITTENTLY BINDING/STICKING SPOOL VALVE
CAMSHAFT PHASER 1/1 FAULTY OR INTERMITTENTLY BINDING/STICKING
OIL PRESSURE ISSUE IN CYLINDER HEAD
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK THE ENGINE OIL LEVEL AND CONDITION**
    1. Turn the igntion off.

NOTE: **The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.**

- **LOW ENGINE OIL LEVEL**
- **CONTAMINATED, DIRTY, AERATED OR DETERIORATED ENGINE OIL**
- **INCORRECT ENGINE OIL VISCOSITY**
- **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
- **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**

Were any of the above conditions present?

Yes

- Repair as necessary. If the engine oil was not at the proper level, top off the engine oil to the proper specification. Start the engine and allow it to idle for 2 - 3 minutes. Turn the engine off, ignition on, and using the scan tool, erase the DTC. Start the engine and drive the vehicle to verify repair. If the DTC does not return, repair is complete.
- If the DTC returns, Go To 3

No

- Go To 2

2. **CHECK FOR AN ACTIVE DTC**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs and record on the repair order. Copy DTC and Freeze Frame information.
    3. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.

    WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

    4. With the scan tool, read DTCs.

    Is the DTC active or pending?

    Yes

    - Go To 3

    No

    - Go To 27

3. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

    Are there any 5-Volt Reference, Dual Stage Oil Pump or Oil Pressure related DTCs active or pending?

    Yes

    - Perform the applicable diagnostic procedure(s) before continuing with this test procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

    No

    - Go To 4

4. **CHECK FOR RELATED CAM SENSOR DTCS**

    Is the P0340 or P0344 DTC also active at this time?

    Yes

    - Go To 5

    No

- Go To 8

5. **CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT**

   NOTE: **Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.**

   1. Turn the ignition off.
   2. Disconnect the CMP Sensor 1 harness connector.
   3. Turn the ignition on.
   4. Measure the voltage on the (F856) 5-Volt Supply circuit at the CMP Sensor 1 harness connector.

      Is the voltage between 4.8 and 5.2 volts?

      Yes

      - Go To 6

      No

      - Repair the (F856) 5-Volt Supply circuit for an open or shorted circuit.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE CMP SENSOR 1 (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. Turn the ignition off.
   2. Disconnect the PCM C2 harness connector.

      CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
   4. Measure the resistance of the CMP Sensor 1 (K900) Sensor Ground circuit between the CMP Sensor 1 harness connector and the GPEC Adaptor.

      Is the resistance below 3.0 Ohms?

      Yes

      - Go To 7

      No

      - Repair the CMP Sensor 1 (K900) Sensor Ground circuit for an open or high resistance.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
   1. Remove and exchange the CMP Sensor 1 with the CMP Sensor on the opposite bank.

      NOTE: **Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed**

every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.

2. Reconnect the PCM C2 and CMP Sensor harness connectors.
3. Turn the ignition on,
4. With the scan tool, erase DTCs.
5. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.
6. With the scan tool, read DTCs.

   Did the CMP Sensor DTCs for the opposite bank set?

   Yes

   - Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 22

8. **CHECK THE CMP SENSOR 1 (K441) POSITION SIGNAL 2 CIRCUIT FOR A SHORT TO VOLTAGE**

   NOTE: **Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.**

   1. Disconnect the CMP Sensor 1 harness connector.
   2. Measure the voltage on the CMP Sensor 1 (K441) Position Signal 2 circuit in the CMP Sensor 1 harness connector.

      Is the voltage above 5.2 volts?

      Yes

      - Repair the CMP Sensor 1 (K441) Position Signal 2 circuit for a short to voltage.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 9

9. **CHECK THE CMP SENSOR 1 (K441) POSITION SIGNAL 2 CIRCUIT FOR A SHORT TO GROUND**

   1. Turn the ignition off.
   2. Disconnect the PCM C2 harness connector.
   3. Check for continuity between ground and the CMP Sensor 1 (K441) Position Signal 2 circuit at the CMP Sensor 1 harness connector.

Is there continuity between ground and the CMP Sensor 1 (K441) Position Signal 2 circuit?

Yes

- Repair the CMP Sensor 1 (K441) Position Signal 2 circuit for a short to ground.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 10

10. **CHECK FOR THE CMP SENSOR 1 (K441) POSITION SIGNAL 2 CIRCUIT SHORTED TO THE CMP SENSOR 1 (K900) SENSOR GROUND CIRCUIT**
    1. Check for continuity between the CMP Sensor 1 (K441) Position Signal 2 circuit and the CMP Sensor 1 (K900) Sensor Ground circuit at the CMP Sensor 1 harness connector.

       Is there continuity between ground and the CMP Sensor 1 (K441) Position Signal 2 circuit and the CMP Sensor 1 (K900) Sensor Ground circuit?

       Yes

       - Repair the short between the CMP Sensor 1 (K441) Position Signal 2 circuit and the CMP Sensor 1 (K900) Sensor Ground circuit.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 11

11. **CHECK THE CMP SENSOR 1 (K441) POSITION SIGNAL 2 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
    2. Measure the resistance of the CMP Sensor 1 (K441) Position Signal 2 circuit between the CMP Sensor 1 harness connector and the GPEC Adaptor.

       Is the resistance below 3.0 Ohms?

       Yes

       - Go To 12

       No

       - Repair the CMP Sensor 1 (K441) Position Signal 2 circuit for an open or high resistance.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

12. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

    NOTE: **During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure**

with the adaptor tool and a gauge on the later model engines where the adaptor can be used.

1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

NOTE: **If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.**

Is the oil pressure reading stable and above 16.0 psi?

Yes

- Go To 13

No

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**
    1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
    2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
    3. Start the engine and allow it to idle.
    4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

NOTE: **The oil pressure reading at the Cylinder Head should be above 14.0 psi.**

Is the oil pressure reading stable and above 14.0 psi?

Yes

- Go To 14

No

- Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

14. **CHECK THE CAMSHAFT 1/1 OIL CONTROL VALVE OPERATION**
    1. Turn the ignition off.
    2. Remove the Camshaft Position Solenoid 1/1.
    3. Inspect the spring loaded spool valve on the Oil Control Valve.

    NOTE: **The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.**

    4. Push and release the spring loaded spool valve against the return spring with a small punch.

    NOTE: **The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.**

    Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

    Yes

    - Go To 15

    No

    - Replace the Camshaft 1/1 Oil Control Valve in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

15. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
    1. Remove and exchange the CMP Sensor 1 with the CMP Sensor on the opposite bank.

    NOTE: **Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.**

    2. Reconnect the PCM C2 and Cam Sensor harness connectors.
    3. Turn the ignition on,
    4. With the scan tool, erase DTCs.
    5. Start the engine and allow it to idle or crank the engine if it will not start.
    6. With the scan tool, read DTCs.

    Did the CMP Sensor DTCs for the opposite bank set as active?

    Yes

    - Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank**

Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 16

16. **INSPECT CAMSHAFT SENSOR TONE WHEEL FOR DAMAGE OR LOOSENESS**
    1. Remove the Cylinder Head Cover and inspect the Camshaft Sensor Tone Wheel for any looseness or signs of damage.
    2. Using the (special tool #2027902090, Check Tool, Tone Wheel Right) check the alignment of the CMP Sensor Tone Wheel in accordance with the service information.

    Were any issues found with the CMP Sensor Tone Wheel?

    Yes

    - Replace the Camshaft Assembly in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 17
17. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 18
18. **CHECK THE CAM PHASER AND CAMSHAFT ASSEMBLY**
    1. Check the Cam Phaser to verify it has returned to lock pin.

2. Put a wrench on the flat of the Camshaft behind the phaser and attempt to move the Camshaft back and forth.

NOTE: **The Cam Phaser should always return to lock pin when the engine is turned off. If the Cam Phaser is not at lock pin, there will be movement felt between the Camshaft and the Cam Phaser.**

Is there movement between the Camshaft and Cam Phaser?

Yes

- Replace the Cam Phaser in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
- Go To 19

No

- Replace the Cam Phaser and Camshaft in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
- Go To 19

19. **VERIFY THE REPAIR**
    1. With the scan tool, erase DTCs.
    2. Test drive the vehicle in accordance with the Freeze Frame data collected.

    Did the DTC return?

    Yes

    - Go To 20

    No

    - Repair is complete.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

20. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.

- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 21

No

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
- Test complete.

21. **REPLACE THE PCM AND RETEST FOR DTC**
    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

    Did the CMP Sensor DTC return?

    Yes

    - Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Repair is complete.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
22. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

NOTE: **During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.**

1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

   NOTE: **If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.**

   Is the oil pressure reading stable and above 16.0 psi?

   Yes

   - Go To 23

   No

   - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

23. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**
    1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
    2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
    3. Start the engine and allow it to idle.
    4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

    NOTE: **The oil pressure reading at the Cylinder Head should be above 14.0 psi.**

    Is the oil pressure reading stable and above 14.0 psi?

    Yes

    - Go To 24

    No

    - Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or

CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

24. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 25
25. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.

9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 26

    No

    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
    - Test complete.

26. **REPLACE THE PCM AND RETEST FOR DTC**
    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

       Did the CMP Sensor DTC return?

       Yes

       - Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Repair is complete.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

27. **WIRE HARNESS/CKP SENSOR INSPECTION**
    1. Turn the ignition off.
    2. Disconnect the harness connectors at the PCM and Cam Sensor. Inspect for wire chaffing or rub conditions, spread terminals, terminals pushed out of the wiring connector, bent terminals at the PCM and Cam Sensor, water in the connector cavities, presence of corrosion on the terminals of the connectors or components.
    3. Visually inspect the mounting area of Cam Sensor for debris/damage or a loose sensor. Remove the Cam Sensor and inspect the end of the sensor for signs of damage or debris. Rotate the engine and if possible, inspect the tone wheel for any signs of damage. Reinstall the Cam Sensor and ensure that the sensor is properly installed and torqued to proper specification.

NOTE: **Due to the fact that this DTC is set by an intermittent loss of the signal, the DTC may be caused by a poor connection at the Cam Sensor or PCM terminals, or a poor signal between the Cam Sensor**

and tone wheel. Because of this, unplugging and reconnecting the harness connectors, or repositioning the Cam Sensor will often repair the condition that set the DTC.

Were any problems found?

Yes

- Perform the appropriate repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 28

28. **CHECK THE VEHICLE'S REPAIR HISTORY**
    1. Check the history of the vehicle for previous Cam Sensor related DTCs.

       Did the repair history show that the vehicle was previously in the dealership with a Cam Sensor fault?

       Yes

       - If the current DTC being diagnosed is for the **same** engine bank as the DTC that set on the previous visit, perform the diagnostics starting at test step #12 in this diagnostic procedure.
       - If the current DTC being diagnosed is for the **opposite** engine bank as the DTC that set on the previous visit, replace the Cam Sensor in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Swap the Cam Sensor with the Cam Sensor on the opposite bank and clear DTCs. The cause may have been a poor connection at one of the harness connectors. Unplugging and reconnecting the harness connector may resolve the issue. Verify the DTC does not return.

         NOTE: **The sensors must be exchanged to aid in determining the possible failure if the vehicle returns to the dealership in the future with another Cam Sensor related DTC.**

       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0369-CAMSHAFT POSITION SENSOR INTERMITTENT - BANK 1 SENSOR 2

For a complete IGNITION SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

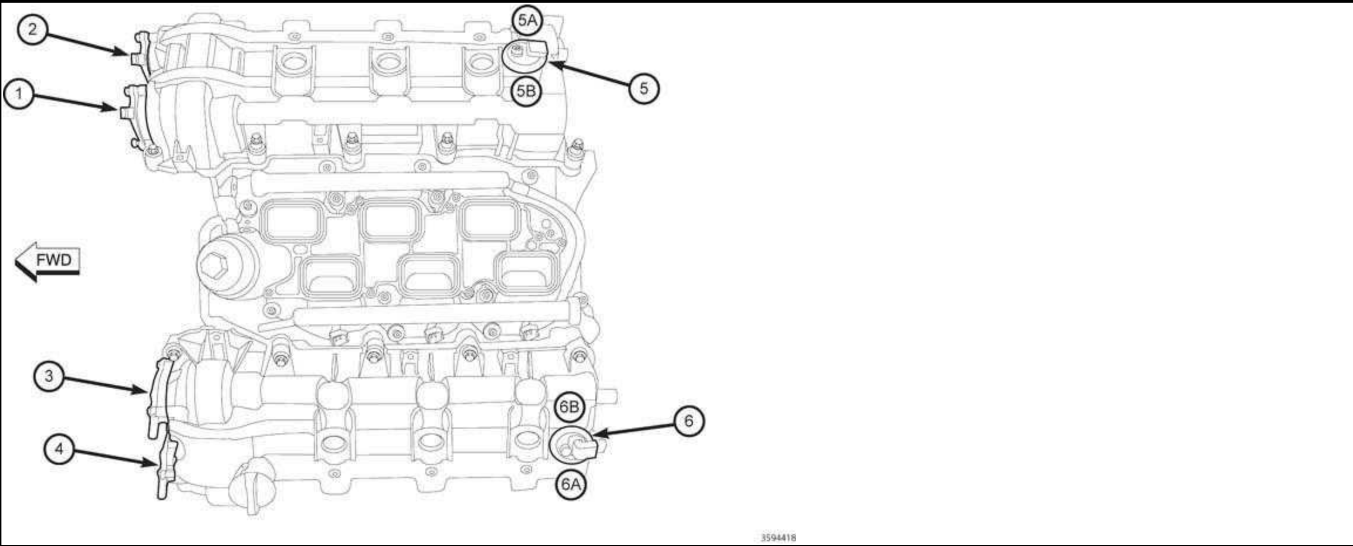
The Camshaft Position (CMP) Sensor circuits consist of a Powertrain Control Module (PCM) supplied 5-Volt reference circuit, low reference circuit, and an output signal circuit. The CMP Sensor detects magnetic flux from the peaks and valleys between the magnets of the tone wheel attached to the camshaft. As each magnet rotates past the CMP Sensor, the resulting change in the magnetic field is used by the sensor electronics to produce a digital output pulse. The sensor returns a digital ON/OFF DC voltage pulse of varying frequency output pulses per Camshaft revolution that represent an image of the camshaft tone wheel. The frequency of the CMP Sensor output depends on the velocity of the camshaft. The PCM decodes the tooth pattern to identify camshaft position. This information is then used to sequence the ignition timing and fuel injection events for the engine. The PCM also uses CMP Sensor output information to determine the camshaft relative position to the Crankshaft, to control the CMP Actuator operation if equipped.

NOTE: **The engine may still start even if either the Crankshaft Position (CKP) Sensor or CMP fails. The PCM eventually sorts out engine position and starts the vehicle on just one of these two inputs. However, there is a slight delay in starting until the PCM can establish sync. A DTC is set and the MIL illuminates if either of the CKP or CMP Sensor signals are not present during engine cranking.**

There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and tables below indicating the CMP Sensor, Position Solenoid/Phaser and DTC orientation).

3.2L / 3.6L DTCs RELATED TO EACH CAMSHAFT					
CAMSHAFT LOCATIONS	**CALLOUT #**	**RELATED CAM SENSOR DTCS**	**PHASER/ACTUATOR DTCS**	**MISALIGNMENT DTCS**	**COLD START PERFORMANCE DTCS**
Bank 1 Intake Camshaft	1	P0365, P0369	P000A, P0010	P0017	P052A, P052B
Bank 1 Exhaust Camshaft	2	P0340, P0344	P000B, P0013	P0016	P054A, P054B
Bank 2 Intake Camshaft	3	P0390, P0394	P000C, P0020	P0019	P052C, P052D
Bank 2 Exhaust Camshaft	4	P0345, P0349	P000D, P0023	P0018	P054C, P054D

3.2L / 3.6L VVT Component Locations			
CALLOUT	**DESCRIPTION**	**CALLOUT**	**DESCRIPTION**
1	CMP Position Solenoid - Bank 1 Position 1 (INTAKE)	5A	CMP Sensor - Bank 1 Sensor 1 (EXHAUST)
2	CMP Position Solenoid - Bank 1 Position 2 (EXHAUST)	5B	CMP Sensor - Bank 1 Sensor 2 (INTAKE)
3	CMP Position Solenoid - Bank 2 Position 1 (INTAKE)	6	Bank 2 Camshaft Sensor
4	CMP Position Solenoid - Bank 2 Position 2 (EXHAUST)	6A	CMP Sensor - Bank 2 Sensor 1 (EXHAUST)
5	Bank 1 Camshaft Sensor	6B	CMP Sensor - Bank 2 Sensor 2 (INTAKE)



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage is above approximately 11.0 volts.

SET CONDITION

- With the engine running, the Powertrain Control Module (PCM) acquires and locks in on a pattern for the Camshaft Position (CMP) Sensor signal. If the CMP Sensor signal pattern changes between unlock and lock at least four times during a period of eight Crankshaft revolutions, a fault is set.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
LOW ENGINE OIL LEVEL
ENGINE OIL AERATED OR CONTAMINATED
INCORRECT ENGINE OIL FILTER
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
5-VOLT SUPPLY CIRCUIT SHORTED TO VOLTAGE
5-VOLT SUPPLY CIRCUIT OPEN
5-VOLT SUPPLY CIRCUIT SHORTED TO GROUND
5-VOLT SUPPLY CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 1/2 SIGNAL CIRCUIT SHORTED TO VOLTAGE
CMP 1/2 SIGNAL CIRCUIT SHORTED TO GROUND
CMP 1/2 SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 1/2 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
CAMSHAFT POSITION SENSOR 1
CAMSHAFT TONE WHEEL LOOSE/DAMAGED OR MISALIGNED
CAMSHAFT PHASER 1/1 OIL CONTROL VALVE FAULTY OR INTERMITTENTLY BINDING/STICKING SPOOL VALVE
CAMSHAFT PHASER 1/1 FAULTY OR INTERMITTENTLY BINDING/STICKING

Possible Causes
OIL PRESSURE ISSUE IN CYLINDER HEAD
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK THE ENGINE OIL LEVEL AND CONDITION**
    1. Turn the ignition off.

    NOTE: **The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.**

    - **LOW ENGINE OIL LEVEL**
    - **CONTAMINATED, DIRTY, AERATED OR DETERIORATED ENGINE OIL**
    - **INCORRECT ENGINE OIL VISCOSITY**
    - **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
    - **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**

    Were any of the above conditions present?

    Yes

    - Repair as necessary. If the engine oil was not at the proper level, top off the engine oil to the proper specification. Start the engine and allow it to idle for 2 - 3 minutes. Turn the engine off, ignition on, and using the scan tool, erase the DTC. Start the engine and drive the vehicle to verify repair. If the DTC does not return, repair is complete.
    - If the DTC returns, Go To 3

    No

    - Go To 2
2. **CHECK FOR AN ACTIVE DTC**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs and record on the repair order. Copy DTC and Freeze Frame information.
    3. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.

    WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

    4. With the scan tool, read DTCs.

    Is the DTC active or pending?

    Yes

    - Go To 3

No

- Go To 27

3. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any 5-Volt Reference, Dual Stage Oil Pump or Oil Pressure related DTCs active or pending?

        Yes

        - Perform the applicable diagnostic procedure(s) before continuing with this test procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 4

4. **CHECK FOR RELATED CAM SENSOR DTCS**

    Is the P0340 or P0344 DTC also active at this time?

    Yes

    - Go To 5

    No

    - Go To 8

5. **CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT**

    NOTE: **Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.**

    1. Turn the ignition off.
    2. Disconnect the CMP Sensor 1 harness connector.
    3. Turn the ignition on.
    4. Measure the voltage on the (F856) 5-Volt Supply circuit at the CMP Sensor 1 harness connector.

        Is the voltage between 4.8 and 5.2 volts?

        Yes

        - Go To 6

        No

        - Repair the (F856) 5-Volt Supply circuit for an open or shorted circuit.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE CMP SENSOR 1 (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. Turn the ignition off.
    2. Disconnect the PCM C2 harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
4. Measure the resistance of the CMP Sensor 1 (K900) Sensor Ground circuit between the CMP Sensor 1 harness connector and the GPEC Adaptor.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 7

   No

   - Repair the CMP Sensor 1 (K900) Sensor Ground circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
   1. Remove and exchange the CMP Sensor 1 with the CMP Sensor on the opposite bank.

      NOTE: **Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.**

   2. Reconnect the PCM C2 and CMP Sensor harness connectors.
   3. Turn the ignition on,
   4. With the scan tool, erase DTCs.
   5. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.
   6. With the scan tool, read DTCs.

   Did the CMP Sensor DTCs for the opposite bank set?

   Yes

   - Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 22

8. **CHECK THE CMP SENSOR 1 (K441) POSITION SIGNAL 2 CIRCUIT FOR A SHORT TO VOLTAGE**

   NOTE: **Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.**

   1. Disconnect the CMP Sensor 1 harness connector.
   2. Measure the voltage on the CMP Sensor 1 (K441) Position Signal 2 circuit in the CMP Sensor 1 harness connector.

      Is the voltage above 5.2 volts?

      Yes

      - Repair the CMP Sensor 1 (K441) Position Signal 2 circuit for a short to voltage.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 9
9. **CHECK THE CMP SENSOR 1 (K441) POSITION SIGNAL 2 CIRCUIT FOR A SHORT TO GROUND**
   1. Turn the ignition off.
   2. Disconnect the PCM C2 harness connector.
   3. Check for continuity between ground and the CMP Sensor 1 (K441) Position Signal 2 circuit at the CMP Sensor 1 harness connector.

      Is there continuity between ground and the CMP Sensor 1 (K441) Position Signal 2 circuit?

      Yes

      - Repair the CMP Sensor 1 (K441) Position Signal 2 circuit for a short to ground.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 10
10. **CHECK FOR THE CMP SENSOR 1 (K441) POSITION SIGNAL 2 CIRCUIT SHORTED TO THE CMP SENSOR 1 (K900) SENSOR GROUND CIRCUIT**
    1. Check for continuity between the CMP Sensor 1 (K441) Position Signal 2 circuit and the CMP Sensor 1 (K900) Sensor Ground circuit at the CMP Sensor 1 harness connector.

       Is there continuity between ground and the CMP Sensor 1 (K441) Position Signal 2 circuit and the CMP Sensor 1 (K900) Sensor Ground circuit?

       Yes

       - Repair the short between the CMP Sensor 1 (K441) Position Signal 2 circuit and the CMP Sensor 1 (K900) Sensor Ground circuit.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

- Go To 11

11. **CHECK THE CMP SENSOR 1 (K441) POSITION SIGNAL 2 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
    2. Measure the resistance of the CMP Sensor 1 (K441) Position Signal 2 circuit between the CMP Sensor 1 harness connector and the GPEC Adaptor.

       Is the resistance below 3.0 Ohms?

       Yes

       - Go To 12

       No

       - Repair the CMP Sensor 1 (K441) Position Signal 2 circuit for an open or high resistance.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

12. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

    NOTE: **During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.**

    1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
    2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
    3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
    4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
    5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

       NOTE: **If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.**

       Is the oil pressure reading stable and above 16.0 psi?

       Yes

       - Go To 13

       No

       - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**
    1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
    2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
    3. Start the engine and allow it to idle.
    4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

    NOTE: **The oil pressure reading at the Cylinder Head should be above 14.0 psi.**

    Is the oil pressure reading stable and above 14.0 psi?

    Yes

    - Go To 14

    No

    - Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

14. **CHECK THE CAMSHAFT 1/1 OIL CONTROL VALVE OPERATION**
    1. Turn the ignition off.
    2. Remove the Camshaft Position Solenoid 1/1.
    3. Inspect the spring loaded spool valve on the Oil Control Valve.

    NOTE: **The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.**

    4. Push and release the spring loaded spool valve against the return spring with a small punch.

    NOTE: **The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.**

    Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

    Yes

    - Go To 15

    No

    - Replace the Camshaft 1/1 Oil Control Valve in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing

chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

15. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
    1. Remove and exchange the CMP Sensor 1 with the CMP Sensor on the opposite bank.

       NOTE: **Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.**

    2. Reconnect the PCM C2 and Cam Sensor harness connectors.
    3. Turn the ignition on,
    4. With the scan tool, erase DTCs.
    5. Start the engine and allow it to idle or crank the engine if it will not start.
    6. With the scan tool, read DTCs.

    Did the CMP Sensor DTCs for the opposite bank set as active?

    Yes

    - Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to ENGINE SENSORS, REMOVAL AND INSTALLATION . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

    No

    - Go To 16

16. **INSPECT CAMSHAFT SENSOR TONE WHEEL FOR DAMAGE OR LOOSENESS**
    1. Remove the Cylinder Head Cover and inspect the Camshaft Sensor Tone Wheel for any looseness or signs of damage.
    2. Using the (special tool #2027902090, Check Tool, Tone Wheel Right) check the alignment of the CMP Sensor Tone Wheel in accordance with the service information.

    Were any issues found with the CMP Sensor Tone Wheel?

    Yes

    - Replace the Camshaft Assembly in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

No

- Go To 17

17. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 18

18. **CHECK THE CAM PHASER AND CAMSHAFT ASSEMBLY**
    1. Check the Cam Phaser to verify it has returned to lock pin.
    2. Put a wrench on the flat of the Camshaft behind the phaser and attempt to move the Camshaft back and forth.

    NOTE: **The Cam Phaser should always return to lock pin when the engine is turned off. If the Cam Phaser is not at lock pin, there will be movement felt between the Camshaft and the Cam Phaser.**

    Is there movement between the Camshaft and Cam Phaser?

    Yes

    - Replace the Cam Phaser in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Go To 19

    No

    - Replace the Cam Phaser and Camshaft in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Go To 19

19. **VERIFY THE REPAIR**
    1. With the scan tool, erase DTCs.

2. Test drive the vehicle in accordance with the Freeze Frame data collected.

   Did the DTC return?

   Yes

   - Go To 20

   No

   - Repair is complete.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

20. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
       - Proper connector installation.
       - Damaged connector locks.
       - Corrosion.
       - Other signs of water intrusion.
       - Weather seal damage (if equipped).
       - Bent terminals.
       - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
       - Terminals that have been pushed back into the connector cavity.
       - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Go To 21

        No

        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

- Test complete.

21. **REPLACE THE PCM AND RETEST FOR DTC**
    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

    Did the CMP Sensor DTC return?

    Yes

    - Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Repair is complete.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

22. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

    NOTE: During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.

    1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
    2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
    3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
    4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
    5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

       NOTE: If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.

    Is the oil pressure reading stable and above 16.0 psi?

    Yes

    - Go To 23

No

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

23. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**
    1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
    2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
    3. Start the engine and allow it to idle.
    4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

    NOTE: **The oil pressure reading at the Cylinder Head should be above 14.0 psi.**

    Is the oil pressure reading stable and above 14.0 psi?

    Yes

    - Go To 24

    No

    - Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

24. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 25

25. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Go To 26

        No

        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
        - Test complete.

26. **REPLACE THE PCM AND RETEST FOR DTC**
    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

       Did the CMP Sensor DTC return?

Yes

- Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. Refer to **CYLINDER HEAD ASSEMBLY, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Repair is complete.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

27. **WIRE HARNESS/CKP SENSOR INSPECTION**
    1. Turn the ignition off.
    2. Disconnect the harness connectors at the PCM and Cam Sensor. Inspect for wire chaffing or rub conditions, spread terminals, terminals pushed out of the wiring connector, bent terminals at the PCM and Cam Sensor, water in the connector cavities, presence of corrosion on the terminals of the connectors or components.
    3. Visually inspect the mounting area of Cam Sensor for debris/damage or a loose sensor. Remove the Cam Sensor and inspect the end of the sensor for signs of damage or debris. Rotate the engine and if possible, inspect the tone wheel for any signs of damage. Reinstall the Cam Sensor and ensure that the sensor is properly installed and torqued to proper specification.

    NOTE: **Due to the fact that this DTC is set by an intermittent loss of the signal, the DTC may be caused by a poor connection at the Cam Sensor or PCM terminals, or a poor signal between the Cam Sensor and tone wheel. Because of this, unplugging and reconnecting the harness connectors, or repositioning the Cam Sensor will often repair the condition that set the DTC.**

    Were any problems found?

    Yes

    - Perform the appropriate repair.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 28

28. **CHECK THE VEHICLE'S REPAIR HISTORY**
    1. Check the history of the vehicle for previous Cam Sensor related DTCs.

    Did the repair history show that the vehicle was previously in the dealership with a Cam Sensor fault?

    Yes

    - If the current DTC being diagnosed is for the **same** engine bank as the DTC that set on the previous visit, perform the diagnostics starting at test step #12 in this diagnostic procedure.

- If the current DTC being diagnosed is for the **opposite** engine bank as the DTC that set on the previous visit, replace the Cam Sensor in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Swap the Cam Sensor with the Cam Sensor on the opposite bank and clear DTCs. The cause may have been a poor connection at one of the harness connectors. Unplugging and reconnecting the harness connector may resolve the issue. Verify the DTC does not return.

  NOTE: **The sensors must be exchanged to aid in determining the possible failure if the vehicle returns to the dealership in the future with another Cam Sensor related DTC.**

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0390-CAMSHAFT POSITION SENSOR CIRCUIT - BANK 2 SENSOR 2

For a complete IGNITION SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Camshaft Position (CMP) Sensor circuits consist of a Powertrain Control Module (PCM) supplied 5-Volt reference circuit, low reference circuit, and an output signal circuit. The CMP Sensor detects magnetic flux from the peaks and valleys between the magnets of the tone wheel attached to the camshaft. As each magnet rotates past the CMP Sensor, the resulting change in the magnetic field is used by the sensor electronics to produce a digital output pulse. The sensor returns a digital ON/OFF DC voltage pulse of varying frequency output pulses per Camshaft revolution that represent an image of the camshaft tone wheel. The frequency of the CMP Sensor output depends on the velocity of the camshaft. The PCM decodes the tooth pattern to identify camshaft position. This information is then used to sequence the ignition timing and fuel injection events for the engine. The PCM also uses CMP Sensor output information to determine the camshaft relative position to the Crankshaft, to control the CMP Actuator operation if equipped.

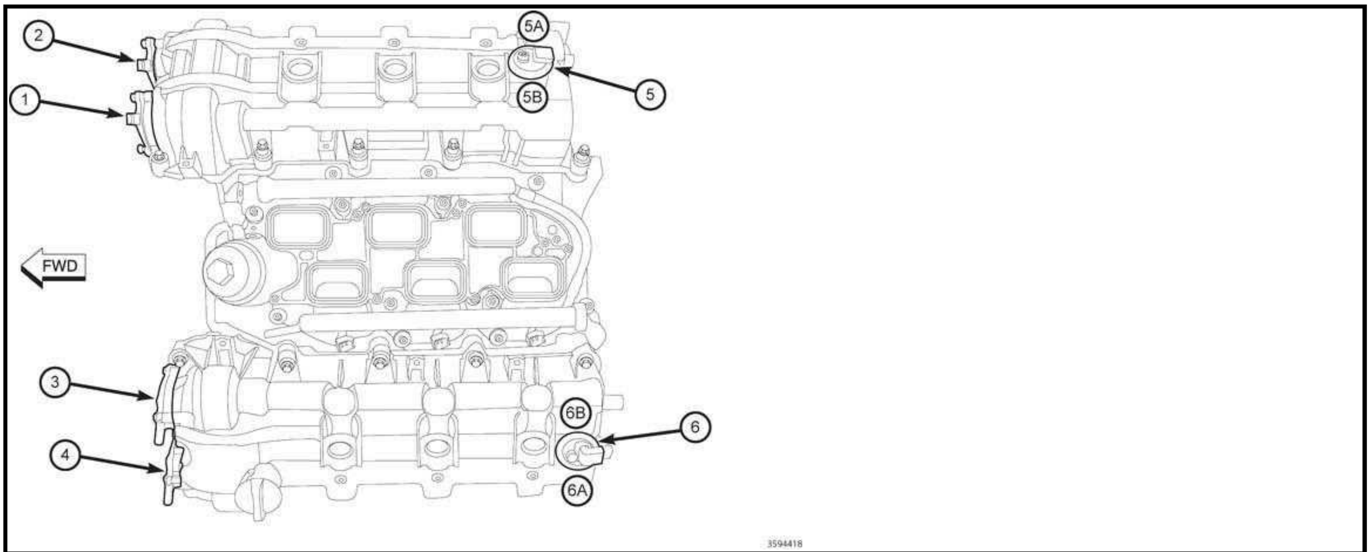
NOTE: **The engine may still start even if either the Crankshaft Position (CKP) Sensor or CMP fails. The PCM eventually sorts out engine position and starts the vehicle on just one of these two inputs. However, there is a slight delay in starting until the PCM can establish sync. A DTC is set and the MIL illuminates if either of the CKP or CMP Sensor signals are not present during engine cranking.**

There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and tables below indicating the CMP Sensor, Position Solenoid/Phaser and DTC orientation).

3.2L / 3.6L DTCs RELATED TO EACH CAMSHAFT					
CAMSHAFT LOCATIONS	CALLOUT #	RELATED CAM SENSOR DTCS	PHASER/ACTUATOR DTCS	MISALIGNMENT DTCS	COLD START PERFORMANCE DTCS
Bank 1 Intake Camshaft	1	P0365, P0369	P000A, P0010	P0017	P052A, P052B

3.2L / 3.6L DTCs RELATED TO EACH CAMSHAFT					
CAMSHAFT LOCATIONS	**CALLOUT #**	**RELATED CAM SENSOR DTCS**	**PHASER/ACTUATOR DTCS**	**MISALIGNMENT DTCS**	**COLD START PERFORMANCE DTCS**
Bank 1 Exhaust Camshaft	2	P0340, P0344	P000B, P0013	P0016	P054A, P054B
Bank 2 Intake Camshaft	3	P0390, P0394	P000C, P0020	P0019	P052C, P052D
Bank 2 Exhaust Camshaft	4	P0345, P0349	P000D, P0023	P0018	P054C, P054D

3.2L / 3.6L VVT Component Locations			
CALLOUT	**DESCRIPTION**	**CALLOUT**	**DESCRIPTION**
1	CMP Position Solenoid - Bank 1 Position 1 (INTAKE)	5A	CMP Sensor - Bank 1 Sensor 1 (EXHAUST)
2	CMP Position Solenoid - Bank 1 Position 2 (EXHAUST)	5B	CMP Sensor - Bank 1 Sensor 2 (INTAKE)
3	CMP Position Solenoid - Bank 2 Position 1 (INTAKE)	6	Bank 2 Camshaft Sensor
4	CMP Position Solenoid - Bank 2 Position 2 (EXHAUST)	6A	CMP Sensor - Bank 2 Sensor 1 (EXHAUST)
5	Bank 1 Camshaft Sensor	6B	CMP Sensor - Bank 2 Sensor 2 (INTAKE)



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine cranking and with the engine running.
- Battery voltage is above approximately 11.0 volts.

SET CONDITION

- During cranking, at least 2.5 seconds have elapsed with a Crankshaft Position Sensor signal present but no Camshaft Position Sensor signal.
- With the engine running, the Camshaft Position Sensor signal is lost for at least 0.4 seconds with a Crankshaft Position Sensor signal present.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
LOW ENGINE OIL LEVEL
ENGINE OIL AERATED OR CONTAMINATED
INCORRECT ENGINE OIL FILTER
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
5-VOLT SUPPLY CIRCUIT SHORTED TO VOLTAGE
5-VOLT SUPPLY CIRCUIT OPEN
5-VOLT SUPPLY CIRCUIT SHORTED TO GROUND
5-VOLT SUPPLY CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 2/2 SIGNAL CIRCUIT SHORTED TO VOLTAGE
CMP 2/2 SIGNAL CIRCUIT SHORTED TO GROUND
CMP 2/2 SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 2/2 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
CAMSHAFT POSITION SENSOR 2
CAMSHAFT TONE WHEEL LOOSE/DAMAGED OR MISALIGNED
CAMSHAFT PHASER 2/1 OIL CONTROL VALVE FAULTY OR INTERMITTENTLY BINDING/STICKING SPOOL VALVE
CAMSHAFT PHASER 2/1 FAULTY OR INTERMITTENTLY BINDING/STICKING
OIL PRESSURE ISSUE IN CYLINDER HEAD
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK THE ENGINE OIL LEVEL AND CONDITION**
    1. Turn the ignition off.

NOTE: **The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.**

- **LOW ENGINE OIL LEVEL**
- **CONTAMINATED, DIRTY, AERATED OR DETERIORATED ENGINE OIL**
- **INCORRECT ENGINE OIL VISCOSITY**
- **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
- **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**

Were any of the above conditions present?

Yes

- Repair as necessary. If the engine oil was not at the proper level, top off the engine oil to the proper specification. Start the engine and allow it to idle for 2 - 3 minutes. Turn the engine off, ignition on, and using the scan tool, erase the DTC. Start the engine and drive the vehicle to verify repair. If the DTC does not return, repair is complete.
- If the DTC returns, Go To 3

No

- Go To 2

2. **CHECK FOR AN ACTIVE DTC**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs and record on the repair order. Copy DTC and Freeze Frame information.
    3. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.

    WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

    4. With the scan tool, read DTCs.

    Is the DTC active or pending?

    Yes

    - Go To 3

    No

    - Go To 27
3. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

    Are there any 5-Volt Reference, Dual Stage Oil Pump or Oil Pressure related DTCs active or pending?

    Yes

    - Perform the applicable diagnostic procedure(s) before continuing with this test procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

    No

    - Go To 4
4. **CHECK FOR RELATED CAM SENSOR DTCS**

    Is the P0390 or P0394 DTC also active at this time?

    Yes

    - Go To 5

    No

    - Go To 8

5. **CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT**

    NOTE: **Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.**

    1. Turn the ignition off.
    2. Disconnect the CMP Sensor 2 harness connector.
    3. Turn the ignition on.
    4. Measure the voltage on the (F856) 5-Volt Supply circuit at the CMP Sensor 2 harness connector.

        Is the voltage between 4.8 and 5.2 volts?

        Yes

        - Go To 6

        No

        - Repair the (F856) 5-Volt Supply circuit for an open or shorted circuit.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
6. **CHECK THE CMP SENSOR 2 (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. Turn the ignition off.
    2. Disconnect the PCM C2 harness connector.

        CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
    4. Measure the resistance of the CMP Sensor 2 (K900) Sensor Ground circuit between the CMP Sensor 2 harness connector and the GPEC Adaptor.

        Is the resistance below 3.0 Ohms?

        Yes

        - Go To 7

        No

        - Repair the CMP Sensor 2 (K900) Sensor Ground circuit for an open or high resistance.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
7. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
    1. Remove and exchange the CMP Sensor 2 with the CMP Sensor on the opposite bank.

        NOTE: **Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP**

Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.

2. Reconnect the PCM C2 and CMP Sensor harness connectors.
3. Turn the ignition on,
4. With the scan tool, erase DTCs.
5. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.
6. With the scan tool, read DTCs.

   Did the CMP Sensor DTCs for the opposite bank set?

   Yes

   - Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 22

8. **CHECK THE CMP SENSOR 2 (K445) SIGNAL 2 CIRCUIT FOR A SHORT TO VOLTAGE**

   NOTE: **Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.**

   1. Disconnect the CMP Sensor 2 harness connector.
   2. Measure the voltage on the CMP Sensor 2 (K445) Signal 2 circuit in the CMP Sensor 2 harness connector.

      Is the voltage above 5.2 volts?

      Yes

      - Repair the CMP Sensor 2 (K445) Signal 2 circuit for a short to voltage.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 9

9. **CHECK THE CMP SENSOR 2 (K445) SIGNAL 2 CIRCUIT FOR A SHORT TO GROUND**
   1. Turn the ignition off.
   2. Disconnect the PCM C2 harness connector.
   3. Check for continuity between ground and the CMP Sensor 2 (K445) Signal 2 circuit at the CMP Sensor 2 harness connector.

      Is there continuity between ground and the CMP Sensor 2 (K445) Signal 2 circuit?

Yes

- Repair the CMP Sensor 2 (K445) Signal 2 circuit for a short to ground.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 10

10. **CHECK FOR THE CMP SENSOR 2 (K445) SIGNAL 2 CIRCUIT SHORTED TO THE CMP SENSOR 2 (K900) SENSOR GROUND CIRCUIT**
    1. Check for continuity between the CMP Sensor 2 (K445) Signal 2 circuit and the CMP Sensor 2 (K900) Sensor Ground circuit at the CMP Sensor 2 harness connector.

       Is there continuity between ground and the CMP Sensor 2 (K445) Signal 2 circuit and the CMP Sensor 2 (K900) Sensor Ground circuit?

       Yes

       - Repair the short between the CMP Sensor 2 (K445) Signal 2 circuit and the CMP Sensor 2 (K900) Sensor Ground circuit.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 11

11. **CHECK THE CMP SENSOR 2 (K445) SIGNAL 2 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
    2. Measure the resistance of the CMP Sensor 2 (K445) Signal 2 circuit between the CMP Sensor 2 harness connector and the GPEC Adaptor.

       Is the resistance below 3.0 Ohms?

       Yes

       - Go To 12

       No

       - Repair the CMP Sensor 2 (K445) Signal 2 circuit for an open or high resistance.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

12. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

    NOTE: **During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.**

1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

NOTE: **If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.**

Is the oil pressure reading stable and above 16.0 psi?

Yes

- Go To 13

No

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**
    1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
    2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
    3. Start the engine and allow it to idle.
    4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

NOTE: **The oil pressure reading at the Cylinder Head should be within above 14.0 psi.**

Is the oil pressure reading stable and above 14.0 psi?

Yes

- Go To 14

No

- Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

14. **CHECK THE CAMSHAFT 2/2 OIL CONTROL VALVE OPERATION**

1. Turn the ignition off.
2. Remove the Camshaft Position Solenoid 2/2.
3. Inspect the spring loaded spool valve on the Oil Control Valve.

NOTE: **The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.**

4. Push and release the spring loaded spool valve against the return spring with a small punch.

NOTE: **The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.**

Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

Yes

- Go To 15

No

- Replace the Camshaft 2/2 Oil Control Valve in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

15. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
    1. Remove and exchange the CMP Sensor 2 with the CMP Sensor on the opposite bank.

NOTE: **Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.**

2. Reconnect the PCM C2 and Cam Sensor harness connectors.
3. Turn the ignition on,
4. With the scan tool, erase DTCs.
5. Start the engine and allow it to idle or crank the engine if it will not start.
6. With the scan tool, read DTCs.

Did the CMP Sensor DTCs for the opposite bank set as active?

Yes

- Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears.

Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 16

16. **INSPECT CAMSHAFT SENSOR TONE WHEEL FOR DAMAGE OR LOOSENESS**
    1. Remove the Cylinder Head Cover and inspect the Camshaft Sensor Tone Wheel for any looseness or signs of damage.
    2. Using the (special tool #2027902090, Check Tool, Tone Wheel Right) check the alignment of the CMP Sensor Tone Wheel in accordance with the service information.

    Were any issues found with the CMP Sensor Tone Wheel?

    Yes

    - Replace the Camshaft Assembly in accordance with the Service Information. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 17

17. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 18

18. **CHECK THE CAM PHASER AND CAMSHAFT ASSEMBLY**
    1. Check the Cam Phaser to verify it has returned to lock pin.

2. Put a wrench on the flat of the Camshaft behind the phaser and attempt to move the Camshaft back and forth.

   NOTE: **The Cam Phaser should always return to lock pin when the engine is turned off. If the Cam Phaser is not at lock pin, there will be movement felt between the Camshaft and the Cam Phaser.**

   Is there movement between the Camshaft and Cam Phaser?

   Yes

   - Replace the Cam Phaser in accordance with the Service Information. . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
   - Go To 19

   No

   - Replace the Cam Phaser and Camshaft in accordance with the Service Information. Refer to **CAMSHAFT, ENGINE, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
   - Go To 19

19. **VERIFY THE REPAIR**
    1. With the scan tool, erase DTCs.
    2. Test drive the vehicle in accordance with the Freeze Frame data collected.

    Did the DTC return?

    Yes

    - Go To 20

    No

    - Repair is complete.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

20. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
       - Proper connector installation.
       - Damaged connector locks.
       - Corrosion.
       - Other signs of water intrusion.
       - Weather seal damage (if equipped).

- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 21

No

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
- Test complete.

21. **REPLACE THE PCM AND RETEST FOR DTC**
    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

    Did the CMP Sensor DTC return?

    Yes

    - Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Repair is complete.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
22. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

NOTE: **During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.**

1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

NOTE: **If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.**

Is the oil pressure reading stable and above 16.0 psi?

Yes

- Go To 23

No

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

23. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**
    1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
    2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
    3. Start the engine and allow it to idle.
    4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

NOTE: **The oil pressure reading at the Cylinder Head should be above 14.0 psi.**

Is the oil pressure reading stable and above 14.0 psi?

Yes

- Go To 24

No

- Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or

CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
  - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

24. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 25
25. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
       - Proper connector installation.
       - Damaged connector locks.
       - Corrosion.
       - Other signs of water intrusion.
       - Weather seal damage (if equipped).
       - Bent terminals.
       - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
       - Terminals that have been pushed back into the connector cavity.
       - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.

9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 26

    No

    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
    - Test complete.

26. **REPLACE THE PCM AND RETEST FOR DTC**
    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

       Did the CMP Sensor DTC return?

       Yes

       - Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Repair is complete.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

27. **WIRE HARNESS/CKP SENSOR INSPECTION**
    1. Turn the ignition off.
    2. Disconnect the harness connectors at the PCM and Cam Sensor. Inspect for wire chaffing or rub conditions, spread terminals, terminals pushed out of the wiring connector, bent terminals at the PCM and Cam Sensor, water in the connector cavities, presence of corrosion on the terminals of the connectors or components.
    3. Visually inspect the mounting area of Cam Sensor for debris/damage or a loose sensor. Remove the Cam Sensor and inspect the end of the sensor for signs of damage or debris. Rotate the engine and if possible, inspect the tone wheel for any signs of damage. Reinstall the Cam Sensor and ensure that the sensor is properly installed and torqued to proper specification.

       NOTE: **Due to the fact that this DTC is set by an intermittent loss of the signal, the DTC may be caused by a poor connection at the Cam Sensor or PCM terminals, or a poor signal between the Cam Sensor and tone wheel. Because of this, unplugging and reconnecting the**

harness connectors, or repositioning the Cam Sensor will often repair the condition that set the DTC.

Were any problems found?

Yes

- Perform the appropriate repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 28

28. **CHECK THE VEHICLE'S REPAIR HISTORY**
    1. Check the history of the vehicle for previous Cam Sensor related DTCs.

    Did the repair history show that the vehicle was previously in the dealership with a Cam Sensor fault?

    Yes

    - If the current DTC being diagnosed is for the **same** engine bank as the DTC that set on the previous visit, perform the diagnostics starting at test step #12 in this diagnostic procedure.
    - If the current DTC being diagnosed is for the **opposite** engine bank as the DTC that set on the previous visit, replace the Cam Sensor in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Swap the Cam Sensor with the Cam Sensor on the opposite bank and clear DTCs. The cause may have been a poor connection at one of the harness connectors. Unplugging and reconnecting the harness connector may resolve the issue. Verify the DTC does not return.

    NOTE: **The sensors must be exchanged to aid in determining the possible failure if the vehicle returns to the dealership in the future with another Cam Sensor related DTC.**

    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0394-CAMSHAFT POSITION SENSOR INTERMITTENT - BANK 2 SENSOR 2

For a complete IGNITION SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Camshaft Position (CMP) Sensor circuits consist of a Powertrain Control Module (PCM) supplied 5-Volt reference circuit, low reference circuit, and an output signal circuit. The CMP Sensor detects magnetic flux from the peaks and valleys between the magnets of the tone wheel attached to the camshaft. As each magnet rotates past the CMP Sensor, the resulting change in the magnetic field is used by the sensor electronics to produce a digital output pulse. The sensor returns a digital ON/OFF DC voltage pulse of varying frequency output pulses per Camshaft revolution that represent an image of the camshaft tone wheel. The frequency of the

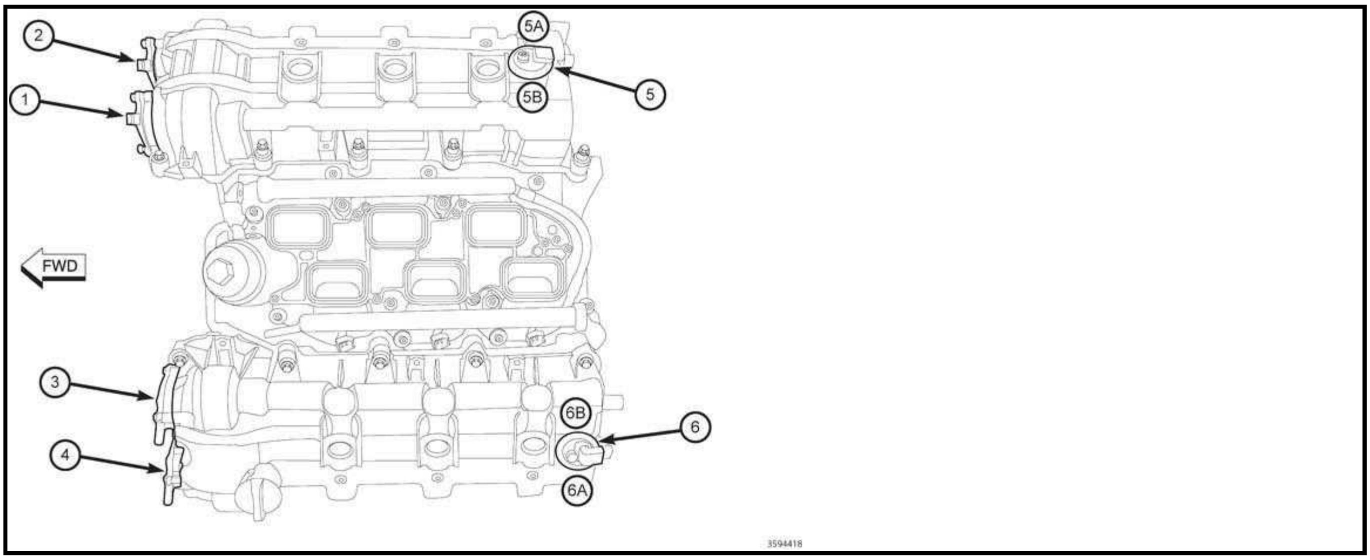
CMP Sensor output depends on the velocity of the camshaft. The PCM decodes the tooth pattern to identify camshaft position. This information is then used to sequence the ignition timing and fuel injection events for the engine. The PCM also uses CMP Sensor output information to determine the camshaft relative position to the Crankshaft, to control the CMP Actuator operation if equipped.

NOTE: **The engine may still start even if either the Crankshaft Position (CKP) Sensor or CMP fails. The PCM eventually sorts out engine position and starts the vehicle on just one of these two inputs. However, there is a slight delay in starting until the PCM can establish sync. A DTC is set and the MIL illuminates if either of the CKP or CMP Sensor signals are not present during engine cranking.**

There are four Camshafts and two CMP Sensors. Each CMP Sensor has two CMP Sensor signals that provide feedback indicating the position of each Camshaft on its correlating engine bank (See the illustration and tables below indicating the CMP Sensor, Position Solenoid/Phaser and DTC orientation).

3.2L / 3.6L DTCs RELATED TO EACH CAMSHAFT					
CAMSHAFT LOCATIONS	**CALLOUT #**	**RELATED CAM SENSOR DTCS**	**PHASER/ACTUATOR DTCS**	**MISALIGNMENT DTCS**	**COLD START PERFORMANCE DTCS**
Bank 1 Intake Camshaft	1	P0365, P0369	P000A, P0010	P0017	P052A, P052B
Bank 1 Exhaust Camshaft	2	P0340, P0344	P000B, P0013	P0016	P054A, P054B
Bank 2 Intake Camshaft	3	P0390, P0394	P000C, P0020	P0019	P052C, P052D
Bank 2 Exhaust Camshaft	4	P0345, P0349	P000D, P0023	P0018	P054C, P054D

3.2L / 3.6L VVT Component Locations			
CALLOUT	**DESCRIPTION**	**CALLOUT**	**DESCRIPTION**
1	CMP Position Solenoid - Bank 1 Position 1 (INTAKE)	5A	CMP Sensor - Bank 1 Sensor 1 (EXHAUST)
2	CMP Position Solenoid - Bank 1 Position 2 (EXHAUST)	5B	CMP Sensor - Bank 1 Sensor 2 (INTAKE)
3	CMP Position Solenoid - Bank 2 Position 1 (INTAKE)	6	Bank 2 Camshaft Sensor
4	CMP Position Solenoid - Bank 2 Position 2 (EXHAUST)	6A	CMP Sensor - Bank 2 Sensor 1 (EXHAUST)
5	Bank 1 Camshaft Sensor	6B	CMP Sensor - Bank 2 Sensor 2 (INTAKE)



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage is above approximately 11.0 volts.

SET CONDITION

- With the engine running, the Powertrain Control Module (PCM) acquires and locks in on a pattern for the Camshaft Position (CMP) Sensor signal. If the CMP Sensor signal pattern changes between unlock and lock at least four times during a period of eight Crankshaft revolutions, a fault is set.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
LOW ENGINE OIL LEVEL
ENGINE OIL AERATED OR CONTAMINATED
INCORRECT ENGINE OIL FILTER
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
5-VOLT SUPPLY CIRCUIT SHORTED TO VOLTAGE
5-VOLT SUPPLY CIRCUIT OPEN
5-VOLT SUPPLY CIRCUIT SHORTED TO GROUND
5-VOLT SUPPLY CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 2/2 SIGNAL CIRCUIT SHORTED TO VOLTAGE
CMP 2/2 SIGNAL CIRCUIT SHORTED TO GROUND
CMP 2/2 SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
CMP 2/2 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
CAMSHAFT POSITION SENSOR 2
CAMSHAFT TONE WHEEL LOOSE/DAMAGED OR MISALIGNED
CAMSHAFT PHASER 2/1 OIL CONTROL VALVE FAULTY OR INTERMITTENTLY BINDING/STICKING SPOOL VALVE
CAMSHAFT PHASER 2/1 FAULTY OR INTERMITTENTLY BINDING/STICKING

Possible Causes
POWERTRAIN CONTROL MODULE (PCM)
OIL PRESSURE ISSUE IN CYLINDER HEAD

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK THE ENGINE OIL LEVEL AND CONDITION**
    1. Turn the ignition off.

    NOTE: **The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.**

    - **LOW ENGINE OIL LEVEL**
    - **CONTAMINATED, DIRTY, AERATED OR DETERIORATED ENGINE OIL**
    - **INCORRECT ENGINE OIL VISCOSITY**
    - **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
    - **INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)**

    Were any of the above conditions present?

    Yes

    - Repair as necessary. If the engine oil was not at the proper level, top off the engine oil to the proper specification. Start the engine and allow it to idle for 2 - 3 minutes. Turn the engine off, ignition on, and using the scan tool, erase the DTC. Start the engine and drive the vehicle to verify repair. If the DTC does not return, repair is complete.
    - If the DTC returns, Go To 3

    No

    - Go To 2
2. **CHECK FOR AN ACTIVE DTC**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs and record on the repair order. Copy DTC and Freeze Frame information.
    3. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.

    WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

    4. With the scan tool, read DTCs.

    Is the DTC active or pending?

    Yes

    - Go To 3

No

- Go To 27

3. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any 5-Volt Reference, Dual Stage Oil Pump or Oil Pressure related DTCs active or pending?

       Yes

       - Perform the applicable diagnostic procedure(s) before continuing with this test procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 4

4. **CHECK FOR RELATED CAM SENSOR DTCS**

   Is the P0390 or P0394 DTC also active at this time?

   Yes

   - Go To 5

   No

   - Go To 8

5. **CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT**

   NOTE: **Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.**

    1. Turn the ignition off.
    2. Disconnect the CMP Sensor 2 harness connector.
    3. Turn the ignition on.
    4. Measure the voltage on the (F856) 5-Volt Supply circuit at the CMP Sensor 2 harness connector.

       Is the voltage between 4.8 and 5.2 volts?

       Yes

       - Go To 6

       No

       - Repair the (F856) 5-Volt Supply circuit for an open or shorted circuit.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE CMP SENSOR 2 (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. Turn the ignition off.
    2. Disconnect the PCM C2 harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
4. Measure the resistance of the CMP Sensor 2 (K900) Sensor Ground circuit between the CMP Sensor 2 harness connector and the GPEC Adaptor.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 7

   No

   - Repair the CMP Sensor 2 (K900) Sensor Ground circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
   1. Remove and exchange the CMP Sensor 2 with the CMP Sensor on the opposite bank.

      NOTE: **Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.**

   2. Reconnect the PCM C2 and CMP Sensor harness connectors.
   3. Turn the ignition on,
   4. With the scan tool, erase DTCs.
   5. Start the engine and allow it to idle or crank the engine if it will not start. Attempt to operate vehicle under conditions similar to freeze frame data.
   6. With the scan tool, read DTCs.

      Did the CMP Sensor DTCs for the opposite bank set?

      Yes

      - Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 22

8. **CHECK THE CMP SENSOR 2 (K445) SIGNAL 2 CIRCUIT FOR A SHORT TO VOLTAGE**

NOTE: **Keep in mind during the following electrical circuit checks that this is an intermittent loss of the Cam Sensor signal. It may be best to wiggle the wiring harness and connectors while performing the check of the circuits.**

1. Disconnect the CMP Sensor 2 harness connector.
2. Measure the voltage on the CMP Sensor 2 (K445) Signal 2 circuit in the CMP Sensor 2 harness connector.

   Is the voltage above 5.2 volts?

   Yes

   - Repair the CMP Sensor 2 (K445) Signal 2 circuit for a short to voltage.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 9

9. **CHECK THE CMP SENSOR 2 (K445) SIGNAL 2 CIRCUIT FOR A SHORT TO GROUND**
   1. Turn the ignition off.
   2. Disconnect the PCM C2 harness connector.
   3. Check for continuity between ground and the CMP Sensor 2 (K445) Signal 2 circuit at the CMP Sensor 2 harness connector.

      Is there continuity between ground and the CMP Sensor 2 (K445) Signal 2 circuit?

      Yes

      - Repair the CMP Sensor 2 (K445) Signal 2 circuit for a short to ground.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 10

10. **CHECK FOR THE CMP SENSOR 2 (K445) SIGNAL 2 CIRCUIT SHORTED TO THE CMP SENSOR 2 (K900) SENSOR GROUND CIRCUIT**
    1. Check for continuity between the CMP Sensor 2 (K445) Signal 2 circuit and the CMP Sensor 2 (K900) Sensor Ground circuit at the CMP Sensor 2 harness connector.

       Is there continuity between ground and the CMP Sensor 2 (K445) Signal 2 circuit and the CMP Sensor 2 (K900) Sensor Ground circuit?

       Yes

       - Repair the short between the CMP Sensor 2 (K445) Signal 2 circuit and the CMP Sensor 2 (K900) Sensor Ground circuit.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 11

11. **CHECK THE CMP SENSOR 2 (K445) SIGNAL 2 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
2. Measure the resistance of the CMP Sensor 2 (K445) Signal 2 circuit between the CMP Sensor 2 harness connector and the GPEC Adaptor.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 12

   No

   - Repair the CMP Sensor 2 (K445) Signal 2 circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

12. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

NOTE: During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.

1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

   NOTE: If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.

   Is the oil pressure reading stable and above 16.0 psi?

   Yes

   - Go To 13

   No

   - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**

1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
3. Start the engine and allow it to idle.
4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

NOTE: The oil pressure reading at the Cylinder Head should be within above 14.0 psi.

Is the oil pressure reading stable and above 14.0 psi?

Yes

- Go To 14

No

- Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

14. **CHECK THE CAMSHAFT 2/2 OIL CONTROL VALVE OPERATION**
    1. Turn the ignition off.
    2. Remove the Camshaft Position Solenoid 2/2.
    3. Inspect the spring loaded spool valve on the Oil Control Valve.

NOTE: The spring loaded spool valve should be flush with the surface of the Oil Control Valve when at rest.

4. Push and release the spring loaded spool valve against the return spring with a small punch.

NOTE: The spring loaded spool valve should move freely without binding and return to the flush position if there are no problems with the Oil Control Valve.

Was the spring loaded spool valve flush and able to move freely without dragging or sticking?

Yes

- Go To 15

No

- Replace the Camshaft 2/2 Oil Control Valve in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

15. **EXCHANGE THE CMP SENSORS AND CHECK FOR THE DTC TO CHANGE TO THE OTHER BANK**
    1. Remove and exchange the CMP Sensor 2 with the CMP Sensor on the opposite bank.

       NOTE: **Inspect the Camshaft magnetic tone wheel for damage in accordance with the Service Information. If a problem is found repair as necessary. The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.**

    2. Reconnect the PCM C2 and Cam Sensor harness connectors.
    3. Turn the ignition on,
    4. With the scan tool, erase DTCs.
    5. Start the engine and allow it to idle or crank the engine if it will not start.
    6. With the scan tool, read DTCs.

    Did the CMP Sensor DTCs for the opposite bank set as active?

    Yes

    - Replace the faulty Camshaft Position Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 16

16. **INSPECT CAMSHAFT SENSOR TONE WHEEL FOR DAMAGE OR LOOSENESS**
    1. Remove the Cylinder Head Cover and inspect the Camshaft Sensor Tone Wheel for any looseness or signs of damage.
    2. Using the (special tool #2027902090, Check Tool, Tone Wheel Right) check the alignment of the CMP Sensor Tone Wheel in accordance with the service information.

    Were any issues found with the CMP Sensor Tone Wheel?

    Yes

    - Replace the Camshaft Assembly in accordance with the Service Information. . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

- Go To 17

17. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 18

18. **CHECK THE CAM PHASER AND CAMSHAFT ASSEMBLY**
    1. Check the Cam Phaser to verify it has returned to lock pin.
    2. Put a wrench on the flat of the Camshaft behind the phaser and attempt to move the Camshaft back and forth.

    NOTE: **The Cam Phaser should always return to lock pin when the engine is turned off. If the Cam Phaser is not at lock pin, there will be movement felt between the Camshaft and the Cam Phaser.**

    Is there movement between the Camshaft and Cam Phaser?

    Yes

    - Replace the Cam Phaser in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Go To 19

    No

    - Replace the Cam Phaser and Camshaft in accordance with the Service Information. Refer to **PHASER, CAMSHAFT, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Go To 19

19. **VERIFY THE REPAIR**
    1. With the scan tool, erase DTCs.

2. Test drive the vehicle in accordance with the Freeze Frame data collected.

   Did the DTC return?

   Yes

   - Go To 20

   No

   - Repair is complete.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

20. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
       - Proper connector installation.
       - Damaged connector locks.
       - Corrosion.
       - Other signs of water intrusion.
       - Weather seal damage (if equipped).
       - Bent terminals.
       - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
       - Terminals that have been pushed back into the connector cavity.
       - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Go To 21

        No

        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

- Test complete.

21. **REPLACE THE PCM AND RETEST FOR DTC**

    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

    Did the CMP Sensor DTC return?

    Yes

    - Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Repair is complete.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

22. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**

    NOTE: **During this test step it will be easier to check the oil pressure reading with the scan tool, especially during the test drive. If the oil pressure reading is borderline on the scan tool or suspected to be off, verify the oil pressure with the adaptor tool and a gauge on the later model engines where the adaptor can be used.**

    1. Start the engine and allow it to reach operating temperature. Check the oil pressure at idle and while test driving the vehicle in accordance with the Freeze Frame data collected.
    2. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.
    3. To check the oil pressure manually, turn the engine off. Remove the Oil Filter cap.
    4. Install the (special tool #2021500090, Adapter, Late Version 3.6L Oil Pressure Test)to the oil filter cap and install an oil pressure gauge to the adaptor. If the adaptor is not available, monitor the oil pressure reading with the scan tool.
    5. Start the engine and allow it to reach operating temperature. Monitor the engine oil pressure reading on the gauge while operating the vehicle.

    NOTE: **If the oil pressure goes below 16.0 psi or is oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response or CMP Sensor intermittent DTC.**

    Is the oil pressure reading stable and above 16.0 psi?

    Yes

    - Go To 23

    No

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

23. **CHECK THE ENGINE OIL PRESSURE AT THE CYLINDER HEAD**
    1. Remove the front Variable Valve Lift (VVL) Solenoid from the Cylinder Head.
    2. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the solenoid.
    3. Start the engine and allow it to idle.
    4. Monitor the engine oil pressure reading on the scan tool while operating the vehicle.

    NOTE: **The oil pressure reading at the Cylinder Head should be above 14.0 psi.**

    Is the oil pressure reading stable and above 14.0 psi?

    Yes

    - Go To 24

    No

    - Remove the Cylinder Head Cover and visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head and repair as necessary. Verify that the oil galley plugs are torqued to the proper specification. If the oil galley plugs/screws are torqued properly and don't appear leaking, replace the Cylinder Head in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

24. **INSPECT THE CYLINDER HEAD FOR MISSING OR IMPROPERLY TORQUED OIL GALLEY PLUGS, AND FOR ANY DAMAGE TO THE TIMING CHAIN LINKS OF PINS**
    1. Visually inspect the Cylinder Head for any missing or damaged plugs/screws in the oil galleys near the front of the Cylinder Head.
    2. Verify that the oil galley plugs are torqued to the proper specification.
    3. Visually inspect the timing chain for broken links or damaged chain pins. Check the Timing Chain tensioners for proper operation.

    Were any issues found with the oil galley plugs or timing chain links, pins or tensioners?

    Yes

    - Perform the appropriate repair. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 25

25. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**

1. Perform any Service Bulletins that apply.
2. Disconnect all PCM harness connectors.
3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
   - Proper connector installation.
   - Damaged connector locks.
   - Corrosion.
   - Other signs of water intrusion.
   - Weather seal damage (if equipped).
   - Bent terminals.
   - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
   - Terminals that have been pushed back into the connector cavity.
   - Check for spread terminals and verify proper terminal tension.

   Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 26

    No

    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
    - Test complete.

26. **REPLACE THE PCM AND RETEST FOR DTC**
    1. Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle.
    5. With the scan tool, read DTCs.

       Did the CMP Sensor DTC return?

       Yes

- Replace the Cylinder Head Assembly, Timing Chain and tensioners in accordance with the Service Information. . **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Repair is complete.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

27. **WIRE HARNESS/CKP SENSOR INSPECTION**
    1. Turn the ignition off.
    2. Disconnect the harness connectors at the PCM and Cam Sensor. Inspect for wire chaffing or rub conditions, spread terminals, terminals pushed out of the wiring connector, bent terminals at the PCM and Cam Sensor, water in the connector cavities, presence of corrosion on the terminals of the connectors or components.
    3. Visually inspect the mounting area of Cam Sensor for debris/damage or a loose sensor. Remove the Cam Sensor and inspect the end of the sensor for signs of damage or debris. Rotate the engine and if possible, inspect the tone wheel for any signs of damage. Reinstall the Cam Sensor and ensure that the sensor is properly installed and torqued to proper specification.

    NOTE: **Due to the fact that this DTC is set by an intermittent loss of the signal, the DTC may be caused by a poor connection at the Cam Sensor or PCM terminals, or a poor signal between the Cam Sensor and tone wheel. Because of this, unplugging and reconnecting the harness connectors, or repositioning the Cam Sensor will often repair the condition that set the DTC.**

    Were any problems found?

    Yes

    - Perform the appropriate repair.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 28

28. **CHECK THE VEHICLE'S REPAIR HISTORY**
    1. Check the history of the vehicle for previous Cam Sensor related DTCs.

    Did the repair history show that the vehicle was previously in the dealership with a Cam Sensor fault?

    Yes

    - If the current DTC being diagnosed is for the **same** engine bank as the DTC that set on the previous visit, perform the diagnostics starting at test step #12 in this diagnostic procedure.
    - If the current DTC being diagnosed is for the **opposite** engine bank as the DTC that set on the previous visit, replace the Cam Sensor in accordance with the Service Information. **The "Cam/Crank Relearn" Procedure** must be performed every time there has been a

repair/replacement made to a CMP Sensor and/or CKP Sensor, flywheel, valvetrain, timing chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Swap the Cam Sensor with the Cam Sensor on the opposite bank and clear DTCs. The cause may have been a poor connection at one of the harness connectors. Unplugging and reconnecting the harness connector may resolve the issue. Verify the DTC does not return.

NOTE: **The sensors must be exchanged to aid in determining the possible failure if the vehicle returns to the dealership in the future with another Cam Sensor related DTC.**

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0401-EGR SYSTEM PERFORMANCE

For a complete EGR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

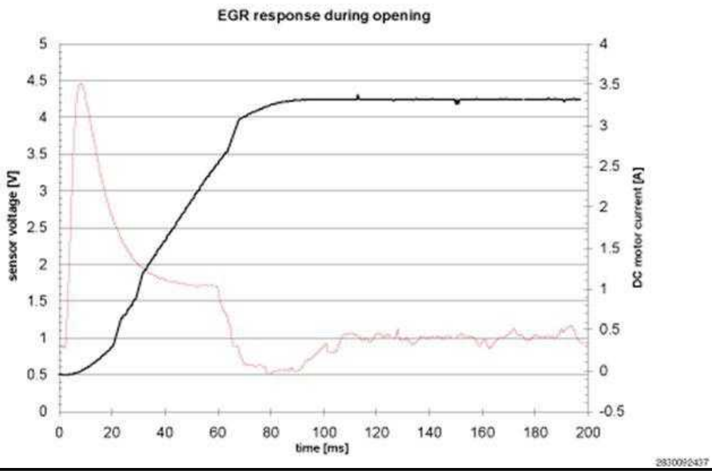
THEORY OF OPERATION

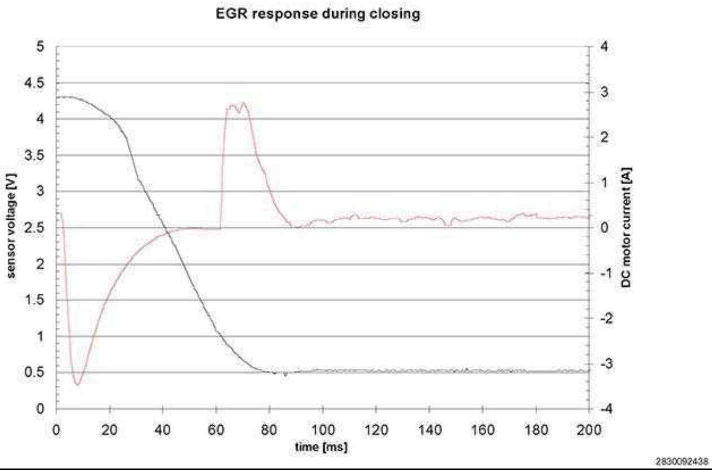
The Cooled Exhaust Gas Recirculation (EGR) Valve Assembly contains an electric Direct Current (DC) Motor and a gear box. An eccentric drive translates the gearbox output from a rotating motion (DC Motor) to a linear stroke (output shaft). The full range of travel of the shaft is approximately 5.0 mm from a fully closed to fully open position. An internal return spring ensures that the valve returns back to its closed position as a fail safe. The EGR Valve is controlled by the Powertrain Control Module (PCM) H-Bridge driver. The H-Bridge operates the DC Motor using a Pulse Width Modulation (PWM) control to help reduce current draw. This helps protect the DC Motor from overheating and reduces electrical load on the system voltage.

- During initial opening of the EGR Valve the PCM drives the Pulse Width Modulation (PWM) voltage high resulting in a high current draw. After the valve is fully opened the PCM voltage is reduced to maintain the EGR Valve position. This reduces the current draw and protects from overheating the DC Motor.
  - The PCM monitors the temperature and current draw of the DC Motor inside EGR Valve and will adjust the duty cycle to prevent the EGR Valve windings from overheating. Typically, the peak current draw by the EGR Valve occurs during opening and the maximum current load for a typical application is approximately 6.0 amps. The duty cycle is adjusted after opening so that the typical average current draw is approximately 0.5 amps while holding the valve open.
- The PCM also applies a current in the closing direction to fulfill the required dynamic performance. This is done to control the closing speed of the shaft near the stop. This ensures that the valve does not close too fast causing the valve disk to be forced into the stop harshly which may damage the internal gearbox.

There is a position sensor located on the output shaft. The sensor operates as a typical three wire sensor, with a 5-Volt Supply, Sensor Signal, and Sensor Ground circuit. Full range of travel of the output shaft will result in a change of approximately 3.9 volts in the position sensor reading. During normal operation the position sensor signal voltage will range between approximately 0.5 volts (closed) and 4.3 volts (open).

NOTE: **See the figures below for a typical current draw on the DC Motor and voltage reading of the sensor during the EGR Valve opening and closing. The red line represents current draw of the DC Motor and the black line represents the position sensor voltage.**





WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Engine run time longer than two minutes.
- Engine coolant temperature above 158B°F (70B°C).
- During a slight acceleration condition or steady state driving.

SET CONDITION

- During a slight acceleration condition, the PCM turns on the EGR Valve and monitors the reaction of the fuel trim. If the expected reaction is not detected, a fault is set.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EGR VALVE PASSAGE BLOCKED/RESTRICTED
EGR SYSTEM LEAK
EGR VALVE ASSEMBLY

Always perform the Pre-Diagnostic TROUBLESHOOTING PROCEDURE BEFORE PROCEEDING. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Go To 2
2. **CHECK THE VEHICLE'S REPAIR HISTORY**
    1. Check the history of the vehicle for previous EGR Valve performance related DTCs within the past 90 days.

        Does the repair history show that the vehicle was in dealership for a EGR Valve performance fault within the past 90 days?

        Yes, and the EGR Valve was cleaned during the previous visit

        - Verify that the connector is completely connected. Check the connector terminals for any pushed out, corroded or spread terminals causing a poor or intermittent connection. If the connector is good, replace the EGR Valve Assembly in accordance with the Service Information. Refer to **VALVE, EXHAUST GAS RECIRCULATION (EGR), REMOVAL AND INSTALLATION** . The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        Yes, and the EGR Valve was replaced during the previous visit

        - Verify that the connector is completely connected. Check the connector terminals for any pushed out, corroded or spread terminals causing a poor or intermittent connection. If the connector is good, Clean the valve by running Mopar Combustion Chamber cleaner through the engine. The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine. Test drive the vehicle and verify the DTC does not return. If the fault does not return, check the engine for any fuel or air handling issues that can cause excessive soot or carbon buildup in the engine.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Test complete. Verify that the connector is completely connected. Check the connector terminals for any pushed out, corroded or spread terminals causing a poor or intermittent connection. The EGR Valve may have had carbon or been sooted up temporarily. Clean the valve by running Mopar Combustion Chamber cleaner through the engine. The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine. Test drive the vehicle and verify the DTC does not return.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

    Are there any EGR Valve Position Sensor or EGR Valve Control circuit DTCs present?

    Yes

    - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

    No

    - Go To 4
4. **CHECK THE EGR SYSTEM FOR LEAKS**
    1. Turn the ignition off.
    2. Visually inspect the entire EGR system for signs of a leak. Look for signs of soot around mounting surfaces and connection points in the system.

    Does the EGR system show signs of any leaks?

    Yes

    - Repair the leaks in the EGR system. Test drive the vehicle and verify the DTC does not return.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5
5. **CHECK THE EGR VALVE FOR CARBON OR SOOT BUILD UP**
    1. Turn the ignition off.
    2. Remove the EGR Valve Assembly.
    3. Visually inspect the EGR Valve stem, disc and passages for signs of damage or excessive carbon build up.

    Does the EGR Valve show signs of excessive carbon or soot build up?

    Yes

    - Clean and reinstall the EGR Valve Assembly. The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine. Test drive the vehicle and verify the DTC does not return.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Replace the EGR Valve Assembly in accordance with the Service Information. Refer to **VALVE, EXHAUST GAS RECIRCULATION (EGR), REMOVAL AND INSTALLATION** . The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0404-EGR POSITION SENSOR PERFORMANCE

For a complete EGR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

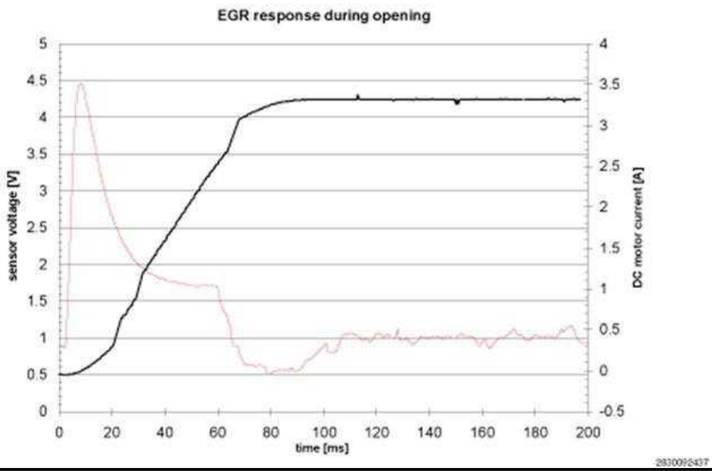
THEORY OF OPERATION

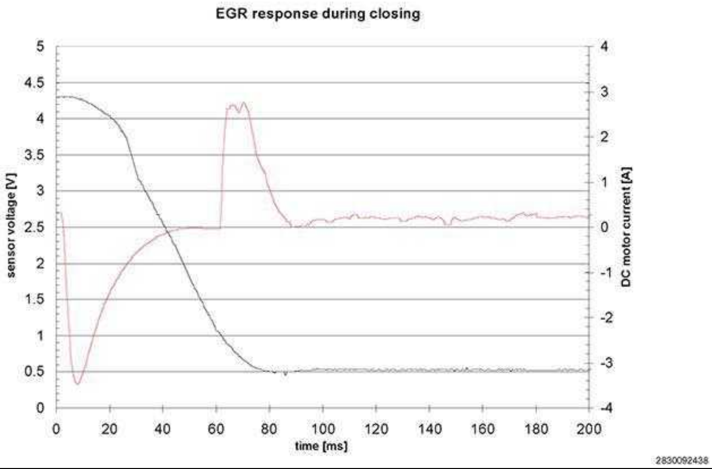
The Cooled Exhaust Gas Recirculation (EGR) Valve Assembly contains an electric Direct Current (DC) Motor and a gear box. An eccentric drive translates the gearbox output from a rotating motion (DC Motor) to a linear stroke (output shaft). The full range of travel of the shaft is approximately 5.0 mm from a fully closed to fully open position. An internal return spring ensures that the valve returns back to its closed position as a fail safe. The EGR Valve is controlled by the Powertrain Control Module (PCM) H-Bridge driver. The H-Bridge operates the DC Motor using a Pulse Width Modulation (PWM) control to help reduce current draw. This helps protect the DC Motor from overheating and reduces electrical load on the system voltage.

- During initial opening of the EGR Valve the PCM drives the Pulse Width Modulation (PWM) voltage high resulting in a high current draw. After the valve is fully opened the PCM voltage is reduced to maintain the EGR Valve position. This reduces the current draw and protects from overheating the DC Motor.
  - The PCM monitors the temperature and current draw of the DC Motor inside EGR Valve and will adjust the duty cycle to prevent the EGR Valve windings from overheating. Typically, the peak current draw by the EGR Valve occurs during opening and the maximum current load for a typical application is approximately 6.0 amps. The duty cycle is adjusted after opening so that the typical average current draw is approximately 0.5 amps while holding the valve open.
- The PCM also applies a current in the closing direction to fulfill the required dynamic performance. This is done to control the closing speed of the shaft near the stop. This ensures that the valve does not close too fast causing the valve disk to be forced into the stop harshly which may damage the internal gearbox.

There is a position sensor located on the output shaft. The sensor operates as a typical three wire sensor, with a 5-Volt Supply, Sensor Signal, and Sensor Ground circuit. Full range of travel of the output shaft will result in a change of approximately 3.9 volts in the position sensor reading. During normal operation the position sensor signal voltage will range between approximately 0.5 volts (closed) and 4.3 volts (open).

NOTE: **See the figures below for a typical current draw on the DC Motor and voltage reading of the sensor during the EGR Valve opening and closing. The red line represents current draw of the DC Motor and the black line represents the position sensor voltage.**





WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running for more than one minute.
- The PCM has performed and passed the Zero Learn diagnostic (P1404).
- Throttle input indicating an open throttle condition for more than approximately 2.0 seconds.
- The EGR Valve position is commanded open.
  - During normal operation the PCM monitors the difference between the EGR Valve open position actual and desired positions.

SET CONDITION

- If during the EGR Valve open position rationality test, the Powertrain Control Module (PCM) determines that the difference between the EGR Valve actual position and desired position is greater that a calibrated threshold, a fault is detected.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED
EXCESSIVE EGR WINDING TEMPERATURE
EGR VALVE ASSEMBLY STICKING
EGR VALVE ASSEMBLY

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Go To 2
2. **CHECK THE VEHICLE'S REPAIR HISTORY**
    1. Check the history of the vehicle for previous EGR Valve performance related DTCs within the past 90 days.

        Does the repair history show that the vehicle was in dealership for a EGR Valve performance fault within the past 90 days?

        Yes, and the EGR Valve was cleaned during the previous visit

        - Verify that the connector is completely connected. Check the connector terminals for any pushed out, corroded or spread terminals causing a poor or intermittent connection. If the connector is good, replace the EGR Valve Assembly in accordance with the Service Information. Refer to **VALVE, EXHAUST GAS RECIRCULATION (EGR), REMOVAL AND INSTALLATION** . The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        Yes, and the EGR Valve was replaced during the previous visit

        - Verify that the connector is completely connected. Check the connector terminals for any pushed out, corroded or spread terminals causing a poor or intermittent connection. If the connector is good, Clean the valve by running Mopar Combustion Chamber cleaner through the engine. The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine. Test drive the vehicle and verify the DTC does not return. If the fault does not return, check the engine for any fuel or air handling issues that can cause excessive soot or carbon buildup in the engine.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Test complete. Verify that the connector is completely connected. Check the connector terminals for any pushed out, corroded or spread terminals causing a poor or intermittent connection. The EGR Valve may have been carboned/sooted up temporarily. Clean the valve by running Mopar Combustion Chamber cleaner through the engine. The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine. Test drive the vehicle and verify the DTC does not return.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT FOR PROPER VOLTAGE AT THE EGR VALVE SENSOR HARNESS CONNECTOR**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
   3. Turn the ignition on.
   4. Set the DVOM to measure DC voltage.
   5. Connect the negative lead of the DVOM to a known good ground.
   6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **Normal operating voltage should be between 4.8 and 5.2 volts.**

   Does the circuit have the proper voltage present?

   Yes

   - Go To 4

   No

   - Repair the (F856) 5-Volt Supply circuit for an open or short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE EGR VALVE FOR CARBON OR SOOT BUILD UP**
   1. Turn the ignition off.
   2. Remove the EGR Valve Assembly.
   3. Visually inspect the EGR Valve stem, disc and passages for signs of damage or excessive carbon build up.

Does the EGR Valve show signs of excessive carbon or soot build up?

Yes

- Clean and reinstall the EGR Valve Assembly. The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine. Test drive the vehicle and verify the DTC does not return.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Replace the EGR Valve Assembly in accordance with the Service Information. Refer to **VALVE, EXHAUST GAS RECIRCULATION (EGR), REMOVAL AND INSTALLATION** . The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

DIAGNOSIS AND TESTING

P0405-EGR POSITION SENSOR CIRCUIT LOW

For a complete EGR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

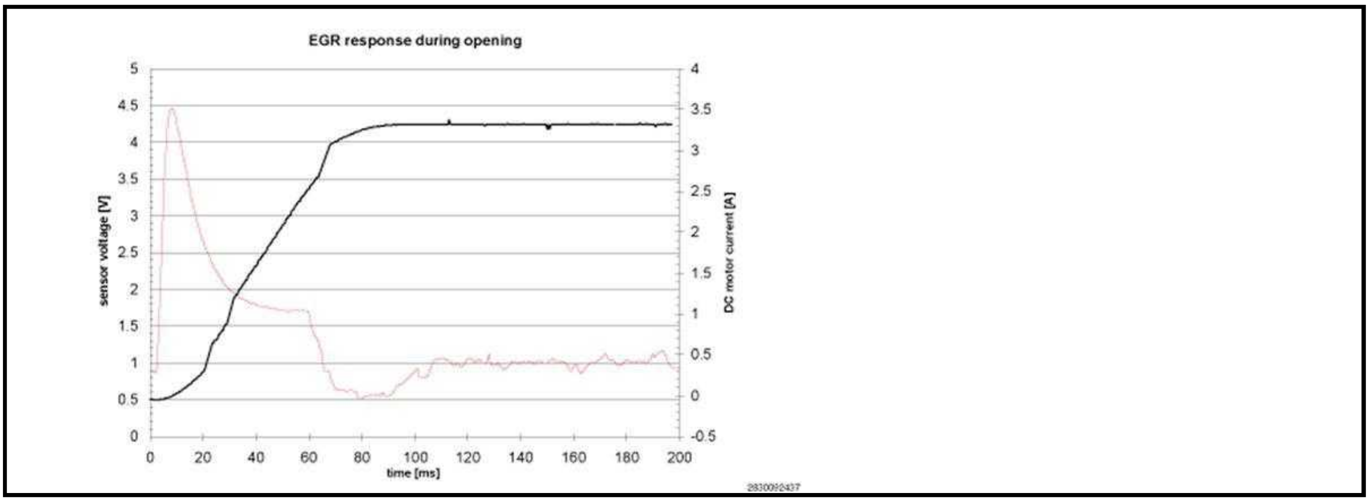
THEORY OF OPERATION

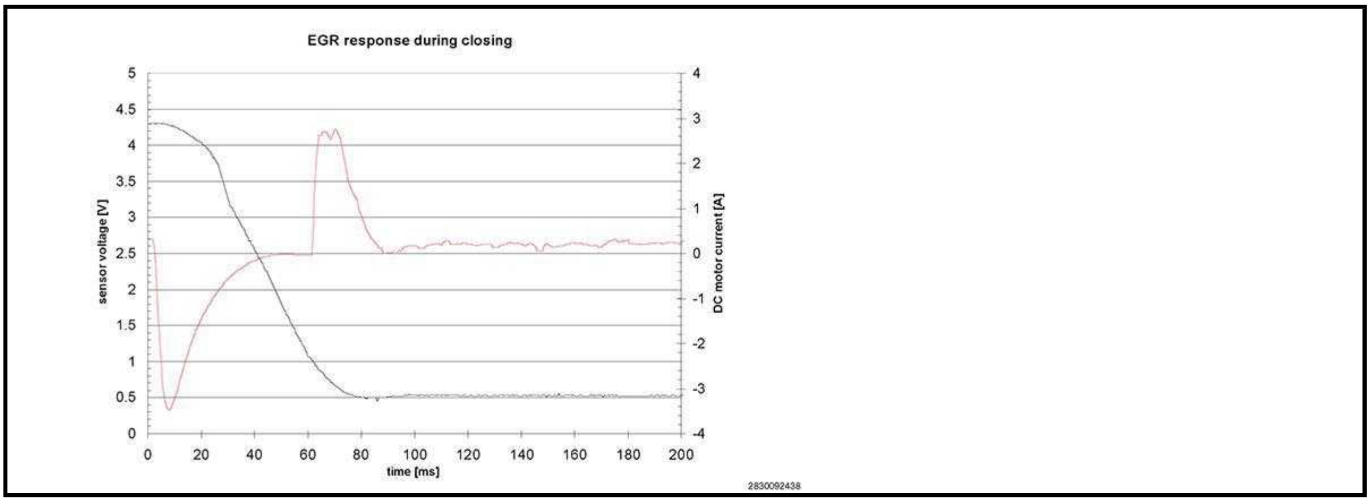
The Cooled Exhaust Gas Recirculation (EGR) Valve Assembly contains an electric Direct Current (DC) Motor and a gear box. An eccentric drive translates the gearbox output from a rotating motion (DC Motor) to a linear stroke (output shaft). The full range of travel of the shaft is approximately 5.0 mm from a fully closed to fully open position. An internal return spring ensures that the valve returns back to its closed position as a fail safe. The EGR Valve is controlled by the Powertrain Control Module (PCM) H-Bridge driver. The H-Bridge operates the DC Motor using a Pulse Width Modulation (PWM) control to help reduce current draw. This helps protect the DC Motor from overheating and reduces electrical load on the system voltage.

- During initial opening of the EGR Valve the PCM drives the Pulse Width Modulation (PWM) voltage high resulting in a high current draw. After the valve is fully opened the PCM voltage is reduced to maintain the EGR Valve position. This reduces the current draw and protects from overheating the DC Motor.
    - The PCM monitors the temperature and current draw of the DC Motor inside EGR Valve and will adjust the duty cycle to prevent the EGR Valve windings from overheating. Typically, the peak current draw by the EGR Valve occurs during opening and the maximum current load for a typical application is approximately 6.0 amps. The duty cycle is adjusted after opening so that the typical average current draw is approximately 0.5 amps while holding the valve open.
- The PCM also applies a current in the closing direction to fulfill the required dynamic performance. This is done to control the closing speed of the shaft near the stop. This ensures that the valve does not close too fast causing the valve disk to be forced into the stop harshly which may damage the internal gearbox.

There is a position sensor located on the output shaft. The sensor operates as a typical three wire sensor, with a 5-Volt Supply, Sensor Signal, and Sensor Ground circuit. Full range of travel of the output shaft will result in a change of approximately 3.9 volts in the position sensor reading. During normal operation the position sensor signal voltage will range between approximately 0.5 volts (closed) and 4.3 volts (open).

NOTE: **See the figures below for a typical current draw on the DC Motor and voltage reading of the sensor during the EGR Valve opening and closing. The red line represents current draw of the DC Motor and the black line represents the position sensor voltage.**





WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage above approximately 10.4 volts.
- The Auto Shutdown (ASD) Relay is energized.

SET CONDITION

- The EGR Position Sensor signal voltage to the Powertrain Control Module (PCM) is below 0.1 volts.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EGR VALVE POSITION SENSOR SIGNAL CIRCUIT SHORTED TO GROUND
EGR VALVE POSITION SENSOR SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
EGR VALVE ASSEMBLY
POWERTRAIN CONTROL MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.

7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **ISOLATE AND CHECK THE EGR VALVE (K683) POSITION SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **ISOLATE AND CHECK THE EGR VALVE (K683) POSITION SIGNAL CIRCUIT FOR A SHORT TO THE (K900) SENSOR GROUND CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to**

pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between the circuits being tested.**

   Is there continuity between the circuits?

   Yes

   - Repair the short between the circuits.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **CONNECT A FUSED JUMPER BETWEEN THE EGR VALVE (K683) POSITION SIGNAL CIRCUIT AND THE (F856) 5-VOLT SUPPLY CIRCUIT AT THE EGR VALVE HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL CIRCUIT HIGH DTC**
   1. The Electronic Control Module (ECU) harness connectors must be connected to the ECU during this test step.
   2. Disconnect the sensor harness connector.
   3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the 5-Volt Supply circuit at the sensor harness connector.
   4. Turn the ignition on.
   5. With the scan tool, read DTCs.

   Does the scan tool display the SENSOR SIGNAL CIRCUIT HIGH DTC with the jumper in place?

   Yes

   - Replace the faulty sensor in accordance with the Service Information. Refer to **SENSOR, EGR TEMPERATURE, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.

- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0406-EGR POSITION SENSOR CIRCUIT HIGH

For a complete EGR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Cooled Exhaust Gas Recirculation (EGR) Valve Assembly contains an electric Direct Current (DC) Motor and a gear box. An eccentric drive translates the gearbox output from a rotating motion (DC Motor) to a linear stroke (output shaft). The full range of travel of the shaft is approximately 5.0 mm from a fully closed to fully open position. An internal return spring ensures that the valve returns back to its closed position as a fail safe. The EGR Valve is controlled by the Powertrain Control Module (PCM) H-Bridge driver. The H-Bridge operates the DC Motor using a Pulse Width Modulation (PWM) control to help reduce current draw. This helps protect the DC Motor from overheating and reduces electrical load on the system voltage.

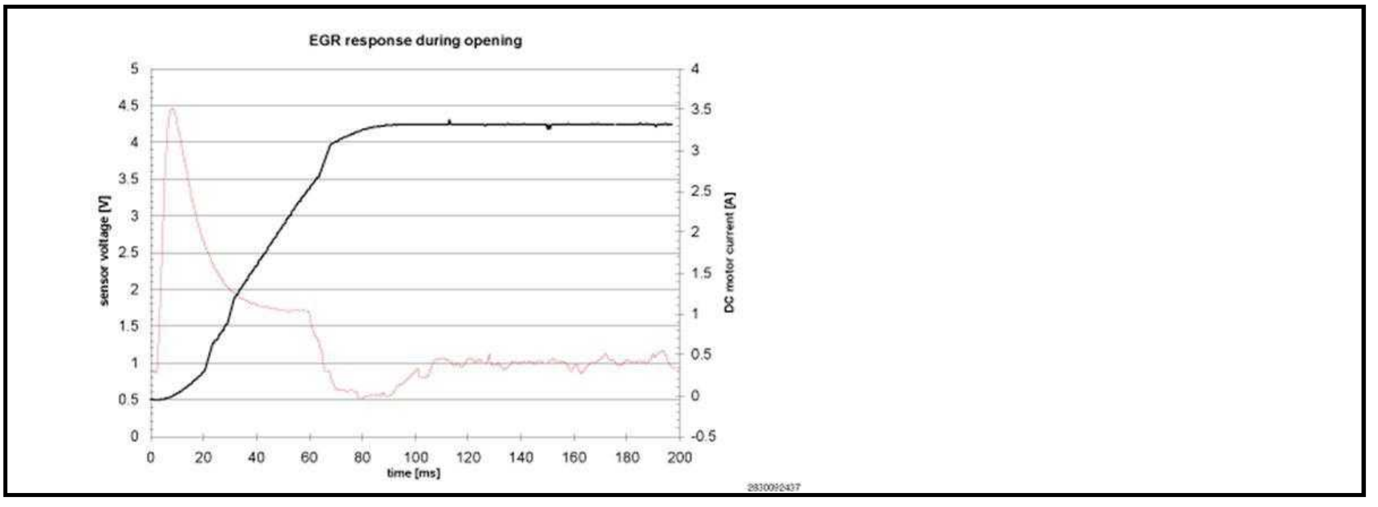
- During initial opening of the EGR Valve the PCM drives the Pulse Width Modulation (PWM) voltage high resulting in a high current draw. After the valve is fully opened the PCM voltage is reduced to maintain the EGR Valve position. This reduces the current draw and protects from overheating the DC Motor.
  - The PCM monitors the temperature and current draw of the DC Motor inside EGR Valve and will adjust the duty cycle to prevent the EGR Valve windings from overheating. Typically, the peak current draw by the EGR Valve occurs during opening and the maximum current load for a typical

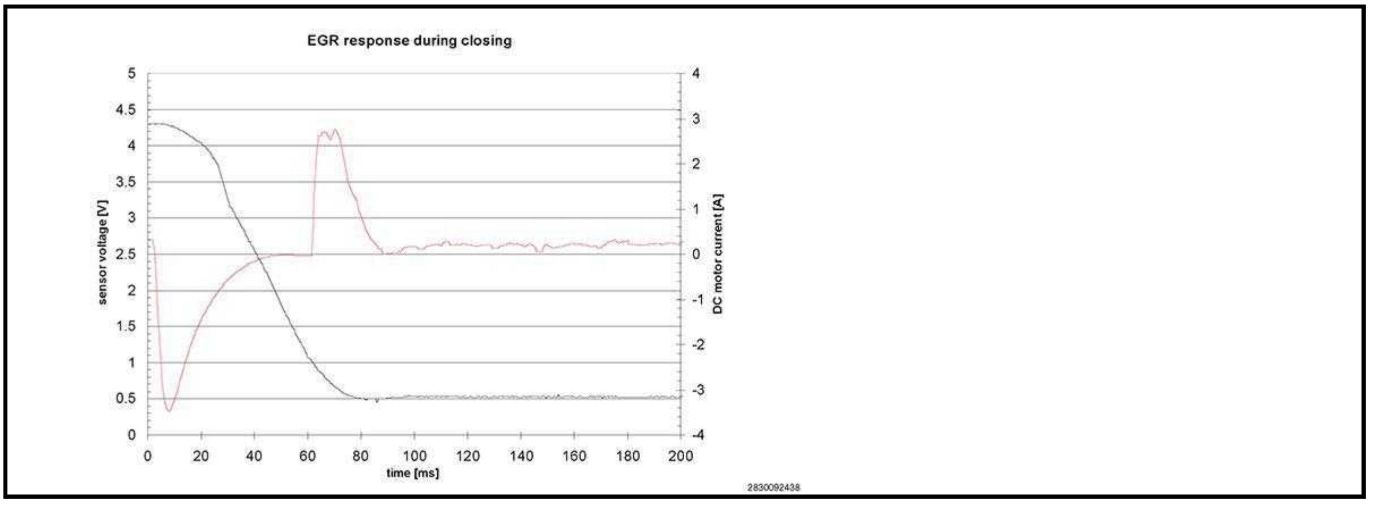
application is approximately 6.0 amps. The duty cycle is adjusted after opening so that the typical average current draw is approximately 0.5 amps while holding the valve open.

- The PCM also applies a current in the closing direction to fulfill the required dynamic performance. This is done to control the closing speed of the shaft near the stop. This ensures that the valve does not close too fast causing the valve disk to be forced into the stop harshly which may damage the internal gearbox.

There is a position sensor located on the output shaft. The sensor operates as a typical three wire sensor, with a 5-Volt Supply, Sensor Signal, and Sensor Ground circuit. Full range of travel of the output shaft will result in a change of approximately 3.9 volts in the position sensor reading. During normal operation the position sensor signal voltage will range between approximately 0.5 volts (closed) and 4.3 volts (open).

NOTE: See the figures below for a typical current draw on the DC Motor and voltage reading of the sensor during the EGR Valve opening and closing. The red line represents current draw of the DC Motor and the black line represents the position sensor voltage.





WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage above approximately 10.4 volts.
- The Auto Shutdown (ASD) Relay is energized.

SET CONDITION

- The EGR Position Sensor signal voltage to the Powertrain Control Module (PCM) is above 4.89 volts.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED
EGR VALVE POSITION SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE
EGR VALVE POSITION SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
EGR VALVE ASSEMBLY
POWERTRAIN CONTROL MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

    NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

    Is the voltage above 5.2 volts?

    Yes

- Go To 3

No

- Go To 4

3. **ISOLATE AND CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 9
4. **CHECK THE EGR VALVE (K683) POSITION SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

    NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

    Is the voltage above 5.2 volts?

    Yes

    - Go To 5

    No

    - Go To 6
5. **ISOLATE AND CHECK THE EGR VALVE (K683) POSITION SIGNAL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**

1. The ignition must be off when performing a resistance check to find a short between circuits.
2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 9

6. **ISOLATE AND CHECK THE EGR VALVE (K683) POSITION SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 7

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **ISOLATE AND CHECK THE (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

        NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 8

    No

    - Repair the circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CONNECT A FUSED JUMPER BETWEEN THE EGR VALVE (K683) POSITION SIGNAL CIRCUIT AND THE (K900) SENSOR GROUND CIRCUIT AT THE EGR VALVE HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL CIRCUIT LOW DTC**
    1. The Electronic Control Module (ECU) harness connectors must be connected to the ECU during this test step.
    2. Disconnect the sensor harness connector.
    3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the sensor ground circuit at the sensor harness connector.
    4. Turn the ignition on.
    5. With the scan tool, read DTCs.

    Does the scan tool display the SENSOR SIGNAL CIRCUIT LOW DTC with the jumper in place?

    Yes

- Replace the faulty sensor in accordance with the Service Information. Refer to **SENSOR, EGR TEMPERATURE, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 9

9. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P040B-EXHAUST GAS RECIRCULATION TEMPERATURE SENSOR 1 CIRCUIT PERFORMANCE

For a complete EGR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Exhaust Gas Recirculation (EGR) Temperature Sensor is positioned between the EGR Cooler and EGR Valve. The feedback signal from the sensor is used to monitor the cooling efficiency of the recirculated exhaust gases passing through the EGR Cooler Assembly. At lower temperatures the signal feedback voltage will read closer to the upper operating parameter. As the recirculated exhaust gas temperature increases, the signal feedback voltage will decrease toward the lower operating parameter.

There is a sensor rationality monitor that runs after a cold soak condition, at initial engine start up. When certain enable conditions are met, the Powertrain Control Module (PCM) will compare the EGR Temperature Sensor reading to the Engine Coolant Temperature (ECT), Ambient Air Temperature (AAT) Sensor readings for plausibility.

A second monitor will run when the EGR system is active to monitor the sensor plausibility. It works as follows: There is a small voltage difference between the upper operating parameter and the voltage threshold that will set a circuit high fault. The same is also true for the lower operating parameter and the voltage threshold that will set a circuit low fault. These small voltage windows are used for checking the coherency of the sensor. If the signal voltage reads in one of these windows, a sensor circuit performance fault will set.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- After an ignition off cold soak of 480 minutes.
- P0071, P0115, and P0116 DTCs are not active.
- After initial engine start up and the vehicle speed high enough to register an accurate Ambient Air Temperature Sensor reading.

SET CONDITION

- The difference between the EGR Temperature Sensor and either the ECT Sensor reading or AAT Sensor reading is greater than 15B°C (27B°F).

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
HIGH RESISTANCE IN THE EGR TEMPERATURE SENSOR SIGNAL CIRCUIT
HIGH RESISTANCE IN THE SENSOR GROUND CIRCUIT
EGR TEMPERATURE SENSOR
POWERTRAIN CONTROL MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **COMPARE TEMPERATURE SENSOR VALUES AFTER COLD SOAK**
    1. Turn the ignition off.
    2. Allow the vehicle to sit with the ignition off in an environment where the temperature is consistent and above -64B°C (-83B°F) until the engine coolant temperature is equal to ambient temperature.

3. Turn the ignition on.
4. With the scan tool, compare the Ambient Air Temperature (AAT), Engine Coolant Temperature (ECT), Intake Air Temperature (IAT) and Exhaust Gas Recirculation (EGR) Temperature Sensor values.

   Is the EGR Temperature Sensor value within 15B°C (27B°F) of the other sensor values?

   Yes

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

   No

   - Go To 2

2. **ISOLATE AND CHECK THE EGR TEMPERATURE SENSOR (K932) TEMP SIGNAL CIRCUIT FOR HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

      NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 3

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **ISOLATE AND CHECK THE (K900) SENSOR GROUND CIRCUIT FOR HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.

3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 4

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE ABILITY OF THE PCM TO READ THE EGR TEMPERATURE SENSOR SIGNAL**
   1. Turn the ignition off.
   2. Remove the GPEC Adaptor and reconnect the PCM C2 harness connector.
   3. Turn the ignition on.
   4. With the scan tool, read the EGR Temperature Sensor voltage.

      NOTE: **The-P04D0-COOLED EGR TEMPERATURE SENSOR CIRCUIT LOW should be displayed with the EGR Temperature Sensor harness connector disconnected.**

   5. Connect a jumper between the EGR Temperature Sensor (K932) Temp Signal circuit and the (K900) Sensor Ground circuit at the EGR Temperature Sensor harness connector.

      NOTE: **The-P04D1-COOLED EGR TEMPERATURE SENSOR CIRCUIT HIGH should be displayed with the jumper in place.**

   Does the scan tool display as described above?

   Yes

   - Replace the EGR Temperature Sensor in accordance with the service information. Refer to **SENSOR, EGR TEMPERATURE, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

- Go To 5

5. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0420-CATALYST SYSTEM EFFICIENCY BELOW THRESHOLD BANK 1

THEORY OF OPERATION

General Operation: The **State of Change (SOC)** catalyst monitor uses the signals from both the Upstream and Downstream Oxygen (O2) Sensors to detect aging of the catalyst. The Upstream O2 Sensor slow response monitor runs simultaneously to determine if the sensor signal is plausible. A pass/fail determination is made on the O2 Sensor slow response diagnostic before a catalyst determination is made to prevent a false fail of the catalyst monitor.

Catalyst Failure Rationality: The catalyst determination is based on the fact that when a catalyst ages it loses some of its Oxygen Storage Capacity (OSC). As a result, the exhaust gases can break through the catalyst causing the Downstream O2 Sensor to deviate from its relatively neutral baseline position to a higher **State of Change** value. In general, as more exhaust gases break through and lower the Oxygen Storage Capacity of the Catalytic Converter, the Downstream O2 Sensor **State of Change** will increase and get closer to the Upstream O2 Sensor **State of Change** . By observing and comparing the activity in the Downstream O2 Sensor signal located in the exhaust path downstream of the Catalytic Converter, with the Upstream O2 Sensor located before the catalyst the degradation level of catalyst can be detected.

Diagnostic Algorithm: To make the determination the Powertrain Control Module (PCM) monitors and compares the ratio between the Downstream O2 Sensor and the Upstream O2 Sensor over a calibrated period of time. **Typically, if the catalyst is working properly the ratio between the Downstream O2 Sensor and the Upstream O2 Sensor is approximately (0.2/1).** A simple way to understand this comparison is to understand that the shortest distance between two points is a straight line. Using this logic, if the sine wave signal of both sensors was recorded for a calibrated time period and straightened out for comparison, the length of the Downstream O2 Sensor line would only measure approximately 20% of the length of the Upstream O2 Sensor line. As the Catalytic Converter begins failing, the ratio will move towards 1/1. Typically, if the ratio becomes greater than a calibrated threshold, approximately 0.6/1, the PCM will consider the catalyst as failing and fault the system.

DIAGNOSTIC OVERVIEW - CATALYST SYSTEM

The PCM makes a determination of the Catalyst efficiency based on the comparison of the Upstream and Downstream O2 Sensors. Besides an obvious failed catalyst, there are other conditions that can cause the Catalyst Monitor to fail. These conditions should be considered and checked before replacing a Catalytic Converter.

- A leak in the exhaust system, especially before the Catalytic Converter can cause an the Upstream O2 Sensor to drift out of range or not switch properly and fail the Catalyst Monitor. Depending on the location of the leak, even a very small exhaust leak can cause the Catalyst Monitor to fail.
- The catalyst protects the Downstream O2 Sensor from fouling but the Upstream O2 Sensor is located directly in the output path of the cylinders and is not protected. An engine that has a mechanical failure causing it to burn oil, coolant or excessive fuel can foul the Upstream O2 Sensor and cause the Catalyst Monitor to fail.
- A new Downstream O2 Sensor paired with an aging Upstream O2 Sensor can sometimes cause the Catalyst Monitor to fail.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- No other O2 Sensor circuit faults active.
- There are several different catalyst efficiency monitoring windows. Each specific window has several different enable conditions. The best opportunity for the catalyst efficiency monitor to run is:
  - Engine temperature above 70B°C (158B°F).
  - Engine speed between approximately 1000 rpm and 3000 rpm.
  - Vehicle speed between 20 mph and 85 mph, under moderate engine load.

SET CONDITION

- The Powertrain Control Module (PCM) detects a failed catalyst if the final Downstream O2 Sensor state of change test ratio is within the calibrated fail threshold.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EXHAUST LEAK
ENGINE MECHANICAL CONDITION
AGING OR FOULED UPSTREAM O2 SENSOR
CATALYTIC CONVERTER

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any Upstream or Downstream O2 Sensor signal or heater circuit DTCs present?

        Yes

        - Perform the applicable O2 Sensor diagnostic procedure(s) before continuing with this diagnostic procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **VISUALLY INSPECT CATALYTIC CONVERTER**
    1. Inspect the Catalytic Converter inlet and outlet for the following damage:
        - Physical damage (dents or holes) to the Catalytic Converter.
        - Catalytic Converter leaking.

- Catalytic Converter internally broken.
- Severe discoloration caused by overheating the Catalytic Converter.

Were any problems found?

Yes

- Repair the condition that may have caused the failure and replace the Catalytic Converter in accordance with the Service Information. Refer to **CONVERTER, CATALYTIC, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **CHECK THE EXHAUST SYSTEM FOR LEAKS**
    1. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

    Were any exhaust leaks found?

    Yes

    - Repair or replace the leaking exhaust components as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

5. **CHECK THE ENGINE MECHANICAL CONDITION**
    1. Check the exhaust for excessive smoke caused by an internal problem in the engine.

    Is an engine mechanical condition present?

    Yes

    - Repair the engine mechanical condition as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 6

6. **CHECK FOR AN AGING UPSTREAM O2 SENSOR AND NEW DOWNSTREAM O2 SENSOR**

    NOTE: **A new Downstream O2 Sensor along with an aging Upstream O2 Sensor may cause the DTC to set.**

    1. Review the vehicles repair history.

    Has the Downstream O2 Sensor been replaced without replacing the Upstream O2 Sensor?

    Yes

- Replace the Upstream O2 Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **REPLACE THE CATALYTIC CONVERTER**

   If there are no possible causes remaining, view repair.

   Repair

   - Replace the Catalytic Converter in accordance with the Service Information. Refer to **CONVERTER, CATALYTIC, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0430-CATALYST SYSTEM EFFICIENCY BELOW THRESHOLD BANK 2

THEORY OF OPERATION

General Operation: The **State of Change (SOC)** catalyst monitor uses the signals from both the Upstream and Downstream Oxygen (O2) Sensors to detect aging of the catalyst. The Upstream O2 Sensor slow response monitor runs simultaneously to determine if the sensor signal is plausible. A pass/fail determination is made on the O2 Sensor slow response diagnostic before a catalyst determination is made to prevent a false fail of the catalyst monitor.

Catalyst Failure Rationality: The catalyst determination is based on the fact that when a catalyst ages it loses some of its Oxygen Storage Capacity (OSC). As a result, the exhaust gases can break through the catalyst causing the Downstream O2 Sensor to deviate from its relatively neutral baseline position to a higher **State of Change** value. In general, as more exhaust gases break through and lower the Oxygen Storage Capacity of the Catalytic Converter, the Downstream O2 Sensor **State of Change** will increase and get closer to the Upstream O2 Sensor **State of Change** . By observing and comparing the activity in the Downstream O2 Sensor signal located in the exhaust path downstream of the Catalytic Converter, with the Upstream O2 Sensor located before the catalyst the degradation level of catalyst can be detected.

Diagnostic Algorithm: To make the determination the Powertrain Control Module (PCM) monitors and compares the ratio between the Downstream O2 Sensor and the Upstream O2 Sensor over a calibrated period of time. **Typically, if the catalyst is working properly the ratio between the Downstream O2 Sensor and the Upstream O2 Sensor is approximately (0.2/1).** A simple way to understand this comparison is to understand that the shortest distance between two points is a straight line. Using this logic, if the sine wave signal of both sensors was recorded for a calibrated time period and straightened out for comparison, the length of the Downstream O2 Sensor line would only measure approximately 20% of the length of the Upstream O2 Sensor line. As the Catalytic Converter begins failing, the ratio will move towards 1/1. Typically, if the ratio becomes greater than a calibrated threshold, approximately 0.6/1, the PCM will consider the catalyst as failing and fault the system.

DIAGNOSTIC OVERVIEW - CATALYST SYSTEM

The PCM makes a determination of the Catalyst efficiency based on the comparison of the Upstream and Downstream O2 Sensors. Besides an obvious failed catalyst, there are other conditions that can cause the Catalyst Monitor to fail. These conditions should be considered and checked before replacing a Catalytic Converter.

- A leak in the exhaust system, especially before the Catalytic Converter can cause an the Upstream O2 Sensor to drift out of range or not switch properly and fail the Catalyst Monitor. Depending on the location of the leak, even a very small exhaust leak can cause the Catalyst Monitor to fail.

- The catalyst protects the Downstream O2 Sensor from fouling but the Upstream O2 Sensor is located directly in the output path of the cylinders and is not protected. An engine that has a mechanical failure causing it to burn oil, coolant or excessive fuel can foul the Upstream O2 Sensor and cause the Catalyst Monitor to fail.
- A new Downstream O2 Sensor paired with an aging Upstream O2 Sensor can sometimes cause the Catalyst Monitor to fail.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- No other O2 Sensor circuit faults active.
- There are several different catalyst efficiency monitoring windows. Each specific window has several different enable conditions. The best opportunity for the catalyst efficiency monitor to run is:
  - Engine temperature above 70B°C (158B°F).
  - Engine speed between approximately 1000 rpm and 3000 rpm.
  - Vehicle speed between 20 mph and 85 mph, under moderate engine load.

SET CONDITION

- The Powertrain Control Module (PCM) detects a failed catalyst if the final Downstream O2 Sensor state of change test ratio is greater than the calibrated fail threshold.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EXHAUST LEAK
ENGINE MECHANICAL CONDITION
AGING OR FOULED O2 SENSOR
CATALYTIC CONVERTER

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any Upstream or Downstream O2 Sensor DTCs present?

       Yes

       - Perform the applicable O2 Sensor diagnostic procedure(s) before continuing with this diagnostic procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 3
3. **VISUALLY INSPECT CATALYTIC CONVERTER**
    1. Inspect the Catalytic Converter inlet and outlet for the following damage:
       - Physical damage (dents or holes) to the Catalytic Converter.
       - Catalytic Converter leaking.
       - Catalytic Converter internally broken.
       - Severe discoloration caused by overheating the Catalytic Converter.

       Were any problems found?

       Yes

       - Replace the Catalytic Converter. Repair the condition that may have caused the failure. Refer to **CONVERTER, CATALYTIC, REMOVAL AND INSTALLATION** .
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 4
4. **CHECK THE EXHAUST SYSTEM FOR LEAKS**
    1. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

       Were any exhaust leaks found?

       Yes

       - Repair or replace the leaking exhaust parts as necessary.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 5
5. **CHECK THE ENGINE MECHANICAL CONDITION**

1. Check the exhaust for excessive smoke caused by an internal problem in the engine.

   Is an engine mechanical condition present?

   Yes

   - Repair the engine mechanical condition as necessary.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6

6. **CHECK FOR AN AGING UPSTREAM O2 SENSOR AND NEW DOWNSTREAM O2 SENSOR**

   NOTE: **A new Downstream O2 Sensor along with an aging Upstream O2 Sensor may cause the DTC to set.**

   1. Review the vehicles repair history.

      Has the Downstream O2 Sensor been replaced without replacing the Upstream O2 Sensor?

      Yes

      - Replace the front O2 Sensor as necessary. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 7

7. **REPLACE THE CATALYTIC CONVERTER**

   If there are no possible cause remaining, view repair.

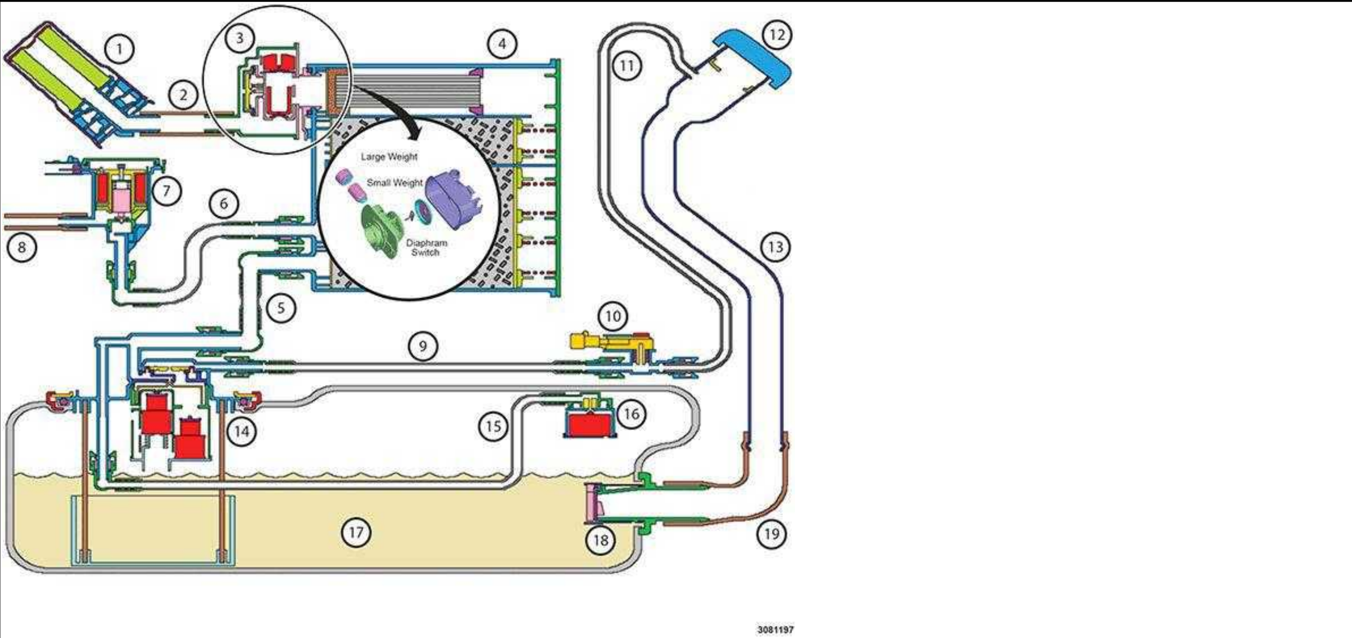
   Repair

   - Replace the Catalytic Converter in accordance with the Service Information. Refer to **CONVERTER, CATALYTIC, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0440-GENERAL EVAP SYSTEM FAILURE

For a complete EVAPORATIVE EMISSIONS SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION



EVAP SYSTEM COMPONENTS			
CALLOUT	DESCRIPTION	CALLOUT	DESCRIPTION
1	Filter - Fresh Air Inlet	11	Recirculation Tube (metal portion) (FTPS to Fuel Filler Tube)
2	Filter Hose (Filter to ESIM)	12	Gas Cap or Cap-less Refueling Unit (if equipped)
3	Evaporative System Integrity Monitor (ESIM)	13	Fuel Filler Tube
4	Evaporative Charcoal Canister	14	Multi-Function Control Valve (MFCV) in the Fuel Delivery Flange
5	Canister Tube (Fuel Tank to Canister)	15	GVV Tube (GVV to MFCV)
6	Purge Tube (Purge Solenoid to Canister)	16	Grade Vent Valve (GVV)
7	Purge Solenoid	17	Fuel Tank
8	Manifold Hose (Purge Solenoid to Engine Manifold)	18	Inlet Check Valve (ICV)
9	Recirculation Tube (Fuel Tank to FTPS)	19	Hose - Fuel Filler Tube to ICV
10	Fuel Tank Pressure Sensor (FTPS)	-	-

EVAPORATIVE SYSTEM OVERVIEW: The Powertrain Control Module (PCM) monitors the Evaporative Emission System operation. The two main areas being monitored are the integrity of the system against leaks and the ability of the system to purge fuel vapor from the canister to the Intake Manifold. The basic strategy used is that in a **sealed system** , pressure will naturally increase or decrease in relation to temperature. **The Evaporative System Integrity Monitor (ESIM) Switch is used for all leak fault detection.** There is a vacuum actuated switch that closes when the vacuum reaches a calibrated threshold. If the switch closes it indicates that the system is not leaking.

ESIM SWITCH STUCK CLOSED MONITOR: At ignition off, the state of the ESIM Switch is evaluated. If the switch is open, a pass flag will set so the PCM power down process can complete. If the switch is closed, the PCM will wait a calibrated delay time and open the Purge Solenoid. In a normally functioning system, this will relieve the vacuum trapped in the Charcoal Canister allowing the switch to open. When the switch opens, a pass flag is set and the PCM will power down. If the ESIM switch does not open, after a calibrated time, an error is detected and a switch stuck closed failure event is set **(P0452)** . Two consecutive failed events will mature a fault.

SMALL LEAK MONITOR: This is an accumulative monitor and the data from each valid event is recorded and added to the previously recorded events. The PCM timer records the engine on/drive cycle and engine off time for each small leak monitor event. For an event to be valid the PCM must see;

1. An engine on/drive cycle for a minimum of 2-5 minutes.

   NOTE: The Engine on timer is clipped to a maximum of 26 minutes on any given trip.

2. And, when the engine is shut down, an engine off timer starts. There is a 12 minute delay time in which the PCM will ignore ESIM Switch input. The engine off timer period will continue to count until one of the three conditions exist:
   - The engine is started without a switch closure during the event.

     NOTE: At the next key on cycle a determination is made as to whether the event was valid and the information is kept.

   - An ESIM Switch closed input is received after the 12 minute delay during the event.

     NOTE: If the switch closed input is received, the PCM records that the switch has closed and stores the engine shut down time.

   - After a maximum time of 17.5 hours without an ESIM Switch closure during the event.

This monitor will **increment** the **accumulation fail timers** until **both** have reached a calibrated threshold (Engine on - 100 minutes and Engine off - 70 hours). When the monitor records a valid **switch closure (small leak passing event)** the fail timers are reset.

LEAK SIZE DETERMINATION: If the PCM did not see an ESIM Switch closed signal during the previous ignition off cycle, the event was valid, and there is a cold start, an intrusive leak test is run to determine if a large leak is present. Immediately after start-up, while the engine is cold the Purge Solenoid is opened to create vacuum in the evaporative system to a calibrated vacuum point that is beyond the ESIM Switch closing threshold. **The pass/fail time will vary based on the total fuel volume at the time of the test.**

- If the switch does not close at all during purging, because of a switch that is stuck open or vacuum cannot be created below -250 Pa within a calibrated time, it is determined to be a general evaporative system failure **(P0440)** .
- If vacuum is created and the switch has closed, the Purge Solenoid is commanded off and the PCM monitors the switch closure time. If the switch opens before a calibrated threshold, a large leak is present. Two consecutive failure events will mature a fault **(P0455).**
- If vacuum is created and the switch has closed, the Purge Solenoid is commanded off and the PCM monitors the switch closure time. If the switch stays closed longer than a calibrated threshold, it is determined that a large leak is not present. If the Large Leak diagnostic does not fail before the accumulated small leak timer reaches it's threshold it is determined that a small leak is present **(P0456).**

NOTE: It is important to understand how extreme temperature changes can effect your results when diagnosing the system. It can either mask a leak by creating vacuum too rapidly temporarily overcoming the leak, or make a sealed system appear to be leaking due to excessive vapor build-up decaying vacuum too rapidly. This could be from the vehicle heat soaking after a long drive cycle or being brought into a shop environment that is vastly different from the outside environment. Be aware of these factors when performing the system checks in the test below.

NOTE: It is usually best to analyze the entire Evap System components and wiring regardless of the DTC present. A sealed system will create vacuum as it cools or pressure as it heats up. Even a slight temperature change will cause the

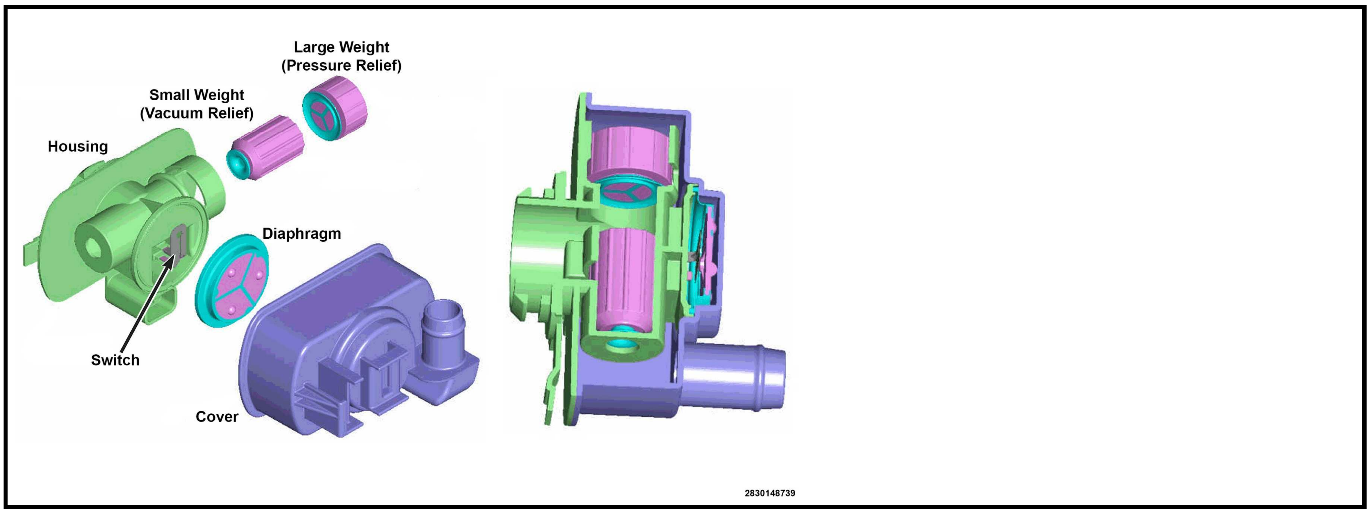
system to build pressure or create vacuum if the system is sealed and not leaking. We will use this principle in the test steps below to diagnose the system by monitoring the ESIM signal, Fuel Tank Pressure (FTP) Sensor signal and Purge Solenoid duty cycle with the scan tool while performing a few simple checks to help in determining if in fact the system is failing, and to possibly pin point the cause of the issue before disassembling any components.

NOTE: **The Fuel Tank Pressure Sensor is not used by the PCM in determining a leak but can be used to help in diagnosing the system.**

COMPONENT FUNCTIONAL DESCRIPTION - EVAPORATIVE SYSTEM INTEGRITY MODULE (ESIM) AND SWITCH

FUNCTIONAL OPERATION OF THE ESIM: The ESIM is configured with a normally open vacuum switch and normally closed vacuum relief and pressure relief valves (see figure). **The PCM uses the ESIM for all system leak diagnostics (P0440, P0455 and P0456).** The relief valves regulate the system pressure between approximately 1" H2O and -2" H2O (250Pa and -500Pa).

- When the system vacuum reaches between (-187Pa) and (-250Pa) it acts on the diaphragm and closes the vacuum switch. When the switch closes it allows continuity between the terminals. This allows the **ESIM Signal** to pass through the switch, pulling the signal low to ground. The PCM monitors the signal to determine the state of the switch (open or closed). The ESIM Signal will typically be a 12.0 volt or 5.0 volt signal depending on the vehicle. The voltage signals can vary between vehicles and may be somewhere between 5.0 and 12.0 volts. **Basically, when the PCM reads voltage on the signal circuit it determines the switch is open and when the signal is pulled low it determines the switch is closed.**
- The vacuum relief valve is intended to maintain the seal on the system during engine off events. However if the vacuum exceeds the regulation point the valve will pull off the seat to protect the system from excessive vacuum conditions.
- The pressure relief valve limits any pressure build up in the Fuel Tank during refueling and allows the tank pressure to normalize during increasing temperature events. This is additionally beneficial because it achieves a switch closed (pass threshold) sooner than if the tank has to decay from a much higher pressure.



WHEN MONITORED

This diagnostic runs when the following conditions are met:

- After engine start up and the ESIM Switch did not close during a previous ignition off event that was valid. Must be a cold start and the following are true:
  - The difference between the ECT and AAT inputs is less than 10B°C (19B°F).
  - Fuel Level between 12% and 88%.
  - Manifold vacuum greater than a calculated minimum value.

- Ambient temperature between 4B°C and 35B°C (40B°F and 95B°F).

SET CONDITION

- The Powertrain Control Module (PCM) initiates an intrusive test to determine the leak size. This DTCs sets when the ESIM Switch did not close during the test period.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EVAP PURGE SOLENOID VACUUM SUPPLY
EVAP PURGE TUBE OBSTRUCTION
OBSTRUCTION IN THE VENT HOSE OR FILTER
ESIM ORIENTATION OR INSTALLED INCORRECTLY
LARGE EVAPORATIVE EMISSION LEAK
ESIM SIGNAL CIRCUIT OPEN
ESIM GROUND CIRCUIT OPEN
EVAPORATIVE SYSTEM INTEGRITY MONITOR (ESIM) SWITCH STUCK OPEN
EVAP PURGE SOLENOID
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS THAT APPLY**
   1. Before proceeding with this test procedure, perform any Service Bulletins or PCM Flash updates that relate to this fault code.

      Are there any Service Bulletins or PCM Flash updates available?

      Yes

      - Perform the applicable Service Bulletins or PCM Flash update.
      - Verify the system is operating properly by testing the system, Go To 2

      No

      - Go To 2
2. **PERFORM A MANUAL EVALUATION OF THE EVAP SYSTEM FOR A LEAK**

   NOTE: **For best results when testing the Fuel Tank should have less than 95% of Fuel Tank capacity.**

   NOTE: **The results of these checks are subjective, not absolute. They can vary based on the size of the Fuel Tank and system, fuel volume, barometric pressure, ambient and fuel temperature. These conditions should be accounted for when analyzing the results and making your determination if the system has a leak.**

1. There are 5 test phases that will be performed. The timing of each phase is important. Take time to read and understand each phase before beginning the test. There are three data reads in the Data Display tab of the scan tool that are referenced to monitor and document during this test.
    - Purge Duty Cycle % - This is monitored to determine if purging is on or off
    - ESIM Switch State
    - Fuel Tank Pressure: Pa
2. The short or simple version of the 5 phases are as follows:
    1. Vent the system and document the ESIM and FTP Sensor data reads.
    2. Monitor and document the ESIM state and FTP Sensor data reads for 2-3 minutes.
    3. Start the engine and document the ESIM state and FTP Sensor data reads immediately after engine starts (before purge is active).
    4. Allow purging to become active just long enough to create maximum vacuum and document the ESIM state and FTP Sensor data.
    5. Turn engine off, monitor and document the ESIM state and FTP Sensor data reads for 3-4 minutes.

NOTE: **These are explained in more detail below along with helpful tips and alternative methods for some of the test phases to try and account for all possible systems and functionalities. Compare the results of each phase to the expected results and possible failures in the table below.**

3. **Test Phase 1 (Check Zero Reference of FTP Sensor):** With the ignition on vent the system to atmosphere and monitor the data reads. Document the ESIM Switch state and Fuel Tank Pressure Sensor reading.
    - This can be done by removing the gas cap, opening the capless filler or actuating the purge solenoid **for one minute** with the scan tool. Actuating the purge solenoid allows not disturbing any components that could be a possible leak point. However, it does not vent quickly on all systems and can take a minute to reach atmosphere.
    - **The FTP sensor reading may not be exactly at zero.** This is normal. Whatever the reading is when it is vented is the zero reference.
4. **Test Phase 2 (Non-intrusive leak check):** Monitor readings for 2-3 minutes with ignition on, engine not running, after the system is closed. Document the Fuel Tank Pressure Sensor reading.
    - Even if the system appears to be normal and not leaking at this point it is best to continue to check the operation of the entire system.
    - A change of more than 200 Pa in 1 minute would indicate the system is too unstable to accurately test.
5. **Test Phase 3 (Purge Solenoid leak check):** Start the engine and monitor and document the ESIM Switch state and Fuel Tank Pressure Sensor reading within 5-10 seconds after the engine is started while the **purge solenoid is off** .
    - A small amount of vacuum is created due to fuel being pulled from the tank. (Typically between approximately -25 and -50 Pa).
6. **Test Phase 4 (Starting the Intrusive leak check - Also checking ESIM Switch function and General Evap failure):** Allow purging to become active long enough to create maximum vacuum and stabilize. Shut off engine immediately after maximum vacuum is achieved. Should reach approximately -600 Pa. Document the ESIM Switch state and Fuel Tank Pressure Sensor reading.
    - This phase can be done several ways. It is important to get purging to happen in the shortest time possible to keep from generating too much heat in the fuel and Fuel Tank. This can cause the vacuum to decay too quickly in the next test phase and lead to misleading findings.
    - Engine purging is different for each engine and vehicle configuration. Some vehicles will start purging naturally shortly after engine is started. Other engines will need to have the engine speed increased for purging to happen.

- The recommended method would be to turn the engine off after writing down the ESIM Switch state and FTP Sensor reading in Test Phase 3. Navigate to the Systems Tests and run the "Purge Vapors System Test" and follow the on-screen instructions. Once purge is activated and vacuum is created turn the engine off and navigate back to the data reads in Data Display.

7. **Test Phase 5 (Intrusive leak check):** Once max vacuum is created and stable, turn off engine and monitor the FTP Sensor and ESIM Switch readings for an additional 3-4 minutes. Document the ESIM Switch state and Fuel Tank Pressure Sensor reading immediately after engine is turned off and after 3-4 minutes

   Analyze the results recorded from the scan tool or manual system tests above: Listed in the table are the expected results and various failures that can possibly occur

TEST PHASE	EXPECTED RESULTS	ACTUAL RESULTS / POSSIBLE FAILURES
1	ESIM Switch should be open and FTP sensor should read near zero.	If the ESIM switch is reading closed at this point it would indicate 1 of 3 failure modes. • The ESIM signal wire is shorted to ground. • The ESIM switch is stuck in the closed position. • Purge solenoid did not open if actuated. A good indication of this would be if the fuel tank pressure did not change as well.
2	The fuel tank pressure reading should start to slowly change positive or negative. **NOTE:** **More than a 200 Pa change in 1 minute would indicate the system is too unstable to accurately test.** If the system is not leaking it should start to slowly create pressure or vacuum depending on whether it is heating up or cooling down.	A steady value would indicate either a leak is present, or the system temperature is too stable to cause a change. **Continue testing to determine if system is leaking.** • A very rapid pressure change would indicate that the temperature change is too large causing an invalid result. **NOTE:** **This can occur if bringing a vehicle from outside during a cold ambient temp into a warm shop or very hot ambient temperature into a cooler shop condition. If the vehicle was at operating temperature it will create excessive**

TEST PHASE	EXPECTED RESULTS	ACTUAL RESULTS / POSSIBLE FAILURES
		heat in the system as well.
3	A small amount of vacuum is created due to fuel being pulled from the tank. (Typically is between approximately -25 and -50 Pa).	If vacuum is created instantly after engine is started near or below the ESIM regulation point (-500 PA) it would indicate that the purge solenoid is leaking. **NOTE:** **Since the purge performance diagnostics look for a delta change in the FTP Sensor signal when purge is commanded on, and again when it is commanded off, this condition may also cause a P0441-Purge System Performance fault to set.**
4	The fuel tank pressure should drop quickly to approximately -600 Pa and the ESIM Switch state changes to closed. **NOTE:** **It is normal for the vacuum to go slightly below the regulation point. when the engine is purging.**	• If the fuel tank pressure drops as expected but the ESIM switch does not close it would indicate that the switch is stuck open, or an open in the ESIM signal or ground circuit. **Note: This condition can also cause the P0440-General Evap System Failure DTC to set since that fault occurs when the ESIM switch does not close when the PCM performs the large leak diagnostic.** • If the ESIM switch closes but the fuel tank pressure changes very little or not at all it would indicate a restriction in one of the lines between the canister and FTP sensor or a faulty (stuck) sensor. Before condemning a sensor verify that the 5-Volt supply is present at the sensor. If the 5-Volt supply is not present to the sensor it can cause the sensor signal to stick mid-range and not change.

<table>
<tr><th>TEST PHASE</th><th>EXPECTED RESULTS</th><th>ACTUAL RESULTS / POSSIBLE FAILURES</th></tr>
<tr><td></td><td></td><td>If the ESIM switch does not close and the fuel tank pressure does not change or changes very little it would indicate either a very large leak or the purge solenoid is not opening when actuated. Note: This condition can also cause the P0440-General Evap System Failure DTC to set.
If the vacuum created is 2 to 3 times the expected reading it would indicate the Canister vent hose or fresh air filter are plugged or the ESIM vacuum vent valve is stuck closed. This would also lead to difficulty filling the Fuel Tank during refueling</td></tr>
<tr><td>5</td><td>The FTP Sensor reading should quickly return to the vacuum relief regulation point (approximately -500 Pa) and stabilize.

NOTE:
The weights can sometimes bounce when the purge solenoid is suddenly shut off causing the vacuum to drop below -500 Pa.

The vacuum should stay below approximately -250 Pa and the ESIM switch should remain closed for the additional 3-4 minutes of monitoring.</td><td>If the fuel tank pressure reading rises quickly near zero or above -250 Pa and the ESIM switch opens within the 3-4 minutes it would indicate that the system has a leak. Go To Refer to 3.
If the expected results were attained during each phase of testing the system is most likely not leaking at this time. Some possible causes for the false failure could be:
Software issues. Check for any Service Bulletins that may apply.
Debris was stuck in the purge solenoid or one of the ESIM relief valves that has since cleared.
The ESIM is not mounted correctly with the switch at the 3 o'clock position causing the relief valves not to seal properly.</td></tr>
</table>

3. **CHOOSE A METHOD TO LEAK CHECK THE EVAP SYSTEM**

   What is the preferred method to leak check the system?

   Leak test the entire system as a whole:

   - Go To 4

   Split the system at the Charcoal Canister and leak test:

   - Go To 5

4. **PERFORM THE EVAPORATIVE EMISSION LEAK DETECTION ON THE WHOLE SYSTEM**

1. To continue testing you will need the (special tool #8404C, Kit, EELD And Accessory).
2. Connect the red power lead of the EELD to the Battery positive terminal and the black ground lead to Battery negative terminal.
3. Connect shop air to the EELD.
4. Set the smoke/air control switch to **AIR** to pressurize the system.
5. Press the remote smoke/air start button.
6. Block off the end of the tester's AIR supply tip (clear hose) while pressing the remote start button.

NOTE: **The indicator ball should be resting on the bottom of the air flow meter (this is calibrated to no leak present) if the EELD is calibrated correctly.**

7. If the indicator ball is not resting on the bottom of air flow meter, position the red flag on the air flow meter so it is aligned with ball.
8. Connect the service adapter (special tool #8404-ADP, Smoke Machine Adapters) to the ESIM vent hose.
9. Connect the **AIR** supply tip (clear hose) to the adapter.
10. Press the remote button to activate **AIR flow.**

NOTE: **Depending on the vehicles fuel level, or vehicle venting configuration, it can take several minutes to fill the system.**

11. Compare the flow meter indicator ball reading to the red flag.

NOTE: **If the indicator ball drops down to the bottom of the air flow meter, or below the red flag that would indicate that the system is sealed and not leaking.**

Select the appropriate response from the list below:

The ball drops down to the bottom of the air flow meter, or below the red flag;

- This indicates that the leak is coming from the vent valves inside the ESIM since the rest of the system is not leaking. Replace the ESIM in accordance with the Service Information.
- Perform the Intrusive Leak Evaluation again to verify repair.

The ball stays above the red flag indicating a leak in the system;

- This indicates that the leak is not coming from vent valves inside the ESIM. There is a leak elsewhere in the system. **Leak test the system to find and repair the leak using one of the following methods;**
- **Smoke test:** Attach the black hose to the adaptor and switch the EELD tester to smoke. Pressurize the system with smoke from the EELD tester and look for smoke coming from around all connections and sealing points in the system. Repair or replace the leaking component.
- **Hydrocarbon Sniffer:** Continue pressurizing the system and check for a leak using the TIF8800X - Combustible Gas Detector or equivalent around all connections and sealing points in the system. Repair or replace the leaking component.
- **Bubble test:** Continue pressurizing the system and check for a leak by applying Mopar Air Leak Detector or equivalent around all connections and sealing points in the system and look for bubbles indicating a leak. Repair or replace the leaking component.
- **To check the Purge Solenoid** for an internal leak, remove the Manifold Hose from the Purge Solenoid, fill the system with smoke and check for smoke coming through the Purge

Solenoid. If smoke is present, replace the Purge Solenoid in accordance with the Service Information.

- **Perform the Intrusive Leak Evaluation again to verify repair.**

5. **SEPARATE THE SYSTEM TO DETERMINE WHICH SIDE OF THE EVAPORATIVE SYSTEM IS LEAKING**
   1. Remove the Canister Tube (that connects to the Fuel Tank on the other end) from the Charcoal Canister.
   2. Attach a hand vacuum pump to the fitting on the canister.

      NOTE: **A small clamp or zip tie can be used to make sure the hose is tightly secured and not leaking.**

   3. Pump the hand vacuum pump until the ESIM Switch closes.

      NOTE: **This should only take a few pumps.**

   4. With the scan tool, monitor the ESIM Switch state for up to 10 minutes.

      NOTE: **This checks for leaks on the fresh air side of system (ESIM internal valves and seal, Charcoal Canister, Purge Solenoid and Purge Tube between the solenoid and canister). The ESIM Switch should remain closed since pressure from the fuel tank vapors are no longer acting on the canister and switch assuming no or minimal temperature change.**

   Did the ESIM Switch remain closed for a minimum of 5 minutes?

   Yes

   - The leak is on the Fuel Tank side of the system. Go To 6

   No

   - The leak is on the fresh air (canister) side of the system. Go To 7

6. **FUEL TANK SIDE EVAPORATIVE EMISSION LEAK DETECTION**
   1. To continue testing you will need the (special tool #8404C, Kit, EELD And Accessory).
   2. Connect the red power lead of the EELD to the Battery positive terminal and the black ground lead to Battery negative terminal.
   3. Connect shop air to the EELD.
   4. Set the smoke/air control switch to **Smoke** .
   5. Attach the black hose to the Canister Tube.
   6. Press the remote button to fill the Fuel Tank side of the system with smoke.

   Leak test the system to find and repair the leak using one of the following methods:

   - **Smoke test:** Attach the black hose to the adaptor and switch the EELD tester to smoke. Pressurize the system with smoke from the EELD tester and look for smoke coming from around all connections and sealing points in the system. Repair or replace the leaking component.
   - **Hydrocarbon Sniffer:** Continue pressurizing the system and check for a leak using the TIF8800X - Combustible Gas Detector or equivalent around all connections and sealing points in the system. Repair or replace the leaking component.
   - **Bubble test:** Continue pressurizing the system and check for a leak by applying Mopar Air Leak Detector or equivalent around all connections and sealing points in the system and look

for bubbles indicating a leak. Repair or replace the leaking component.

- **To check the Purge Solenoid** for an internal leak, remove the Manifold Hose from the Purge Solenoid, fill the system with smoke and check for smoke coming through the Purge Solenoid. If smoke is present, replace the Purge Solenoid in accordance with the Service Information.
- **Perform the Intrusive Leak Evaluation again to verify repair.**

7. **FRESH AIR SIDE EVAPORATIVE EMISSION LEAK DETECTION**
    1. To continue testing you will need the (special tool #8404C, Kit, EELD And Accessory).
    2. Connect the red power lead of the EELD to the Battery positive terminal and the black ground lead to Battery negative terminal.
    3. Connect shop air to the EELD.
    4. Set the smoke/air control switch to **AIR** to pressurize the system.
    5. Press the remote smoke/air start button.
    6. Block off the end of the tester's AIR supply tip (clear hose) while pressing the remote start button.

    NOTE: **The indicator ball should be resting on the bottom of the air flow meter (this is calibrated to no leak present) if the EELD is calibrated correctly.**

    7. If the indicator ball is not resting on the bottom of air flow meter, position the red flag on the air flow meter so it is aligned with ball.
    8. Connect the service adapter (special tool #8404-ADP, Smoke Machine Adapters) to the ESIM vent hose.
    9. Connect the **AIR** supply tip (clear hose) to the adapter.
    10. Press the remote button to activate **AIR flow.**
    11. Compare the flow meter indicator ball reading to the red flag.

    Select the appropriate response from the list below:

    The ball drops down to the bottom of the air flow meter, or below the red flag;

    - This indicates that the leak is coming from the vent valves inside the ESIM. Replace the ESIM in accordance with the Service Information.

    The ball stays above the red flag indicating a leak in the system;

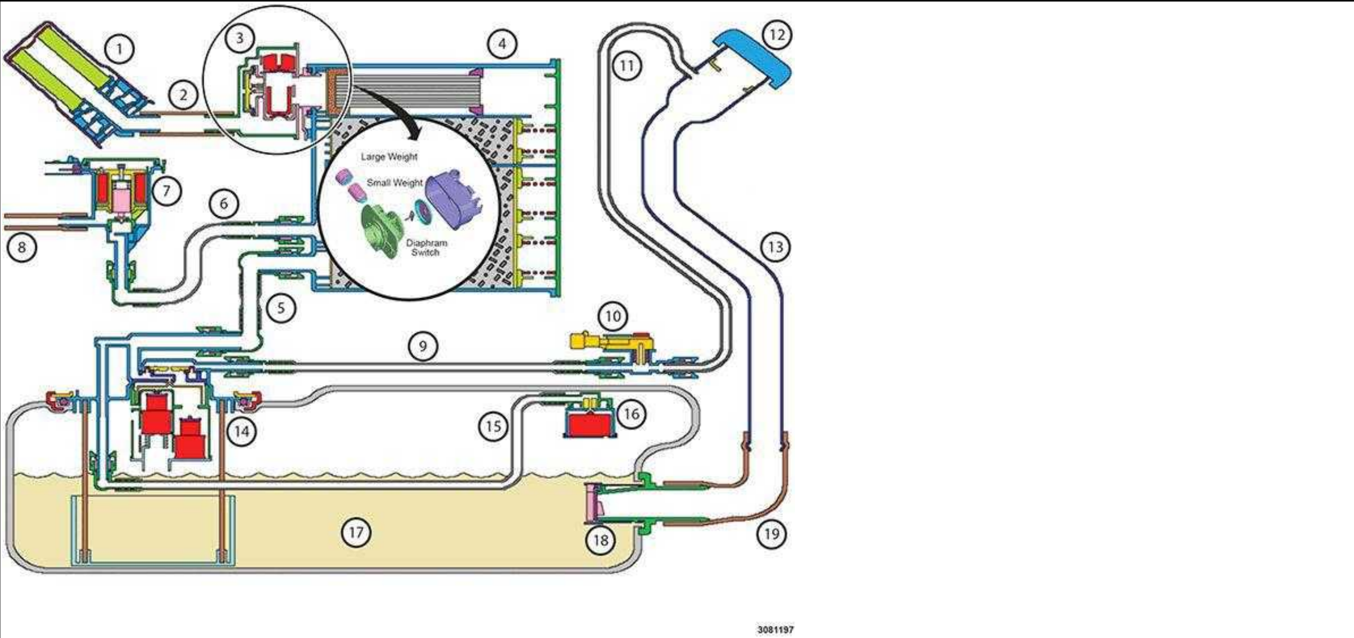
    - This indicates that the leak is not coming from vent valves inside the ESIM. There is a leak elsewhere in the system. **Leak test the system to find and repair the leak using one of the following methods;**
    - **Smoke test:** Attach the black hose to the adaptor and switch the EELD tester to smoke. Pressurize the system with smoke from the EELD tester and look for smoke coming from around all connections and sealing points in the system. Repair or replace the leaking component.
    - **Hydrocarbon Sniffer:** Continue pressurizing the system and check for a leak using the TIF8800X - Combustible Gas Detector or equivalent around all connections and sealing points in the system. Repair or replace the leaking component.
    - **Bubble test:** Continue pressurizing the system and check for a leak by applying Mopar Air Leak Detector or equivalent around all connections and sealing points in the system and look for bubbles indicating a leak. Repair or replace the leaking component.
    - **To check the Purge Solenoid** for an internal leak, remove the Manifold Hose from the Purge Solenoid, fill the system with smoke and check for smoke coming through the Purge Solenoid. If smoke is present, replace the Purge Solenoid in accordance with the Service Information.

- **Perform the Intrusive Leak Evaluation again to verify repair.**

P0441-EVAP PURGE SYSTEM PERFORMANCE

For a complete EVAPORATIVE EMISSIONS SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION



EVAP SYSTEM COMPONENTS			
CALLOUT	**DESCRIPTION**	**CALLOUT**	**DESCRIPTION**
1	Filter - Fresh Air Inlet	11	Recirculation Tube (metal portion) (FTPS to Fuel Filler Tube)
2	Filter Hose (Filter to ESIM)	12	Gas Cap or Cap-less Refueling Unit (if equipped)
3	Evaporative System Integrity Monitor (ESIM)	13	Fuel Filler Tube
4	Evaporative Charcoal Canister	14	Multi-Function Control Valve (MFCV), Liquid \ Vapor Separator and Drain Valve (LVS) in the Fuel Delivery Flange
5	Canister Tube (Fuel Tank to Canister)	15	Grade Vent Valve (GVV) Tube (GVV to MFCV or LVS)
6	Purge Tube (Purge Solenoid to Canister)	16	Grade Vent Valve (GVV)
7	Purge Solenoid	17	Fuel Tank
8	Manifold Hose (Purge Solenoid to Engine Manifold)	18	Inlet Check Valve (ICV)
9	Recirculation Tube (Fuel Tank to FTPS)	19	Hose - Fuel Filler Tube to ICV
10	Fuel Tank Pressure Sensor (FTPS)	-	-

PURGE FLOW MONITOR: The operation of the Purge Solenoid and evaporative purge flow is monitored using inputs from the Fuel Tank Pressure Sensor. The Purge Flow Monitor will only run if the previous engine off Small Leak event was a pass. The small leak diagnostic can only verify that the fuel tank system is sealed while the purge valve is closed. Therefore, it cannot be determined if the purge line between the solenoid and Intake Manifold is pinched or leaking. The Purge Flow Monitor is needed to verify these failure modes. The

Purge Flow Monitor works on the premise that as flow through the system increases, so does the pressure drop in the system. The PCM monitors the Fuel Tank Pressure Sensor and looks for increasing vacuum in the Fuel Tank with increasing purge flow. Conversely, it looks for decreasing vacuum in the Fuel Tank with decreasing flow.

- **The non-intrusive purge monitor** runs during normal operation once the enable conditions are met and looks for a calibrated increase in vacuum in the fuel tank with increased purge flow, referred to as side 1. If side 1 passes, the purge monitor looks for a calibrated decrease in vacuum in the Fuel Tank with decreasing purge flow, referred to as side 2. If side 2 passes, the purge monitor is complete. If the purge flow monitor fails either side 1 or side 2, or does not complete both side 1 and side 2 within a specified time, an intrusive test is initiated to verify the results from the non-intrusive test.
- **The intrusive diagnostic** increases and decreases the purge flow in a more controlled manner to allow a more accurate test result. If the PCM detects a failure during the intrusive test, a purge system performance fault is set **(P0441).**

Only the Fuel Tank Pressure (FTP) Sensor is used for Purge Performance diagnostics. The ESIM Switch is not used for diagnosing the purge system.

COMPONENT FUNCTIONAL DESCRIPTION - PURGE SOLENOID

Functional Operation: The Purge solenoid has one inlet port that connects to the canister and one outlet port that connects to the Intake Manifold. Once in closed loop the Purge Solenoid is energized by the Powertrain Control Module (PCM) using a Pulse Width Modulated (PWM) control circuit. The normally closed Purge Solenoid will open and allow engine vacuum from the Intake Manifold to draw vapors from the Charcoal Canister into the Intake Manifold to be burned by the engine. The PCM varies the vapor flow rate by changing the duty cycle on the purge solenoid control circuit. The PCM adjusts the pulse width of the Purge Solenoid based on engine operating conditions.

Diagnostic Overview: The Powertrain Control Module (PCM) performs circuit fault diagnostics on the Purge Solenoid control circuitry for opens or short circuits. The PCM can also detect a stuck closed Purge Solenoid using the Purge Flow Monitor diagnostic. The Purge Solenoid functionality can be tested using a hand vacuum pump.

- With the Purge Solenoid de-energized, connect the hand vacuum pump to the outlet port for the Intake Manifold and apply approximately 10 - 15 in. Hg. The solenoid should hold the vacuum if the Purge Solenoid is closed.
- To verify the Purge Solenoid is not stuck closed, energize the solenoid to open it with vacuum applied at the outlet port. The vacuum should dissipate when the solenoid is energized.

COMPONENT FUNCTIONAL DESCRIPTION - FUEL TANK PRESSURE (FTP) SENSOR

Since the vacuum hose between the Purge Solenoid and Intake Manifold cannot be checked during the small leak diagnostic, the FTP Sensor is used to monitor the Evaporative System pressure change during purging to determine if the hose is disconnected or restricted. **The PCM uses the FTP Sensor for the purge system performance diagnostics.** The diagnostic works in two phases:

- First the Purge Solenoid is actuated and the PCM monitors the change in the FTP Sensor reading over time. The PCM expects to see the pressure/vacuum reading decrease more than a calibrated threshold over a calibrated period.
- The Purge Solenoid is then deactivated and the PCM monitors the change again over time. The PCM expects to see the pressure reading increase more than a calibrated threshold over a calibrated period.

If either diagnostic fails the threshold, the purge performance fault is set.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Purge Solenoid control circuit DTC is not active.

- The Evap System Small Leak test has passed during the last valid ignition off event.

SET CONDITION

- The Powertrain Control Module detects that the change (delta) in fuel tank pressure is below a calibrated threshold during side 1 (Purge Solenoid ramped up) or side 2 (Purge Solenoid ramped down) of both the non-intrusive and intrusive diagnostic.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
FUEL TANK PRESSURE (FTP) SENSOR 5-VOLT SUPPLY OPEN/HIGH RESISTANCE
PURGE SOLENOID VACUUM LINE LEAKING OR BROKEN
PURGE SOLENOID VACUUM LINE OR PORT RESTRICTED/OBSTRUCTED
PINCHED/OBSTRUCTED LINE BETWEEN THE PURGE SOLENOID AND CANISTER
PINCHED/OBSTRUCTED LINE BETWEEN THE CANISTER AND FUEL TANK
FUEL IN THE CHARCOAL CANISTER OR TUBES DUE TO FUEL DELIVERY FLANGE TUBE DISCONNECTED INSIDE FUEL TANK
FAULTY PURGE SOLENOID
FUEL TANK PRESSURE (FTP) SENSOR

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR OTHER DTCS**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs and record on the repair order.

       Are there any 5-Volt Reference or Purge Solenoid circuit DTCs active or pending?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 2
2. **CHECK FOR AN ACTIVE CONDITION**

   NOTE: **The ESIM/Purge Flow Forced Monitor Test is designed to help determine if there is an issue with the Evaporative system, and if so what part of the system is failing. This routine runs the General Evap, Large Leak and Purge Performance diagnostics, and makes a pass/fail determination. Note: The values in the Pass Threshold column are unique to each vehicle application.**

    1. Turn the ignition on.

       NOTE: **Before starting the "ESIM/Purge Flow Forced Monitor" routine with the scan tool, vent the pressure or vacuum in the Fuel Tank by**

opening the Capless Fuel Filler with the vent or removing and installing the Fuel Cap. This will bring the Fuel Tank pressure closer to atmosphere and give more consistent results during the scan tool routine.

2. With the scan tool, start the "ESIM/Purge Flow Forced Monitor" test and analyze the results.
    - The top four rows show the live data readings while the test is running for the key components used in leak detection (ESIM Switch State) and purge performance (FTP Sensor), along with the Purge Solenoid which is used for both diagnostics.
    - **Lowest Recorded FTP Sensor Reading row** - Shows the peak Fuel Tank vacuum that was created during the Purge Solenoid activation.
    - **Range Reference (FTP Sensor) row** - Displays the starting FTP Sensor value taken before the Purge Solenoid is activated. If the starting value is not between the minimum and maximum values in the Pass Threshold column, a fail is recorded. Even if the Range Reference fails, the purge monitor test is still performed and will pass/fail based on the side 1 and side 2 results.
    - **Side 1 (FTP Sensor pressure change) row** - The Purge Solenoid is commanded on for a calibrated period with the intent of decreasing pressure (more vacuum) in the Fuel Tank. The **Actual Result** displays the delta pressure change in the FTP Sensor reading from the initial range reference value during this period. **A positive value indicates a pressure increase and a negative value indicates a pressure decrease from the initial reading.** If the Actual Result shows that pressure decreased more than the **Pass Threshold** value the diagnostic will pass (for example, using a -50 Pa Pass Threshold, a pressure decrease of -20 Pa fails and a pressure decrease of -60 Pa passes).
    - **Side 2 (FTP Sensor pressure change) row** - During side 2 evaluation, the Purge Solenoid is commanded off with the intent of increasing pressure. The **Actual Result** displays the pressure change in the FTP Sensor reading. **A positive value indicates that pressure increased and a negative value indicates that pressure decreased after the Purge Solenoid was turned off.** If the pressure does not increase more than the value in the Pass Threshold column the diagnostic will fail.
    - **General Evap (ESIM Switch) row** - Displays whether the ESIM Switch closed while the Purge Solenoid was commanded on. If the ESIM Switch did not close at any time during Purge actuation the General Evap diagnostic fails.
    - **Large Leak (ESIM Switch Closed) row** - Displays results from the large leak test. The Pass Threshold column shows the amount of time the ESIM Switch must remain closed after the Purge Solenoid is turned off to record a pass. If the time in the Actual Result column reaches the threshold the system is passing. A system with a leak will display time values less than the threshold and time values closer to the threshold are indicative of smaller leaks.

    Pick the scenario that best matches the results from the routine?

    All of the monitors pass and side 1 and side 2 actual pressure changes are well beyond the pass thresholds:

    - The purge system is passing and not in need of repair at this time.

    All of the monitors pass but side 1 and side 2 actual pressure changes are close to the pass thresholds:

    - The system is passing but there could be a partial restriction in the Intake Manifold or manifold hose (Callout 8 in the Evap system figure) if only the P0441 DTC was present.

    Side 1 passed/Side 2 failed/the vacuum created was very high (well below the ESIM regulation point of approximately -500 Pa) with the Purge Solenoid commanded on and holds steady or dissipates very slowly after the Purge Solenoid is commanded off:

- Repair the restriction at the Fresh Air Inlet Filter or hose (Callouts 1 and 2 in the Evap system figure). If removing the Fresh Air Inlet Filter and hose does not reduce the vacuum to the ESIM regulation point (approximately -500 Pa), the ESIM internal vacuum vent valve is stuck closed.
- Perform the "ESIM/Purge Flow Forced Monitor" test to confirm system is repaired.

Side 1 and/or side 2 failed (FTP Sensor reading doesn't change or changes very little), ESIM Switch closes and large leak fails:

- Check for a broken, plugged or damaged Canister Tube (Callout 5 in the Evap system figure), Recirculation Tube (Callout 9 in the Evap system figure), damaged Evaporative Charcoal Canister (Callout 4 in the Evap system figure) or a partially broken Purge Tube (Callout 6 in the Evap system figure).

NOTE: **Check for fuel present inside the Charcoal Canister or tubes. If fuel is present, replace the Charcoal Canister and check for a disconnected or broken line to the Fuel Delivery Flange inside the Fuel Tank. If the line is disconnected fuel will be pushed through the Fuel Delivery Flange to the Charcoal Canister.**

- Perform the "ESIM/Purge Flow Forced Monitor" test to confirm system is repaired.

Side 1 and/or side 2 failed (FTP Sensor reading doesn't change or changes very little), ESIM Switch closes and large leak passes:

- Go To 3

Side 1 and/or side 2 failed and ESIM Switch does not close or you suspect a possible faulty Purge Solenoid:

- Go To 6

3. **CHECK FOR FUEL IN THE CHARCOAL CANISTER AND TUBES**
   1. Turn the ignition off.
   2. Remove the Canister Tube (Callout 5 in the Evap system figure) from the Charcoal Canister.
   3. Remove the Recirculation Tube (Callout 9 in the Evap system figure) from the fill pipe.
   4. Check for fuel present inside the Charcoal Canister or tubes.

   NOTE: **It may be necessary to remove the Charcoal Canister and turn it over to determine is fuel is present in the canister.**

   Is evidence of fuel present in the Charcoal Canister or tubes?

   Yes

   - Replace the Charcoal Canister and check for a disconnected or broken line to the Fuel Delivery Flange inside the Fuel Tank. Reconnect the line and confirm proper retention or replace if necessary.

   NOTE: **If the line is disconnected fuel will be pushed through the Fuel Delivery Flange to the Charcoal Canister. Replacing the Charcoal Canister without checking the Fuel Delivery Flange tube could cause a repeat failure of the canister.**

   - Perform the "ESIM/Purge Flow Forced Monitor" test to confirm system is repaired.

   No

- Go To 4

4. **CHECK FOR A BLOCKAGE BETWEEN THE CHARCOAL CANISTER AND THE FUEL TANK PRESSURE SENSOR**
    1. Attach a hand vacuum pump to the FTP Sensor.
    2. While monitoring the FTP Sensor reading on the scan tool, apply vacuum to the sensor.

       Does the FTP Sensor value change when applying vacuum to the sensor?

       Yes

       - Repair the restriction in the Canister Tube (Callout 5 in the Evap system figure) or Recirculation Tube (Callout 9 in the Evap system figure).
       - Perform the "ESIM/Purge Flow Forced Monitor" test to confirm system is repaired.

       No

       - Go To 5

5. **CHECK THE (K859) 5-VOLT SUPPLY CIRCUIT FOR PROPER VOLTAGE AT THE FUEL TANK PRESSURE SENSOR HARNESS CONNECTOR**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
    3. Turn the ignition on.
    4. Set the DVOM to measure DC voltage.
    5. Connect the negative lead of the DVOM to a known good ground.
    6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

    NOTE: **Normal operating voltage should be between 4.8 and 5.2 volts.**

    Does the circuit have the proper voltage present?

    Yes

    - Verify that there is good pin to terminal contact in the Fuel Tank Pressure Sensor connector. If no problems were found with the connector, replace the Fuel Tank Pressure Sensor in accordance with the Service Information. Refer to **SENSOR, FUEL TANK PRESSURE, REMOVAL AND INSTALLATION** .
    - Perform the "ESIM/Purge Flow Forced Monitor" test to confirm system is repaired.

    No

    - Repair the (K859) 5-Volt Supply circuit for an open or high resistance.
    - Perform the "ESIM/Purge Flow Forced Monitor" test to confirm system is repaired.

6. **CHECK THE INTAKE MANIFOLD PORT FOR A RESTRICTION OR BLOCKAGE**

    NOTE: **It is important to note that a restriction in the vacuum supply may not decrease the vacuum reading but can still reduce the flow causing the purge performance diagnostic to fail. Therefore the vacuum port on the Intake Manifold and the Manifold Hose need to be inspected closely even if vacuum is present.**

    1. Remove the Manifold Hose vacuum line at the Intake Manifold vacuum port.

    2. Visually inspect inside the vacuum port for restriction or blockage due to flashing or carbon build up.

       Is the port restricted?

       Yes

       - Repair the restriction in the vacuum port on the Intake Manifold.
       - Perform the "ESIM/Purge Flow Forced Monitor" test to confirm system is repaired.

       No

       - Go To 7

7. **CHECK THE MANIFOLD HOSE AND THE VACUUM SUPPLY AT THE INLET OF THE PURGE SOLENOID**
    1. Install the Manifold Hose vacuum line to the Intake Manifold port.
    2. Remove the Manifold Hose vacuum line at the inlet port of the Purge Solenoid (this is the vacuum line that comes from the Intake Manifold).
    3. Start the engine and allow it to idle.
    4. Check the vacuum supply to the Purge Solenoid.

       Is there sufficient engine vacuum present?

       Yes

       - Go To 8

       No

       - Repair the broken or plugged Manifold Hose (Callout 8 in the Evap system figure).
       - Perform the "ESIM/Purge Flow Forced Monitor" test to confirm system is repaired.
8. **CHECK THE VACUUM SUPPLY AT THE OUTLET OF THE PURGE SOLENOID**
    1. Turn the ignition off.
    2. Reconnect the Manifold Hose vacuum line at the inlet port of the Purge Solenoid.
    3. Remove the vacuum line at the outlet port of the Purge Solenoid (this is the line that leads to the Evaporative Canister).
    4. Connect a vacuum gauge to the outlet port of the Purge Solenoid.
    5. Start the engine and allow it to idle long enough for the Purge Solenoid to cycle on.
    6. Check the vacuum supply at the Purge Solenoid outlet port.

       Is there sufficient engine vacuum present?

       Yes

       - Check the Purge Tube (Callout 6 in the Evap system figure) for signs of damage (broken, disconnected or plugged).
       - Perform the "ESIM/Purge Flow Forced Monitor" test to confirm system is repaired.

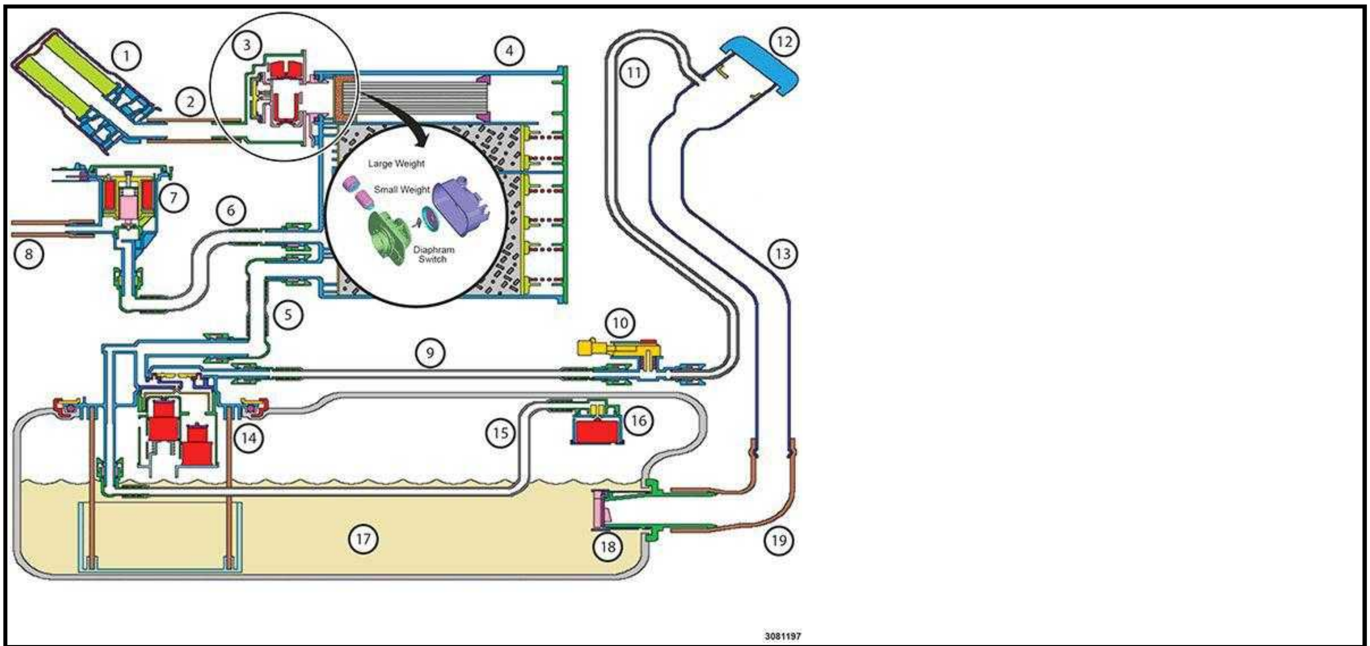
       No

       - Verify that there is good pin to terminal contact in the solenoid and PCM harness connectors. Replace the Purge Solenoid if no problems were found in the connectors. Refer to **SOLENOID, EVAPORATIVE EMISSIONS PURGE, REMOVAL AND INSTALLATION** .
       - Perform the "ESIM/Purge Flow Forced Monitor" test to confirm system is repaired.

P0443-EVAP PURGE 1 CONTROL CIRCUIT

For a complete EVAPORATIVE EMISSIONS SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION



EVAP SYSTEM COMPONENTS			
CALLOUT	**DESCRIPTION**	**CALLOUT**	**DESCRIPTION**
1	Filter - Fresh Air Inlet	11	Recirculation Tube (metal portion) (FTPS to Fuel Filler Tube)
2	Filter Hose (Filter to ESIM)	12	Gas Cap or Cap-less Refueling Unit (if equipped)
3	Evaporative System Integrity Monitor (ESIM)	13	Fuel Filler Tube
4	Evaporative Charcoal Canister	14	Multi-Function Control Valve (MFCV) in the Fuel Delivery Flange
5	Canister Tube (Fuel Tank to Canister)	15	GVV Tube (GVV to MFCV)
6	Purge Tube (Purge Solenoid to Canister)	16	Grade Vent Valve (GVV)
7	Purge Solenoid	17	Fuel Tank
8	Manifold Hose (Purge Solenoid to Engine Manifold)	18	Inlet Check Valve (ICV)
9	Recirculation Tube (Fuel Tank to FTPS)	19	Hose - Fuel Filler Tube to ICV
10	Fuel Tank Pressure Sensor (FTPS)	-	-

EVAPORATIVE SYSTEM OVERVIEW: The Powertrain Control Module (PCM) monitors the Evaporative Emission System operation. The two main areas being monitored are the integrity of the system against leaks and the ability of the system to purge fuel vapor from the canister to the Intake Manifold. The basic strategy used is that in a **sealed system** , pressure will naturally increase or decrease in relation to temperature. **The Evaporative System Integrity Monitor (ESIM) Switch is used for all leak fault detection.** There is a vacuum actuated switch that closes when the vacuum reaches a calibrated threshold. If the switch closes it indicates that the system is not leaking.

ESIM SWITCH STUCK CLOSED MONITOR: At ignition off, the state of the ESIM Switch is evaluated. If the switch is open, a pass flag will set so the PCM power down process can complete. If the switch is closed, the PCM will wait a calibrated delay time and open the Purge Solenoid. In a normally functioning system, this will relieve the vacuum trapped in the Charcoal Canister allowing the switch to open. When the switch opens, a pass flag is set and the PCM will power down. If the ESIM switch does not open, after a calibrated time, an error is detected and a switch stuck closed failure event is set **(P0452)** . Two consecutive failed events will mature a fault.

SMALL LEAK MONITOR: This is an accumulative monitor and the data from each valid event is recorded and added to the previously recorded events. The PCM timer records the engine on/drive cycle and engine off time for each small leak monitor event. For an event to be valid the PCM must see;

1. An engine on/drive cycle for a minimum of 2-5 minutes.

   NOTE: **The Engine on timer is clipped to a maximum of 26 minutes on any given trip.**

2. And, when the engine is shut down, an engine off timer starts. There is a 12 minute delay time in which the PCM will ignore ESIM Switch input. The engine off timer period will continue to count until one of the three conditions exist:
   - The engine is started without a switch closure during the event.

     NOTE: **At the next key on cycle a determination is made as to whether the event was valid and the information is kept.**

   - An ESIM Switch closed input is received after the 12 minute delay during the event.

     NOTE: **If the switch closed input is received, the PCM records that the switch has closed and stores the engine shut down time.**

   - After a maximum time of 17.5 hours without an ESIM Switch closure during the event.

This monitor will **increment** the **accumulation fail timers** until **both** have reached a calibrated threshold (Engine on - 100 minutes and Engine off - 70 hours). When the monitor records a valid **switch closure (small leak passing event)** the fail timers are reset.

LEAK SIZE DETERMINATION: If the PCM did not see an ESIM Switch closed signal during the previous ignition off cycle, the event was valid, and there is a cold start, an intrusive leak test is run to determine if a large leak is present. Immediately after start-up, while the engine is cold the Purge Solenoid is opened to create vacuum in the evaporative system to a calibrated vacuum point that is beyond the ESIM Switch closing threshold. **The pass/fail time will vary based on the total fuel volume at the time of the test.**

- If the switch does not close at all during purging, because of a switch that is stuck open or vacuum cannot be created below -250 Pa within a calibrated time, it is determined to be a general evaporative system failure **(P0440)** .
- If vacuum is created and the switch has closed, the Purge Solenoid is commanded off and the PCM monitors the switch closure time. If the switch opens before a calibrated threshold, a large leak is present. Two consecutive failure events will mature a fault **(P0455).**
- If vacuum is created and the switch has closed, the Purge Solenoid is commanded off and the PCM monitors the switch closure time. If the switch stays closed longer than a calibrated threshold, it is determined that a large leak is not present. If the Large Leak diagnostic does not fail before the accumulated small leak timer reaches it's threshold it is determined that a small leak is present **(P0456).**

NOTE: **It is important to understand how extreme temperature changes can effect your results when diagnosing the system. It can either mask a leak by creating vacuum too rapidly temporarily overcoming the leak, or make a sealed system appear to be leaking due to excessive vapor build-up decaying vacuum too**

rapidly. This could be from the vehicle heat soaking after a long drive cycle or being brought into a shop environment that is vastly different from the outside environment. Be aware of these factors when performing the system checks in the test below.

NOTE: **It is usually best to analyze the entire Evap System components and wiring regardless of the DTC present. A sealed system will create vacuum as it cools or pressure as it heats up. Even a slight temperature change will cause the system to build pressure or create vacuum if the system is sealed and not leaking. We will use this principle in the test steps below to diagnose the system by monitoring the ESIM signal, Fuel Tank Pressure (FTP) Sensor signal and Purge Solenoid duty cycle with the scan tool while performing a few simple checks to help in determining if in fact the system is failing, and to possibly pin point the cause of the issue before disassembling any components.**

NOTE: **The Fuel Tank Pressure Sensor is not used by the PCM in determining a leak but can be used to help in diagnosing the system.**

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Engine run time above a calibrated value.
- Battery voltage greater than 10.4 volts.
- ECT within a specific range.
- Evap Purge Solenoid control active.

SET CONDITION

- The PCM compares the circuit feedback to a calibrated closed range when the circuit is de-energized or to a calibrated open range when the circuit is energized. A fault is determined if the value is out of the calibrated range in either the de-energized or energized state for more than a calibrated amount of time.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EVAP PURGE CONTROL CIRCUIT SHORTED TO VOLTAGE
EVAP PURGE CONTROL CIRCUIT SHORTED TO GROUND
EVAP PURGE CONTROL CIRCUIT OPEN/HIGH RESISTANCE
EVAP PURGE GROUND CIRCUIT OPEN/HIGH RESISTANCE
EVAP PURGE SOLENOID
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **VEHICLE HISTORY AND SERVICE BULLETIN INVESTIGATION**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs. Record DTCs and the related Freeze Frame data if any DTCs are present.

3. Check the following items which may assist in repairing the customer's complaint successfully:
    - Check the vehicle's repair history. If the vehicle has a repair history that pertains to the customer's current complaint, review the repair.
    - Inspect the vehicle for any aftermarket accessories that may have been installed incorrectly.
    - Check for any service bulletin(s) related to the customer's complaint or DTCs. If a service bulletin applies, follow the instructions per the service bulletin.

    Choose the following scenario that best applies:

    The vehicle inspection or service bulletin repaired the customer's complaint.

    - Testing complete.

    A DTC is present, the vehicle inspection revealed no concerns, no service bulletins apply, or the service bulletin did not repair the customer's complaint.

    - Go To 2

2. **CHECK FOR AN ACTIVE DTC**
    1. Start the engine and allow it to idle long enough for the Purge Solenoid to become active.
    2. With the scan tool, read DTCs and record on the repair order.

    Is the DTC active or pending?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **ISOLATE AND CHECK THE PURGE SOLENOID (K52) CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 4

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

4. **ISOLATE AND CHECK THE PURGE SOLENOID (K52) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

      NOTE: **There should be no continuity between ground and the circuit being tested.**

      Is there continuity between ground and the circuit being tested?

      Yes

      - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 5
5. **ISOLATE AND LOAD TEST THE PURGE SOLENOID (K52) CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
   3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
   4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
   5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
   6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

   NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of**

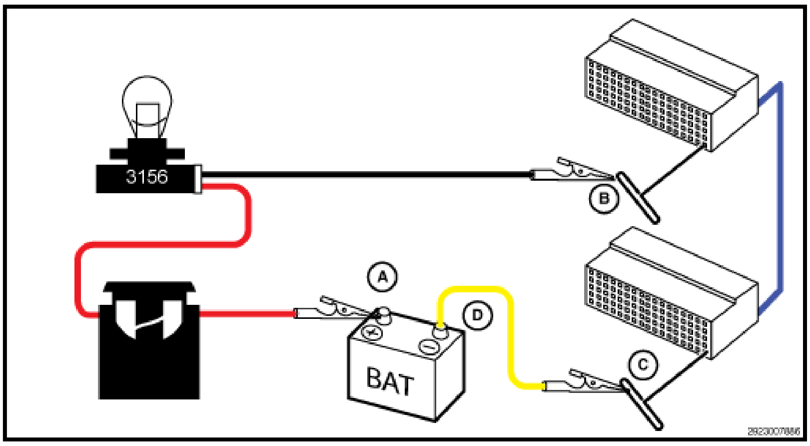
resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .

NOTE: Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: Do not load test any circuits with components still connected to the circuit.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 6

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE (Z907) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
   1. Disconnect the component harness connector to isolate the ground circuit.
   2. Connect the positive lead of the load test tool to the positive side of the Battery.
   3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
   4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

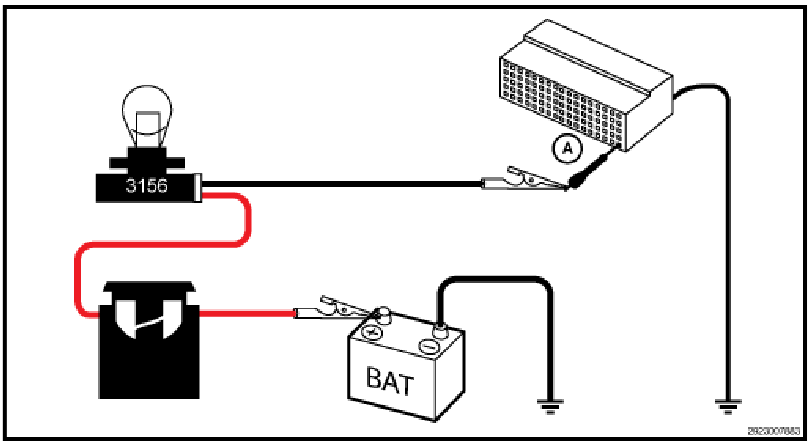
NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**

3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 7

   No

   - Repair the ground circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK THE PURGE SOLENOID FOR PROPER OPERATION**
   1. Reconnect the PCM C1 harness connector.
   2. Start the engine.
   3. With the scan tool, start the Purge Vapors System test. Select open to actuate the Purge Solenoid to the on position.

4. Using a 12 volt test light connected to ground, probe the (K52) Purge Control circuit at the Purge Solenoid harness connector.

   Is the test light illuminated during the actuation?

   Yes

   - Replace the Purge Solenoid in accordance with the Service Information. Refer to **SENSOR, FUEL TANK PRESSURE, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 8

   NOTE: **The voltage supplied to the solenoid circuit during the actuation may be less than battery voltage. The test light should be illuminated, but may not be as bright as a direct connection to the battery.**

8. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. With the scan tool, erase DTCs.
   9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   10. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0452-EVAP PRESSURE SWITCH STUCK CLOSED

For a complete EVAPORATIVE EMISSIONS SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DIAGNOSTIC OVERVIEW - ESIM SWITCH STUCK CLOSED (P0452) DIAGNOSTIC

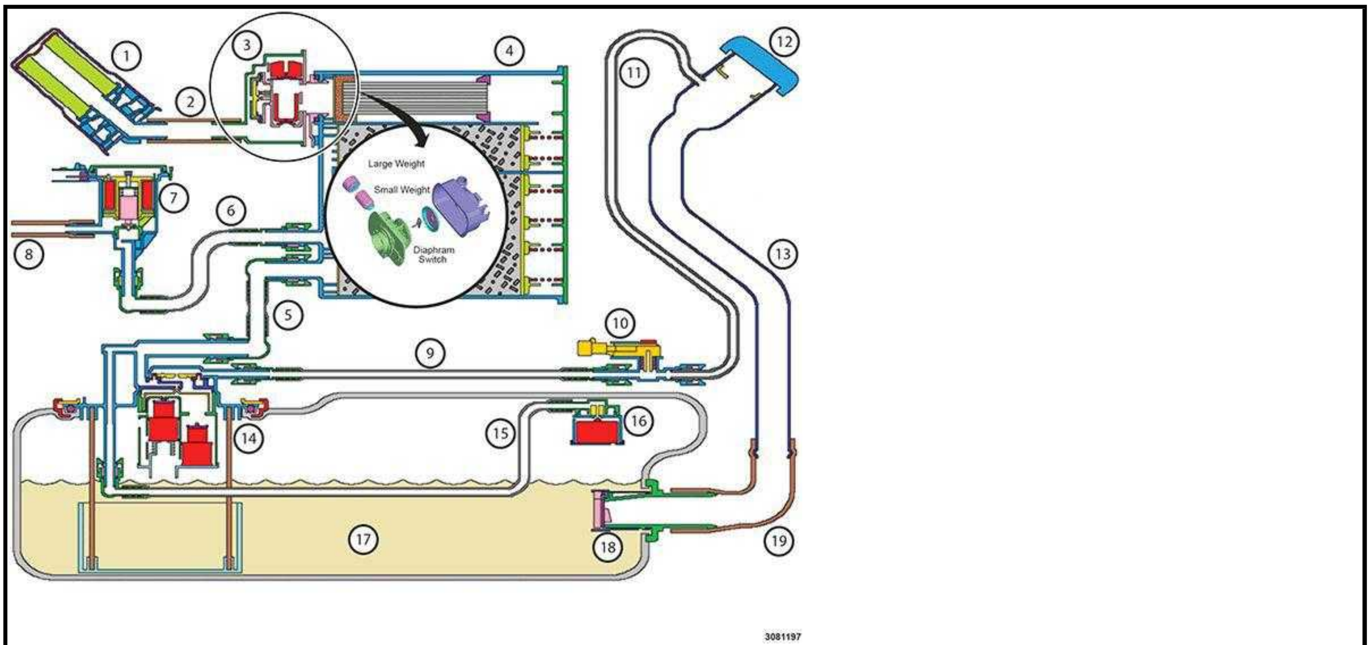
ESIM SWITCH STUCK CLOSED MONITOR: At ignition off, the state of the ESIM Switch is evaluated. If the switch is open, a pass flag will set so the PCM power down process can complete. If the switch is closed, the PCM will wait a calibrated delay time and open the Purge Solenoid. In a normally functioning system, this will relieve the vacuum trapped in the Charcoal Canister allowing the switch to open. When the switch opens, a pass flag is set and the PCM will power down. If the ESIM switch does not open, after a calibrated time, an error is detected and a switch stuck closed failure event is set **(P0452)** . Two consecutive failed events will mature a fault. The Switch stuck closed fault can set because of an electrical or mechanical issue. The electrical failures could be a short low in the ESIM signal or the switch is stuck closed inside the ESIM. **NOTE: An open signal would cause it to be high and never read closed which would set one of the leak faults.** The mechanical failures could be a blockage somewhere in the purge circuit that is not allowing vacuum to be relieved when the Purge Solenoid is energized. The best way to diagnose the issue is to first determine if the issue is due to an electrical issue or mechanical issue (blockage).

Diagnosing the system for an electrical or mechanical issue:

- First, remove the Fuel Cap or open the Capless fuel filler using a funnel while monitoring the ESIM Switch state. If the switch state changes to open, the likely cause is a blockage in the Purge Tube, Manifold Tube, intake port, or a faulty Purge Solenoid that is not opening. The reason the switch was able to open when removing the Fuel Cap or opening the capless fuel filler is because this is a different path to atmosphere than the system uses during the diagnostic (refer to the generic graphic below). This also proves that the ESIM Switch is not stuck closed and the signal is not shorted.
- If the ESIM Switch stayed closed when vented it is likely due to a stuck switch or signal circuit shorted low. If the vehicle is equipped with a Fuel Tank Pressure Sensor, monitoring the sensor reading can confirm the system vacuum was relieved. The Fuel Tank pressure should read near 0 Pa with the system vented.
- Monitor the ESIM Switch state and disconnect the ESIM harness connector. Try not to disturb the wiring harness so that you don't incidentally disturb a wiring issue. If the switch state changes to open when unplugged, a wiring issue can likely be ruled out since an open signal circuit should cause the switch state to change to open. If the switch state still reads closed with the ESIM connector unplugged the signal circuit is shorted low.

EVAP SYSTEM COMPONENTS			
CALLOUT	**DESCRIPTION**	**CALLOUT**	**DESCRIPTION**
1	Filter - Fresh Air Inlet	11	Recirculation Tube (metal portion) (FTPS to Fuel Filler Tube)
2	Filter Hose (Filter to ESIM)	12	Gas Cap or Cap-less Refueling Unit (if equipped)

EVAP SYSTEM COMPONENTS			
CALLOUT	DESCRIPTION	CALLOUT	DESCRIPTION
3	Evaporative System Integrity Monitor (ESIM)	13	Fuel Filler Tube
4	Evaporative Charcoal Canister	14	Multi-Function Control Valve (MFCV), Liquid \ Vapor Separator and Drain Valve (LVS) in the Fuel Delivery Flange
5	Canister Tube (Fuel Tank to Canister)	15	Grade Vent Valve (GVV) Tube (GVV to MFCV or LVS)
6	Purge Tube (Purge Solenoid to Canister)	16	Grade Vent Valve (GVV)
7	Purge Solenoid	17	Fuel Tank
8	Manifold Hose (Purge Solenoid to Engine Manifold)	18	Inlet Check Valve (ICV)
9	Recirculation Tube (Fuel Tank to FTPS)	19	Hose - Fuel Filler Tube to ICV
10	Fuel Tank Pressure Sensor (FTPS)	-	-

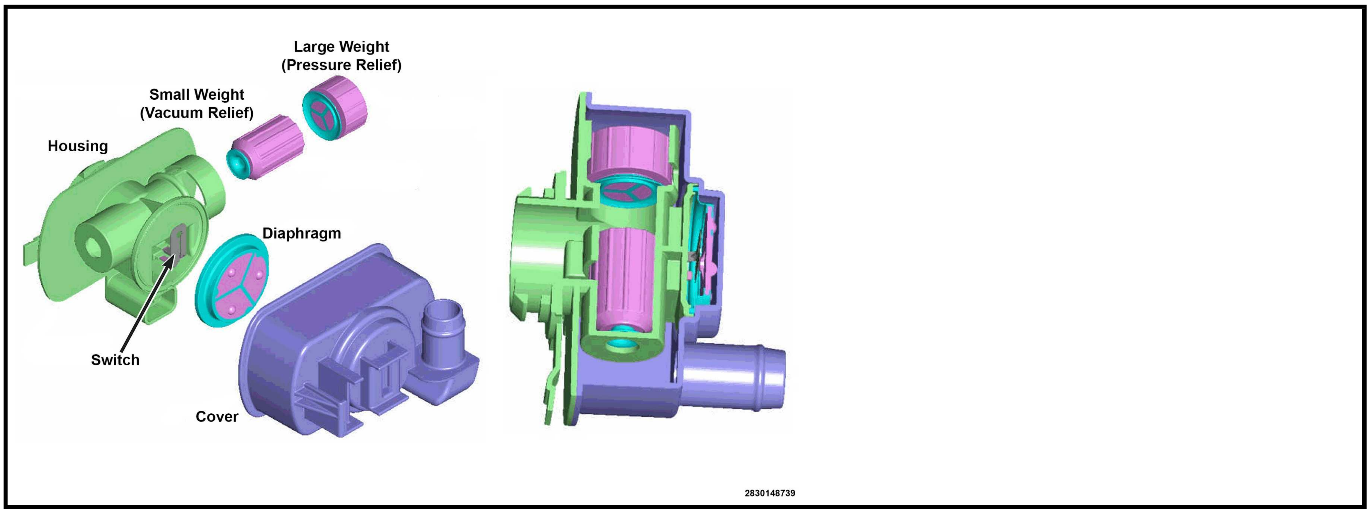


COMPONENT FUNCTIONAL DESCRIPTION - EVAPORATIVE SYSTEM INTEGRITY MODULE (ESIM) AND SWITCH

FUNCTIONAL OPERATION OF THE ESIM: The ESIM is configured with a normally open vacuum switch and normally closed vacuum relief and pressure relief valves (see figure). **The PCM uses the ESIM for all system leak diagnostics (P0440, P0455 and P0456).** The relief valves regulate the system pressure between approximately 1" H2O and -2" H2O (250Pa and -500Pa).

- When the system vacuum reaches between (-187Pa) and (-250Pa) it acts on the diaphragm and closes the vacuum switch. When the switch closes it allows continuity between the terminals. This allows the **ESIM Signal** to pass through the switch, pulling the signal low to ground. The PCM monitors the signal to determine the state of the switch (open or closed). The ESIM Signal will typically be a 12.0 volt or 5.0 volt signal depending on the vehicle. The voltage signals can vary between vehicles and may be somewhere between 5.0 and 12.0 volts. **Basically, when the PCM reads voltage on the signal circuit it determines the switch is open and when the signal is pulled low it determines the switch is closed.**
- The vacuum relief valve is intended to maintain the seal on the system during engine off events. However if the vacuum exceeds the regulation point the valve will pull off the seat to protect the system from excessive vacuum conditions.

- The pressure relief valve limits any pressure build up in the Fuel Tank during refueling and allows the tank pressure to normalize during increasing temperature events. This is additionally beneficial because it achieves a switch closed (pass threshold) sooner than if the tank has to decay from a much higher pressure.



COMPONENT FUNCTIONAL DESCRIPTION - PURGE SOLENOID

Functional Operation: The Purge solenoid has one inlet port that connects to the canister and one outlet port that connects to the Intake Manifold. Once in closed loop the Purge Solenoid is energized by the Powertrain Control Module (PCM) using a Pulse Width Modulated (PWM) control circuit. The normally closed Purge Solenoid will open and allow engine vacuum from the Intake Manifold to draw vapors from the Charcoal Canister into the Intake Manifold to be burned by the engine. The PCM varies the vapor flow rate by changing the duty cycle on the purge solenoid control circuit. The PCM adjusts the pulse width of the Purge Solenoid based on engine operating conditions.

Diagnostic Overview: The Powertrain Control Module (PCM) performs circuit fault diagnostics on the Purge Solenoid control circuitry for opens or short circuits. The PCM can also detect a stuck closed Purge Solenoid using the Purge Flow Monitor diagnostic. The Purge Solenoid functionality can be tested using a hand vacuum pump.

- With the Purge Solenoid de-energized, connect the hand vacuum pump to the outlet port for the Intake Manifold and apply approximately 10 - 15 in. Hg. The solenoid should hold the vacuum if the Purge Solenoid is closed.
- To verify the Purge Solenoid is not stuck closed, energize the solenoid to open it with vacuum applied at the outlet port. The vacuum should dissipate when the solenoid is energized.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- The ignition is turned off and the PCM has power down.
- The ambient temperature between 4B°C (39.2B°F) and 43B°C (109B°F).

SET CONDITION

- The PCM does not detect the ESIM Switch in an open state at any time during the ESIM Switch Stuck Closed diagnostic monitor, an error is detected and failure is set at the next engine run cycle.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
ESIM SIGNAL CIRCUIT SHORTED TO GROUND
ESIM SIGNAL CIRCUIT SHORTED TO THE ESIM GROUND CIRCUIT
PINCHED/OBSTRUCTED LINE BETWEEN THE INTAKE MANIFOLD AND CHARCOAL CANISTER
PLUGGED CHARCOAL CANISTER
PURGE SOLENOID STUCK CLOSED
EVAPORATIVE SYSTEM INTEGRITY MONITOR (ESIM) SWITCH STUCK CLOSED
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ELECTRICAL OR MECHANICAL ISSUE CAUSING THE ESIM SWITCH FAULT**

   WARNING: **Keep lit cigarettes, sparks, flames, and other ignition sources away from the test area to prevent the ignition of explosive gases. Keep the test area well ventilated. Failure to do so may result in possible serious or fatal injury.**

   1. Remove the fuel cap or use a funnel to vent the tank on a capless system.
   2. Turn the ignition on.
   3. With a scan tool, read the ESIM Switch state and the fuel tank pressure reading (if equipped with a Fuel Tank Pressure Sensor).

      NOTE: **We are trying to determine if the issue is being caused by an electrical or mechanical issue. Monitoring the ESIM Switch state and fuel tank pressure (if equipped with a Fuel Tank Pressure Sensor) while opening the system to atmosphere can help us determine the most likely issue and best diagnostic path to follow. The tank pressure should be reading near 0 Pa with the system vented.**

   What is the ESIM Switch state when venting the system?

   ESIM Switch reads closed?

   - Go To 2

   ESIM Switch reads open?

   - The condition could be caused by an intermittent wiring issue. If an intermittent short in the wiring is ruled out, inspect the Evaporative Charcoal Canister, Intake Manifold port, Purge Tube, Manifold Tube (callouts 4, 6 and 8 in the figure) for being restricted, pinched or kinked. If the Canister, Intake port and tubes are clear, verify that the Purge Solenoid is opening properly (see the Purge Solenoid Functional Description above).
2. **CHECK FOR THE ESIM SWITCH STUCK CLOSED**
   1. Disconnect the ESIM harness connector.

      NOTE: **Try to disturb the wiring harness as little as possible. You do not want to disturb a possible short in the wiring while disconnecting the harness connector.**

   Does the ESIM Switch state change from closed to open when the switch is disconnected?

Yes

- Replace the ESIM in accordance with the Service Information. Refer to **SWITCH, EVAPORATIVE EMISSIONS SYSTEM MONITOR, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **CHECK THE ESIM (K108) SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. Check the ESIM (K108) Signal circuit for a short to ground at the ESIM harness connector.

       Is the ESIM (K108) Signal circuit shorted to ground?

       Yes

       - Repair the ESIM (K108) Signal circuit for a short to ground or a short to the ESIM Ground circuit in the harness.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 4
4. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
       - Proper connector installation.
       - Damaged connector locks.
       - Corrosion.
       - Other signs of water intrusion.
       - Weather seal damage (if equipped).
       - Bent terminals.
       - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
       - Terminals that have been pushed back into the connector cavity.
       - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.

10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

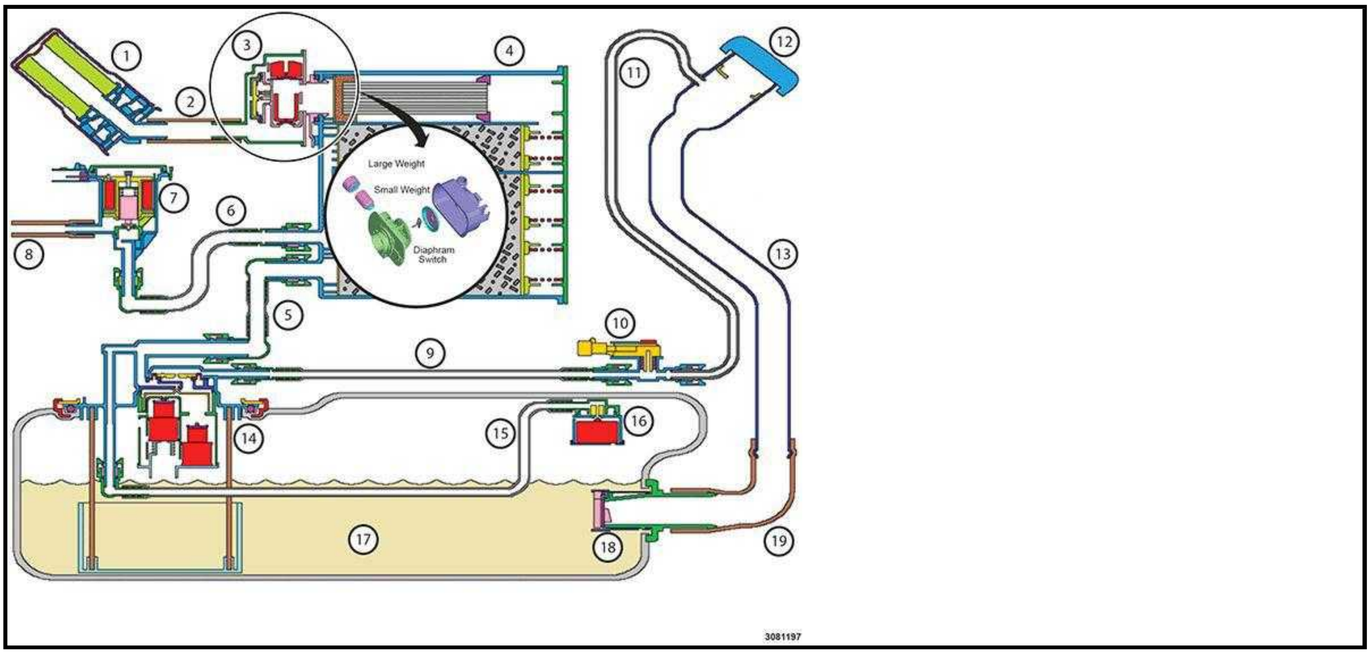
- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0455-EVAP SYSTEM LARGE LEAK

THEORY OF OPERATION



EVAP SYSTEM COMPONENTS			
CALLOUT	**DESCRIPTION**	**CALLOUT**	**DESCRIPTION**
1	Filter - Fresh Air Inlet	11	Recirculation Tube (metal portion) (FTPS to Fuel Filler Tube)
2	Filter Hose (Filter to ESIM)	12	Gas Cap or Cap-less Refueling Unit (if equipped)
3	Evaporative System Integrity Monitor (ESIM)	13	Fuel Filler Tube
4	Evaporative Charcoal Canister	14	Multi-Function Control Valve (MFCV) in the Fuel Delivery Flange
5	Canister Tube (Fuel Tank to Canister)	15	GVV Tube (GVV to MFCV)
6	Purge Tube (Purge Solenoid to Canister)	16	Grade Vent Valve (GVV)
7	Purge Solenoid	17	Fuel Tank

EVAP SYSTEM COMPONENTS			
CALLOUT	DESCRIPTION	CALLOUT	DESCRIPTION
8	Manifold Hose (Purge Solenoid to Engine Manifold)	18	Inlet Check Valve (ICV)
9	Recirculation Tube (Fuel Tank to FTPS)	19	Hose - Fuel Filler Tube to ICV
10	Fuel Tank Pressure Sensor (FTPS)	-	-

EVAPORATIVE SYSTEM OVERVIEW: The Powertrain Control Module (PCM) monitors the Evaporative Emission System operation. The two main areas being monitored are the integrity of the system against leaks and the ability of the system to purge fuel vapor from the canister to the Intake Manifold. The basic strategy used is that in a **sealed system** , pressure will naturally increase or decrease in relation to temperature. **The Evaporative System Integrity Monitor (ESIM) Switch is used for all leak fault detection.** There is a vacuum actuated switch that closes when the vacuum reaches a calibrated threshold. If the switch closes it indicates that the system is not leaking.

ESIM SWITCH STUCK CLOSED MONITOR: At ignition off, the state of the ESIM Switch is evaluated. If the switch is open, a pass flag will set so the PCM power down process can complete. If the switch is closed, the PCM will wait a calibrated delay time and open the Purge Solenoid. In a normally functioning system, this will relieve the vacuum trapped in the Charcoal Canister allowing the switch to open. When the switch opens, a pass flag is set and the PCM will power down. If the ESIM switch does not open, after a calibrated time, an error is detected and a switch stuck closed failure event is set **(P0452)** . Two consecutive failed events will mature a fault.

SMALL LEAK MONITOR: This is an accumulative monitor and the data from each valid event is recorded and added to the previously recorded events. The PCM timer records the engine on/drive cycle and engine off time for each small leak monitor event. For an event to be valid the PCM must see;

1. An engine on/drive cycle for a minimum of 2-5 minutes.

   NOTE: **The Engine on timer is clipped to a maximum of 26 minutes on any given trip.**

2. And, when the engine is shut down, an engine off timer starts. There is a 12 minute delay time in which the PCM will ignore ESIM Switch input. The engine off timer period will continue to count until one of the three conditions exist:
   - The engine is started without a switch closure during the event.

     NOTE: **At the next key on cycle a determination is made as to whether the event was valid and the information is kept.**

   - An ESIM Switch closed input is received after the 12 minute delay during the event.

     NOTE: **If the switch closed input is received, the PCM records that the switch has closed and stores the engine shut down time.**

   - After a maximum time of 17.5 hours without an ESIM Switch closure during the event.

This monitor will **increment** the **accumulation fail timers** until **both** have reached a calibrated threshold (Engine on - 100 minutes and Engine off - 70 hours). When the monitor records a valid **switch closure (small leak passing event)** the fail timers are reset.

LEAK SIZE DETERMINATION: If the PCM did not see an ESIM Switch closed signal during the previous ignition off cycle, the event was valid, and there is a cold start, an intrusive leak test is run to determine if a large leak is present. Immediately after start-up, while the engine is cold the Purge Solenoid is opened to create vacuum in the evaporative system to a calibrated vacuum point that is beyond the ESIM Switch closing threshold. **The pass/fail time will vary based on the total fuel volume at the time of the test.**

- If the switch does not close at all during purging, because of a switch that is stuck open or vacuum cannot be created below -250 Pa within a calibrated time, it is determined to be a general evaporative system failure **(P0440)** .
- If vacuum is created and the switch has closed, the Purge Solenoid is commanded off and the PCM monitors the switch closure time. If the switch opens before a calibrated threshold, a large leak is present. Two consecutive failure events will mature a fault **(P0455).**
- If vacuum is created and the switch has closed, the Purge Solenoid is commanded off and the PCM monitors the switch closure time. If the switch stays closed longer than a calibrated threshold, it is determined that a large leak is not present. If the Large Leak diagnostic does not fail before the accumulated small leak timer reaches it's threshold it is determined that a small leak is present **(P0456).**

NOTE: **It is important to understand how extreme temperature changes can effect your results when diagnosing the system. It can either mask a leak by creating vacuum too rapidly temporarily overcoming the leak, or make a sealed system appear to be leaking due to excessive vapor build-up decaying vacuum too rapidly. This could be from the vehicle heat soaking after a long drive cycle or being brought into a shop environment that is vastly different from the outside environment. Be aware of these factors when performing the system checks in the test below.**

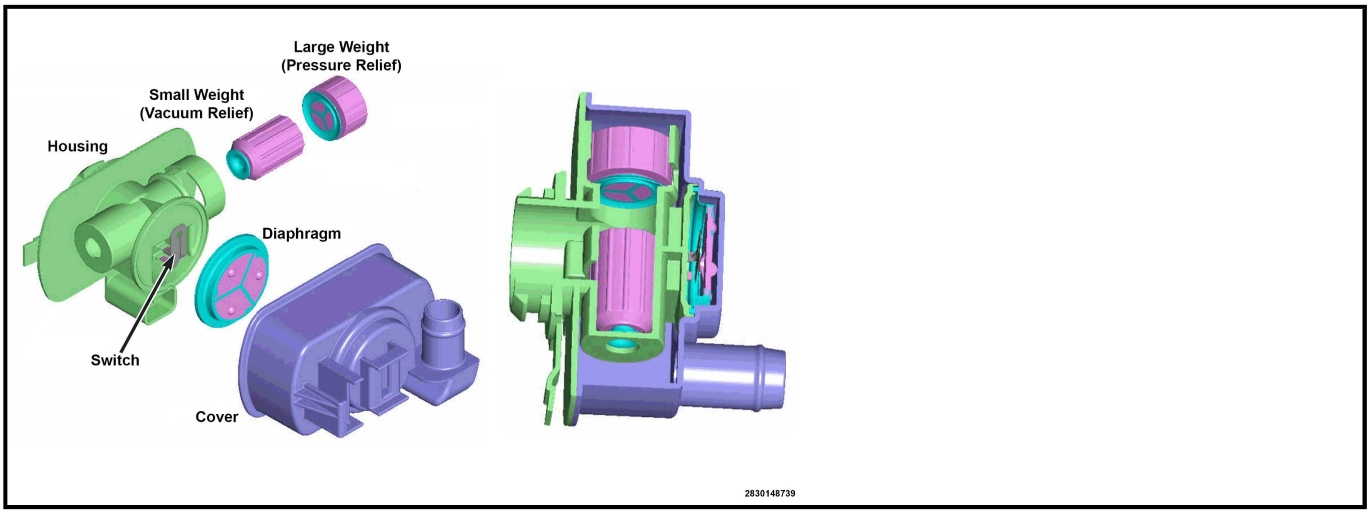
NOTE: **It is usually best to analyze the entire Evap System components and wiring regardless of the DTC present. A sealed system will create vacuum as it cools or pressure as it heats up. Even a slight temperature change will cause the system to build pressure or create vacuum if the system is sealed and not leaking. We will use this principle in the test steps below to diagnose the system by monitoring the ESIM signal, Fuel Tank Pressure (FTP) Sensor signal and Purge Solenoid duty cycle with the scan tool while performing a few simple checks to help in determining if in fact the system is failing, and to possibly pin point the cause of the issue before disassembling any components.**

NOTE: **The Fuel Tank Pressure Sensor is not used by the PCM in determining a leak but can be used to help in diagnosing the system.**

COMPONENT FUNCTIONAL DESCRIPTION - EVAPORATIVE SYSTEM INTEGRITY MODULE (ESIM) AND SWITCH

FUNCTIONAL OPERATION OF THE ESIM: The ESIM is configured with a normally open vacuum switch and normally closed vacuum relief and pressure relief valves (see figure). **The PCM uses the ESIM for all system leak diagnostics (P0440, P0455 and P0456).** The relief valves regulate the system pressure between approximately 1" H_2O and -2" H_2O (250Pa and -500Pa).

- When the system vacuum reaches between (-187Pa) and (-250Pa) it acts on the diaphragm and closes the vacuum switch. When the switch closes it allows continuity between the terminals. This allows the **ESIM Signal** to pass through the switch, pulling the signal low to ground. The PCM monitors the signal to determine the state of the switch (open or closed). The ESIM Signal will typically be a 12.0 volt or 5.0 volt signal depending on the vehicle. The voltage signals can vary between vehicles and may be somewhere between 5.0 and 12.0 volts. **Basically, when the PCM reads voltage on the signal circuit it determines the switch is open and when the signal is pulled low it determines the switch is closed.**
- The vacuum relief valve is intended to maintain the seal on the system during engine off events. However if the vacuum exceeds the regulation point the valve will pull off the seat to protect the system from excessive vacuum conditions.
- The pressure relief valve limits any pressure build up in the Fuel Tank during refueling and allows the tank pressure to normalize during increasing temperature events. This is additionally beneficial because it achieves a switch closed (pass threshold) sooner than if the tank has to decay from a much higher pressure.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- On a cold start condition when the Evap System Small Leak test has failed during the last valid ignition off event.
- Ambient temperature between 4B°C and 35B°C (39B°F and 95B°F).
- Fuel level is between 12% and 88%.
- Elevation is below 8000 feet.

SET CONDITION

- The Powertrain Control Module (PCM) initiates an intrusive test to determine the leak size. During the test the ESIM switch opened before a calibrated period of time, indicating a large leak is present.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EVAP SYSTEM PLUMBING LEAKING
CHARCOAL CANISTER LEAKING
FUEL TANK OR FUEL PUMP SEAL LEAKING
ESIM SWITCH OR WIRING ISSUE
ESIM MOUNTING SEAL LEAKING
ESIM INTERNAL CHECK VALVES LEAKING
ESIM MOUNTED INCORRECTLY ON THE CANISTER
PURGE SOLENOID LEAKING

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS THAT APPLY**
    1. Before proceeding with this test procedure, perform any Service Bulletins or PCM Flash updates that relate to this fault code.

       Are there any Service Bulletins or PCM Flash updates available?

Yes

- Perform the applicable Service Bulletins or PCM Flash update.
- Verify the system is not leaking by leak testing the system, Go To 2

No

- Go To 2

2. **PERFORM THE SMALL LEAK VERIFICATION TEST**
   1. Turn the ignition on.
   2. With the scan tool, navigate to the Small Leak Verification Test routine and follow the instructions on the screen.

      NOTE: **The routine tests the system using similar methodology as the manual leak evaluation in the next test step with one exception. The routine is based solely on the pressure reading from the FTP Sensor. The ESIM Switch state is not factored into the decision in the routine even though it is solely used for leak detection by the PCM. The ESIM state is shown and documented so that it can be verified for proper operation using the information provided in the table in test step 3 below.**

   3. 3. Document the results from each phase recorded in the Small Leak Verification Test routine.

      Small Leak Verification Test results?

      Passed

      - This indicates that the system may be sealed and not leaking. Compare the results from the routine to the expected results and possible failures in the table below in test step 3. If the system is functioning properly, no attempt at a repair should be performed.

      Failed

      - Compare the results from the routine to the expected results and possible failures in the table below in test step. Refer to 3.

      Not available on scan tool or will not run

      - Go To 3

3. **PERFORM A MANUAL EVALUATION OF THE EVAP SYSTEM FOR A LEAK**

   NOTE: **For best results when testing the Fuel Tank should have less than 95% of Fuel Tank capacity.**

   NOTE: **The results of these checks are subjective, not absolute. They can vary based on the size of the Fuel Tank and system, fuel volume, barometric pressure, ambient and fuel temperature. These conditions should be accounted for when analyzing the results and making your determination if the system has a leak.**

   1. There are 5 test phases that will be performed. The timing of each phase is important. Take time to read and understand each phase before beginning the test. There are three data reads in the Data Display tab of the scan tool that are referenced to monitor and document during this test.
      - Purge Duty Cycle % - This is monitored to determine if purging is on or off
      - ESIM Switch State

- Fuel Tank Pressure: Pa

2. The short or simple version of the 5 phases are as follows:
    1. Vent the system and document the ESIM and FTP Sensor data reads.
    2. Monitor and document the ESIM state and FTP Sensor data reads for 2-3 minutes.
    3. Start the engine and document the ESIM state and FTP Sensor data reads immediately after engine starts (before purge is active).
    4. Allow purging to become active just long enough to create maximum vacuum and document the ESIM state and FTP Sensor data.
    5. Turn engine off, monitor and document the ESIM state and FTP Sensor data reads for 3-4 minutes.

NOTE: **These are explained in more detail below along with helpful tips and alternative methods for some of the test phases to try and account for all possible systems and functionalities. Compare the results of each phase to the expected results and possible failures in the table below.**

3. **Test Phase 1 (Check Zero Reference of FTP Sensor):** With the ignition on vent the system to atmosphere and monitor the data reads. Document the ESIM Switch state and Fuel Tank Pressure Sensor reading.
    - This can be done by removing the gas cap, opening the capless filler or actuating the purge solenoid **for one minute** with the scan tool. Actuating the purge solenoid allows not disturbing any components that could be a possible leak point. However, it does not vent quickly on all systems and can take a minute to reach atmosphere.
    - **The FTP sensor reading may not be exactly at zero.** This is normal. Whatever the reading is when it is vented is the zero reference.
4. **Test Phase 2 (Non-intrusive leak check):** Monitor readings for 2-3 minutes with ignition on, engine not running, after the system is closed. Document the Fuel Tank Pressure Sensor reading.
    - Even if the system appears to be normal and not leaking at this point it is best to continue to check the operation of the entire system.
    - A change of more than 200 Pa in 1 minute would indicate the system is too unstable to accurately test.
5. **Test Phase 3 (Purge Solenoid leak check):** Start the engine and monitor and document the ESIM Switch state and Fuel Tank Pressure Sensor reading within 5-10 seconds after the engine is started while the **purge solenoid is off** .
    - A small amount of vacuum is created due to fuel being pulled from the tank. (Typically between approximately -25 and -50 Pa).
6. **Test Phase 4 (Starting the Intrusive leak check - Also checking ESIM Switch function and General Evap failure):** Allow purging to become active long enough to create maximum vacuum and stabilize. Shut off engine immediately after maximum vacuum is achieved. Should reach approximately -600 Pa. Document the ESIM Switch state and Fuel Tank Pressure Sensor reading.
    - This phase can be done several ways. It is important to get purging to happen in the shortest time possible to keep from generating too much heat in the fuel and Fuel Tank. This can cause the vacuum to decay too quickly in the next test phase and lead to misleading findings.
    - Engine purging is different for each engine and vehicle configuration. Some vehicles will start purging naturally shortly after engine is started. Other engines will need to have the engine speed increased for purging to happen.
    - The recommended method would be to turn the engine off after writing down the ESIM Switch state and FTP Sensor reading in Test Phase 3. Navigate to the Systems Tests and run the "Purge Vapors System Test" and follow the on-screen instructions. Once purge is activated and vacuum is created turn the engine off and navigate back to the data reads in Data Display.

7. **Test Phase 5 (Intrusive leak check):** Once max vacuum is created and stable, turn off engine and monitor the FTP Sensor and ESIM Switch readings for an additional 3-4 minutes. Document the ESIM Switch state and Fuel Tank Pressure Sensor reading immediately after engine is turned off and after 3-4 minutes

   Analyze the results recorded from the scan tool or manual system tests above: Listed in the table are the expected results and various failures that can possibly occur

-

TEST PHASE	EXPECTED RESULTS	ACTUAL RESULTS / POSSIBLE FAILURES
1	ESIM Switch should be open and FTP sensor should read near zero.	If the ESIM switch is reading closed at this point it would indicate 1 of 3 failure modes. • The ESIM signal wire is shorted to ground. • The ESIM switch is stuck in the closed position. • Purge solenoid did not open if actuated. A good indication of this would be if the fuel tank pressure did not change as well.
2	The fuel tank pressure reading should start to slowly change positive or negative. **NOTE:** **More than a 200 Pa change in 1 minute would indicate the system is too unstable to accurately test.** If the system is not leaking it should start to slowly create pressure or vacuum depending on whether it is heating up or cooling down.	A steady value would indicate either a leak is present, or the system temperature is too stable to cause a change. **Continue testing to determine if system is leaking.** • A very rapid pressure change would indicate that the temperature change is too large causing an invalid result. **NOTE:** **This can occur if bringing a vehicle from outside during a cold ambient temp into a warm shop or very hot ambient temperature into a cooler shop condition. If the vehicle was at operating temperature it will create excessive heat in the system as well.**
3	A small amount of vacuum is created due to fuel being pulled	If vacuum is created instantly after engine is started near or below the ESIM regulation

TEST PHASE	EXPECTED RESULTS	ACTUAL RESULTS / POSSIBLE FAILURES
	from the tank. (Typically is between approximately -25 and -50 Pa).	point (-500 PA) it would indicate that the purge solenoid is leaking. **NOTE:** **Since the purge performance diagnostics look for a delta change in the FTP Sensor signal when purge is commanded on, and again when it is commanded off, this condition may also cause a P0441-Purge System Performance fault to set.**
4	The fuel tank pressure should drop quickly to approximately -600 Pa and the ESIM Switch state changes to closed. **NOTE:** **It is normal for the vacuum to go slightly below the regulation point. when the engine is purging.**	• If the fuel tank pressure drops as expected but the ESIM switch does not close it would indicate that the switch is stuck open, or an open in the ESIM signal or ground circuit. **Note: This condition can also cause the P0440-General Evap System Failure DTC to set since that fault occurs when the ESIM switch does not close when the PCM performs the large leak diagnostic.** • If the ESIM switch closes but the fuel tank pressure changes very little or not at all it would indicate a restriction in one of the lines between the canister and FTP sensor or a faulty (stuck) sensor. Before condemning a sensor verify that the 5-Volt supply is present at the sensor. If the 5-Volt supply is not present to the sensor it can cause the sensor signal to stick mid-range and not change. • If the ESIM switch does not close and the fuel tank pressure does not change or changes very little it would indicate either a very large leak or the purge solenoid is not opening when actuated.

<table>
<tr><th>TEST PHASE</th><th>EXPECTED RESULTS</th><th>ACTUAL RESULTS / POSSIBLE FAILURES</th></tr>
<tr><td></td><td></td><td>Note: This condition can also cause the P0440-General Evap System Failure DTC to set.
If the vacuum created is 2 to 3 times the expected reading it would indicate the Canister vent hose or fresh air filter are plugged or the ESIM vacuum vent valve is stuck closed. This would also lead to difficulty filling the Fuel Tank during refueling</td></tr>
<tr><td>5</td><td>The FTP Sensor reading should quickly return to the vacuum relief regulation point (approximately -500 Pa) and stabilize.

NOTE:
The weights can sometimes bounce when the purge solenoid is suddenly shut off causing the vacuum to drop below -500 Pa.

The vacuum should stay below approximately -250 Pa and the ESIM switch should remain closed for the additional 3-4 minutes of monitoring.</td><td>If the fuel tank pressure reading rises quickly near zero or above -250 Pa and the ESIM switch opens within the 3-4 minutes it would indicate that the system has a leak. Go To Refer to 4.
If the expected results were attained during each phase of testing the system is most likely not leaking at this time. Some possible causes for the false failure could be:
Software issues. Check for any Service Bulletins that may apply.
Debris was stuck in the purge solenoid or one of the ESIM relief valves that has since cleared.
The ESIM is not mounted correctly with the switch at the 3 o'clock position causing the relief valves not to seal properly.</td></tr>
</table>

4. **CHOOSE A METHOD TO LEAK CHECK THE EVAP SYSTEM**

   What is the preferred method to leak check the system?

   Leak test the entire system as a whole:

   - Go To 5

   Split the system at the Charcoal Canister and leak test:

   - Go To 6

5. **PERFORM THE EVAPORATIVE EMISSION LEAK DETECTION ON THE WHOLE SYSTEM**
   1. To continue testing you will need the (special tool #8404C, Kit, EELD And Accessory).
   2. Connect the red power lead of the EELD to the Battery positive terminal and the black ground lead to Battery negative terminal.
   3. Connect shop air to the EELD.

4. Set the smoke/air control switch to **AIR** to pressurize the system.
5. Press the remote smoke/air start button.
6. Block off the end of the tester's AIR supply tip (clear hose) while pressing the remote start button.

NOTE: **The indicator ball should be resting on the bottom of the air flow meter (this is calibrated to no leak present) if the EELD is calibrated correctly.**

7. If the indicator ball is not resting on the bottom of air flow meter, position the red flag on the air flow meter so it is aligned with ball.
8. Connect the service adapter (special tool #8404-ADP, Smoke Machine Adapters) to the ESIM vent hose.
9. Connect the **AIR** supply tip (clear hose) to the adapter.
10. Press the remote button to activate **AIR flow.**

NOTE: **Depending on the vehicles fuel level, or vehicle venting configuration, it can take several minutes to fill the system.**

11. Compare the flow meter indicator ball reading to the red flag.

NOTE: **If the indicator ball drops down to the bottom of the air flow meter, or below the red flag that would indicate that the system is sealed and not leaking.**

Select the appropriate response from the list below:

The ball drops down to the bottom of the air flow meter, or below the red flag;

- This indicates that the leak is coming from the vent valves inside the ESIM since the rest of the system is not leaking. Replace the ESIM in accordance with the Service Information.
- Perform the Intrusive Leak Evaluation again to verify repair.

The ball stays above the red flag indicating a leak in the system;

- This indicates that the leak is not coming from vent valves inside the ESIM. There is a leak elsewhere in the system. **Leak test the system to find and repair the leak using one of the following methods;**
- **Smoke test:** Attach the black hose to the adaptor and switch the EELD tester to smoke. Pressurize the system with smoke from the EELD tester and look for smoke coming from around all connections and sealing points in the system. Repair or replace the leaking component.
- **Hydrocarbon Sniffer:** Continue pressurizing the system and check for a leak using the TIF8800X - Combustible Gas Detector or equivalent around all connections and sealing points in the system. Repair or replace the leaking component.
- **Bubble test:** Continue pressurizing the system and check for a leak by applying Mopar Air Leak Detector or equivalent around all connections and sealing points in the system and look for bubbles indicating a leak. Repair or replace the leaking component.
- **To check the Purge Solenoid** for an internal leak, remove the Manifold Hose from the Purge Solenoid, fill the system with smoke and check for smoke coming through the Purge Solenoid. If smoke is present, replace the Purge Solenoid in accordance with the Service Information.
- **Perform the Intrusive Leak Evaluation again to verify repair.**

6. **SEPARATE THE SYSTEM TO DETERMINE WHICH SIDE OF THE EVAPORATIVE SYSTEM IS LEAKING**

1. Remove the Canister Tube (that connects to the Fuel Tank on the other end) from the Charcoal Canister.
2. Attach a hand vacuum pump to the fitting on the canister.

   NOTE: **A small clamp or zip tie can be used to make sure the plug is tightly secured and not leaking.**

3. Pump the hand vacuum pump until the ESIM Switch closes.

   NOTE: **This should only take a few pumps.**

4. With the scan tool, monitor the ESIM Switch state for up to 10 minutes.

   NOTE: **This checks for leaks on the fresh air side of system (ESIM internal valves and seal, Charcoal Canister, Purge Solenoid and Purge Tube between the solenoid and canister). The ESIM Switch should remain closed since pressure from the fuel tank vapors are no longer acting on the canister and switch assuming no or minimal temperature change.**

   Did the ESIM Switch remain closed for a minimum of 5 minutes?

   Yes

   - The leak is on the Fuel Tank side of the system. Go To 7

   No

   - The leak is on the fresh air (canister) side of the system. Go To 8

7. **FUEL TANK SIDE EVAPORATIVE EMISSION LEAK DETECTION**
   1. To continue testing you will need the (special tool #8404C, Kit, EELD And Accessory).
   2. Connect the red power lead of the EELD to the Battery positive terminal and the black ground lead to Battery negative terminal.
   3. Connect shop air to the EELD.
   4. Set the smoke/air control switch to **Smoke** .
   5. Attach the black hose to the Canister Tube.
   6. Press the remote button to fill the Fuel Tank side of the system with smoke.

   Leak test the system to find and repair the leak using one of the following methods:

   - **Smoke test:** Attach the black hose to the adaptor and switch the EELD tester to smoke. Pressurize the system with smoke from the EELD tester and look for smoke coming from around all connections and sealing points in the system. Repair or replace the leaking component.
   - **Hydrocarbon Sniffer:** Continue pressurizing the system and check for a leak using the TIF8800X - Combustible Gas Detector or equivalent around all connections and sealing points in the system. Repair or replace the leaking component.
   - **Bubble test:** Continue pressurizing the system and check for a leak by applying Mopar Air Leak Detector or equivalent around all connections and sealing points in the system and look for bubbles indicating a leak. Repair or replace the leaking component.
   - **To check the Purge Solenoid** for an internal leak, remove the Manifold Hose from the Purge Solenoid, fill the system with smoke and check for smoke coming through the Purge Solenoid. If smoke is present, replace the Purge Solenoid in accordance with the Service Information.

- **Perform the Intrusive Leak Evaluation again to verify repair.**

8. **FRESH AIR SIDE EVAPORATIVE EMISSION LEAK DETECTION**
    1. To continue testing you will need the (special tool #8404C, Kit, EELD And Accessory).
    2. Connect the red power lead of the EELD to the Battery positive terminal and the black ground lead to Battery negative terminal.
    3. Connect shop air to the EELD.
    4. Set the smoke/air control switch to **AIR** to pressurize the system.
    5. Press the remote smoke/air start button.
    6. Block off the end of the tester's AIR supply tip (clear hose) while pressing the remote start button.

    NOTE: **The indicator ball should be resting on the bottom of the air flow meter (this is calibrated to no leak present) if the EELD is calibrated correctly.**

    7. If the indicator ball is not resting on the bottom of air flow meter, position the red flag on the air flow meter so it is aligned with ball.
    8. Connect the service adapter (special tool #8404-ADP, Smoke Machine Adapters) to the ESIM vent hose.
    9. Connect the **AIR** supply tip (clear hose) to the adapter.
    10. Press the remote button to activate **AIR flow.**
    11. Compare the flow meter indicator ball reading to the red flag.

    Select the appropriate response from the list below:

    The ball drops down to the bottom of the air flow meter, or below the red flag;

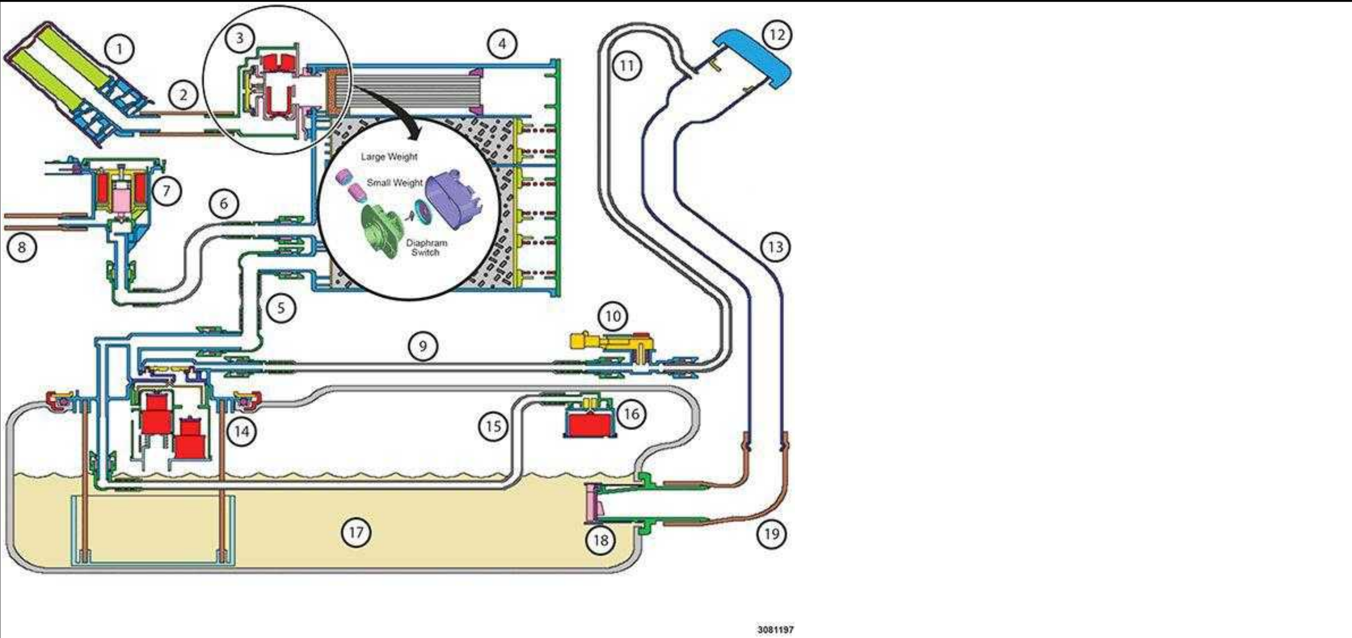
    - This indicates that the leak is coming from the vent valves inside the ESIM. Replace the ESIM in accordance with the Service Information.

    The ball stays above the red flag indicating a leak in the system;

    - This indicates that the leak is not coming from vent valves inside the ESIM. There is a leak elsewhere in the system. **Leak test the system to find and repair the leak using one of the following methods;**
    - **Smoke test:** Attach the black hose to the adaptor and switch the EELD tester to smoke. Pressurize the system with smoke from the EELD tester and look for smoke coming from around all connections and sealing points in the system. Repair or replace the leaking component.
    - **Hydrocarbon Sniffer:** Continue pressurizing the system and check for a leak using the TIF8800X - Combustible Gas Detector or equivalent around all connections and sealing points in the system. Repair or replace the leaking component.
    - **Bubble test:** Continue pressurizing the system and check for a leak by applying Mopar Air Leak Detector or equivalent around all connections and sealing points in the system and look for bubbles indicating a leak. Repair or replace the leaking component.
    - **To check the Purge Solenoid** for an internal leak, remove the Manifold Hose from the Purge Solenoid, fill the system with smoke and check for smoke coming through the Purge Solenoid. If smoke is present, replace the Purge Solenoid in accordance with the Service Information.
    - **Perform the Intrusive Leak Evaluation again to verify repair.**

P0456-EVAP SYSTEM SMALL LEAK

THEORY OF OPERATION



EVAP SYSTEM COMPONENTS			
CALLOUT	DESCRIPTION	CALLOUT	DESCRIPTION
1	Filter - Fresh Air Inlet	11	Recirculation Tube (metal portion) (FTPS to Fuel Filler Tube)
2	Filter Hose (Filter to ESIM)	12	Gas Cap or Cap-less Refueling Unit (if equipped)
3	Evaporative System Integrity Monitor (ESIM)	13	Fuel Filler Tube
4	Evaporative Charcoal Canister	14	Multi-Function Control Valve (MFCV) in the Fuel Delivery Flange
5	Canister Tube (Fuel Tank to Canister)	15	GVV Tube (GVV to MFCV)
6	Purge Tube (Purge Solenoid to Canister)	16	Grade Vent Valve (GVV)
7	Purge Solenoid	17	Fuel Tank
8	Manifold Hose (Purge Solenoid to Engine Manifold)	18	Inlet Check Valve (ICV)
9	Recirculation Tube (Fuel Tank to FTPS)	19	Hose - Fuel Filler Tube to ICV
10	Fuel Tank Pressure Sensor (FTPS)	-	-

EVAPORATIVE SYSTEM OVERVIEW: The Powertrain Control Module (PCM) monitors the Evaporative Emission System operation. The two main areas being monitored are the integrity of the system against leaks and the ability of the system to purge fuel vapor from the canister to the Intake Manifold. The basic strategy used is that in a **sealed system** , pressure will naturally increase or decrease in relation to temperature. **The Evaporative System Integrity Monitor (ESIM) Switch is used for all leak fault detection.** There is a vacuum actuated switch that closes when the vacuum reaches a calibrated threshold. If the switch closes it indicates that the system is not leaking.

ESIM SWITCH STUCK CLOSED MONITOR: At ignition off, the state of the ESIM Switch is evaluated. If the switch is open, a pass flag will set so the PCM power down process can complete. If the switch is closed, the PCM will wait a calibrated delay time and open the Purge Solenoid. In a normally functioning system, this will relieve the vacuum trapped in the Charcoal Canister allowing the switch to open. When the switch opens, a pass flag is set and the PCM will power down. If the ESIM switch does not open, after a calibrated time, an error is detected and a switch stuck closed failure event is set **(P0452)** . Two consecutive failed events will mature a fault.

SMALL LEAK MONITOR: This is an accumulative monitor and the data from each valid event is recorded and added to the previously recorded events. The PCM timer records the engine on/drive cycle and engine off time for each small leak monitor event. For an event to be valid the PCM must see;

1. An engine on/drive cycle for a minimum of 2-5 minutes.

   NOTE: **The Engine on timer is clipped to a maximum of 26 minutes on any given trip.**

2. And, when the engine is shut down, an engine off timer starts. There is a 12 minute delay time in which the PCM will ignore ESIM Switch input. The engine off timer period will continue to count until one of the three conditions exist:
   - The engine is started without a switch closure during the event.

     NOTE: **At the next key on cycle a determination is made as to whether the event was valid and the information is kept.**

   - An ESIM Switch closed input is received after the 12 minute delay during the event.

     NOTE: **If the switch closed input is received, the PCM records that the switch has closed and stores the engine shut down time.**

   - After a maximum time of 17.5 hours without an ESIM Switch closure during the event.

This monitor will **increment** the **accumulation fail timers** until **both** have reached a calibrated threshold (Engine on - 100 minutes and Engine off - 70 hours). When the monitor records a valid **switch closure (small leak passing event)** the fail timers are reset.

LEAK SIZE DETERMINATION: If the PCM did not see an ESIM Switch closed signal during the previous ignition off cycle, the event was valid, and there is a cold start, an intrusive leak test is run to determine if a large leak is present. Immediately after start-up, while the engine is cold the Purge Solenoid is opened to create vacuum in the evaporative system to a calibrated vacuum point that is beyond the ESIM Switch closing threshold. **The pass/fail time will vary based on the total fuel volume at the time of the test.**

- If the switch does not close at all during purging, because of a switch that is stuck open or vacuum cannot be created below -250 Pa within a calibrated time, it is determined to be a general evaporative system failure **(P0440)** .
- If vacuum is created and the switch has closed, the Purge Solenoid is commanded off and the PCM monitors the switch closure time. If the switch opens before a calibrated threshold, a large leak is present. Two consecutive failure events will mature a fault **(P0455).**
- If vacuum is created and the switch has closed, the Purge Solenoid is commanded off and the PCM monitors the switch closure time. If the switch stays closed longer than a calibrated threshold, it is determined that a large leak is not present. If the Large Leak diagnostic does not fail before the accumulated small leak timer reaches it's threshold it is determined that a small leak is present **(P0456).**

NOTE: **It is important to understand how extreme temperature changes can effect your results when diagnosing the system. It can either mask a leak by creating vacuum too rapidly temporarily overcoming the leak, or make a sealed system appear to be leaking due to excessive vapor build-up decaying vacuum too rapidly. This could be from the vehicle heat soaking after a long drive cycle or being brought into a shop environment that is vastly different from the outside environment. Be aware of these factors when performing the system checks in the test below.**

NOTE: **It is usually best to analyze the entire Evap System components and wiring regardless of the DTC present. A sealed system will create vacuum as it cools or pressure as it heats up. Even a slight temperature change will cause the**

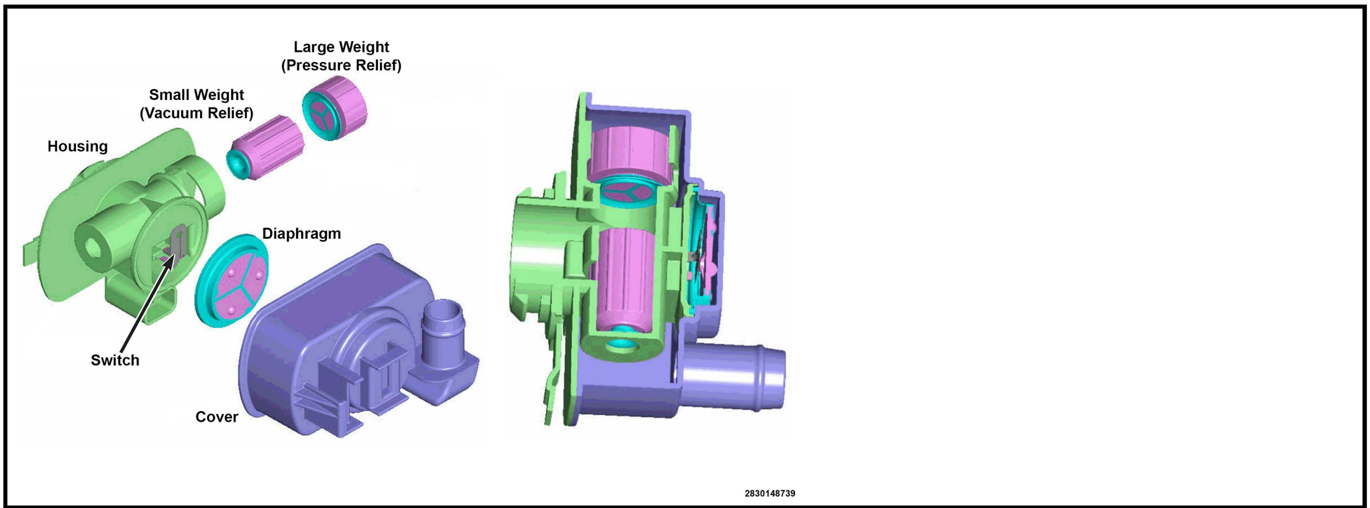
system to build pressure or create vacuum if the system is sealed and not leaking. We will use this principle in the test steps below to diagnose the system by monitoring the ESIM signal, Fuel Tank Pressure (FTP) Sensor signal and Purge Solenoid duty cycle with the scan tool while performing a few simple checks to help in determining if in fact the system is failing, and to possibly pin point the cause of the issue before disassembling any components.

NOTE: **The Fuel Tank Pressure Sensor is not used by the PCM in determining a leak but can be used to help in diagnosing the system.**

COMPONENT FUNCTIONAL DESCRIPTION - EVAPORATIVE SYSTEM INTEGRITY MODULE (ESIM) AND SWITCH

FUNCTIONAL OPERATION OF THE ESIM: The ESIM is configured with a normally open vacuum switch and normally closed vacuum relief and pressure relief valves (see figure). **The PCM uses the ESIM for all system leak diagnostics (P0440, P0455 and P0456).** The relief valves regulate the system pressure between approximately 1" H2O and -2" H2O (250Pa and -500Pa).

- When the system vacuum reaches between (-187Pa) and (-250Pa) it acts on the diaphragm and closes the vacuum switch. When the switch closes it allows continuity between the terminals. This allows the **ESIM Signal** to pass through the switch, pulling the signal low to ground. The PCM monitors the signal to determine the state of the switch (open or closed). The ESIM Signal will typically be a 12.0 volt or 5.0 volt signal depending on the vehicle. The voltage signals can vary between vehicles and may be somewhere between 5.0 and 12.0 volts. **Basically, when the PCM reads voltage on the signal circuit it determines the switch is open and when the signal is pulled low it determines the switch is closed.**
- The vacuum relief valve is intended to maintain the seal on the system during engine off events. However if the vacuum exceeds the regulation point the valve will pull off the seat to protect the system from excessive vacuum conditions.
- The pressure relief valve limits any pressure build up in the Fuel Tank during refueling and allows the tank pressure to normalize during increasing temperature events. This is additionally beneficial because it achieves a switch closed (pass threshold) sooner than if the tank has to decay from a much higher pressure.



WHEN MONITORED

This diagnostic runs continuously when the ignition is turned off and the following conditions are met:

- The previous engine run cycle was a minimum of 5 minutes.
- After the engine is off for a minimum time of 12 minutes a pass event can be recorded. The engine must be off for a minimum of 2 hours for a fail event to be recorded.
- Fuel level less than 88%.
- Ambient temperature between 4B°C and 35B°C (39B°F and 95B°F).

- Elevation is below 8000 feet.

SET CONDITION

- If no ESIM Switch closures were recorded and the accumulative timer has reached 70 hours of engine off time and 100 minutes of engine run time, it is determined that a small leak is present. This will take a minimum of 4 straight "fail events".
  - All other Evap system faults should be diagnosed before performing the small leak diagnostics.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EVAP SYSTEM PLUMBING LEAKING
CHARCOAL CANISTER LEAKING
FUEL TANK OR FUEL PUMP SEAL LEAKING
ESIM SWITCH OR WIRING ISSUE
ESIM MOUNTING SEAL LEAKING
ESIM INTERNAL CHECK VALVES LEAKING
ESIM MOUNTED INCORRECTLY ON THE CANISTER
PURGE SOLENOID LEAKING
RESTRICTION IN THE CANISTER TUBE BETWEEN THE FUEL TANK AND CHARCOAL CANISTER

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to **PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .**

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS THAT APPLY**
   1. Before proceeding with this test procedure, perform any Service Bulletins or PCM Flash updates that relate to this fault code.

      Are there any Service Bulletins or PCM Flash updates available?

      Yes

      - Perform the applicable Service Bulletins or PCM Flash update.
      - Verify the system is not leaking by leak testing the system, Go To 2

      No

      - Go To 2
2. **PERFORM THE SMALL LEAK VERIFICATION TEST**
   1. Turn the ignition on.
   2. With the scan tool, navigate to the Small Leak Verification Test routine and follow the instructions on the screen.

      NOTE: **The routine tests the system using similar methodology as the manual leak evaluation in the next test step with one exception. The routine is based solely on the pressure reading from the FTP Sensor. The ESIM Switch state is not factored into the decision in the routine even though it is solely used for leak detection by the PCM. The**

ESIM state is shown and documented so that it can be verified for proper operation using the information provided in the table in test step 3 below.

3. 3. Document the results from each phase recorded in the Small Leak Verification Test routine.

   Small Leak Verification Test results?

   Passed

   - This indicates that the system may be sealed and not leaking. Compare the results from the routine to the expected results and possible failures in the table below in test step 3. If the system is functioning properly, no attempt at a repair should be performed.

   Failed

   - Compare the results from the routine to the expected results and possible failures in the table below in test step. Refer to 3.

   Not available on scan tool or will not run

   - Go To 3

3. **PERFORM A MANUAL EVALUATE OF THE EVAP SYSTEM FOR A LEAK**

NOTE: **For best results when testing the Fuel Tank should have less than 95% of Fuel Tank capacity.**

NOTE: **The results of these checks are subjective, not absolute. They can vary based on the size of the Fuel Tank and system, fuel volume, barometric pressure, ambient and fuel temperature. These conditions should be accounted for when analyzing the results and making your determination if the system has a leak.**

1. There are 5 test phases that will be performed. The timing of each phase is important. Take time to read and understand each phase before beginning the test. There are three data reads in the Data Display tab of the scan tool that are referenced to monitor and document during this test.
   - Purge Duty Cycle % - This is monitored to determine if purging is on or off
   - ESIM Switch State
   - Fuel Tank Pressure: Pa
2. The short or simple version of the 5 phases are as follows:
   1. Vent the system and document the ESIM and FTP Sensor data reads.
   2. Monitor and document the ESIM state and FTP Sensor data reads for 2-3 minutes.
   3. Start the engine and document the ESIM state and FTP Sensor data reads immediately after engine starts (before purge is active).
   4. Allow purging to become active just long enough to create maximum vacuum and document the ESIM state and FTP Sensor data.
   5. Turn engine off, monitor and document the ESIM state and FTP Sensor data reads for 3-4 minutes.

   NOTE: **These are explained in more detail below along with helpful tips and alternative methods for some of the test phases to try and account for all possible systems and functionality. Compare the results of each phase to the expected results and possible failures in the table below.**

3. **Test Phase 1 (Check Zero Reference of FTP Sensor):** With the ignition on vent the system to atmosphere and monitor the data reads. Document the ESIM Switch state and Fuel Tank Pressure Sensor reading.
    - This can be done by removing the gas cap, opening the capless filler or actuating the purge solenoid **for one minute** with the scan tool. Actuating the purge solenoid allows not disturbing any components that could be a possible leak point. However, it does not vent quickly on all systems and can take a minute to reach atmosphere.
    - **The FTP sensor reading may not be exactly at zero.** This is normal. Whatever the reading is when it is vented is the zero reference.
4. **Test Phase 2 (Non-intrusive leak check):** Monitor readings for 2-3 minutes with ignition on, engine not running, after the system is closed. Document the Fuel Tank Pressure Sensor reading.
    - Even if the system appears to be normal and not leaking at this point it is best to continue to check the operation of the entire system.
    - A change of more than 200 Pa in 1 minute would indicate the system is too unstable to accurately test.
5. **Test Phase 3 (Purge Solenoid leak check):** Start the engine and monitor and document the ESIM Switch state and Fuel Tank Pressure Sensor reading within 5-10 seconds after the engine is started while the **purge solenoid is off** .
    - A small amount of vacuum is created due to fuel being pulled from the tank. (Typically between approximately -25 and -50 Pa).
6. **Test Phase 4 (Starting the Intrusive leak check - Also checking ESIM Switch function and General Evap failure):** Allow purging to become active long enough to create maximum vacuum and stabilize. Shut off engine immediately after maximum vacuum is achieved. Should reach approximately -600 Pa. Document the ESIM Switch state and Fuel Tank Pressure Sensor reading.
    - This phase can be done several ways. It is important to get purging to happen in the shortest time possible to keep from generating too much heat in the fuel and Fuel Tank. This can cause the vacuum to decay too quickly in the next test phase and lead to misleading findings.
    - Engine purging is different for each engine and vehicle configuration. Some vehicles will start purging naturally shortly after engine is started. Other engines will need to have the engine speed increased for purging to happen.
    - The recommended method would be to turn the engine off after writing down the ESIM Switch state and FTP Sensor reading in Test Phase 3. Navigate to the Systems Tests and run the "Purge Vapors System Test" and follow the on-screen instructions. Once purge is activated and vacuum is created turn the engine off and navigate back to the data reads in Data Display.
7. **Test Phase 5 (Intrusive leak check):** Once max vacuum is created and stable, turn off engine and monitor the FTP Sensor and ESIM Switch readings for an additional 3-4 minutes. Document the ESIM Switch state and Fuel Tank Pressure Sensor reading immediately after engine is turned off and after 3-4 minutes

    Analyze the results recorded from the scan tool or manual system tests above: Listed in the table are the expected results and various failures that can possibly occur

TEST PHASE	EXPECTED RESULTS	ACTUAL RESULTS / POSSIBLE FAILURES
1	ESIM Switch should be open and FTP sensor should read near zero.	If the ESIM switch is reading closed at this point it would indicate 1 of 3 failure modes. • The ESIM signal wire is shorted to ground. • The ESIM switch is stuck in the closed position. • Purge solenoid did not open if actuated. A good indication of this would be if

TEST PHASE	EXPECTED RESULTS	ACTUAL RESULTS / POSSIBLE FAILURES
		the fuel tank pressure did not change as well.
2	The fuel tank pressure reading should start to slowly change positive or negative. **NOTE:** **More than a 200 Pa change in 1 minute would indicate the system is too unstable to accurately test.** If the system is not leaking it should start to slowly create pressure or vacuum depending on whether it is heating up or cooling down.	A steady value would indicate either a leak is present, or the system temperature is too stable to cause a change. **Continue testing to determine if system is leaking.** • A very rapid pressure change would indicate that the temperature change is too large causing an invalid result. **NOTE:** **This can occur if bringing a vehicle from outside during a cold ambient temp into a warm shop or very hot ambient temperature into a cooler shop condition. If the vehicle was at operating temperature it will create excessive heat in the system as well.**
3	A small amount of vacuum is created due to fuel being pulled from the tank. (Typically is between approximately -25 and -50 Pa).	If vacuum is created instantly after engine is started near or below the ESIM regulation point (-500 PA) it would indicate that the purge solenoid is leaking. **NOTE:** **Since the purge performance diagnostics look for a delta change in the FTP Sensor signal when purge is commanded on, and again when**

TEST PHASE	EXPECTED RESULTS	ACTUAL RESULTS / POSSIBLE FAILURES
		it is commanded off, this condition may also cause a P0441-Purge System Performance fault to set.
4	The fuel tank pressure should drop quickly to approximately -600 Pa and the ESIM Switch state changes to closed. **NOTE:** **It is normal for the vacuum to go slightly below the regulation point. when the engine is purging.**	• If the fuel tank pressure drops as expected but the ESIM switch does not close it would indicate that the switch is stuck open, or an open in the ESIM signal or ground circuit. **Note: This condition can also cause the P0440-General Evap System Failure DTC to set since that fault occurs when the ESIM switch does not close when the PCM performs the large leak diagnostic.** • If the ESIM switch closes but the fuel tank pressure changes very little or not at all it would indicate a restriction in one of the lines between the canister and FTP sensor or a faulty (stuck) sensor. Before condemning a sensor verify that the 5-Volt supply is present at the sensor. If the 5-Volt supply is not present to the sensor it can cause the sensor signal to stick mid-range and not change. • If the ESIM switch does not close and the fuel tank pressure does not change or changes very little it would indicate either a very large leak or the purge solenoid is not opening when actuated. **Note: This condition can also cause the P0440-General Evap System Failure DTC to set.** • If the vacuum created is 2 to 3 times the expected reading it would indicate the Canister vent hose or fresh air filter are plugged or the ESIM vacuum vent valve is stuck closed. This would also lead to difficulty filling the Fuel Tank during refueling
5	The FTP Sensor reading should quickly return to the vacuum relief regulation point (approximately -500 Pa) and stabilize.	If the fuel tank pressure reading rises quickly near zero or above -250 Pa and the ESIM switch opens within the 3-4 minutes it would indicate that the system has a leak. **Go To** Refer to 4.

TEST PHASE	EXPECTED RESULTS	ACTUAL RESULTS / POSSIBLE FAILURES

	NOTE: **The weights can sometimes bounce when the purge solenoid is suddenly shut off causing the vacuum to drop below -500 Pa.**
	
	The vacuum should stay below approximately -250 Pa and the ESIM switch should remain closed for the additional 3-4 minutes of monitoring.
		• If the expected results were attained during each phase of testing the system is most likely not leaking at this time. Some possible causes for the false failure could be:
		  ◦ Software issues. Check for any Service Bulletins that may apply.
		  ◦ Debris was stuck in the purge solenoid or one of the ESIM relief valves that has since cleared.
		  ◦ The ESIM is not mounted correctly with the switch at the 3 o'clock position causing the relief valves not to seal properly.

4. **CHOOSE A METHOD TO LEAK CHECK THE EVAP SYSTEM**

   What is the preferred method to leak check the system?

   Leak test the entire system as a whole:

   - Go To 5

   Split the system at the Charcoal Canister and leak test:

   - Go To 6

5. **PERFORM THE EVAPORATIVE EMISSION LEAK DETECTION ON THE WHOLE SYSTEM**
   1. To continue testing you will need the (special tool #8404C, Kit, EELD And Accessory).
   2. Connect the red power lead of the EELD to the Battery positive terminal and the black ground lead to Battery negative terminal.
   3. Connect shop air to the EELD.
   4. Set the smoke/air control switch to **AIR** to pressurize the system.
   5. Press the remote smoke/air start button.
   6. Block off the end of the tester's AIR supply tip (clear hose) while pressing the remote start button.

      NOTE: **The indicator ball should be resting on the bottom of the air flow meter (this is calibrated to no leak present) if the EELD is calibrated correctly.**

   7. If the indicator ball is not resting on the bottom of air flow meter, position the red flag on the air flow meter so it is aligned with ball.
   8. Connect the service adapter (special tool #8404-ADP, Smoke Machine Adapters) to the ESIM vent hose.
   9. Connect the **AIR** supply tip (clear hose) to the adapter.
   10. Press the remote button to activate **AIR flow.**

NOTE: **Depending on the vehicles fuel level, or vehicle venting configuration, it can take several minutes to fill the system.**

11. Compare the flow meter indicator ball reading to the red flag.

NOTE: **If the indicator ball drops down to the bottom of the air flow meter, or below the red flag that would indicate that the system is sealed and not leaking.**

Select the appropriate response from the list below:

The ball drops down to the bottom of the air flow meter, or below the red flag;

- This indicates that the leak is coming from the vent valves inside the ESIM since the rest of the system is not leaking. Replace the ESIM in accordance with the Service Information.
- Perform the Intrusive Leak Evaluation again to verify repair.

The ball stays above the red flag indicating a leak in the system;

- This indicates that the leak is not coming from vent valves inside the ESIM. There is a leak elsewhere in the system. **Leak test the system to find and repair the leak using one of the following methods;**
- **Smoke test:** Attach the black hose to the adaptor and switch the EELD tester to smoke. Pressurize the system with smoke from the EELD tester and look for smoke coming from around all connections and sealing points in the system. Repair or replace the leaking component.
- **Hydrocarbon Sniffer:** Continue pressurizing the system and check for a leak using the TIF8800X - Combustible Gas Detector or equivalent around all connections and sealing points in the system. Repair or replace the leaking component.
- **Bubble test:** Continue pressurizing the system and check for a leak by applying Mopar Air Leak Detector or equivalent around all connections and sealing points in the system and look for bubbles indicating a leak. Repair or replace the leaking component.
- **To check the Purge Solenoid** for an internal leak, remove the Manifold Hose from the Purge Solenoid, fill the system with smoke and check for smoke coming through the Purge Solenoid. If smoke is present, replace the Purge Solenoid in accordance with the Service Information.
- **Perform the Intrusive Leak Evaluation again to verify repair.**

6. **SEPARATE THE SYSTEM TO DETERMINE WHICH SIDE OF THE EVAPORATIVE SYSTEM IS LEAKING**
   1. Remove the Canister Tube (that connects to the Fuel Tank on the other end) from the Charcoal Canister.
   2. Attach a hand vacuum pump to the fitting on the canister.

   NOTE: **A small clamp or zip tie can be used to make sure the plug is tightly secured and not leaking.**

   3. Pump the hand vacuum pump until the ESIM Switch closes.

   NOTE: **This should only take a few pumps.**

   4. With the scan tool, monitor the ESIM Switch state for up to 10 minutes.

   NOTE: **This checks for leaks on the fresh air side of system (ESIM internal valves and seal, Charcoal Canister, Purge Solenoid and Purge Tube between the solenoid and canister). The ESIM Switch should remain closed since pressure from the fuel tank vapors are no longer acting**

on the canister and switch assuming no or minimal temperature change.

Did the ESIM Switch remain closed for a minimum of 5 minutes?

Yes

- The leak is on the Fuel Tank side of the system. Go To 7

No

- The leak is on the fresh air (canister) side of the system. Go To 8

7. **FUEL TANK SIDE EVAPORATIVE EMISSION LEAK DETECTION**
    1. To continue testing you will need the (special tool #8404C, Kit, EELD And Accessory).
    2. Connect the red power lead of the EELD to the Battery positive terminal and the black ground lead to Battery negative terminal.
    3. Connect shop air to the EELD.
    4. Set the smoke/air control switch to **Smoke** .
    5. Attach the black hose to the Canister Tube.
    6. Press the remote button to fill the Fuel Tank side of the system with smoke.

    Leak test the system to find and repair the leak using one of the following methods:

    - **Smoke test:** Attach the black hose to the adaptor and switch the EELD tester to smoke. Pressurize the system with smoke from the EELD tester and look for smoke coming from around all connections and sealing points in the system. Repair or replace the leaking component.
    - **Hydrocarbon Sniffer:** Continue pressurizing the system and check for a leak using the TIF8800X - Combustible Gas Detector or equivalent around all connections and sealing points in the system. Repair or replace the leaking component.
    - **Bubble test:** Continue pressurizing the system and check for a leak by applying Mopar Air Leak Detector or equivalent around all connections and sealing points in the system and look for bubbles indicating a leak. Repair or replace the leaking component.
    - **To check the Purge Solenoid** for an internal leak, remove the Manifold Hose from the Purge Solenoid, fill the system with smoke and check for smoke coming through the Purge Solenoid. If smoke is present, replace the Purge Solenoid in accordance with the Service Information.
    - **Perform the Intrusive Leak Evaluation again to verify repair.**
8. **FRESH AIR SIDE EVAPORATIVE EMISSION LEAK DETECTION**
    1. To continue testing you will need the (special tool #8404C, Kit, EELD And Accessory).
    2. Connect the red power lead of the EELD to the Battery positive terminal and the black ground lead to Battery negative terminal.
    3. Connect shop air to the EELD.
    4. Set the smoke/air control switch to **AIR** to pressurize the system.
    5. Press the remote smoke/air start button.
    6. Block off the end of the tester's AIR supply tip (clear hose) while pressing the remote start button.

    NOTE: **The indicator ball should be resting on the bottom of the air flow meter (this is calibrated to no leak present) if the EELD is calibrated correctly.**

    7. If the indicator ball is not resting on the bottom of air flow meter, position the red flag on the air flow meter so it is aligned with ball.

8. Connect the service adapter (special tool #8404-ADP, Smoke Machine Adapters) to the ESIM vent hose.
9. Connect the **AIR** supply tip (clear hose) to the adapter.
10. Press the remote button to activate **AIR flow.**
11. Compare the flow meter indicator ball reading to the red flag.

    Select the appropriate response from the list below:

    The ball drops down to the bottom of the air flow meter, or below the red flag;

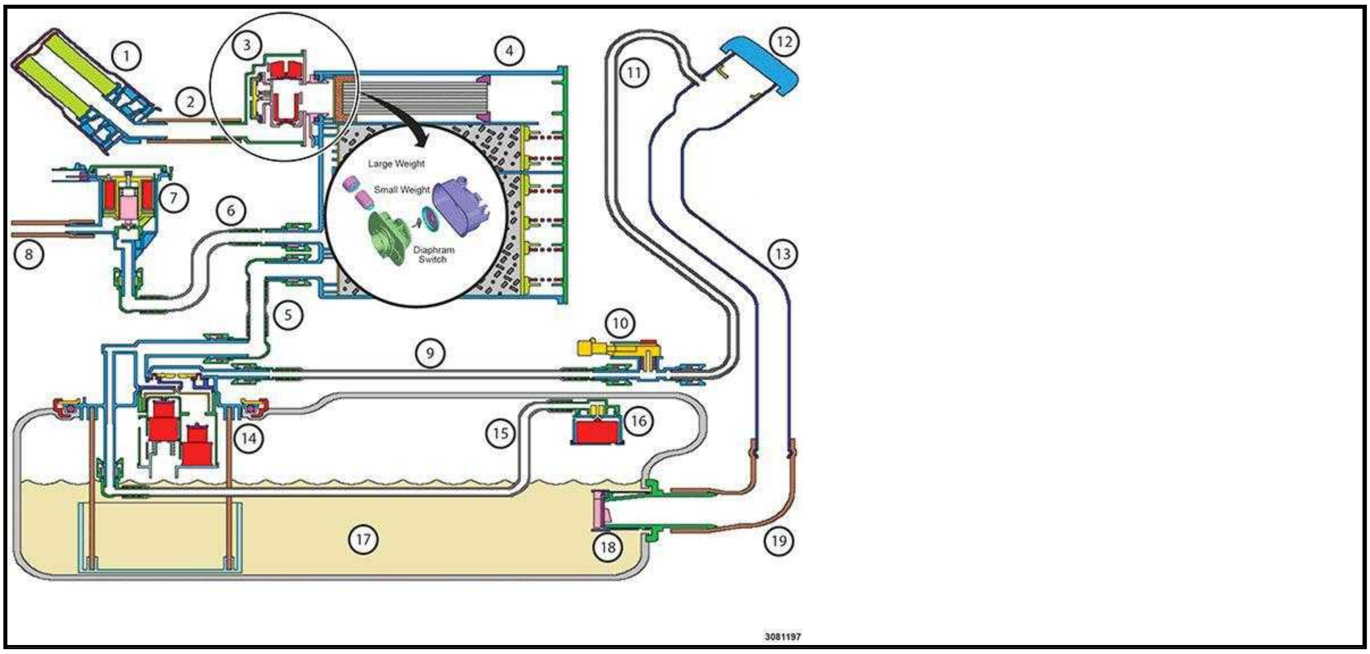
    - This indicates that the leak is coming from the vent valves inside the ESIM. Replace the ESIM in accordance with the Service Information.

    The ball stays above the red flag indicating a leak in the system;

    - This indicates that the leak is not coming from vent valves inside the ESIM. There is a leak elsewhere in the system. **Leak test the system to find and repair the leak using one of the following methods;**
    - **Smoke test:** Attach the black hose to the adaptor and switch the EELD tester to smoke. Pressurize the system with smoke from the EELD tester and look for smoke coming from around all connections and sealing points in the system. Repair or replace the leaking component.
    - **Hydrocarbon Sniffer:** Continue pressurizing the system and check for a leak using the TIF8800X - Combustible Gas Detector or equivalent around all connections and sealing points in the system. Repair or replace the leaking component.
    - **Bubble test:** Continue pressurizing the system and check for a leak by applying Mopar Air Leak Detector or equivalent around all connections and sealing points in the system and look for bubbles indicating a leak. Repair or replace the leaking component.
    - **To check the Purge Solenoid** for an internal leak, remove the Manifold Hose from the Purge Solenoid, fill the system with smoke and check for smoke coming through the Purge Solenoid. If smoke is present, replace the Purge Solenoid in accordance with the Service Information.
    - **Perform the Intrusive Leak Evaluation again to verify repair.**

P0457-EVAP SYSTEM - LOOSE FUEL CAP

THEORY OF OPERATION



EVAP SYSTEM COMPONENTS	
CALLOUT	DESCRIPTION
1	Filter - Fresh Air Inlet
2	Filter Hose (Filter to ESIM)
3	Evaporative System Integrity Monitor (ESIM)
4	Evaporative Canister
5	Canister Tube (Fuel Tank to Canister)
6	Purge Tube (Purge Solenoid to Canister)
7	Purge Solenoid
8	Manifold Hose (Purge Solenoid to Engine Manifold)
9	Recirculation Tube (Fuel Tank to FTPS)
10	Fuel Tank Pressure Sensor (FTPS)
11	Recirculation Tube (metal portion) (FTPS to Fuel Filler Tube)
12	Gas Cap or Cap-less Refueling Unit (if equipped)
13	Fuel Filler Tube
14	Multi-Function Control Valve (MFCV) in the Fuel Delivery Flange
15	GVV Tube (GVV to MFCV)
16	Grade Vent Valve (GVV)
17	Fuel Tank
18	Inlet Check Valve (ICV)
19	Hose - Fuel Filler Tube to ICV

The fuel level is recorded by the Powertrain Control Module (PCM) when the ignition key is turned off, and is compared to the fuel level at the next ignition key on cycle. If the PCM recognizes a 25% increase in fuel level, the Leak Test Monitor is initiated. If the Large leak test fails it is determined that the Fuel Filler Cap is faulty or not installed properly, or the Capless Fuel Filler Assembly flap did not seal properly after fueling. A LOOSE GAS CAP message will be displayed on the cluster to inform the customer.

WHEN MONITORED

- The Powertrain Control Module (PCM) detects a 25% increase in fuel level from the previous ignition on state.

SET CONDITION

- The Powertrain Control Module (PCM) initiates an intrusive test after a 25% fuel level increase and the ESIM Switch either opened before the maximum calibrated time, or the ESIM Switch did not close at all.

DEFAULT ACTION

- Loose Gas Cap light will illuminate.

POSSIBLE CAUSES

POSSIBLE CAUSES
LOOSE OR MISSING FUEL FILLER CAP
LARGE EVAP SYSTEM LEAK

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

CHECK THE FUEL FILLER CAP/CAPLESS FUEL FILLER FOR DAMAGE

1. Visually inspect for the following:
   - Loose, missing, or damaged Fuel Filler Cap or seal
   - Damaged locking tabs on the Fuel Filler Cap and/or filler tube
   - Damaged seal points on the Fuel Filler Cap and/or filler tube
2. If the vehicle is equipped with the Capless Fuel Filler Assembly, visually inspect the flap and seal for proper sealing.

   Were any problems found?

   Yes

   - Repair as necessary.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Perform the P0455-EVAP SYSTEM LARGE LEAK diagnostic procedure.

P0461-FUEL LEVEL SENSOR 1 PERFORMANCE

For a complete FUEL DELIVERY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

COMPONENT FUNCTIONAL DESCRIPTION - FUEL LEVEL SENSOR CIRCUITS

The Primary, and if equipped the Secondary Fuel Level Sensor Signals (saddle tanks or dual tanks depending on platform) are hard-wired to the Body Control Module (BCM). Both Fuel Level Sensor signals are a constant 12.0 volts. **On a normally functioning system,** the raw signal voltage to the BCM will read between approximately 0.5 volts (full stop) and 4.5 volts (empty stop) when the harness is connected. When there is an open in the circuitry the signal circuit voltage will be 12.0 volts. **The data reading value on the scan tool is clipped to read 5.0 volts when the signal circuit is open.** The BCM reads the voltage and converts the analog signals to digital signals. The digital signals are broadcast over the CAN bus. The Powertrain Control Module (PCM) receives and interprets the digital signals as a voltage read. The PCM, and in most cases the BCM, perform circuit fault diagnostics on the signal input.

The Fuel Level Rationality diagnostics are only performed by the PCM. The Fuel Level rationality diagnostics are explained in more detail in the Fuel Level Rationality diagnostic information below.

The Fuel Level Sensor Tables are available at the bottom of the test procedure.

THEORY OF OPERATION - FUEL LEVEL RATIONALITY

SINGLE TANK FUEL LEVEL RATIONALITY DIAGNOSTIC DESCRIPTION: The intent of the **Fuel Level Rationality** is to check for a "stuck" fuel level reading. This is done to keep high or low fuel levels that are stuck from disabling OBD monitors. Since the amount of fuel consumed from trip to trip varies based on customer drive cycles, this diagnostic can accumulate fuel consumption over multiple drive cycles. The diagnostic will run until enough fuel has been consumed to make a decision. The PCM compares the difference between the fuel level value at the start of the diagnostic and the fuel level value after a calibrated amount of fuel consumption should have occurred. If the difference is less than a calibrated threshold, the test fails. Once a decision is made, a new diagnostic test will start. If a fault is set, the fuel level will default to a value that will allow other OBD diagnostics to run.

SADDLE TANK FUEL LEVEL RATIONALITY GENERAL INFORMATION: The Fuel Level Sensor information is a direct input to the Body Control Module (BCM) which is sent to the Powertrain Control Module (PCM) via CAN bus. On the primary side of the saddle tank is the Electric Fuel Pump Module that feeds the engine and the Primary Fuel Level Sensor. On the secondary side of the saddle tank is a Venturi Jet Pump and the Secondary Fuel Level Sensor. The Jet Pump is connected to the Electric Fuel Pump Module on the primary side by way of a siphon tube. The PCM uses the average from both sides to determine the total fuel volume.

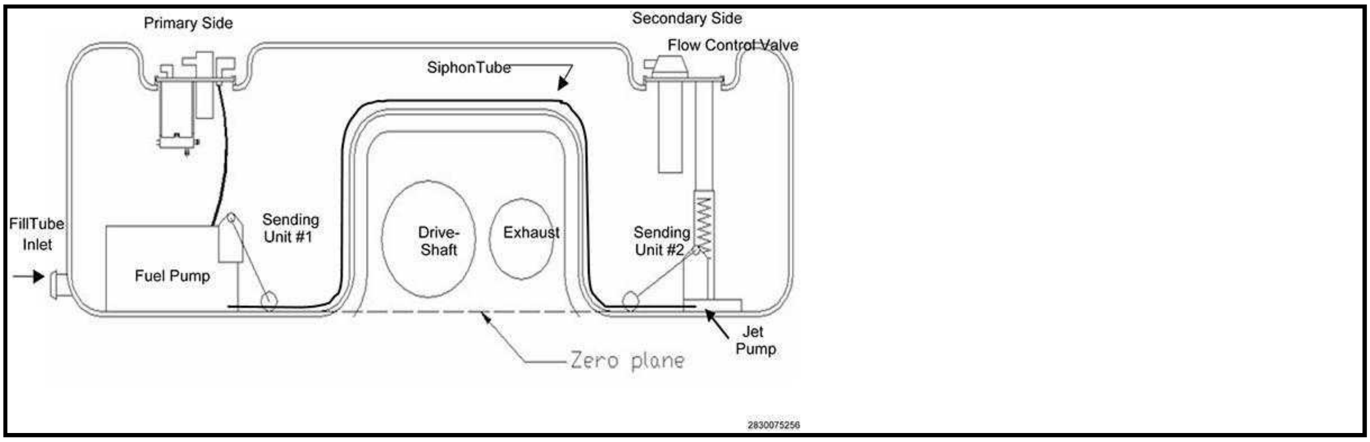
SADDLE TANK FUEL LEVEL RATIONALITY DIAGNOSTIC DESCRIPTION: On a properly operating system, the fuel volume on the secondary side of the Fuel Tank will be at empty before the primary side of the Fuel Tank will begin to decrease due to the siphon tube flow rate always exceeding the engines fuel consumption rate. Using this assumption, the PCM performs a diagnostic to check the rationality of both Fuel Level Sensors, as well as the operation of the jet pump and siphon tube as follows;

- When the total fuel volume is greater than 50% the primary tank should remain at the full position. As fuel is consumed, or sloshes over to the secondary tank while driving, the jet pump and siphon tube will replenish the primary tank to the full position and the secondary fuel level should decrease.
- When the total fuel volume is less than 50%, the secondary tank should be at empty and the primary fuel volume should start to decrease as fuel is consumed by the engine.

If either scenario fails to happen the PCM will determine that one of the Fuel Level Sensors is stuck in range, or that the Jet Pump or siphon tube is faulty not allowing fuel to transfer from the secondary side to the primary side of the Fuel Tank.

- The rationality diagnostic for the **primary side** of the tank will not become enabled until the secondary side level is near empty.
- The rationality diagnostic for the **secondary side** of the tank is based on the average fuel volume in the tank. It is enabled when there is enough total fuel to fill the primary tank plus enough fuel to check the rationality of the Secondary Fuel Level Sensor when a calibrated amount of fuel is consumed.

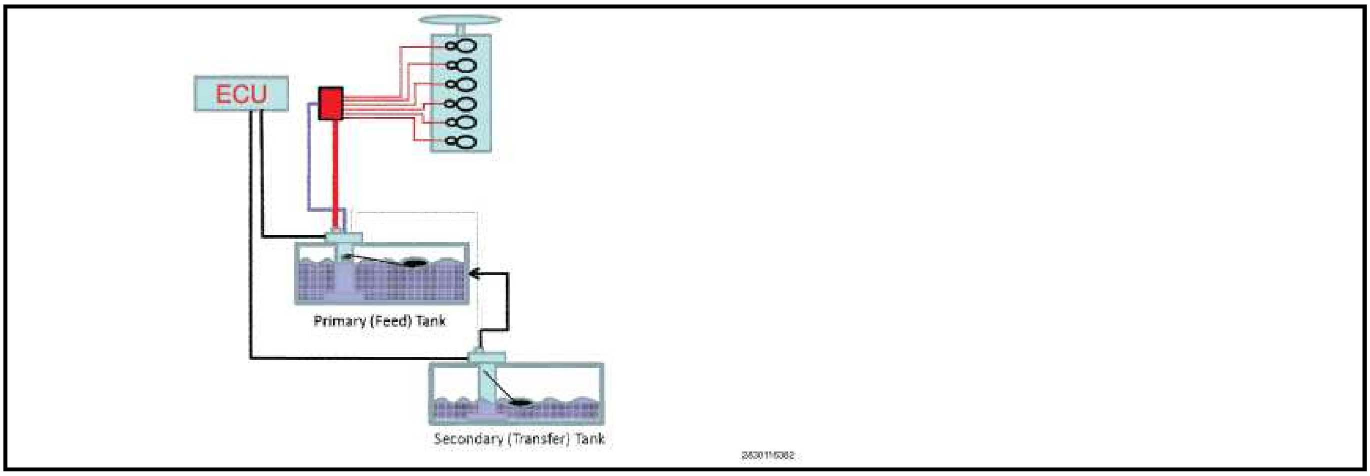
Since the amount of fuel consumed from trip to trip varies based on customer drive cycles, this monitor can accumulate fuel consumption over multiple drive cycles. The monitor will run until enough fuel has been consumed to make a decision. Once a decision is made, a new test will start.



DUAL FUEL TANK FUEL LEVEL RATIONALITY DIAGNOSTIC DESCRIPTION: Some D-Trucks add a second Fuel Tank (Auxiliary Fuel Tank) to allow the fuel capacity to be increased. Both Fuel Tanks have an independent Fuel Pump Module and Fuel Level Sensor (located inside the tanks); and fuel fill tube. The Fuel Level Sensor information is a bussed message from the Body Control Module (BCM) to the Powertrain Control Module (PCM).

- **The Main Fuel Tank** supplies fuel to the engine for consumption. The PCM performs the **Primary Fuel Level Rationality** diagnostic to check for a "stuck" fuel level reading in the same way as on a single tank system. **Refer to the Single Tank Fuel Level Rationality Diagnostic Description above.**
- **The Auxiliary Fuel Tank** is used to fill the Main Fuel Tank when the fuel level in the Main Fuel Tank reaches a minimum threshold. **It does not supply the fuel directly to the engine.** The Auxiliary Fuel Pump will be de-activated when the Main Fuel Tank fuel level reaches the maximum threshold, or the Auxiliary Fuel Tank fuel level reaches a minimum threshold before or during a tank transfer event. This is to prevent an overfill of the Main Fuel Tank or the Auxiliary Fuel Pump running in a dry condition. The PCM performs the **Secondary Fuel Level Rationality** diagnostic during a fuel transfer event.

There are 2 relays that control the Auxiliary Fuel Pump: The Fuel Pump 2 Relay and the Fuel Pump 2 On/Off Relay. The PCM controls the low side driver of the Fuel Pump 2 Relay. The Fuel Pump 2 Relay is supplied power from the Fuel Pump 2 On/Off Relay, which is controlled by the BCM. In the event that the Fuel Pump 2 Relay is stuck on and over filling the Main Fuel Tank, the BCM can turn off the Fuel Pump 2 On/Off Relay. This will turn off the power supply to the Fuel Pump 2 Relay and the Auxiliary Fuel Pump Module.



ENABLING/SET CONDITIONS AND POSSIBLE CAUSES - FUEL LEVEL SENSOR FAULTS

When Monitored - Circuit Faults (P0462, P0463, P2067, P2068, P2065-11, P2065-15):

These diagnostics run when the following conditions are met:

- With the ignition on.
- Battery voltage above 10.4 volts.
- No active fuel level missing message faults (PCM only).

When Monitored - Rationality Faults (P0461, P2066):

These diagnostics run when the following conditions are met:

Single Tank System:

- With the engine running for more than two minutes.
- After the PCM decides that a calibrated amount of fuel should have been consumed (between approximately one and five gallons depending on initial fuel level).
  - This is determined by the accumulated amount of fuel injected into the engine through the Fuel Injectors.

Saddle Tank System:

- The primary level rationality diagnostic runs when the Fuel Level Sensor 2 (Secondary) is reading empty.
- The secondary level rationality diagnostic runs when the Fuel Level Sensor 1 (Primary) is reading full.

Dual Tank System:

- The primary level rationality diagnostic functions the same as the Single Tank System.
- The secondary level rationality diagnostic runs when a fuel transfer event is occurring.

FAULT SETTING CRITERIA	
Circuit Low/High Faults - (P0462, P0463, P2067, P2068, P2065-11, P2065-15)	• Circuit Low - The Fuel Level Sensor signal voltage is below approximately 0.2 volts for more than 3.2 seconds. • Circuit High - The Fuel Level Sensor signal voltage is above approximately 4.9 volts for more than 3.2 seconds.
Rationality Faults - Single Tank Systems	When the PCM does not see a change in fuel level of greater than 0.06 volts after the calibrated amount of fuel should have been consumed the diagnostic will fail.
Rationality Faults - Saddle Tank Systems	• Primary Fault (P0461) - If the PCM does not see a change in Fuel Level Sensor 1 of greater than 0.06 volts after the calibrated amount of fuel should have been consumed the diagnostic will fail. • Secondary Fault (P2066) - If the PCM does not see a change in Fuel Level Sensor 2 of greater than 0.06 volts after the calibrated amount of fuel should have been consumed the diagnostic will fail.
Rationality Faults - Saddle Tank Systems	• Primary Fault (P0461) - If the PCM does not see a change in fuel level of greater than 0.06 volts after the calibrated amount of fuel should have been consumed the diagnostic will fail. • Secondary Fault (P2066) - No change in Fuel Level Sensor 2 circuit voltage after a significant amount of fuel should have been transferred from the Auxiliary Fuel Tank to the Primary Fuel Tank.

Default Actions:

- The MIL is illuminated.

Possible Causes - Circuit Faults
FUEL LEVEL SENSOR HARNESS CONNECTOR DAMAGED OR NOT CONNECTED COMPLETELY
FUEL LEVEL SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW FAULT)
FUEL LEVEL SENSOR SIGNAL CIRCUIT SHORTED TO THE SENSOR RETURN CIRCUIT (CIRCUIT LOW FAULT)
FUEL LEVEL SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH FAULT)
FUEL LEVEL SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH FAULT)
FUEL LEVEL SENSOR RETURN CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH FAULT)
FAULTY FUEL LEVEL SENSOR
FAULTY BODY CONTROL MODULE (BCM)

Possible Causes - Rationality Faults
FUEL LEVEL SENSOR HARNESS CONNECTOR DAMAGED OR NOT CONNECTED COMPLETELY
FUEL TANK DAMAGED
OBSTRUCTION TO THE PRIMARY OR SECONDARY FUEL LEVEL SENSOR
PRIMARY OR SECONDARY FUEL LEVEL SENSOR FAULTY OR BROKEN
SECONDARY PUMP OR SIPHON TUBE LEAKING OR DISCONNECTED (SADDLE TANK SYSTEM)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCs and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns, or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. **The resistor card on Fuel Level Sensors can occasionally have a bad spot on the card which can cause a fault to be inactive when testing.** In some cases this could result in an open circuit during the period when the fuel level is at the bad spot. In other cases the bad spot could result in the resistors on the card blurring together. This could cause the fuel level reading to stay constant when the fuel level travels through that portion of the resistor card. This condition can cause a performance fault since the PCM will not see a fuel level change as fuel is consumed during this time.
2. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
3. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
4. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply, check for connection issues by wiggle testing any wiring harnesses and in-line connectors the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach a lab scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor battery system voltage or poor ground connections can affect systems in different or odd ways. Check the battery or batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
5. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving. Operate the components through a full range of operation while monitoring functionality.

PRIMARY AND SECONDARY FUEL LEVEL SENSOR CIRCUIT FAULT DIAGNOSTICS

NOTE: **There are multiple test methods listed below. There can be advantages to using each method. All of the methods do not need to be performed. Pick the best test method based on accessibility, ease of testing or availability of test equipment. In some cases it may be beneficial to use parts of each method to test for different failure modes.**

CIRCUIT DIAGNOSTICS USING THE ELECTRICAL TEST LEAD KIT: Check the BCM signal and return circuits together to determine if the Fuel Level Sensor is faulty. Disconnect the Fuel Pump harness connector. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the Fuel Level Signal and Return Signal circuits in the Fuel Pump harness connector. Move the switch on the Electrical Test Lead Kit between the open and closed positions while monitoring the scan tool. If monitoring for faults, the circuit high fault should set when switched to the open position and the circuit low fault should set when switched to the closed position. If the sensor voltage is available, monitor the voltage readings on the scan tool. It should be 5.0 volts when switched to the open position and 0.0 volts when switched to the closed position. Move the switch to adjust and use the tool to vary the resistance between the Full Stop and Empty Stop resistance ranges while monitoring the BCM signal voltage on the scan tool with the ignition on.

NOTE: **Even though the actual signal will read 12.0 volts with the switch in the open position, the scan tool will register the signal as 5.0 volts**

1. **If the faults set as described and the signal voltage is 5.0 volts and 0.0 volts on the scan tool** - the BCM and Fuel Level Sensor circuits are testing good. The Fuel Level Sensor is most likely faulty or has a poor connection at the harness connector. Check the Fuel Pump harness connector for pushed out, spread, corroded or dirty terminals before condemning the sensor. The internal resistance of the sensor can be measured and compared to the table (if available) to verify a faulty sensor.
2. **If the signal voltage is stuck low or only the circuit low fault sets** - the most likely cause is the Fuel Level Sensor Signal circuit shorted to chassis ground or the Fuel Level Sensor Return circuit. Check the Fuel Level Sensor Signal circuit for a short to ground or the Sensor Return circuit. If the signal circuit is not shorted, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals before condemning a BCM. If no issues are found, the BCM is faulty.
3. **If the signal voltage is stuck high or only the circuit high fault sets** - the most likely cause is an open or very high resistance in the Fuel Level Sensor Signal or Return circuit. Continue testing in step 4.
4. **If the signal reading on the scan tool shows voltage present when switched to closed** - remove the test lead from the sensor return circuit and connect it to a good chassis ground while observing the voltage on the scan tool. If the voltage drops to 0.0 volts the resistance is in the sensor return circuit. If the voltage is still present the resistance is in the sensor signal circuit. Check the appropriate circuit for high resistance. Typically should be less than 3.0 Ohms. If the circuits check good, continue testing in step 5.
5. **If the circuits are checked and do not have excessive resistance** - Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BCM. If no issues are found, the BCM is faulty.

CIRCUIT DIAGNOSTICS USING CONVENTIONAL VOLTAGE TESTING WITH A DVOM:

1. Verify the Fuel Pump and BCM harness connectors are connected and locked properly.
2. Turn the ignition on. Back Probe and measure the voltage on the Fuel Level Sensor Signal circuit at the Fuel Pump harness connector.
    1. **If the signal voltage is reading between 0.5 and 4.5 volts** - the sensor signal is giving a legitimate reading. If the circuit fault is active and the voltage reading on the scan tool does not match the voltage reading, the BCM is likely faulty.
    2. **If the signal has a constant 0.0 volt reading** - this indicates that the signal circuit is shorted to ground or has an open between the BCM and Fuel Level Sensor. If the circuit high fault is set, the most likely failure is an open in the signal circuit. If the circuit low fault is set, the most likely failure is short to ground in the signal circuit. Disconnect the Fuel Pump and BCM harness connectors. Check the signal circuit for high resistance and short to ground. If the signal circuit checks good, check at all connectors in the system for pushed out, spread, corroded or dirty terminals before condemning a BCM.
    3. **If the signal reading has a constant 12.0 volts** - this indicates an open further downstream in the circuitry. Most likely the Fuel Level Sensor or the Fuel Level Sensor Return circuit.
3. To check the Fuel Level Sensor, move the test lead over and back probe the Fuel Level Sensor Return circuit at the Fuel Pump harness connector.
    1. **If the signal changes to 0.0 volts** - this would indicate an open in, or short across the Fuel Level Sensor resistance card. The internal resistance of the Fuel Level Sensor can be measured and compared to the table (if available) to verify a faulty sensor.

2. **If the signal is still at 12.0 volts** - this indicates an open in the Fuel Level Sensor Return circuit path. Disconnect the Fuel Pump and BCM harness connectors. Check the return circuit for high resistance. If the return circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals before condemning a BCM. If no issues are found, the BCM is faulty.

CIRCUIT DIAGNOSTICS USING CONVENTIONAL RESISTANCE TESTING WITH A DVOM:

1. Verify the Fuel Pump and BCM harness connectors are connected and locked properly.
2. Disconnect and check the Fuel Pump and BCM harness connectors for pushed out, spread, corroded or dirty terminals.
3. Check the Fuel Level Sensor Signal circuit for an open/high resistance, short to the return circuit or short to ground.
4. Check the Fuel Level Sensor Return circuit for an open/high resistance.
5. Check for the Fuel Level Sensor resistance being above or below the minimum and maximum specifications.
6. Reconnect the BCM harness connector leaving the Fuel Pump harness connector disconnected. Turn the ignition on and monitor the scan tool for faults. The circuit high fault should set with the Fuel Pump harness connector disconnected. Connect a fused jumper between the Fuel Level Sensor Signal circuit and the Fuel Level Sensor Return at the Fuel Pump harness connector. The circuit low fault should set with the jumper in place. If the faults set as described, replace the Fuel Level Sensor. If the faults do not set as described, the BCM is faulty.

FUEL LEVEL SENSOR RATIONALITY DIAGNOSTICS (P0461, P2066)

Excessive pressure build up or vacuum in the Evaporative system could possibly contribute to this DTC being set. Diagnose and repair any Evaporative System DTCs before continuing with this fault.

SINGLE TANK FUEL LEVEL SENSOR RATIONALITY DIAGNOSTICS:

1. Visually inspect the Fuel Tank for any obvious physical damage that may restrict the Fuel Level Sensor float from moving. If the Fuel Tank is damaged, replace the tank assembly. If the Fuel Tank has no visible damage, and there are no circuit faults present, the rationality fault is most likely due to an intermittent connection, obstructed float arm, bad spot on the Fuel Level Sensor resistor card, or faulty BCM. Continue to step 2.
2. Verify that the Fuel Pump connector is properly connected and locked. Check the Fuel Pump and BCM harness connectors and terminals for pushed out, spread, corroded or dirty terminals. If the connector or terminals appear damaged, repair or replace the damaged connector or terminals.
3. Check the ability of the BCM to read the Fuel Level Sensor signal correctly. Disconnect the Fuel Pump harness connector. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the Fuel Level Signal and Return Signal circuits at the Fuel Pump harness connector. Turn the ignition on. Move the switch on the Electrical Test Lead Kit to the adjust position. For most Fuel Level Sensors, the typical resistance on the resistor card is between approximately 50 Ohms (Full Stop) and 1000 Ohms (Empty Stop). Turn the ignition on and monitor the signal voltage on the scan tool, while varying the resistance on the Electrical Test Lead Kit between approximately 50 and 1000 Ohms.

1. **If the signal voltage is changing between 0.0 volts and 5.0 volts while changing the resistance** - the BCM is reading the Fuel Level Sensor signal correctly. The Fuel Level Sensor is most likely faulty or has a poor connection at the harness connector. Check the Fuel Pump harness connector for pushed out, spread, corroded or dirty terminals before condemning the sensor. If the terminals and connector check good, replace the faulty Fuel Level Sensor.
2. **If the signal voltage is not changing between 0.0 volts and 5.0 volts while changing the resistance** - Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals. If no issues are found, check the Fuel Level Sensor Signal and Return Signal circuits for high resistance (refer to the appropriate circuit fault information for additional assistance on testing the circuits). If the circuits test good, the BCM is faulty.

SADDLE TANK FUEL LEVEL SENSOR RATIONALITY DIAGNOSTICS: Before starting it is important to note that in a properly operating system the primary side of the tank should always be at or very close to full if there is fuel in the secondary side of the tank. Therefore, the primary level sensor rationality fault should only set if the secondary side is empty and the primary level sensor is not changing as fuel is consumed. The secondary level sensor rationality fault should only set if the primary side is full and the secondary level sensor is not changing as fuel is consumed. It is possible for a secondary Fuel Level Sensor to be stuck in the empty position causing a primary Fuel Level Sensor rationality fault. Therefore, a good practice is to look at, and compare both level sensor values when diagnosing either rationality DTC to verify which sensor to diagnose.

1. Visually inspect the Fuel Tank for any obvious physical damage that may restrict either Fuel Level Sensor float from moving. If the Fuel Tank is damaged, replace the tank assembly. If the Fuel Tank has no visible damage, and there are no circuit faults present, the rationality fault is most likely due to an intermittent connection, obstructed float arm, bad spot on the Fuel Level Sensor resistor card, or faulty BCM. Continue to step 2.
2. Using the scan tool check for any Evaporative System or Fuel Level Sensor circuit faults.
    1. Diagnose and repair any Evaporative System DTCs before continuing with this fault.
    2. Diagnose any Fuel Level Sensor circuit faults before continuing with the rationality diagnostic.
        - If no other faults are present, continue to step 3.
3. This step is designed to try and determine which sensor is giving a false reading. Using the scan tool, read the voltage for both Fuel Level Sensors in the BCM data. This step may require adding or removing fuel in the tank in order to make a decision as to which level sensor to diagnose. **NOTE: A normally functioning level sensor will typically read between approximately 4.3 - 4.5 volts at empty and 0.5 - 0.65 volts at full.**
    1. If the primary side of the tank is reading less than full and the secondary side of the tank is reading empty, Go to step 4.

    2. If the primary side of the tank is reading less than full, but the secondary side of the tank is showing fuel present, Go to step 4.
    3. If the primary side of the tank is reading full and the secondary side of the tank is reading empty, Go to step 4.
    4. If the primary side of the tank is reading full and the secondary side of the tank is showing fuel present, Go to step 5.
4. Add the amount of fuel to the tank that it takes to fill the primary side to guarantee that there is overflow to the secondary side of the Fuel Tank. Using the scan tool, read the voltage for both Fuel Level Sensors in the BCM data. The primary level sensor should read full and the secondary level sensor should show some fuel present. Follow the scenario that best fits below:
    1. If the primary side is not reading full, diagnose the primary level sensor in step 6 below.
    2. If the secondary side is not showing any fuel present, diagnose the secondary level sensor in step 6 below.
    3. If both sensors appear to be reading normal, start removing fuel from the tank into an approved storage container. The secondary level sensor should decrease to empty before the primary starts decreasing. If the primary level sensor starts decreasing before the secondary side starts moving diagnose the secondary level sensor in step 6 below.
5. Start removing fuel from the tank into an approved storage container. Remove enough fuel to guarantee the total Fuel Tank level is below 1/2 tank.
    1. If the primary side of the tank is reading full and the secondary side of the tank is reading empty, diagnose the primary level sensor in step 6 below.
    2. If the primary side of the tank is reading less than full but the secondary side of the tank is showing fuel present, diagnose the secondary level sensor in step 6 below.
6. **Perform the following diagnostics on the Fuel Level Sensor that was not reading rational in step 4 or 5.** Verify that the harness connector at the Fuel Pump or Auxiliary Fuel Pump/Level Sensor is properly connected and locked. Check the Fuel Pump, Auxiliary Fuel Pump/Level Sensor and BCM harness connectors and terminals for pushed out, spread, corroded or dirty terminals. If the connector or terminals appear damaged, repair or replace the damaged connector or terminals.
7. Check the ability of the BCM to read the Fuel Level Sensor signal correctly. Disconnect the appropriate harness connector. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the Fuel Level Signal and Return Signal circuits in the harness connector. Move the switch on the Electrical Test Lead Kit to the adjust position. For most Fuel Level Sensors, the typical resistance on the resistor card is between approximately 50 Ohms (Full Stop) and 1000 Ohms (Empty Stop). Turn the ignition on and monitor the signal voltage on the scan tool, while varying the resistance on the Electrical Test Lead Kit between approximately 50 and 1000 Ohms.

1. **If the signal voltage is changing between 0.0 volts and 5.0 volts while changing the resistance** - the BCM is reading the Fuel Level Sensor signal correctly. The Fuel Level Sensor is most likely faulty or has a poor connection at the harness connector. **If the issue is with the secondary side showing fuel when the primary is less than full** this issue could be caused by the fuel not being pulled over from the secondary side to the primary side of the Fuel Tank due to a damaged or faulty siphon tube or Auxiliary Pump. Remove the Auxiliary Pump assembly and check for fuel stuck on the secondary side. If the secondary side is empty, replace the faulty Fuel Level Sensor. If the secondary side still has fuel when the primary side is less than full, examine and repair or replace the Auxiliary Pump or siphon tube assembly.
2. **If the signal voltage is not changing between 0.0 volts and 5.0 volts while changing the resistance** - check the Fuel Level Sensor Signal and Return circuits for high resistance (refer to the appropriate circuit fault information for additional assistance on testing the circuits). If the circuits test good, Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning BCM. If no issues are found, the BCM is faulty.

FUEL LEVEL SENSOR TABLES

The table below gives approximate internal resistance and raw voltage values for a Fuel Level Sensor based on fuel volume. **These can be used as a general reference when the actual values are not available for any single tank or saddle tank Fuel Level Sensors.** As can be seen in the table, the full travel of the sensor (Full Stop/Empty Stop) is slightly more than the full tank and empty tank thresholds used for the fuel gauge.

Generic Fuel Tank Table Values		
Fuel level reading	**Typical resistance of level sensor (Ohms)**	**Typical raw voltage signal input (volts)**
Full Stop (Max full travel)	50 - 60	0.5 - 0.7
Full tank	60 - 75	0.75 - 1.0
1/2 tank	160 - 225	1.6 - 2.2
Empty tank	725 - 770	3.4 - 4
Empty Stop (Max empty travel)	930 - 990	3.9 - 4.5

The tables below are for L-body vehicles.

Primary Fuel Tank Table			
Fuel level reading	**Fuel Volume (Gallons)**	**Fuel Volume (Liters)**	**Resistance of level sensor (Ohms)**
Full Stop (Max full travel)	10.1	38.5	51.1
Full tank	9.2	34.7	93
3/4 tank	7.3	27.9	172.5
1/2 tank	5.1	19.2	281.3
1/4 tank	2.9	11.1	471.1
Empty tank	0.6	2.3	910
Empty Stop (Max empty travel)	0.4	1.5	992

Secondary Fuel Tank Table			
Fuel level reading	**Fuel Volume (Gallons)**	**Fuel Volume (Liters)**	**Resistance of level sensor**
Full Stop (Max full travel)	8.4	31.83	51.1
Full tank	7.8	29.6	75.6
1/2 tank	3.8	14.4	281.3
1/4 tank	2.0	7.4	370.5

Secondary Fuel Tank Table			
Fuel level reading	**Fuel Volume (Gallons)**	**Fuel Volume (Liters)**	**Resistance of level sensor**
Empty tank	0.98	0.3	835.7
Empty Stop (Max empty travel)	0	0	992

The tables below are for WK/WD vehicles.

NOTE: **The diesel engine end stop and 1/2 tank values are the same.**

Primary Fuel Tank Table				
Fuel level reading	**Fuel Volume (Gallons) - 3.6L**	**Resistance of level sensor (Ohms) - 3.6L**	**Fuel Volume (Gallons) - 5.7L**	**Resistance of level sensor (Ohms) - 5.7L**
Full Stop (Max full travel)	12.9	59	12.9	59
Full tank	10.8	101.7	10.5	109
3/4 tank	8.8	145.6	8.4	156
1/2 tank	6.4	220	6.4	220
1/4 tank	4.2	325	4.5	309
Empty tank	0.8	848	0.9	776
Empty Stop (Max empty travel)	0.35	991	0.35	991

Secondary Fuel Tank Table				
Fuel level reading	**Fuel Volume (Gallons) - 3.6L**	**Resistance of level sensor (Ohms) - 3.6L**	**Fuel Volume (Gallons) - 5.7L**	**Resistance of level sensor (Ohms) - 5.7L**
Full Stop (Max full travel)	11.9	64	11.9	64
Full tank	10.1	109	9.5	123.9
3/4 tank	7.7	174	7.4	182.9
1/2 tank	5.6	261	5.6	261
1/4 tank	3.3	424	3.5	399.5
Empty tank	0	919.7	0	848
Empty Stop (Max empty travel)	0	991	0	991

The tables below are for HDCC vehicles.

28 Gallon Fuel Tank Table Values		
Fuel level reading	**Typical resistance of level sensor (Ohms)**	**Typical raw voltage signal input (volts)**
Full Stop (Max full travel)	50 - 60	0.5 - 0.7
Full tank	60 - 75	0.75 - 1.0
1/2 tank	240 - 255	1.9 - 2.3
Empty tank	850 - 900	4.1 - 4.2
Empty Stop (Max empty travel)	930 - 990	4.3 - 4.5

22 Gallon Dual Fuel Tank Table Values		
Fuel level reading	**Typical resistance of level sensor (Ohms)**	**Typical raw voltage signal input (volts)**
Full Stop (Max full travel)	50 - 60	0.5 - 0.7
Full tank	80 - 100	0.8 - 1.0
1/2 tank	250 - 265	2.3 - 2.5
Empty tank	670 - 965	3.2 - 4.4
Empty Stop (Max empty travel)	930 - 990	4.3 - 4.5

52 Gallon Dual Fuel Tank Table Values		
Fuel level reading	**Typical resistance of level sensor (Ohms)**	**Typical raw voltage signal input (volts)**
Full Stop (Max full travel)	50 - 60	0.5 - 0.7
Full tank	60 - 75	0.75 - 1.0
1/2 tank	250 - 270	2.0 - 2.4
Empty tank	815 - 930	4.0 - 4.2
Empty Stop (Max empty travel)	930 - 990	4.3 - 4.5

POWERTRAIN VERIFICATION TEST

VERIFICATION OF REPAIR:

1. Inspect the vehicle to make sure that all engine components are properly installed and connected. Reassemble and reconnect components as necessary.
2. After repairs are complete, erase all DTCs with the scan tool.
3. Refer to the table below to determine if a learn procedure should be performed for the component that was removed or replaced. Not all learn procedures are available for all vehicles. If a component listed in the table is replaced and the correlating learn procedure is present in the scan tool, navigate to "Miscellaneous Functions" and perform the learn procedure before verifying repair. Failure to do so may cause the same, or another DTC to set.

Scan Tool Learn Procedures	Component replaced or removed: Note: (All available Learn procedures should be performed when a PCM is replaced)
Brake Pedal Learn	Brake Pedal Position Sensor, Brake Pedal Assembly
Cam Crank Relearn (NGC/GPEC Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clear Misfire TLC (Magneti Marelli Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clutch Pedal Learn	Clutch Pedal Position Sensor, Clutch Pedal, Clutch Assembly (pressure plate and disc)
EGR Valve Replaced	EGR Valve
Learn ETC	Throttle Body
Check PCM Odometer	PCM Replaced
Check PCM VIN	PCM Replaced
PCM Replaced Routine	PCM Replaced
Learn Gear Shift Sensor	Gear Shift Position Sensor, Transmission Shifter components

4. **If the PCM has been replaced** , perform the Module Programming procedure. The PCM Reprogramming procedure is either in Electronic Control Modules/PCM Programming Folder or PCM Standard Procedure Folder depending on the vehicle application. Be certain that the secret key code, VIN and odometer mileage are programmed after programming the PCM.
5. Operate the vehicle in accordance with the parameters and specific information found in the Monitoring Conditions and Theory of Operation of the DTC that was repaired.

6. With the scan tool, verify that no DTCs have returned.
    1. If the DTC returned check for any service bulletins or star online cases that may apply. If no bulletins exist, return to and perform the DTC procedure.
    2. If the DTC or condition did not return, repair is complete.

P0462-FUEL LEVEL SENSOR 1 CIRCUIT LOW

For a complete FUEL DELIVERY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

COMPONENT FUNCTIONAL DESCRIPTION - FUEL LEVEL SENSOR CIRCUITS

The Primary, and if equipped the Secondary Fuel Level Sensor Signals (saddle tanks or dual tanks depending on platform) are hard-wired to the Body Control Module (BCM). Both Fuel Level Sensor signals are a constant 12.0 volts. **On a normally functioning system,** the raw signal voltage to the BCM will read between approximately 0.5 volts (full stop) and 4.5 volts (empty stop) when the harness is connected. When there is an open in the circuitry the signal circuit voltage will be 12.0 volts. **The data reading value on the scan tool is clipped to read 5.0 volts when the signal circuit is open.** The BCM reads the voltage and converts the analog signals to digital signals. The digital signals are broadcast over the CAN bus. The Powertrain Control Module (PCM) receives and interprets the digital signals as a voltage read. The PCM, and in most cases the BCM, perform circuit fault diagnostics on the signal input.

The Fuel Level Rationality diagnostics are only performed by the PCM. The Fuel Level rationality diagnostics are explained in more detail in the Fuel Level Rationality diagnostic information below.

The Fuel Level Sensor Tables are available at the bottom of the test procedure.

THEORY OF OPERATION - FUEL LEVEL RATIONALITY

SINGLE TANK FUEL LEVEL RATIONALITY DIAGNOSTIC DESCRIPTION: The intent of the **Fuel Level Rationality** is to check for a "stuck" fuel level reading. This is done to keep high or low fuel levels that are stuck from disabling OBD monitors. Since the amount of fuel consumed from trip to trip varies based on customer drive cycles, this diagnostic can accumulate fuel consumption over multiple drive cycles. The diagnostic will run until enough fuel has been consumed to make a decision. The PCM compares the difference between the fuel level value at the start of the diagnostic and the fuel level value after a calibrated amount of fuel consumption should have occurred. If the difference is less than a calibrated threshold, the test fails. Once a decision is made, a new diagnostic test will start. If a fault is set, the fuel level will default to a value that will allow other OBD diagnostics to run.

SADDLE TANK FUEL LEVEL RATIONALITY GENERAL INFORMATION: The Fuel Level Sensor information is a direct input to the Body Control Module (BCM) which is sent to the Powertrain Control Module (PCM) via CAN bus. On the primary side of the saddle tank is the Electric Fuel Pump Module that feeds the engine and the Primary Fuel Level Sensor. On the secondary side of the saddle tank is a Venturi Jet Pump and the Secondary Fuel Level Sensor. The Jet Pump is connected to the Electric Fuel Pump Module on the primary side by way of a siphon tube. The PCM uses the average from both sides to determine the total fuel volume.

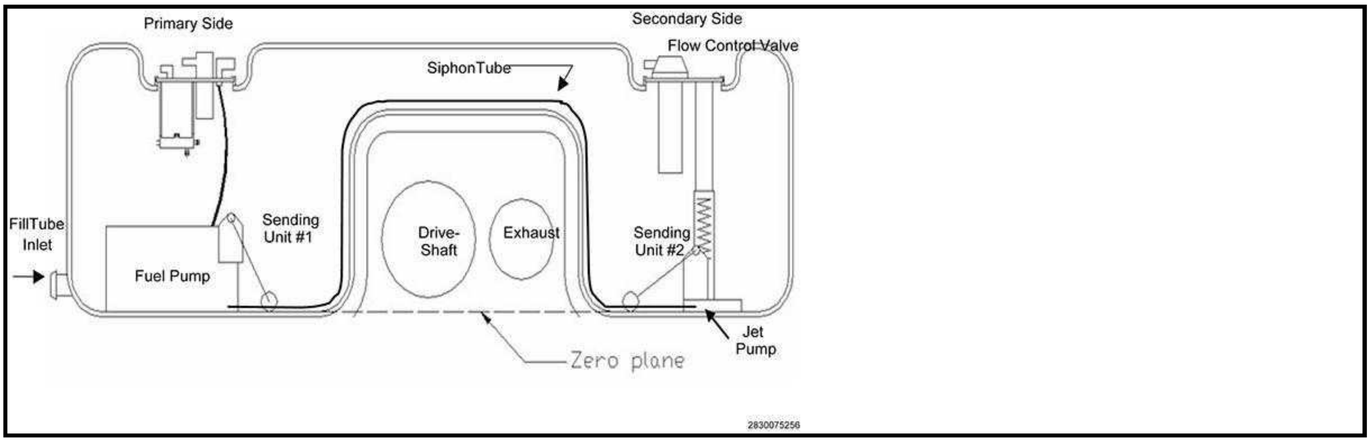
SADDLE TANK FUEL LEVEL RATIONALITY DIAGNOSTIC DESCRIPTION: On a properly operating system, the fuel volume on the secondary side of the Fuel Tank will be at empty before the primary side of the Fuel Tank will begin to decrease due to the siphon tube flow rate always exceeding the engines fuel consumption rate. Using this assumption, the PCM performs a diagnostic to check the rationality of both Fuel Level Sensors, as well as the operation of the jet pump and siphon tube as follows;

- When the total fuel volume is greater than 50% the primary tank should remain at the full position. As fuel is consumed, or sloshes over to the secondary tank while driving, the jet pump and siphon tube will replenish the primary tank to the full position and the secondary fuel level should decrease.
- When the total fuel volume is less than 50%, the secondary tank should be at empty and the primary fuel volume should start to decrease as fuel is consumed by the engine.

If either scenario fails to happen the PCM will determine that one of the Fuel Level Sensors is stuck in range, or that the Jet Pump or siphon tube is faulty not allowing fuel to transfer from the secondary side to the primary side of the Fuel Tank.

- The rationality diagnostic for the **primary side** of the tank will not become enabled until the secondary side level is near empty.
- The rationality diagnostic for the **secondary side** of the tank is based on the average fuel volume in the tank. It is enabled when there is enough total fuel to fill the primary tank plus enough fuel to check the rationality of the Secondary Fuel Level Sensor when a calibrated amount of fuel is consumed.

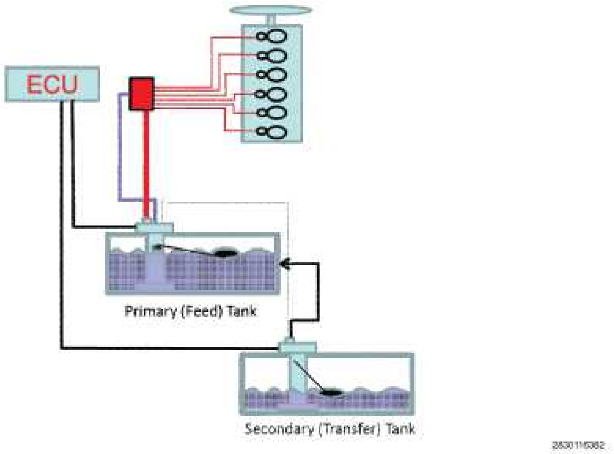
Since the amount of fuel consumed from trip to trip varies based on customer drive cycles, this monitor can accumulate fuel consumption over multiple drive cycles. The monitor will run until enough fuel has been consumed to make a decision. Once a decision is made, a new test will start.



DUAL FUEL TANK FUEL LEVEL RATIONALITY DIAGNOSTIC DESCRIPTION: Some D-Trucks add a second Fuel Tank (Auxiliary Fuel Tank) to allow the fuel capacity to be increased. Both Fuel Tanks have an independent Fuel Pump Module and Fuel Level Sensor (located inside the tanks); and fuel fill tube. The Fuel Level Sensor information is a bussed message from the Body Control Module (BCM) to the Powertrain Control Module (PCM).

- **The Main Fuel Tank** supplies fuel to the engine for consumption. The PCM performs the **Primary Fuel Level Rationality** diagnostic to check for a "stuck" fuel level reading in the same way as on a single tank system. **Refer to the Single Tank Fuel Level Rationality Diagnostic Description above.**
- **The Auxiliary Fuel Tank** is used to fill the Main Fuel Tank when the fuel level in the Main Fuel Tank reaches a minimum threshold. **It does not supply the fuel directly to the engine.** The Auxiliary Fuel Pump will be de-activated when the Main Fuel Tank fuel level reaches the maximum threshold, or the Auxiliary Fuel Tank fuel level reaches a minimum threshold before or during a tank transfer event. This is to prevent an overfill of the Main Fuel Tank or the Auxiliary Fuel Pump running in a dry condition. The PCM performs the **Secondary Fuel Level Rationality** diagnostic during a fuel transfer event.

There are 2 relays that control the Auxiliary Fuel Pump: The Fuel Pump 2 Relay and the Fuel Pump 2 On/Off Relay. The PCM controls the low side driver of the Fuel Pump 2 Relay. The Fuel Pump 2 Relay is supplied power from the Fuel Pump 2 On/Off Relay, which is controlled by the BCM. In the event that the Fuel Pump 2 Relay is stuck on and over filling the Main Fuel Tank, the BCM can turn off the Fuel Pump 2 On/Off Relay. This will turn off the power supply to the Fuel Pump 2 Relay and the Auxiliary Fuel Pump Module.



ENABLING/SET CONDITIONS AND POSSIBLE CAUSES - FUEL LEVEL SENSOR FAULTS

When Monitored - Circuit Faults (P0462, P0463, P2067, P2068, P2065-11, P2065-15):

These diagnostics run when the following conditions are met:

- With the ignition on.
- Battery voltage above 10.4 volts.
- No active fuel level missing message faults (PCM only).

When Monitored - Rationality Faults (P0461, P2066):

These diagnostics run when the following conditions are met:

Single Tank System:

- With the engine running for more than two minutes.
- After the PCM decides that a calibrated amount of fuel should have been consumed (between approximately one and five gallons depending on initial fuel level).
  - This is determined by the accumulated amount of fuel injected into the engine through the Fuel Injectors.

Saddle Tank System:

- The primary level rationality diagnostic runs when the Fuel Level Sensor 2 (Secondary) is reading empty.
- The secondary level rationality diagnostic runs when the Fuel Level Sensor 1 (Primary) is reading full.

Dual Tank System:

- The primary level rationality diagnostic functions the same as the Single Tank System.
- The secondary level rationality diagnostic runs when a fuel transfer event is occurring.

FAULT SETTING CRITERIA	
Circuit Low/High Faults - (P0462, P0463, P2067, P2068, P2065-11, P2065-15)	• Circuit Low - The Fuel Level Sensor signal voltage is below approximately 0.2 volts for more than 3.2 seconds. • Circuit High - The Fuel Level Sensor signal voltage is above approximately 4.9 volts for more than 3.2 seconds.
Rationality Faults - Single Tank Systems	When the PCM does not see a change in fuel level of greater than 0.06 volts after the calibrated amount of fuel should have been consumed the diagnostic will fail.

FAULT SETTING CRITERIA	
Rationality Faults - Saddle Tank Systems	• Primary Fault (P0461) - If the PCM does not see a change in Fuel Level Sensor 1 of greater than 0.06 volts after the calibrated amount of fuel should have been consumed the diagnostic will fail. • Secondary Fault (P2066) - If the PCM does not see a change in Fuel Level Sensor 2 of greater than 0.06 volts after the calibrated amount of fuel should have been consumed the diagnostic will fail.
Rationality Faults - Saddle Tank Systems	• Primary Fault (P0461) - If the PCM does not see a change in fuel level of greater than 0.06 volts after the calibrated amount of fuel should have been consumed the diagnostic will fail. • Secondary Fault (P2066) - No change in Fuel Level Sensor 2 circuit voltage after a significant amount of fuel should have been transferred from the Auxiliary Fuel Tank to the Primary Fuel Tank.

Default Actions:

- The MIL is illuminated.

Possible Causes - Circuit Faults
FUEL LEVEL SENSOR HARNESS CONNECTOR DAMAGED OR NOT CONNECTED COMPLETELY
FUEL LEVEL SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW FAULT)
FUEL LEVEL SENSOR SIGNAL CIRCUIT SHORTED TO THE SENSOR RETURN CIRCUIT (CIRCUIT LOW FAULT)
FUEL LEVEL SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH FAULT)
FUEL LEVEL SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH FAULT)
FUEL LEVEL SENSOR RETURN CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH FAULT)
FAULTY FUEL LEVEL SENSOR
FAULTY BODY CONTROL MODULE (BCM)

Possible Causes - Rationality Faults
FUEL LEVEL SENSOR HARNESS CONNECTOR DAMAGED OR NOT CONNECTED COMPLETELY
FUEL TANK DAMAGED
OBSTRUCTION TO THE PRIMARY OR SECONDARY FUEL LEVEL SENSOR
PRIMARY OR SECONDARY FUEL LEVEL SENSOR FAULTY OR BROKEN
SECONDARY PUMP OR SIPHON TUBE LEAKING OR DISCONNECTED (SADDLE TANK SYSTEM)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCs and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns, or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. **The resistor card on Fuel Level Sensors can occasionally have a bad spot on the card which can cause a fault to be inactive when testing.** In some cases this could result in an open circuit during the period when the fuel level is at the bad spot. In other cases the bad spot could result in the resistors on the card blurring together. This could cause the fuel level reading to stay constant when the fuel level travels through that portion of the resistor card. This condition can cause a performance fault since the PCM will not see a fuel level change as fuel is consumed during this time.
2. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
3. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
4. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply, check for connection issues by wiggle testing any wiring harnesses and in-line connectors the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach a lab scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor battery system voltage or poor ground connections can affect systems in different or odd ways. Check the battery or batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
5. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving. Operate the components through a full range of operation while monitoring functionality.

PRIMARY AND SECONDARY FUEL LEVEL SENSOR CIRCUIT FAULT DIAGNOSTICS

NOTE: **There are multiple test methods listed below. There can be advantages to using each method. All of the methods do not need to be performed. Pick the best test method based on accessibility, ease of testing or availability of test equipment. In some cases it may be beneficial to use parts of each method to test for different failure modes.**

CIRCUIT DIAGNOSTICS USING THE ELECTRICAL TEST LEAD KIT: Check the BCM signal and return circuits together to determine if the Fuel Level Sensor is faulty. Disconnect the Fuel Pump harness connector. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the Fuel Level Signal and Return Signal circuits in the Fuel Pump harness connector. Move the switch on the Electrical Test Lead Kit between the open and closed positions while monitoring the scan tool. If monitoring for faults, the circuit high fault should set when switched to the open position and the circuit low fault should set when switched to the closed position. If the sensor voltage is available, monitor the voltage readings on the scan tool. It should be 5.0 volts when switched to the open position and 0.0 volts when switched to the closed position. Move the switch to adjust and use the tool to vary the resistance between the Full Stop and Empty Stop resistance ranges while monitoring the BCM signal voltage on the scan tool with the ignition on.

NOTE: **Even though the actual signal will read 12.0 volts with the switch in the open position, the scan tool will register the signal as 5.0 volts**

1. **If the faults set as described and the signal voltage is 5.0 volts and 0.0 volts on the scan tool** - the BCM and Fuel Level Sensor circuits are testing good. The Fuel Level Sensor is most likely faulty or has a poor connection at the harness connector. Check the Fuel Pump harness connector for pushed out, spread, corroded or dirty terminals before condemning the sensor. The internal resistance of the sensor can be measured and compared to the table (if available) to verify a faulty sensor.
2. **If the signal voltage is stuck low or only the circuit low fault sets** - the most likely cause is the Fuel Level Sensor Signal circuit shorted to chassis ground or the Fuel Level Sensor Return circuit. Check the Fuel Level Sensor Signal circuit for a short to ground or the Sensor Return circuit. If the signal circuit is not shorted, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals before condemning a BCM. If no issues are found, the BCM is faulty.
3. **If the signal voltage is stuck high or only the circuit high fault sets** - the most likely cause is an open or very high resistance in the Fuel Level Sensor Signal or Return circuit. Continue testing in step 4.
4. **If the signal reading on the scan tool shows voltage present when switched to closed** - remove the test lead from the sensor return circuit and connect it to a good chassis ground while observing the voltage on the scan tool. If the voltage drops to 0.0 volts the resistance is in the sensor return circuit. If the voltage is still present the resistance is in the sensor signal circuit. Check the appropriate circuit for high resistance. Typically should be less than 3.0 Ohms. If the circuits check good, continue testing in step 5.
5. **If the circuits are checked and do not have excessive resistance** - Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BCM. If no issues are found, the BCM is faulty.

CIRCUIT DIAGNOSTICS USING CONVENTIONAL VOLTAGE TESTING WITH A DVOM:

1. Verify the Fuel Pump and BCM harness connectors are connected and locked properly.
2. Turn the ignition on. Back Probe and measure the voltage on the Fuel Level Sensor Signal circuit at the Fuel Pump harness connector.
   1. **If the signal voltage is reading between 0.5 and 4.5 volts** - the sensor signal is giving a legitimate reading. If the circuit fault is active and the voltage reading on the scan tool does not match the voltage reading, the BCM is likely faulty.
   2. **If the signal has a constant 0.0 volt reading** - this indicates that the signal circuit is shorted to ground or has an open between the BCM and Fuel Level Sensor. If the circuit high fault is set, the most likely failure is an open in the signal circuit. If the circuit low fault is set, the most likely failure is short to ground in the signal circuit. Disconnect the Fuel Pump and BCM harness connectors. Check the signal circuit for high resistance and short to ground. If the signal circuit checks good, check at all connectors in the system for pushed out, spread, corroded or dirty terminals before condemning a BCM.
   3. **If the signal reading has a constant 12.0 volts** - this indicates an open further downstream in the circuitry. Most likely the Fuel Level Sensor or the Fuel Level Sensor Return circuit.
3. To check the Fuel Level Sensor, move the test lead over and back probe the Fuel Level Sensor Return circuit at the Fuel Pump harness connector.
   1. **If the signal changes to 0.0 volts** - this would indicate an open in, or short across the Fuel Level Sensor resistance card. The internal resistance of the Fuel Level Sensor can be measured and compared to the table (if available) to verify a faulty sensor.
   2. **If the signal is still at 12.0 volts** - this indicates an open in the Fuel Level Sensor Return circuit path. Disconnect the Fuel Pump and BCM harness connectors. Check the return circuit for high resistance. If the return circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals before condemning a BCM. If no issues are found, the BCM is faulty.

CIRCUIT DIAGNOSTICS USING CONVENTIONAL RESISTANCE TESTING WITH A DVOM:

1. Verify the Fuel Pump and BCM harness connectors are connected and locked properly.
2. Disconnect and check the Fuel Pump and BCM harness connectors for pushed out, spread, corroded or dirty terminals.
3. Check the Fuel Level Sensor Signal circuit for an open/high resistance, short to the return circuit or short to ground.
4. Check the Fuel Level Sensor Return circuit for an open/high resistance.
5. Check for the Fuel Level Sensor resistance being above or below the minimum and maximum specifications.
6. Reconnect the BCM harness connector leaving the Fuel Pump harness connector disconnected. Turn the ignition on and monitor the scan tool for faults. The circuit high fault should set with the Fuel Pump harness connector disconnected. Connect a fused jumper between the Fuel Level Sensor Signal circuit and the Fuel Level Sensor Return at the Fuel Pump harness connector. The circuit low fault should set with the jumper in place. If the faults set as described, replace the Fuel Level Sensor. If the faults do not set as described, the BCM is faulty.

FUEL LEVEL SENSOR RATIONALITY DIAGNOSTICS (P0461, P2066)

Excessive pressure build up or vacuum in the Evaporative system could possibly contribute to this DTC being set. Diagnose and repair any Evaporative System DTCs before continuing with this fault.

SINGLE TANK FUEL LEVEL SENSOR RATIONALITY DIAGNOSTICS:

1. Visually inspect the Fuel Tank for any obvious physical damage that may restrict the Fuel Level Sensor float from moving. If the Fuel Tank is damaged, replace the tank assembly. If the Fuel Tank has no visible damage, and there are no circuit faults present, the rationality fault is most likely due to an intermittent connection, obstructed float arm, bad spot on the Fuel Level Sensor resistor card, or faulty BCM. Continue to step 2.
2. Verify that the Fuel Pump connector is properly connected and locked. Check the Fuel Pump and BCM harness connectors and terminals for pushed out, spread, corroded or dirty terminals. If the connector or terminals appear damaged, repair or replace the damaged connector or terminals.
3. Check the ability of the BCM to read the Fuel Level Sensor signal correctly. Disconnect the Fuel Pump harness connector. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the Fuel Level Signal and Return Signal circuits at the Fuel Pump harness connector. Turn the ignition on. Move the switch on the Electrical Test Lead Kit to the adjust position. For most Fuel Level Sensors, the typical resistance on the resistor card is between approximately 50 Ohms (Full Stop) and 1000 Ohms (Empty Stop). Turn the ignition on and monitor the signal voltage on the scan tool, while varying the resistance on the Electrical Test Lead Kit between approximately 50 and 1000 Ohms.

1. **If the signal voltage is changing between 0.0 volts and 5.0 volts while changing the resistance** - the BCM is reading the Fuel Level Sensor signal correctly. The Fuel Level Sensor is most likely faulty or has a poor connection at the harness connector. Check the Fuel Pump harness connector for pushed out, spread, corroded or dirty terminals before condemning the sensor. If the terminals and connector check good, replace the faulty Fuel Level Sensor.
2. **If the signal voltage is not changing between 0.0 volts and 5.0 volts while changing the resistance** - Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals. If no issues are found, check the Fuel Level Sensor Signal and Return Signal circuits for high resistance (refer to the appropriate circuit fault information for additional assistance on testing the circuits). If the circuits test good, the BCM is faulty.

SADDLE TANK FUEL LEVEL SENSOR RATIONALITY DIAGNOSTICS: Before starting it is important to note that in a properly operating system the primary side of the tank should always be at or very close to full if there is fuel in the secondary side of the tank. Therefore, the primary level sensor rationality fault should only set if the secondary side is empty and the primary level sensor is not changing as fuel is consumed. The secondary level sensor rationality fault should only set if the primary side is full and the secondary level sensor is not changing as fuel is consumed. It is possible for a secondary Fuel Level Sensor to be stuck in the empty position causing a primary Fuel Level Sensor rationality fault. Therefore, a good practice is to look at, and compare both level sensor values when diagnosing either rationality DTC to verify which sensor to diagnose.

1. Visually inspect the Fuel Tank for any obvious physical damage that may restrict either Fuel Level Sensor float from moving. If the Fuel Tank is damaged, replace the tank assembly. If the Fuel Tank has no visible damage, and there are no circuit faults present, the rationality fault is most likely due to an intermittent connection, obstructed float arm, bad spot on the Fuel Level Sensor resistor card, or faulty BCM. Continue to step 2.
2. Using the scan tool check for any Evaporative System or Fuel Level Sensor circuit faults.
    1. Diagnose and repair any Evaporative System DTCs before continuing with this fault.
    2. Diagnose any Fuel Level Sensor circuit faults before continuing with the rationality diagnostic.
        - If no other faults are present, continue to step 3.
3. This step is designed to try and determine which sensor is giving a false reading. Using the scan tool, read the voltage for both Fuel Level Sensors in the BCM data. This step may require adding or removing fuel in the tank in order to make a decision as to which level sensor to diagnose. **NOTE: A normally functioning level sensor will typically read between approximately 4.3 - 4.5 volts at empty and 0.5 - 0.65 volts at full.**
    1. If the primary side of the tank is reading less than full and the secondary side of the tank is reading empty, Go to step 4.
    2. If the primary side of the tank is reading less than full, but the secondary side of the tank is showing fuel present, Go to step 4.
    3. If the primary side of the tank is reading full and the secondary side of the tank is reading empty, Go to step 4.
    4. If the primary side of the tank is reading full and the secondary side of the tank is showing fuel present, Go to step 5.
4. Add the amount of fuel to the tank that it takes to fill the primary side to guarantee that there is overflow to the secondary side of the Fuel Tank. Using the scan tool, read the voltage for both Fuel Level Sensors in the BCM data. The primary level sensor should read full and the secondary level sensor should show some fuel present. Follow the scenario that best fits below:
    1. If the primary side is not reading full, diagnose the primary level sensor in step 6 below.
    2. If the secondary side is not showing any fuel present, diagnose the secondary level sensor in step 6 below.
    3. If both sensors appear to be reading normal, start removing fuel from the tank into an approved storage container. The secondary level sensor should decrease to empty before the primary starts decreasing. If the primary level sensor starts decreasing before the secondary side starts moving diagnose the secondary level sensor in step 6 below.

5. Start removing fuel from the tank into an approved storage container. Remove enough fuel to guarantee the total Fuel Tank level is below 1/2 tank.
    1. If the primary side of the tank is reading full and the secondary side of the tank is reading empty, diagnose the primary level sensor in step 6 below.
    2. If the primary side of the tank is reading less than full but the secondary side of the tank is showing fuel present, diagnose the secondary level sensor in step 6 below.
6. **Perform the following diagnostics on the Fuel Level Sensor that was not reading rational in step 4 or 5.** Verify that the harness connector at the Fuel Pump or Auxiliary Fuel Pump/Level Sensor is properly connected and locked. Check the Fuel Pump, Auxiliary Fuel Pump/Level Sensor and BCM harness connectors and terminals for pushed out, spread, corroded or dirty terminals. If the connector or terminals appear damaged, repair or replace the damaged connector or terminals.
7. Check the ability of the BCM to read the Fuel Level Sensor signal correctly. Disconnect the appropriate harness connector. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the Fuel Level Signal and Return Signal circuits in the harness connector. Move the switch on the Electrical Test Lead Kit to the adjust position. For most Fuel Level Sensors, the typical resistance on the resistor card is between approximately 50 Ohms (Full Stop) and 1000 Ohms (Empty Stop). Turn the ignition on and monitor the signal voltage on the scan tool, while varying the resistance on the Electrical Test Lead Kit between approximately 50 and 1000 Ohms.

    1. **If the signal voltage is changing between 0.0 volts and 5.0 volts while changing the resistance** - the BCM is reading the Fuel Level Sensor signal correctly. The Fuel Level Sensor is most likely faulty or has a poor connection at the harness connector. **If the issue is with the secondary side showing fuel when the primary is less than full** this issue could be caused by the fuel not being pulled over from the secondary side to the primary side of the Fuel Tank due to a damaged or faulty siphon tube or Auxiliary Pump. Remove the Auxiliary Pump assembly and check for fuel stuck on the secondary side. If the secondary side is empty, replace the faulty Fuel Level Sensor. If the secondary side still has fuel when the primary side is less than full, examine and repair or replace the Auxiliary Pump or siphon tube assembly.
    2. **If the signal voltage is not changing between 0.0 volts and 5.0 volts while changing the resistance** - check the Fuel Level Sensor Signal and Return circuits for high resistance (refer to the appropriate circuit fault information for additional assistance on testing the circuits). If the circuits test good, Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning BCM. If no issues are found, the BCM is faulty.

FUEL LEVEL SENSOR TABLES

The table below gives approximate internal resistance and raw voltage values for a Fuel Level Sensor based on fuel volume. **These can be used as a general reference when the actual values are not available for any single tank or saddle tank Fuel Level Sensors.** As can be seen in the table, the full travel of the sensor (Full Stop/Empty Stop) is slightly more than the full tank and empty tank thresholds used for the fuel gauge.

Generic Fuel Tank Table Values		
Fuel level reading	**Typical resistance of level sensor (Ohms)**	**Typical raw voltage signal input (volts)**
Full Stop (Max full travel)	50 - 60	0.5 - 0.7
Full tank	60 - 75	0.75 - 1.0
1/2 tank	160 - 225	1.6 - 2.2
Empty tank	725 - 770	3.4 - 4
Empty Stop (Max empty travel)	930 - 990	3.9 - 4.5

The tables below are for L-body vehicles.

Primary Fuel Tank Table			
Fuel level reading	**Fuel Volume (Gallons)**	**Fuel Volume (Liters)**	**Resistance of level sensor (Ohms)**
Full Stop (Max full travel)	10.1	38.5	51.1
Full tank	9.2	34.7	93
3/4 tank	7.3	27.9	172.5
1/2 tank	5.1	19.2	281.3
1/4 tank	2.9	11.1	471.1
Empty tank	0.6	2.3	910
Empty Stop (Max empty travel)	0.4	1.5	992

Secondary Fuel Tank Table			
Fuel level reading	**Fuel Volume (Gallons)**	**Fuel Volume (Liters)**	**Resistance of level sensor**
Full Stop (Max full travel)	8.4	31.83	51.1
Full tank	7.8	29.6	75.6
1/2 tank	3.8	14.4	281.3
1/4 tank	2.0	7.4	370.5
Empty tank	0.98	0.3	835.7
Empty Stop (Max empty travel)	0	0	992

The tables below are for WK/WD vehicles.

NOTE: **The diesel engine end stop and 1/2 tank values are the same.**

Primary Fuel Tank Table				
Fuel level reading	**Fuel Volume (Gallons) - 3.6L**	**Resistance of level sensor (Ohms) - 3.6L**	**Fuel Volume (Gallons) - 5.7L**	**Resistance of level sensor (Ohms) - 5.7L**
Full Stop (Max full travel)	12.9	59	12.9	59
Full tank	10.8	101.7	10.5	109
3/4 tank	8.8	145.6	8.4	156

Primary Fuel Tank Table				
Fuel level reading	**Fuel Volume (Gallons) - 3.6L**	**Resistance of level sensor (Ohms) - 3.6L**	**Fuel Volume (Gallons) - 5.7L**	**Resistance of level sensor (Ohms) - 5.7L**
1/2 tank	6.4	220	6.4	220
1/4 tank	4.2	325	4.5	309
Empty tank	0.8	848	0.9	776
Empty Stop (Max empty travel)	0.35	991	0.35	991

Secondary Fuel Tank Table				
Fuel level reading	**Fuel Volume (Gallons) - 3.6L**	**Resistance of level sensor (Ohms) - 3.6L**	**Fuel Volume (Gallons) - 5.7L**	**Resistance of level sensor (Ohms) - 5.7L**
Full Stop (Max full travel)	11.9	64	11.9	64
Full tank	10.1	109	9.5	123.9
3/4 tank	7.7	174	7.4	182.9
1/2 tank	5.6	261	5.6	261
1/4 tank	3.3	424	3.5	399.5
Empty tank	0	919.7	0	848
Empty Stop (Max empty travel)	0	991	0	991

The tables below are for HDCC vehicles.

28 Gallon Fuel Tank Table Values		
Fuel level reading	**Typical resistance of level sensor (Ohms)**	**Typical raw voltage signal input (volts)**
Full Stop (Max full travel)	50 - 60	0.5 - 0.7
Full tank	60 - 75	0.75 - 1.0
1/2 tank	240 - 255	1.9 - 2.3
Empty tank	850 - 900	4.1 - 4.2
Empty Stop (Max empty travel)	930 - 990	4.3 - 4.5

22 Gallon Dual Fuel Tank Table Values		
Fuel level reading	**Typical resistance of level sensor (Ohms)**	**Typical raw voltage signal input (volts)**
Full Stop (Max full travel)	50 - 60	0.5 - 0.7
Full tank	80 - 100	0.8 - 1.0
1/2 tank	250 - 265	2.3 - 2.5
Empty tank	670 - 965	3.2 - 4.4
Empty Stop (Max empty travel)	930 - 990	4.3 - 4.5

52 Gallon Dual Fuel Tank Table Values		
Fuel level reading	**Typical resistance of level sensor (Ohms)**	**Typical raw voltage signal input (volts)**
Full Stop (Max full travel)	50 - 60	0.5 - 0.7
Full tank	60 - 75	0.75 - 1.0
1/2 tank	250 - 270	2.0 - 2.4
Empty tank	815 - 930	4.0 - 4.2

52 Gallon Dual Fuel Tank Table Values		
Fuel level reading	**Typical resistance of level sensor (Ohms)**	**Typical raw voltage signal input (volts)**
Empty Stop (Max empty travel)	930 - 990	4.3 - 4.5

POWERTRAIN VERIFICATION TEST

VERIFICATION OF REPAIR:

1. Inspect the vehicle to make sure that all engine components are properly installed and connected. Reassemble and reconnect components as necessary.
2. After repairs are complete, erase all DTCs with the scan tool.
3. Refer to the table below to determine if a learn procedure should be performed for the component that was removed or replaced. Not all learn procedures are available for all vehicles. If a component listed in the table is replaced and the correlating learn procedure is present in the scan tool, navigate to "Miscellaneous Functions" and perform the learn procedure before verifying repair. Failure to do so may cause the same, or another DTC to set.

Scan Tool Learn Procedures	Component replaced or removed: Note: (All available Learn procedures should be performed when a PCM is replaced)
Brake Pedal Learn	Brake Pedal Position Sensor, Brake Pedal Assembly
Cam Crank Relearn (NGC/GPEC Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clear Misfire TLC (Magneti Marelli Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clutch Pedal Learn	Clutch Pedal Position Sensor, Clutch Pedal, Clutch Assembly (pressure plate and disc)
EGR Valve Replaced	EGR Valve
Learn ETC	Throttle Body
Check PCM Odometer	PCM Replaced
Check PCM VIN	PCM Replaced
PCM Replaced Routine	PCM Replaced
Learn Gear Shift Sensor	Gear Shift Position Sensor, Transmission Shifter components

4. **If the PCM has been replaced** , perform the Module Programming procedure. The PCM Reprogramming procedure is either in Electronic Control Modules/PCM Programming Folder or PCM Standard Procedure Folder depending on the vehicle application. Be certain that the secret key code, VIN and odometer mileage are programmed after programming the PCM.
5. Operate the vehicle in accordance with the parameters and specific information found in the Monitoring Conditions and Theory of Operation of the DTC that was repaired.
6. With the scan tool, verify that no DTCs have returned.
   1. If the DTC returned check for any service bulletins or star online cases that may apply. If no bulletins exist, return to and perform the DTC procedure.
   2. If the DTC or condition did not return, repair is complete.

P0463-FUEL LEVEL SENSOR 1 CIRCUIT HIGH

For a complete FUEL DELIVERY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

COMPONENT FUNCTIONAL DESCRIPTION - FUEL LEVEL SENSOR CIRCUITS

The Primary, and if equipped the Secondary Fuel Level Sensor Signals (saddle tanks or dual tanks depending on platform) are hard-wired to the Body Control Module (BCM). Both Fuel Level Sensor signals are a constant 12.0 volts. **On a normally functioning system,** the raw signal voltage to the BCM will read between approximately 0.5 volts (full stop) and 4.5 volts (empty stop) when the harness is connected. When there is an open in the circuitry the signal circuit voltage will be 12.0 volts. **The data reading value on the scan tool is clipped to read 5.0 volts when the signal circuit is open.** The BCM reads the voltage and converts the analog signals to digital signals. The digital signals are broadcast over the CAN bus. The Powertrain Control Module (PCM) receives and interprets the digital signals as a voltage read. The PCM, and in most cases the BCM, perform circuit fault diagnostics on the signal input.

The Fuel Level Rationality diagnostics are only performed by the PCM. The Fuel Level rationality diagnostics are explained in more detail in the Fuel Level Rationality diagnostic information below.

The Fuel Level Sensor Tables are available at the bottom of the test procedure.

THEORY OF OPERATION - FUEL LEVEL RATIONALITY

SINGLE TANK FUEL LEVEL RATIONALITY DIAGNOSTIC DESCRIPTION: The intent of the **Fuel Level Rationality** is to check for a "stuck" fuel level reading. This is done to keep high or low fuel levels that are stuck from disabling OBD monitors. Since the amount of fuel consumed from trip to trip varies based on customer drive cycles, this diagnostic can accumulate fuel consumption over multiple drive cycles. The diagnostic will run until enough fuel has been consumed to make a decision. The PCM compares the difference between the fuel level value at the start of the diagnostic and the fuel level value after a calibrated amount of fuel consumption should have occurred. If the difference is less than a calibrated threshold, the test fails. Once a decision is made, a new diagnostic test will start. If a fault is set, the fuel level will default to a value that will allow other OBD diagnostics to run.

SADDLE TANK FUEL LEVEL RATIONALITY GENERAL INFORMATION: The Fuel Level Sensor information is a direct input to the Body Control Module (BCM) which is sent to the Powertrain Control Module (PCM) via CAN bus. On the primary side of the saddle tank is the Electric Fuel Pump Module that feeds the engine and the Primary Fuel Level Sensor. On the secondary side of the saddle tank is a Venturi Jet Pump and the Secondary Fuel Level Sensor. The Jet Pump is connected to the Electric Fuel Pump Module on the primary side by way of a siphon tube. The PCM uses the average from both sides to determine the total fuel volume.

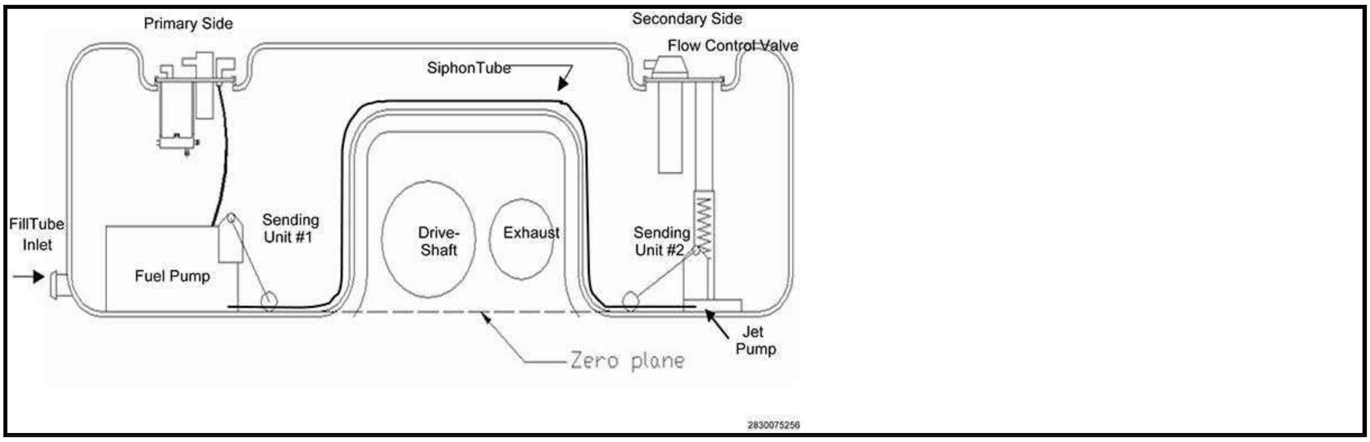
SADDLE TANK FUEL LEVEL RATIONALITY DIAGNOSTIC DESCRIPTION: On a properly operating system, the fuel volume on the secondary side of the Fuel Tank will be at empty before the primary side of the Fuel Tank will begin to decrease due to the siphon tube flow rate always exceeding the engines fuel consumption rate. Using this assumption, the PCM performs a diagnostic to check the rationality of both Fuel Level Sensors, as well as the operation of the jet pump and siphon tube as follows;

- When the total fuel volume is greater than 50% the primary tank should remain at the full position. As fuel is consumed, or sloshes over to the secondary tank while driving, the jet pump and siphon tube will replenish the primary tank to the full position and the secondary fuel level should decrease.
- When the total fuel volume is less than 50%, the secondary tank should be at empty and the primary fuel volume should start to decrease as fuel is consumed by the engine.

If either scenario fails to happen the PCM will determine that one of the Fuel Level Sensors is stuck in range, or that the Jet Pump or siphon tube is faulty not allowing fuel to transfer from the secondary side to the primary side of the Fuel Tank.

- The rationality diagnostic for the **primary side** of the tank will not become enabled until the secondary side level is near empty.
- The rationality diagnostic for the **secondary side** of the tank is based on the average fuel volume in the tank. It is enabled when there is enough total fuel to fill the primary tank plus enough fuel to check the rationality of the Secondary Fuel Level Sensor when a calibrated amount of fuel is consumed.

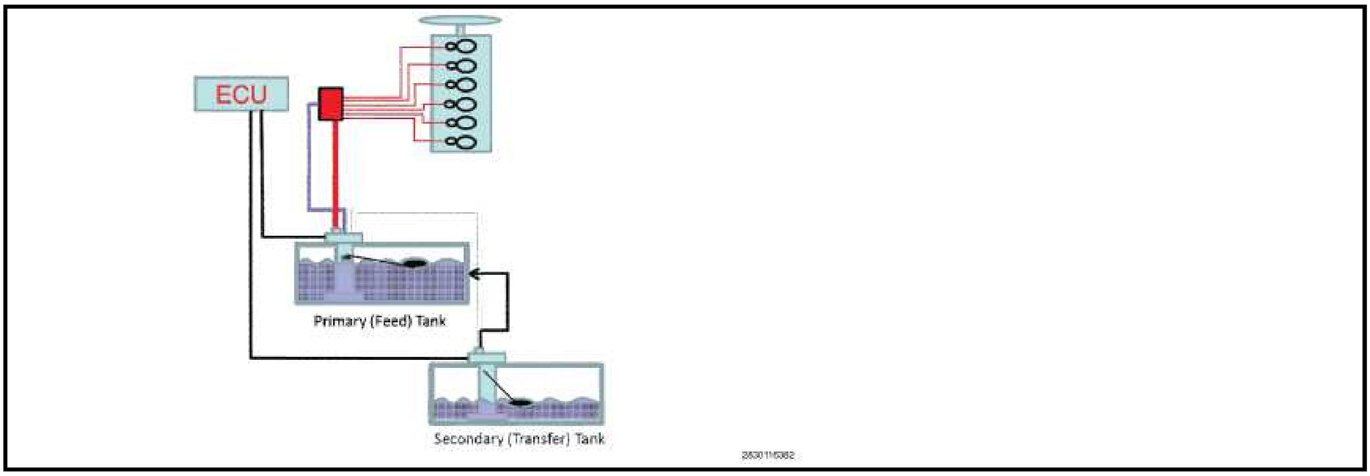
Since the amount of fuel consumed from trip to trip varies based on customer drive cycles, this monitor can accumulate fuel consumption over multiple drive cycles. The monitor will run until enough fuel has been consumed to make a decision. Once a decision is made, a new test will start.



DUAL FUEL TANK FUEL LEVEL RATIONALITY DIAGNOSTIC DESCRIPTION: Some D-Trucks add a second Fuel Tank (Auxiliary Fuel Tank) to allow the fuel capacity to be increased. Both Fuel Tanks have an independent Fuel Pump Module and Fuel Level Sensor (located inside the tanks); and fuel fill tube. The Fuel Level Sensor information is a bussed message from the Body Control Module (BCM) to the Powertrain Control Module (PCM).

- **The Main Fuel Tank** supplies fuel to the engine for consumption. The PCM performs the **Primary Fuel Level Rationality** diagnostic to check for a "stuck" fuel level reading in the same way as on a single tank system. **Refer to the Single Tank Fuel Level Rationality Diagnostic Description above.**
- **The Auxiliary Fuel Tank** is used to fill the Main Fuel Tank when the fuel level in the Main Fuel Tank reaches a minimum threshold. **It does not supply the fuel directly to the engine.** The Auxiliary Fuel Pump will be de-activated when the Main Fuel Tank fuel level reaches the maximum threshold, or the Auxiliary Fuel Tank fuel level reaches a minimum threshold before or during a tank transfer event. This is to prevent an overfill of the Main Fuel Tank or the Auxiliary Fuel Pump running in a dry condition. The PCM performs the **Secondary Fuel Level Rationality** diagnostic during a fuel transfer event.

There are 2 relays that control the Auxiliary Fuel Pump: The Fuel Pump 2 Relay and the Fuel Pump 2 On/Off Relay. The PCM controls the low side driver of the Fuel Pump 2 Relay. The Fuel Pump 2 Relay is supplied power from the Fuel Pump 2 On/Off Relay, which is controlled by the BCM. In the event that the Fuel Pump 2 Relay is stuck on and over filling the Main Fuel Tank, the BCM can turn off the Fuel Pump 2 On/Off Relay. This will turn off the power supply to the Fuel Pump 2 Relay and the Auxiliary Fuel Pump Module.



ENABLING/SET CONDITIONS AND POSSIBLE CAUSES - FUEL LEVEL SENSOR FAULTS

When Monitored - Circuit Faults (P0462, P0463, P2067, P2068, P2065-11, P2065-15):

These diagnostics run when the following conditions are met:

- With the ignition on.
- Battery voltage above 10.4 volts.
- No active fuel level missing message faults (PCM only).

When Monitored - Rationality Faults (P0461, P2066):

These diagnostics run when the following conditions are met:

Single Tank System:

- With the engine running for more than two minutes.
- After the PCM decides that a calibrated amount of fuel should have been consumed (between approximately one and five gallons depending on initial fuel level).
    - This is determined by the accumulated amount of fuel injected into the engine through the Fuel Injectors.

Saddle Tank System:

- The primary level rationality diagnostic runs when the Fuel Level Sensor 2 (Secondary) is reading empty.
- The secondary level rationality diagnostic runs when the Fuel Level Sensor 1 (Primary) is reading full.

Dual Tank System:

- The primary level rationality diagnostic functions the same as the Single Tank System.
- The secondary level rationality diagnostic runs when a fuel transfer event is occurring.

FAULT SETTING CRITERIA	
Circuit Low/High Faults - (P0462, P0463, P2067, P2068, P2065-11, P2065-15)	• Circuit Low - The Fuel Level Sensor signal voltage is below approximately 0.2 volts for more than 3.2 seconds. • Circuit High - The Fuel Level Sensor signal voltage is above approximately 4.9 volts for more than 3.2 seconds.
Rationality Faults - Single Tank Systems	When the PCM does not see a change in fuel level of greater than 0.06 volts after the calibrated amount of fuel should have been consumed the diagnostic will fail.
Rationality Faults - Saddle Tank Systems	• Primary Fault (P0461) - If the PCM does not see a change in Fuel Level Sensor 1 of greater than 0.06 volts after the calibrated amount of fuel should have been consumed the diagnostic will fail. • Secondary Fault (P2066) - If the PCM does not see a change in Fuel Level Sensor 2 of greater than 0.06 volts after the calibrated amount of fuel should have been consumed the diagnostic will fail.
Rationality Faults - Saddle Tank Systems	• Primary Fault (P0461) - If the PCM does not see a change in fuel level of greater than 0.06 volts after the calibrated amount of fuel should have been consumed the diagnostic will fail. • Secondary Fault (P2066) - No change in Fuel Level Sensor 2 circuit voltage after a significant amount of fuel should have been transferred from the Auxiliary Fuel Tank to the Primary Fuel Tank.

Default Actions:

- The MIL is illuminated.

Possible Causes - Circuit Faults
FUEL LEVEL SENSOR HARNESS CONNECTOR DAMAGED OR NOT CONNECTED COMPLETELY
FUEL LEVEL SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW FAULT)
FUEL LEVEL SENSOR SIGNAL CIRCUIT SHORTED TO THE SENSOR RETURN CIRCUIT (CIRCUIT LOW FAULT)
FUEL LEVEL SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH FAULT)
FUEL LEVEL SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH FAULT)
FUEL LEVEL SENSOR RETURN CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT HIGH FAULT)
FAULTY FUEL LEVEL SENSOR
FAULTY BODY CONTROL MODULE (BCM)

Possible Causes - Rationality Faults
FUEL LEVEL SENSOR HARNESS CONNECTOR DAMAGED OR NOT CONNECTED COMPLETELY
FUEL TANK DAMAGED
OBSTRUCTION TO THE PRIMARY OR SECONDARY FUEL LEVEL SENSOR
PRIMARY OR SECONDARY FUEL LEVEL SENSOR FAULTY OR BROKEN
SECONDARY PUMP OR SIPHON TUBE LEAKING OR DISCONNECTED (SADDLE TANK SYSTEM)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCs and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns, or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. **The resistor card on Fuel Level Sensors can occasionally have a bad spot on the card which can cause a fault to be inactive when testing.** In some cases this could result in an open circuit during the period when the fuel level is at the bad spot. In other cases the bad spot could result in the resistors on the card blurring together. This could cause the fuel level reading to stay constant when the fuel level travels through that portion of the resistor card. This condition can cause a performance fault since the PCM will not see a fuel level change as fuel is consumed during this time.
2. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
3. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
4. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply, check for connection issues by wiggle testing any wiring

harnesses and in-line connectors the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach a lab scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor battery system voltage or poor ground connections can affect systems in different or odd ways. Check the battery or batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.

5. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving. Operate the components through a full range of operation while monitoring functionality.

PRIMARY AND SECONDARY FUEL LEVEL SENSOR CIRCUIT FAULT DIAGNOSTICS

NOTE: **There are multiple test methods listed below. There can be advantages to using each method. All of the methods do not need to be performed. Pick the best test method based on accessibility, ease of testing or availability of test equipment. In some cases it may be beneficial to use parts of each method to test for different failure modes.**

CIRCUIT DIAGNOSTICS USING THE ELECTRICAL TEST LEAD KIT: Check the BCM signal and return circuits together to determine if the Fuel Level Sensor is faulty. Disconnect the Fuel Pump harness connector. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the Fuel Level Signal and Return Signal circuits in the Fuel Pump harness connector. Move the switch on the Electrical Test Lead Kit between the open and closed positions while monitoring the scan tool. If monitoring for faults, the circuit high fault should set when switched to the open position and the circuit low fault should set when switched to the closed position. If the sensor voltage is available, monitor the voltage readings on the scan tool. It should be 5.0 volts when switched to the open position and 0.0 volts when switched to the closed position. Move the switch to adjust and use the tool to vary the resistance between the Full Stop and Empty Stop resistance ranges while monitoring the BCM signal voltage on the scan tool with the ignition on.

NOTE: **Even though the actual signal will read 12.0 volts with the switch in the open position, the scan tool will register the signal as 5.0 volts**

1. **If the faults set as described and the signal voltage is 5.0 volts and 0.0 volts on the scan tool** - the BCM and Fuel Level Sensor circuits are testing good. The Fuel Level Sensor is most likely faulty or has a poor connection at the harness connector. Check the Fuel Pump harness connector for pushed out, spread, corroded or dirty terminals before condemning the sensor. The internal resistance of the sensor can be measured and compared to the table (if available) to verify a faulty sensor.
2. **If the signal voltage is stuck low or only the circuit low fault sets** - the most likely cause is the Fuel Level Sensor Signal circuit shorted to chassis ground or the Fuel Level Sensor Return circuit. Check the Fuel Level Sensor Signal circuit for a short to ground or the Sensor Return circuit. If the signal circuit is not shorted, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals before condemning a BCM. If no issues are found, the BCM is faulty.
3. **If the signal voltage is stuck high or only the circuit high fault sets** - the most likely cause is an open or very high resistance in the Fuel Level Sensor Signal or Return circuit. Continue testing in step 4.
4. **If the signal reading on the scan tool shows voltage present when switched to closed** - remove the test lead from the sensor return circuit and connect it to a good chassis ground while observing the voltage on the scan tool. If the voltage drops to 0.0 volts the resistance is in the sensor return circuit. If the voltage is still present the resistance is in the sensor signal circuit. Check the appropriate circuit for high resistance. Typically should be less than 3.0 Ohms. If the circuits check good, continue testing in step 5.
5. **If the circuits are checked and do not have excessive resistance** - Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BCM. If no issues are found, the BCM is faulty.

CIRCUIT DIAGNOSTICS USING CONVENTIONAL VOLTAGE TESTING WITH A DVOM:

1. Verify the Fuel Pump and BCM harness connectors are connected and locked properly.
2. Turn the ignition on. Back Probe and measure the voltage on the Fuel Level Sensor Signal circuit at the Fuel Pump harness connector.
    1. **If the signal voltage is reading between 0.5 and 4.5 volts** - the sensor signal is giving a legitimate reading. If the circuit fault is active and the voltage reading on the scan tool does not match the voltage reading, the BCM is likely faulty.
    2. **If the signal has a constant 0.0 volt reading** - this indicates that the signal circuit is shorted to ground or has an open between the BCM and Fuel Level Sensor. If the circuit high fault is set, the most likely failure is an open in the signal circuit. If the circuit low fault is set, the most likely failure is short to ground in the signal circuit. Disconnect the Fuel Pump and BCM harness connectors. Check the signal circuit for high resistance and short to ground. If the signal circuit checks good, check at all connectors in the system for pushed out, spread, corroded or dirty terminals before condemning a BCM.
    3. **If the signal reading has a constant 12.0 volts** - this indicates an open further downstream in the circuitry. Most likely the Fuel Level Sensor or the Fuel Level Sensor Return circuit.
3. To check the Fuel Level Sensor, move the test lead over and back probe the Fuel Level Sensor Return circuit at the Fuel Pump harness connector.
    1. **If the signal changes to 0.0 volts** - this would indicate an open in, or short across the Fuel Level Sensor resistance card. The internal resistance of the Fuel Level Sensor can be measured and compared to the table (if available) to verify a faulty sensor.
    2. **If the signal is still at 12.0 volts** - this indicates an open in the Fuel Level Sensor Return circuit path. Disconnect the Fuel Pump and BCM harness connectors. Check the return circuit for high resistance. If the return circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals before condemning a BCM. If no issues are found, the BCM is faulty.

CIRCUIT DIAGNOSTICS USING CONVENTIONAL RESISTANCE TESTING WITH A DVOM:

1. Verify the Fuel Pump and BCM harness connectors are connected and locked properly.
2. Disconnect and check the Fuel Pump and BCM harness connectors for pushed out, spread, corroded or dirty terminals.
3. Check the Fuel Level Sensor Signal circuit for an open/high resistance, short to the return circuit or short to ground.
4. Check the Fuel Level Sensor Return circuit for an open/high resistance.
5. Check for the Fuel Level Sensor resistance being above or below the minimum and maximum specifications.
6. Reconnect the BCM harness connector leaving the Fuel Pump harness connector disconnected. Turn the ignition on and monitor the scan tool for faults. The circuit high fault should set with the Fuel Pump harness connector disconnected. Connect a fused jumper between the Fuel Level Sensor Signal circuit and the Fuel Level Sensor Return at the Fuel Pump harness connector. The circuit low fault should set with the jumper in place. If the faults set as described, replace the Fuel Level Sensor. If the faults do not set as described, the BCM is faulty.

FUEL LEVEL SENSOR RATIONALITY DIAGNOSTICS (P0461, P2066)

Excessive pressure build up or vacuum in the Evaporative system could possibly contribute to this DTC being set. Diagnose and repair any Evaporative System DTCs before continuing with this fault.

SINGLE TANK FUEL LEVEL SENSOR RATIONALITY DIAGNOSTICS:

1. Visually inspect the Fuel Tank for any obvious physical damage that may restrict the Fuel Level Sensor float from moving. If the Fuel Tank is damaged, replace the tank assembly. If the Fuel Tank has no visible damage, and there are no circuit faults present, the rationality fault is most likely due to an

intermittent connection, obstructed float arm, bad spot on the Fuel Level Sensor resistor card, or faulty BCM. Continue to step 2.

2. Verify that the Fuel Pump connector is properly connected and locked. Check the Fuel Pump and BCM harness connectors and terminals for pushed out, spread, corroded or dirty terminals. If the connector or terminals appear damaged, repair or replace the damaged connector or terminals.
3. Check the ability of the BCM to read the Fuel Level Sensor signal correctly. Disconnect the Fuel Pump harness connector. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the Fuel Level Signal and Return Signal circuits at the Fuel Pump harness connector. Turn the ignition on. Move the switch on the Electrical Test Lead Kit to the adjust position. For most Fuel Level Sensors, the typical resistance on the resistor card is between approximately 50 Ohms (Full Stop) and 1000 Ohms (Empty Stop). Turn the ignition on and monitor the signal voltage on the scan tool, while varying the resistance on the Electrical Test Lead Kit between approximately 50 and 1000 Ohms.

   1. **If the signal voltage is changing between 0.0 volts and 5.0 volts while changing the resistance** - the BCM is reading the Fuel Level Sensor signal correctly. The Fuel Level Sensor is most likely faulty or has a poor connection at the harness connector. Check the Fuel Pump harness connector for pushed out, spread, corroded or dirty terminals before condemning the sensor. If the terminals and connector check good, replace the faulty Fuel Level Sensor.
   2. **If the signal voltage is not changing between 0.0 volts and 5.0 volts while changing the resistance** - Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals. If no issues are found, check the Fuel Level Sensor Signal and Return Signal circuits for high resistance (refer to the appropriate circuit fault information for additional assistance on testing the circuits). If the circuits test good, the BCM is faulty.

SADDLE TANK FUEL LEVEL SENSOR RATIONALITY DIAGNOSTICS: Before starting it is important to note that in a properly operating system the primary side of the tank should always be at or very close to full if there is fuel in the secondary side of the tank. Therefore, the primary level sensor rationality fault should only set if the secondary side is empty and the primary level sensor is not changing as fuel is consumed. The secondary level sensor rationality fault should only set if the primary side is full and the secondary level sensor is not changing as fuel is consumed. It is possible for a secondary Fuel Level Sensor to be stuck in the empty position causing a primary Fuel Level Sensor rationality fault. Therefore, a good practice is to look at, and compare both level sensor values when diagnosing either rationality DTC to verify which sensor to diagnose.

1. Visually inspect the Fuel Tank for any obvious physical damage that may restrict either Fuel Level Sensor float from moving. If the Fuel Tank is damaged, replace the tank assembly. If the Fuel Tank has no visible damage, and there are no circuit faults present, the rationality fault is most likely due to an

intermittent connection, obstructed float arm, bad spot on the Fuel Level Sensor resistor card, or faulty BCM. Continue to step 2.

2. Using the scan tool check for any Evaporative System or Fuel Level Sensor circuit faults.
    1. Diagnose and repair any Evaporative System DTCs before continuing with this fault.
    2. Diagnose any Fuel Level Sensor circuit faults before continuing with the rationality diagnostic.
        - If no other faults are present, continue to step 3.
3. This step is designed to try and determine which sensor is giving a false reading. Using the scan tool, read the voltage for both Fuel Level Sensors in the BCM data. This step may require adding or removing fuel in the tank in order to make a decision as to which level sensor to diagnose. **NOTE: A normally functioning level sensor will typically read between approximately 4.3 - 4.5 volts at empty and 0.5 - 0.65 volts at full.**
    1. If the primary side of the tank is reading less than full and the secondary side of the tank is reading empty, Go to step 4.
    2. If the primary side of the tank is reading less than full, but the secondary side of the tank is showing fuel present, Go to step 4.
    3. If the primary side of the tank is reading full and the secondary side of the tank is reading empty, Go to step 4.
    4. If the primary side of the tank is reading full and the secondary side of the tank is showing fuel present, Go to step 5.
4. Add the amount of fuel to the tank that it takes to fill the primary side to guarantee that there is overflow to the secondary side of the Fuel Tank. Using the scan tool, read the voltage for both Fuel Level Sensors in the BCM data. The primary level sensor should read full and the secondary level sensor should show some fuel present. Follow the scenario that best fits below:
    1. If the primary side is not reading full, diagnose the primary level sensor in step 6 below.
    2. If the secondary side is not showing any fuel present, diagnose the secondary level sensor in step 6 below.
    3. If both sensors appear to be reading normal, start removing fuel from the tank into an approved storage container. The secondary level sensor should decrease to empty before the primary starts decreasing. If the primary level sensor starts decreasing before the secondary side starts moving diagnose the secondary level sensor in step 6 below.
5. Start removing fuel from the tank into an approved storage container. Remove enough fuel to guarantee the total Fuel Tank level is below 1/2 tank.
    1. If the primary side of the tank is reading full and the secondary side of the tank is reading empty, diagnose the primary level sensor in step 6 below.
    2. If the primary side of the tank is reading less than full but the secondary side of the tank is showing fuel present, diagnose the secondary level sensor in step 6 below.
6. **Perform the following diagnostics on the Fuel Level Sensor that was not reading rational in step 4 or 5.** Verify that the harness connector at the Fuel Pump or Auxiliary Fuel Pump/Level Sensor is properly connected and locked. Check the Fuel Pump, Auxiliary Fuel Pump/Level Sensor and BCM harness connectors and terminals for pushed out, spread, corroded or dirty terminals. If the connector or terminals appear damaged, repair or replace the damaged connector or terminals.
7. Check the ability of the BCM to read the Fuel Level Sensor signal correctly. Disconnect the appropriate harness connector. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the Fuel Level Signal and Return Signal circuits in the harness connector. Move the switch on the Electrical Test Lead Kit to the adjust position. For most Fuel Level Sensors, the typical resistance on the resistor card is between approximately 50 Ohms (Full Stop) and 1000 Ohms (Empty Stop). Turn the ignition on and monitor the signal voltage on the scan tool, while varying the resistance on the Electrical Test Lead Kit between approximately 50 and 1000 Ohms.

1. **If the signal voltage is changing between 0.0 volts and 5.0 volts while changing the resistance** - the BCM is reading the Fuel Level Sensor signal correctly. The Fuel Level Sensor is most likely faulty or has a poor connection at the harness connector. **If the issue is with the secondary side showing fuel when the primary is less than full** this issue could be caused by the fuel not being pulled over from the secondary side to the primary side of the Fuel Tank due to a damaged or faulty siphon tube or Auxiliary Pump. Remove the Auxiliary Pump assembly and check for fuel stuck on the secondary side. If the secondary side is empty, replace the faulty Fuel Level Sensor. If the secondary side still has fuel when the primary side is less than full, examine and repair or replace the Auxiliary Pump or siphon tube assembly.
2. **If the signal voltage is not changing between 0.0 volts and 5.0 volts while changing the resistance** - check the Fuel Level Sensor Signal and Return circuits for high resistance (refer to the appropriate circuit fault information for additional assistance on testing the circuits). If the circuits test good, Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning BCM. If no issues are found, the BCM is faulty.

FUEL LEVEL SENSOR TABLES

The table below gives approximate internal resistance and raw voltage values for a Fuel Level Sensor based on fuel volume. **These can be used as a general reference when the actual values are not available for any single tank or saddle tank Fuel Level Sensors.** As can be seen in the table, the full travel of the sensor (Full Stop/Empty Stop) is slightly more than the full tank and empty tank thresholds used for the fuel gauge.

Generic Fuel Tank Table Values		
Fuel level reading	**Typical resistance of level sensor (Ohms)**	**Typical raw voltage signal input (volts)**
Full Stop (Max full travel)	50 - 60	0.5 - 0.7
Full tank	60 - 75	0.75 - 1.0
1/2 tank	160 - 225	1.6 - 2.2
Empty tank	725 - 770	3.4 - 4
Empty Stop (Max empty travel)	930 - 990	3.9 - 4.5

The tables below are for L-body vehicles.

Primary Fuel Tank Table			
Fuel level reading	**Fuel Volume (Gallons)**	**Fuel Volume (Liters)**	**Resistance of level sensor (Ohms)**
Full Stop (Max full travel)	10.1	38.5	51.1
Full tank	9.2	34.7	93
3/4 tank	7.3	27.9	172.5
1/2 tank	5.1	19.2	281.3
1/4 tank	2.9	11.1	471.1
Empty tank	0.6	2.3	910
Empty Stop (Max empty travel)	0.4	1.5	992

Secondary Fuel Tank Table			
Fuel level reading	**Fuel Volume (Gallons)**	**Fuel Volume (Liters)**	**Resistance of level sensor**
Full Stop (Max full travel)	8.4	31.83	51.1
Full tank	7.8	29.6	75.6
1/2 tank	3.8	14.4	281.3
1/4 tank	2.0	7.4	370.5
Empty tank	0.98	0.3	835.7
Empty Stop (Max empty travel)	0	0	992

The tables below are for WK/WD vehicles.

NOTE: **The diesel engine end stop and 1/2 tank values are the same.**

Primary Fuel Tank Table				
Fuel level reading	**Fuel Volume (Gallons) - 3.6L**	**Resistance of level sensor (Ohms) - 3.6L**	**Fuel Volume (Gallons) - 5.7L**	**Resistance of level sensor (Ohms) - 5.7L**
Full Stop (Max full travel)	12.9	59	12.9	59
Full tank	10.8	101.7	10.5	109
3/4 tank	8.8	145.6	8.4	156
1/2 tank	6.4	220	6.4	220
1/4 tank	4.2	325	4.5	309
Empty tank	0.8	848	0.9	776
Empty Stop (Max empty travel)	0.35	991	0.35	991

Secondary Fuel Tank Table				
Fuel level reading	**Fuel Volume (Gallons) - 3.6L**	**Resistance of level sensor (Ohms) - 3.6L**	**Fuel Volume (Gallons) - 5.7L**	**Resistance of level sensor (Ohms) - 5.7L**
Full Stop (Max full travel)	11.9	64	11.9	64
Full tank	10.1	109	9.5	123.9
3/4 tank	7.7	174	7.4	182.9
1/2 tank	5.6	261	5.6	261
1/4 tank	3.3	424	3.5	399.5

Secondary Fuel Tank Table				
Fuel level reading	**Fuel Volume (Gallons) - 3.6L**	**Resistance of level sensor (Ohms) - 3.6L**	**Fuel Volume (Gallons) - 5.7L**	**Resistance of level sensor (Ohms) - 5.7L**
Empty tank	0	919.7	0	848
Empty Stop (Max empty travel)	0	991	0	991

The tables below are for HDCC vehicles.

28 Gallon Fuel Tank Table Values		
Fuel level reading	**Typical resistance of level sensor (Ohms)**	**Typical raw voltage signal input (volts)**
Full Stop (Max full travel)	50 - 60	0.5 - 0.7
Full tank	60 - 75	0.75 - 1.0
1/2 tank	240 - 255	1.9 - 2.3
Empty tank	850 - 900	4.1 - 4.2
Empty Stop (Max empty travel)	930 - 990	4.3 - 4.5

22 Gallon Dual Fuel Tank Table Values		
Fuel level reading	**Typical resistance of level sensor (Ohms)**	**Typical raw voltage signal input (volts)**
Full Stop (Max full travel)	50 - 60	0.5 - 0.7
Full tank	80 - 100	0.8 - 1.0
1/2 tank	250 - 265	2.3 - 2.5
Empty tank	670 - 965	3.2 - 4.4
Empty Stop (Max empty travel)	930 - 990	4.3 - 4.5

52 Gallon Dual Fuel Tank Table Values		
Fuel level reading	**Typical resistance of level sensor (Ohms)**	**Typical raw voltage signal input (volts)**
Full Stop (Max full travel)	50 - 60	0.5 - 0.7
Full tank	60 - 75	0.75 - 1.0
1/2 tank	250 - 270	2.0 - 2.4
Empty tank	815 - 930	4.0 - 4.2
Empty Stop (Max empty travel)	930 - 990	4.3 - 4.5

POWERTRAIN VERIFICATION TEST

VERIFICATION OF REPAIR:

1. Inspect the vehicle to make sure that all engine components are properly installed and connected. Reassemble and reconnect components as necessary.
2. After repairs are complete, erase all DTCs with the scan tool.
3. Refer to the table below to determine if a learn procedure should be performed for the component that was removed or replaced. Not all learn procedures are available for all vehicles. If a component listed in the table is replaced and the correlating learn procedure is present in the scan tool, navigate to "Miscellaneous Functions" and perform the learn procedure before verifying repair. Failure to do so may cause the same, or another DTC to set.

Scan Tool Learn Procedures	Component replaced or removed: Note: (All available Learn procedures should be performed when a PCM is replaced)
Brake Pedal Learn	Brake Pedal Position Sensor, Brake Pedal Assembly

Scan Tool Learn Procedures	Component replaced or removed: Note: (All available Learn procedures should be performed when a PCM is replaced)
Cam Crank Relearn (NGC/GPEC Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clear Misfire TLC (Magneti Marelli Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clutch Pedal Learn	Clutch Pedal Position Sensor, Clutch Pedal, Clutch Assembly (pressure plate and disc)
EGR Valve Replaced	EGR Valve
Learn ETC	Throttle Body
Check PCM Odometer	PCM Replaced
Check PCM VIN	PCM Replaced
PCM Replaced Routine	PCM Replaced
Learn Gear Shift Sensor	Gear Shift Position Sensor, Transmission Shifter components

4. **If the PCM has been replaced** , perform the Module Programming procedure. The PCM Reprogramming procedure is either in Electronic Control Modules/PCM Programming Folder or PCM Standard Procedure Folder depending on the vehicle application. Be certain that the secret key code, VIN and odometer mileage are programmed after programming the PCM.
5. Operate the vehicle in accordance with the parameters and specific information found in the Monitoring Conditions and Theory of Operation of the DTC that was repaired.
6. With the scan tool, verify that no DTCs have returned.
   1. If the DTC returned check for any service bulletins or star online cases that may apply. If no bulletins exist, return to and perform the DTC procedure.
   2. If the DTC or condition did not return, repair is complete.

P0480-COOLING FAN 1 CONTROL CIRCUIT (VARIABLE SPEED FAN)

For a complete COOLING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Radiator Fan Module is a smart device which is integrated into the Radiator Fan Assembly and receives the Pulse-Width Modulated (PWM) Radiator Fan speed signal from the Powertrain Control Module (PCM) to control fan speed. The Radiator Fan Module will control the fan speed based on this input. The Radiator Fan Module performs diagnostics on the Radiator Fan circuits. If a fault is detected in the voltage supply, ground or internal fan circuitry, the Radiator Fan Module sends a fault message to the PCM using the same PWM circuit. During normal operation, the Radiator Fan can be operated between 10% duty cycle (Low speed) and 92% duty cycle (High speed).

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.0 volts.

SET CONDITION

- The Powertrain Control Module (PCM) controls the Cooling Fan operation by sending a Pulse-Width Modulated (PWM) signal to the Cooling Fan Module to control fan speed. The PCM determines an open or shorted circuit is detected in the Radiator Fan Control circuit.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

POSSIBLE CAUSES
FUSED B+ CIRCUIT TO THE RADIATOR FAN ASSEMBLY OPEN/HIGH RESISTANCE
FUSED B+ CIRCUIT TO THE RADIATOR FAN ASSEMBLY SHORTED TO GROUND
GROUND CIRCUIT TO THE RADIATOR FAN ASSEMBLY OPEN/HIGH RESISTANCE
PWM RADIATOR FAN CONTROL CIRCUIT OPEN/HIGH RESISTANCE
PWM RADIATOR FAN CONTROL CIRCUIT SHORTED TO GROUND
PWM RADIATOR FAN ASSEMBLY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE CONDITION**
    1. Turn the ignition on.
    2. With a scan tool, select Radiator Cooling Fan Control State to actuate the Cooling Fan.

    Is the Cooling Fan operating?

    Yes

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

    No

    - Go To 2
2. **CHECK THE (A13) FUSED B+ CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Disconnect the component harness connector to isolate the 12.0 volt supply circuit.
    2. Connect the positive lead of the load test tool to the 12.0 volt supply circuit at the component harness connector (A). **Note:** refer to the diagram below.
    3. Connect the negative lead of the load test tool to the ground circuit of the Battery or a good chassis ground.
    4. Ensure that the circuit being tested is being powered on. If the 12.0 volt circuit being tested is an ignition feed for example, the ignition must be on. If testing an output from a relay, verify that the relay is energized and on.
    5. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

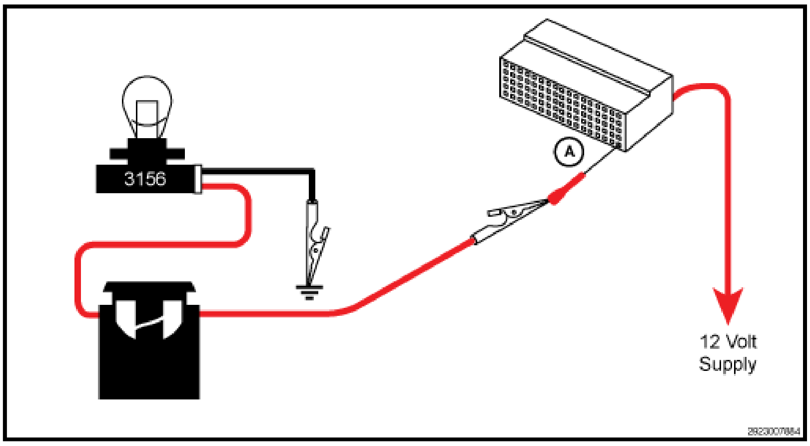
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit.**

Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
- **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

- Go To 3

No

- Repair the 12.0 volt circuit for an open or high resistance. If the fuse is found to be open, check the circuit for a short to ground.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **CHECK THE (Z904) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Disconnect the component harness connector to isolate the 12.0 volt supply circuit.
    2. Connect the positive lead of the load test tool to the 12.0 volt supply circuit at the component harness connector (A). **Note:** refer to the diagram below.
    3. Connect the negative lead of the load test tool to the ground circuit of the Battery or a good chassis ground.
    4. Ensure that the circuit being tested is being powered on. If the 12.0 volt circuit being tested is an ignition feed for example, the ignition must be on. If testing an output from a relay, verify that the relay is energized and on.
    5. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

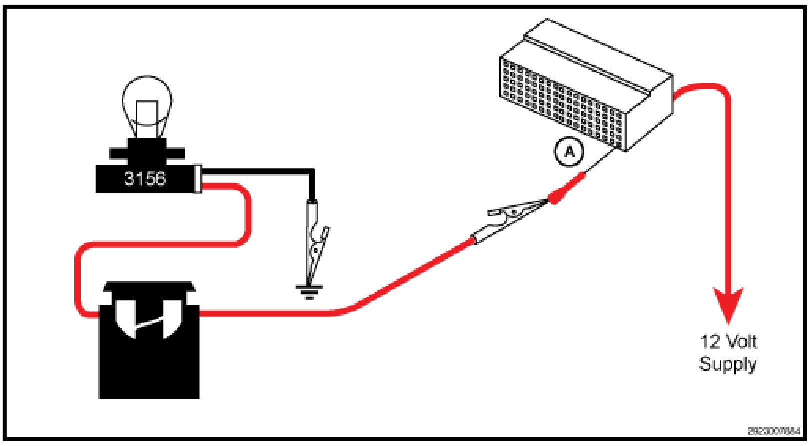
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
- **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the

CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 4

   No

   - Repair the 12.0 volt circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE RADIATOR FAN (K173) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to**

pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **ISOLATE AND CHECK THE RADIATOR FAN (K173) CONTROL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 6

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE RADIATOR FAN FOR PROPER OPERATION**

1. Reconnect the PCM C1 harness connector.
2. Reconnect the Radiator Fan harness connector.
3. Using a voltmeter, back probe the Radiator Fan (K173) Control circuit at the Radiator Fan harness connector.
4. Turn the ignition on.
5. With the scan tool actuate the Radiator Fan.

   Is there any voltage present?

   Yes

   - Replace the Radiator Fan Assembly in accordance with the Service Information. Refer to **FAN, COOLING, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 7

7. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

   Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0489-EGR CONTROL CIRCUIT LOW

For a complete EGR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

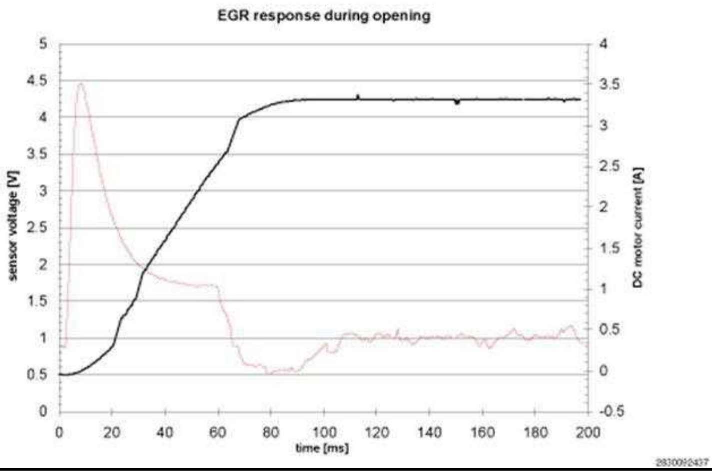
THEORY OF OPERATION

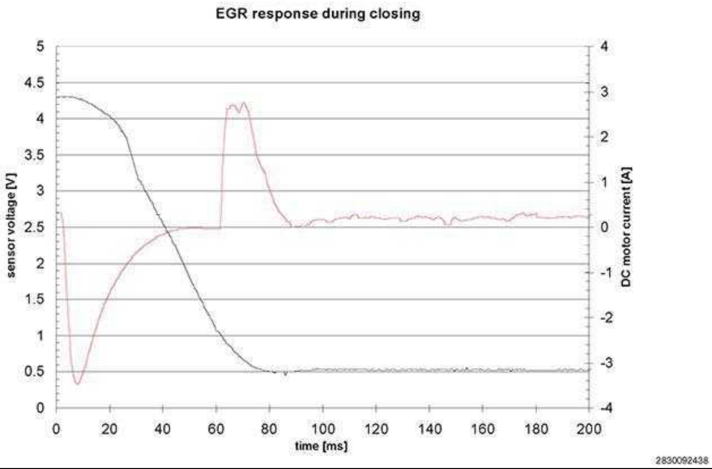
The Cooled Exhaust Gas Recirculation (EGR) Valve Assembly contains an electric Direct Current (DC) Motor and a gear box. An eccentric drive translates the gearbox output from a rotating motion (DC Motor) to a linear stroke (output shaft). The full range of travel of the shaft is approximately 5.0 mm from a fully closed to fully open position. An internal return spring ensures that the valve returns back to its closed position as a fail safe. The EGR Valve is controlled by the Powertrain Control Module (PCM) H-Bridge driver. The H-Bridge operates the DC Motor using a Pulse Width Modulation (PWM) control to help reduce current draw. This helps protect the DC Motor from overheating and reduces electrical load on the system voltage.

- During initial opening of the EGR Valve the PCM drives the Pulse Width Modulation (PWM) voltage high resulting in a high current draw. After the valve is fully opened the PCM voltage is reduced to maintain the EGR Valve position. This reduces the current draw and protects from overheating the DC Motor.
    - The PCM monitors the temperature and current draw of the DC Motor inside EGR Valve and will adjust the duty cycle to prevent the EGR Valve windings from overheating. Typically, the peak current draw by the EGR Valve occurs during opening and the maximum current load for a typical application is approximately 6.0 amps. The duty cycle is adjusted after opening so that the typical average current draw is approximately 0.5 amps while holding the valve open.
- The PCM also applies a current in the closing direction to fulfill the required dynamic performance. This is done to control the closing speed of the shaft near the stop. This ensures that the valve does not close too fast causing the valve disk to be forced into the stop harshly which may damage the internal gearbox.

There is a position sensor located on the output shaft. The sensor operates as a typical three wire sensor, with a 5-Volt Supply, Sensor Signal, and Sensor Ground circuit. Full range of travel of the output shaft will result in a change of approximately 3.9 volts in the position sensor reading. During normal operation the position sensor signal voltage will range between approximately 0.5 volts (closed) and 4.3 volts (open).

NOTE: **See the figures below for a typical current draw on the DC Motor and voltage reading of the sensor during the EGR Valve opening and closing. The red line represents current draw of the DC Motor and the black line represents the position sensor voltage.**





WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage above approximately 10.4 volts.
- The Auto Shutdown (ASD) Relay is energized.

SET CONDITION

- The EGR Valve Control 2 circuit can be driven high or low depending on whether the EGR Valve is being opened or closed by the PCM. The PCM monitors the circuit for excessive current draw in both directions. The PCM will set the P0489 or P0490 DTC depending on which direction the EGR Valve is being driven when the fault occurs.
  - For this fault, the PCM detects a current draw above 8.6 amps on the EGR Valve Control 2 circuit when the circuit is being driven low.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EGR VALVE CONTROL 2 CIRCUIT SHORTED TO GROUND
EGR VALVE ASSEMBLY
POWERTRAIN CONTROL MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **ISOLATE AND CHECK THE EGR VALVE (K684) CONTROL 2 CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

        NOTE: **There should be no continuity between ground and the circuit being tested.**

        Is there continuity between ground and the circuit being tested?

        Yes

        - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **REPLACE THE EGR VALVE AND RETEST FOR DTC**
    1. Replace the EGR Valve in accordance with the Service Information. Refer to **VALVE, EXHAUST GAS RECIRCULATION (EGR), REMOVAL AND INSTALLATION** . The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine.
    2. Connect the EGR Valve harness connector.
    3. Connect the PCM C2 harness connector.
    4. Turn the ignition on.
    5. With the scan tool, erase DTCs.
    6. Start the engine and test drive the vehicle.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 4

    No

    - Replacing the EGR Valve repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
4. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.

6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0490-EGR CONTROL CIRCUIT HIGH

For a complete EGR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

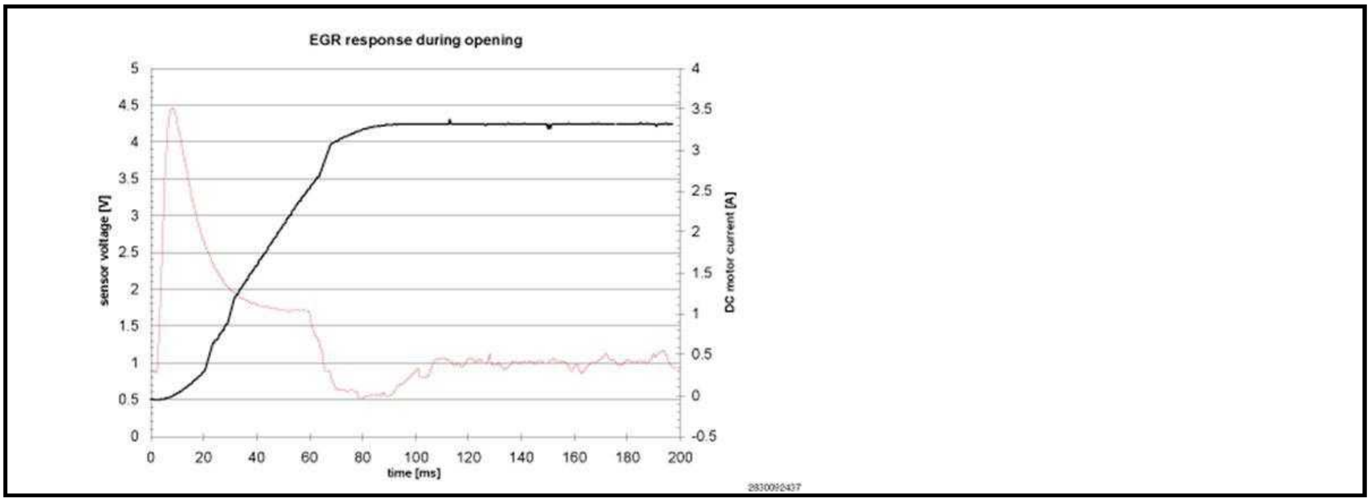
THEORY OF OPERATION

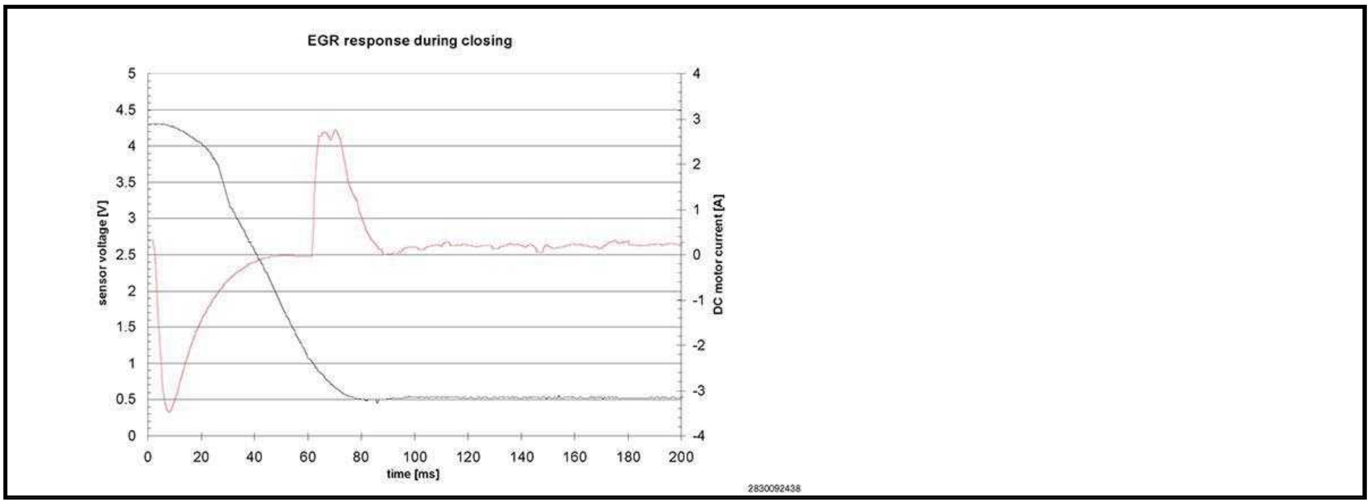
The Cooled Exhaust Gas Recirculation (EGR) Valve Assembly contains an electric Direct Current (DC) Motor and a gear box. An eccentric drive translates the gearbox output from a rotating motion (DC Motor) to a linear stroke (output shaft). The full range of travel of the shaft is approximately 5.0 mm from a fully closed to fully open position. An internal return spring ensures that the valve returns back to its closed position as a fail safe. The EGR Valve is controlled by the Powertrain Control Module (PCM) H-Bridge driver. The H-Bridge operates the DC Motor using a Pulse Width Modulation (PWM) control to help reduce current draw. This helps protect the DC Motor from overheating and reduces electrical load on the system voltage.

- During initial opening of the EGR Valve the PCM drives the Pulse Width Modulation (PWM) voltage high resulting in a high current draw. After the valve is fully opened the PCM voltage is reduced to maintain the EGR Valve position. This reduces the current draw and protects from overheating the DC Motor.
    - The PCM monitors the temperature and current draw of the DC Motor inside EGR Valve and will adjust the duty cycle to prevent the EGR Valve windings from overheating. Typically, the peak current draw by the EGR Valve occurs during opening and the maximum current load for a typical application is approximately 6.0 amps. The duty cycle is adjusted after opening so that the typical average current draw is approximately 0.5 amps while holding the valve open.
- The PCM also applies a current in the closing direction to fulfill the required dynamic performance. This is done to control the closing speed of the shaft near the stop. This ensures that the valve does not close too fast causing the valve disk to be forced into the stop harshly which may damage the internal gearbox.

There is a position sensor located on the output shaft. The sensor operates as a typical three wire sensor, with a 5-Volt Supply, Sensor Signal, and Sensor Ground circuit. Full range of travel of the output shaft will result in a change of approximately 3.9 volts in the position sensor reading. During normal operation the position sensor signal voltage will range between approximately 0.5 volts (closed) and 4.3 volts (open).

NOTE: **See the figures below for a typical current draw on the DC Motor and voltage reading of the sensor during the EGR Valve opening and closing. The red line represents current draw of the DC Motor and the black line represents the position sensor voltage.**





WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage above approximately 10.4 volts.
- The Auto Shutdown (ASD) Relay is energized.

SET CONDITION

- The EGR Valve Control 2 circuit can be driven high or low depending on whether the EGR Valve is being opened or closed by the PCM. The PCM monitors the circuit for excessive current draw in both directions. The PCM will set the P0489 or P0490 DTC depending on which direction the EGR Valve is being driven when the fault occurs.
  - For this fault, the PCM detects a current draw above 8.6 amps on the EGR Valve Control 2 circuit when the circuit is being driven high.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EGR VALVE CONTROL 2 CIRCUIT SHORTED TO GROUND
EGR VALVE ASSEMBLY
POWERTRAIN CONTROL MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **ISOLATE AND CHECK THE EGR VALVE (K684) CONTROL 2 CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **REPLACE THE EGR VALVE AND RETEST FOR DTC**
    1. Replace the EGR Valve in accordance with the Service Information. Refer to **VALVE, EXHAUST GAS RECIRCULATION (EGR), REMOVAL AND INSTALLATION** . The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine.
    2. Reconnect the EGR Valve harness connector.
    3. Reconnect the PCM C2 harness connector.
    4. Turn the ignition on.
    5. With the scan tool, erase DTCs.
    6. Start the engine and test drive the vehicle.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 4

    No

    - Replacing the EGR Valve repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
4. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P04CE-COOLED EGR TEMPERATURE SENSOR CIRCUIT

For a complete EGR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Exhaust Gas Recirculation (EGR) Temperature Sensor is positioned between the EGR Cooler and EGR Valve. The feedback signal from the sensor is used to monitor the cooling efficiency of the recirculated exhaust gases passing through the EGR Cooler Assembly. At lower temperatures the signal feedback voltage will read closer to the upper operating parameter. As the recirculated exhaust gas temperature increases, the signal feedback voltage will decrease toward the lower operating parameter.

There is a sensor rationality monitor that runs after a cold soak condition, at initial engine start up. When certain enable conditions are met, the Powertrain Control Module (PCM) will compare the EGR Temperature Sensor reading to the Engine Coolant Temperature (ECT), Ambient Air Temperature (AAT) Sensor readings for plausibility.

A second monitor will run when the EGR system is active to monitor the sensor plausibility. It works as follows: There is a small voltage difference between the upper operating parameter and the voltage threshold that will set a circuit high fault. The same is also true for the lower operating parameter and the voltage threshold that will set a circuit low fault. These small voltage windows are used for checking the coherency of the sensor. If the signal voltage reads in one of these windows, a sensor circuit performance fault will set.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the engine running.
- Battery voltage above 10.4 volts.
- No ECT Sensor or EGR Temperature Sensor circuit faults active.

- Engine coolant temperature is between 70B°C (158B°F) and 120B°C (248B°F)

SET CONDITION

- The EGR Temperature Sensor signal voltage is below the normal lower calibrated operating threshold, but above the calibrated threshold for the signal circuit low fault to set causing an implausible temperature reading.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
LOW ENGINE COOLANT LEVEL
ENGINE COOLING SYSTEM TEMPERATURE TOO HIGH
LEAK IN THE EGR SYSTEM PLUMBING BETWEEN THE EGR VALVE AND THE EGR COOLER
ENGINE MECHANICAL CONDITION OR VACUUM LEAK/FUEL SYSTEM ISSUE CAUSING A LEAN CONDITION
EGR TEMPERATURE SENSOR

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK THE COOLING SYSTEM FOR PROPER LEVEL AND CONDITION**
    1. Check the cooling system to make sure that the coolant is in good condition, at the proper level, and meets OEM specifications. Refer to **COOLING SYSTEM** .

       Is the coolant level and condition OK?

       Yes

       - Go To 3

       No

       - Inspect the vehicle for a coolant leak and add the necessary amount of coolant. Refer to **COOLING SYSTEM** .
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 3

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **CHECK THE EGR SYSTEM AND PLUMBING FOR A LEAK**
    1. Visually inspect the EGR System for a leak between the EGR Cooler and the EGR Valve for signs of a leak (I.E. loose connections or damaged plumbing).

       Were any problems found?

       Yes

       - Perform the appropriate repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 4
4. **CHECK COOLING SYSTEM FOR PROPER OPERATION**
    1. Check the following cooling system components:
       - Verify condition and operation of the accessory belt and tensioner.
       - Verify proper airflow through the radiator.
       - Verify that the Thermostat is opening correctly.
       - Verify the correct coolant flow throughout the system.
       - During engine warm-up, monitor the coolant temperature and the operation of the Cooling Fan.

       Is the Cooling system operating correctly?

       Yes

       - Go To 5

       No

       - Perform the appropriate repairs.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **CHECK THE FUEL DELIVERY SYSTEM FOR PROPER OPERATION**
    1. Perform the CHECKING THE FUEL DELIVERY SYSTEM test procedure. Refer to **CHECKING THE FUEL DELIVERY SYSTEM (HARD START)** .

       Were any problems found with the fuel system?

       Yes

       - Perform the appropriate repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK THE ENGINE MECHANICAL CONDITION**
    1. Turn the ignition off.
    2. Check for any of the following conditions/mechanical problems:
        - AIR INTAKE SYSTEM - must be free from leaks.
        - ENGINE VACUUM - check the engine for vacuum leaks.
        - ENGINE VALVE TIMING - must be within specifications.
        - POWER BRAKE BOOSTER - no internal vacuum leaks.
        - FUEL - must be free of contamination.
        - FUEL INJECTOR - plugged or restricted injector; control wire not connected to correct injector.

    Are there any engine mechanical problems?

    Yes

    - Repair as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Replace the EGR Temperature Sensor in accordance with the Service Information. Refer to **SENSOR, EGR TEMPERATURE, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P04D0-COOLED EGR TEMPERATURE SENSOR CIRCUIT LOW

For a complete EGR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Exhaust Gas Recirculation (EGR) Temperature Sensor is positioned between the EGR Cooler and EGR Valve. The feedback signal from the sensor is used to monitor the cooling efficiency of the recirculated exhaust gases passing through the EGR Cooler Assembly. At lower temperatures the signal feedback voltage will read closer to the upper operating parameter. As the recirculated exhaust gas temperature increases, the signal feedback voltage will decrease toward the lower operating parameter.

There is a sensor rationality monitor that runs after a cold soak condition, at initial engine start up. When certain enable conditions are met, the Powertrain Control Module (PCM) will compare the EGR Temperature Sensor reading to the Engine Coolant Temperature (ECT), Ambient Air Temperature (AAT) Sensor readings for plausibility.

A second monitor will run when the EGR system is active to monitor the sensor plausibility. It works as follows: There is a small voltage difference between the upper operating parameter and the voltage threshold that will set a circuit high fault. The same is also true for the lower operating parameter and the voltage threshold that will set a circuit low fault. These small voltage windows are used for checking the coherency of the sensor. If the signal voltage reads in one of these windows, a sensor circuit performance fault will set.

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The EGR Temperature Sensor signal voltage is below 0.05 volts for 2.5 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EGR TEMPERATURE SENSOR SIGNAL CIRCUIT SHORTED TO GROUND
EGR TEMPERATURE SENSOR SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
EGR TEMPERATURE SENSOR
POWERTRAIN CONTROL MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **DISCONNECT THE EGR TEMPERATURE SENSOR HARNESS CONNECTOR AND VERIFY THE ABILITY OF THE PCM TO READ THE SENSOR SIGNAL HIGH DTC**
    1. The Electronic Control Unit (ECU) harness connectors must be connected to the ECU during this test step.
    2. With the ignition in the off position, disconnect the sensor harness connector.
    3. Turn the ignition on.
    4. With the scan tool, read DTCs.

    Does the scan tool display the SENSOR SIGNAL CIRCUIT HIGH DTC with the connector disconnected?

Yes

- Replace the faulty sensor in accordance with the Service Information. Refer to **SENSOR, EGR TEMPERATURE, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **ISOLATE AND CHECK THE EGR TEMPERATURE SENSOR (K932) TEMP SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **There should be no continuity between ground and the circuit being tested.**

    Is there continuity between ground and the circuit being tested?

    Yes

    - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 4

4. **ISOLATE AND CHECK THE EGR TEMPERATURE SENSOR (K932) TEMP SIGNAL FOR A SHORT TO THE (K900) SENSOR GROUND CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to**

pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between the circuits being tested.**

   Is there continuity between the circuits?

   Yes

   - Repair the short between the circuits.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. With the scan tool, erase DTCs.
   9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   10. With the scan tool, read DTCs.

      Did the DTC return?

      Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P04D1-COOLED EGR TEMPERATURE SENSOR CIRCUIT HIGH

For a complete EGR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Exhaust Gas Recirculation (EGR) Temperature Sensor is positioned between the EGR Cooler and EGR Valve. The feedback signal from the sensor is used to monitor the cooling efficiency of the recirculated exhaust gases passing through the EGR Cooler Assembly. At lower temperatures the signal feedback voltage will read closer to the upper operating parameter. As the recirculated exhaust gas temperature increases, the signal feedback voltage will decrease toward the lower operating parameter.

There is a sensor rationality monitor that runs after a cold soak condition, at initial engine start up. When certain enable conditions are met, the Powertrain Control Module (PCM) will compare the EGR Temperature Sensor reading to the Engine Coolant Temperature (ECT), Ambient Air Temperature (AAT) Sensor readings for plausibility.

A second monitor will run when the EGR system is active to monitor the sensor plausibility. It works as follows: There is a small voltage difference between the upper operating parameter and the voltage threshold that will set a circuit high fault. The same is also true for the lower operating parameter and the voltage threshold that will set a circuit low fault. These small voltage windows are used for checking the coherency of the sensor. If the signal voltage reads in one of these windows, a sensor circuit performance fault will set.

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The EGR Temperature Sensor signal voltage is above 4.9 volts for 2.5 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EGR TEMPERATURE SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE
EGR TEMPERATURE SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
EGR TEMPERATURE SENSOR
POWERTRAIN CONTROL MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE EGR TEMPERATURE SENSOR (K932) TEMP SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

    NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

    Is the voltage above 5.2 volts?

    Yes

    - Go To 3

    No

    - Go To 4
3. **ISOLATE AND CHECK THE EGR TEMPERATURE SENSOR (K932) TEMP SIGNAL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

4. **ISOLATE AND CHECK THE EGR TEMPERATURE SENSOR (K932) TEMP SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 5

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND CHECK THE (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**

1. The ignition must be off when checking the continuity of a circuit.
2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 6

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CONNECT A FUSED JUMPER BETWEEN THE EGR TEMPERATURE SENSOR (K932) TEMP SIGNAL CIRCUIT AND THE (K900) SENSOR GROUND CIRCUIT AT THE EGR TEMPERATURE SENSOR HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL CIRCUIT LOW DTC**
   1. The Electronic Control Unit (ECU) harness connectors must be connected to the ECU during this test step.
   2. Disconnect the sensor harness connector.
   3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the sensor ground circuit at the sensor harness connector.
   4. Turn the ignition on.
   5. With the scan tool, read DTCs.

   Does the scan tool display the SENSOR SIGNAL CIRCUIT LOW DTC with the jumper in place?

   Yes

   - Replace the faulty sensor in accordance with the Service Information. Refer to **SENSOR, EGR TEMPERATURE, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

- Go To 7

7. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P04D2-COOLED EGR TEMPERATURE SENSOR CIRCUIT INTERMITTENT/ERRATIC

For a complete EGR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Exhaust Gas Recirculation (EGR) Temperature Sensor is positioned between the EGR Cooler and EGR Valve. The feedback signal from the sensor is used to monitor the cooling efficiency of the recirculated exhaust gases passing through the EGR Cooler Assembly. At lower temperatures the signal feedback voltage will read closer to the upper operating parameter. As the recirculated exhaust gas temperature increases, the signal feedback voltage will decrease toward the lower operating parameter.

There is a sensor rationality monitor that runs after a cold soak condition, at initial engine start up. When certain enable conditions are met, the Powertrain Control Module (PCM) will compare the EGR Temperature Sensor reading to the Engine Coolant Temperature (ECT), Ambient Air Temperature (AAT) Sensor readings for plausibility.

A second monitor will run when the EGR system is active to monitor the sensor plausibility. It works as follows: There is a small voltage difference between the upper operating parameter and the voltage threshold that will set a circuit high fault. The same is also true for the lower operating parameter and the voltage threshold that will set a circuit low fault. These small voltage windows are used for checking the coherency of the sensor. If the signal voltage reads in one of these windows, a sensor circuit performance fault will set.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the engine running.
- The EGR Valve is active.

SET CONDITION

- The EGR Temperature Sensor signal voltage is above the normal upper calibrated operating threshold, but below the calibrated threshold for the signal circuit high fault is set.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
HIGH RESISTANCE IN THE EGR TEMPERATURE SENSOR SIGNAL CIRCUIT
HIGH RESISTANCE IN THE SENSOR GROUND CIRCUIT
ENGINE RUNNING TOO RICH
ENGINE TEMPERATURE TOO LOW
EGR TEMPERATURE SENSOR
POWERTRAIN CONTROL MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **COMPARE THE TEMPERATURE SENSOR VALUES WITH THE ENGINE COOLANT TEMPERATURE**
    1. Turn the ignition off.
    2. Allow the vehicle to sit with the ignition off in an environment where the temperature is consistent and above -64B°C (-83B°F) until the engine coolant temperature is equal to ambient temperature.
    3. Turn the ignition on.
    4. With the scan tool, compare the AAT, ECT, IAT and EGR Temperature Sensor values.

       Is the EGR Temperature Sensor value within 15B°C (27B°F) of the other sensor values?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
   1. With the scan tool, read all DTCs and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Are there any other fuel or air handling DTCs active or pending?

   Yes

   - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

   No

   - Go To 3

3. **CHECK THE COOLING SYSTEM FOR PROPER COOLANT LEVEL AND CONDITION**
   1. Check the cooling system to make sure that the coolant is in good condition, at the proper level, and meets OEM specifications. Refer to **COOLING SYSTEM** .

      Is the coolant level and condition OK?

      Yes

      - Go To 4

      No

      - Inspect the vehicle for a coolant leak and add the necessary amount of coolant. Refer to **COOLING SYSTEM** .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK COOLING SYSTEM FOR PROPER OPERATION**
   1. Check the following cooling system components:
      - Verify condition and operation of the accessory belt and tensioner.
      - Verify proper airflow through the radiator.
      - Verify that the Thermostat is opening correctly.
      - Verify the correct coolant flow throughout the system.
      - During engine warm-up, monitor the coolant temperature and the operation of the Cooling Fan.

Is the Cooling system operating correctly?

Yes

- Go To 5

No

- Perform the appropriate repairs.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK THE FUEL DELIVERY SYSTEM FOR PROPER OPERATION**
    1. Perform the CHECKING THE FUEL DELIVERY SYSTEM test procedure. Refer to **CHECKING THE FUEL DELIVERY SYSTEM (HARD START)** .

    Were any problems found with the fuel system?

    Yes

    - Perform the appropriate repair.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 6
6. **CHECK THE ENGINE FOR A MECHANICAL CONDITION**
    1. Turn the ignition off.
    2. Check for any of the following conditions/mechanical problems:
        - AIR INDUCTION SYSTEM - must be free from restrictions.
        - ENGINE VALVE TIMING - must be within specifications.
        - CAM PHASER/OIL CONTROL VALVE - must be operating correctly and not sticking.
        - FUEL - must be free of contamination.
        - FUEL INJECTOR - leaking or improper spray pattern.

    Are there any engine mechanical problems?

    Yes

    - Repair as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 7
7. **ISOLATE AND CHECK THE EGR TEMPERATURE SENSOR (K932) TEMP SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.

4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 8

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **ISOLATE AND CHECK THE (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 9

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **CHECK THE ABILITY OF THE PCM TO READ THE EGR TEMPERATURE SENSOR SIGNAL**
    1. Turn the ignition off.
    2. Reconnect the PCM C2 harness connector.
    3. Turn the ignition on.
    4. With the scan tool, read the EGR Temperature Sensor voltage.

    NOTE: **The-P04D0-COOLED EGR TEMPERATURE SENSOR CIRCUIT LOW should be displayed with the EGR Temperature Sensor harness connector disconnected.**

    5. Connect a jumper between the EGR Temperature Sensor (K932) Temp Signal circuit and the (K900) Sensor Ground circuit at the EGR Temperature Sensor harness connector.

    NOTE: **The-P04D1-COOLED EGR TEMPERATURE SENSOR CIRCUIT HIGH should be displayed with the jumper in place.**

    Does the scan tool display as described above?

    Yes

    - Replace the EGR Temperature Sensor in accordance with the Service Information. Refer to **SENSOR, EGR TEMPERATURE, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 10

10. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P04FC-CRANKCASE VENTILATION SYSTEM PERFORMANCE

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

SYSTEM DESCRIPTION: There are two sides to the Positive Crankcase Ventilation (PCV) system. The dirty side of the system consists of the PCV Valve, installed on the Valve Cover Oil Separator, and the PCV Tube that connects between the PCV Valve and Intake Manifold. The clean air side of the system consists of the Make-Up Air (MUA) Tube that connects between the MUA Oil Separator in the Valve Cover and the Fresh Air Hose, and Crankcase Pressure Sensor.

NATURALLY ASPIRATED OPERATION: When the engine is running naturally aspirated, clean air flows from the Fresh Air Hose, through the MUA Tube and MUA Oil Separator, to the crankcase. The crankcase vapors are pushed into the other Oil Separator in the Valve Cover and drawn into the Intake Manifold through the PCV Valve and PCV Tube where they are burned.

BOOST OPERATION: During boost operation, a check valve in the PCV closes blocking flow through the PCV Tube. The crankcase vapors flow out through the MUA Oil Separator and MUA Tube into the Fresh Air Hose on the clean air side, then into the Turbocharger, and eventually into the Intake Manifold where they are burned.

CLEAN AIR (MUA) SIDE DIAGNOSTICS: If the MUA Tube is disconnected on the clean air tube, PCV vapors will leak into the atmosphere whenever the engine is in boost. The Crankcase Pressure Sensor is used to diagnose a disconnect in the MUA Tube. The Powertrain Control Module (PCM) monitors the pressure pulsations in the Crankcase Pressure Sensor signal to determine whether or not the hose is connected. If the MUA Tube is determined to be disconnected the **P2C90 DTC** is set. The PCM also monitors the sensor and circuits for electrical faults such as opens or shorts.

DIRTY AIR (PCV) SIDE DIAGNOSTICS: The dirty air side of the system does not have a sensor for detecting a hose disconnect. A disconnected PCV Tube will cause a measurable vacuum leak. However, the range of authority of torque management can keep engine rpm in control despite a disconnected PCV Tube causing a vacuum leak. To diagnose this condition an algorithm using the Gas Flow/Air Flow ratio is calculated and compared to a calibrated threshold. If the diagnostic is determined to be failing the **P04FC DTC** will set.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Engine speed below 2500 rpm and at a steady state of speed.
- Low engine torque (less than 120 Nm).

SET CONDITION

- The difference between the actual airflow detected and the airflow calculated by the PCM is more than 40%.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EGR COLD HOSE LEAKING OR DAMAGED
CRANKCASE HOSE LEAKING OR DAMAGED
INTAKE MANIFOLD LEAK
PCV VALVE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.

5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 3

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any 5-Volt Supply circuit or Crankcase Pressure Sensor circuit DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 4
4. **CHECK THE EGR VALVE COLD HOSE FOR LEAKS**
   1. Visually inspect the EGR Cold Hose for proper installation, damage, and signs of leaking.

      Were any issues found with the EGR System?

      Yes

      - Perform the appropriate repair.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 5
5. **CHECK THE CRANKCASE HOSES FOR CLOGGING, LEAKS, OR OTHER DAMAGE**
   1. Turn the ignition off.
   2. Inspect the Crankcase Hose and connections for signs of clogging, leaks, or other damage.

      Is the Crankcase Hose broken, pinched, leaking, or otherwise damaged?

      Yes

      - Replace the damaged hose in accordance with the Service Information.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 6

6. **CHECK THE INTAKE MANIFOLD FOR LEAKS**
    1. Visually inspect the Intake Manifold for signs leaks or damage.

       Were any issues or leaks found at the Intake Manifold?

       Yes

       - Perform the appropriate repair in accordance with the Service Information.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Replace the PCV Valve in accordance with the Service Information.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0501-VEHICLE SPEED SENSOR 1 PERFORMANCE

THEORY OF OPERATION

The vehicle speed sensor rationality is a continuous test that monitors the vehicle speed sensor for lack of activity. The Powertrain Control Module (PCM) receives this information from the Anti-Lock Brake System (ABS) module over the CAN C bus. The CAN C bus is a high speed communication bus that allows real time control capability between various controllers. The rationality test will not run if the brakes are applied, a Brake Switch code is set, or a limp-in condition exists for Manifold Absolute Pressure (MAP) Sensor, Throttle Position, Crankshaft Position (CKP) Sensor, Camshaft Position (CMP) Sensor, or Engine Coolant Temperature (ECT) Sensor. If vehicle speed signal is below a minimum threshold for a calibrated period of time after the vehicle has been operating within the modeled parameters that would indicate it is being driven, a failure will be indicated.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Transmission not in park or neutral.
- Brakes not applied.
- Engine speed above 1500 rpm.

SET CONDITION

- The Powertrain Control Module (PCM) fails the Vehicle Speed Sensor Performance if there is no vehicle speed signal received from the ABS Module for 30 seconds.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
ACTIVE BUS OR COMMUNICATION DTCS
TIRE CIRCUMFERENCE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE TIRES FOR PROPER SIZE AND CONDITION**

    NOTE: **This code can set due to tire circumference differences and from the front or rear wheels being on a slippery surface while the opposite tires are not.**

    1. This code may also set on a hard acceleration on loose gravel or during other off road driving conditions.
    2. Check tire pressure of all the tires.
    3. Check tire wear on all the tires.
    4. Ask the customer what the road and driving conditions were like when the fault set.

        Were any problems found?

        Yes

        - Repair as necessary. If the code set during a front OR rear wheel spin condition, no repair is necessary.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 3
3. **CHECK THE ABS MODULE FOR ACTIVITY ON THE CAN BUS**
    1. Using the scan tool, verify that the ABS Module is active on the CAN bus.

        Is the ABS Module active on the CAN bus?

Yes

- Go To 4

No

- Perform the NO RESPONSE FROM ABS procedure. Refer to the appropriate information.

4. **CHECK FOR DTCS IN THE ABS MODULE**
   1. With the scan tool, read ABS Module DTCs.

      Are any DTCs active or stored in the ABS Module?

      Yes

      - Perform the applicable ABS Module DTC procedure(s). Refer to **ANTILOCK BRAKE SYSTEM (ABS) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 5
5. **CHECK RELATED HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.
   5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. With the scan tool, erase DTCs.
   9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   10. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0506-IDLE SPEED PERFORMANCE LOWER THAN EXPECTED

THEORY OF OPERATION

The objective of the "Idle Speed Rationality" is to monitor the ability of the Powertrain Control Module (PCM) to achieve and maintain a steady idle condition. The Engine Speed Error is calculated by comparing the actual engine speed to a target idle speed. If the actual engine speed is above a calibrated upper limit, or below a lower limit, for a programmable period of time an idle speed performance fault will occur.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Engine running at idle.
- No throttle input requested.
- Vehicle speed equal to zero.
- Engine run time of more than 30.0 seconds.

SET CONDITION

- Engine speed is more than 100 rpm below idle speed for 30.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
AIR INDUCTION SYSTEM RESTRICTIONS
PCV SYSTEM RESTRICTIONS
THROTTLE BODY ASSEMBLY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.

2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
3. With the scan tool, erase all DTCs.
4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any Throttle Body DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3

3. **CHECK THE AIR INDUCTION SYSTEM FOR RESTRICTIONS**
   1. Turn the ignition off.
   2. Inspect the Air Induction System for restrictions - Dirty Air Cleaner, Foreign material trapped in the air intake tube, etc.

      Were any problems found?

      Yes

      - Repair or replace as necessary.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 4

4. **INSPECT THE PCV SYSTEM HOSES AND TUBES FOR RESTRICTIONS**
   1. Inspect the PCV system for restrictions - sticking valve, collapsed hoses or tubes, obstructed passages or ports, etc.

      Were any problems found?

      Yes

- Repair as necessary.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK THE THROTTLE BODY FOR PROPER OPERATION**
    1. Inspect the Throttle Body for carbon build up, other restrictions, and a bent throttle plate using a straight edge.
    2. If the throttle plate does not close entirely it may be bent and needs to be replaced.

    WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts, or fan. Do not wear loose clothing. Failure to follow these instructions can result in possible serious or fatal injury.**

    3. Start the engine.
    4. While the vehicle is running, lightly tap on ETC Motor where applicable, with your hand, and listen for idle to raise.

    Were any problems found or did the idle fluctuate while tapping on the ETC Motor?

    Yes

    - Verify that there is good pin to terminal contact at the Throttle Body and the Powertrain Control Module connectors. Repair or replace the Throttle Body Assembly if no problems were found in the connectors. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** . Disconnect the Battery when replacing the Throttle Body Assembly. After installation is complete, use a scan tool and select the ETC RELEARN function.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 6

6. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0507-IDLE SPEED PERFORMANCE HIGHER THAN EXPECTED

THEORY OF OPERATION

The objective of the "Idle Speed Rationality" is to monitor the ability of the Powertrain Control Module (PCM) to achieve and maintain a steady idle condition. The Engine Speed Error is calculated by comparing the actual engine speed to a target idle speed. If the actual engine speed is above a calibrated upper limit, or below a lower limit, for a programmable period of time an idle speed performance fault will occur.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Engine running at idle.
- No throttle input requested.
- Vehicle speed equal to zero.
- Engine run time of more than 30.0 seconds.

SET CONDITION

- Engine speed is more than 200 rpm above idle speed for 30.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
PCV SYSTEM LEAKS
INTERNAL OR EXTERNAL ENGINE VACUUM LEAKS
LOSS OF COMMUNICATION WITH ABS MODULE
THROTTLE BODY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**

    NOTE: **If there is a loss of communication with the ABS Module or implausible data from the ABS Module DTC present, diagnose and repair those faults before proceeding. A Loss of communication with the ABS Module will cause the PCM to default the vehicle speed to zero while driving and will false fail the idle speed rationality diagnostics, setting this code.**

    1. Refer to the recorded DTCs.

        Are there any active or pending Throttle Body DTCs or ABS Module DTC?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3

3. **CHECK FOR VACUUM LEAKS**

WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts, or fan. Do not wear loose clothing. Failure to follow these instructions can result in possible serious or fatal injury.**

1. Start the engine.
2. Inspect the engine for internal leaks.
3. Inspect any external components that can create a vacuum leak. Inspect the following items, but not limited too:
    - Vacuum supply lines
    - Brake Booster
    - Purge Solenoid
    - Engine seals

   Were any vacuum leaks found?

   Yes

    - Repair the vacuum leak as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

    - Go To 4

4. **CHECK THE PCV SYSTEM FOR PROPER OPERATION**
    1. Inspect the PCV system for restrictions - sticking valve, collapsed hoses or tubes, obstructed passages or ports, etc.

   Were any problems found?

   Yes

    - Repair as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

    - Go To 5

5. **CHECK THE THROTTLE BODY FOR PROPER OPERATION**
    1. Inspect the Throttle Body for carbon build up, other restrictions, and a bent throttle plate using a straight edge.
    2. If the throttle plate does not close entirely it may be bent and needs to be replaced.

    WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts, or fan. Do not wear loose clothing. Failure to follow these instructions can result in possible serious or fatal injury.**

    3. Start the engine.
    4. While the vehicle is running, lightly tap on ETC Motor where applicable, with your hand, and listen for idle to raise.

Were any problems found or did the idle fluctuate while tapping on the ETC Motor?

Yes

- Verify that there is good pin to terminal contact at the Throttle Body and the Powertrain Control Module connectors. Repair or replace the Throttle Body Assembly if no problems were found in the connectors. . Disconnect the Battery when replacing the Throttle Body Assembly. After installation is complete, use a scan tool and select the ETC RELEARN function.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.
    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P050B-COLD START IGNITION TIMING PERFORMANCE

For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Spark adjustment during a cold start is intended to provide quick response to idle speed variations. The spark adjust diagnostics monitors spark advance on a cold start over a period of time, then compares the average spark advance to a threshold.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Cold start condition.
- Engine running at idle.
- The difference between the AAT and ECT at startup less than 15B°C (27B°F).
- Ambient Air temperature between -7B°C and 50B°C (19.4B°F and 122B°F).
- Engine Coolant temperature between -7B°C and 50B°C (19.4B°F and 122B°F).

SET CONDITION

- The Powertrain Control Module (PCM) fails the Cold Start Monitor if the average spark advance is above the threshold, too much spark advance, for 4 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
RESTRICTED INTAKE AIR SYSTEM
LOW BATTERY VOLTAGE
FUEL CONTAMINATION
EXCESSIVE RESISTANCE IN THE ETC MOTOR (+)
EXCESSIVE RESISTANCE IN THE ETC MOTOR (-)
THROTTLE BODY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.

2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
3. With the scan tool, erase all DTCs.
4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **PERFORM AN INSPECTION OF THE THROTTLE BODY FOR FOREIGN MATERIAL, SCORING, OR OTHER DAMAGE THAT COULD CAUSE THE THROTTLE PLATE TO STICK**
    1. Turn the ignition off.
    2. Remove the Air Cleaner Assembly from the Throttle Body.
    3. Check for any signs of a foreign material (ice, dirt, or excessive carbon build up) on the Throttle Plate or in the bore causing the Throttle Plate to stick.

       Were any signs of foreign material or scoring of the throttle plate or bore found?

       Yes

       - Remove the debris if possible or replace the Throttle Body Assembly. Disconnect the Battery when replacing the Throttle Body Assembly. After installation is complete, use a scan tool and select the ETC RELEARN function.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 3
3. **CHECK THE AIR FILTER FOR RESTRICTIONS**
    1. Remove and inspect the Air Filter.

       Is the Air Filter dirty?

       Yes

       - Replace the Air Filter.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 4
4. **CHECK FOR CONTAMINATED FUEL**

1. Inspect the Fuel for contamination (Dirt, water, or other foreign material).

   Is the fuel contaminated?

   Yes

   - Drain the Fuel from the Fuel Tank into an approved gas holding tank and add clean fuel. Refer to **DRAINING FUEL TANK** .

   No

   - Go To 5

5. **ISOLATE AND CHECK THE THROTTLE BODY (K124) MOTOR (+) CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 6

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND CHECK THE THROTTLE BODY (K126) MOTOR (-) CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.

5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 7

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK THE THROTTLE BODY MOTOR FOR PROPER OPERATION**
   1. Turn the ignition off.
   2. Connect the Throttle Body harness connector.
   3. Measure the resistance of the ETC Motor by probing the GPEC Adaptor across the Throttle Body (K124) Motor (+) circuit and the Throttle Body (K126) Motor (-) circuit.

      Is the resistance between 2.5 and 25.0 Ohms at closed throttle?

      Yes

      - Go To 8

      No

      - Verify that there is good pin to terminal contact in the Throttle Body and Powertrain Control Module connectors. Replace the Throttle Body Assembly if no problems were found in the connectors. Disconnect the Battery when replacing the Throttle Body Assembly. After installation is complete, use a scan tool and select the ETC RELEARN function. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.

- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0513-INVALID SKIM KEY

WHEN MONITORED

SET CONDITION

- The Powertrain Control Module (PCM) detects an invalid key or key related fault.
- The seed request sent from the RF Hub is invalid, incorrect or mismatched for the PCM.

NOTE: **This DTC typically sets as a result of a condition that causes other DTCs to set in the RF Hub.**

DEFAULT ACTION

- The is a non MIL fault.
- Vehicle Security Light will illuminate.
- The vehicle will not start and run.
- The vehicle may not crank.

POSSIBLE CAUSES

Possible Causes
IGNITION KEY RELATED FAULT IN THE RF HUB
NO VIN PROGRAMMED IN THE PCM
INCORRECT OR MISMATCHED VIN PROGRAMMED IN THE PCM
INCORRECT OR MISMATCHED VIN PROGRAMMED IN RF HUB
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to <u>PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE</u> .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Go To 2

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any RF HUB DTCs present?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 3
3. **VERIFY THE PROPER VIN IS PROGRAMMED INTO THE PCM**
    1. With the scan tool, display the VIN that is programmed into the PCM.

       Has the correct VIN been programmed into the PCM?

       Yes

- Go To 4

No

- Program the correct VIN into the PCM and retest. If the code return Go To.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **VERIFY THE PROPER VIN IS PROGRAMMED INTO THE RF HUB**
    1. With the scan tool, display the VIN that is programmed into the PCM.

        Has the correct VIN been programmed in the RF HUB?

        Yes

        - Go To

        No

        - Reprogram the correct VIN into the RF HUB and retest. If the fault returns, Go To.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **PERFORM THE PCM REPLACED PROCEDURE**
    1. Using the scan tool, perform the REPLACE PCM PROCEDURE. Refer to **MODULE, POWERTRAIN CONTROL (PCM), MODULE PROGRAMMING** .
    2. With the scan tool, erase all DTCs.
    3. Turn the ignition off for a minimum of 10.0 seconds.
    4. Turn the ignition on.
    5. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.

        Did the DTC return?

        Yes

        - Replace the faulty Ignition Key and retest. If the fault returns, Go To 6

        NOTE: **You must obtain the Secret Key pin number.**

        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The procedure repaired the fault.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.

- Damaged connector locks.
- Corrosion.
- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

DIAGNOSIS AND TESTING

P0520-ENGINE OIL PRESSURE SENSOR CIRCUIT

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

This diagnostic is run to verify the Engine Oil Pressure (EOP) Sensor has a valid zero pressure point (offset check). The oil pressure offset reading is essentially the voltage output of the sensor at atmospheric pressure.

Two assumptions are made for this rationality:

1. The engine oil pressure will always bleed down to atmospheric pressure within a certain time period after the engine has stopped.
2. The EOP Sensor will have a stable output voltage after ignition on and before the vehicle starts to crank.

After a calibrated amount of engine off time to allow the EOP Sensor to stabilize (bleed down to atmospheric pressure) the EOP Sensor offset test will be performed at the next ignition on. A reading of the EOP Sensor output is taken when the ignition is turned to the "on" position before engine cranking. A delay time of approximately 20ms is required before the sensor is powered up and can output a valid reading.

At atmospheric pressure a "good" pressure sensor will output a voltage within an upper and lower voltage limit. The lower threshold is greater than zero volts so a circuit check can be performed on the device. The reason there is a span between the limits is because there is a small amount of air behind the diaphragm that varies in volume based on atmospheric pressure. The PCM will determine that the sensor is invalid and a failure will set if the sensor voltage is beyond normal parameters for a calibrated amount of time.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Battery voltage is above 11.0 volts.
- Barometric pressure is above 22.2 hg.
- With the ignition on and the engine speed at 0 rpm.
  - After the ignition has been off for a minimum of three minutes previously.

SET CONDITION

- The Powertrain Control Module (PCM) detects an oil pressure reading that is below 0.29 volts (less than 0 psi), or greater than 0.78 volts (more than 7.1 psi), indicating a sensor that is stuck or drifted out of range.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
HIGH RESISTANCE IN THE 5-VOLT SUPPLY CIRCUIT
HIGH RESISTANCE IN THE EOP SIGNAL CIRCUIT
HIGH RESISTANCE IN THE SENSOR GROUND CIRCUIT
ENGINE OIL PRESSURE (EOP) SENSOR

Possible Causes
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **CHECK FOR OTHER DTCS**
    1. With the scan tool, read DTCs and Environmental Data and record on the repair order.

       Are there 5-volt Reference, EOP Sensor circuit High or Low DTCs also present?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 3
3. **CHECK FOR AN ACTIVE DTC**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs and record on the repair order.

       Is the DTC active or pending?

       Yes

       - Go To 4

       No

       - Perform the INTERMITTENT DTC diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
4. **ISOLATE AND CHECK THE (F855) 5-VOLT SUPPLY CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.

3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 5

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND CHECK THE EOP SENSOR (G60) PRESSURE SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 6

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND CHECK THE (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 7

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **REPLACE THE ENGINE OIL PRESSURE (EOP) AND RETEST FOR DTCS**
   1. Replace the component in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   2. Connect the component and Electronic Control Unit (ECU) harness connectors.
   3. Turn the ignition on.
   4. With the scan tool, erase DTCs.
   5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
   6. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 8

No

- Replacing the faulty component repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0521-ENGINE OIL PRESSURE SENSOR PERFORMANCE

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) provides a 5-Volt supply to the Engine Oil Pressure (EOP) Sensor on the sensor supply circuit. The PCM also provides a ground on the sensor return circuit. The Engine Oil Pressure Sensor signal can be a pull up (5.0 volts) or pull down (0.0 volts) resistor depending on the PCM internal hardware for the signal circuit. This can vary between vehicles and model years.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the engine running.
- Engine speed above 1150 rpm.

SET CONDITION

- The engine oil pressure is below the calibrated specification for more than 29.8 seconds with the engine speed at or above 1150 rpm.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
ENGINE OIL/ENGINE MECHANICAL
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
HIGH RESISTANCE IN THE EOP SIGNAL CIRCUIT
HIGH RESISTANCE IN THE SENSOR RETURN CIRCUIT
ENGINE OIL PRESSURE (EOP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**

   WARNING: When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.

   With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.

   1. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   2. With the scan tool, erase all DTCs.
   3. Turn the ignition off for a minimum of 10.0 seconds.
   4. Turn the ignition on.

5. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
6. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE ENGINE OIL/ENGINE MECHANICAL CONDITION**

NOTE: **The following items should be considered before determining the cause of this DTC. Failure to do so may lead to misdiagnosis.**

- **ENGINE MECHANICAL TOLERANCES OUT OF SPECIFICATION**
- **ENGINE OIL PRESSURE OUT OF SPECIFICATION**
- **LOW ENGINE OIL**
- **DETERIORATED OR DIRTY OIL**
- **ENGINE OIL CONTAMINATED (i.e., coolant and/or fuel)**

1. If any of the above conditions are found, repair as necessary.

Were any of the above conditions present?

Yes

- Repair as necessary.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **ISOLATE AND CHECK THE EOP SENSOR (G60) PRESSURE SIGNAL CIRCUIT FOR HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 4

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE (F855) 5-VOLT SUPPLY CIRCUIT FOR HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 5

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND CHECK THE (K900) SENSOR GROUND CIRCUIT FOR HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.

3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 6

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE ABILITY OF THE PCM TO READ THE EOP SENSOR SIGNAL**
   1. Connect the PCM C2 harness connector.
   2. Turn the ignition on.
   3. With the scan tool, monitor the EOP Sensor voltage.
   4. Connect a jumper between the (K900) Sensor Ground circuit and the EOP Sensor (G60) Pressure Signal circuit.

   NOTE: **Engine Oil Pressure voltage should change from approximately 4.9 volts to less than 0.1 volt.**

   Is the voltage reading as described above with the EOP Sensor disconnected and with the jumper in place?

   Yes

   - Verify that there is good pin to terminal contact in the Sensor and Powertrain Control Module connectors. Remove the Engine Oil Pressure Sensor and ensure the oil passage/port is free from any blockage. If no problem is found, replace the Engine Oil Pressure Sensor. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 7

     NOTE: **Remove the jumper before continuing.**

7. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0522-ENGINE OIL PRESSURE SENSOR CIRCUIT LOW

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) provides a 5-Volt supply to the Engine Oil Pressure (EOP) Sensor on the sensor supply circuit. The PCM also provides a ground on the sensor return circuit. The Engine Oil Pressure

Sensor signal can be a pull up (5.0 volts) or pull down (0.0 volts) resistor depending on the PCM internal hardware for the signal circuit. This can vary between vehicles and model years.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage above 10.4 volts.

SET CONDITION

- The Engine Oil Pressure (EOP) Sensor Signal voltage at Powertrain Control Module (PCM) is below 0.29 - 0.1 volt (depending on calibration) for approximately one second.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED
EOP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND
EOP SENSOR SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
ENGINE OIL PRESSURE (EOP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

      Did the DTC return?

      Yes

      - Go To 2

      No

      - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**

1. Refer to the recorded DTCs.

   Are there any 5-Volt Reference DTCs present?

   Yes

   - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

   No

   - Go To 3

3. **CHECK THE EOP SENSOR CONNECTOR AND TERMINALS**
   1. Turn the ignition off.
   2. Check the EOP Sensor harness connector for proper connection at the EOP Sensor.
   3. Verify that the connector is completely plugged in and properly locked prior to disconnecting.
   4. Disconnect the EOP Sensor harness connector and check for any pushed out, damaged or spread terminals.

      Were any issues found with the connector or terminals?

      Yes

      - Repair the damaged terminal or properly connect and lock the EOP Sensor harness connector and retest for DTCs.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 4

4. **CHECK THE (F855) 5-VOLT SUPPLY CIRCUIT VOLTAGE**
   1. Disconnect the EOP Sensor harness connector.
   2. Measure the voltage on the (F855) 5-Volt Supply circuit at the EOP Sensor harness connector.

      Is the voltage between 4.9 and 5.1 volts?

      Yes

      - Go To 5

      No

      - Repair the (F855) 5-Volt Supply circuit for an open or short to ground.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK THE EOP SENOR (G6) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO GROUND**
   1. Disconnect the PCM C2 harness connector.
   2. Check for continuity between ground and the EOP Sensor (G6) Pressure Signal circuit at the EOP Sensor harness connector.

      Is there continuity between ground and the EOP Sensor (G6) Pressure Signal circuit?

      Yes

      - Repair the EOP Sensor (G6) Pressure Signal circuit for a short to ground.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK FOR THE EOP SENOR (G6) PRESSURE SIGNAL CIRCUIT SHORTED TO THE (K900) SENSOR GROUND CIRCUIT**
   1. Check for continuity between the EOP Sensor (G6) Pressure Signal circuit and the (K900) Sensor Ground circuit at the EOP Sensor harness connector.

      Is there continuity between the EOP Sensor (G6) Pressure Signal circuit and the (K900) Sensor Ground circuit?

      Yes

      - Repair the EOP Sensor (G6) Pressure Signal circuit for a short to the (K900) Sensor Ground circuit.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 7
7. **CHECK THE ABILITY OF THE PCM TO DETECT THE EOP SENSOR SIGNAL**
   1. Reconnect the PCM C2 harness connector.
   2. Connect a fused jumper between the EOP Sensor (G6) Pressure Signal circuit and the (F855) 5-Volt Supply circuit at the EOP Sensor harness connector.
   3. Turn the ignition on.
   4. With the scan tool, read DTCs and record on the repair order.

      NOTE: **The P0523-ENGINE OIL PRESSURE SENSOR SIGNAL CIRCUIT HIGH DTC should be set with the jumper in place.**

      Does the scan tool display as described above?

      Yes

      - Verify that there is good pin to terminal contact in the Sensor and Powertrain Control Module connectors. If no problem(s) are found, replace the Engine Oil Pressure Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      NOTE: **Disconnect the jumper before proceeding.**

      - Go To 8
8. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.

5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0523-ENGINE OIL PRESSURE SENSOR CIRCUIT HIGH

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) provides a 5-Volt supply to the Engine Oil Pressure (EOP) Sensor on the sensor supply circuit. The PCM also provides a ground on the sensor return circuit. The Engine Oil Pressure Sensor signal can be a pull up (5.0 volts) or pull down (0.0 volts) resistor depending on the PCM internal hardware for the signal circuit. This can vary between vehicles and model years.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The Oil Pressure Signal circuit voltage is above 4.96 volts for approximately one second.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EOP SIGNAL CIRCUIT SHORTED TO VOLTAGE
EOP SIGNAL CIRCUIT SHORTED TO THE 5-VOLT SUPPLY CIRCUIT
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
ENGINE OIL PRESSURE (EOP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE EOP SENSOR (G60) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Turn the ignition on.

4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

Is the voltage above 5.2 volts?

Yes

- Go To 3

No

- Go To 4

3. **ISOLATE AND CHECK THE EOP SENSOR (G60) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 7

4. **ISOLATE AND CHECK THE (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 5

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND CHECK THE EOP SENSOR (G60) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO THE (F855) 5-VOLT SUPPLY CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between the circuits being tested.**

   Is there continuity between the circuits?

   Yes

   - Repair the short between the circuits.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6

6. **CONNECT A FUSED JUMPER BETWEEN THE EOP SENSOR (G60) PRESSURE SIGNAL CIRCUIT AND THE (K900) SENSOR GROUND CIRCUIT AT THE EOP SENSOR HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL CIRCUIT LOW DTC**

1. The Electronic Control Module (ECU) harness connectors must be connected to the ECU during this test step.
2. Disconnect the sensor harness connector.
3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the sensor ground circuit at the sensor harness connector.
4. Turn the ignition on.
5. With the scan tool, read DTCs.

Does the scan tool display the SENSOR SIGNAL CIRCUIT LOW DTC with the jumper in place?

Yes

- Replace the faulty sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

Yes

- Replace the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
- Test complete.

P0532-A/C PRESSURE SENSOR CIRCUIT LOW

For a complete A/C CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

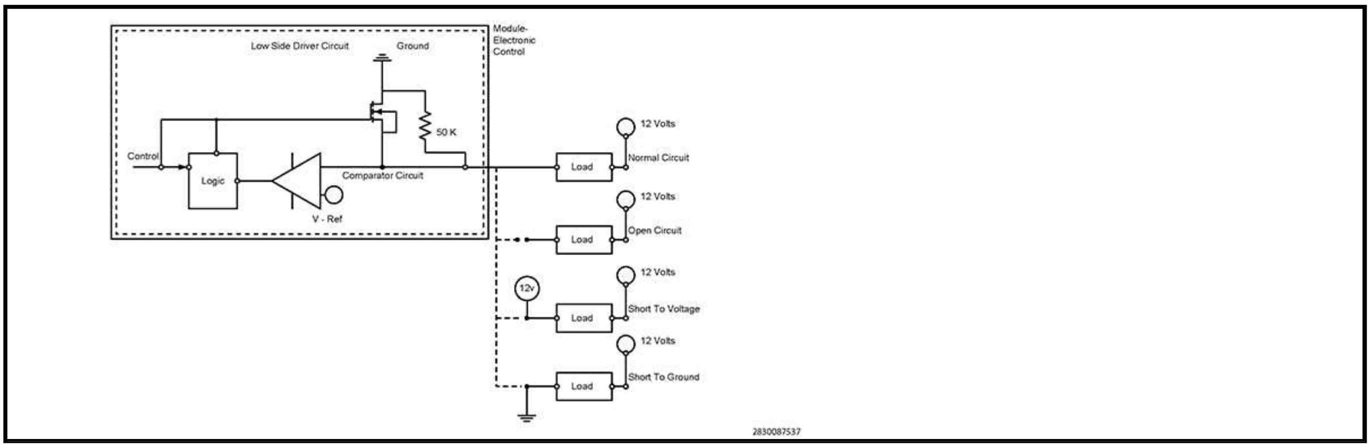
THEORY OF OPERATION

The Powertrain Control Module (PCM) receives a signal requesting the A/C Compressor to be turned on from the HVAC. When the PCM receives this request it energizes the A/C Clutch Relay through a **Low Side Driver** . The Powertrain Control Module (PCM) receives feedback from the A/C Pressure Transducer to monitor the pressure in the high side of the A/C refrigerant system. The A/C Pressure Transducer connects to a fitting on the A/C discharge line and its internal resistance changes in response to the pressure in the system. The PCM is programmed to respond to this and other sensor inputs to control the operation of the A/C Clutch and the Radiator Cooling Fan to help optimize A/C system performance and to protect the A/C system components from damage. The PCM will not allow the A/C Clutch Relay to be energized when the A/C Pressure Transducer reading is too low or excessively high. When the refrigerant pressure rises above a calibrated pressure specific to the PCM, the PCM will actuate the cooling fan.

Typical Low Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver device. The PCM provides a ground to operate the device when switched on. The ground could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device, wiring and internal driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. For diagnostic purposes the PCM uses an internal pull down diagnostic resistor connected in series and a voltage reference (V-Ref) comparator for fault detection:

- **Circuit Open and Circuit Low Detection:** The PCM monitors for an **open circuit** and **short to ground** when the driver is switched off. When switched off, the available voltage passes through the device and the **internal pull down resistor** connected in series. The voltage at the **comparator circuit** should be close to Battery voltage since the majority of the voltage drop occurs through the diagnostic resistor. If the available voltage is less than the V-Ref, a fault is set. In this scenario the V-Ref would be slightly below Battery voltage. **An alternative method of fault detection for an open or short to ground** that is used is to monitor current draw when the internal driver is switched on. If the module does not detect any current draw it determines that the component or circuitry is open. Excessive current draw detected would indicate a short to ground.
- **Circuit High Detection:** The PCM monitors for a **short to voltage** when the driver is switched on. When the driver is switched on providing a path to ground through the transistor, the available voltage should be pulled low, near zero volts since the **comparator circuit** is monitoring the ground side of the device. If the voltage is greater than V-Ref, a fault is detected. In this scenario V-Ref would be slightly above zero volts.

NOTE: **A load that has a resistance that is below manufacturer specification, or a second load device shorted to the low side driver circuit can cause excessive current draw on the internal driver. The driver will be switched off to protect against overheating and damaging the driver. In this instance the Circuit High fault may be detected because the available voltage on the comparator circuit is above V-Ref.**



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- A/C is learned and A/C Clutch Relay energized.

SET CONDITION

- The A/C Pressure Sensor signal voltage is below approximately 0.18 volts.

DEFAULT ACTION

- This is a non-MIL fault.

POSSIBLE CAUSES

Possible Causes
A/C PRESSURE SIGNAL CIRCUIT SHORTED TO GROUND
A/C PRESSURE SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
A/C PRESSURE SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    2. With the scan tool, erase all DTCs.
    3. Turn the ignition off for a minimum of 10.0 seconds.
    4. Turn the ignition on.
    5. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

NOTE: **Make sure the A/C refrigerant System is properly charged in accordance with the Service Information. Refer to TECHNICAL SPECIFICATIONS .**

2. **ISOLATE AND CHECK THE A/C PRESSURE SENSOR (C18) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 3

3. **ISOLATE AND CHECK THE A/C PRESSURE SENSOR (C18) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO THE (K917) SENSOR GROUND CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between the circuits being tested.**

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **CONNECT A FUSED JUMPER BETWEEN THE A/C PRESSURE SENSOR (C18) PRESSURE SIGNAL CIRCUIT AND THE (K854) 5-VOLT SUPPLY CIRCUIT AT THE A/C PRESSURE SENSOR HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL CIRCUIT HIGH DTC**
   1. The Electronic Control Module (ECU) harness connectors must be connected to the ECU during this test step.
   2. Disconnect the sensor harness connector.
   3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the 5-Volt Supply circuit at the sensor harness connector.
   4. Turn the ignition on.
   5. With the scan tool, read DTCs.

   Does the scan tool display the SENSOR SIGNAL CIRCUIT HIGH DTC with the jumper in place?

   Yes

   - Replace the faulty sensor in accordance with the Service Information. Refer to **TRANSDUCER, A/C PRESSURE, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.

- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0533-A/C PRESSURE SENSOR CIRCUIT HIGH

For a complete A/C CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

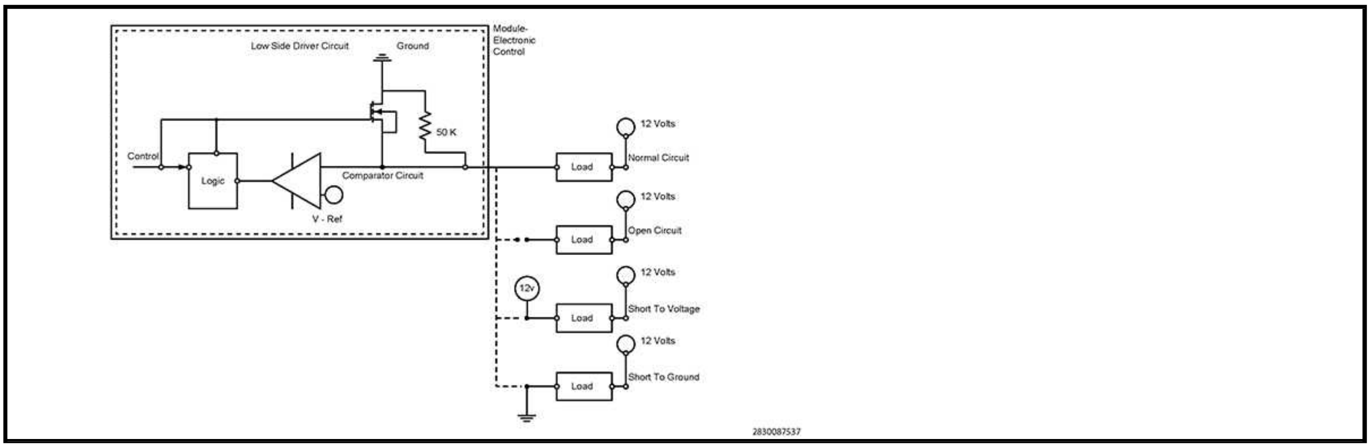
THEORY OF OPERATION

The Powertrain Control Module (PCM) receives a signal requesting the A/C Compressor to be turned on from the HVAC. When the PCM receives this request it energizes the A/C Clutch Relay through a **Low Side Driver** . The Powertrain Control Module (PCM) receives feedback from the A/C Pressure Transducer to monitor the pressure in the high side of the A/C refrigerant system. The A/C Pressure Transducer connects to a fitting on the A/C discharge line and its internal resistance changes in response to the pressure in the system. The PCM is programmed to respond to this and other sensor inputs to control the operation of the A/C Clutch and the Radiator Cooling Fan to help optimize A/C system performance and to protect the A/C system components from damage. The PCM will not allow the A/C Clutch Relay to be energized when the A/C Pressure Transducer reading is too low or excessively high. When the refrigerant pressure rises above a calibrated pressure specific to the PCM, the PCM will actuate the cooling fan.

Typical Low Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver device. The PCM provides a ground to operate the device when switched on. The ground could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device, wiring and internal driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. For diagnostic purposes the PCM uses an internal pull down diagnostic resistor connected in series and a voltage reference (V-Ref) comparator for fault detection:

- **Circuit Open and Circuit Low Detection:** The PCM monitors for an **open circuit** and **short to ground** when the driver is switched off. When switched off, the available voltage passes through the device and the **internal pull down resistor** connected in series. The voltage at the **comparator circuit** should be close to Battery voltage since the majority of the voltage drop occurs through the diagnostic resistor. If the available voltage is less than the V-Ref, a fault is set. In this scenario the V-Ref would be slightly below Battery voltage. **An alternative method of fault detection for an open or short to ground** that is used is to monitor current draw when the internal driver is switched on. If the module does not detect any current draw it determines that the component or circuitry is open. Excessive current draw detected would indicate a short to ground.
- **Circuit High Detection:** The PCM monitors for a **short to voltage** when the driver is switched on. When the driver is switched on providing a path to ground through the transistor, the available voltage should be pulled low, near zero volts since the **comparator circuit** is monitoring the ground side of the device. If the voltage is greater than V-Ref, a fault is detected. In this scenario V-Ref would be slightly above zero volts.

NOTE: **A load that has a resistance that is below manufacturer specification, or a second load device shorted to the low side driver circuit can cause excessive current draw on the internal driver. The driver will be switched off to protect against overheating and damaging the driver. In this instance the Circuit High fault may be detected because the available voltage on the comparator circuit is above V-Ref.**



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- A/C Clutch Relay energized.

SET CONDITION

- The A/C Pressure Sensor signal to the PCM is above approximately 4.9 volts.

DEFAULT ACTION

- This is a non MIL fault.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT OPEN/HIGH RESISTANCE
5-VOLT SUPPLY CIRCUIT SHORTED TO GROUND
5-VOLT SUPPLY CIRCUIT SHORTED TO VOLTAGE
A/C PRESSURE SIGNAL CIRCUIT SHORTED TO VOLTAGE

Possible Causes
A/C PRESSURE SIGNAL CIRCUIT SHORTED TO THE 5-VOLT SUPPLY CIRCUIT
A/C PRESSURE SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
A/C PRESSURE SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    2. With the scan tool, erase all DTCs.
    3. Turn the ignition off for a minimum of 10.0 seconds.
    4. Turn the ignition on.
    5. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    NOTE: **Make sure the A/C refrigerant System is properly charged in accordance with the Service Information. Refer to TECHNICAL SPECIFICATIONS .**

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE (K854) 5-VOLT SUPPLY CIRCUIT VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the A/C Pressure Sensor harness connector.
    3. Turn the ignition on.
    4. Measure the voltage on the (K854) 5-Volt Supply circuit in the A/C Pressure Sensor harness connector.

        Is the voltage reading between 4.8 and 5.2 volts?

        Yes

        - Go To 3

        No, voltage is too high

        - Repair the (K854) 5-Volt Supply circuit for a short to voltage.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No, voltage is too low

- Repair the (K854) 5-Volt Supply circuit for an open or short to ground.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **CHECK THE A/C PRESSURE SENSOR (C18) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

    NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

    Is the voltage above 5.2 volts?

    Yes

    - Go To 4

    No

    - Go To 5
4. **ISOLATE AND CHECK THE A/C PRESSURE SENSOR (C18) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

        NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

        Is there continuity between the circuit being tested and any other circuit?

        Yes

        - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 8
5. **ISOLATE AND CHECK THE A/C PRESSURE SENSOR (C18) PRESSURE SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**

1. The ignition must be off when checking the continuity of a circuit.
2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 6

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND CHECK THE (K917) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 7

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CONNECT A FUSED JUMPER BETWEEN THE A/C PRESSURE SENSOR (C18) PRESSURE SIGNAL CIRCUIT AND THE (K917) SENSOR GROUND CIRCUIT AT THE A/C PRESSURE SENSOR HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL CIRCUIT LOW DTC**
    1. The Electronic Control Module (ECU) harness connectors must be connected to the ECU during this test step.
    2. Disconnect the sensor harness connector.
    3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the sensor ground circuit at the sensor harness connector.
    4. Turn the ignition on.
    5. With the scan tool, read DTCs.

    Does the scan tool display the SENSOR SIGNAL CIRCUIT LOW DTC with the jumper in place?

    Yes

    - Replace the faulty sensor in accordance with the Service Information. Refer to **TRANSDUCER, A/C PRESSURE, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 8
8. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

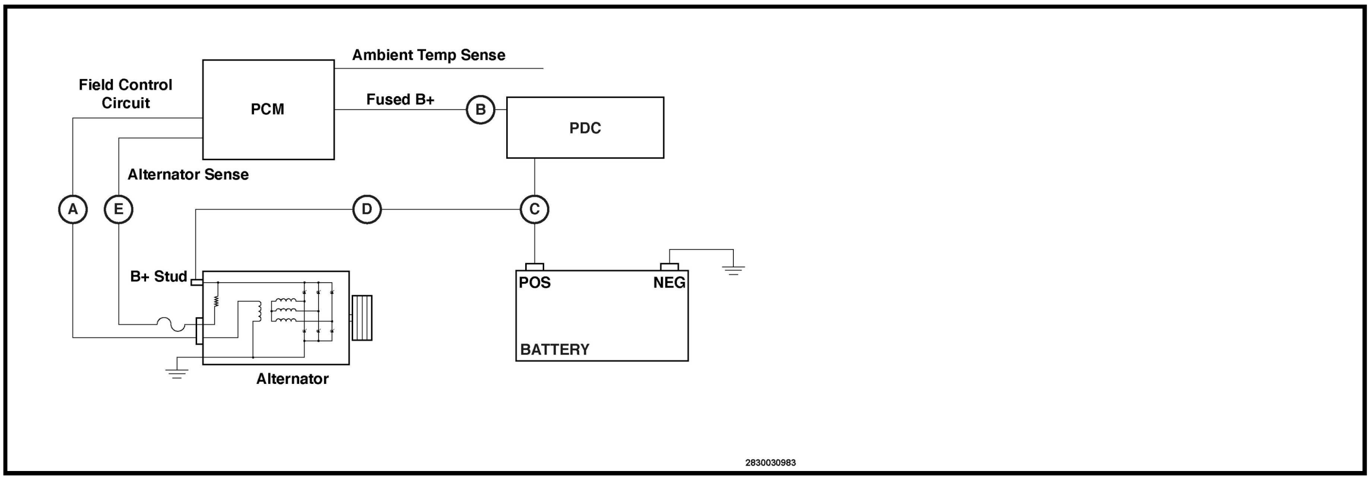
    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0562-BATTERY/SYSTEM VOLTAGE LOW

For a complete STARTING/CHARGING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION



The Electronic Voltage Regulation (EVR) system maintains the system voltage at a desired level by turning the Pulse Width Modulated (PWM) Alternator Field Control circuit (A) on and off. When the Alternator field is turned on, the system voltage increases. When the Alternator field is turned off, the system voltage slowly drops. The rate at which this happens is dependent upon the existing electrical loads, ambient under hood temperature, and the engine speed. A constant system voltage (D, C, B) can be maintained only when the Alternator field is switched on and off at a duty cycle that very accurately emulates the existing electrical loads given the existing ambient under hood temperature and engine speed.

During normal operation, the voltage reading at the Alternator output stud will be very close to the target charging voltage viewed on the scan tool. This is the system voltage and is sensed by the Powertrain Control

Module (PCM) through the Fused B+ circuit (B). With the Alternator connector plugged in, and back probing the Alternator Sense circuit (E), the voltage reading will be approximately 3.5 volts less than the voltage at the Alternator output stud due the resistor inside the Alternator. This is the Alternator Sense (E) input to the PCM. These two voltage sense inputs are used and compared during the different diagnostics performed on the EVR System by the PCM.

WHEN MONITORED

- With the engine running for more than 30 seconds.

SET CONDITION

- Battery voltage at the Powertrain Control Module (PCM) is less than a calibrated threshold for a set period of time.

DEFAULT ACTION

- The ETC light will flash.
- Battery light is illuminated.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

POSSIBLE CAUSES
DEFECTIVE BATTERY
RESISTANCE IN THE BATTERY POSITIVE CABLE OR END
RESISTANCE IN THE BATTERY NEGATIVE CABLE OR END
POOR GROUND CONNECTION AT THE ENGINE BLOCK OR BODY CONNECTIONS
FUSED B+ CIRCUIT HIGH RESISTANCE
PCM POWERS AND GROUNDS
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE CONDITION**
   1. Start the engine and allow it to idle.
   2. With the scan tool, navigate to data display and monitor the voltage sense to the PCM.

      Is the voltage within 0.2 volts of the target charging voltage?

      Yes

      - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

      No

      - Go To 2
2. **CHECK THE CONDITION OF THE BATTERY**

   NOTE: **Inspect the vehicle for aftermarket accessories that may exceed the Alternator System output.**

NOTE: **Inspect the fusible link in the charge wire or fuses in the PDC depending on application. If an open fusible link or fuse is found, use the wire diagram/schematic as a guide and inspect the wiring and connectors for damage.**

1. Use the (special tool #GR8-1220KIT-CHRY, AGM Battery Tester/Charger Station)or equivalent to load test the Battery.

   Did the Battery pass or fail?

   Passed

   - Go To 3

   Failed

   - Perform the appropriate repair according to the Battery tester.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **CHECK FOR HIGH RESISTANCE IN THE BATTERY POSITIVE CIRCUIT**
   1. Perform a voltage drop test between the Battery Positive (+) Post;
      - and the Alternator stud.
      - and the PDC B+ terminal.

      Is the voltage reading above 0.2 volts for either measurement?

      Yes

      - Repair the Battery Positive (+) circuit for high resistance.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 4
4. **CHECK FOR HIGH RESISTANCE IN THE BATTERY GROUND CABLE**
   1. Perform a voltage drop test between the Battery Negative (-) post;
      - to the engine ground eyelet.
      - to the body ground eyelet.

      Is the voltage reading above 0.2 volts for either measurement?

      Yes

      - Repair the Battery ground circuit for high resistance.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 5
5. **CHECK THE (A106) FUSED B+ CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
   1. Disconnect the component harness connector to isolate the 12.0 volt supply circuit.

2. Connect the positive lead of the load test tool to the 12.0 volt supply circuit at the component harness connector (A). **Note:** refer to the diagram below.
3. Connect the negative lead of the load test tool to the ground circuit of the Battery or a good chassis ground.
4. Ensure that the circuit being tested is being powered on. If the 12.0 volt circuit being tested is an ignition feed for example, the ignition must be on. If testing an output from a relay, verify that the relay is energized and on.
5. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

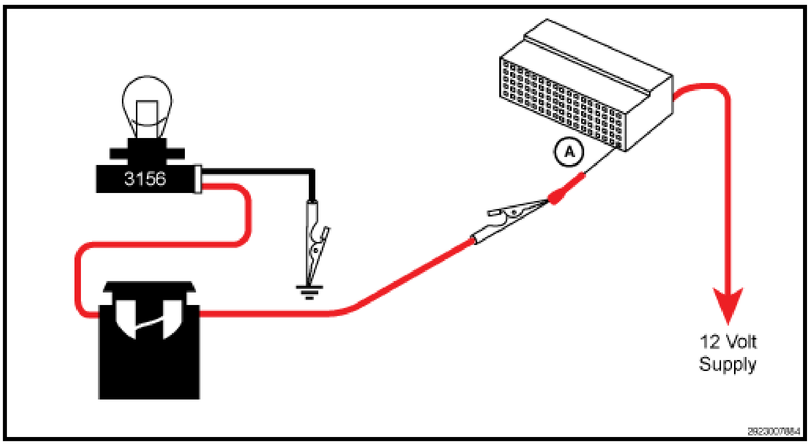
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
- **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 6

   No

   - Repair the 12.0 volt circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK RELATED PCM AND COMPONENT HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.

- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

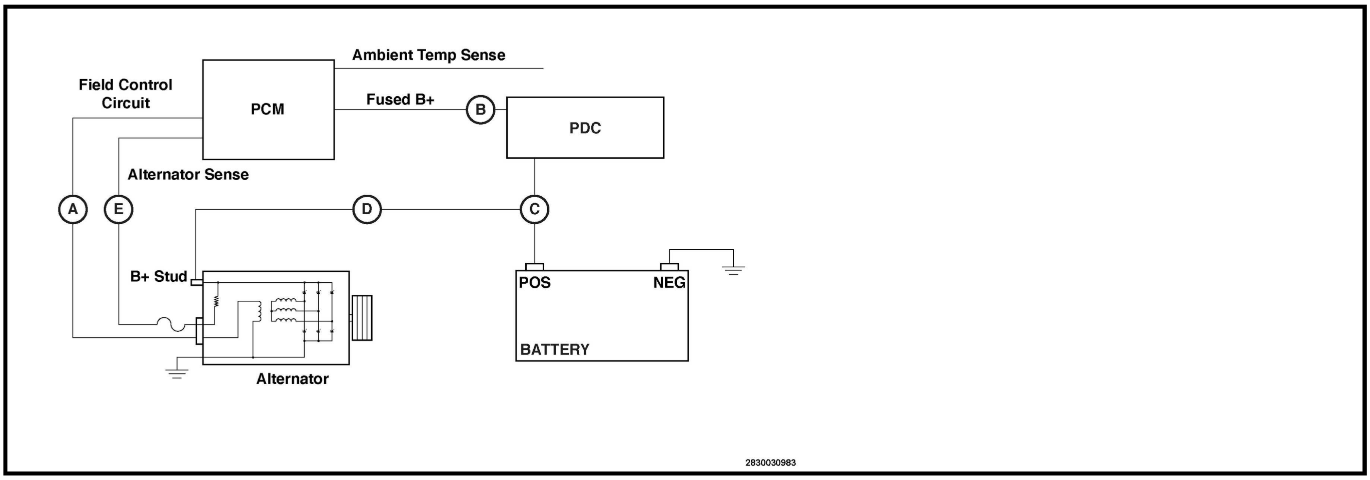
No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0563-BATTERY/SYSTEM VOLTAGE HIGH

For a complete STARTING/CHARGING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION



The Electronic Voltage Regulation (EVR) system maintains the system voltage at a desired level by turning the Pulse Width Modulated (PWM) Alternator Field Control circuit (A) on and off. When the Alternator field is turned on, the system voltage increases. When the Alternator field is turned off, the system voltage slowly drops. The rate at which this happens is dependent upon the existing electrical loads, ambient under hood temperature, and the engine speed. A constant system voltage (B, C, D) can be maintained only when the Alternator field is switched on and off at a duty cycle that very accurately emulates the existing electrical loads given the existing ambient under hood temperature and engine RPM.

During normal operation, the voltage reading at the Alternator output stud will be very close to the target charging voltage viewed on the scan tool. This is the system voltage and it is sensed by the Powertrain Control Module (PCM) through the Fused B+ circuit (B). With the Alternator connector plugged in and back probing the Alternator Sense circuit (E), the voltage reading will be approximately 3.5 volts less than the voltage at the Alternator output stud due the resistor inside the Alternator. This is the Alternator Sense input to the PCM. These two voltage sense inputs are used and compared during the different diagnostics performed on the EVR System by the PCM.

Diagnostic Mode: When the PCM detects that the output voltage is too high or too low, the PCM runs a series of diagnostics to determine the cause. The PCM will run the **Charging System Voltage High** diagnostic and will give a rapid warning that the system voltage (B, C, D) is higher than the target charging voltage by 1.0 volt for a calibrated amount of time.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the engine running.
- No other charging system DTCs set.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the battery voltage is greater than the targeted charging system voltage by at least 1.0 volt for a calibrated period of time.

DEFAULT ACTION

- This is a non-MIL fault.

POSSIBLE CAUSES

Possible Causes
ALTERNATOR FIELD CONTROL CIRCUIT SHORTED TO VOLTAGE
ALTERNATOR SENSE CIRCUIT SHORTED TO GROUND
ALTERNATOR SENSE CIRCUIT OPEN/HIGH RESISTANCE
ALTERNATOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to **PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .**

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE CONDITION**
    1. Start the engine and allow it to idle.

       WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

    2. With the scan tool, read the target charging voltage.
    3. Measure the voltage on the Alternator output stud.

       Is the voltage more than 1.0 volt above the target charging voltage?

       Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE CONDITION OF THE BATTERY**
   1. Use the (special tool #GR8-1220KIT-CHRY, AGM Battery Tester/Charger Station)or equivalent to load test the Battery.

      Did the Battery pass or fail?

      Passed

      - Go To 3

      Failed

      - Perform the appropriate repair according to the Battery tester.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
3. **CHECK THE ALTERNATOR DUTY CYCLE**
   1. With the scan tool, check the Duty Cycle reading for the Alternator.

      NOTE: **During normal operation the typical duty cycle of the field control at idle with minimal loads is approximately 35-40%, which will equate to between 4.0 and 5.0 volts. Depending on the charging issue, the PCM can drive the duty cycle to off (0%), which will equate to zero volts, or full field (100%), which will equate to between 11.0 and 12.0 volts.**

      What is the Alternator duty cycle on the scan tool?

      0%

      - Go To 4

      100%

      - Go To 5
4. **CHECK THE ALTERNATOR (K20) FIELD CONTROL CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Back probe the Alternator (K20) Field Control circuit at the Alternator harness connector.

      WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

   2. Measure the voltage on the Alternator (K20) Field Control circuit at the Alternator harness connector.

      Is there any voltage present?

      Yes

      - Repair the Alternator (K20) Field Control circuit for a short to voltage.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Verify that there is good pin to terminal contact in the Alternator and Powertrain Control Module connectors. If no problem is found, replace the Alternator in accordance with the Service Information. Refer to **GENERATOR, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND CHECK THE ALTERNATOR (A804) SENSE CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **ISOLATE AND CHECK THE ALTERNATOR (A804) SENSE CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 7

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK RELATED PM AND COMPONENT HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. With the scan tool, erase DTCs.
   9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   10. With the scan tool, read DTCs.

   Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P057B-BRAKE PEDAL POSITION SENSOR "A" CIRCUIT PERFORMANCE

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE: **If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.
- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced

around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)
- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.
- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR

POSSIBLE CAUSES
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. Use the wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.

4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.

4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.
   1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
   2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
   1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
   2. If the temp sensor signal and ground circuits test good, use the wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).

- If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
- If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

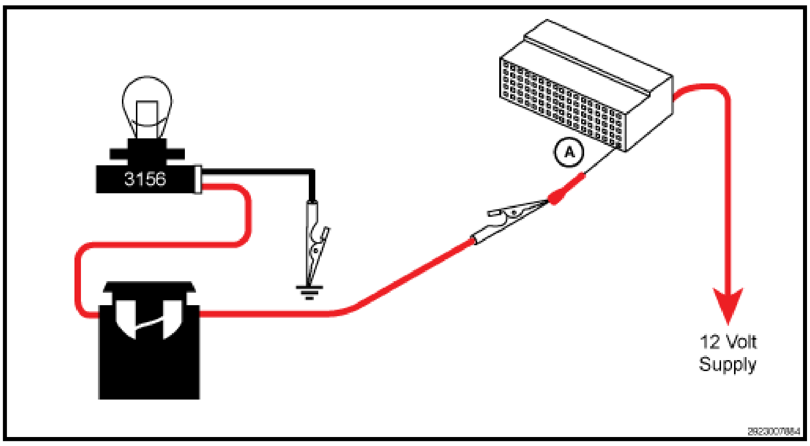
NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

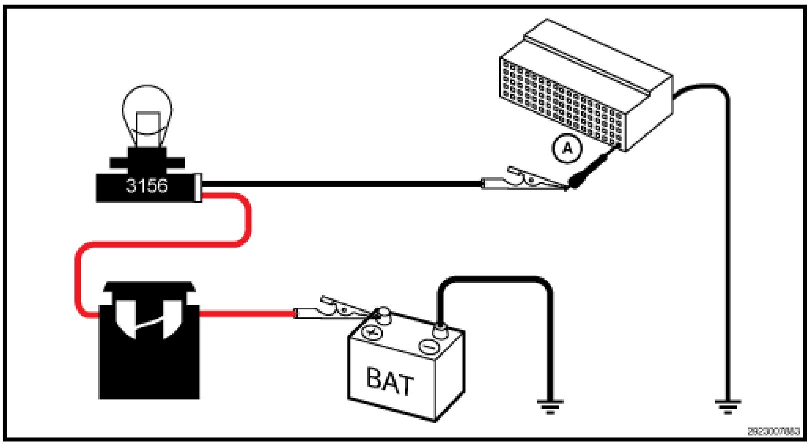
NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.
4. Using the appropriate wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
    1. If the fuse(s) are good, continue testing in step 5.
    2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .
2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
   - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
   - If both circuits pass the load test, continue testing in step 6.

6. 

Load test the BSCM Ground circuit.

1. If the ground circuit fails load testing, repair the BSCM chassis ground.
2. If the ground circuit tests good, continue testing in step 7.

7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
   1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

      NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

   2. If both voltage readings match the values given, the BSCM is likely faulty. Use the wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

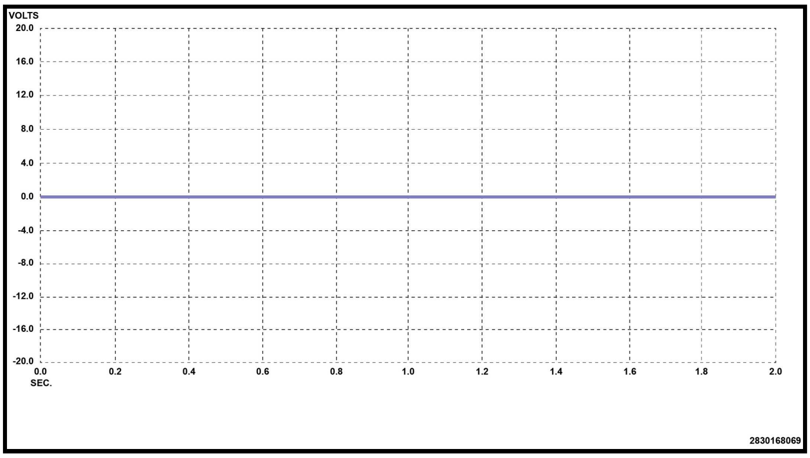
1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
    1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
    2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

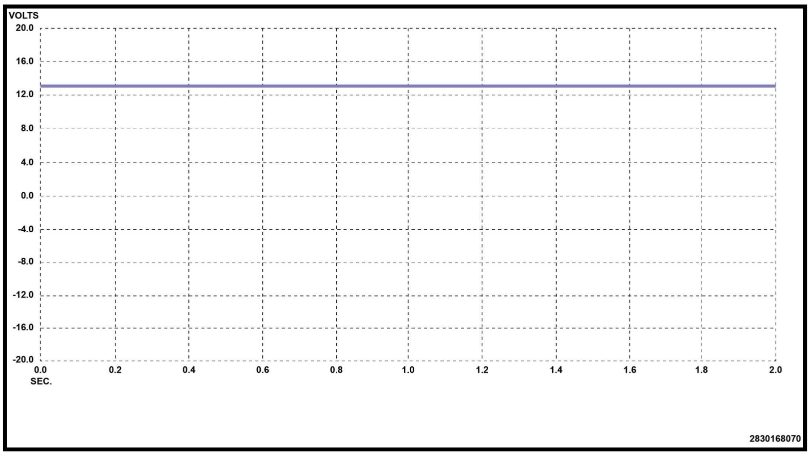
1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.
    1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
    2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
        - Check the WSS for physical damage and verify it is mounted and fastened properly.
        - If equipped with a tone wheel, inspect the tone wheel for physical damage.

        - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
        - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.

    3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



    4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
    1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
    2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.
    1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. Use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.
    1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. Use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

P057C-BRAKE PEDAL POSITION SENSOR CIRCUIT LOW

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal

Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE: **If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.

- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)
- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
		and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.
- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the

difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.

- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold

soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.

2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. Use the wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

    1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
    2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.
4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.
    1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
    2. If the temp sensor signal and ground circuits test good, use the wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).

- If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
- If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

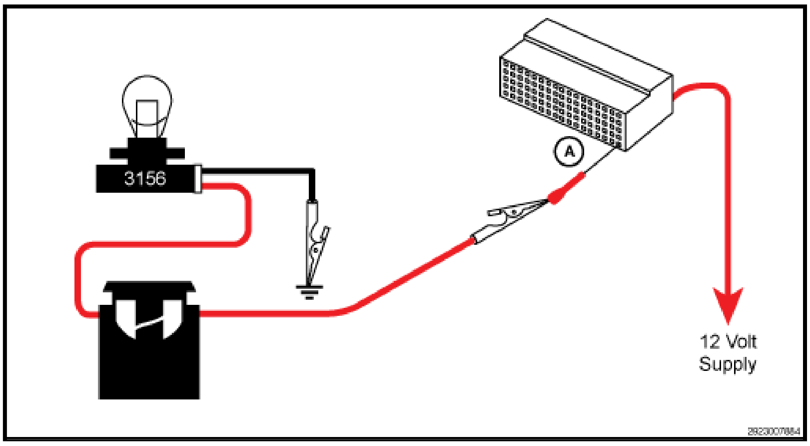
PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

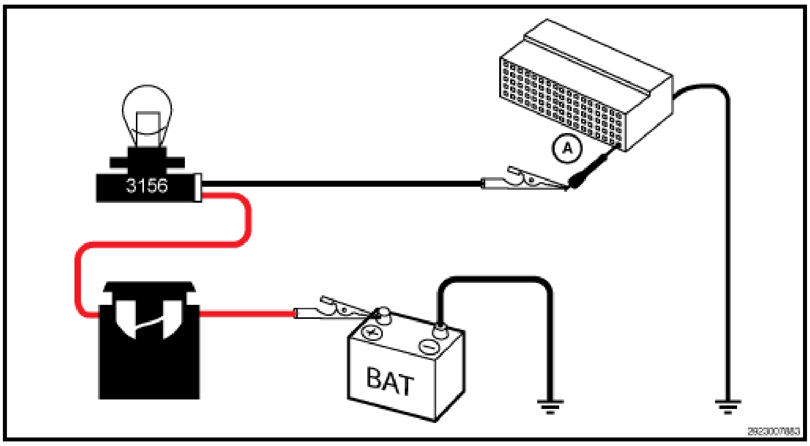
NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.

4. Using the appropriate wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
    1. If the fuse(s) are good, continue testing in step 5.
    2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

    Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

    1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .
    2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
        - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
        - If both circuits pass the load test, continue testing in step 6.
6. 

    Load test the BSCM Ground circuit.

    1. If the ground circuit fails load testing, repair the BSCM chassis ground.
    2. If the ground circuit tests good, continue testing in step 7.
7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
    1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

2. If both voltage readings match the values given, the BSCM is likely faulty. Use the wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

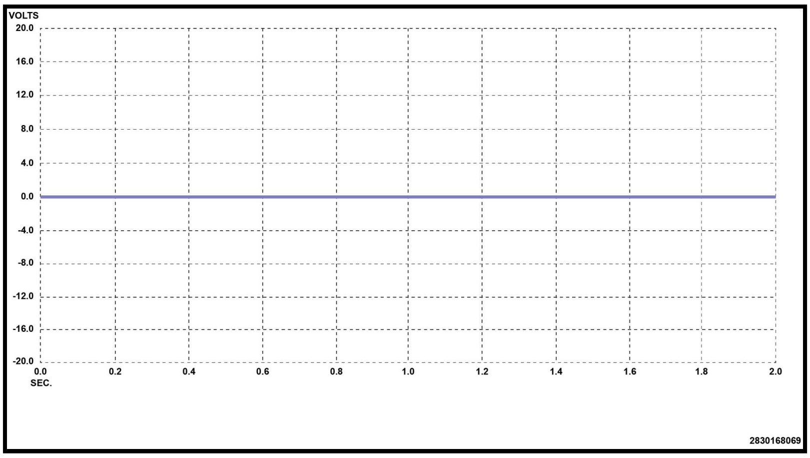
1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
   1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
   2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

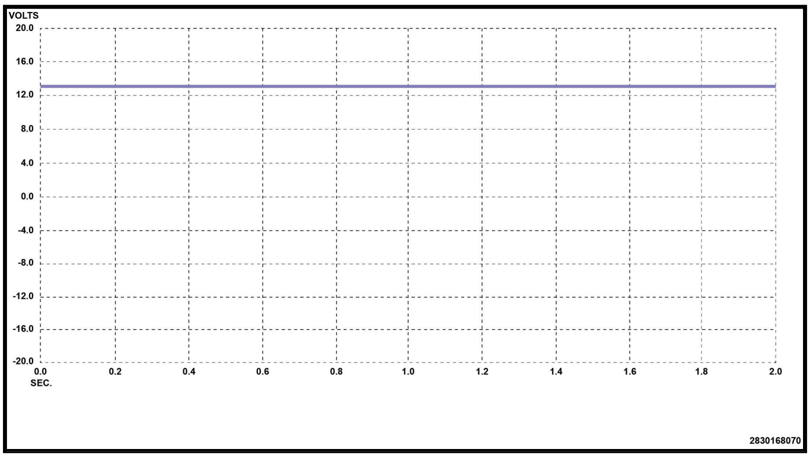
1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the

signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.

1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
    - Check the WSS for physical damage and verify it is mounted and fastened properly.
    - If equipped with a tone wheel, inspect the tone wheel for physical damage.
    - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
    - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.
3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
    1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
    2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.
    1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. Use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.

1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. Use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

P057D-BRAKE PEDAL POSITION SENSOR CIRCUIT HIGH

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE: **If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.

- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)
- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
		on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.

- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. Use the wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.

2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.

    1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
    2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.
4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.

    1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
    2. If the temp sensor signal and ground circuits test good, use the wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if**

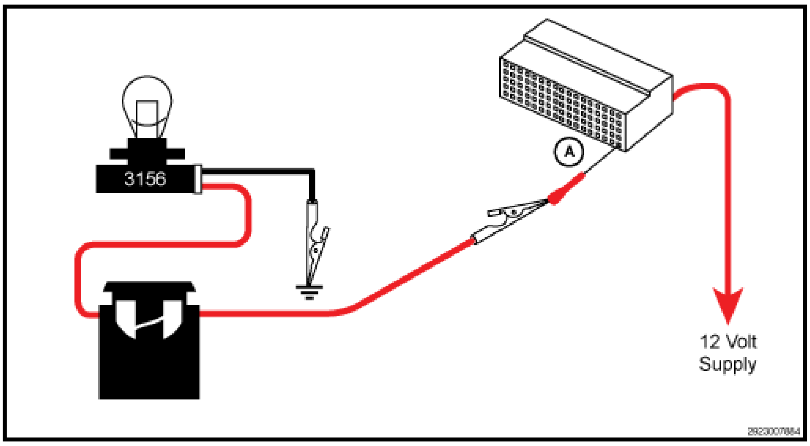
the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

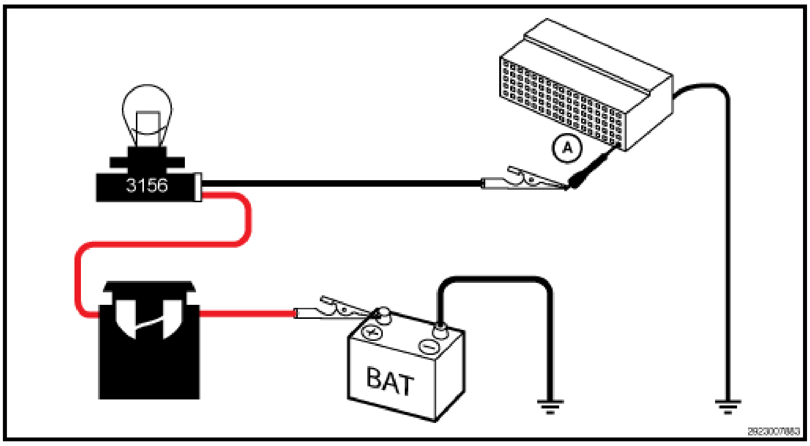
PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.
4. Using the appropriate wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
   1. If the fuse(s) are good, continue testing in step 5.
   2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

   Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

   1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .

2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
    - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
    - If both circuits pass the load test, continue testing in step 6.

6. 

Load test the BSCM Ground circuit.

1. If the ground circuit fails load testing, repair the BSCM chassis ground.
2. If the ground circuit tests good, continue testing in step 7.

7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
    1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

    NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

    2. If both voltage readings match the values given, the BSCM is likely faulty. Use the wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)

- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

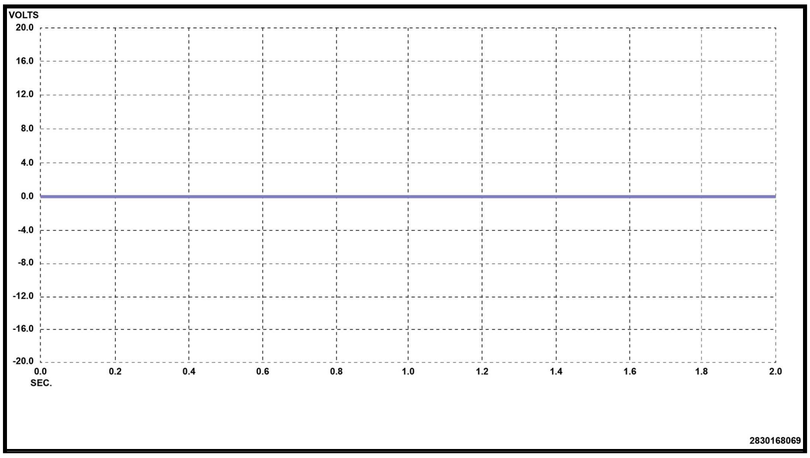
DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
    1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
    2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

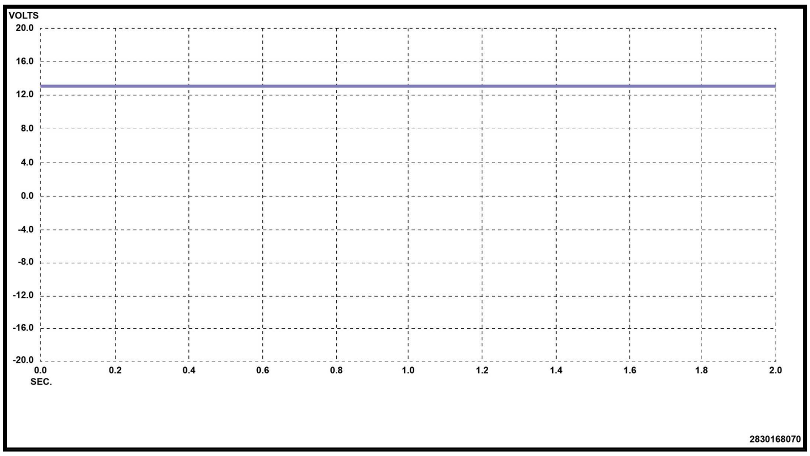
PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.
    1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
    2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
        - Check the WSS for physical damage and verify it is mounted and fastened properly.
        - If equipped with a tone wheel, inspect the tone wheel for physical damage.
        - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
        - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.
    3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS

Signal circuit checks good, use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
    1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
    2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.
    1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.

    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. Use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.
    1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. Use the wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

P0585-SPEED CONTROL SWITCH 1/2 CORRELATION

For a complete SPEED CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Speed Control Switch Assembly sends signals via a Local Interconnect Network (LIN) Bus circuit to the Steering Column Control Module (SCCM). The SCCM acts as a pass through that delivers the signals/inputs from the Speed Control Switch Assembly on to the Powertrain Control Module (PCM) via the Controlled Area Network (CAN) Bus.

COMPONENT FUNCTIONAL DESCRIPTION-MULTIPLEX (MUX) SWITCH

Component Functional Operation: The Speed Control (S/C) Switch is a Smart Device that is supplied a Battery feed, ground and LIN Bus circuit. The S/C Switch has internal redundant MUX signals and a sensor ground circuit. When a S/C button is pressed the smart switch interprets the voltage signals to a S/C function. The S/C Switch sends a message with the function selected over the LIN Bus circuit to the Steering Column Control Module (SCCM) or Body Control Module (BCM) depending on the vehicle.

DIAGNOSTIC OVERVIEW - S/C SWITCH

The S/C Switch performs diagnostics on the internal signal circuits. If a fault is detected the S/C Switch reports the fault to the SCCM over the LIN Bus circuit. If a speed control fault is present, verify that the switch has the proper Battery feed, ground and a good LIN Bus connection between the switch and SCCM or BCM depending on vehicle. If the circuits test good, the switch is the most likely cause of the DTC.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
    - The Speed Control System button positions are monitored.

SET CONDITION

- The Powertrain Control Module (PCM) receives a non-permissable combination message for the S/C Switch Assembly for 0.5 seconds.

DEFAULT ACTION

- This is a non MIL fault.

POSSIBLE CAUSES

Possible Causes
SPEED CONTROL SWITCH

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

CHECK FOR AN ACTIVE CONDITION

1. Cycle the ignition off and back on.
2. Test drive the vehicle and operate the Set (+), Set (-), Resume and Cancel functions of the speed control system.

NOTE: **The scan tool will display the fault as active only when a Speed Control Switch is pressed.**

3. With the scan tool, read DTCs and record on the repair order.

Does the scan tool display this DTC as active or pending?

Yes

WARNING: **Turn the ignition off disconnect the 12-volt battery and wait two minutes before proceeding. Failure to follow these instructions may result in possible serious or fatal injury.**

WARNING: **Do not place an intact non-deployed airbag face down on a hard surface, the airbag propels into the air if accidentally deployed. Failure to follow these instructions may result in possible serious or fatal injury.**

- Replace the Speed Control Switch Assembly in accordance with the Service Information. Refer to **SWITCH, SPEED CONTROL, REMOVAL AND INSTALLATION** . Test drive the vehicle and operate the Set (+) and Resume buttons functions of the speed control system to verify repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

P058A- BATTERY MONITOR MODULE PERFORMANCE

THEORY OF OPERATION - SMART CHARGING STRATEGY

Vehicles that utilize the Smart Charging control strategy are equipped with an Intelligent Battery Sensor (IBS). The Smart Charging strategy can be used with any combination of the following configurations:

- Single Battery system.
- Dual Battery system.
- Electronic Voltage Regulation (EVR) Charging systems using a standard Alternator directly controlled by the PCM.
- Charging systems using a Smart Alternator communicating with the PCM via LIN Bus.

The IBS is an important component of the Smart Charging control strategy. The Smart Charging control functions differently than the traditional EVR systems that do not utilize an IBS.When the IBS is reporting little to no electrical demand on the Battery, particularly at idle, it is common for the PCM to suspend charging, reducing the load on the engine. This in turn helps with emissions and fuel economy. Because of this strategy it is not uncommon for the voltage at the Alternator stud to be equal to, or close to Battery voltage at idle.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage above 11.0 volts.

SET CONDITION

- The Intelligent Battery Sensor (IBS) is reporting an internal calibration error or the signal is not available.

DEFAULT ACTION

- This is a non-MIL fault.

POSSIBLE CAUSES

Possible Causes
FUSED B+ CIRCUIT OPEN/HIGH RESISTANCE
GROUND CIRCUIT OPEN/HIGH RESISTANCE
INTELLIGENT BATTERY SENSOR (IBS)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any Battery or charging system DTCs present?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 3

3. **CHECK THE IBS (A916) FUSED B+ CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Disconnect the component harness connector to isolate the 12.0 volt supply circuit.
    2. Connect the positive lead of the load test tool to the 12.0 volt supply circuit at the component harness connector (A). **Note:** refer to the diagram below.
    3. Connect the negative lead of the load test tool to the ground circuit of the Battery or a good chassis ground.
    4. Ensure that the circuit being tested is being powered on. If the 12.0 volt circuit being tested is an ignition feed for example, the ignition must be on. If testing an output from a relay, verify that the relay is energized and on.
    5. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

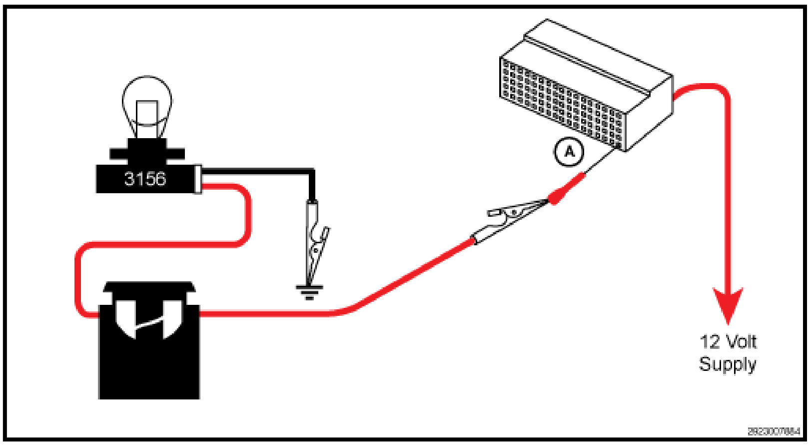
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**

- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
- **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 4

No

- Repair the 12.0 volt circuit for an open or high resistance. If the fuse in the PDC is found to be open, check the circuit for a short to ground.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

4. **CHECK THE IBS (Z901) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
   1. Disconnect the component harness connector to isolate the ground circuit.
   2. Connect the positive lead of the load test tool to the positive side of the Battery.
   3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
   4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of**

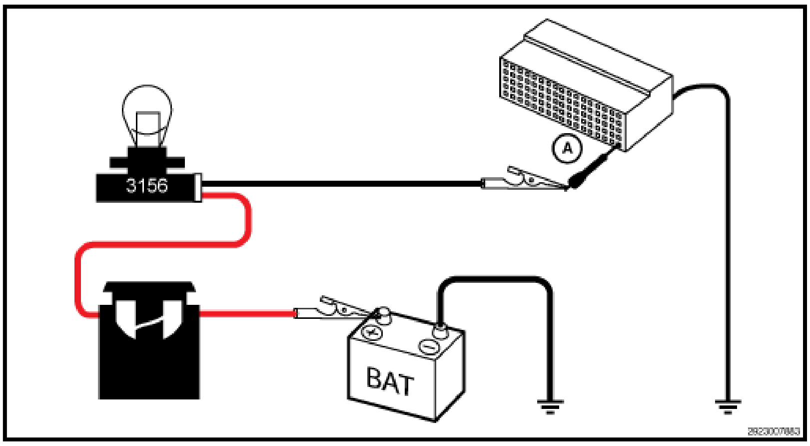
resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .

NOTE: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

- 1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
- 2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
- 3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



NOTE: Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.

Is the load test bulb illuminated and bright?

Yes

- Go To 5

No

- Repair the ground circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **REPLACE THE INTELLIGENT BATTERY SENSOR (IBS)**

   The Intelligent Battery Sensor is reporting an irrational temperature signal, view repair to continue.

   Repair

   - Replace the Intelligent Battery Sensor in accordance with the service information. Refer to **SENSOR, INTELLIGENT BATTERY (IBS), REMOVAL AND INSTALLATION** **SENSOR, INTELLIGENT BATTERY (IBS), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0600-SERIAL COMMUNICATION LINK

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage greater than 11.0 volts.

SET CONDITION

- Internal bus communication failure between processors.

DEFAULT ACTION

- The MIL light will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0601-INTERNAL MEMORY CHECKSUM INVALID

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- Internal checksum for software failed, does not match calculated value.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:

- Proper connector installation.
- Damaged connector locks.
- Corrosion.
- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0602-CONTROL MODULE PROGRAMMING ERROR/NOT PROGRAMMED

THEORY OF OPERATION

Each Powertrain Control Module (PCM) has an internal identifier that is programmed in the memory by the manufacturer. The PCM internal identification is checked each time the ignition is turned on.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Each time the ignition is turned on the PCM internal identification is checked.

SET CONDITION

- If the PCM internal identification is not correct for the vehicle, the fault will set immediately.

DEFAULT ACTION

- This is a non MIL fault.
- The vehicle will not crank or start if this fault is active.

POSSIBLE CAUSES

Possible Causes
PCM INTERNAL FAILURE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

POWERTRAIN CONTROL MODULE INTERNAL FAILURE

This DTC is indicating that the PCM has an internal memory identification error.

View Repair

- Replace and program the Powertrain Control Module in accordance with the Service information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0606-INTERNAL CONTROL PROCESSOR

WHEN MONITORED

- With the engine running.

SET CONDITION

- When the Powertrain Control Module (PCM) recognizes an internal failure to communicate or the CMP and CKP Sensor count periods are too short.

DEFAULT ACTION

- The ETC light will flash.
- Throttle input and vehicle speed are limited.
- The MIL will illuminate.
- Throttle input and vehicle speed are limited.

POSSIBLE CAUSES

Possible Causes
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.

2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
3. With the scan tool, erase all DTCs.
4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

   Are there any low system voltage, CMP Sensor, or CKP Sensor DTCs active or pending?

   Yes

   - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

   No

   - Go To 3

3. **CHECK RELATED HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

   Repair any conditions that are found.

   5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.

6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0607-ECU INTERNAL PERFORMANCE

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.
- During an Auto-stop event on an ESS equipped vehicle.

SET CONDITION

- The Powertrain Control Module (PCM) internal safety monitoring software detects that the monitor for passenger departure during an Auto-stop has lost detection ability.
- On non-ESS equipped vehicles this diagnostic is reporting an internal safety monitoring software detection fault.

DEFAULT ACTION

- The MIL will illuminate.
- The Stop/Start system is disable when this DTC is set.

POSSIBLE CAUSES

Possible Causes
BATTERY VOLTAGE SUPPLY ISSUES
MALFUNCTION IN OTHER ESS DETECTION SYSTEMS (I.E. SEAT BELT, DRIVER DOOR AJAR, BRAKE SWITCH/SENSOR)
PASSENGER ATTEMPTING TO LEAVE VEHICLE DURING AN AUTO-STOP EVENT
PCM POWER AND GROUND CIRCUITS OPEN OR SHORTED
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **CHECK FOR OTHER DTCS**

   NOTE: **If there are any system or component DTCs (I.E. including but not limited to Seat Belt, Door Ajar, Brake pedal position, Occupant detection) present that are monitored for ESS disablement, those DTCs should be addressed before continuing. The PCM is not the failure if there are other Battery voltage or ESS disablement system or component DTCs present.**

    1. Refer to the recorded DTCs.

       Are there any Seat Belt, Door Ajar, Brake Switch/Sensor or Battery voltage DTCs present in any module?

       Yes

       - Perform the applicable diagnostic procedure(s).

       No

       - Go To 3
3. **CHECK PCM POWER AND GROUNDS**
    1. Perform the CHECKING THE PCM POWER AND GROUND CIRCUITS diagnostic procedure. Refer to **CHECKING THE PCM POWER AND GROUND CIRCUITS - 3.6L** .

       Were any problem found with the PCM powers and grounds?

       Yes

       - Repair as necessary.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 4
4. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**

   NOTE: **The PCM should only be replaced if the DTC set alone with no other faults against the systems called out in step 2 above.**

    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).

3. Disconnect the related component harness connectors.
4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

5. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P060B-ETC A/D GROUND PERFORMANCE

THEORY OF OPERATION

The Accelerator Pedal Position (APP) Sensor consists of two separate internal sensors. The Powertrain Control Module (PCM) uses the two APP Sensor signals to read the position of the accelerator pedal. A ground check of the APP 2 Sensor Ground circuit is performed a number of times per second to ensure proper functionality of the PCM internal ground circuit. Secondary software will determine if the PCM internal ground circuit is operating correctly.

WHEN MONITORED

- This diagnostic runs continuously when the following condition is met:

- With the ignition on.
- With throttle being commanded.

SET CONDITION

- When the voltage reading from APP Sensor 2 is above 0.12 volts during the ground check, this fault sets.
  - The test typically runs a couple of times per second and is the reason why APP2 signal spikes to ground a couple of times per second in normal running.
  - Reprogramming the module may not always fix this fault.

DEFAULT ACTION

- The ETC light will flash.
- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
PCM SOFTWARE UPDATE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**

   NOTE: **If any other DTCs are set, they must be diagnosed and repaired before continuing this test.**

   1. Refer to the recorded DTCs.

Are there any other DTCs active or pending?

Yes

- Perform the applicable diagnostic procedure(s) before continuing with this test procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

No

- Go To 3

3. **CHECK FOR PCM SOFTWARE UPDATE**
    1. With the scan tool, read and record the PCM part number.
    2. Verify the Powertrain Control Module (PCM) is at the latest calibration (flash level).

    Is the PCM at the latest software level?

    Yes

    - Go To 5

    No

    - Go To 4

4. **UPDATE PCM SOFTWARE AND RETEST FOR DTC**
    1. With the scan tool, update the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to the appropriate information .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs in the PCM.
    4. Start the engine and allow it to idle.

    WARNING: When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.

    5. Operate the accelerator pedal by gradually tipping in and out of the throttle and performing various throttle maneuvers. Do not exceed 3500 rpm.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 5

    No

    - Updating the PCM software repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.

4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
   - Proper connector installation.
   - Damaged connector locks.
   - Corrosion.
   - Other signs of water intrusion.
   - Weather seal damage (if equipped).
   - Bent terminals.
   - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
   - Terminals that have been pushed back into the connector cavity.
   - Check for spread terminals and verify proper terminal tension.

   Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P060D-ETC LEVEL 2 APP PERFORMANCE

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Throttle Body Motor is powered.
- No matured DTCs related to APP Sensors present.

SET CONDITION

- When secondary software determines that APP Sensor 1 and APP Sensor 2 signals do not match for a period of time.

DEFAULT ACTION

- ETC lamp will flash.
- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
PCM SOFTWARE UPDATE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR PCM SOFTWARE UPDATE**
    1. With the scan tool, read and record the PCM part number.
    2. Verify the Powertrain Control Module (PCM) is at the latest calibration (flash level).

        Is the PCM at the latest software level?

        Yes

        - Go To 4

        No

        - Go To 3
3. **UPDATE PCM SOFTWARE AND RETEST FOR DTC**
    1. With the scan tool, update the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to the appropriate information .

2. Turn the ignition on.
3. With the scan tool, erase DTCs in the PCM.
4. Start the engine and allow it to idle.

WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

5. Operate the accelerator pedal by gradually tipping in and out of the throttle and performing various throttle maneuvers. Do not exceed 3500 rpm.
6. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 4

   No

   - Updating the PCM software repaired the fault.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. With the scan tool, erase DTCs.
   9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P060E-ETC LEVEL 2 TPS PERFORMANCE

THEORY OF OPERATION

The Powertrain Control Module (PCM) monitors throttle position through inputs from the two Throttle Position Sensors (TPS) inside the Throttle Body Assembly. If there is a discrepancy between the two sensors, then a failure is set. If the primary diagnostic feature does not capture the failure, then secondary software will determine that there is a coherency failure between the sensors.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Throttle Body Motor is powered.
    - No matured DTCs related to the Throttle Position Sensors.

SET CONDITION

- When secondary software determines that TPS 1 and TPS 2 signals do not match for a period of time.

DEFAULT ACTION

- ETC lamp will flash.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
THROTTLE POSITION SENSOR FAULTS
PCM SOFTWARE UPDATE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.

2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
3. With the scan tool, erase all DTCs.
4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any TPS DTCs active or pending?

       Yes

       - Perform the applicable diagnostic procedure(s) before continuing with this test procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 3
3. **CHECK FOR PCM SOFTWARE UPDATE**
    1. With the scan tool, read and record the PCM part number.
    2. Verify the Powertrain Control Module (PCM) is at the latest calibration (flash level).

       Is the PCM at the latest software level?

       Yes

       - Go To 5

       No

       - Go To 4
4. **UPDATE PCM SOFTWARE AND RETEST FOR DTC**
    1. With the scan tool, update the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to the appropriate information .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs in the PCM.
    4. Start the engine and allow it to idle.

       WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear**

loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.

5. Operate the accelerator pedal by gradually tipping in and out of the throttle and performing various throttle maneuvers. Do not exceed 3500 rpm.
6. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 5

   No

   - Updating the PCM software repaired the fault.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. With the scan tool, erase DTCs.
   9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   10. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND**

INSTALLATION .

- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

P060F-ETC LEVEL 2 ECT PERFORMANCE

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Throttle Body Motor is powered.
- No matured DTCs related to ECT Sensor.

SET CONDITION

- When secondary software determines that the Coolant Temperature is implausible for a period of time.

DEFAULT ACTION

- ETC lamp will flash.
- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
PCM SOFTWARE UPDATE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR PCM SOFTWARE UPDATE**
    1. With the scan tool, read and record the PCM part number.
    2. Verify the Powertrain Control Module (PCM) is at the latest calibration (flash level).

        Is the PCM at the latest software level?

        Yes

        - Go To 4

        No

        - Go To 3
3. **UPDATE PCM SOFTWARE AND RETEST FOR DTC**
    1. With the scan tool, update the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to the appropriate information .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs in the PCM.
    4. Start the engine and allow it to idle.

        WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

    5. Operate the accelerator pedal by gradually tipping in and out of the throttle and performing various throttle maneuvers. Do not exceed 3500 rpm.
    6. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Go To 4

        No

        - Updating the PCM software repaired the fault.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
4. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.

- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0615-STARTER CONTROL CIRCUIT/OPEN

For a complete STARTING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Engine Stop/Start (ESS) system utilizes two Starter Relays to operate the Engine Starter Motor. The Body Control Module (BCM) controls one relay with a Low Side Driver (LSD). When the BCM controlled relay is energized, it provides Ground to the other Starter Relay controlled by the Powertrain Control Module (PCM). The PCM controls engine cranking by energizing the second Starter Relay. The Starter Motor can be disengaged by de-energizing either relay. **The relay names and DTC descriptions may not match and can be confusing. In the PCM diagnostics, the relay controlled by the PCM is always considered starter relay 1 and the BCM controlled relay is considered starter relay 2.**

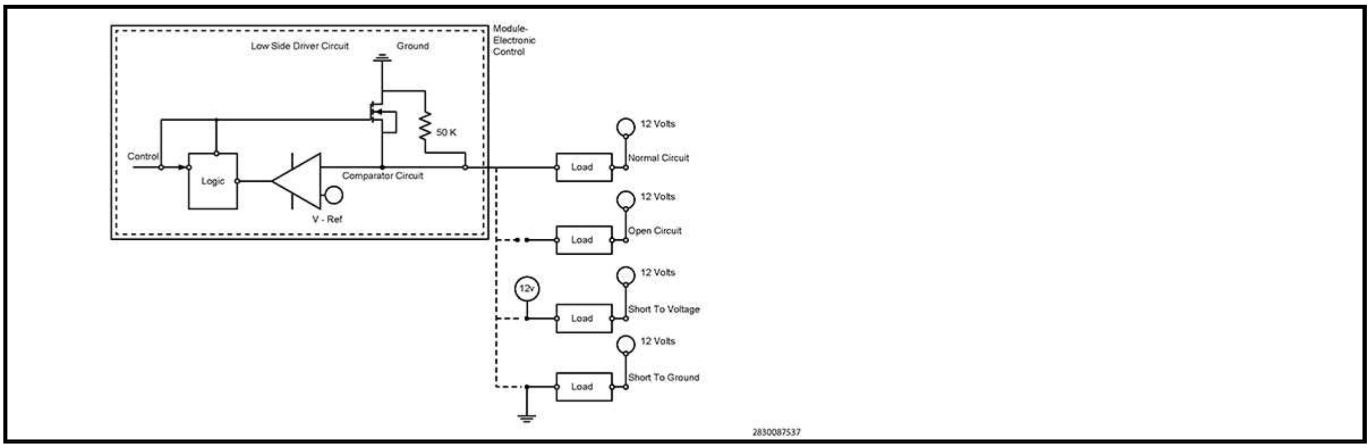
The control circuits for both relays are monitored for circuit faults. The PCM also monitors and performs diagnostics on the output to the Starter Motor on the Ignition Crank Sense circuit. In addition to the control circuit diagnostics for each relay, the PCM also performs diagnostics to detect if one of the relays is stuck in the closed position.

- **Ignition Crank Sense Diagnostics:** The PCM monitors the Ignition Crank Sense circuit voltage when engine cranking is commanded. The Ignition Crank Sense circuit is connected to the Starter Solenoid Feed circuit inside the PDC. During an engine cranking event the PCM expects to see Battery voltage at the Ignition Crank Sense circuit. If no voltage is detected a fault is set.
- **Stuck Relay Diagnostic:** After the engine is initially started, the Powertrain Control Module (PCM) will command one of the Starter Relays closed and the other Starter Relay open and monitor the Ignition Crank Sense circuit for voltage. It will then open the closed relay and close the open relay and monitor the Ignition Crank Sense circuit for voltage. If there is voltage present on the feedback circuit during either of these tests, then the relay that was commanded off when voltage was detected is determined to be stuck closed and a performance fault is set against that relay.

Typical Low Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver device. The PCM provides a ground to operate the device when switched on. The ground could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device, wiring and internal driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. For diagnostic purposes the PCM uses an internal pull down diagnostic resistor connected in series and a voltage reference (V-Ref) comparator for fault detection:

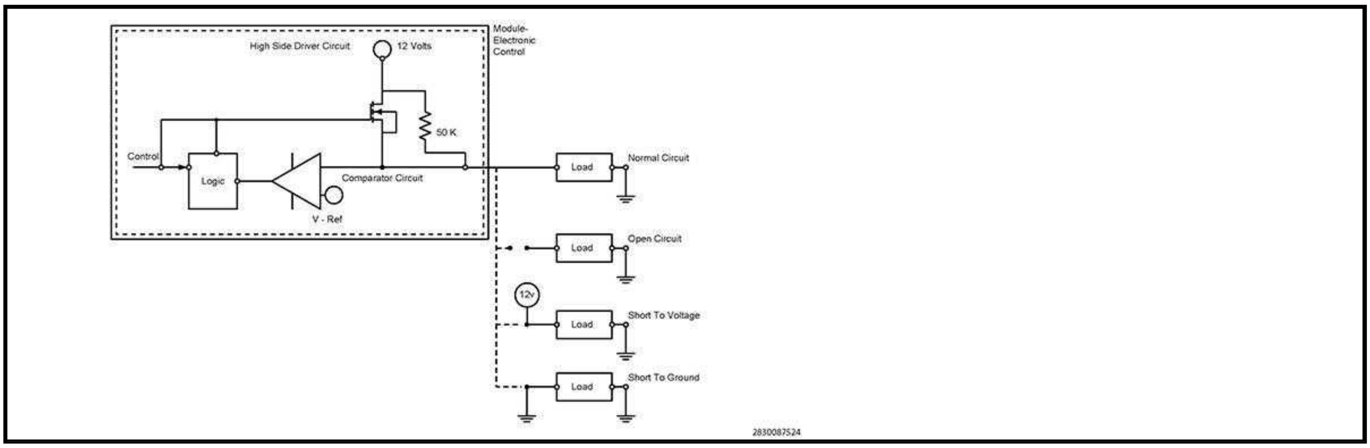
- **Circuit Open and Circuit Low Detection:** The PCM monitors for an **open circuit** and **short to ground** when the driver is switched off. When switched off, the available voltage passes through the device and the **internal pull down resistor** connected in series. The voltage at the **comparator circuit** should be close to Battery voltage since the majority of the voltage drop occurs through the diagnostic resistor. If the available voltage is less than the V-Ref, a fault is set. In this scenario the V-Ref would be slightly below Battery voltage. **An alternative method of fault detection for an open or short to ground** that is used is to monitor current draw when the internal driver is switched on. If the module does not detect any current draw it determines that the component or circuitry is open. Excessive current draw detected would indicate a short to ground.
- **Circuit High Detection:** The PCM monitors for a **short to voltage** when the driver is switched on. When the driver is switched on providing a path to ground through the transistor, the available voltage should be pulled low, near zero volts since the **comparator circuit** is monitoring the ground side of the device. If the voltage is greater than V-Ref, a fault is detected. In this scenario V-Ref would be slightly above zero volts.

NOTE: **A load that has a resistance that is below manufacturer specification, or a second load device shorted to the low side driver circuit can cause excessive current draw on the internal driver. The driver will be switched off to protect against overheating and damaging the driver. In this instance the Circuit High fault may be detected because the available voltage on the comparator circuit is above V-Ref.**



Typical High Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The voltage could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device, wiring and internal driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. The graphic shows how the PCM performs diagnostics using an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A milliampere voltage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect. **An alternative method of fault detection for an open** that is used is to monitor current draw when the internal driver is switched on. If the module does not detect any current draw it determines that the component or circuitry is open.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected. **An alternative method of fault detection for a short to ground** that is used is to monitor current draw when the internal driver is switched on. Excessive current draw detected would indicate a short to ground.



WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the Starter Relay Control commanded off.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The Powertrain Control Module (PCM) detects an open condition in the Starter Relay Control circuit.

DEFAULT ACTION

- This is a non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
STARTER SOLENOID RELAY CONTROL CIRCUIT OPEN/HIGH RESISTANCE
POWER DISTRIBUTION CENTER GROUND CIRCUITS OPEN/HIGH RESISTANCE
STARTER SOLENOID RELAY
POWER DISTRIBUTION CENTER (PDC)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE STARTER RELAY CONFIGURATION**
    1. Check the Power Distribution Center layout in the wiring information to determine if the Starter Solenoid Relay is removable or a Printed Circuit Board (PCB) Relay in the PDC.

        What type of relay is the PDC configured with?

        Removable Relay:

        - Go To 3

        PCB Relay:

        - Go To 8
3. **CHECK THE STARTER SOLENOID RELAY COIL GROUND FOR AN OPEN/HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Remove the Starter Solenoid Relay from the PDC.
    2. Connect the positive lead of the load test tool to the positive side of the Battery.
    3. Connect the negative lead of the load test tool at terminal 85 of the Starter Solenoid Relay connector in the PDC.
    4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

NOTE:	**Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws**

approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .

NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 5

No

- Go To 4

4. **CHECK THE PDC GROUND CIRCUITS FOR AN OPEN/HIGH RESISTANCE BY LOAD TESTING THE CIRCUITS**
   1. Using the appropriate wiring information, disconnect the PDC harness connectors to isolate all of the ground circuits connected to the PDC.

NOTE: **There are multiple ground circuits connected to the PDC through multiple connectors. All of the ground circuits must be tested.**

2. Connect the positive lead of the load test tool to the positive side of the Battery.
3. Connect the negative lead of the load test tool to each ground circuit at the PDC harness connectors.
4. The bulb on the load test tool should be illuminated and bright for each ground circuit if there is no resistance in the circuitry.

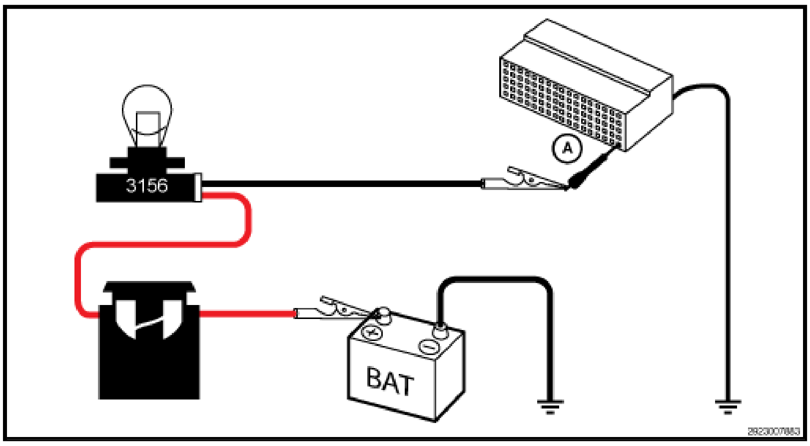
NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright for all ground circuits?

Yes

- Replace the Power Distribution Center (PDC) in accordance with the Service Information. Refer to **CENTER, POWER DISTRIBUTION (PDC), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Repair the faulty ground circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK THE STARTER SOLENOID RELAY (K8) CONTROL CIRCUIT FOR AN OPEN/HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Connect the positive lead of the load test tool at terminal 85 of the Starter Solenoid Relay connector in the PDC.
    2. Connect the negative lead of the load test tool to the negative side of the Battery or a good chassis ground.
    3. Monitor the load tool while attempting to crank/start the engine.
    4. The bulb on the load test tool should be illuminated and bright when the engine is attempting to crank if there is no resistance in the circuitry.

NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To**

perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

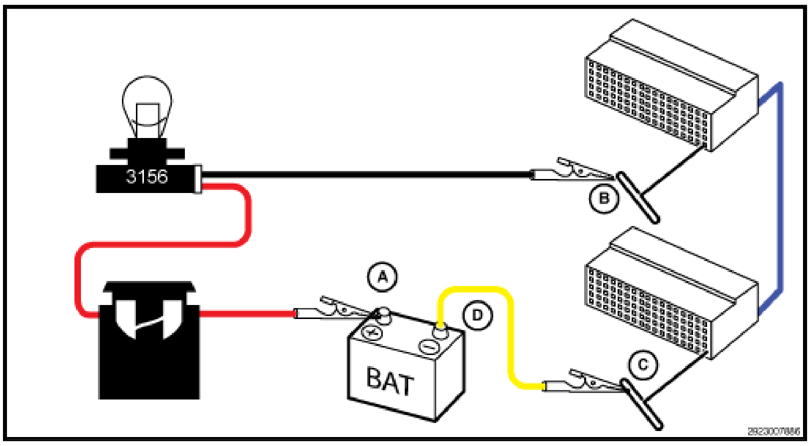
Yes

- Replace the Starter Solenoid Relay in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

No

- Go To 6

6. **ISOLATE AND LOAD TEST THE STARTER SOLENOID RELAY (K8) CONTROL CIRCUIT TO CHECK FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Powertrain Control Module (PCM) and PDC harness connectors.
   3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
   4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
   5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
   6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.



CAUTION:	**Do not load test any circuits with components still connected to the circuit.**

CAUTION:	**Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

7. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE:	**The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE:	**Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 7

No

- Repair the (K8) Starter Solenoid Relay Control circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK THE PCM DRIVER FOR THE STARTER SOLENOID RELAY CONTROL CIRCUIT**
    1. Turn the ignition off.
    2. Connect the PDC and PCM harness connectors.
    3. Connect the negative lead of the load test tool to the negative side of the Battery or a good chassis ground.
    4. Back probe and connect the positive lead of the load test tool to the Starter Solenoid Relay (K8) control circuit at the PDC connector.
    5. Monitor the test light while attempting to crank/start the engine.
    6. The bulb on the load test tool should be illuminated and bright when the engine is attempting to crank.

NOTE:	**Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Check all of the fuses in the PDC. If a fuse is open, replace the fuse and retest. If no problems are found with the fuses replace the PDC in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 11

8. **LOAD TEST TO CHECK (STARTER SOLENOID RELAY (K8) CONTROL CIRCUIT AND PCM DRIVER FOR THE STARTER SOLENOID RELAY CONTROL CIRCUIT**
    1. Turn the ignition off.
    2. Connect the negative lead of the load test tool to the negative side of the Battery or a good chassis ground.
    3. Back probe and connect the positive lead of the load test tool to the Starter Solenoid Relay (K8) control circuit at the PDC connector.
    4. Monitor the bulb while attempting to crank/start the engine.
    5. The bulb on the load test tool should be illuminated and bright when the engine is attempting to crank.

    NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

    Is the load test bulb illuminated and bright?

    Yes

    - Go To 9

    No

    - Go To 10

9. **CHECK THE PDC GROUND CIRCUITS FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUITS**
    1. Using the appropriate wiring information, disconnect the PDC harness connectors to isolate all of the ground circuits to the PDC.

    NOTE: **There are multiple ground circuits connected to the PDC through multiple connectors. All of the ground circuits must be tested.**

    2. Connect the positive lead of the load test tool to the positive side of the Battery.
    3. Connect the negative lead of the load test tool to each ground circuit at the PDC harness connectors.
    4. The bulb on the load test tool should be illuminated and bright for each ground circuit if there is no resistance in the circuitry.

    NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test**

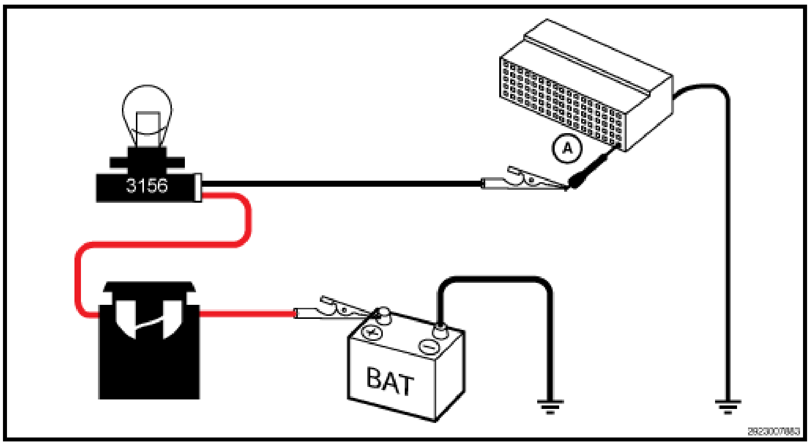
tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .

NOTE: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



NOTE: Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.

Is the load test bulb illuminated and bright for all ground circuits?

Yes

- Check all of the fuses in the PDC. If a fuse is open, replace the fuse and retest. If no problems are found with the fuses replace the PDC in accordance with the Service

Information. Refer to **CENTER, POWER DISTRIBUTION (PDC), REMOVAL AND INSTALLATION** .

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Repair the faulty ground circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **ISOLATE AND LOAD TEST THE STARTER SOLENOID RELAY (K8) CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
    3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
    4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
    5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
    6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

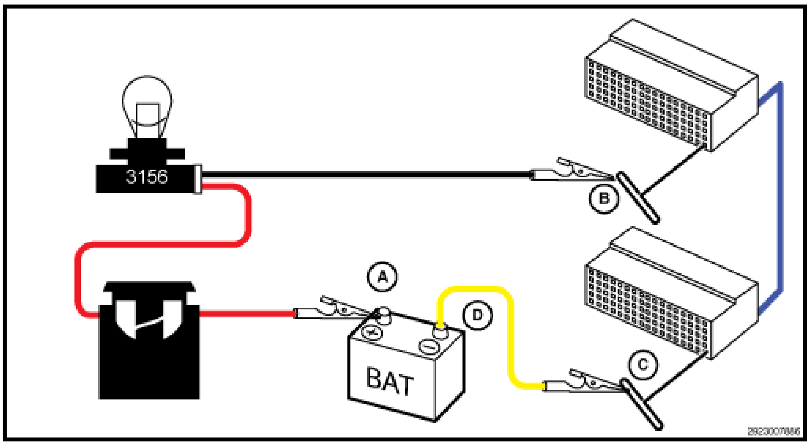
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
- **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 11

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.

5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P061A-LEVEL 2 TORQUE PERFORMANCE

THEORY OF OPERATION

When the Powertrain Control Module (PCM) secondary software determines that the engines torque output is greater than the customers requested output, the engine output is reduced by PCM control.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
- Throttle input is being commanded.

SET CONDITION

- When secondary software determines that engine output exceeds the customers requested output for a period of time.

DEFAULT ACTION

- ETC lamp will flash.
- The MIL will illuminate.
- The Throttle input and vehicle speed are limited.

POSSIBLE CAUSES

Possible Causes
PCM SOFTWARE UPDATE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    NOTE: **An intermittent loss of power to the PCM without performing an ETC Relearn procedure may cause this DTC to set.**

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

        Are there any applicable Service Bulletins or Flash updates?

        Yes

        - Perform the applicable repair.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **CHECK FOR OTHER DTCS**

   NOTE: **Check the engine for air/vacuum leaks and diagnose as needed before continuing.**

   1. Refer to the recorded DTCs.

      Are there any Fuel System Lean/Rich or MAP Sensor DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 4

4. **CHECK RELATED HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. With the scan tool, erase DTCs.
   9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   10. With the scan tool, read DTCs.

       Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P061C-ETC LEVEL 2 RPM PERFORMANCE

THEORY OF OPERATION

The vehicle uses a secondary software to calculate engine RPM independently of the base RPM. The Powertrain Control Module (PCM) compares the value of the secondary software calculation and base RPM to determine if there is a discrepancy.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Throttle input is being commanded.
- No camshaft or crankshaft electrical signal related DTCs are set.

SET CONDITION

- When secondary software determines that the engine speed is implausible for a period of time.

DEFAULT ACTION

- ETC lamp will flash.
- The MIL will illuminate.
- Acceleration rate and engine output are limited.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
PCM SOFTWARE UPDATE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.

2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
3. With the scan tool, erase all DTCs.
4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

NOTE: **An intermittent loss of power to the PCM without performing an ETC Relearn procedure may cause this DTC to set.**

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**

   NOTE: **Check the engine for air/vacuum leaks and diagnose as needed before continuing.**

   1. Refer to the recorded DTCs.

      Are there any Fuel System Lean/Rich or MAP Sensor DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3

3. **CHECK FOR PCM SOFTWARE UPDATE**
   1. With the scan tool, read and record the PCM part number.
   2. Verify the Powertrain Control Module (PCM) is at the latest calibration (flash level).

      Is the PCM at the latest software level?

      Yes

      - Go To 5

      No

      - Go To 4

4. **UPDATE PCM SOFTWARE AND RETEST FOR DTC**
   1. With the scan tool, update the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to the appropriate information .
   2. Turn the ignition on.

3. With the scan tool, erase DTCs in the PCM.
4. Start the engine and allow it to idle.

WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

5. Operate the accelerator pedal by gradually tipping in and out of the throttle and performing various throttle maneuvers. Do not exceed 3500 rpm.
6. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 5

No

- Updating the PCM software repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED PCM OR COMPONENT CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

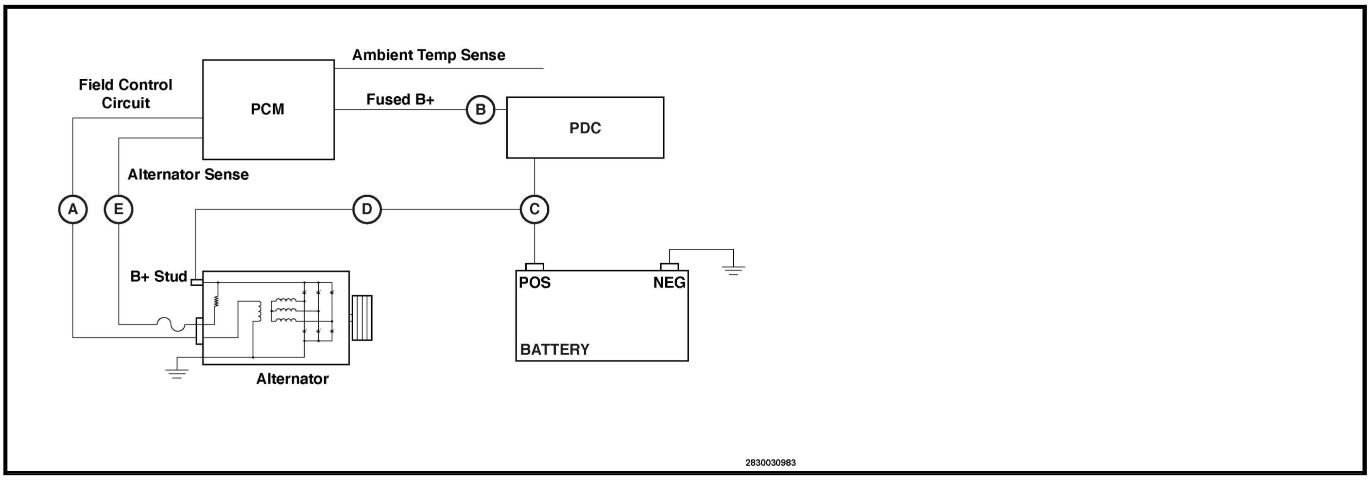
No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0622-GENERATOR FIELD CONTROL CIRCUIT/OPEN

For a complete STARTING/CHARGING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION



The Electronic Voltage Regulation (EVR) system maintains the system voltage at a desired level by turning the Pulse Width Modulated (PWM) Alternator Field Control circuit (A) on and off. When the Alternator field is turned on, the system voltage increases. When the Alternator field is turned off, the system voltage slowly drops. The rate at which this happens is dependent upon the existing electrical loads, ambient under hood temperature, and the engine speed. A constant system voltage (B, C, D) can be maintained only when the Alternator field is switched on and off at a duty cycle that very accurately emulates the existing electrical loads given the existing ambient under hood temperature and engine speed.

During normal operation: The voltage reading at the Alternator output stud will be very close to the target charging voltage viewed on the scan tool. This is the system voltage and is sensed by the Powertrain Control Module (PCM) through the Fused B+ circuit (B). With the Alternator connector plugged in, the voltage reading on the Alternator Sense circuit will be approximately 3.5 volts less than the voltage at the Alternator output stud due the resistor inside the Alternator. This is the Alternator Sense (E) input to the PCM. These two voltage sense inputs are used and compared during the different diagnostics performed on the EVR System by the PCM.

Diagnostic Mode: When the PCM detects that the output voltage is too high or too low, the PCM runs a series of diagnostics to determine the cause. When the diagnostic is initiated, the PCM will change the field control circuit and look for a change in the output voltage. If no reaction is detected, the PCM rationalizes that it has lost control of the Alternator Field Control (A) due to an open or shorted condition. If the Alternator Field control is active, and the engine speed is above a calibrated threshold, the PCM will run a series of tests that turn the Alternator Field control off and on for a brief period of time and monitors the system voltage (B) for a calibrated amount of change in the voltage, to determine a failure of the Alternator. This diagnostic test requires repeated failures to insure that an erroneous fault is not set.

WHEN MONITORED AND SET CONDITIONS

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.

Set Conditions:

- The Powertrain Control Module (PCM) attempts to regulate the Alternator field with no result during monitoring.

Default Actions:

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

Possible Causes
ALTERNATOR FIELD CONTROL CIRCUIT SHORTED TO BATTERY VOLTAGE
ALTERNATOR FIELD CONTROL CIRCUIT OPEN/HIGH RESISTANCE
ALTERNATOR FIELD CONTROL CIRCUIT SHORTED TO GROUND
POOR ENGINE BLOCK OR ALTERNATOR CASE GROUND
ALTERNATOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To2

    No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE ALTERNATOR DUTY CYCLE**
   1. With the scan tool, check the Duty Cycle reading for the Alternator.

   NOTE: **During normal operation the typical duty cycle of the field control at idle with minimal loads is approximately 35-40%, which will equate to between 4.0 and 5.0 volts. Depending on the charging issue, the PCM can drive the duty cycle to off (0%), which will equate to zero volts, or full field (100%), which will equate to between 11.0 and 12.0 volts.**

   What is the Alternator duty cycle on the scan tool?

   0%

   - Go To 3

   100%

   - Go To 5

3. **CHECK THE ALTERNATOR (K20) FIELD CONTROL CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Turn the ignition on.
   4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

   NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

   Is the voltage above 5.2 volts?

   Yes

   - Go To 5

   No

   - Go To 4

4. **ISOLATE AND CHECK THE ALTERNATOR (K20) FIELD CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
   4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK THE ALTERNATOR FIELD CONTROL CIRCUIT VOLTAGE**
    1. Back probe the (K20) Alternator Field Control circuit at the Alternator harness connector.

    WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

    2. Measure the voltage on the (K20) Alternator Field Control circuit at the Alternator harness connector.

    Is the voltage between 11.0 and 12.0 volts?

    Yes

    - Verify that there is good pin to terminal contact in the Alternator and Powertrain Control Module connectors. Also verify that engine block has a good ground and the Alternator has a good case ground. If OK, replace the Alternator. Refer to **GENERATOR, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 6
6. **ISOLATE AND CHECK THE ALTERNATOR (K20) FIELD CONTROL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 7

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **ISOLATE AND CHECK THE ALTERNATOR (K20) FIELD CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, (special tool #10436, Adapter, GPEC Diagnostic) connect the to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 8

8. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.

5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0627-FUEL PUMP CONTROL CIRCUIT OPEN

For a complete FUEL DELIVERY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

GENERAL OPERATION: When the Powertrain Control Module (PCM) receives a 'Start' or 'Run' signal, it energizes the Fuel Pump Relay which sends a continuous 12.0 volt supply to the Fuel Pump Control Module (FPCM). Depending on vehicle configuration, the Fuel Pump Relay can be either a removable component or part of the Printed Circuit Board (PCB) inside the Power Distribution Center (PDC). The PCM sends commands to the FPCM through a Pulse Width Modulated (PWM) control signal. The FPCM in turn regulates the PWM voltage output to the Fuel Pump Assembly based on inputs from the Fuel Pressure Sensor and other engine demands. The PWM signal will vary from 10-100% to maintain the proper fuel pressure in the system.

This is a Constant Pressure Fuel system which means any fuel pressure test performed on the Fuel Pump should show a continuous pressure (regardless of the changes in PWM).

DIAGNOSTICS: The PCM directly monitors the Fuel Pump Relay Control circuit and the Fuel Pressure Sensor for circuit faults. The PCM also monitors the feedback from the FP Sensor to determine if the Fuel Pump Assembly is able to achieve and maintain the desired pressure in the fuel system. The FPCM is a smart device which monitors the Fuel Pump Assembly wiring for circuit faults and reports the faults to the PCM. The PCM receives the feedback from the FPCM through the PWM feedback signal. These faults reported will be stored in the PCM. The pump motor is also monitored for mechanical and performance issues such as Fuel Pump Motor over temperature, blocked pump rotor, dry run, and pump motor speed deviation. If any of these conditions are present, the FPCM will default the duty cycle for the Fuel Pump Assembly to (80%) to maintain fuel pressure. The default duty cycle could cause the fuel system pressure to be higher than calibrated threshold, which can also cause the P062A-Fuel Pump Control Performance fault to set. **If other FPCM DTCs are present along with the P062A they should always be diagnosed first.**

NOTE: **The Fuel Pump Assembly can be failing as stated above and still produce high fuel pressure in the system when the FPCM is defaulted to 80% duty cycle. If the P062A DTC is not accompanied by another fuel control system DTC, and the Fuel Rail Pressure Sensor is reading correctly, the Fuel Pump Assembly is the most likely cause of this DTC.**

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The Powertrain Control Module (PCM) detects an open or shorted condition on the Fuel Pump Relay Control circuitry.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
FUEL PUMP RELAY CONTROL CIRCUIT SHORTED TO VOLTAGE
FUEL PUMP RELAY CONTROL CIRCUIT SHORTED TO GROUND
FUEL PUMP RELAY CONTROL CIRCUIT OPEN
POWER DISTRIBUTION CENTER
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding.
Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.

3. With the scan tool, erase all DTCs.
4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **ISOLATE AND CHECK THE FUEL PUMP RELAY (N9) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 3

3. **ISOLATE AND CHECK THE FUEL PUMP RELAY (N9) CONTROL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide

to follow the path of the circuit.

3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 4

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE POWER DISTRIBUTION CENTER**
   1. Reconnect the PDC harness connector.
   2. Turn the ignition on.
   3. Measure the voltage on the Fuel Pump Relay (N9) Control circuit at the GPEC Adaptor.

   Is the voltage equal to Battery voltage?

   Yes

   - Go To 5

   No

   - Check all of the fuses in the Power Distribution Center. If all of the fuses are good, replace the Power Distribution Center in accordance with the Service Information. Refer to **CENTER, POWER DISTRIBUTION (PDC), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:

- Proper connector installation.
- Damaged connector locks.
- Corrosion.
- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

P0628-FUEL PUMP CONTROL CIRCUIT LOW

For a complete FUEL DELIVERY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

KNOWN ISSUES - FPCM SYSTEM

While the FPCM has the capability of detected failure modes, the faults are not always reported out as intended. Some vehicles have incorrect calibrations that will read the FPCM messages incorrectly and set the DTCs incorrectly. On these vehicles it is best not to rely on the DTC, or DTC Description when deciding which portion of the system to diagnose. In these cases it is best to read and understand how the system operates, then diagnose the entire system to determine where the failure lies by performing the **Complete Fuel Pump Control Module System Diagnostics (Not DTC Specific)** procedure when diagnosing this system. This diagnostic can also be used to diagnose the FPCM command, feedback and fuel pump control circuits on vehicles with the correct calibration software.

The vehicles listed below will set faults incorrectly for the model years listed and should always be diagnosed using the Not DTC specific system approach.

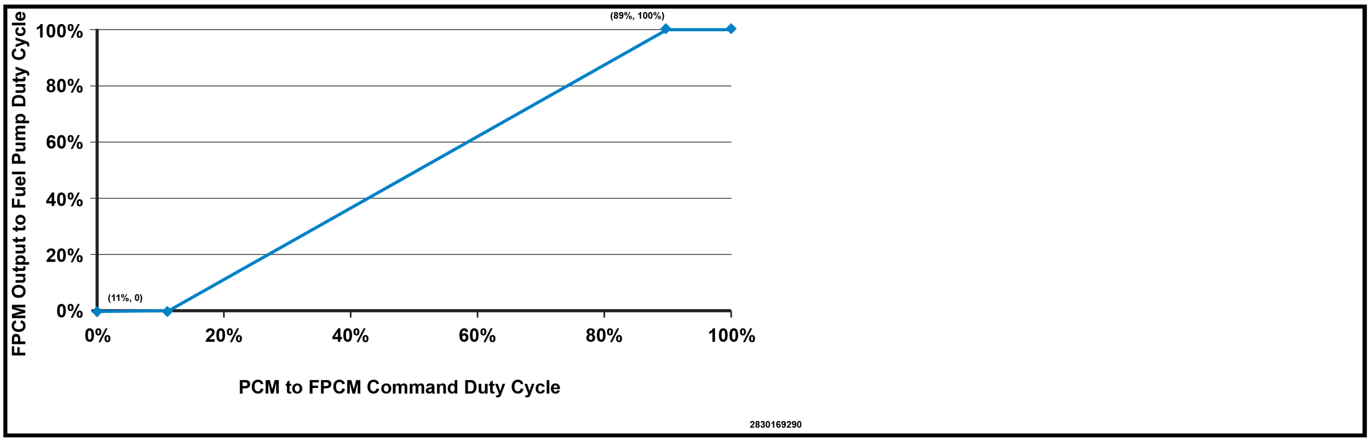
- DS - model years 2016-2019
- RU - model years 2017-2018
- JL - model year 2018
- JT - model year 2020

The exceptions to the information above are the Loss of Communication, Fuel Rail Pressure Sensor and Fuel Pump Relay Control circuit faults. These faults will typically set correctly since they are detected by the PCM directly, not the FPCM.

FPCM SYSTEM DESCRIPTION AND OPERATION

SYSTEM DESCRIPTION: When the Powertrain Control Module (PCM) requires Fuel Pump operation it energizes the Fuel Pump Relay. The Battery voltage output from the relay does not connect directly to the Fuel Pump like traditional systems. Instead, the Battery voltage is supplied to the Fuel Pump Control Module (FPCM). When the ignition is switched on, the Battery voltage is present for approximately five seconds. Battery voltage should always be present during cranking or when the engine is running. The purpose of FPCM is to operate the Fuel Pump at a reduced voltage output to reduce electrical load on the system. Most vehicle/engine combinations operate as a **fixed pressure system** . Vehicles with the 6.2L engine operate as a **variable pressure system** . It is necessary on some vehicles with the 6.2L engine to have a second Fuel Pump and FPCM to meet engine needs. The second FPCM performs the same diagnostics as the primary module but uses different DTCs.

SYSTEM OPERATION: To maintain the desired fuel pressure, the PCM sends a Pulse Width Modulated (PWM) duty cycle signal to the FPCM. If there are no system faults present, the Fuel Pump Control output to the Fuel Pump is based on the duty cycle sent by the PCM. The graph below shows the FPCM output to the Fuel Pump in proportion to the PCM command signal. **The FPCM output to the fuel pump will not read as a duty cycle when monitoring with a Mopar Scope. It will be a consistent voltage output that is a percentage of battery voltage.**



COMPONENT FUNCTIONAL DESCRIPTION- FUEL PUMP CONTROL MODULE (FPCM) AND FUEL PUMP

The FPCM performs fault detection and reports faults to the PCM through the PWM Feedback circuit. The feedback circuit can be monitored using the Mopar Scope and functions as follows:

- The feedback circuit is a 5.0 volt duty cycle.
- The PCM supplies the 5.0 volts for the feedback circuit.
- The FPCM pulses the low side of the circuit to communicate with the PCM.
- The normal duty cycle operating range is between 3% and 97%.
- When the system is operating normally, the FPCM will send a 50% duty cycle on the feedback circuit to the PCM.
- When the FPCM detects a fault it will send a duty cycle that aligns with the failure mode detected.

- If the duty cycle is 0% or 100% the PCM will set the Loss of Communication fault against the FPCM.

NOTE: **Monitoring the FPCM internal driver with an open feedback circuit using the Mopar Scope will show a pulse width signal with a very low voltage (.025v - 0.5v). This is picking up voltage from the internal driver device that is still trying to pulse the duty cycle to the PCM. This can be useful when performing diagnostics on the feedback circuitry.**

Depending on the failure mode detected by the PCM and FPCM, the FPCM can react by either reducing the PWM output duty cycle, or defaulting to an 80% duty cycle for the fuel pump operation. The FPCM reactions are explained further in the PCM/FPCM Reaction column of the Enable Conditions and Failure Modes information.

Fuel Pump: The Fuel Pump operates in the same manner as a typical Brushed DC motor. The only difference is that the speed is reduced due to the PWM output voltage from the FPCM being less than 100%. The voltage supplied is based on the command received from the PCM.

Vehicles with Dual Pump Systems: The fuel pumps operate independently, but may be serviced as an assembly on some vehicles. During normal operation both Fuel Pumps are used to provide the system pressure and volume needed during most engine operating conditions. **The exception is at idle, or idle and purging where there is extremely low fuel demand.** During this mode Fuel Pump 2 is typically turned off. When more fuel demand is needed (typically off idle) Fuel Pump 2 is turned on and both pumps are operated at the same duty cycle. If either pump is failing the vehicle may still operate normally during most driving conditions but would have performance issues under heavy engine load when both pumps are needed. If a failure is detected for either Fuel Pump or circuitry, the duty cycle will typically default to 80%. If Fuel Pump 1 (primary) is defaulted to 80%, Fuel Pump 2 may remain off during most operating conditions. **However, if Fuel Pump 2 is defaulted to 80%, the primary pump will continue to operate at the lower duty cycle range. The reason for this is that the primary pump operates the jet pump to pull fuel from the secondary side of the Fuel Tank and also fills the Fuel Pump assembly reservoir.**

COMPONENT FUNCTIONAL DESCRIPTION - POWERTRAIN CONTROL MODULE (PCM)

The PCM monitors the input signal from the Fuel Rail Pressure Sensor to determine the commanded duty cycle to the FPCM. On a fixed pressure system the PCM varies the commanded duty cycle to maintain a constant pressure. On variable pressure systems the commanded duty cycle is varied to adjust fuel pressure based on engine needs. Ambient temperature and fuel temperature can also contribute to fuel pressure changes. The pressure is raised during high ambient temperatures to prevent boiling of the fuel.

NOTE: **On vehicles with diesel engines or high pressure gas fuel systems, the PCM monitors the Fuel Pressure Sensor on the low pressure side of the system to determine the commanded duty cycle, not the Fuel Rail Pressure Sensor on the high pressure side.**

The command circuit can be monitored using the Mopar Scope and functions as follows:

- The command circuit is a 12.0 volt duty cycle.
- The FPCM supplies the 12.0 volts for the command circuit.
- The PCM pulses the low side of the circuit to communicate with the DTCM.
- The normal duty cycle operating range is between 11% and 89%.
- If the FPCM does not receive a valid command signal from the PCM it will send a fault message on the feedback circuit and operates the fuel pump at a defaulted value (typically 80%).

With an open command circuit, the PCM internal driver will show a pulse width signal of approximately 2.5v if checking at the PCM connector with the Mopar Scope. This is picking up voltage from the internal driver device that is still trying to pulse the duty cycle to the FPCM. This can be useful when performing diagnostics on the command circuitry.

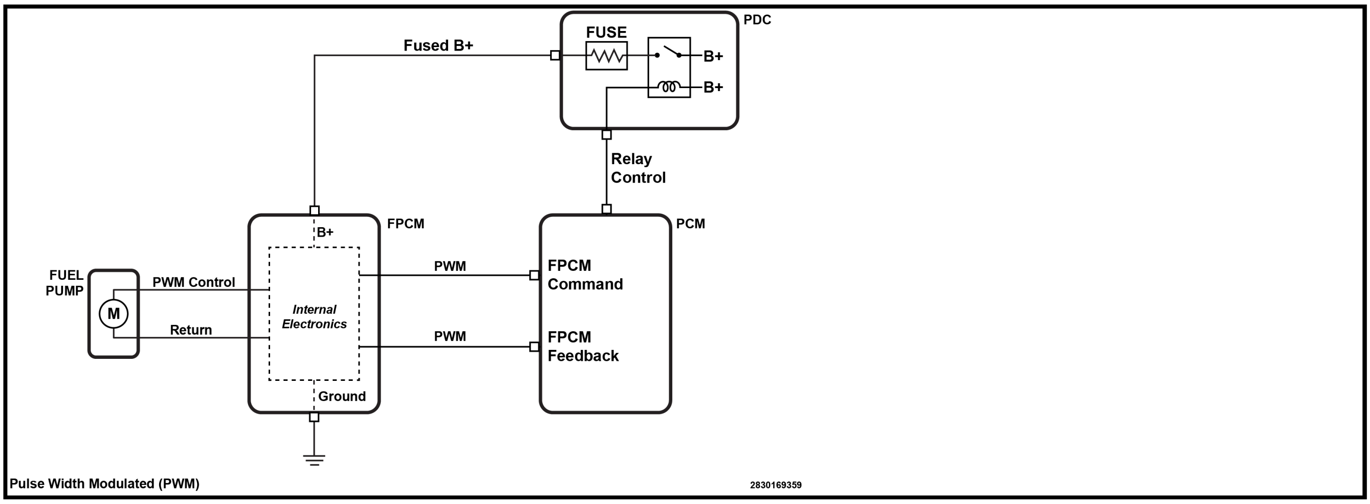
When the PCM loses communication with the FPCM it will default to the highest duty cycle. This will cause the FPCM to provide maximum voltage output to the fuel pump.

TECHNICAL DATA-FUEL SYSTEM PRESSURE SPECIFICATIONS

The table below shows the fuel system pressure specifications.

VARIABLE FUEL PRESSURE SYSTEM SPECIFICATIONS (6.2L ENGINES)		
CRANKING	520 kPa (75.4 psi)	System operates in open loop during cranking
IDLE	340 - 400 kPa (49 - 58 psi)	Normal operating range at idle - Pressure is dependant on ambient and fuel temp. Pressure is raised during high temp to prevent boiling
NORMAL RANGE OF OPERATION	340 - 550 kPa (49 - 80 psi)	Normal operating range between idle and high engine demand
100% DUTY CYCLE	600 - 700 kPa (87 - 101.5 psi)	This is regulated by the pressure relief valve in the Fuel Pump. The pressure can vary from pump to pump.
Â		
4 CYLINDER (1.0L/1.3L GSET / 2.0L GMET ENGINES)		
CRANKING	580 kPa (84.1 psi)	System operates in open loop during cranking
ALL OTHER OPERATING CONDITIONS	520 kPa (75.4 psi)	The fixed pressure systems should maintain approximately 75.0 psi during normal operation
Â		
FIXED PRESSURE SYSTEM SPECIFICATIONS (ALL OTHER ENGINES)		
The fixed pressure systems should maintain approximately 400 kPa (58.0) psi during normal operation		

GENERIC SYSTEM SCHEMATIC:



WHEN MONITORED

SET CONDITION

- The Powertrain Control Module (PCM) detects a fault in the Fuel Pump Control System.

DEFAULT ACTION

- The MIL will illuminate.

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

The table below shows the FPCM DTCs and the correlating INTENDED failure modes. **NOTE: On some vehicles the faults may not always set as expected which may lead to a misdiagnosis (See the know issue information). Therefore, it is usually best to perform the "Complete Fuel Pump Control Module System Testing (Not DTC Specific)" in the diagnostic information.**

POSSIBLE CAUSES

FPCM 1 DTC	FPCM 2 DTC	FAILURE MODES	POSSIBLE CAUSES	PCM/FPCM REACTION
P025A	P027A	Missing or invalid PWM Command signal from PCM	1. PCM to FPCM Command Signal open 2. PCM to FPCM Command Signal shorted low or high 3. Invalid PWM signal - frequency out of range 4. FPCM 5. PCM	• FPCM defaults the output to the Fuel Pump to 80% duty cycle **NOTE:** **It is not uncommon for the P025A DTC to set erroneously for several other failure modes**
P025B	P027B	Output driver over temp	1. FPCM Output partially shorted to ground 2. Faulty Fuel Pump (high mechanical resistance) 3. Faulty FPCM internal driver	• PCM sets fault, waits a calibrated period and commands a safe duty cycle • FPCM output to Fuel Pump to 50% duty cycle for a calibrated period. If over temp continues, shut down output driver.
P025C	P027C	System under voltage - Fuel Pump Relay output voltage to FPCM is below a calibrated threshold (approximately 6.0 volts)	1. High resistance in the Fuel Pump Relay output circuit 2. FPCM	• PCM requests 100% Fuel Pump operation • FPCM defaults the output to the Fuel Pump to 80% duty cycle
P025D	P027D	System over voltage - Fuel Pump Relay output voltage to FPCM is above a calibrated threshold (approximately 16.0 volts)	1. Charging system issue	• PCM applies over voltage strategy • FPCM reacts to PCM input command
P0628	P2633	FPCM output to Fuel Pump shorted to ground	1. Fuel Pump PWM Control circuit shorted to ground	• PCM reduces PWM duty cycle until issue clears • FPCM reacts to PCM input command

FPCM 1 DTC	FPCM 2 DTC	FAILURE MODES	POSSIBLE CAUSES	PCM/FPCM REACTION
P0629	P2634	FPCM output to Fuel Pump shorted to voltage	1. Fuel Pump PWM Control circuit shorted to voltage	• FPCM output to Fuel Pump to 50% duty cycle for a calibrated period. If condition continues, shut down output driver.
P062A	P062A	Actual fuel pressure is above or below the desired fuel pressure by more than a calibrated threshold. • Fixed pressure system - 5.8 psi above or 14.5 psi below • Variable pressure system - 10.9 psi above or below	1. No fuel in the Fuel Tank 2. Fuel supply tube broken/leaking 3. Fuel supply tube pinched/restricted 4. FPCM defaulted to 80% due to another failure detected 5. FPCM duty cycle output reduced due to another failure detected 6. Faulty Fuel Pump	• PCM requests 100% Fuel Pump operation • FPCM defaults the output to the Fuel Pump to 80% duty cycle
P064A	P26EA	Current draw exceeds calibrated threshold	1. Fuel Pump PWM Control circuit shorted to voltage 2. Faulty Fuel Pump - internal short or high mechanical resistance	• PCM reduces PWM duty cycle until issue clears • FPCM reacts to PCM input command
P1205	P120A	FPCM Micro internal fault	1. Fuel Pump Control Module	• FPCM continues to run in normal mode - run Fuel Pump according to PCM command signal
P1206	P120B	FPCM output to Fuel Pump open circuit	1. Fuel Pump PWM Control circuit open 2. Fuel Pump Return/Ground circuit open 3. FPCM Ground circuit open 4. FPCM	• PCM reduces PWM duty cycle until issue clears • FPCM reacts to PCM input command
U0109	U016C	PCM Loss of Communication with FPCM	1. FPCM PWM Feedback circuit open 2. FPCM PWM Feedback shorted low or high 3. Fuel Pump Relay output circuit to FPCM open or shorted to ground 4. FPCM Ground circuit open	• PCM requests 100% Fuel Pump operation • FPCM defaults the output to the Fuel Pump to 80% duty cycle

FPCM 1 DTC	FPCM 2 DTC	FAILURE MODES	POSSIBLE CAUSES	PCM/FPCM REACTION
			5. Fuel Pump PWM Control circuit shorted to ground 6. FPCM 7. PCM	

DIAGNOSTIC OVERVIEW-FUEL PUMP CONTROL MODULE

GENERAL DIAGNOSTIC INFORMATION: There are several faults associated with this system. The failure modes being monitored for are Loss of Communication, internal FPCM faults, system voltage faults, Thermal Protection, circuit faults, and system performance. **On several vehicles, multiple or incorrect faults** can set which can mislead diagnosing the vehicle. For this reason, it is a good practice to perform a total system diagnosis regardless of the DTC present for most faults. The communication faults are detected directly by the PCM and will typically set correctly. See Communication Diagnostics explanation below.

PCM DIAGNOSTICS: The PCM directly monitors the Fuel Pump Relay Control circuit, FPCM Feedback circuit and the Fuel Pressure Sensor circuits for faults. The Fuel Pressure Sensor signal must be rationalized since the signal is monitored to perform fuel system pressure performance diagnostics. This is done by watching the signal at initial engine start up for both types of systems. **On the fixed pressure system** the normally stable fuel pressure is dynamic for the first few seconds. The pressure will spike above the set point approximately 40-50 kPa (5.8-7.25 psi), then drop below the set point approximately 60-70 kPa (8.7-10.2 psi), and quickly dampen and settle at the set point 400kPa (58.0 psi). At initial engine start up, when the engine speed reaches approximately 500 rpm, the Powertrain Control Module (PCM) measures the delta pressure change between the highest pressure reading and lowest pressure reading and make determinations about sensor rationality. The diagnostic works the same **on the variable pressure system** as the fixed pressure system except that the system is in open loop at start up and the pressure is commanded to a preset known value to perform the diagnostic.

SYSTEM VOLTAGE DIAGNOSTICS: The FPCM monitors the Battery voltage supply coming from the Fuel Pump Relay to the module. A fault will set if the voltage is too high or too low. Typically a voltage high fault would indicate a charging system issue. The voltage low fault could also be a charging system issue, but may also be caused by resistance in the Battery supply or ground circuit.

COMMUNICATION DIAGNOSTICS: Unlike other system faults, the Loss of Communication fault will typically set correctly. The PCM will set this fault when the FPCM PWM Feedback duty cycle is below 3% or above 97%. This can occur if the FPCM Battery voltage supply or ground circuits are open, or the FPCM PWM Feedback circuit is open or shorted.

FUEL PUMP PERFORMANCE DIAGNOSTICS: The PCM fails the **P062A** Fuel System Performance diagnostic when the actual fuel pressure is approximately **100 kPa (14.5 psi) below or 40 kPa (5.8 psi) above the desired fuel pressure.** This fault usually sets along with other faults since the FPCM will default to 80% duty cycle for many failure modes which causes the actual pressure to be higher than the desired set point. The entire system should be examined when this fault is set, including the Fuel Pressure Sensor and circuits. A sensor drifted out of range, or high resistance in the signal or sensor ground circuit can cause a false reading on a normally operating system.

- **The dual pump variable pressure systems can be tricky when diagnosing a performance fault.** The fuel pressure may be good with one failed pump during most normal operating conditions. The condition may only be present under very heavy engine load conditions when both pumps are needed to produce the pressure and volume needed. If available on the scan tool, monitoring duty cycle for both pumps can help diagnosing the issue. If a failure is detected for either Fuel Pump or circuitry, the duty cycle will typically default to 80%. If Fuel Pump 1 (primary) is defaulted to 80%, Fuel Pump 2 may remain off during most operating conditions. However, if Fuel Pump 2 is defaulted to 80%, the primary pump will continue to operate at the lower duty cycle range. The reason for this is that the primary pump operates the jet pump to pull fuel from the secondary side of the Fuel Tank and also fills the Fuel Pump reservoir.

The FPCM fails the **P064A** Fuel Pump Control Module Performance when excessive current draw is detected on the fuel pump circuitry. The FPCM will default and reduce the duty cycle to the fuel pump to the lowest possible duty cycle while the issue is present.

For most vehicles the fuel pressure desired and actual values, as well as the Fuel Pump output duty cycle data can be viewed on the scan tool. These readings can be very useful during the diagnosis of the system.

TECH TIP: A vehicle will typically have one of two issues;

1. The vehicle has no fuel pressure/pump is not operating.
   - The first thing to check for is a Loss of Communication fault. The reason is that the same Battery supply and ground circuit that are used to power up the FPCM are also used for the Fuel Pump motor to operate. A loss of Battery supply, or a poor chassis ground for the module will cause both issues.
   - The next thing to look for is an output from the FPCM to the pump. This can be done with the scan tool or by checking the duty cycle output from the FPCM. If there is any output from the FPCM to the Fuel Pump, the pump should be operating and creating fuel pressure. If the pump is not running then the Fuel Pump and circuits between the FPCM and Fuel Pump should be focused on during diagnostics. If the Loss of Communication fault is not present the Battery supply and chassis ground are most likely good.
2. The vehicle runs normally, has a DTC or DTCs present, and the output duty cycle to the Fuel Pump is defaulted. In most cases, the output is defaulted to 80% and the actual pressure is greater than the desired pressure.
   - The first thing to check is for a Loss of Communication fault. If the vehicle is running with a Loss of Communication fault, and an 80% output duty cycle, it would typically point to an issue with the FPCM PWM Feedback circuit. A loss of Battery supply or a poor chassis ground would usually cause no Fuel Pump operation and a no start condition.
   - If there is no Loss of Communication fault then this condition is most likely present due to an issue with the command circuit, an over current draw or over temp condition with the Fuel Pump.

PRELIMINARY DIAGNOSTIC CHECKS

1. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the ECU. Low Battery voltage can cause a DTC.
3. Circuit faults should typically be diagnosed before rationality/performance faults.
4. Check the component harness connector(s) for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the component harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCs and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns, or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. **Since the FPCM monitors the Fuel Pump circuits and motor for excessive current draw and over temperature conditions,** it is possible that the pump may need to run for an extended period for the condition to be present.

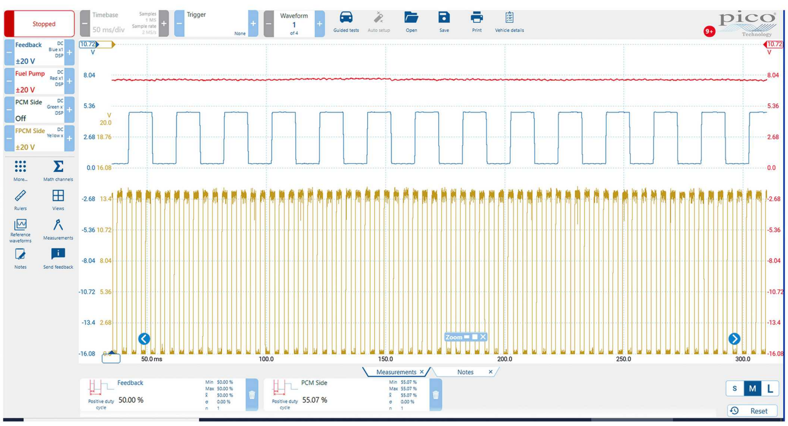
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply, check for connection issues by wiggle testing any wiring harnesses and in-line connectors the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach a lab scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor battery system voltage or poor ground connections can affect systems in different or odd ways. Check the battery or batteries for proper charge and operation along with proper connections. Use the wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving. Operate the components through a full range of operation while monitoring functionality.

DIAGNOSTIC TEST - FUEL PUMP PWM CONTROL CIRCUIT FAULTS (P0628, P0629, P1205, P120B, P2633, P2634)

TECH TIP: The FPCM DTCs will set incorrectly for some vehicles/model years due to incorrect calibrations. For those vehicles it is best to perform the "COMPLETE FUEL PUMP CONTROL MODULE SYSTEM TESTING (NOT DTC SPECIFIC)" diagnostic procedure. Refer to the "KNOW ISSUES" information above for a list of the vehicles with incorrect calibrations.

FUEL PUMP PWM CONTROL CIRCUIT OPEN/LOW/HIGH (P0628, P0629, P1205, P120B, P2633, P2634): There should be a relatively constant voltage on the fuel pump control circuit. When the system is operating normally without any faults the output voltage is typically around 7.0 - 9.0 volts. When there is a fault in the system the output is typically higher due to the FPCM defaulting to a higher output (between 10.5 volts and battery voltage). For this reason the fuel pump output voltage may be high near battery voltage due to an issue in the Fuel Pump circuits or one of the other FPCM circuits (Command or Feedback). If one of those circuits indicates an issue or has a DTC set against it, diagnose that circuit before continuing with the diagnosis of the fuel pump circuits.

The test method listed below can be performed using the Mopar Scope or with a meter.



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Blue Channel - Feedback circuit
Red Channel - Fuel Pump Control circuit
Yellow Channel - Command circuit

1. Back probe the fuel pump PWM control circuit and fuel pump ground circuit at the fuel pump harness connector. Crank or start the engine while monitoring the voltage on both circuits. The red channel on the pattern above shows the normal output to the fuel pump on the fuel pump PWM control from the FPCM. The fuel pump PWM control circuit voltage is typically around 7.0 - 9.0 volts. The ground circuit should have 0 volts and the pump should operate if the pump and circuits are working properly. Select the result that best matches the voltage readings.
    1. The voltage on both circuits reads as described above and the fuel pump is running, the fuel pump and circuits are operating normally.
        - The issue could be either an intermittent condition, poor pin fit at a connector, or a calibration issue setting the incorrect DTC. If the terminals appear good and an intermittent issue isn't found perform the "DIAGNOSTIC TEST - COMPLETE FUEL PUMP CONTROL MODULE SYSTEM TESTING (NOT DTC SPECIFIC)" diagnostic to check the entire system operation.
    2. The voltage on both circuits reads as described above but the fuel pump does not operate, the fuel pump is faulty.
        - Replace the fuel pump in accordance with the service information.
    3. There is equal voltage present on both the fuel pump PWM control circuit and ground circuit. Example: 10 volts on both circuits.
        - Repair the ground circuit for an open. **NOTE: The fuel pump ground circuit grounds through the FPCM chassis ground circuit. this condition may also be accompanied by a loss of communication DTC. This will likely lead to a no start with no fuel pump operation.**
    4. If the fuel pump PWM control circuit and ground circuit voltage is 0 at the Fuel Pump harness connector, the fuel pump PWM control circuit is open or shorted to ground. Repair the circuit for an open or short to ground. **NOTE: A short to ground in the fuel pump PWM control circuit may cause the fuse to open for the FPCM Battery voltage supply from the relay, which can cause a Loss of Communication fault also. This will lead to a no start with no fuel pump operation.**
    5. The fuel pump PWM control circuit is reading battery voltage and the fuel pump ground circuit voltage is 0 volts. Either there is a fault with another circuit or the fuel pump PWM control circuit is shorted to battery voltage.
        - The condition will most likely occur due to a fault in the command or feedback circuit. Perform the "DIAGNOSTIC TEST - COMPLETE FUEL PUMP CONTROL MODULE SYSTEM TESTING (NOT DTC SPECIFIC)" diagnostic to check the entire system operation. If the command and feedback circuits are functioning properly and the voltage supply to the FPCM is good, the fuel pump PWM control circuit is likely shorted to battery voltage. Repair the circuit for a short to voltage.

DIAGNOSTIC TEST - COMPLETE FUEL PUMP CONTROL MODULE SYSTEM TESTING (NOT DTC SPECIFIC)

TECH TIP: The FPCM DTCs will set incorrectly for some vehicles/model years due to incorrect calibrations. For those vehicles it is best to perform the "COMPLETE FUEL PUMP CONTROL MODULE SYSTEM TESTING (NOT DTC SPECIFIC)" diagnostic procedure. Refer to the "KNOW ISSUES" information above for a list of the vehicles with incorrect calibrations.

COMPLETE FUEL PUMP CONTROL MODULE SYSTEM DIAGNOSTICS:

Using the Mopar Scope is the preferred and best method for diagnosing the FPCM and circuits. The circuits can be monitored one at a time or all together using all four channels of the scope.

This test is written with the leads back probed and connected at the FPCM connector unless otherwise specified

Crank or start the engine while monitoring each of the following circuits:

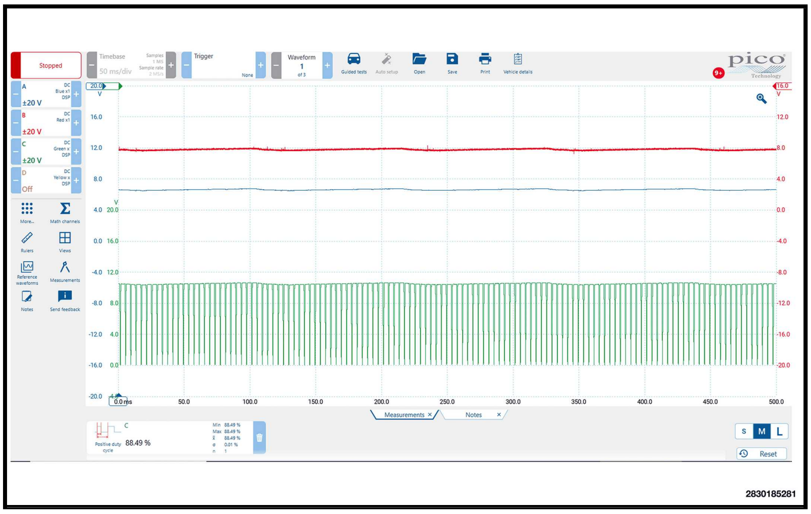
- PWM Command circuit

- PWM Feedback circuit
- Fuel Pump Control circuit
- Relay output to FPCM (Battery supply)

Below are the expected results along with failure modes for each of the circuits:

1. **BATTERY SUPPLY CIRCUIT:**
    1. The relay output voltage to the FPCM should remain constant and equal to battery voltage during operation.
        - If the voltage is constant battery voltage during cranking, the relay output is not the cause of the issue.
    2. If no voltage is present during cranking there is an open in the relay output circuit.
        - Check the fuse for the circuit. If the fuse is open, check the Fuel Pump Relay Output circuit for a short to ground before replacing the fuse. If the fuse is good check the relay output circuit for an open.
    3. Voltage is present but below battery voltage.
        - Check for resistance in the relay output and FPCM ground circuits.

    NOTE: **An open ground circuit can cause the feedback circuit voltage to change from a 5v duty cycle to a constant voltage or approximately 6.5v as seen in the figure below.**

Blue Channel - Feedback circuit
Red Channel - Fuel pump output circuit
Green Channel - Command circuit

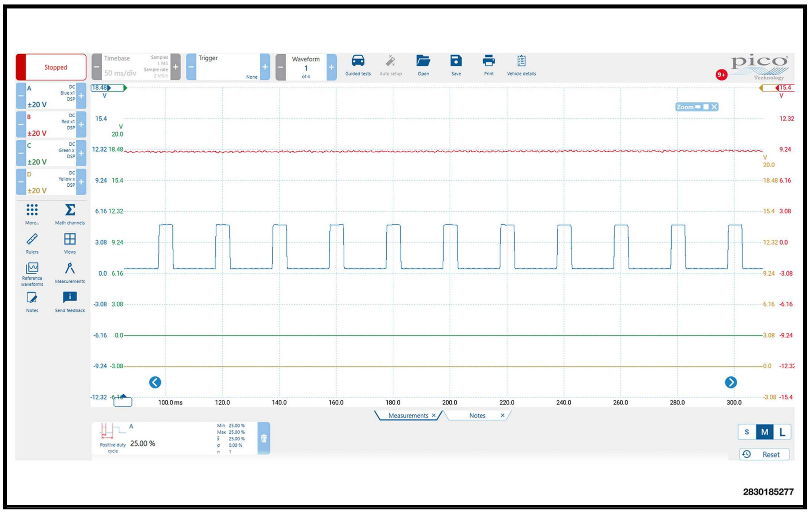
2. **FUEL PUMP PWM COMMAND CIRCUIT:**

    For a detailed description on the functionality of the command circuit, read the PCM component functional description information above. The FPCM will still operate the fuel pump when there is an issue with the command circuit. Typically the output voltage to the fuel pump will be higher than during normal operation. The command circuit can be tested at the FPCM or at the PCM using the GPEC Adaptor connected in-line. Both results are described below.

    SCOPE LEAD CONNECTED AT THE FPCM

    1. If the PWM Command circuit is functioning normally the signal should have a 12v duty cycle between 11% and 89%.
        - If the command circuit is functioning as described above the command circuit is not the cause of the issue.

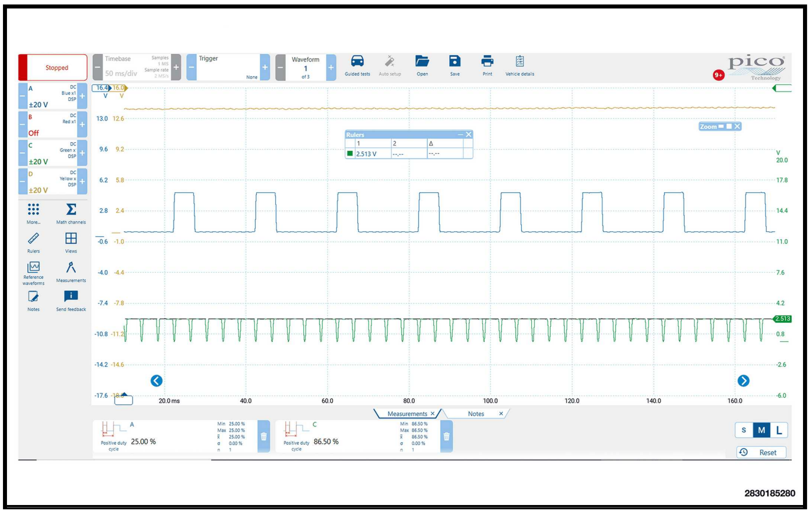
2. If the PWM Command circuit is reading a constant 0 volts, it would indicate that the control circuit is shorted to ground.



Blue Channel - Feedback circuit
Red Channel - Fuel pump output circuit
Green Channel - Command circuit

- Test and repair the short to ground in the command circuit.

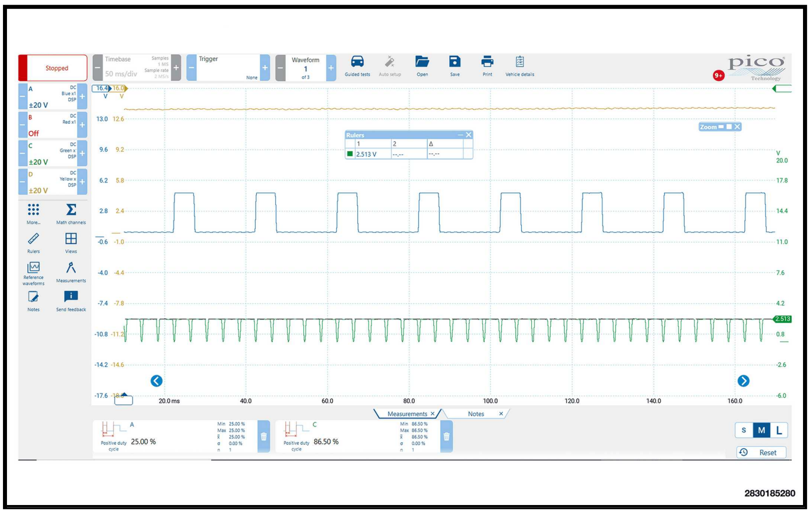
3. If the PWM Command circuit is a reading a constant battery voltage, it would indicate an open in the command circuit or the PCM internal driver is faulty.



Blue Channel - Feedback circuit
Yellow Channel - Command circuit on the FPCM side of the open
Green Channel - Command circuit on the PCM side of the open

- Isolate and measure the resistance of the command circuit. If the circuit is open or has high resistance repair the circuit. If the circuit has less than 5.0 Ohms of resistance, the PCM driver is faulty. Replace the powertrain control module in accordance with the service information.

4. If the PWM Command circuit is duty cycling, but the voltage is approximately 2.5v instead of the normal 12v duty cycle, it indicates that the command circuit and PCM internal driver are good. The FPCM is not producing the 12v output on the command circuit.

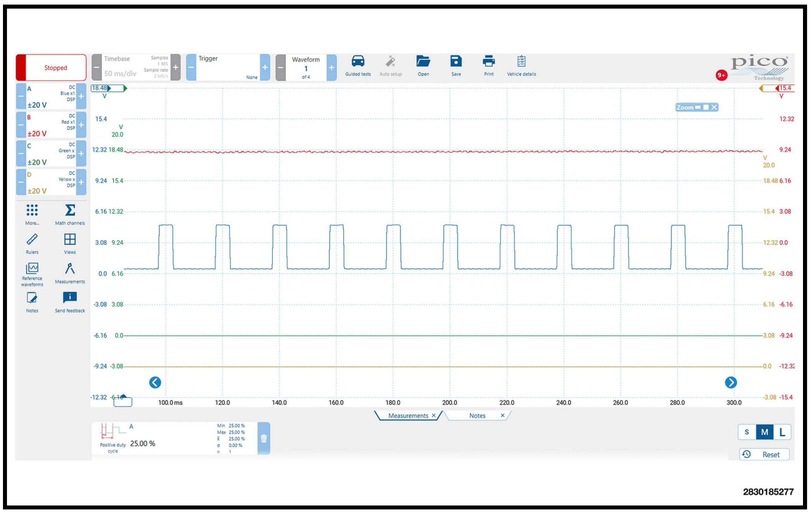


Blue Channel - Feedback circuit	
Yellow Channel - Command circuit on the FPCM side of the open	
Green Channel - Command circuit on the PCM side of the open	

- Verify that the relay output battery supply to the FPCM is constant and the FPCM ground circuit is good. If both circuits test good replace the fuel pump control module in accordance with the service information.

SCOPE LEAD CONNECTED AT THE GPEC ADAPTOR IN-LINE WITH THE PCM

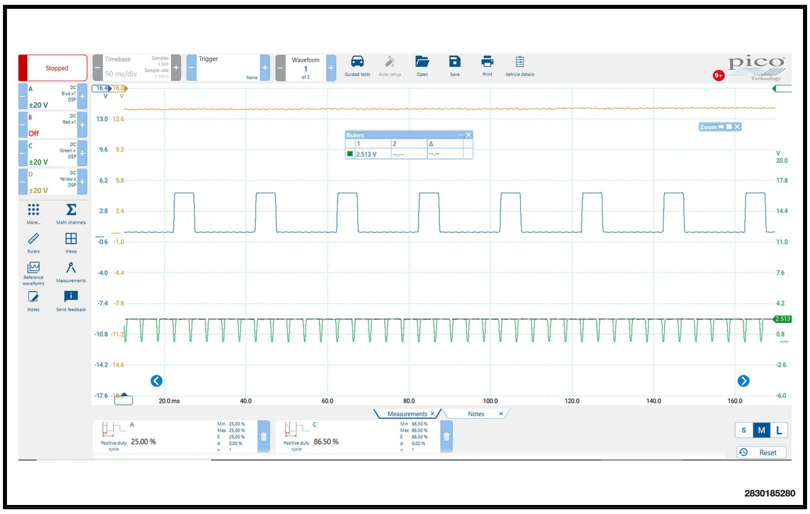
1. If the PWM Command circuit is functioning normally the signal should have a 12v duty cycle between 11% and 89%.
   - If the command circuit is functioning as described above the command circuit is not the cause of the issue.
2. If the PWM Command circuit is reading a constant 0 volts, it would indicate that the command circuit is shorted to ground.



Blue Channel - Feedback circuit
Red Channel - Fuel pump output circuit
Green Channel - Command circuit

- Test and repair the short to ground in the command circuit.

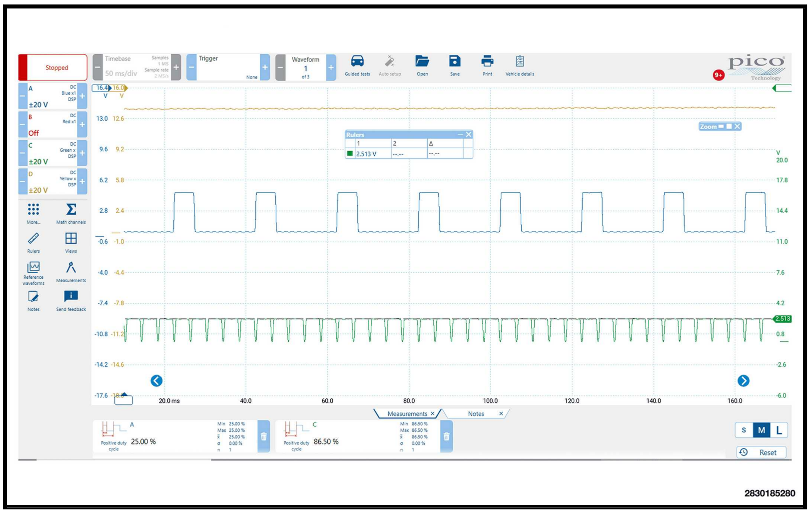
3. If the PWM Command circuit is a reading a constant battery voltage, it indicates the command circuit and FPCM output are good. The PCM internal driver is faulty.



Blue Channel - Feedback circuit
Yellow Channel - Command circuit on the FPCM side of the open
Green Channel - Command circuit on the PCM side of the open

- Replace the powertrain control module in accordance with the service information.

4. If the PWM Command circuit is duty cycling, but the voltage is approximately 2.5v instead of the normal 12v duty cycle, it indicates that the PCM internal driver is good. There is an open in the command circuit or the FPCM is not producing the 12v output on the command circuit.



Blue Channel - Feedback circuit
Yellow Channel - Command circuit on the FPCM side of the open
Green Channel - Command circuit on the PCM side of the open

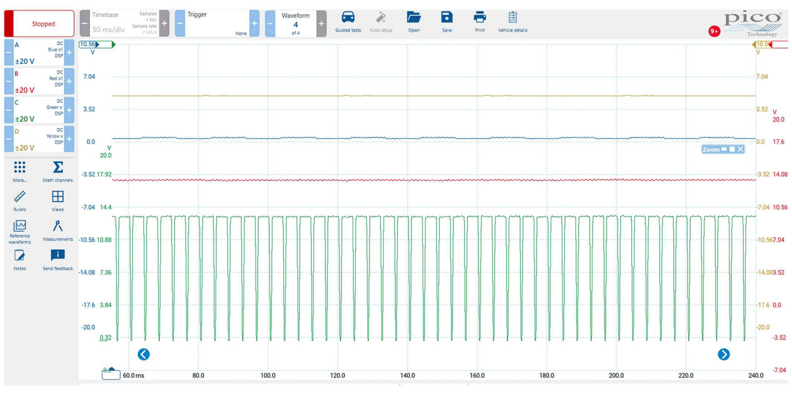
- Isolate and measure the resistance of the command circuit. If the circuit is open or has high resistance repair the circuit. If the circuit has less than 5.0 Ohms of resistance, the FPCM output is faulty. Replace the fuel pump control module in accordance with the service information.

3. **FPCM PWM FEEDBACK CIRCUIT:**

For a detailed description on the functionality of the feedback circuit, read the FPCM component functional description information above. The PCM will command the highest command duty cycle when it cannot receive feedback from the FPCM due to an issue with the feedback circuit. The fuel pump should still operate when the communication is lost between the FPCM and PCM due to a feedback signal circuit issue. Typically the output voltage to the fuel pump will be higher than during normal operation. The feedback circuit can be tested at the FPCM or at the PCM using the GPEC Adaptor connected in-line. Both results are described below.

SCOPE LEAD CONNECTED AT THE FPCM

1. If the FPCM PWM Feedback circuit is functioning normally the signal should have a 5v duty cycle between 3% and 97%.
   - If the feedback circuit is functioning as described above the feedback circuit is not the cause of the issue.
2. If the PWM feedback circuit is reading a constant 0 volts, it would indicate that the control circuit is shorted to ground.
   - Test and repair the short to ground in the feedback circuit.
3. If the PWM feedback circuit is reading a constant 5.0 volts, it would indicate that FPCM internal driver is faulty.



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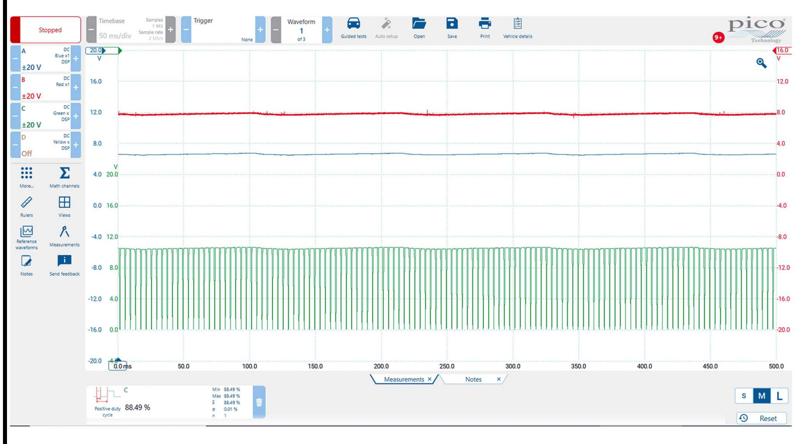
Blue Channel - Feedback circuit on the FPCM side of the open	
Yellow Channel - Feedback circuit on the PCM side of the open	
Green Channel - Command circuit	
Red Channel - Fuel pump output circuit	

   - Replace the fuel pump control module in accordance with the service information.
4. An open or partially open ground circuit can effect the feedback pattern in different ways. The PWM feedback circuit may read a constant voltage approximately 6.5 volts, or it could be a pulsed voltage between 5.0 volts and 8.0 volts when the FPCM ground circuit is open.



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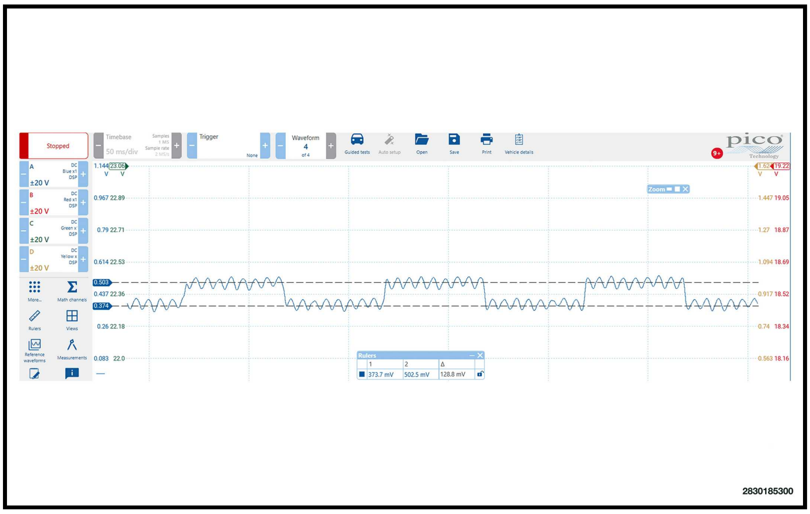
Blue Channel - Feedback circuit
Red Channel - Fuel pump output circuit
Green Channel - Command circuit

- Test and repair the FPCM ground circuit for an open or high resistance.

5. If the PWM feedback circuit is duty cycling between approximately 0.3v and 0.6v instead of the normal 5v duty cycle, it indicates that the FPCM internal driver is good. Either the feedback circuit is open or the PCM is not producing the 5v output on the feedback circuit.



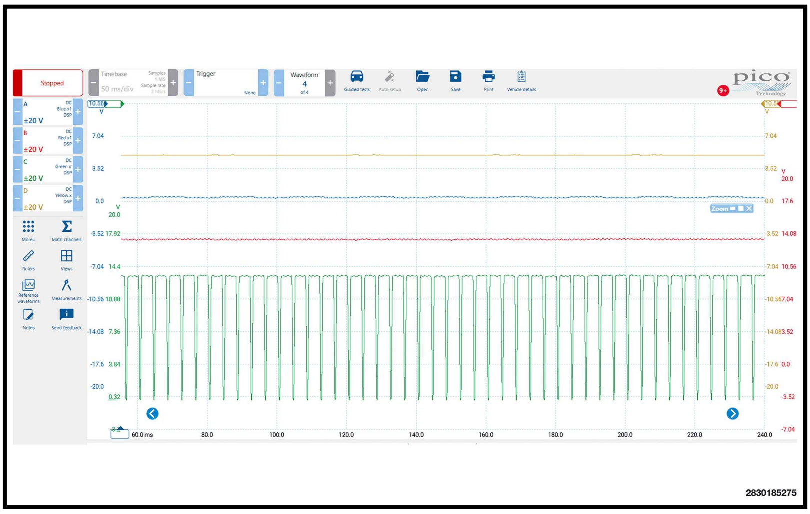
Blue Channel - Feedback circuit on the FPCM side of the open

- If the circuit is open or has high resistance repair the circuit. If the circuit has less than 5.0 Ohms of resistance, the PCM output driver is faulty. Replace the powertrain control module in accordance with the service information.

NOTE: **Another way to test the output and circuit is to connect a scope lead to the PCM connector using the GPEC Adaptor tool. If the 5v output is present at the PCM connector, but not at the FPCM, the PCM is good and the feedback circuit is open.**

SCOPE LEAD CONNECTED AT THE GPEC ADAPTOR CONNECTED IN-LINE WITH THE PCM

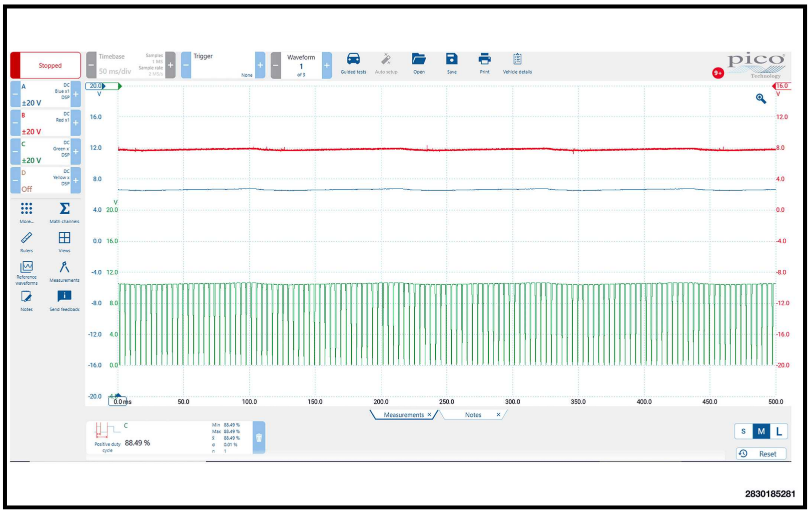
1. If the FPCM PWM Feedback circuit is functioning normally the signal should have a 5v duty cycle between 3% and 97%.
   - If the feedback circuit is functioning as described above the feedback circuit is not the cause of the issue.
2. If the PWM feedback circuit is reading a constant 0 volts, it would indicate that the control circuit is shorted to ground.
   - Test and repair the short to ground in the feedback circuit.
3. If the PWM feedback circuit is reading a constant 5.0 volts, it would indicate that the feedback circuit is open or the FPCM internal driver is faulty.



Blue Channel - Feedback circuit on the FPCM side of the open
Yellow Channel - Feedback circuit on the PCM side of the open
Green Channel - Command circuit
Red Channel - Fuel pump output circuit

- If the circuit is open or has high resistance repair the circuit. If the circuit has less than 5.0 Ohms of resistance, the FPCM driver is faulty. Replace the fuel pump control module in accordance with the service information.

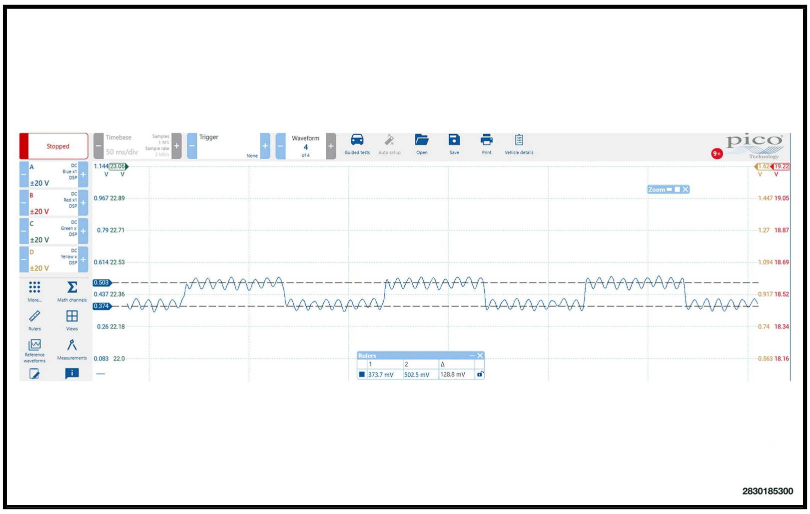
4. If the PWM feedback circuit is reading a constant voltage approximately 6.5 volts, it would indicate that the FPCM ground circuit is open.



Blue Channel - Feedback circuit
Red Channel - Fuel pump output circuit
Green Channel - Command circuit

- Test and repair the FPCM ground circuit for an open or high resistance.

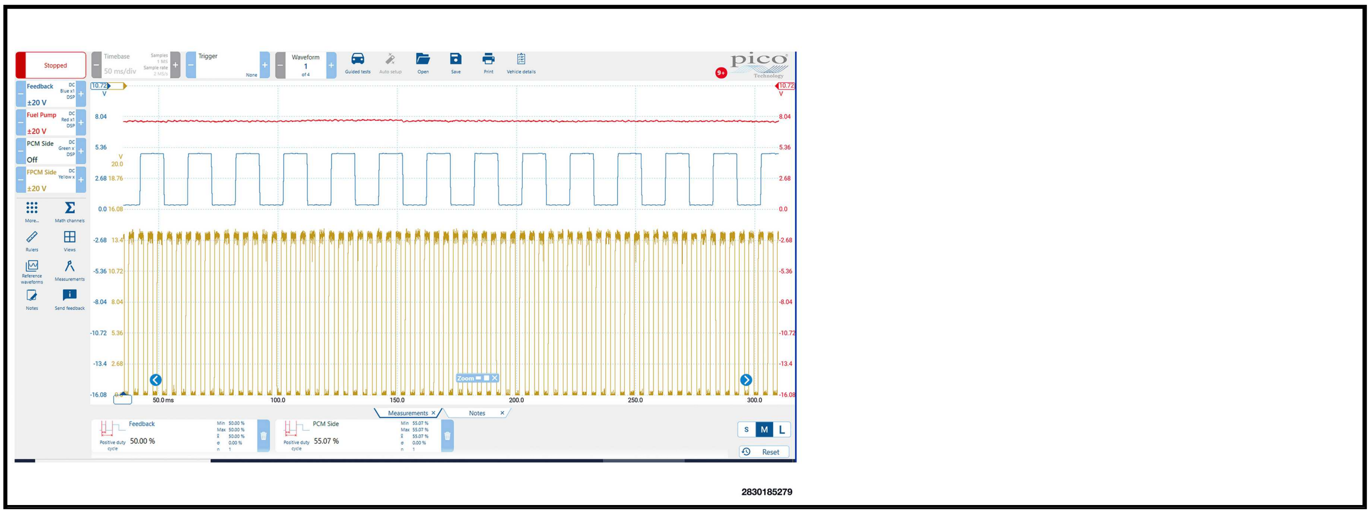
5. If the PWM feedback circuit is duty cycling between approximately 0.3v and 0.6v instead of the normal 5v duty cycle, it indicates that the feedback circuit and FPCM internal driver is good. The PCM is not producing the 5v output on the feedback circuit.



Blue Channel - Feedback circuit on the FPCM side of the open

- Replace the powertrain control module in accordance with the service information.

4. **FUEL PUMP AND CONTROL CIRCUITS:** There should be a relatively constant voltage on the fuel pump control circuit. When the system is operating normally without any faults the output voltage is typically around 7.0 - 9.0 volts. When there is a fault in the system the output is typically higher due to the FPCM defaulting to a higher output (between 10.5 volts and battery voltage). For this reason the fuel pump output voltage may be high near battery voltage due to an issue in the Fuel Pump circuits or one of the other FPCM circuits (Command or Feedback). If one of those circuits indicates an issue, diagnose that circuit before continuing with the diagnosis of the fuel pump circuits.
    1. If the Fuel Pump Control circuit voltage is functioning normally it should be less than battery voltage (between approximately 7.0 - 9.0 volts).
        - If the voltage on the Fuel Pump Control circuit reads as described above, the output from the FPCM is normal.
        - If the voltage on the Fuel Pump Control circuit is reading 0v or near battery voltage, **continue to step b.**
    2. Gain access to the Fuel Pump harness connector. Using the Mopar Scope, back probe the Fuel Pump Control circuit and Fuel Pump Return circuit. Crank or start the engine while monitor the voltage on each circuit.
        - If the Fuel Pump Control circuit voltage is 0 at the Fuel Pump harness connector, the Fuel Pump Control circuit is open or shorted to ground. Repair the circuit. **NOTE: A short to ground in the Fuel Pump PWM Control circuit may open the fuse for the FPCM Battery voltage supply from the relay, which can cause a Loss of Communication fault also.**
        - If the Fuel Pump Control circuit voltage is the same as the output from the FPCM, the Fuel Pump Return circuit is 0v, and the Fuel Pump does not operate, the Fuel Pump is faulty.
        - If the Fuel Pump Return circuit voltage matches the Fuel Pump Control circuit at the Fuel Pump harness connector, the Fuel Pump Return circuit is open to ground. **NOTE: The return circuit grounds through the FPCM chassis ground circuit. This will likely lead to a no start with no fuel pump operation.**



Blue Channel - Feedback circuit
Red Channel - Fuel Pump Control circuit
Yellow Channel - Command circuit

POWERTRAIN VERIFICATION TEST

VERIFICATION OF REPAIR:

1. Inspect the vehicle to make sure that all engine components are properly installed and connected. Reassemble and reconnect components as necessary.
2. After repairs are complete, erase all DTCs with the scan tool.
3. Refer to the table below to determine if a learn procedure should be performed for the component that was removed or replaced. Not all learn procedures are available for all vehicles. If a component listed in the table is replaced and the correlating learn procedure is present in the scan tool, navigate to "Miscellaneous Functions" and perform the learn procedure before verifying repair. Failure to do so may cause the same, or another DTC to set.

Scan Tool Learn Procedures	Component replaced or removed: Note: (All available Learn procedures should be performed when a PCM is replaced)
Brake Pedal Learn	Brake Pedal Position Sensor, Brake Pedal Assembly
Cam Crank Relearn (NGC/GPEC Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clear Misfire TLC (Magneti Marelli Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clutch Pedal Learn	Clutch Pedal Position Sensor, Clutch Pedal, Clutch Assembly (pressure plate and disc)
EGR Valve Replaced	EGR Valve
Learn ETC	Throttle Body
Check PCM Odometer	PCM Replaced
Check PCM VIN	PCM Replaced
PCM Replaced Routine	PCM Replaced
Learn Gear Shift Sensor	Gear Shift Position Sensor, Transmission Shifter components

4. **If the PCM has been replaced** , perform the Module Programming procedure. The PCM Reprogramming procedure is either in Electronic Control Modules/PCM Programming Folder or PCM Standard Procedure Folder depending on the vehicle application. Be certain that the secret key code, VIN and odometer mileage are programmed after programming the PCM.
5. Operate the vehicle in accordance with the parameters and specific information found in the Monitoring Conditions and Theory of Operation of the DTC that was repaired.
6. With the scan tool, verify that no DTCs have returned.

1. If the DTC returned check for any service bulletins or star online cases that may apply. If no bulletins exist, return to and perform the DTC procedure.
2. If the DTC or condition did not return, repair is complete.

DIAGNOSIS AND TESTING

P0629-FUEL PUMP CONTROL CIRCUIT HIGH

For a complete FUEL DELIVERY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

KNOWN ISSUES - FPCM SYSTEM

While the FPCM has the capability of detected failure modes, the faults are not always reported out as intended. Some vehicles have incorrect calibrations that will read the FPCM messages incorrectly and set the DTCs incorrectly. On these vehicles it is best not to rely on the DTC, or DTC Description when deciding which portion of the system to diagnose. In these cases it is best to read and understand how the system operates, then diagnose the entire system to determine where the failure lies by performing the **Complete Fuel Pump Control Module System Diagnostics (Not DTC Specific)** procedure when diagnosing this system. This diagnostic can also be used to diagnose the FPCM command, feedback and fuel pump control circuits on vehicles with the correct calibration software.

The vehicles listed below will set faults incorrectly for the model years listed and should always be diagnosed using the Not DTC specific system approach.

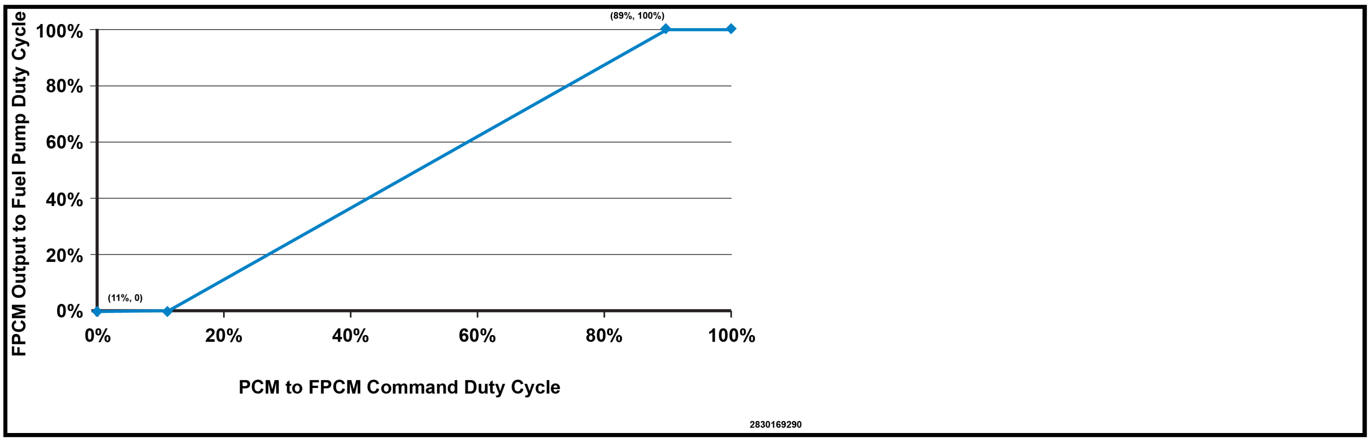
- DS - model years 2016-2019
- RU - model years 2017-2018
- JL - model year 2018
- JT - model year 2020

The exceptions to the information above are the Loss of Communication, Fuel Rail Pressure Sensor and Fuel Pump Relay Control circuit faults. These faults will typically set correctly since they are detected by the PCM directly, not the FPCM.

FPCM SYSTEM DESCRIPTION AND OPERATION

SYSTEM DESCRIPTION: When the Powertrain Control Module (PCM) requires Fuel Pump operation it energizes the Fuel Pump Relay. The Battery voltage output from the relay does not connect directly to the Fuel Pump like traditional systems. Instead, the Battery voltage is supplied to the Fuel Pump Control Module (FPCM). When the ignition is switched on, the Battery voltage is present for approximately five seconds. Battery voltage should always be present during cranking or when the engine is running. The purpose of FPCM is to operate the Fuel Pump at a reduced voltage output to reduce electrical load on the system. Most vehicle/engine combinations operate as a **fixed pressure system** . Vehicles with the 6.2L engine operate as a **variable pressure system** . It is necessary on some vehicles with the 6.2L engine to have a second Fuel Pump and FPCM to meet engine needs. The second FPCM performs the same diagnostics as the primary module but uses different DTCs.

SYSTEM OPERATION: To maintain the desired fuel pressure, the PCM sends a Pulse Width Modulated (PWM) duty cycle signal to the FPCM. If there are no system faults present, the Fuel Pump Control output to the Fuel Pump is based on the duty cycle sent by the PCM. The graph below shows the FPCM output to the Fuel Pump in proportion to the PCM command signal. **The FPCM output to the fuel pump will not read as a duty cycle when monitoring with a Mopar Scope. It will be a consistent voltage output that is a percentage of battery voltage.**



COMPONENT FUNCTIONAL DESCRIPTION- FUEL PUMP CONTROL MODULE (FPCM) AND FUEL PUMP

The FPCM performs fault detection and reports faults to the PCM through the PWM Feedback circuit. The feedback circuit can be monitored using the Mopar Scope and functions as follows:

- The feedback circuit is a 5.0 volt duty cycle.
- The PCM supplies the 5.0 volts for the feedback circuit.
- The FPCM pulses the low side of the circuit to communicate with the PCM.
- The normal duty cycle operating range is between 3% and 97%.
- When the system is operating normally, the FPCM will send a 50% duty cycle on the feedback circuit to the PCM.
- When the FPCM detects a fault it will send a duty cycle that aligns with the failure mode detected.
- If the duty cycle is 0% or 100% the PCM will set the Loss of Communication fault against the FPCM.

NOTE: **Monitoring the FPCM internal driver with an open feedback circuit using the Mopar Scope will show a pulse width signal with a very low voltage (.025v - 0.5v). This is picking up voltage from the internal driver device that is still trying to pulse the duty cycle to the PCM. This can be useful when performing diagnostics on the feedback circuitry.**

Depending on the failure mode detected by the PCM and FPCM, the FPCM can react by either reducing the PWM output duty cycle, or defaulting to an 80% duty cycle for the fuel pump operation. The FPCM reactions are explained further in the PCM/FPCM Reaction column of the Enable Conditions and Failure Modes information.

Fuel Pump: The Fuel Pump operates in the same manner as a typical Brushed DC motor. The only difference is that the speed is reduced due to the PWM output voltage from the FPCM being less than 100%. The voltage supplied is based on the command received from the PCM.

Vehicles with Dual Pump Systems: The fuel pumps operate independently, but may be serviced as an assembly on some vehicles. During normal operation both Fuel Pumps are used to provide the system pressure and volume needed during most engine operating conditions. **The exception is at idle, or idle and purging where there is extremely low fuel demand.** During this mode Fuel Pump 2 is typically turned off. When more fuel demand is needed (typically off idle) Fuel Pump 2 is turned on and both pumps are operated at the same duty cycle. If either pump is failing the vehicle may still operate normally during most driving conditions but would have performance issues under heavy engine load when both pumps are needed. If a failure is detected for either Fuel Pump or circuitry, the duty cycle will typically default to 80%. If Fuel Pump 1 (primary) is defaulted to 80%, Fuel Pump 2 may remain off during most operating conditions. **However, if Fuel Pump 2 is defaulted to 80%, the primary pump will continue to operate at the lower duty cycle range. The reason for this is that the primary pump operates the jet pump to pull fuel from the secondary side of the Fuel Tank and also fills the Fuel Pump assembly reservoir.**

COMPONENT FUNCTIONAL DESCRIPTION - POWERTRAIN CONTROL MODULE (PCM)

The PCM monitors the input signal from the Fuel Rail Pressure Sensor to determine the commanded duty cycle to the FPCM. On a fixed pressure system the PCM varies the commanded duty cycle to maintain a constant pressure. On variable pressure systems the commanded duty cycle is varied to adjust fuel pressure based on engine needs. Ambient temperature and fuel temperature can also contribute to fuel pressure changes. The pressure is raised during high ambient temperatures to prevent boiling of the fuel.

NOTE: **On vehicles with diesel engines or high pressure gas fuel systems, the PCM monitors the Fuel Pressure Sensor on the low pressure side of the system to determine the commanded duty cycle, not the Fuel Rail Pressure Sensor on the high pressure side.**

The command circuit can be monitored using the Mopar Scope and functions as follows:

- The command circuit is a 12.0 volt duty cycle.
- The FPCM supplies the 12.0 volts for the command circuit.
- The PCM pulses the low side of the circuit to communicate with the DTCM.
- The normal duty cycle operating range is between 11% and 89%.
- If the FPCM does not receive a valid command signal from the PCM it will send a fault message on the feedback circuit and operates the fuel pump at a defaulted value (typically 80%).

With an open command circuit, the PCM internal driver will show a pulse width signal of approximately 2.5v if checking at the PCM connector with the Mopar Scope. This is picking up voltage from the internal driver device that is still trying to pulse the duty cycle to the FPCM. This can be useful when performing diagnostics on the command circuitry.

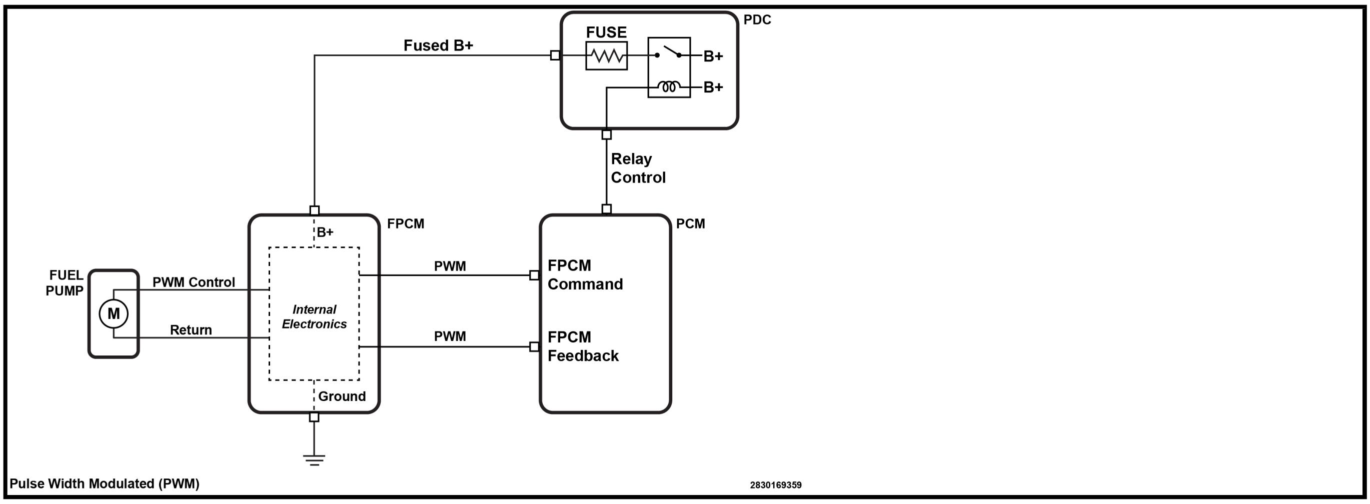
When the PCM loses communication with the FPCM it will default to the highest duty cycle. This will cause the FPCM to provide maximum voltage output to the fuel pump.

TECHNICAL DATA-FUEL SYSTEM PRESSURE SPECIFICATIONS

The table below shows the fuel system pressure specifications.

VARIABLE FUEL PRESSURE SYSTEM SPECIFICATIONS (6.2L ENGINES)		
CRANKING	520 kPa (75.4 psi)	System operates in open loop during cranking
IDLE	340 - 400 kPa (49 - 58 psi)	Normal operating range at idle - Pressure is dependant on ambient and fuel temp. Pressure is raised during high temp to prevent boiling
NORMAL RANGE OF OPERATION	340 - 550 kPa (49 - 80 psi)	Normal operating range between idle and high engine demand
100% DUTY CYCLE	600 - 700 kPa (87 - 101.5 psi)	This is regulated by the pressure relief valve in the Fuel Pump. The pressure can vary from pump to pump.
B		
4 CYLINDER (1.0L/1.3L GSET / 2.0L GMET ENGINES)		
CRANKING	580 kPa (84.1 psi)	System operates in open loop during cranking
ALL OTHER OPERATING CONDITIONS	520 kPa (75.4 psi)	The fixed pressure systems should maintain approximately 75.0 psi during normal operation
B		
FIXED PRESSURE SYSTEM SPECIFICATIONS (ALL OTHER ENGINES)		
The fixed pressure systems should maintain approximately 400 kPa (58.0) psi during normal operation		

GENERIC SYSTEM SCHEMATIC:



WHEN MONITORED

SET CONDITION

- The Powertrain Control Module (PCM) detects a fault in the Fuel Pump Control System.

DEFAULT ACTION

- The MIL will illuminate.

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

The table below shows the FPCM DTCs and the correlating INTENDED failure modes. **NOTE: On some vehicles the faults may not always set as expected which may lead to a misdiagnosis (See the know issue information). Therefore, it is usually best to perform the "Complete Fuel Pump Control Module System Testing (Not DTC Specific)" in the diagnostic information.**

POSSIBLE CAUSES

FPCM 1 DTC	FPCM 2 DTC	FAILURE MODES	POSSIBLE CAUSES	PCM/FPCM REACTION
P025A	P027A	Missing or invalid PWM Command signal from PCM	1. PCM to FPCM Command Signal open 2. PCM to FPCM Command Signal shorted low or high 3. Invalid PWM signal - frequency out of range 4. FPCM 5. PCM	• FPCM defaults the output to the Fuel Pump to 80% duty cycle **NOTE:** **It is not uncommon for the P025A DTC to set erroneously for several other failure modes**
P025B	P027B	Output driver over temp	1. FPCM Output partially shorted to ground 2. Faulty Fuel Pump (high mechanical resistance) 3. Faulty FPCM internal driver	• PCM sets fault, waits a calibrated period and commands a safe duty cycle • FPCM output to Fuel Pump to 50% duty cycle for a calibrated period. If over temp continues, shut down output driver.
P025C	P027C	System under voltage - Fuel Pump Relay output voltage to FPCM is below a calibrated threshold (approximately 6.0 volts)	1. High resistance in the Fuel Pump Relay output circuit 2. FPCM	• PCM requests 100% Fuel Pump operation • FPCM defaults the output to the Fuel Pump to 80% duty cycle
P025D	P027D	System over voltage - Fuel Pump Relay output voltage to FPCM is above a calibrated threshold (approximately 16.0 volts)	1. Charging system issue	• PCM applies over voltage strategy • FPCM reacts to PCM input command
P0628	P2633	FPCM output to Fuel Pump shorted to ground	1. Fuel Pump PWM Control circuit shorted to ground	• PCM reduces PWM duty cycle until issue clears • FPCM reacts to PCM input command
P0629	P2634	FPCM output to Fuel Pump shorted to voltage	1. Fuel Pump PWM Control circuit shorted to voltage	• FPCM output to Fuel Pump to 50% duty cycle for a calibrated period. If condition continues, shut down output driver.

FPCM 1 DTC	FPCM 2 DTC	FAILURE MODES	POSSIBLE CAUSES	PCM/FPCM REACTION
P062A	P062A	Actual fuel pressure is above or below the desired fuel pressure by more than a calibrated threshold. • Fixed pressure system - 5.8 psi above or 14.5 psi below • Variable pressure system - 10.9 psi above or below	1. No fuel in the Fuel Tank 2. Fuel supply tube broken/leaking 3. Fuel supply tube pinched/restricted 4. FPCM defaulted to 80% due to another failure detected 5. FPCM duty cycle output reduced due to another failure detected 6. Faulty Fuel Pump	• PCM requests 100% Fuel Pump operation • FPCM defaults the output to the Fuel Pump to 80% duty cycle
P064A	P26EA	Current draw exceeds calibrated threshold	1. Fuel Pump PWM Control circuit shorted to voltage 2. Faulty Fuel Pump - internal short or high mechanical resistance	• PCM reduces PWM duty cycle until issue clears • FPCM reacts to PCM input command
P1205	P120A	FPCM Micro internal fault	1. Fuel Pump Control Module	• FPCM continues to run in normal mode - run Fuel Pump according to PCM command signal
P1206	P120B	FPCM output to Fuel Pump open circuit	1. Fuel Pump PWM Control circuit open 2. Fuel Pump Return/Ground circuit open 3. FPCM Ground circuit open 4. FPCM	• PCM reduces PWM duty cycle until issue clears • FPCM reacts to PCM input command
U0109	U016C	PCM Loss of Communication with FPCM	1. FPCM PWM Feedback circuit open 2. FPCM PWM Feedback shorted low or high 3. Fuel Pump Relay output circuit to FPCM open or shorted to ground 4. FPCM Ground circuit open 5. Fuel Pump PWM Control circuit shorted to ground 6. FPCM 7. PCM	• PCM requests 100% Fuel Pump operation • FPCM defaults the output to the Fuel Pump to 80% duty cycle

DIAGNOSTIC OVERVIEW-FUEL PUMP CONTROL MODULE

GENERAL DIAGNOSTIC INFORMATION: There are several faults associated with this system. The failure modes being monitored for are Loss of Communication, internal FPCM faults, system voltage faults, Thermal Protection, circuit faults, and system performance. **On several vehicles, multiple or incorrect faults** can set which can mislead diagnosing the vehicle. For this reason, it is a good practice to perform a total system diagnosis regardless of the DTC present for most faults. The communication faults are detected directly by the PCM and will typically set correctly. See Communication Diagnostics explanation below.

PCM DIAGNOSTICS: The PCM directly monitors the Fuel Pump Relay Control circuit, FPCM Feedback circuit and the Fuel Pressure Sensor circuits for faults. The Fuel Pressure Sensor signal must be rationalized since the signal is monitored to perform fuel system pressure performance diagnostics. This is done by watching the signal at initial engine start up for both types of systems. **On the fixed pressure system** the normally stable fuel pressure is dynamic for the first few seconds. The pressure will spike above the set point approximately 40-50 kPa (5.8-7.25 psi), then drop below the set point approximately 60-70 kPa (8.7-10.2 psi), and quickly dampen and settle at the set point 400kPa (58.0 psi). At initial engine start up, when the engine speed reaches approximately 500 rpm, the Powertrain Control Module (PCM) measures the delta pressure change between the highest pressure reading and lowest pressure reading and make determinations about sensor rationality. The diagnostic works the same **on the variable pressure system** as the fixed pressure system except that the system is in open loop at start up and the pressure is commanded to a preset known value to perform the diagnostic.

SYSTEM VOLTAGE DIAGNOSTICS: The FPCM monitors the Battery voltage supply coming from the Fuel Pump Relay to the module. A fault will set if the voltage is too high or too low. Typically a voltage high fault would indicate a charging system issue. The voltage low fault could also be a charging system issue, but may also be caused by resistance in the Battery supply or ground circuit.

COMMUNICATION DIAGNOSTICS: Unlike other system faults, the Loss of Communication fault will typically set correctly. The PCM will set this fault when the FPCM PWM Feedback duty cycle is below 3% or above 97%. This can occur if the FPCM Battery voltage supply or ground circuits are open, or the FPCM PWM Feedback circuit is open or shorted.

FUEL PUMP PERFORMANCE DIAGNOSTICS: The PCM fails the **P062A** Fuel System Performance diagnostic when the actual fuel pressure is approximately **100 kPa (14.5 psi) below or 40 kPa (5.8 psi) above the desired fuel pressure.** This fault usually sets along with other faults since the FPCM will default to 80% duty cycle for many failure modes which causes the actual pressure to be higher than the desired set point. The entire system should be examined when this fault is set, including the Fuel Pressure Sensor and circuits. A sensor drifted out of range, or high resistance in the signal or sensor ground circuit can cause a false reading on a normally operating system.

- **The dual pump variable pressure systems can be tricky when diagnosing a performance fault.** The fuel pressure may be good with one failed pump during most normal operating conditions. The condition may only be present under very heavy engine load conditions when both pumps are needed to produce the pressure and volume needed. If available on the scan tool, monitoring duty cycle for both pumps can help diagnosing the issue. If a failure is detected for either Fuel Pump or circuitry, the duty cycle will typically default to 80%. If Fuel Pump 1 (primary) is defaulted to 80%, Fuel Pump 2 may remain off during most operating conditions. However, if Fuel Pump 2 is defaulted to 80%, the primary pump will continue to operate at the lower duty cycle range. The reason for this is that the primary pump operates the jet pump to pull fuel from the secondary side of the Fuel Tank and also fills the Fuel Pump reservoir.

The FPCM fails the **P064A** Fuel Pump Control Module Performance when excessive current draw is detected on the fuel pump circuitry. The FPCM will default and reduce the duty cycle to the fuel pump to the lowest possible duty cycle while the issue is present.

For most vehicles the fuel pressure desired and actual values, as well as the Fuel Pump output duty cycle data can be viewed on the scan tool. These readings can be very useful during the diagnosis of the system.

TECH TIP: A vehicle will typically have one of two issues;

1. The vehicle has no fuel pressure/pump is not operating.
    - The first thing to check for is a Loss of Communication fault. The reason is that the same Battery supply and ground circuit that are used to power up the FPCM are also used for the Fuel Pump

motor to operate. A loss of Battery supply, or a poor chassis ground for the module will cause both issues.

- The next thing to look for is an output from the FPCM to the pump. This can be done with the scan tool or by checking the duty cycle output from the FPCM. If there is any output from the FPCM to the Fuel Pump, the pump should be operating and creating fuel pressure. If the pump is not running then the Fuel Pump and circuits between the FPCM and Fuel Pump should be focused on during diagnostics. If the Loss of Communication fault is not present the Battery supply and chassis ground are most likely good.

2. The vehicle runs normally, has a DTC or DTCs present, and the output duty cycle to the Fuel Pump is defaulted. In most cases, the output is defaulted to 80% and the actual pressure is greater than the desired pressure.
    - The first thing to check is for a Loss of Communication fault. If the vehicle is running with a Loss of Communication fault, and an 80% output duty cycle, it would typically point to an issue with the FPCM PWM Feedback circuit. A loss of Battery supply or a poor chassis ground would usually cause no Fuel Pump operation and a no start condition.
    - If there is no Loss of Communication fault then this condition is most likely present due to an issue with the command circuit, an over current draw or over temp condition with the Fuel Pump.

PRELIMINARY DIAGNOSTIC CHECKS

1. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the ECU. Low Battery voltage can cause a DTC.
3. Circuit faults should typically be diagnosed before rationality/performance faults.
4. Check the component harness connector(s) for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the component harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCs and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns, or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. **Since the FPCM monitors the Fuel Pump circuits and motor for excessive current draw and over temperature conditions,** it is possible that the pump may need to run for an extended period for the condition to be present.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply, check for connection issues by wiggle testing any wiring harnesses and in-line connectors the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach a lab scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor battery system voltage or poor ground connections can affect systems in different or odd ways. Check the battery or batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the

components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.

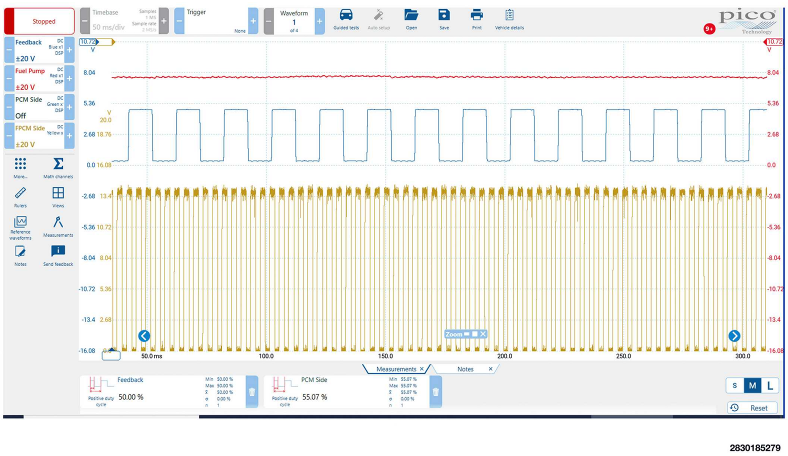
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving. Operate the components through a full range of operation while monitoring functionality.

DIAGNOSTIC TEST - FUEL PUMP PWM CONTROL CIRCUIT FAULTS (P0628, P0629, P1205, P120B, P2633, P2634)

TECH TIP: The FPCM DTCs will set incorrectly for some vehicles/model years due to incorrect calibrations. For those vehicles it is best to perform the "COMPLETE FUEL PUMP CONTROL MODULE SYSTEM TESTING (NOT DTC SPECIFIC)" diagnostic procedure. Refer to the "KNOW ISSUES" information above for a list of the vehicles with incorrect calibrations.

FUEL PUMP PWM CONTROL CIRCUIT OPEN/LOW/HIGH (P0628, P0629, P1205, P120B, P2633, P2634): There should be a relatively constant voltage on the fuel pump control circuit. When the system is operating normally without any faults the output voltage is typically around 7.0 - 9.0 volts. When there is a fault in the system the output is typically higher due to the FPCM defaulting to a higher output (between 10.5 volts and battery voltage). For this reason the fuel pump output voltage may be high near battery voltage due to an issue in the Fuel Pump circuits or one of the other FPCM circuits (Command or Feedback). If one of those circuits indicates an issue or has a DTC set against it, diagnose that circuit before continuing with the diagnosis of the fuel pump circuits.

The test method listed below can be performed using the Mopar Scope or with a meter.



Blue Channel - Feedback circuit	
Red Channel - Fuel Pump Control circuit	
Yellow Channel - Command circuit	

1. Back probe the fuel pump PWM control circuit and fuel pump ground circuit at the fuel pump harness connector. Crank or start the engine while monitoring the voltage on both circuits. The red channel on the pattern above shows the normal output to the fuel pump on the fuel pump PWM control from the FPCM. The fuel pump PWM control circuit voltage is typically around 7.0 - 9.0 volts. The ground circuit should have 0 volts and the pump should operate if the pump and circuits are working properly. Select the result that best matches the voltage readings.
   1. The voltage on both circuits reads as described above and the fuel pump is running, the fuel pump and circuits are operating normally.
      - The issue could be either an intermittent condition, poor pin fit at a connector, or a calibration issue setting the incorrect DTC. If the terminals appear good and an intermittent issue isn't found perform the "DIAGNOSTIC TEST - COMPLETE FUEL PUMP CONTROL MODULE SYSTEM TESTING (NOT DTC SPECIFIC)" diagnostic to check the entire system operation.

2. The voltage on both circuits reads as described above but the fuel pump does not operate, the fuel pump is faulty.
    - Replace the fuel pump in accordance with the service information.
3. There is equal voltage present on both the fuel pump PWM control circuit and ground circuit. Example: 10 volts on both circuits.
    - Repair the ground circuit for an open. **NOTE: The fuel pump ground circuit grounds through the FPCM chassis ground circuit. this condition may also be accompanied by a loss of communication DTC. This will likely lead to a no start with no fuel pump operation.**
4. If the fuel pump PWM control circuit and ground circuit voltage is 0 at the Fuel Pump harness connector, the fuel pump PWM control circuit is open or shorted to ground. Repair the circuit for an open or short to ground. **NOTE: A short to ground in the fuel pump PWM control circuit may cause the fuse to open for the FPCM Battery voltage supply from the relay, which can cause a Loss of Communication fault also. This will lead to a no start with no fuel pump operation.**
5. The fuel pump PWM control circuit is reading battery voltage and the fuel pump ground circuit voltage is 0 volts. Either there is a fault with another circuit or the fuel pump PWM control circuit is shorted to battery voltage.
    - The condition will most likely occur due to a fault in the command or feedback circuit. Perform the "DIAGNOSTIC TEST - COMPLETE FUEL PUMP CONTROL MODULE SYSTEM TESTING (NOT DTC SPECIFIC)" diagnostic to check the entire system operation. If the command and feedback circuits are functioning properly and the voltage supply to the FPCM is good, the fuel pump PWM control circuit is likely shorted to battery voltage. Repair the circuit for a short to voltage.

DIAGNOSTIC TEST - COMPLETE FUEL PUMP CONTROL MODULE SYSTEM TESTING (NOT DTC SPECIFIC)

TECH TIP: The FPCM DTCs will set incorrectly for some vehicles/model years due to incorrect calibrations. For those vehicles it is best to perform the "COMPLETE FUEL PUMP CONTROL MODULE SYSTEM TESTING (NOT DTC SPECIFIC)" diagnostic procedure. Refer to the "KNOW ISSUES" information above for a list of the vehicles with incorrect calibrations.

COMPLETE FUEL PUMP CONTROL MODULE SYSTEM DIAGNOSTICS:

Using the Mopar Scope is the preferred and best method for diagnosing the FPCM and circuits. The circuits can be monitored one at a time or all together using all four channels of the scope.

This test is written with the leads back probed and connected at the FPCM connector unless otherwise specified

Crank or start the engine while monitoring each of the following circuits:

- PWM Command circuit
- PWM Feedback circuit
- Fuel Pump Control circuit
- Relay output to FPCM (Battery supply)

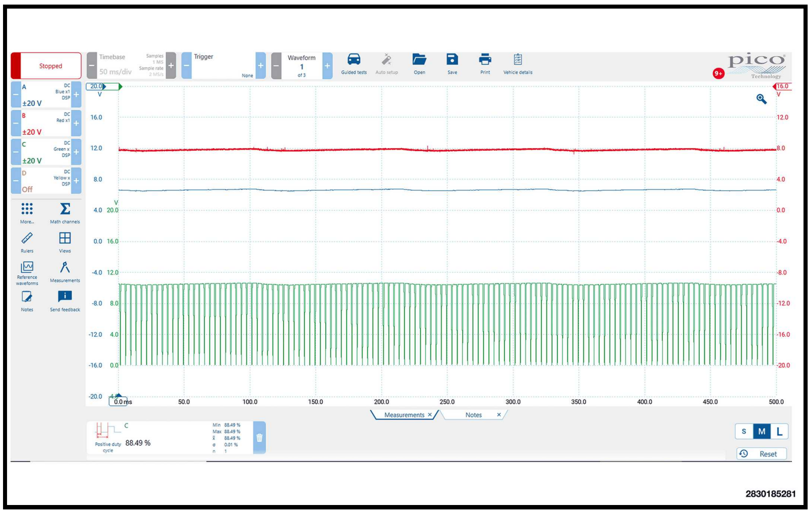
Below are the expected results along with failure modes for each of the circuits:

1. **BATTERY SUPPLY CIRCUIT:**
    1. The relay output voltage to the FPCM should remain constant and equal to battery voltage during operation.
        - If the voltage is constant battery voltage during cranking, the relay output is not the cause of the issue.
    2. If no voltage is present during cranking there is an open in the relay output circuit.

- Check the fuse for the circuit. If the fuse is open, check the Fuel Pump Relay Output circuit for a short to ground before replacing the fuse. If the fuse is good check the relay output circuit for an open.

3. Voltage is present but below battery voltage.
   - Check for resistance in the relay output and FPCM ground circuits.

NOTE: An open ground circuit can cause the feedback circuit voltage to change from a 5v duty cycle to a constant voltage or approximately 6.5v as seen in the figure below.



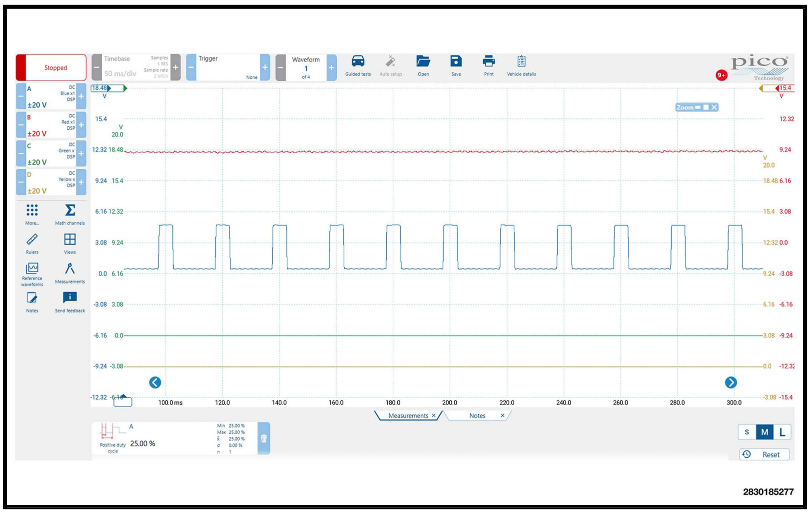
Blue Channel - Feedback circuit
Red Channel - Fuel pump output circuit
Green Channel - Command circuit

2. **FUEL PUMP PWM COMMAND CIRCUIT:**

For a detailed description on the functionality of the command circuit, read the PCM component functional description information above. The FPCM will still operate the fuel pump when there is an issue with the command circuit. Typically the output voltage to the fuel pump will be higher than during normal operation. The command circuit can be tested at the FPCM or at the PCM using the GPEC Adaptor connected in-line. Both results are described below.

SCOPE LEAD CONNECTED AT THE FPCM

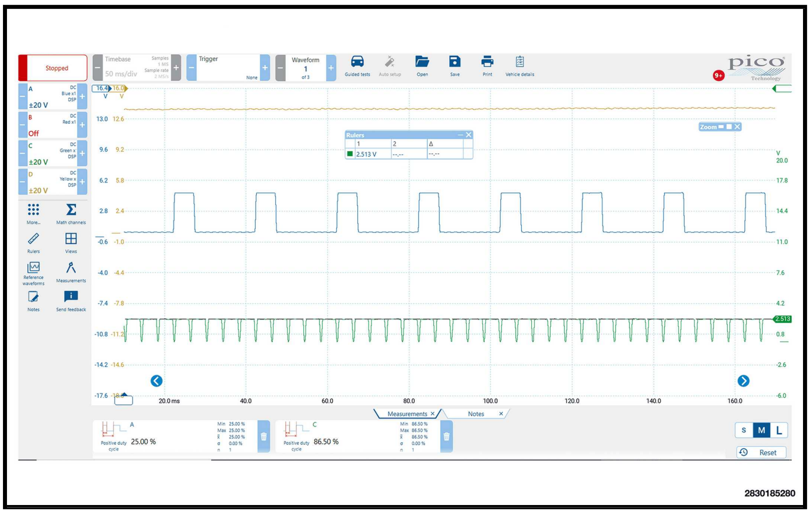
1. If the PWM Command circuit is functioning normally the signal should have a 12v duty cycle between 11% and 89%.
   - If the command circuit is functioning as described above the command circuit is not the cause of the issue.
2. If the PWM Command circuit is reading a constant 0 volts, it would indicate that the control circuit is shorted to ground.



Blue Channel - Feedback circuit
Red Channel - Fuel pump output circuit
Green Channel - Command circuit

- Test and repair the short to ground in the command circuit.

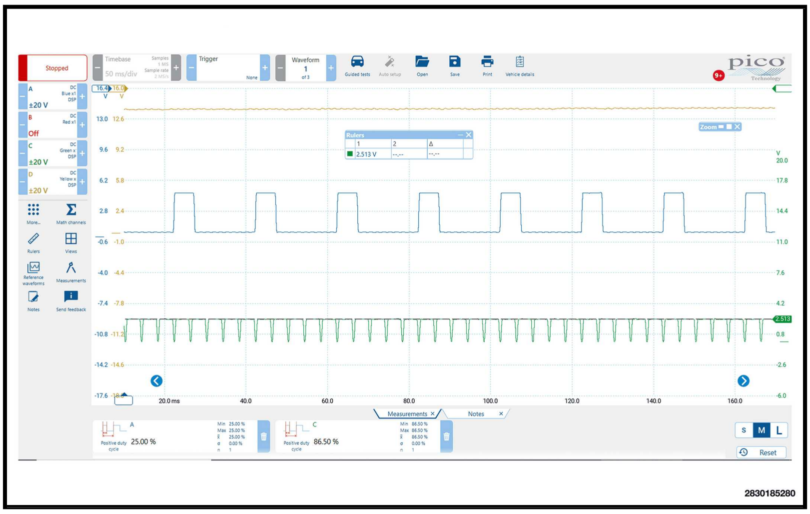
3. If the PWM Command circuit is a reading a constant battery voltage, it would indicate an open in the command circuit or the PCM internal driver is faulty.



Blue Channel - Feedback circuit
Yellow Channel - Command circuit on the FPCM side of the open
Green Channel - Command circuit on the PCM side of the open

- Isolate and measure the resistance of the command circuit. If the circuit is open or has high resistance repair the circuit. If the circuit has less than 5.0 Ohms of resistance, the PCM driver is faulty. Replace the powertrain control module in accordance with the service information.

4. If the PWM Command circuit is duty cycling, but the voltage is approximately 2.5v instead of the normal 12v duty cycle, it indicates that the command circuit and PCM internal driver are good. The FPCM is not producing the 12v output on the command circuit.

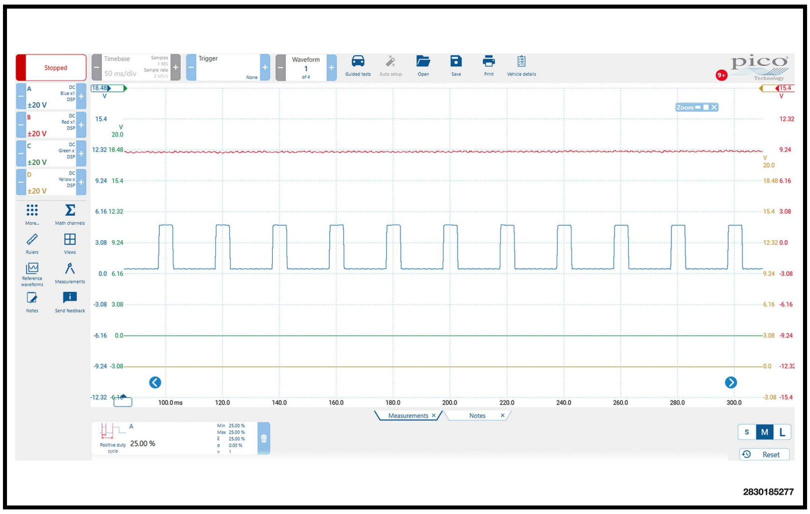


Blue Channel - Feedback circuit	
Yellow Channel - Command circuit on the FPCM side of the open	
Green Channel - Command circuit on the PCM side of the open	

- Verify that the relay output battery supply to the FPCM is constant and the FPCM ground circuit is good. If both circuits test good replace the fuel pump control module in accordance with the service information.

SCOPE LEAD CONNECTED AT THE GPEC ADAPTOR IN-LINE WITH THE PCM

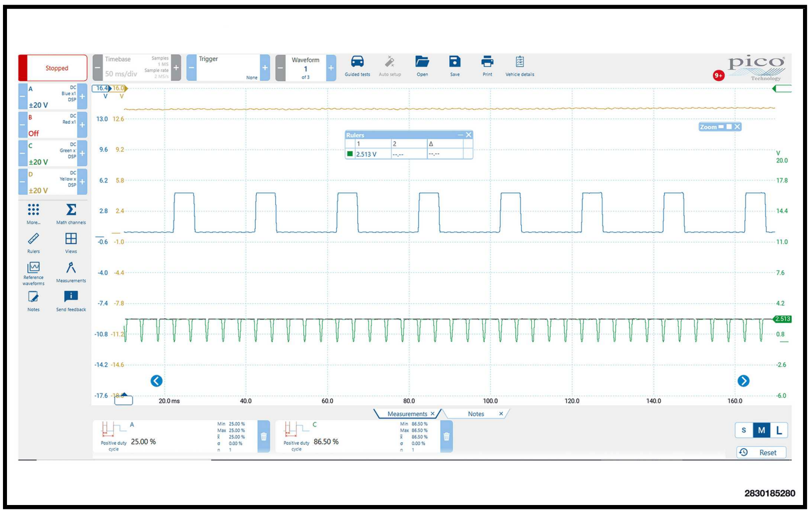
1. If the PWM Command circuit is functioning normally the signal should have a 12v duty cycle between 11% and 89%.
    - If the command circuit is functioning as described above the command circuit is not the cause of the issue.
2. If the PWM Command circuit is reading a constant 0 volts, it would indicate that the command circuit is shorted to ground.



Blue Channel - Feedback circuit	
Red Channel - Fuel pump output circuit	
Green Channel - Command circuit	

- Test and repair the short to ground in the command circuit.

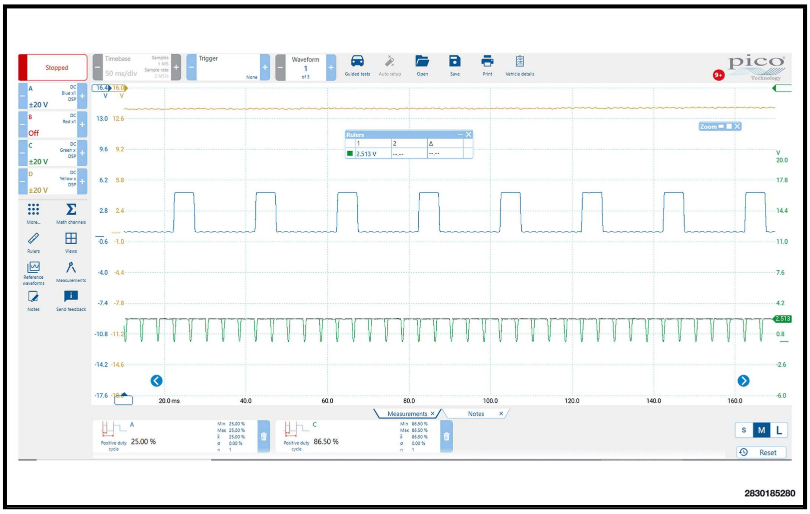
3. If the PWM Command circuit is a reading a constant battery voltage, it indicates the command circuit and FPCM output are good. The PCM internal driver is faulty.



Blue Channel - Feedback circuit	
Yellow Channel - Command circuit on the FPCM side of the open	
Green Channel - Command circuit on the PCM side of the open	

- Replace the powertrain control module in accordance with the service information.

4. If the PWM Command circuit is duty cycling, but the voltage is approximately 2.5v instead of the normal 12v duty cycle, it indicates that the PCM internal driver is good. There is an open in the command circuit or the FPCM is not producing the 12v output on the command circuit.



Blue Channel - Feedback circuit	
Yellow Channel - Command circuit on the FPCM side of the open	
Green Channel - Command circuit on the PCM side of the open	

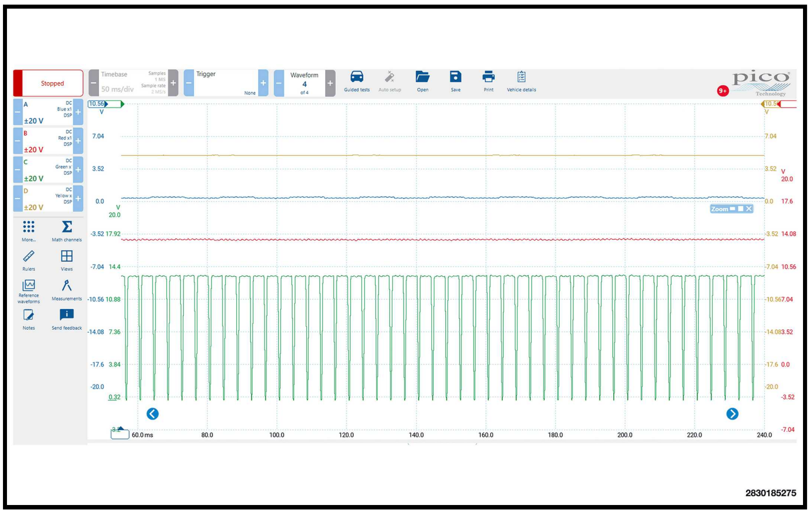
- Isolate and measure the resistance of the command circuit. If the circuit is open or has high resistance repair the circuit. If the circuit has less than 5.0 Ohms of resistance, the FPCM output is faulty. Replace the fuel pump control module in accordance with the service information.

3. **FPCM PWM FEEDBACK CIRCUIT:**

For a detailed description on the functionality of the feedback circuit, read the FPCM component functional description information above. The PCM will command the highest command duty cycle when it cannot receive feedback from the FPCM due to an issue with the feedback circuit. The fuel pump should still operate when the communication is lost between the FPCM and PCM due to a feedback signal circuit issue. Typically the output voltage to the fuel pump will be higher than during normal operation. The feedback circuit can be tested at the FPCM or at the PCM using the GPEC Adaptor connected in-line. Both results are described below.

SCOPE LEAD CONNECTED AT THE FPCM

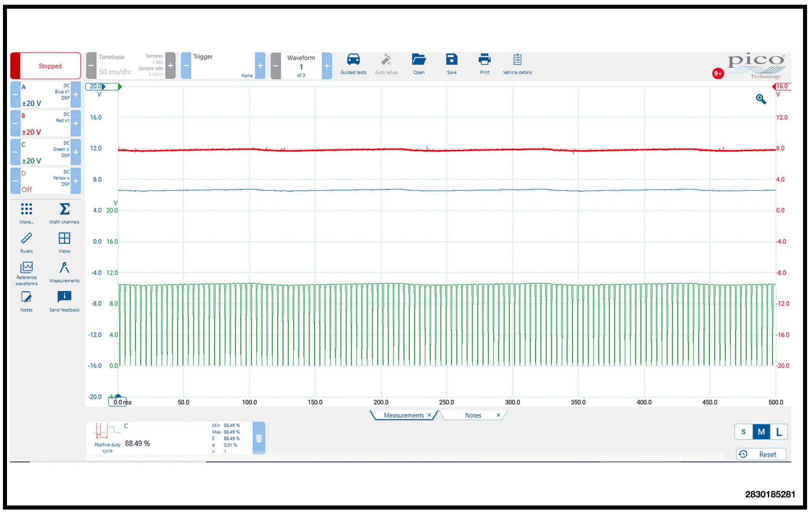
1. If the FPCM PWM Feedback circuit is functioning normally the signal should have a 5v duty cycle between 3% and 97%.
    - If the feedback circuit is functioning as described above the feedback circuit is not the cause of the issue.
2. If the PWM feedback circuit is reading a constant 0 volts, it would indicate that the control circuit is shorted to ground.
    - Test and repair the short to ground in the feedback circuit.
3. If the PWM feedback circuit is reading a constant 5.0 volts, it would indicate that FPCM internal driver is faulty.



Blue Channel - Feedback circuit on the FPCM side of the open
Yellow Channel - Feedback circuit on the PCM side of the open
Green Channel - Command circuit
Red Channel - Fuel pump output circuit

- Replace the fuel pump control module in accordance with the service information.

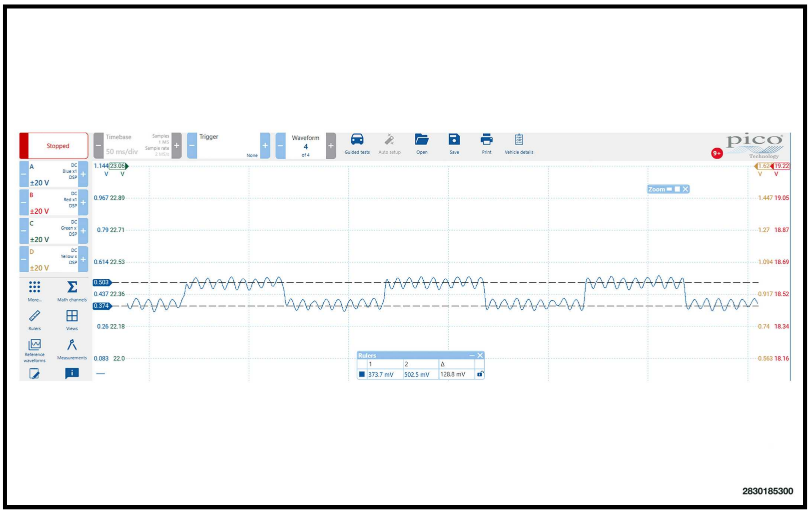
4. An open or partially open ground circuit can effect the feedback pattern in different ways. The PWM feedback circuit may read a constant voltage approximately 6.5 volts, or it could be a pulsed voltage between 5.0 volts and 8.0 volts when the FPCM ground circuit is open.



Blue Channel - Feedback circuit
Red Channel - Fuel pump output circuit
Green Channel - Command circuit

- Test and repair the FPCM ground circuit for an open or high resistance.

5. If the PWM feedback circuit is duty cycling between approximately 0.3v and 0.6v instead of the normal 5v duty cycle, it indicates that the FPCM internal driver is good. Either the feedback circuit is open or the PCM is not producing the 5v output on the feedback circuit.



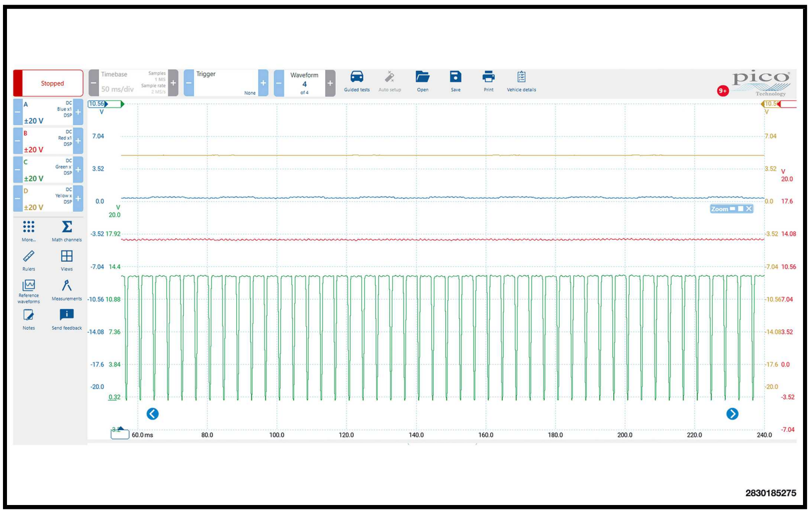
Blue Channel - Feedback circuit on the FPCM side of the open

- If the circuit is open or has high resistance repair the circuit. If the circuit has less than 5.0 Ohms of resistance, the PCM output driver is faulty. Replace the powertrain control module in accordance with the service information.

NOTE: **Another way to test the output and circuit is to connect a scope lead to the PCM connector using the GPEC Adaptor tool. If the 5v output is present at the PCM connector, but not at the FPCM, the PCM is good and the feedback circuit is open.**

SCOPE LEAD CONNECTED AT THE GPEC ADAPTOR CONNECTED IN-LINE WITH THE PCM

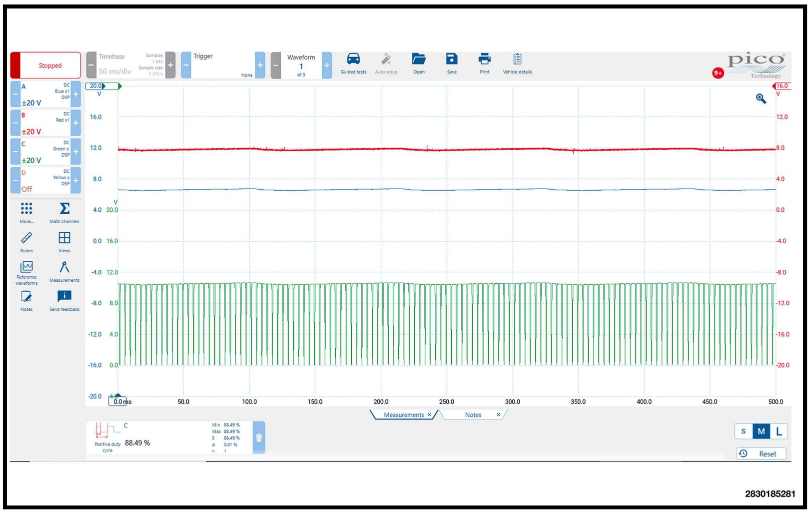
1. If the FPCM PWM Feedback circuit is functioning normally the signal should have a 5v duty cycle between 3% and 97%.
   - If the feedback circuit is functioning as described above the feedback circuit is not the cause of the issue.
2. If the PWM feedback circuit is reading a constant 0 volts, it would indicate that the control circuit is shorted to ground.
   - Test and repair the short to ground in the feedback circuit.
3. If the PWM feedback circuit is reading a constant 5.0 volts, it would indicate that the feedback circuit is open or the FPCM internal driver is faulty.



Blue Channel - Feedback circuit on the FPCM side of the open
Yellow Channel - Feedback circuit on the PCM side of the open
Green Channel - Command circuit
Red Channel - Fuel pump output circuit

- If the circuit is open or has high resistance repair the circuit. If the circuit has less than 5.0 Ohms of resistance, the FPCM driver is faulty. Replace the fuel pump control module in accordance with the service information.

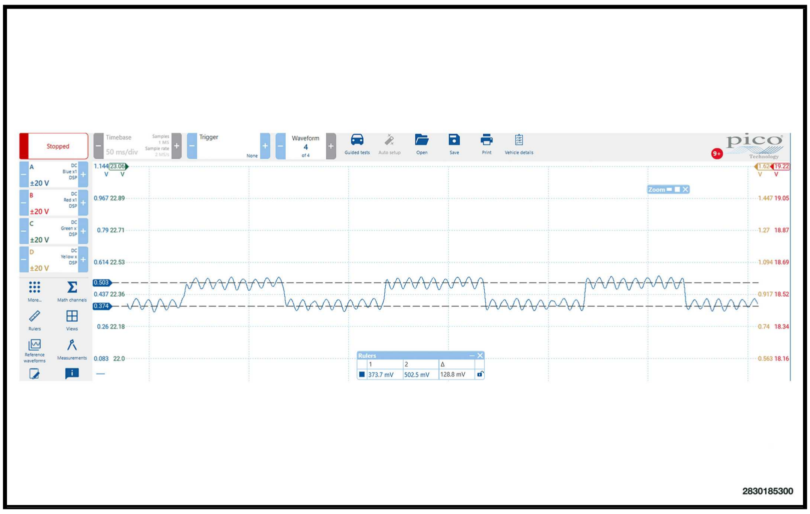
4. If the PWM feedback circuit is reading a constant voltage approximately 6.5 volts, it would indicate that the FPCM ground circuit is open.



Blue Channel - Feedback circuit
Red Channel - Fuel pump output circuit
Green Channel - Command circuit

- Test and repair the FPCM ground circuit for an open or high resistance.

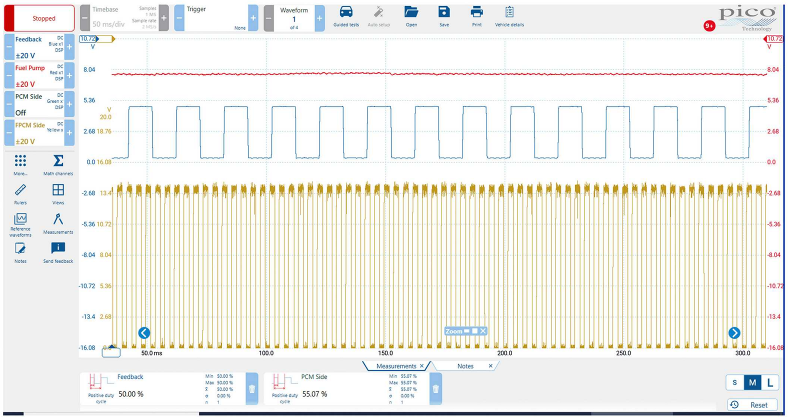
5. If the PWM feedback circuit is duty cycling between approximately 0.3v and 0.6v instead of the normal 5v duty cycle, it indicates that the feedback circuit and FPCM internal driver is good. The PCM is not producing the 5v output on the feedback circuit.



Blue Channel - Feedback circuit on the FPCM side of the open

- Replace the powertrain control module in accordance with the service information.

4. **FUEL PUMP AND CONTROL CIRCUITS:** There should be a relatively constant voltage on the fuel pump control circuit. When the system is operating normally without any faults the output voltage is typically around 7.0 - 9.0 volts. When there is a fault in the system the output is typically higher due to the FPCM defaulting to a higher output (between 10.5 volts and battery voltage). For this reason the fuel pump output voltage may be high near battery voltage due to an issue in the Fuel Pump circuits or one of the other FPCM circuits (Command or Feedback). If one of those circuits indicates an issue, diagnose that circuit before continuing with the diagnosis of the fuel pump circuits.
    1. If the Fuel Pump Control circuit voltage is functioning normally it should be less than battery voltage (between approximately 7.0 - 9.0 volts).
        - If the voltage on the Fuel Pump Control circuit reads as described above, the output from the FPCM is normal.
        - If the voltage on the Fuel Pump Control circuit is reading 0v or near battery voltage, **continue to step b.**
    2. Gain access to the Fuel Pump harness connector. Using the Mopar Scope, back probe the Fuel Pump Control circuit and Fuel Pump Return circuit. Crank or start the engine while monitor the voltage on each circuit.
        - If the Fuel Pump Control circuit voltage is 0 at the Fuel Pump harness connector, the Fuel Pump Control circuit is open or shorted to ground. Repair the circuit. **NOTE: A short to ground in the Fuel Pump PWM Control circuit may open the fuse for the FPCM Battery voltage supply from the relay, which can cause a Loss of Communication fault also.**
        - If the Fuel Pump Control circuit voltage is the same as the output from the FPCM, the Fuel Pump Return circuit is 0v, and the Fuel Pump does not operate, the Fuel Pump is faulty.
        - If the Fuel Pump Return circuit voltage matches the Fuel Pump Control circuit at the Fuel Pump harness connector, the Fuel Pump Return circuit is open to ground. **NOTE: The return circuit grounds through the FPCM chassis ground circuit. This will likely lead to a no start with no fuel pump operation.**



2830185279

Blue Channel - Feedback circuit	
Red Channel - Fuel Pump Control circuit	
Yellow Channel - Command circuit	

POWERTRAIN VERIFICATION TEST

VERIFICATION OF REPAIR:

1. Inspect the vehicle to make sure that all engine components are properly installed and connected. Reassemble and reconnect components as necessary.
2. After repairs are complete, erase all DTCs with the scan tool.
3. Refer to the table below to determine if a learn procedure should be performed for the component that was removed or replaced. Not all learn procedures are available for all vehicles. If a component listed in the table is replaced and the correlating learn procedure is present in the scan tool, navigate to "Miscellaneous Functions" and perform the learn procedure before verifying repair. Failure to do so may cause the same, or another DTC to set.

Scan Tool Learn Procedures	Component replaced or removed: Note: (All available Learn procedures should be performed when a PCM is replaced)
Brake Pedal Learn	Brake Pedal Position Sensor, Brake Pedal Assembly
Cam Crank Relearn (NGC/GPEC Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clear Misfire TLC (Magneti Marelli Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clutch Pedal Learn	Clutch Pedal Position Sensor, Clutch Pedal, Clutch Assembly (pressure plate and disc)
EGR Valve Replaced	EGR Valve
Learn ETC	Throttle Body
Check PCM Odometer	PCM Replaced
Check PCM VIN	PCM Replaced
PCM Replaced Routine	PCM Replaced
Learn Gear Shift Sensor	Gear Shift Position Sensor, Transmission Shifter components

4. **If the PCM has been replaced** , perform the Module Programming procedure. The PCM Reprogramming procedure is either in Electronic Control Modules/PCM Programming Folder or PCM Standard Procedure Folder depending on the vehicle application. Be certain that the secret key code, VIN and odometer mileage are programmed after programming the PCM.
5. Operate the vehicle in accordance with the parameters and specific information found in the Monitoring Conditions and Theory of Operation of the DTC that was repaired.
6. With the scan tool, verify that no DTCs have returned.

1. If the DTC returned check for any service bulletins or star online cases that may apply. If no bulletins exist, return to and perform the DTC procedure.
2. If the DTC or condition did not return, repair is complete.

P062A-FUEL PUMP CONTROL PERFORMANCE

For a complete FUEL DELIVERY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

KNOWN ISSUES - FPCM SYSTEM

While the FPCM has the capability of detected failure modes, the faults are not always reported out as intended. Some vehicles have incorrect calibrations that will read the FPCM messages incorrectly and set the DTCs incorrectly. On these vehicles it is best not to rely on the DTC, or DTC Description when deciding which portion of the system to diagnose. In these cases it is best to read and understand how the system operates, then diagnose the entire system to determine where the failure lies by performing the **Complete Fuel Pump Control Module System Diagnostics (Not DTC Specific)** procedure when diagnosing this system. This diagnostic can also be used to diagnose the FPCM command, feedback and fuel pump control circuits on vehicles with the correct calibration software.

The vehicles listed below will set faults incorrectly for the model years listed and should always be diagnosed using the Not DTC specific system approach.

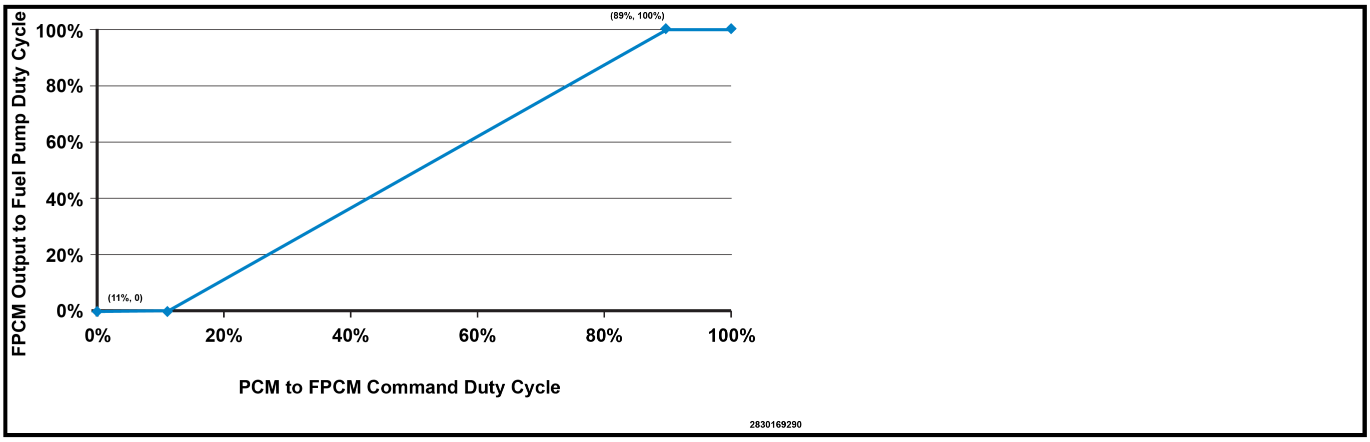
- DS - model years 2016-2019
- RU - model years 2017-2018
- JL - model year 2018
- JT - model year 2020

The exceptions to the information above are the Loss of Communication, Fuel Rail Pressure Sensor and Fuel Pump Relay Control circuit faults. These faults will typically set correctly since they are detected by the PCM directly, not the FPCM.

FPCM SYSTEM DESCRIPTION AND OPERATION

SYSTEM DESCRIPTION: When the Powertrain Control Module (PCM) requires Fuel Pump operation it energizes the Fuel Pump Relay. The Battery voltage output from the relay does not connect directly to the Fuel Pump like traditional systems. Instead, the Battery voltage is supplied to the Fuel Pump Control Module (FPCM). When the ignition is switched on, the Battery voltage is present for approximately five seconds. Battery voltage should always be present during cranking or when the engine is running. The purpose of FPCM is to operate the Fuel Pump at a reduced voltage output to reduce electrical load on the system. Most vehicle/engine combinations operate as a **fixed pressure system** . Vehicles with the 6.2L engine operate as a **variable pressure system** . It is necessary on some vehicles with the 6.2L engine to have a second Fuel Pump and FPCM to meet engine needs. The second FPCM performs the same diagnostics as the primary module but uses different DTCs.

SYSTEM OPERATION: To maintain the desired fuel pressure, the PCM sends a Pulse Width Modulated (PWM) duty cycle signal to the FPCM. If there are no system faults present, the Fuel Pump Control output to the Fuel Pump is based on the duty cycle sent by the PCM. The graph below shows the FPCM output to the Fuel Pump in proportion to the PCM command signal. **The FPCM output to the fuel pump will not read as a duty cycle when monitoring with a Mopar Scope. It will be a consistent voltage output that is a percentage of battery voltage.**



COMPONENT FUNCTIONAL DESCRIPTION- FUEL PUMP CONTROL MODULE (FPCM) AND FUEL PUMP

The FPCM performs fault detection and reports faults to the PCM through the PWM Feedback circuit. The feedback circuit can be monitored using the Mopar Scope and functions as follows:

- The feedback circuit is a 5.0 volt duty cycle.
- The PCM supplies the 5.0 volts for the feedback circuit.
- The FPCM pulses the low side of the circuit to communicate with the PCM.
- The normal duty cycle operating range is between 3% and 97%.
- When the system is operating normally, the FPCM will send a 50% duty cycle on the feedback circuit to the PCM.
- When the FPCM detects a fault it will send a duty cycle that aligns with the failure mode detected.
- If the duty cycle is 0% or 100% the PCM will set the Loss of Communication fault against the FPCM.

NOTE: **Monitoring the FPCM internal driver with an open feedback circuit using the Mopar Scope will show a pulse width signal with a very low voltage (.025v - 0.5v). This is picking up voltage from the internal driver device that is still trying to pulse the duty cycle to the PCM. This can be useful when performing diagnostics on the feedback circuitry.**

Depending on the failure mode detected by the PCM and FPCM, the FPCM can react by either reducing the PWM output duty cycle, or defaulting to an 80% duty cycle for the fuel pump operation. The FPCM reactions are explained further in the PCM/FPCM Reaction column of the Enable Conditions and Failure Modes information.

Fuel Pump: The Fuel Pump operates in the same manner as a typical Brushed DC motor. The only difference is that the speed is reduced due to the PWM output voltage from the FPCM being less than 100%. The voltage supplied is based on the command received from the PCM.

Vehicles with Dual Pump Systems: The fuel pumps operate independently, but may be serviced as an assembly on some vehicles. During normal operation both Fuel Pumps are used to provide the system pressure and volume needed during most engine operating conditions. **The exception is at idle, or idle and purging where there is extremely low fuel demand.** During this mode Fuel Pump 2 is typically turned off. When more fuel demand is needed (typically off idle) Fuel Pump 2 is turned on and both pumps are operated at the same duty cycle. If either pump is failing the vehicle may still operate normally during most driving conditions but would have performance issues under heavy engine load when both pumps are needed. If a failure is detected for either Fuel Pump or circuitry, the duty cycle will typically default to 80%. If Fuel Pump 1 (primary) is defaulted to 80%, Fuel Pump 2 may remain off during most operating conditions. **However, if Fuel Pump 2 is defaulted to 80%, the primary pump will continue to operate at the lower duty cycle range. The reason for this is that the primary pump operates the jet pump to pull fuel from the secondary side of the Fuel Tank and also fills the Fuel Pump assembly reservoir.**

COMPONENT FUNCTIONAL DESCRIPTION - POWERTRAIN CONTROL MODULE (PCM)

The PCM monitors the input signal from the Fuel Rail Pressure Sensor to determine the commanded duty cycle to the FPCM. On a fixed pressure system the PCM varies the commanded duty cycle to maintain a constant pressure. On variable pressure systems the commanded duty cycle is varied to adjust fuel pressure based on engine needs. Ambient temperature and fuel temperature can also contribute to fuel pressure changes. The pressure is raised during high ambient temperatures to prevent boiling of the fuel.

NOTE: **On vehicles with diesel engines or high pressure gas fuel systems, the PCM monitors the Fuel Pressure Sensor on the low pressure side of the system to determine the commanded duty cycle, not the Fuel Rail Pressure Sensor on the high pressure side.**

The command circuit can be monitored using the Mopar Scope and functions as follows:

- The command circuit is a 12.0 volt duty cycle.
- The FPCM supplies the 12.0 volts for the command circuit.
- The PCM pulses the low side of the circuit to communicate with the DTCM.
- The normal duty cycle operating range is between 11% and 89%.
- If the FPCM does not receive a valid command signal from the PCM it will send a fault message on the feedback circuit and operates the fuel pump at a defaulted value (typically 80%).

With an open command circuit, the PCM internal driver will show a pulse width signal of approximately 2.5v if checking at the PCM connector with the Mopar Scope. This is picking up voltage from the internal driver device that is still trying to pulse the duty cycle to the FPCM. This can be useful when performing diagnostics on the command circuitry.

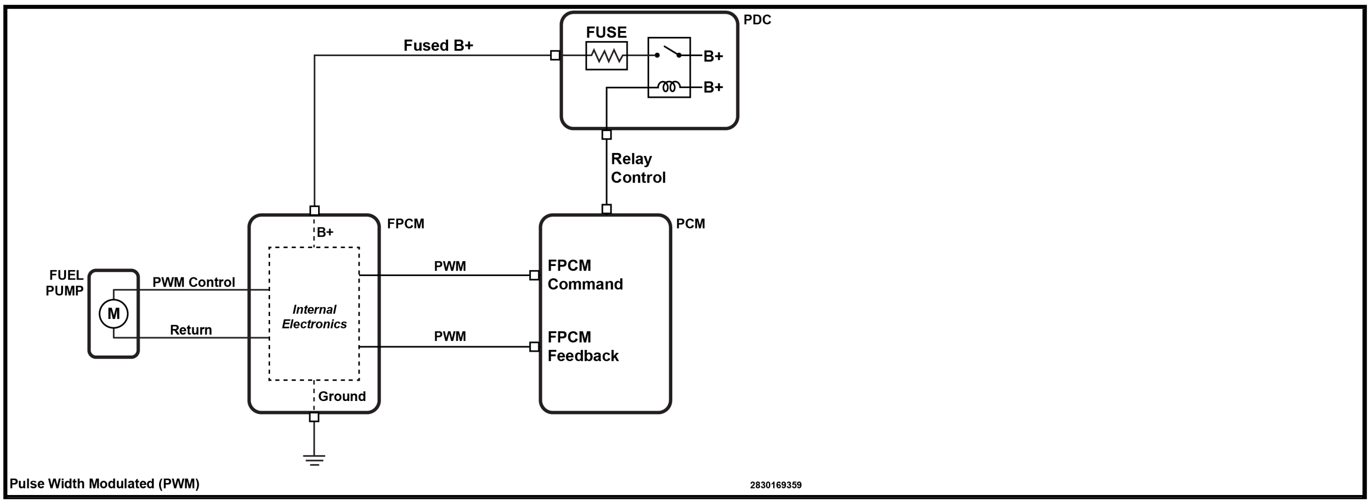
When the PCM loses communication with the FPCM it will default to the highest duty cycle. This will cause the FPCM to provide maximum voltage output to the fuel pump.

TECHNICAL DATA-FUEL SYSTEM PRESSURE SPECIFICATIONS

The table below shows the fuel system pressure specifications.

VARIABLE FUEL PRESSURE SYSTEM SPECIFICATIONS (6.2L ENGINES)		
CRANKING	520 kPa (75.4 psi)	System operates in open loop during cranking
IDLE	340 - 400 kPa (49 - 58 psi)	Normal operating range at idle - Pressure is dependant on ambient and fuel temp. Pressure is raised during high temp to prevent boiling
NORMAL RANGE OF OPERATION	340 - 550 kPa (49 - 80 psi)	Normal operating range between idle and high engine demand
100% DUTY CYCLE	600 - 700 kPa (87 - 101.5 psi)	This is regulated by the pressure relief valve in the Fuel Pump. The pressure can vary from pump to pump.
B		
4 CYLINDER (1.0L/1.3L GSET / 2.0L GMET ENGINES)		
CRANKING	580 kPa (84.1 psi)	System operates in open loop during cranking
ALL OTHER OPERATING CONDITIONS	520 kPa (75.4 psi)	The fixed pressure systems should maintain approximately 75.0 psi during normal operation
B		
FIXED PRESSURE SYSTEM SPECIFICATIONS (ALL OTHER ENGINES)		
The fixed pressure systems should maintain approximately 400 kPa (58.0) psi during normal operation		

GENERIC SYSTEM SCHEMATIC:



WHEN MONITORED

SET CONDITION

- The Powertrain Control Module (PCM) detects a fault in the Fuel Pump Control System.

DEFAULT ACTION

- The MIL will illuminate.

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

The table below shows the FPCM DTCs and the correlating INTENDED failure modes. **NOTE: On some vehicles the faults may not always set as expected which may lead to a misdiagnosis (See the know issue information). Therefore, it is usually best to perform the "Complete Fuel Pump Control Module System Testing (Not DTC Specific)" in the diagnostic information.**

POSSIBLE CAUSES

FPCM 1 DTC	FPCM 2 DTC	FAILURE MODES	POSSIBLE CAUSES	PCM/FPCM REACTION
P025A	P027A	Missing or invalid PWM Command signal from PCM	1. PCM to FPCM Command Signal open 2. PCM to FPCM Command Signal shorted low or high 3. Invalid PWM signal - frequency out of range 4. FPCM 5. PCM	• FPCM defaults the output to the Fuel Pump to 80% duty cycle **NOTE:** **It is not uncommon for the P025A DTC to set erroneously for several other failure modes**
P025B	P027B	Output driver over temp	1. FPCM Output partially shorted to ground 2. Faulty Fuel Pump (high mechanical resistance) 3. Faulty FPCM internal driver	• PCM sets fault, waits a calibrated period and commands a safe duty cycle • FPCM output to Fuel Pump to 50% duty cycle for a calibrated period. If over temp continues, shut down output driver.
P025C	P027C	System under voltage - Fuel Pump Relay output voltage to FPCM is below a calibrated threshold (approximately 6.0 volts)	1. High resistance in the Fuel Pump Relay output circuit 2. FPCM	• PCM requests 100% Fuel Pump operation • FPCM defaults the output to the Fuel Pump to 80% duty cycle
P025D	P027D	System over voltage - Fuel Pump Relay output voltage to FPCM is above a calibrated threshold (approximately 16.0 volts)	1. Charging system issue	• PCM applies over voltage strategy • FPCM reacts to PCM input command
P0628	P2633	FPCM output to Fuel Pump shorted to ground	1. Fuel Pump PWM Control circuit shorted to ground	• PCM reduces PWM duty cycle until issue clears • FPCM reacts to PCM input command
P0629	P2634	FPCM output to Fuel Pump shorted to voltage	1. Fuel Pump PWM Control circuit shorted to voltage	• FPCM output to Fuel Pump to 50% duty cycle for a calibrated period. If condition continues, shut down output driver.

FPCM 1 DTC	FPCM 2 DTC	FAILURE MODES	POSSIBLE CAUSES	PCM/FPCM REACTION
P062A	P062A	Actual fuel pressure is above or below the desired fuel pressure by more than a calibrated threshold. • Fixed pressure system - 5.8 psi above or 14.5 psi below • Variable pressure system - 10.9 psi above or below	1. No fuel in the Fuel Tank 2. Fuel supply tube broken/leaking 3. Fuel supply tube pinched/restricted 4. FPCM defaulted to 80% due to another failure detected 5. FPCM duty cycle output reduced due to another failure detected 6. Faulty Fuel Pump	• PCM requests 100% Fuel Pump operation • FPCM defaults the output to the Fuel Pump to 80% duty cycle
P064A	P26EA	Current draw exceeds calibrated threshold	1. Fuel Pump PWM Control circuit shorted to voltage 2. Faulty Fuel Pump - internal short or high mechanical resistance	• PCM reduces PWM duty cycle until issue clears • FPCM reacts to PCM input command
P1205	P120A	FPCM Micro internal fault	1. Fuel Pump Control Module	• FPCM continues to run in normal mode - run Fuel Pump according to PCM command signal
P1206	P120B	FPCM output to Fuel Pump open circuit	1. Fuel Pump PWM Control circuit open 2. Fuel Pump Return/Ground circuit open 3. FPCM Ground circuit open 4. FPCM	• PCM reduces PWM duty cycle until issue clears • FPCM reacts to PCM input command
U0109	U016C	PCM Loss of Communication with FPCM	1. FPCM PWM Feedback circuit open 2. FPCM PWM Feedback shorted low or high 3. Fuel Pump Relay output circuit to FPCM open or shorted to ground 4. FPCM Ground circuit open 5. Fuel Pump PWM Control circuit shorted to ground 6. FPCM 7. PCM	• PCM requests 100% Fuel Pump operation • FPCM defaults the output to the Fuel Pump to 80% duty cycle

DIAGNOSTIC OVERVIEW-FUEL PUMP CONTROL MODULE

GENERAL DIAGNOSTIC INFORMATION: There are several faults associated with this system. The failure modes being monitored for are Loss of Communication, internal FPCM faults, system voltage faults, Thermal Protection, circuit faults, and system performance. **On several vehicles, multiple or incorrect faults** can set which can mislead diagnosing the vehicle. For this reason, it is a good practice to perform a total system diagnosis regardless of the DTC present for most faults. The communication faults are detected directly by the PCM and will typically set correctly. See Communication Diagnostics explanation below.

PCM DIAGNOSTICS: The PCM directly monitors the Fuel Pump Relay Control circuit, FPCM Feedback circuit and the Fuel Pressure Sensor circuits for faults. The Fuel Pressure Sensor signal must be rationalized since the signal is monitored to perform fuel system pressure performance diagnostics. This is done by watching the signal at initial engine start up for both types of systems. **On the fixed pressure system** the normally stable fuel pressure is dynamic for the first few seconds. The pressure will spike above the set point approximately 40-50 kPa (5.8-7.25 psi), then drop below the set point approximately 60-70 kPa (8.7-10.2 psi), and quickly dampen and settle at the set point 400kPa (58.0 psi). At initial engine start up, when the engine speed reaches approximately 500 rpm, the Powertrain Control Module (PCM) measures the delta pressure change between the highest pressure reading and lowest pressure reading and make determinations about sensor rationality. The diagnostic works the same **on the variable pressure system** as the fixed pressure system except that the system is in open loop at start up and the pressure is commanded to a preset known value to perform the diagnostic.

SYSTEM VOLTAGE DIAGNOSTICS: The FPCM monitors the Battery voltage supply coming from the Fuel Pump Relay to the module. A fault will set if the voltage is too high or too low. Typically a voltage high fault would indicate a charging system issue. The voltage low fault could also be a charging system issue, but may also be caused by resistance in the Battery supply or ground circuit.

COMMUNICATION DIAGNOSTICS: Unlike other system faults, the Loss of Communication fault will typically set correctly. The PCM will set this fault when the FPCM PWM Feedback duty cycle is below 3% or above 97%. This can occur if the FPCM Battery voltage supply or ground circuits are open, or the FPCM PWM Feedback circuit is open or shorted.

FUEL PUMP PERFORMANCE DIAGNOSTICS: The PCM fails the **P062A** Fuel System Performance diagnostic when the actual fuel pressure is approximately **100 kPa (14.5 psi) below or 40 kPa (5.8 psi) above the desired fuel pressure.** This fault usually sets along with other faults since the FPCM will default to 80% duty cycle for many failure modes which causes the actual pressure to be higher than the desired set point. The entire system should be examined when this fault is set, including the Fuel Pressure Sensor and circuits. A sensor drifted out of range, or high resistance in the signal or sensor ground circuit can cause a false reading on a normally operating system.

- **The dual pump variable pressure systems can be tricky when diagnosing a performance fault.** The fuel pressure may be good with one failed pump during most normal operating conditions. The condition may only be present under very heavy engine load conditions when both pumps are needed to produce the pressure and volume needed. If available on the scan tool, monitoring duty cycle for both pumps can help diagnosing the issue. If a failure is detected for either Fuel Pump or circuitry, the duty cycle will typically default to 80%. If Fuel Pump 1 (primary) is defaulted to 80%, Fuel Pump 2 may remain off during most operating conditions. However, if Fuel Pump 2 is defaulted to 80%, the primary pump will continue to operate at the lower duty cycle range. The reason for this is that the primary pump operates the jet pump to pull fuel from the secondary side of the Fuel Tank and also fills the Fuel Pump reservoir.

The FPCM fails the **P064A** Fuel Pump Control Module Performance when excessive current draw is detected on the fuel pump circuitry. The FPCM will default and reduce the duty cycle to the fuel pump to the lowest possible duty cycle while the issue is present.

For most vehicles the fuel pressure desired and actual values, as well as the Fuel Pump output duty cycle data can be viewed on the scan tool. These readings can be very useful during the diagnosis of the system.

TECH TIP: A vehicle will typically have one of two issues;

1. The vehicle has no fuel pressure/pump is not operating.
    - The first thing to check for is a Loss of Communication fault. The reason is that the same Battery supply and ground circuit that are used to power up the FPCM are also used for the Fuel Pump

motor to operate. A loss of Battery supply, or a poor chassis ground for the module will cause both issues.

- The next thing to look for is an output from the FPCM to the pump. This can be done with the scan tool or by checking the duty cycle output from the FPCM. If there is any output from the FPCM to the Fuel Pump, the pump should be operating and creating fuel pressure. If the pump is not running then the Fuel Pump and circuits between the FPCM and Fuel Pump should be focused on during diagnostics. If the Loss of Communication fault is not present the Battery supply and chassis ground are most likely good.

2. The vehicle runs normally, has a DTC or DTCs present, and the output duty cycle to the Fuel Pump is defaulted. In most cases, the output is defaulted to 80% and the actual pressure is greater than the desired pressure.
   - The first thing to check is for a Loss of Communication fault. If the vehicle is running with a Loss of Communication fault, and an 80% output duty cycle, it would typically point to an issue with the FPCM PWM Feedback circuit. A loss of Battery supply or a poor chassis ground would usually cause no Fuel Pump operation and a no start condition.
   - If there is no Loss of Communication fault then this condition is most likely present due to an issue with the command circuit, an over current draw or over temp condition with the Fuel Pump.

PRELIMINARY DIAGNOSTIC CHECKS

1. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the ECU. Low Battery voltage can cause a DTC.
3. Circuit faults should typically be diagnosed before rationality/performance faults.
4. Check the component harness connector(s) for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the component harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCs and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns, or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. **Since the FPCM monitors the Fuel Pump circuits and motor for excessive current draw and over temperature conditions,** it is possible that the pump may need to run for an extended period for the condition to be present.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply, check for connection issues by wiggle testing any wiring harnesses and in-line connectors the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach a lab scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor battery system voltage or poor ground connections can affect systems in different or odd ways. Check the battery or batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the

components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.

4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving. Operate the components through a full range of operation while monitoring functionality.

DIAGNOSTIC TEST - FUEL PUMP CONTROL PERFORMANCE FAULTS (P025B, P027B, P062A, P064A, P26EA)

TECH TIP: The FPCM DTCs will set incorrectly for some vehicles/model years due to incorrect calibrations. For those vehicles it is best to perform the "COMPLETE FUEL PUMP CONTROL MODULE SYSTEM TESTING (NOT DTC SPECIFIC)" diagnostic procedure. Refer to the "KNOW ISSUES" information above for a list of the vehicles with incorrect calibrations.

FUEL PUMP CONTROL MODULE OUTPUT OVERTEMP (P025B, P027B): This fault will set when the FPCM detects an internal overtemp condition for the fuel pump output circuitry. Anything that can cause excessive current draw can cause the FPCM to eventually overheat and shut down.

1. Check the wiring and connectors at the FPCM and PCM for signs of spread terminal or corrosion that can cause an excessive electrical load on the FPCM. Check for a high mechanical draw due to a faulty Fuel Pump Assembly or severely restricted filter. Any of these conditions can cause an overtemp condition on the FPCM internal driver circuitry and should be confirmed good before condemning the module.
   - If any connection or mechanical issues are found with the module or fuel pump, repair the issue and retest the system.
   - If no other issues are found, replace the FPCM in accordance with the service information.

FUEL PUMP CONTROL PERFORMANCE (P062A): This fault usually sets along with other faults since the FPCM will either default to 80% duty cycle, or reduce the duty cycle PWM Output to the Fuel Pump when another fault is present. Either condition can cause the delta between the actual fuel pressure and the desired fuel pressure to be greater than the calibrated thresholds. If this fault is present with any other FPCM related faults, perform the other appropriate diagnostic procedure to find the failure. If **only this fault** is set, perform this diagnostic procedure.

NOTE: **The Fuel Rail Pressure Sensor is used to detect this failure (Low Fuel Pressure Sensor on the fuel high pressure system engines). A drifted Fuel Rail Pressure Sensor reading due to a faulty sensor or high circuit resistance can cause this DTC to set. The Fuel Rail Pressure Sensor rationality is checked by the PCM at each engine start up event. If it fails it will set a Fuel Rail Pressure Sensor Performance fault. If the Fuel Rail Pressure Sensor Performance fault is present, perform that test procedure before continuing.**

1. If available on the scan tool, check the Fuel Pump duty cycle, the actual and desired fuel pressure data readings.
   1. If the duty cycle is 80%, and the actual pressure is approximately 64 - 65 psi, **continue testing in step 2.**
   2. If the actual pressure is lower than the desired pressure, there is likely a fuel pressure issue.
      - Verify that the vehicle is not out of fuel.
      - Check the fuel lines for leaks or restrictions.
      - Before condemning the Fuel Pump, the Fuel Pump PWM Control and return circuits should be checked for high resistance causing low Fuel Pump output. If both circuits check good, the Fuel Pump is most likely faulty.
2. It is possible to have resistance in Fuel Rail Pressure Sensor signal or sensor ground circuit causing the signal to read off. Check the actual fuel system pressure with a pressure gauge and compare it to the Fuel Rail Pressure Sensor reading on the scan tool. Refer to the CHECKING THE FUEL DELIVERY SYSTEM test procedure for checking fuel pressure. Refer to CHECKING THE FUEL DELIVERY SYSTEM (HARD START) .

1. If the actual fuel pressure and the Fuel Rail Pressure Sensor reading is the same, replace the Fuel Pump. The Fuel Pump Assembly can be failing and still produce high fuel pressure in the system when the FPCM is defaulted to 80% duty cycle.
    - If the actual fuel pressure and the Fuel Rail Pressure Sensor reading is different, **continue testing in step 3.**
3. Isolate and check the Fuel Rail Pressure Sensor circuit for high resistance.
    1. If any of the circuits measure above 5.0 Ohms of resistance, repair the high resistance.
    2. If the circuits check good, replace the Fuel Rail Pressure Sensor.

FUEL PUMP CONTROL MODULE PERFORMANCE (P064A, P26EA): This DTC sets due to an over current condition in the fuel pump circuity. This can occur from high mechanical resistance in the fuel pump or an electrical issue with the fuel pump PWM control circuit. Typically the FPCM will reduce the duty cycle output to the fuel when this failure is occurring to reduce the load on the circuit.

1. Disconnect the fuel pump control module and fuel pump harness connectors. Check the fuel pump PWM control circuit for continuity to ground.
    1. If there is continuity between ground and the fuel pump PWM control circuit, repair the circuit for a short to ground.
    2. If the circuit checks good, **continue testing in step 2.**
2. Check the fuel pump PWM control circuit for a short to all other circuits at the FPCM harness connector.
    1. If there is continuity between the fuel pump PWM control circuit and any other circuit, repair the short between the circuits.
    2. If the circuit checks good replace the fuel pump in accordance with the service information.

POWERTRAIN VERIFICATION TEST

VERIFICATION OF REPAIR:

1. Inspect the vehicle to make sure that all engine components are properly installed and connected. Reassemble and reconnect components as necessary.
2. After repairs are complete, erase all DTCs with the scan tool.
3. Refer to the table below to determine if a learn procedure should be performed for the component that was removed or replaced. Not all learn procedures are available for all vehicles. If a component listed in the table is replaced and the correlating learn procedure is present in the scan tool, navigate to "Miscellaneous Functions" and perform the learn procedure before verifying repair. Failure to do so may cause the same, or another DTC to set.

Scan Tool Learn Procedures	Component replaced or removed: Note: (All available Learn procedures should be performed when a PCM is replaced)
Brake Pedal Learn	Brake Pedal Position Sensor, Brake Pedal Assembly
Cam Crank Relearn (NGC/GPEC Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clear Misfire TLC (Magneti Marelli Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clutch Pedal Learn	Clutch Pedal Position Sensor, Clutch Pedal, Clutch Assembly (pressure plate and disc)
EGR Valve Replaced	EGR Valve
Learn ETC	Throttle Body
Check PCM Odometer	PCM Replaced
Check PCM VIN	PCM Replaced
PCM Replaced Routine	PCM Replaced
Learn Gear Shift Sensor	Gear Shift Position Sensor, Transmission Shifter components

4. **If the PCM has been replaced** , perform the Module Programming procedure. The PCM Reprogramming procedure is either in Electronic Control Modules/PCM Programming Folder or PCM Standard Procedure Folder depending on the vehicle application. Be certain that the secret key code, VIN and odometer mileage are programmed after programming the PCM.
5. Operate the vehicle in accordance with the parameters and specific information found in the Monitoring Conditions and Theory of Operation of the DTC that was repaired.
6. With the scan tool, verify that no DTCs have returned.
   1. If the DTC returned check for any service bulletins or star online cases that may apply. If no bulletins exist, return to and perform the DTC procedure.
   2. If the DTC or condition did not return, repair is complete.

P062C-ETC LEVEL 2 MPH PERFORMANCE

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Throttle Body Motor is powered.
- No vehicle speed related DTCs have matured.

SET CONDITION

- When secondary software determines that the vehicle speed is implausible for a period of time.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
PCM SOFTWARE UPDATE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

NOTE: **An intermittent loss of power to the PCM without performing an ETC Relearn procedure may cause this DTC to set.**

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**

   NOTE: **Check the engine for air/vacuum leaks and diagnose as needed before continuing.**

   1. Refer to the recorded DTCs.

      Are there any Fuel System Lean/Rich or MAP Sensor DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3

3. **CHECK FOR PCM SOFTWARE UPDATE**
   1. With the scan tool, read and record the PCM part number.
   2. Verify the Powertrain Control Module (PCM) is at the latest calibration (flash level).

      Is the PCM at the latest software level?

      Yes

      - Go To 5

      No

      - Go To 4

4. **UPDATE PCM SOFTWARE AND RETEST FOR DTC**
   1. With the scan tool, update the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to the appropriate information .
   2. Turn the ignition on.
   3. With the scan tool, erase DTCs in the PCM.
   4. Start the engine and allow it to idle.

      WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

   5. Operate the accelerator pedal by gradually tipping in and out of the throttle and performing various throttle maneuvers. Do not exceed 3500 rpm.
   6. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 5

No

- Updating the PCM software repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED PCM OR COMPONENT CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0630-VIN NOT PROGRAMMED IN PCM

WHEN MONITORED

- This diagnostic runs at initialization.

SET CONDITION

- The VIN has not been programmed into the PCM.

DEFAULT ACTION

- The MIL will illuminate.
- The MIL will be turned off on the third consecutive trip that the diagnostic passes.

POSSIBLE CAUSES

Possible Causes
THE CORRECT VIN IS NOT PROGRAMMED INTO PCM
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

PROGRAM VIN INTO THE PCM

1. Turn the ignition on.
2. With the scan tool, program VIN into the PCM.
3. Start the engine.

NOTE: **If the engine will not start, crank the engine over for 15 seconds. Crank at least two times with the ignition switch returning to the off position each time.**

4. Allow the engine to reach normal operating temperature.
5. With the scan tool, read DTCs and record on the repair order.

   Does the DTC return?

   Yes

   - Replace and program the Powertrain Control Module in accordance with the Service Information.. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - The VIN has been successfully programmed into the PCM. Test is complete.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0632-ODOMETER NOT PROGRAMMED IN PCM

WHEN MONITORED

- With the ignition on.

SET CONDITION

- Odometer is not programed into the Powertrain Control Module (PCM).

DEFAULT ACTION

- The MIL will illuminate.
- The MIL will be turned off on the third consecutive trip that the diagnostic passes.

POSSIBLE CAUSES

Possible Causes
THE MILEAGE IS NOT PROGRAMMED INTO THE PCM
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

PROGRAMMING MILEAGE INTO THE PCM

1. Turn the ignition on.
2. With the scan tool, erase DTCs.
3. Using a scan tool, program the mileage into the PCM.
4. Start the engine.
5. Allow the engine to reach normal operating temperature.
6. With the scan tool, read DTCs and record on the repair order.

   Does the DTC return?

   Yes

   - Replace and program the Powertrain Control Module in accordance with the Service Information.. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - The mileage has been successfully programmed into the PCM. Test is complete.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0633-SKIM SECRET KEY NOT STORED IN PCM

THEORY OF OPERATION

NORMAL OPERATION:

- **Wireless Ignition Node (WIN) or Wireless Control Module (WCM):** On vehicles equipped with a WCM/WIN, the Secret Key data is a component of the encryption data used by the WCM/WIN for programming Keys/FOBIKs. Each WCM/WIN comes from the manufacture pre-programmed with its own unique Secret Key. When the vehicle is built this Secret Key data is used to program the Key/FOBIK and a back-up copy of the Secret Key data is stored in the PCM. The WCM/WIN unique secret key data then becomes the Original Secret Key for that vehicle. When a new Key/FOBIK is added and programmed, the secret key data in the WCM/WIN is used for the programming. The Key/FOBIK programming procedure permanently changes the Key/FOBIK so after it is programmed it becomes dedicated to that WCM/WIN.

  NOTE: **No new Keys/FOBIKs can be programmed to the vehicle if the P0633 DTC is active. Follow the repair procedure below to correct the P0633 DTC active condition before attempting to program new Keys/FOBIKs.**

- **Powertrain Control Module (PCM):** The PCM stores the backup copy of the Secret Key in case of a WCM/WIN replacement. The original Secret Key data can be transferred from the PCM stored location to the new WCM/WIN. **When a PCM is replaced,** the new PCM comes with **default Secret Key stored** in the Secret Key location. Running the "PCM Replaced" routine will transfer the original Secret Key and VIN from the WCM/WIN to the PCM. **If the VIN is manually written without the "PCM Replaced" routine being performed** the PCM Secret Key data will remain default, but the vehicle will start and run. The PCM checks this location during every ignition on key cycle. If the data stored in this location of the PCM has a **default** value, the P0633 DTC sets. **This DTC will not illuminate the MIL. It will also not cause any issues with the existing Keys/FOBIKs as long as the default data is not transferred to the WCM/WIN.**

VEHICLE PIN FUNCTION: Each vehicle has a unique 4 digit PIN number. The PIN is required to enter the Security Access Mode of the WCM/WIN using the scan tool. The WCM/WIN must be placed in the Security Access Mode to permit any programming functions or WCM/WIN configuration changes to occur. The WCM/WIN learns the PIN during its initial programming. Only one PIN can be learned. After the WCM/WIN has learned the PIN it cannot learn another.

DIAGNOSTIC OVERVIEW - SKIM SECRET KEY NOT STORED IN PCM (P0633)

If the default Secret Key HAS NOT BEEN transferred to the WCM/WIN the DTC can be fixed and cleared. If the default Secret Key HAS BEEN transferred to the WCM/WIN the fault cannot be corrected without replacing the WCM/WIN and Keys/FOBIKs. **The default data gets transferred to the WCM/WIN when a "WCM/WIN Replaced" routine is run on a vehicle that has the P0633 fault due to default data in the PCM, but the DTC was cleared prior to the routine being initiated.** Therefore, if P0633 is active it is IMPORTANT NOT TO ERASE THE DTC before attempting any repair on the vehicle. **Replacing the PCM will not fix this condition.** It is possible in some cases for the vehicle to start and run if a new Key/FOBIK was programmed to the default value in the WCM/WIN. In some, but not all instances, clearing the DTC and then programming a Key/FOBIK will allow the Key/FOBIK to operate. If the customer is in for a MIL on, and not for a Key/FOBIK concern, diagnose the other DTCs that are present causing the MIL and ignore the active P0633 since it will not turn on the MIL.

Important "WCM/WIN Replaced" Scan Tool Routine Info: When the "WCM/WIN Replaced" routine is initiated and the PIN is entered, the scan tool looks for an unlocked message from the WCM/WIN. If the unlocked message is seen, the scan tool determines that the WCM/WIN is new (new unique Secret Key stored). If it does not get the unlock message it determines that the WCM/WIN is not new (original Secret Key stored). After making this determination **the routine will then take one of two paths depending on if there is an active P0633 fault present.** This is why it is important NOT TO ERASE THE FAULT.

1. **Orignial WCM/WIN:**
   - **If the scan tool does not see an active P0633** when the "WCM/WIN Replaced" routine is initiated it will transfer the Secret Key from the PCM to existing WCM/WIN. **If the PCM has the default value stored it value will be transferred to the WCM/WIN which will cause all Keys/FOBIKs to be inoperative and stop working.**

NOTE: **Once this occurs, running the "PCM Replaced" or "WCM/WIN Replaced" routines will show a message that the data was successfully transferred but the default data is being sent back and forth. If this happens the vehicle cannot be fixed without replacing the WCM/WIN and Keys/FOBIKs.**

NOTE: **If the original PCM with the original Secret Key stored is available it could be re-connected to the vehicle and the original Secret Key could be transferred back to the WCM/WIN by running the "WCM/WIN Replaced" with the old PCM connected.**

- **If P0633 is active** when the routine is initiated, the scan tool will prompt the original Secret Key stored in the WCM/WIN to transfer to the PCM.

2. **New WCM/WIN:** If a new WCM/WIN is being used as a replacement part, its unique Secret Key can be over-written with the stored back-up copy of the original Secret Key by transferring the back-up copy of the original Secret Key from the PCM to the replacement WCM/WIN. This permits the original Keys/FOBIKs to be retained.
    - If the condition causing the P0633 is present but the active DTC was erased, the scan tool will not see an active P0633 when the routine is initiated. In this scenario the scan tool assumes the PCM has the original Secret Key stored and transfers the data from the PCM to the new WCM/WIN. **This overwrites the valid data and will cause the new WCM/WIN to be inoperative.**

NOTE: **Once this occurs, running the "PCM Replaced" or "WCM/WIN Replaced" routines will show a message that the data was successfully transferred but the default data is being sent back and forth. If this happens the vehicle cannot be fixed without replacing the WCM/WIN and Keys/FOBIKs.**

    - **If P0633 is active** when the routine is initiated, the scan tool will request the unique Secret Key value in the new WCM/WIN be transferred to the PCM. The new unique Secret Key value transfers from the WCM/WIN to the PCM. This replaces the default Secret Key data in the PCM with new Secret Key data. On the next key cycle the P0633 should change to stored and new Keys/FOBIKs can be programmed.

WHEN MONITORED

- With the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) has a default value stored in the Secret Key location.

DEFAULT ACTION

- This is a non MIL fault.

POSSIBLE CAUSES

Possible Causes
PCM WAS REPLACED AND THE "PCM REPLACED" ROUTINE HAS NOT BEEN RUN
DEFAULT SECRET KEY VALUE WAS RECORDED IN THE WCM/WIN DUE TO DTC BEING ERASED BEFORE THE "WCM/WIN REPLACED" ROUTINE WAS RUN

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to **PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .**

DIAGNOSTIC TEST

1. **ATTEMPT TO TRANSFER THE SKIM SECRET KEY INTO THE PCM**

   NOTE: **DO NOT ERASE ANY FAULTS BEFORE PERFORMING THIS TEST PROCEDURE.**

   NOTE: **No new Keys/FOBIKs can be programmed to the vehicle if the P0633 DTC is active.**

   1. If the defaulted value has not been transferred to the WCM/WIN the fault can be fixed by simply running the "PCM Replaced" routine. The only way to verify if the WCM/WIN Secret Key is not the default value is to run the "PCM Replaced" routine with the DTC active. If the fault changes to stored after the routine is complete, the WIN/WCM has the original Secret Key stored and it was transferred successfully to the PCM. Follow the steps below to determine if the Secret Key can be transferred.
   2. Turn the ignition on.
   3. With the scan tool, perform the "PCM Replaced" routine.
   4. Turn the ignition off for 10 seconds.
   5. Turn the ignition on.
   6. With the scan tool, read DTCs.

   Did the P0633 DTC change to stored?

   Yes

   - The Secret Key information has been successfully transferred into the PCM. The fault can be cleared and Keys/FOBIKs can be programmed.

     NOTE: **This is a non MIL fault. If the customers complaint is for a MIL on, this repair will not fix the condition that caused the MIL to be on.**

   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   NOTE: **The Secret Key information is no longer stored on the vehicle. Both the PCM and WCM/WIN have default data stored.**

   - Go To 2

2. **FOLLOW THE RECOMMENDED PROCEDURE FOR THE SCENARIO IN THE TABLE BELOW**

VEHICLE CONDITION	RECOMMENDED REPAIR ACTION(S)
Vehicle runs, customer complaint is MIL on and P0633 is active with other DTCs present	The P0633 DTC is active because of a prior PCM replacement without the Secret Key being transferred. The fault will not change to stored because the default Secret key data was transferred to the WCM/WIN. The vehicle runs because the Key/FOBIK is programmed to the default value in the WCM/WIN. • If the customer complaint is the MIL on, there should be other DTCs present in the PCM. **The MIL is on because of the other DTCs,** regardless of whether they are active or stored. **The P0633 fault will not turn on the MIL.** Repairing the other faults and clearing DTCs will turn off the MIL even with P0633

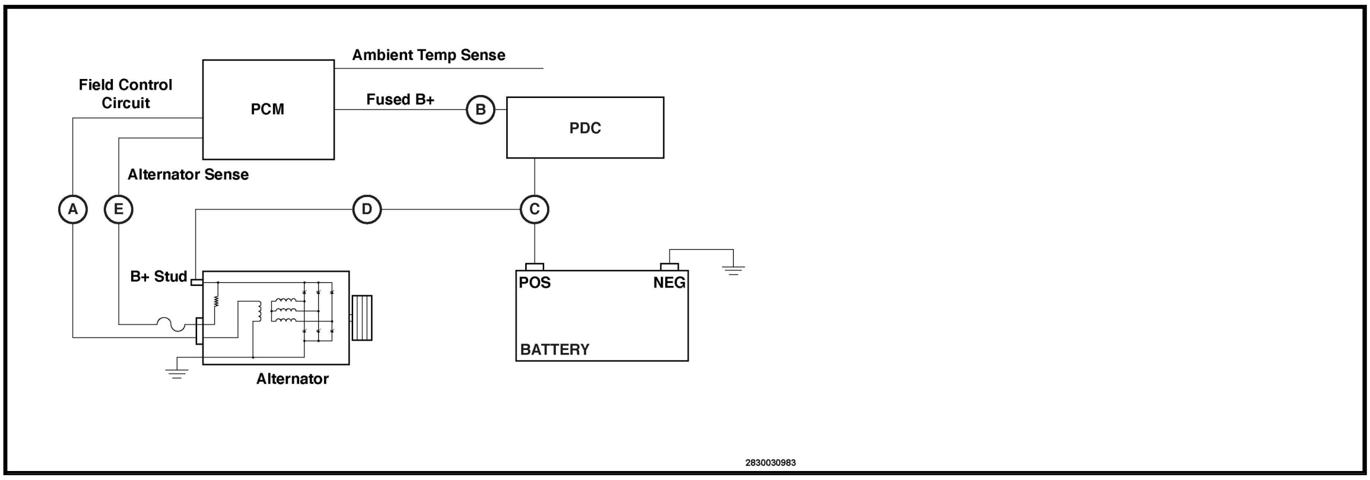
VEHICLE CONDITION	RECOMMENDED REPAIR ACTION(S)
	active. If the customer is not adding Keys/FOBIKs, it is not necessary to repair the P0633 DTC since this is a non MIL fault.
Vehicle runs and customer complaint is not related to the WCM/WIN Keys/FOBIKs, or a MIL	The P0633 DTC is active because of a prior PCM replacement without the Secret Key being transferred. The fault will not change to stored because the default Secret key data was transferred to the WCM/WIN. The vehicle runs because the Key/FOBIK is programmed to the default value in the WCM/WIN. • **The MIL is not on because P0633 is a non-MIL fault.** If the customer is not adding Keys/FOBIKs, it is not necessary to repair the P0633 fault.
The "WIN/WCN Replaced" routine was run with default data in the PCM and vehicle Keys/FOBIKs are not working with an active P0633	**NOTE:** **If the original PCM or WCM/WIN are available and can communicate, it may be possible to reconnect one of them to the vehicle and transfer the original Secret Key data back into the vehicle. This would allow the original Keys/FOBIKs to operate again.** Replace the WIN/WCM. **DO NOT ERASE THE P0633 FAULT.** With the P0633 DTC active, the scan tool will request the unique Secret Key value in the new WIN/WCM get transferred to the PCM and over-write the default value. Using the scan tool, perform the "WIN/WCM Replaced" routine. When the routine starts the three messages listed below will appear. If you read the messages below on the screen before selecting continue, the routine will time out and fail before you can finish reading the messages. Select the continue button without reading the on screen messages to allow the unique Secret Key data to transfer to the new WIN/WCM and PCM. • **On screen messages that will be displayed:** 1. Important: DTC P0633 is present in the PCM. This means that the PCM does NOT contain a secret key. 2. To prevent having to cut and program new keys you should attempt to recover the original secret key information from either the original WCM or the original PCM by running the appropriate WCM Misc Function (PCM replaced or WCM replaced). 3. If neither the original PCM or WCM is available, then continue this function. IMPORTANT!!! The vehicles

VEHICLE CONDITION	RECOMMENDED REPAIR ACTION(S)
	original keys will no longer work for this vehicle. Cut the new keys if needed and program them into WCM. • After the new Secret Key data is programmed successfully in the WIN/WCM and PCM, program the new Keys/FOBIKs to the new WIN/WCM.
Vehicle runs and customer wants additional Keys/FOBIKs added and programmed with P0633 Active	The active P0633 DTC will prevent any additional Keys/FOBIKs from being programmed. To add new Keys/FOBIKs the WIN/WCM will have to be replaced. This will make any current Keys/FOBIKs inoperative. **DO NOT ERASE THE P0633 FAULT.** The new WIN/WCM can accept the unique Secret Key transfer if the P0633 DTC is active. 1. Replace the WIN/WCM. 2. Using the scan tool, perform the "WIN/WCM Replaced" routine. 3. When the routine starts the three messages listed below will appear. If you read the messages below on the screen before selecting continue, the routine will time out and fail before you can finish reading the messages. Select the continue button without reading the on screen messages to allow the unique Secret Key data to transfer to the new WIN/WCM and PCM. • **On screen messages that will be displayed:** \\ • Important: DTC P0633 is present in the PCM. This means that the PCM does NOT contain a secret key. • To prevent having to cut and program new keys you should attempt to recover the original secret key information from either the original WCM or the original PCM by running the appropriate WCM Misc Function (PCM replaced or WCM replaced). • If neither the original PCM or WCM is available, then continue this function. IMPORTANT!!! The vehicles original keys will no longer work for this vehicle. Cut the new keys if needed and program them into WCM. • After the new Secret Key data is programmed successfully in the WIN/WCM and PCM, program the new Keys/FOBIKs to the new WIN/WCM.

P063A-GENERATOR VOLTAGE SENSE CIRCUIT

For a complete STARTING/CHARGING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION



The Electronic Voltage Regulation (EVR) system maintains the system voltage at a desired level by turning the Pulse Width Modulated (PWM) Alternator Field Control circuit (A) on and off. When the Alternator field is turned on, the system voltage increases. When the Alternator field is turned off, the system voltage slowly drops. The rate at which this happens is dependent upon the existing electrical loads, ambient under hood temperature, and the engine speed. A constant system voltage (B, C, D) can be maintained only when the Alternator field is switched on and off at a duty cycle that very accurately emulates the existing electrical loads given the existing ambient under hood temperature and engine speed.

During normal operation, the voltage reading at the Alternator output stud will be very close to the target charging voltage viewed on the scan tool. This is the system voltage and is sensed by the Powertrain Control Module (PCM) through the Fused B+ circuit (B). With the Alternator connector plugged in, the voltage reading on the Alternator Sense circuit will be approximately 3.5 volts less than the voltage at the Alternator output stud due the resistor inside the Alternator. This is the Alternator Sense (E) input to the PCM. These two voltage sense inputs are used and compared during the different diagnostics performed on the EVR System by the PCM.

Diagnostic Mode: The PCM will run the **Alternator Voltage Sense Line** diagnostic to determine that the Alternator voltage sense (E) voltage is lower than the system voltage (B, C, D) by a calibrated amount. This is an indication of permanent or intermittent disconnections, or excessive resistance in the Alternator Sense Line wiring caused by either corrosion or a loose connection.

WHEN MONITORED

- This diagnostic runs one time during an ignition cycle with the engine running.

SET CONDITION

- The Alternator Sense circuit voltage is less than the Battery feed circuit voltage.

DEFAULT ACTION

- The Battery light will illuminate.
- The MIL will illuminate.
- The fault will be checked again on the next key cycle

POSSIBLE CAUSES

Possible Causes
ALTERNATOR SENSE CIRCUIT OPEN/HIGH RESISTANCE
ALTERNATOR SENSE CIRCUIT SHORTED TO GROUND
ALTERNATOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE CONDITION OF THE BATTERY**

    NOTE: The Alternator belt and tensioner condition must be checked before continuing.

    1. Use the (special tool #GR8-1220KIT-CHRY, AGM Battery Tester/Charger Station)or equivalent to load test the Battery.

        Did the Battery pass or fail?

        Passed

        - Go To 3

        Failed

        - Perform the appropriate repair according to the Battery tester.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
3. **ISOLATE AND CHECK THE ALTERNATOR (A804) SENSE CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.

4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 4

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE ALTERNATOR (A804) SENSE CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: There should be no continuity between ground and the circuit being tested.

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK THE ALTERNATOR FOR PROPER OPERATION**

WARNING: When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.

1. Reconnect the Alternator harness connector.
2. Reconnect the PCM C2 harness connector with the GPEC Adaptor still connected in line.
3. Start the engine.
4. Measure the voltage at the Alternator Output stud.
5. Probe and measure the voltage of the Alternator (A804) Sense circuit at the GPEC Adaptor.
6. The Alternator Sense circuit reading will normally be approximately 3.5 volts less than the voltage at the Alternator Output terminal due to an internal resistor inside the Alternator.

Does the voltage read as described above?

Yes

- Go To 6

No

- Verify that there is good pin to terminal contact in the Alternator and Powertrain Control Module connectors. Replace the Alternator if no problems were found with the connectors. Refer to **GENERATOR, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

   Repair any conditions that are found.

   5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.

6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0642-SENSOR REFERENCE VOLTAGE 1 CIRCUIT LOW

THEORY OF OPERATION

The Powertrain Control Module (PCM) contains two internal 5-Volt Sensor Supply sources; Reference Voltage 1 and Reference Voltage 2. Each of these 5-Volt Supply sources are split internally into parallel circuits to provide a 5.0 volt reference to multiple three wire sensors. For self protection, if the 5-Volt Supply circuit is shorted to ground or if one of the sensors is internally shorted, the PCM will turn off the 5-Volt Supply circuit until the next ignition cycle.

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- PCM recognizes the Primary 5-Volt Supply circuit voltage is too low.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will flash.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
PRIMARY 5-VOLT SUPPLY CIRCUIT SHORTED TO GROUND
CRANKSHAFT POSITION (CKP) SENSOR
ENGINE OIL PRESSURE (EOP) SENSOR
THROTTLE BODY ASSEMBLY
A/C PRESSURE TRANSDUCER
ACCELERATOR PEDAL POSITION (APP) SENSOR

Possible Causes
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**

    NOTE: **Improperly installed aftermarket accessories can cause this DTC to set.**

    1. Refer to the recorded DTCs.

        Are there any improperly installed aftermarket accessories DTCs present?

        Yes

        - Remove the aftermarket accessories and retest for DTC.

        No

        - Go To 3
3. **CHECK THE (F855) PRIMARY 5-VOLT SUPPLY CIRCUIT VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the PCM C2 harness connector.

        CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).

4. Reconnect the PCM C2 harness connector with the GPEC Adaptor connected in-line with the PCM C2 harness connector.
5. Turn the ignition on.
6. Measure the voltage on the (F855) Primary 5-Volt Supply circuit at the GPEC Adaptor.

   Is the voltage between 4.9 and 5.1 volts?

   Yes

   - Go To 8

   No

   - Go To 4

4. **CHECK THE SENSORS THAT SHARE THE PRIMARY 5-VOLT SUPPLY**
   1. **IMPORTANT - FOLLOW THIS PROCEDURE EXACTLY WHEN CHECKING THE FOLLOWING COMPONENTS:** Turn the ignition off before disconnecting each component. After a component has been disconnected, turn the ignition on and measure the voltage on the (F855) Primary 5-Volt Supply circuit at the GPEC Adaptor. If the 5-Volt Supply voltage returns to 5.0 volts after disconnecting a component, the component that was disconnected is faulty. If the voltage remains low after disconnecting a component, then the disconnected component is not the problem. Leave each component disconnected and move on to the next until the faulty component is discovered or all components have been disconnected. Disconnect only one component at a time during this step.
   2. Disconnect the Throttle Body harness connector and check the Primary 5-Volt Supply circuit voltage.
   3. Disconnect the A/C Pressure Sensor harness connector and check the Primary 5-Volt Supply circuit voltage.
   4. Disconnect the CKP Sensor harness connector and check the Primary 5-Volt Supply circuit voltage.
   5. Disconnect the APP Sensor harness connector and check the Primary 5-Volt Supply circuit voltage.
   6. Disconnect the EOP Sensor harness connector and check the Primary 5-Volt Supply circuit voltage.

   Were any of the above components determined to be at fault?

   Yes

   - Replace the faulty component in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **CHECK THE (F855) PRIMARY 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO GROUND**
   1. Turn the ignition off.

   NOTE: **All of the components should still be disconnected during this test step.**

   2. Disconnect the PCM C2 harness connector from the PCM.
   3. Check for continuity between ground and the (F855) Primary 5-Volt Supply circuit at the GPEC Adaptor.

   Is there continuity between ground and the (F855) Primary 5-Volt Supply circuit(s)?

Yes

- Repair the (F855) Primary 5-Volt Supply circuit for a short to ground.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK THE (K852) PRIMARY 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO GROUND**
   1. Disconnect the PCM C1 harness connector.
   2. Connect the (special tool #10436, Adapter, GPEC Diagnostic) to the PCM C1 harness connector.
   3. Check for continuity between ground and the (K852) 5-Volt Supply circuit at the GPEC Adaptor.

   Is there continuity between ground and the (K852) Primary 5-Volt Supply circuit(s)?

   Yes

   - Repair the (K852) Primary 5-Volt Supply circuit for a short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 7

7. **CHECK THE (F855) PRIMARY 5-VOLT SUPPLY CIRCUIT AND THE (K852) PRIMARY 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO A SENSOR GROUND CIRCUIT AT EACH SENSOR CONNECTOR**
   1. Check for continuity between both Primary 5-Volt Supply circuits and the sensor ground circuits of each disconnected components.

   Is there continuity between any of the sensor ground circuits and the Primary 5-Volt Supply circuit(s)?

   Yes

   - Repair the Primary 5-Volt Supply circuit for a short to the sensor ground circuit that showed continuity.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 8

8. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.

- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0643-SENSOR REFERENCE VOLTAGE 1 CIRCUIT HIGH

THEORY OF OPERATION

The Powertrain Control Module (PCM) contains two internal 5-Volt Sensor Supply sources; Reference Voltage 1 and Reference Voltage 2. Each of these 5-Volt Supply sources are split internally into parallel circuits to provide a 5.0 volt reference to multiple three wire sensors. For self protection, if the 5-Volt Supply circuit is shorted to ground or if one of the sensors is internally shorted, the PCM will turn off the 5-Volt Supply circuit until the next ignition cycle.

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- PCM recognizes the Primary 5-Volt Supply circuit voltage is too high.

DEFAULT ACTION

- The MIL will illuminate.

- The ETC light will flash.

POSSIBLE CAUSES

Possible Causes
(F855) 5-VOLT SUPPLY SHORTED TO VOLTAGE
(K852) 5-VOLT SUPPLY SHORTED TO VOLTAGE
CRANKSHAFT POSITION (CKP) SENSOR
ENGINE OIL PRESSURE (EOP) SENSOR
THROTTLE BODY ASSEMBLY
A/C PRESSURE TRANSDUCER
ACCELERATOR PEDAL POSITION (APP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**

    NOTE: **Improperly installed aftermarket accessories can cause this DTC to set.**

    1. Refer to the recorded DTCs.

        Are there any improperly installed aftermarket accessories DTCs present?

        Yes

        - Remove the aftermarket accessory and retest for DTC.

        No

- Go To 3

3. **CHECK THE (F855) PRIMARY 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the PCM C2 harness connector.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
    4. Reconnect the PCM C2 harness connector with the GPEC Adaptor connected in-line with the PCM C2 harness connector.
    5. Disconnect the Throttle Body harness connector.
    6. Disconnect the A/C Pressure Sensor harness connector.
    7. Disconnect the APP Sensor harness connector.
    8. Disconnect the CKP Sensor harness connector.
    9. Disconnect the EOP Sensor harness connector.
    10. Turn the ignition on.
    11. Measure the voltage on the (F855) Primary 5-Volt Supply circuit at the GPEC Adaptor.

        Is the voltage reading above 5.2 volts?

        Yes

        - Repair the (F855) Primary 5-Volt Supply circuit for a short to voltage.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 4

4. **CHECK THE (K852) PRIMARY 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the PCM C1 harness connector.
    3. Reconnect the PCM C1 harness connector with the GPEC Adaptor connected in-line with the PCM C1 harness connector.
    4. Turn the ignition on.
    5. Measure the voltage on the (K852) Primary 5-Volt Supply circuits at the GPEC Adaptor.

        Is the voltage reading above 5.2 volts?

        Yes

        - Repair the (K852) Primary 5-Volt Supply circuit for a short to voltage.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 5

5. **CHECK FOR SENSOR SHORTED INTERNALLY**

1. **IMPORTANT - FOLLOW THIS PROCEDURE EXACTLY WHEN CHECKING THE FOLLOWING COMPONENTS:** Turn the ignition off before connecting each component. After a component has been connected, turn the ignition on and measure the voltage on the Primary 5-Volt Supply circuits at the GPEC Adaptor. If the 5-Volt Supply voltage goes above 5.1 volts after connecting a component, the component that was connected is faulty. If the voltage remains at 5.0 volts after connecting a component, then the connected component is not the problem. Leave each component connected and move on to the next until the faulty component is discovered or all components have been connected. Connect only one component at a time during this step.
2. Connect the connector for each sensor or component, one at a time, and measure the voltage of the Primary 5-Volt Supply circuits at the GPEC Adaptor.

   Does the voltage go above 5.1 volts when connecting any of the sensors?

   Yes

   - Replace the faulty sensor in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6

6. **CHECKING THE PCM POWER AND GROUND CIRCUITS**
   1. Perform the NO RESPONSE FROM THE PCM test procedure. Refer to the appropriate information.

      NOTE: **Check the PCM B+, Fused Ignition, ASD inputs and ground circuits.**

      Were any problems found?

      Yes

      - Repair the PCM power and ground circuit(s) as necessary.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 7

7. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.

- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0645-A/C CONTROL CIRCUIT/OPEN

For a complete A/C CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

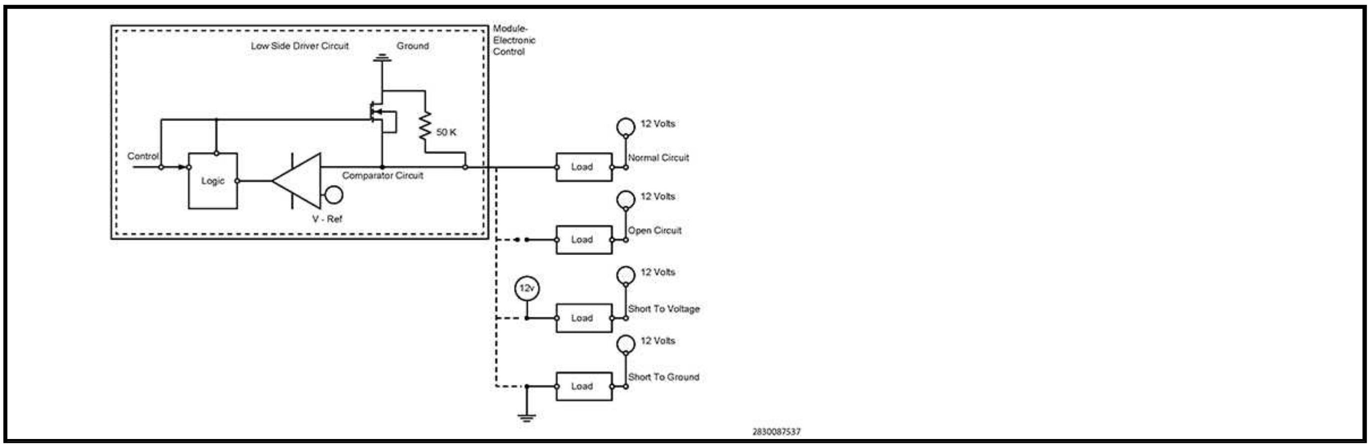
THEORY OF OPERATION

The Powertrain Control Module (PCM) receives a signal requesting the A/C Compressor to be turned on from the HVAC. When the PCM receives this request it energizes the A/C Clutch Relay through a **Low Side Driver** . The Powertrain Control Module (PCM) receives feedback from the A/C Pressure Transducer to monitor the pressure in the high side of the A/C refrigerant system. The A/C Pressure Transducer connects to a fitting on the A/C discharge line and its internal resistance changes in response to the pressure in the system. The PCM is programmed to respond to this and other sensor inputs to control the operation of the A/C Clutch and the Radiator Cooling Fan to help optimize A/C system performance and to protect the A/C system components from damage. The PCM will not allow the A/C Clutch Relay to be energized when the A/C Pressure Transducer reading is too low or excessively high. When the refrigerant pressure rises above a calibrated pressure specific to the PCM, the PCM will actuate the cooling fan.

Typical Low Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver device. The PCM provides a ground to operate the device when switched on. The ground could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device, wiring and internal driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. For diagnostic purposes the PCM uses an internal pull down diagnostic resistor connected in series and a voltage reference (V-Ref) comparator for fault detection:

- **Circuit Open and Circuit Low Detection:** The PCM monitors for an **open circuit** and **short to ground** when the driver is switched off. When switched off, the available voltage passes through the device and the **internal pull down resistor** connected in series. The voltage at the **comparator circuit** should be close to Battery voltage since the majority of the voltage drop occurs through the diagnostic resistor. If the available voltage is less than the V-Ref, a fault is set. In this scenario the V-Ref would be slightly below Battery voltage. **An alternative method of fault detection for an open or short to ground** that is used is to monitor current draw when the internal driver is switched on. If the module does not detect any current draw it determines that the component or circuitry is open. Excessive current draw detected would indicate a short to ground.
- **Circuit High Detection:** The PCM monitors for a **short to voltage** when the driver is switched on. When the driver is switched on providing a path to ground through the transistor, the available voltage should be pulled low, near zero volts since the **comparator circuit** is monitoring the ground side of the device. If the voltage is greater than V-Ref, a fault is detected. In this scenario V-Ref would be slightly above zero volts.

NOTE:	**A load that has a resistance that is below manufacturer specification, or a second load device shorted to the low side driver circuit can cause excessive current draw on the internal driver. The driver will be switched off to protect against overheating and damaging the driver. In this instance the Circuit High fault may be detected because the available voltage on the comparator circuit is above V-Ref.**



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The Powertrain Control Module (PCM) detects an open or short in the A/C Compressor Clutch Control circuitry.

DEFAULT ACTION

- This is a non MIL fault.

POSSIBLE CAUSES

Possible Causes
A/C COMPRESSOR CONTROL CIRCUIT SHORTED TO VOLTAGE
A/C COMPRESSOR CONTROL CIRCUIT SHORTED TO GROUND
A/C COMPRESSOR CONTROL CIRCUIT OPEN OR HIGH RESISTANCE

Possible Causes
A/C CLUTCH RELAY/POWER DISTRIBUTION CENTER (PDC)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE A/C CLUTCH RELAY CONFIGURATION**
    1. Check the Power Distribution Center layout in the wiring information to determine if the A/C Clutch Relay is removable or a Printed Circuit Board (PCB) Relay in the PDC.

        What type of relay is the PDC configured with?

        Removable Relay:

        - Go To 3

        PCB Relay:

        - Go To 4
3. **CHECK THE BATTERY SUPPLY TO THE A/C CLUTCH RELAY CONTROL COIL BY LOAD TESTING THE CIRCUIT**
    1. Remove the A/C Clutch Relay from the PDC.
    2. Using the wiring information as a guide, connect the positive lead of the load test tool to the 12.0 volt supply circuit at the A/C Clutch Relay connector in the PDC.
    3. Connect the negative lead of the load test tool to the ground circuit of the Battery or a good chassis ground.
    4. Ensure that the circuit being tested is being powered on. If the 12.0 volt circuit being tested is an ignition feed for example, the ignition must be on. If testing an output from a relay, verify that the relay is energized and on.

5. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

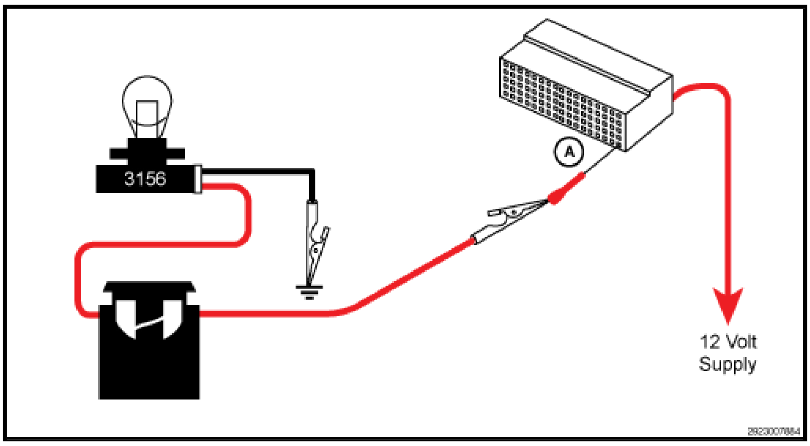
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
- **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 5

No

- Check all of the fuses in the PDC. If a fuse is open, replace the fuse and retest. If no problems are found with the fuses, check the Battery supply to the PDC. If no problems are found replace the PDC in accordance with the Service Information. Refer to **CENTER, POWER DISTRIBUTION (PDC), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK FOR THE BATTERY VOLTAGE TO THE A/C CLUTCH RELAY CONTROL COIL**
   1. Using a DVOM, back probe and measure the voltage on the A/C Clutch Relay (C13) Control circuit at the PDC connector.

NOTE: **The relay must be commanded off when checking for voltage on the circuit. With the relay Low Side Driver control circuit commanded off the voltage should be approximately equal to Battery voltage on the (C13) A/C Clutch Control circuit.**

Is the voltage approximately equal to Battery voltage?

Yes

- Go To 5

No

- Check all of the fuses in the PDC. If a fuse is open, replace the fuse and retest. If no problems are found with the fuses, check the Battery supply to the PDC. If no problems are found replace the PDC in accordance with the Service Information. Refer to **CENTER, POWER DISTRIBUTION (PDC), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK THE A/C CLUTCH RELAY FOR PROPER OPERATION**
   1. If the relay is removable, reinstall the A/C Clutch Relay in the PDC.
   2. Turn the ignition on.
   3. Using a 12-volt test light connected to ground, back probe the A/C Clutch Relay (C13) Control circuit at the PDC harness connector.

NOTE: **The relay should make an audible click when closing. Another way to verify that the relay closed is to back probe and check for voltage on the relay output circuit.**

Did the relay close when connecting the A/C Clutch Relay (C13) Control circuit to ground through the test light?

Yes

- Go To 6

No

- If this is a PCB relay, replace the Power Distribution Center (PDC) in accordance with the Service Information.
- If this is a removable relay and the PDC has an internal PCB and harness connectors, isolate and check the continuity between terminal 86 of the relay connector and the output terminal at the PDC connector. If the resistance is below 3.0 Ohms, replace the A/C Clutch Relay. If the resistance is above 3.0 Ohms, replace the Power Distribution Center (PDC) in accordance with the service information. Refer to **CENTER, POWER DISTRIBUTION (PDC), REMOVAL AND INSTALLATION** .
- If this is a removable relay and the wiring harness is directly hard wired into the PDC, replace the A/C Clutch Relay.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND CHECK THE A/C CLUTCH RELAY (C13) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **ISOLATE AND CHECK THE A/C CLUTCH RELAY (C13) CONTROL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.

3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 8

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.

8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P064A-FUEL PUMP CONTROL MODULE 1

For a complete FUEL DELIVERY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

KNOWN ISSUES - FPCM SYSTEM

While the FPCM has the capability of detected failure modes, the faults are not always reported out as intended. Some vehicles have incorrect calibrations that will read the FPCM messages incorrectly and set the DTCs incorrectly. On these vehicles it is best not to rely on the DTC, or DTC Description when deciding which portion of the system to diagnose. In these cases it is best to read and understand how the system operates, then diagnose the entire system to determine where the failure lies by performing the **Complete Fuel Pump Control Module System Diagnostics (Not DTC Specific)** procedure when diagnosing this system. This diagnostic can also be used to diagnose the FPCM command, feedback and fuel pump control circuits on vehicles with the correct calibration software.

The vehicles listed below will set faults incorrectly for the model years listed and should always be diagnosed using the Not DTC specific system approach.

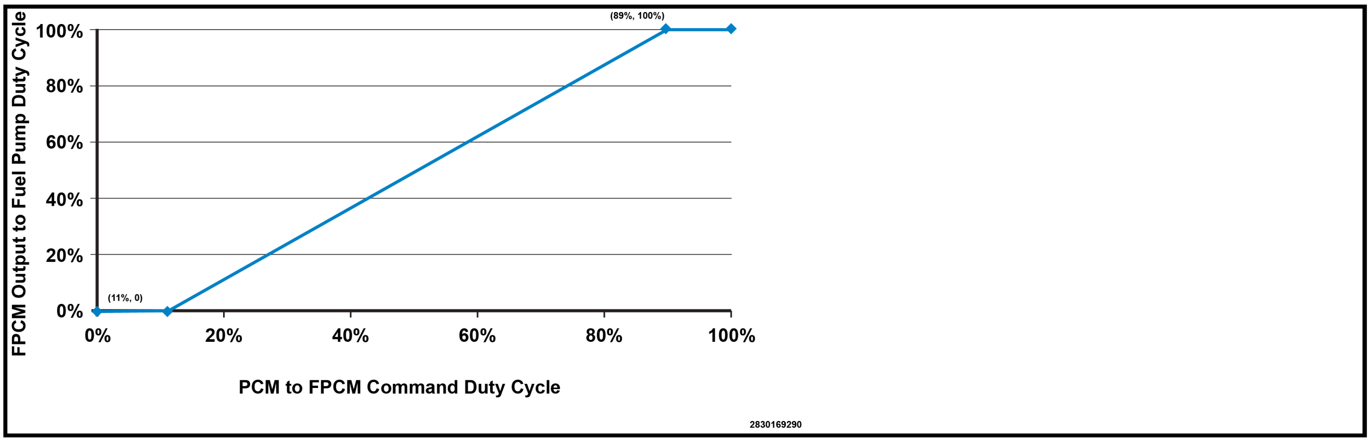
- DS - model years 2016-2019
- RU - model years 2017-2018
- JL - model year 2018
- JT - model year 2020

The exceptions to the information above are the Loss of Communication, Fuel Rail Pressure Sensor and Fuel Pump Relay Control circuit faults. These faults will typically set correctly since they are detected by the PCM directly, not the FPCM.

FPCM SYSTEM DESCRIPTION AND OPERATION

SYSTEM DESCRIPTION: When the Powertrain Control Module (PCM) requires Fuel Pump operation it energizes the Fuel Pump Relay. The Battery voltage output from the relay does not connect directly to the Fuel Pump like traditional systems. Instead, the Battery voltage is supplied to the Fuel Pump Control Module (FPCM). When the ignition is switched on, the Battery voltage is present for approximately five seconds. Battery voltage should always be present during cranking or when the engine is running. The purpose of FPCM is to operate the Fuel Pump at a reduced voltage output to reduce electrical load on the system. Most vehicle/engine combinations operate as a **fixed pressure system** . Vehicles with the 6.2L engine operate as a **variable pressure system** . It is necessary on some vehicles with the 6.2L engine to have a second Fuel Pump and FPCM to meet engine needs. The second FPCM performs the same diagnostics as the primary module but uses different DTCs.

SYSTEM OPERATION: To maintain the desired fuel pressure, the PCM sends a Pulse Width Modulated (PWM) duty cycle signal to the FPCM. If there are no system faults present, the Fuel Pump Control output to the Fuel Pump is based on the duty cycle sent by the PCM. The graph below shows the FPCM output to the Fuel Pump in proportion to the PCM command signal. **The FPCM output to the fuel pump will not read as a duty cycle when monitoring with a Mopar Scope. It will be a consistent voltage output that is a percentage of battery voltage.**



COMPONENT FUNCTIONAL DESCRIPTION- FUEL PUMP CONTROL MODULE (FPCM) AND FUEL PUMP

The FPCM performs fault detection and reports faults to the PCM through the PWM Feedback circuit. The feedback circuit can be monitored using the Mopar Scope and functions as follows:

- The feedback circuit is a 5.0 volt duty cycle.
- The PCM supplies the 5.0 volts for the feedback circuit.
- The FPCM pulses the low side of the circuit to communicate with the PCM.
- The normal duty cycle operating range is between 3% and 97%.
- When the system is operating normally, the FPCM will send a 50% duty cycle on the feedback circuit to the PCM.
- When the FPCM detects a fault it will send a duty cycle that aligns with the failure mode detected.
- If the duty cycle is 0% or 100% the PCM will set the Loss of Communication fault against the FPCM.

NOTE: **Monitoring the FPCM internal driver with an open feedback circuit using the Mopar Scope will show a pulse width signal with a very low voltage (.025v - 0.5v). This is picking up voltage from the internal driver device that is still trying to pulse the duty cycle to the PCM. This can be useful when performing diagnostics on the feedback circuitry.**

Depending on the failure mode detected by the PCM and FPCM, the FPCM can react by either reducing the PWM output duty cycle, or defaulting to an 80% duty cycle for the fuel pump operation. The FPCM reactions are explained further in the PCM/FPCM Reaction column of the Enable Conditions and Failure Modes information.

Fuel Pump: The Fuel Pump operates in the same manner as a typical Brushed DC motor. The only difference is that the speed is reduced due to the PWM output voltage from the FPCM being less than 100%. The voltage supplied is based on the command received from the PCM.

Vehicles with Dual Pump Systems: The fuel pumps operate independently, but may be serviced as an assembly on some vehicles. During normal operation both Fuel Pumps are used to provide the system pressure and volume needed during most engine operating conditions. **The exception is at idle, or idle and purging**

where there is extremely low fuel demand. During this mode Fuel Pump 2 is typically turned off. When more fuel demand is needed (typically off idle) Fuel Pump 2 is turned on and both pumps are operated at the same duty cycle. If either pump is failing the vehicle may still operate normally during most driving conditions but would have performance issues under heavy engine load when both pumps are needed. If a failure is detected for either Fuel Pump or circuitry, the duty cycle will typically default to 80%. If Fuel Pump 1 (primary) is defaulted to 80%, Fuel Pump 2 may remain off during most operating conditions. **However, if Fuel Pump 2 is defaulted to 80%, the primary pump will continue to operate at the lower duty cycle range. The reason for this is that the primary pump operates the jet pump to pull fuel from the secondary side of the Fuel Tank and also fills the Fuel Pump assembly reservoir.**

COMPONENT FUNCTIONAL DESCRIPTION - POWERTRAIN CONTROL MODULE (PCM)

The PCM monitors the input signal from the Fuel Rail Pressure Sensor to determine the commanded duty cycle to the FPCM. On a fixed pressure system the PCM varies the commanded duty cycle to maintain a constant pressure. On variable pressure systems the commanded duty cycle is varied to adjust fuel pressure based on engine needs. Ambient temperature and fuel temperature can also contribute to fuel pressure changes. The pressure is raised during high ambient temperatures to prevent boiling of the fuel.

NOTE: **On vehicles with diesel engines or high pressure gas fuel systems, the PCM monitors the Fuel Pressure Sensor on the low pressure side of the system to determine the commanded duty cycle, not the Fuel Rail Pressure Sensor on the high pressure side.**

The command circuit can be monitored using the Mopar Scope and functions as follows:

- The command circuit is a 12.0 volt duty cycle.
- The FPCM supplies the 12.0 volts for the command circuit.
- The PCM pulses the low side of the circuit to communicate with the DTCM.
- The normal duty cycle operating range is between 11% and 89%.
- If the FPCM does not receive a valid command signal from the PCM it will send a fault message on the feedback circuit and operates the fuel pump at a defaulted value (typically 80%).

With an open command circuit, the PCM internal driver will show a pulse width signal of approximately 2.5v if checking at the PCM connector with the Mopar Scope. This is picking up voltage from the internal driver device that is still trying to pulse the duty cycle to the FPCM. This can be useful when performing diagnostics on the command circuitry.

When the PCM loses communication with the FPCM it will default to the highest duty cycle. This will cause the FPCM to provide maximum voltage output to the fuel pump.

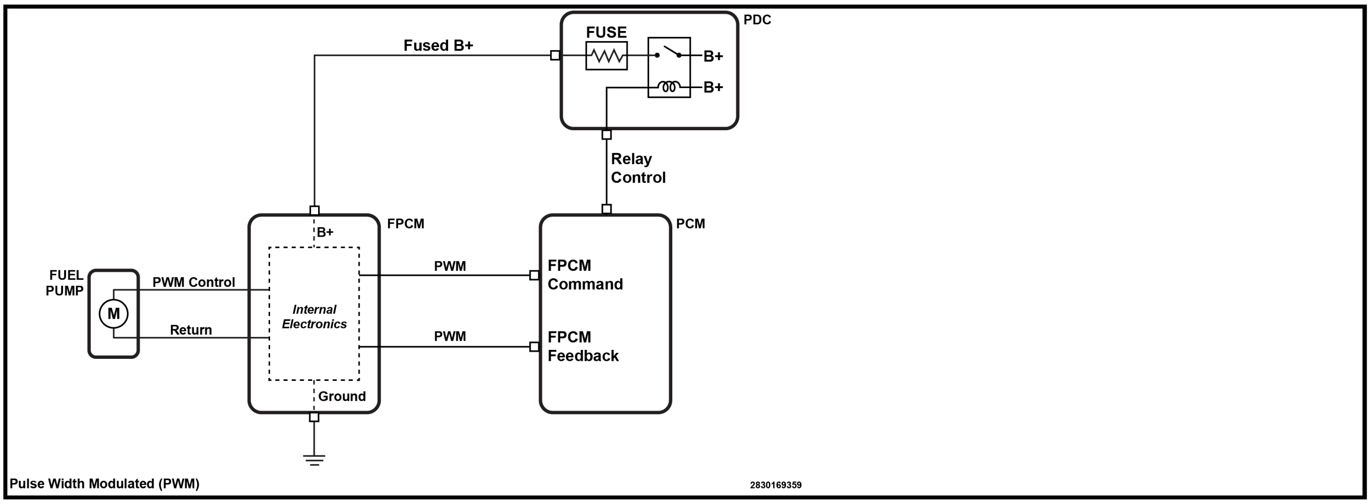
TECHNICAL DATA-FUEL SYSTEM PRESSURE SPECIFICATIONS

The table below shows the fuel system pressure specifications.

VARIABLE FUEL PRESSURE SYSTEM SPECIFICATIONS (6.2L ENGINES)		
CRANKING	520 kPa (75.4 psi)	System operates in open loop during cranking
IDLE	340 - 400 kPa (49 - 58 psi)	Normal operating range at idle - Pressure is dependant on ambient and fuel temp. Pressure is raised during high temp to prevent boiling
NORMAL RANGE OF OPERATION	340 - 550 kPa (49 - 80 psi)	Normal operating range between idle and high engine demand
100% DUTY CYCLE	600 - 700 kPa (87 - 101.5 psi)	This is regulated by the pressure relief valve in the Fuel Pump. The pressure can vary from pump to pump.
B		
4 CYLINDER (1.0L/1.3L GSET / 2.0L GMET ENGINES)		

CRANKING	580 kPa (84.1 psi)	System operates in open loop during cranking
ALL OTHER OPERATING CONDITIONS	520 kPa (75.4 psi)	The fixed pressure systems should maintain approximately 75.0 psi during normal operation
B		
FIXED PRESSURE SYSTEM SPECIFICATIONS (ALL OTHER ENGINES)		
The fixed pressure systems should maintain approximately 400 kPa (58.0) psi during normal operation		

GENERIC SYSTEM SCHEMATIC:



WHEN MONITORED

SET CONDITION

- The Powertrain Control Module (PCM) detects a fault in the Fuel Pump Control System.

DEFAULT ACTION

- The MIL will illuminate.

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

The table below shows the FPCM DTCs and the correlating INTENDED failure modes. **NOTE: On some vehicles the faults may not always set as expected which may lead to a misdiagnosis (See the know issue information). Therefore, it is usually best to perform the "Complete Fuel Pump Control Module System Testing (Not DTC Specific)" in the diagnostic information.**

POSSIBLE CAUSES

FPCM 1 DTC	FPCM 2 DTC	FAILURE MODES	POSSIBLE CAUSES	PCM/FPCM REACTION
P025A	P027A	Missing or invalid PWM Command signal from PCM	1. PCM to FPCM Command Signal open 2. PCM to FPCM Command Signal shorted low or high 3. Invalid PWM signal - frequency out of range 4. FPCM 5. PCM	• FPCM defaults the output to the Fuel Pump to 80% duty cycle **NOTE:** **It is not uncommon for the P025A DTC to set**

FPCM 1 DTC	FPCM 2 DTC	FAILURE MODES	POSSIBLE CAUSES	PCM/FPCM REACTION
				erroneously for several other failure modes
P025B	P027B	Output driver over temp	1. FPCM Output partially shorted to ground 2. Faulty Fuel Pump (high mechanical resistance) 3. Faulty FPCM internal driver	• PCM sets fault, waits a calibrated period and commands a safe duty cycle • FPCM output to Fuel Pump to 50% duty cycle for a calibrated period. If over temp continues, shut down output driver.
P025C	P027C	System under voltage - Fuel Pump Relay output voltage to FPCM is below a calibrated threshold (approximately 6.0 volts)	1. High resistance in the Fuel Pump Relay output circuit 2. FPCM	• PCM requests 100% Fuel Pump operation • FPCM defaults the output to the Fuel Pump to 80% duty cycle
P025D	P027D	System over voltage - Fuel Pump Relay output voltage to FPCM is above a calibrated threshold (approximately 16.0 volts)	1. Charging system issue	• PCM applies over voltage strategy • FPCM reacts to PCM input command
P0628	P2633	FPCM output to Fuel Pump shorted to ground	1. Fuel Pump PWM Control circuit shorted to ground	• PCM reduces PWM duty cycle until issue clears • FPCM reacts to PCM input command
P0629	P2634	FPCM output to Fuel Pump shorted to voltage	1. Fuel Pump PWM Control circuit shorted to voltage	• FPCM output to Fuel Pump to 50% duty cycle for a calibrated period. If condition continues, shut down output driver.
P062A	P062A	Actual fuel pressure is above or below the desired fuel pressure by more than a calibrated threshold. • Fixed pressure system - 5.8 psi above or 14.5 psi below	1. No fuel in the Fuel Tank 2. Fuel supply tube broken/leaking 3. Fuel supply tube pinched/restricted 4. FPCM defaulted to 80% due to another failure detected	• PCM requests 100% Fuel Pump operation • FPCM defaults the output to the Fuel Pump to 80% duty cycle

FPCM 1 DTC	FPCM 2 DTC	FAILURE MODES	POSSIBLE CAUSES	PCM/FPCM REACTION
		• Variable pressure system - 10.9 psi above or below	5. FPCM duty cycle output reduced due to another failure detected 6. Faulty Fuel Pump	
P064A	P26EA	Current draw exceeds calibrated threshold	1. Fuel Pump PWM Control circuit shorted to voltage 2. Faulty Fuel Pump - internal short or high mechanical resistance	• PCM reduces PWM duty cycle until issue clears • FPCM reacts to PCM input command
P1205	P120A	FPCM Micro internal fault	1. Fuel Pump Control Module	• FPCM continues to run in normal mode - run Fuel Pump according to PCM command signal
P1206	P120B	FPCM output to Fuel Pump open circuit	1. Fuel Pump PWM Control circuit open 2. Fuel Pump Return/Ground circuit open 3. FPCM Ground circuit open 4. FPCM	• PCM reduces PWM duty cycle until issue clears • FPCM reacts to PCM input command
U0109	U016C	PCM Loss of Communication with FPCM	1. FPCM PWM Feedback circuit open 2. FPCM PWM Feedback shorted low or high 3. Fuel Pump Relay output circuit to FPCM open or shorted to ground 4. FPCM Ground circuit open 5. Fuel Pump PWM Control circuit shorted to ground 6. FPCM 7. PCM	• PCM requests 100% Fuel Pump operation • FPCM defaults the output to the Fuel Pump to 80% duty cycle

DIAGNOSTIC OVERVIEW-FUEL PUMP CONTROL MODULE

GENERAL DIAGNOSTIC INFORMATION: There are several faults associated with this system. The failure modes being monitored for are Loss of Communication, internal FPCM faults, system voltage faults, Thermal Protection, circuit faults, and system performance. **On several vehicles, multiple or incorrect faults** can set which can mislead diagnosing the vehicle. For this reason, it is a good practice to perform a total system diagnosis regardless of the DTC present for most faults. The communication faults are detected directly by the PCM and will typically set correctly. See Communication Diagnostics explanation below.

PCM DIAGNOSTICS: The PCM directly monitors the Fuel Pump Relay Control circuit, FPCM Feedback circuit and the Fuel Pressure Sensor circuits for faults. The Fuel Pressure Sensor signal must be rationalized since the signal is monitored to perform fuel system pressure performance diagnostics. This is done by watching the signal at initial engine start up for both types of systems. **On the fixed pressure system** the normally stable fuel pressure is dynamic for the first few seconds. The pressure will spike above the set point approximately 40-50 kPa (5.8-7.25 psi), then drop below the set point approximately 60-70 kPa (8.7-10.2 psi), and quickly dampen and settle at the set point 400kPa (58.0 psi). At initial engine start up, when the engine speed reaches approximately 500 rpm, the Powertrain Control Module (PCM) measures the delta pressure change between the highest pressure reading and lowest pressure reading and make determinations about sensor rationality. The diagnostic works the same **on the variable pressure system** as the fixed pressure system except that the system is in open loop at start up and the pressure is commanded to a preset known value to perform the diagnostic.

SYSTEM VOLTAGE DIAGNOSTICS: The FPCM monitors the Battery voltage supply coming from the Fuel Pump Relay to the module. A fault will set if the voltage is too high or too low. Typically a voltage high fault would indicate a charging system issue. The voltage low fault could also be a charging system issue, but may also be caused by resistance in the Battery supply or ground circuit.

COMMUNICATION DIAGNOSTICS: Unlike other system faults, the Loss of Communication fault will typically set correctly. The PCM will set this fault when the FPCM PWM Feedback duty cycle is below 3% or above 97%. This can occur if the FPCM Battery voltage supply or ground circuits are open, or the FPCM PWM Feedback circuit is open or shorted.

FUEL PUMP PERFORMANCE DIAGNOSTICS: The PCM fails the **P062A** Fuel System Performance diagnostic when the actual fuel pressure is approximately **100 kPa (14.5 psi) below or 40 kPa (5.8 psi) above the desired fuel pressure.** This fault usually sets along with other faults since the FPCM will default to 80% duty cycle for many failure modes which causes the actual pressure to be higher than the desired set point. The entire system should be examined when this fault is set, including the Fuel Pressure Sensor and circuits. A sensor drifted out of range, or high resistance in the signal or sensor ground circuit can cause a false reading on a normally operating system.

- **The dual pump variable pressure systems can be tricky when diagnosing a performance fault.** The fuel pressure may be good with one failed pump during most normal operating conditions. The condition may only be present under very heavy engine load conditions when both pumps are needed to produce the pressure and volume needed. If available on the scan tool, monitoring duty cycle for both pumps can help diagnosing the issue. If a failure is detected for either Fuel Pump or circuitry, the duty cycle will typically default to 80%. If Fuel Pump 1 (primary) is defaulted to 80%, Fuel Pump 2 may remain off during most operating conditions. However, if Fuel Pump 2 is defaulted to 80%, the primary pump will continue to operate at the lower duty cycle range. The reason for this is that the primary pump operates the jet pump to pull fuel from the secondary side of the Fuel Tank and also fills the Fuel Pump reservoir.

The FPCM fails the **P064A** Fuel Pump Control Module Performance when excessive current draw is detected on the fuel pump circuitry. The FPCM will default and reduce the duty cycle to the fuel pump to the lowest possible duty cycle while the issue is present.

For most vehicles the fuel pressure desired and actual values, as well as the Fuel Pump output duty cycle data can be viewed on the scan tool. These readings can be very useful during the diagnosis of the system.

TECH TIP: A vehicle will typically have one of two issues;

1. The vehicle has no fuel pressure/pump is not operating.
    - The first thing to check for is a Loss of Communication fault. The reason is that the same Battery supply and ground circuit that are used to power up the FPCM are also used for the Fuel Pump motor to operate. A loss of Battery supply, or a poor chassis ground for the module will cause both issues.
    - The next thing to look for is an output from the FPCM to the pump. This can be done with the scan tool or by checking the duty cycle output from the FPCM. If there is any output from the FPCM to the Fuel Pump, the pump should be operating and creating fuel pressure. If the pump is not running then the Fuel Pump and circuits between the FPCM and Fuel Pump should be focused on during

diagnostics. If the Loss of Communication fault is not present the Battery supply and chassis ground are most likely good.

2. The vehicle runs normally, has a DTC or DTCs present, and the output duty cycle to the Fuel Pump is defaulted. In most cases, the output is defaulted to 80% and the actual pressure is greater than the desired pressure.
   - The first thing to check is for a Loss of Communication fault. If the vehicle is running with a Loss of Communication fault, and an 80% output duty cycle, it would typically point to an issue with the FPCM PWM Feedback circuit. A loss of Battery supply or a poor chassis ground would usually cause no Fuel Pump operation and a no start condition.
   - If there is no Loss of Communication fault then this condition is most likely present due to an issue with the command circuit, an over current draw or over temp condition with the Fuel Pump.

PRELIMINARY DIAGNOSTIC CHECKS

1. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the ECU. Low Battery voltage can cause a DTC.
3. Circuit faults should typically be diagnosed before rationality/performance faults.
4. Check the component harness connector(s) for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the component harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCs and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns, or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. **Since the FPCM monitors the Fuel Pump circuits and motor for excessive current draw and over temperature conditions,** it is possible that the pump may need to run for an extended period for the condition to be present.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply, check for connection issues by wiggle testing any wiring harnesses and in-line connectors the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach a lab scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor battery system voltage or poor ground connections can affect systems in different or odd ways. Check the battery or batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving. Operate the components through a full range of operation while monitoring functionality.

DIAGNOSTIC TEST - FUEL PUMP CONTROL PERFORMANCE FAULTS (P025B, P027B, P062A, P064A, P26EA)

TECH TIP: The FPCM DTCs will set incorrectly for some vehicles/model years due to incorrect calibrations. For those vehicles it is best to perform the "COMPLETE FUEL PUMP CONTROL MODULE SYSTEM TESTING (NOT DTC SPECIFIC)" diagnostic procedure. Refer to the "KNOW ISSUES" information above for a list of the vehicles with incorrect calibrations.

FUEL PUMP CONTROL MODULE OUTPUT OVERTEMP (P025B, P027B): This fault will set when the FPCM detects an internal overtemp condition for the fuel pump output circuitry. Anything that can cause excessive current draw can cause the FPCM to eventually overheat and shut down.

1. Check the wiring and connectors at the FPCM and PCM for signs of spread terminal or corrosion that can cause an excessive electrical load on the FPCM. Check for a high mechanical draw due to a faulty Fuel Pump Assembly or severely restricted filter. Any of these conditions can cause an overtemp condition on the FPCM internal driver circuitry and should be confirmed good before condemning the module.
    - If any connection or mechanical issues are found with the module or fuel pump, repair the issue and retest the system.
    - If no other issues are found, replace the FPCM in accordance with the service information.

FUEL PUMP CONTROL PERFORMANCE (P062A): This fault usually sets along with other faults since the FPCM will either default to 80% duty cycle, or reduce the duty cycle PWM Output to the Fuel Pump when another fault is present. Either condition can cause the delta between the actual fuel pressure and the desired fuel pressure to be greater than the calibrated thresholds. If this fault is present with any other FPCM related faults, perform the other appropriate diagnostic procedure to find the failure. If **only this fault** is set, perform this diagnostic procedure.

NOTE: **The Fuel Rail Pressure Sensor is used to detect this failure (Low Fuel Pressure Sensor on the fuel high pressure system engines). A drifted Fuel Rail Pressure Sensor reading due to a faulty sensor or high circuit resistance can cause this DTC to set. The Fuel Rail Pressure Sensor rationality is checked by the PCM at each engine start up event. If it fails it will set a Fuel Rail Pressure Sensor Performance fault. If the Fuel Rail Pressure Sensor Performance fault is present, perform that test procedure before continuing.**

1. If available on the scan tool, check the Fuel Pump duty cycle, the actual and desired fuel pressure data readings.
    1. If the duty cycle is 80%, and the actual pressure is approximately 64 - 65 psi, **continue testing in step 2.**
    2. If the actual pressure is lower than the desired pressure, there is likely a fuel pressure issue.
        - Verify that the vehicle is not out of fuel.
        - Check the fuel lines for leaks or restrictions.
        - Before condemning the Fuel Pump, the Fuel Pump PWM Control and return circuits should be checked for high resistance causing low Fuel Pump output. If both circuits check good, the Fuel Pump is most likely faulty.
2. It is possible to have resistance in Fuel Rail Pressure Sensor signal or sensor ground circuit causing the signal to read off. Check the actual fuel system pressure with a pressure gauge and compare it to the Fuel Rail Pressure Sensor reading on the scan tool. Refer to the CHECKING THE FUEL DELIVERY SYSTEM test procedure for checking fuel pressure. Refer to **CHECKING THE FUEL DELIVERY SYSTEM (HARD START)** .
    1. If the actual fuel pressure and the Fuel Rail Pressure Sensor reading is the same, replace the Fuel Pump. The Fuel Pump Assembly can be failing and still produce high fuel pressure in the system when the FPCM is defaulted to 80% duty cycle.
        - If the actual fuel pressure and the Fuel Rail Pressure Sensor reading is different, **continue testing in step 3.**
3. Isolate and check the Fuel Rail Pressure Sensor circuit for high resistance.
    1. If any of the circuits measure above 5.0 Ohms of resistance, repair the high resistance.

2. If the circuits check good, replace the Fuel Rail Pressure Sensor.

FUEL PUMP CONTROL MODULE PERFORMANCE (P064A, P26EA): This DTC sets due to an over current condition in the fuel pump circuity. This can occur from high mechanical resistance in the fuel pump or an electrical issue with the fuel pump PWM control circuit. Typically the FPCM will reduce the duty cycle output to the fuel when this failure is occurring to reduce the load on the circuit.

1. Disconnect the fuel pump control module and fuel pump harness connectors. Check the fuel pump PWM control circuit for continuity to ground.
    1. If there is continuity between ground and the fuel pump PWM control circuit, repair the circuit for a short to ground.
    2. If the circuit checks good, **continue testing in step 2.**
2. Check the fuel pump PWM control circuit for a short to all other circuits at the FPCM harness connector.
    1. If there is continuity between the fuel pump PWM control circuit and any other circuit, repair the short between the circuits.
    2. If the circuit checks good replace the fuel pump in accordance with the service information.

POWERTRAIN VERIFICATION TEST

VERIFICATION OF REPAIR:

1. Inspect the vehicle to make sure that all engine components are properly installed and connected. Reassemble and reconnect components as necessary.
2. After repairs are complete, erase all DTCs with the scan tool.
3. Refer to the table below to determine if a learn procedure should be performed for the component that was removed or replaced. Not all learn procedures are available for all vehicles. If a component listed in the table is replaced and the correlating learn procedure is present in the scan tool, navigate to "Miscellaneous Functions" and perform the learn procedure before verifying repair. Failure to do so may cause the same, or another DTC to set.

Scan Tool Learn Procedures	Component replaced or removed: Note: (All available Learn procedures should be performed when a PCM is replaced)
Brake Pedal Learn	Brake Pedal Position Sensor, Brake Pedal Assembly
Cam Crank Relearn (NGC/GPEC Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clear Misfire TLC (Magneti Marelli Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clutch Pedal Learn	Clutch Pedal Position Sensor, Clutch Pedal, Clutch Assembly (pressure plate and disc)
EGR Valve Replaced	EGR Valve
Learn ETC	Throttle Body
Check PCM Odometer	PCM Replaced
Check PCM VIN	PCM Replaced
PCM Replaced Routine	PCM Replaced
Learn Gear Shift Sensor	Gear Shift Position Sensor, Transmission Shifter components

4. **If the PCM has been replaced** , perform the Module Programming procedure. The PCM Reprogramming procedure is either in Electronic Control Modules/PCM Programming Folder or PCM Standard Procedure Folder depending on the vehicle application. Be certain that the secret key code, VIN and odometer mileage are programmed after programming the PCM.
5. Operate the vehicle in accordance with the parameters and specific information found in the Monitoring Conditions and Theory of Operation of the DTC that was repaired.
6. With the scan tool, verify that no DTCs have returned.

1. If the DTC returned check for any service bulletins or star online cases that may apply. If no bulletins exist, return to and perform the DTC procedure.
2. If the DTC or condition did not return, repair is complete.

P0652-SENSOR REFERENCE VOLTAGE 2 CIRCUIT LOW

THEORY OF OPERATION

The Powertrain Control Module (PCM) contains two internal 5-Volt Sensor Supply sources; Reference Voltage 1 and Reference Voltage 2. Each of these 5-Volt Supply sources are split internally into parallel circuits to provide a 5.0 volt reference to multiple three wire sensors. For self protection, if the 5-Volt Supply circuit is shorted to ground or if one of the sensors is internally shorted, the PCM will turn off the 5-Volt Supply circuit until the next ignition cycle.

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- PCM recognizes the Secondary 5-Volt Supply circuit voltage is too low.
- ETC light is flashing.

DEFAULT ACTION

- The ETC light will flash.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
SECONDARY 5-VOLT SUPPLY SHORTED TO GROUND
MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR
CAMSHAFT POSITION (CMP) SENSOR
CAMSHAFT POSITION (CMP) SENSOR 2
ACCELERATOR PEDAL POSITION (APP) SENSOR
FUEL RAIL PRESSURE (FRP) SENSOR
EXHAUST GAS RECIRCULATION (EGR) VALVE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.

7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**

NOTE: **Improperly installed aftermarket accessories can cause this DTC to set.**

1. Refer to the recorded DTCs.

   Are there any improperly installed aftermarket accessories DTCs present?

   Yes

   - Remove the aftermarket accessories and retest for DTC.

   No

   - Go To 3

3. **CHECK THE (F856) SECONDARY 5-VOLT SUPPLY CIRCUIT VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the PCM C2 harness connector.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
   4. Reconnect the PCM C2 harness connector with the GPEC Adaptor connected in-line with the PCM C2 harness connector.
   5. Turn the ignition on.
   6. Measure the voltage on the (F856) Secondary 5-Volt Supply circuit at the GPEC Adaptor.

   Is the voltage between 4.9 and 5.1 volts?

   Yes

   - Go To 7

   No

   - Go To 4

4. **CHECK THE SENSORS THAT SHARE THE SECONDARY 5-VOLT SUPPLY**
   1. **IMPORTANT - FOLLOW THIS PROCEDURE EXACTLY WHEN CHECKING THE FOLLOWING COMPONENTS:** Turn the ignition off before disconnecting each component. After a component has been disconnected, turn the ignition on and measure the voltage on the (F856) Secondary 5-Volt Supply circuit at the GPEC Adaptor. If the 5-Volt Supply voltage returns to 5.0 volts after disconnecting a component, the component that was disconnected is faulty. If the

voltage remains low after disconnecting a component, then the disconnected component is not the problem. Leave each component disconnected and move on to the next until the faulty component is discovered or all components have been disconnected. Disconnect only one component at a time during this step.

2. Disconnect the MAP Sensor harness connector and check the Secondary 5-Volt Supply circuit voltage.
3. Disconnect the Fuel Rail Pressure (FRP) Sensor harness connector and check the Secondary 5-Volt Supply circuit voltage.
4. Disconnect the Accelerator Pedal Position (APP) Sensor harness connector and check the Secondary 5-Volt Supply circuit voltage.
5. Disconnect the Exhaust Gas Recirculation (EGR) Valve harness connector and check the Secondary 5-Volt Supply circuit voltage.
6. Disconnect the CMP Sensor 1 harness connector and check the Secondary 5-Volt Supply circuit voltage.
7. Disconnect the CMP Sensor 2 harness connector and check the Secondary 5-Volt Supply circuit voltage.

Were any of the above components determined to be at fault?

Yes

- Replace the faulty component in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK THE (F856) SECONDARY 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO GROUND**
   1. Turn the ignition off.

   NOTE: **All of the components should still be disconnected during this test step.**

   2. Disconnect the PCM C2 harness connector from the PCM.
   3. Check for continuity between ground and the (F856) Secondary 5-Volt Supply circuit at the GPEC Adaptor.

   Is there continuity between ground and the (F856) Secondary 5-Volt Supply circuit(s)?

   Yes

   - Repair the (F856) Secondary 5-Volt Supply circuit for a short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6
6. **CHECK THE (F854) SECONDARY 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO GROUND**
   1. Disconnect the PCM C1 harness connector.
   2. Connect the (special tool #10436, Adapter, GPEC Diagnostic) to the PCM C1 harness connector.
   3. Check for continuity between ground and the (K854) Secondary 5-Volt Supply circuit at the GPEC Adaptor.

Is there continuity between ground and the (K854) Secondary 5-Volt Supply circuit(s)?

Yes

- Repair the (K854) Secondary 5-Volt Supply circuit for a short to ground.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0653-SENSOR REFERENCE VOLTAGE 2 CIRCUIT HIGH

THEORY OF OPERATION

The Powertrain Control Module (PCM) contains two internal 5-Volt Sensor Supply sources; Reference Voltage 1 and Reference Voltage 2. Each of these 5-Volt Supply sources are split internally into parallel circuits to provide a 5.0 volt reference to multiple three wire sensors. For self protection, if the 5-Volt Supply circuit is shorted to ground or if one of the sensors is internally shorted, the PCM will turn off the 5-Volt Supply circuit until the next ignition cycle.

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Secondary 5-Volt Supply circuit voltage is greater than 5.2 volts.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
SECONDARY 5-VOLT SUPPLY SHORTED TO GROUND
MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR
CAMSHAFT POSITION (CMP) SENSOR
CAMSHAFT POSITION (CMP) SENSOR 2
ACCELERATOR PEDAL POSITION (APP) SENSOR
FUEL RAIL PRESSURE (FRP) SENSOR
EXHAUST GAS RECIRCULATION (EGR) VALVE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the Pre-Diagnostic Troubleshooting procedure before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**

   NOTE: **Improperly installed aftermarket accessories can cause this DTC to set.**

   1. Refer to the recorded DTCs.

      Are there any improperly installed aftermarket accessories DTCs present?

      Yes

      - Remove the aftermarket accessories and retest for DTC.

      No

      - Go To 3

3. **CHECK THE (F856) SECONDARY 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the PCM C2 harness connector.

      CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
   4. Reconnect the PCM C2 harness connector with the GPEC Adaptor connected in-line with the PCM C2 harness connector.
   5. Disconnect the MAP Sensor harness connector.
   6. Disconnect the Fuel Rail Pressure (FRP) Sensor harness connector.
   7. Disconnect the Accelerator Pedal Position (APP) Sensor harness connector.
   8. Disconnect the Exhaust Gas Recirculation (EGR) Valve harness connector.
   9. Disconnect the CMP Sensor 1 harness connector.
   10. Disconnect the CMP Sensor 2 harness connector.
   11. Turn the ignition on.
   12. Measure the voltage on the (F856) Secondary 5-Volt Supply circuit at the GPEC Adaptor.

       Is the voltage reading above 5.2 volts?

       Yes

       - Repair the (F856) Secondary 5-Volt Supply circuit for a short to voltage.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

- Go To 4

4. **CHECK THE (K854) 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the PCM C1 harness connector.
   3. Reconnect the PCM C1 harness connector with the GPEC Adaptor connected in-line with the PCM C1 harness connector.
   4. Turn the ignition on.
   5. Measure the voltage on the (K854) 5-Volt Supply circuits at the GPEC Adaptor.

      Is the voltage reading above 5.2 volts?

      Yes

      - Repair the (K854) 5-Volt Supply circuit for a short to voltage.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 5

5. **CHECK FOR SENSOR SHORTED INTERNALLY**
   1. **IMPORTANT - FOLLOW THIS PROCEDURE EXACTLY WHEN CHECKING THE FOLLOWING COMPONENTS:** Turn the ignition off before connecting each component. After a component has been connected, turn the ignition on and measure the voltage on the Secondary 5-Volt Supply circuits at the GPEC Adaptor. If the 5-Volt Supply voltage goes above 5.2 volts after connecting a component, the component that was connected is faulty. If the voltage remains at 5.0 volts after connecting a component, then the connected component is not the problem. Leave each component connected and move on to the next until the faulty component is discovered or all components have been connected. Connect only one component at a time during this step.
   2. Connect the connector for each sensor or component, one at a time, and measure the voltage on the 5-Volt Supply circuits at the GPEC Adaptor.

      Does the voltage go above 5.2 volts when connecting any of the sensors?

      Yes

      - Replace the faulty sensor in accordance with the Service Information.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 6

6. **CHECKING THE PCM POWER AND GROUND CIRCUITS**
   1. Perform the NO RESPONSE FROM THE PCM test procedure. Refer to the appropriate information.

      NOTE: **Check the PCM B+, Fused Ignition, ASD inputs and ground circuits.**

      Were any problems found?

      Yes

      - Repair the PCM power and ground circuit(s) as necessary.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0685-ASD/MAIN CONTROL CIRCUIT

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

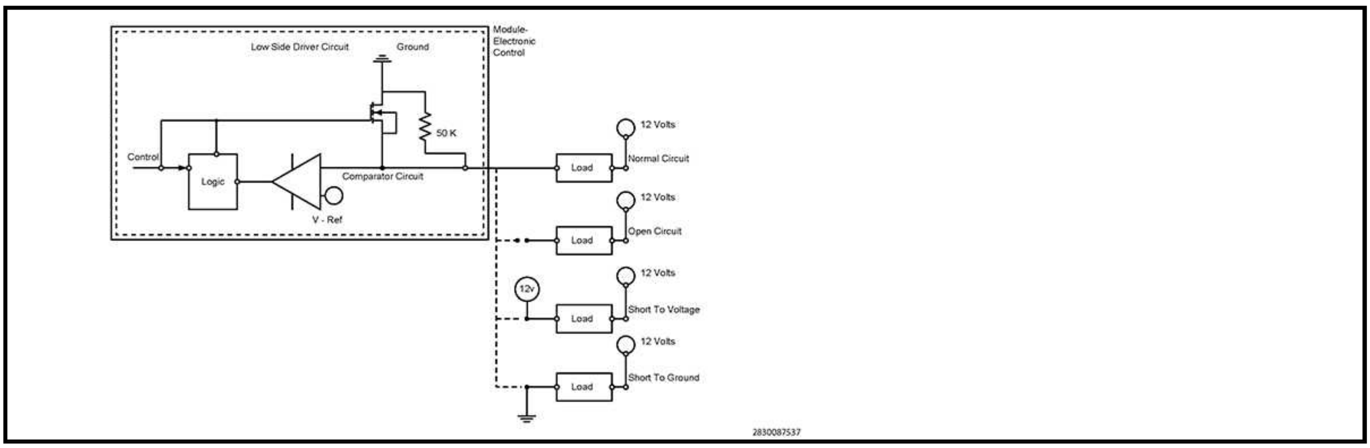
THEORY OF OPERATION

The Powertrain Control Module (PCM) controls the Auto Shutdown (ASD) Relay using a **Low Side Driver** . The ASD Relay Output voltage is supplied to the PCM as well as several engine components. The ASD Relay Output voltage that is supplied to the PCM is used to as the internal actuator supply to power several high side controlled devices. Because the ASD Relay is used for the operation of numerous engine components, the PCM performs diagnostics on both the ASD Relay Control and ASD Relay Output circuits. The PCM operates the ASD Relay Control circuit through a Low Side Driver (LSD).

Typical Low Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver device. The PCM provides a ground to operate the device when switched on. The ground could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device, wiring and internal driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. For diagnostic purposes the PCM uses an internal pull down diagnostic resistor connected in series and a voltage reference (V-Ref) comparator for fault detection:

- **Circuit Open and Circuit Low Detection:** The PCM monitors for an **open circuit** and **short to ground** when the driver is switched off. When switched off, the available voltage passes through the device and the **internal pull down resistor** connected in series. The voltage at the **comparator circuit** should be close to Battery voltage since the majority of the voltage drop occurs through the diagnostic resistor. If the available voltage is less than the V-Ref, a fault is set. In this scenario the V-Ref would be slightly below Battery voltage. **An alternative method of fault detection for an open or short to ground** that is used is to monitor current draw when the internal driver is switched on. If the module does not detect any current draw it determines that the component or circuitry is open. Excessive current draw detected would indicate a short to ground.
- **Circuit High Detection:** The PCM monitors for a **short to voltage** when the driver is switched on. When the driver is switched on providing a path to ground through the transistor, the available voltage should be pulled low, near zero volts since the **comparator circuit** is monitoring the ground side of the device. If the voltage is greater than V-Ref, a fault is detected. In this scenario V-Ref would be slightly above zero volts.

NOTE: **A load that has a resistance that is below manufacturer specification, or a second load device shorted to the low side driver circuit can cause excessive current draw on the internal driver. The driver will be switched off to protect against overheating and damaging the driver. In this instance the Circuit High fault may be detected because the available voltage on the comparator circuit is above V-Ref.**



WHEN MONITORED

This diagnostic runs when the following conditions are met:

- When the ignition is turned on the PCM continuously monitors for a circuit high fault condition.
- When the ignition is turned off, during after-run mode of operation, the PCM monitors for an open or circuit low fault condition.

SET CONDITION

- The PCM detects and open or short in the ASD Relay control circuitry.

DEFAULT ACTION

- This is a non MIL fault.

POSSIBLE CAUSES

POSSIBLE CAUSES
ASD RELAY CONTROL CIRCUIT SHORTED TO VOLTAGE
ASD RELAY CONTROL CIRCUIT SHORTED TO GROUND
ASD RELAY CONTROL CIRCUIT OPEN/HIGH RESISTANCE
AUTO SHUT-DOWN (ASD) RELAY
POWER DISTRIBUTION CENTER (PDC)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Go To 2

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE BATTERY SUPPLY TO THE ASD RELAY CONTROL COIL**
    1. Turn the ignition off.
    2. Remove the ASD Relay from the relay connector in the PDC.
    3. Turn the ignition on.

4. Using a 12-volt test light connected to ground, probe the ASD Relay Battery supply at terminal 86 of the ASD Relay connector in the PDC.

   Is the test light illuminated and bright?

   Yes

   - Go To 3

   No

   - Check the Battery supply to the PDC. If no problems are found replace the PDC in accordance with the Service Information. Refer to **CENTER, POWER DISTRIBUTION (PDC), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **CHECK THE ASD RELAY FOR PROPER OPERATION**
   1. Re-install the ASD Relay in the PDC.
   2. Turn the ignition on.
   3. Using a 12-volt test light connected to ground, back probe the ASD Relay (K51) Control circuit at the PDC connector.

   NOTE: **The relay should make an audible click when closing. Another way to verify that the relay closed is to back probe and check for voltage on the relay output circuit.**

   Did the relay close when connecting the ASD Relay (K51) Control circuit to ground through the test light?

   Yes

   - Go To 4

   No

   - If the PDC has an internal PCB and harness connectors, isolate and check the continuity between terminal 85 of the relay connector and the output terminal at the PDC connector. If the resistance is below 3.0 Ohms, replace the ASD Relay. If the resistance is above 3.0 Ohms, replace the Power Distribution Center (PDC) in accordance with the service information. Refer to **CENTER, POWER DISTRIBUTION (PDC), REMOVAL AND INSTALLATION** .
   - If the wiring harness is directly hard wired into the PDC, replace the ASD Relay.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE ASD RELAY (K51) CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
   4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to**

pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

   Is there continuity between the circuit being tested and any other circuit?

   Yes

   - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **ISOLATE AND CHECK THE ASD RELAY (K51) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, (special tool #10436, Adapter, GPEC Diagnostic) connect the to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

- Go To 6

6. **ISOLATE AND LOAD TEST THE ASD RELAY (K51) CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
   3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
   4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
   5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
   6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

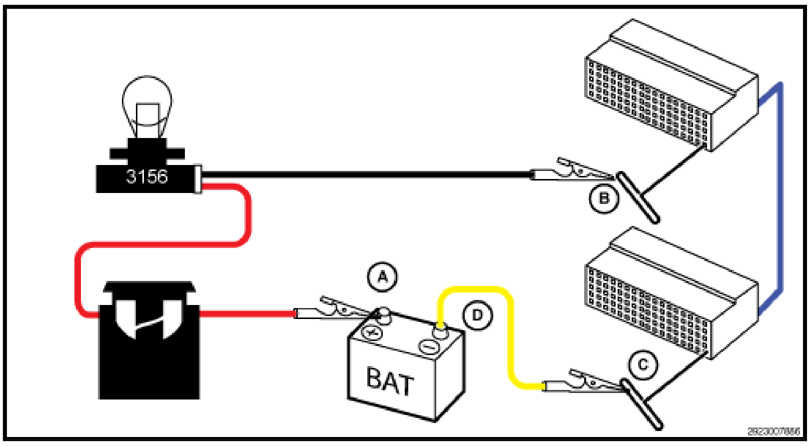
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 7

   No

   - Check the resistance of the ASD Relay (K51) Control circuit between the ASD Relay connector and the output of the PDC. If the circuit is open or has excessive resistance, replace the PDC. If the circuit checks good through the PDC, repair the ASD Relay Control circuit for an open or high resistance. Refer to **CENTER, POWER DISTRIBUTION (PDC), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. CHECK RELATED PCM AND COMPONENT CONNECTIONS
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.

- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and install the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0688-ASD/MAIN SENSE CIRCUIT

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

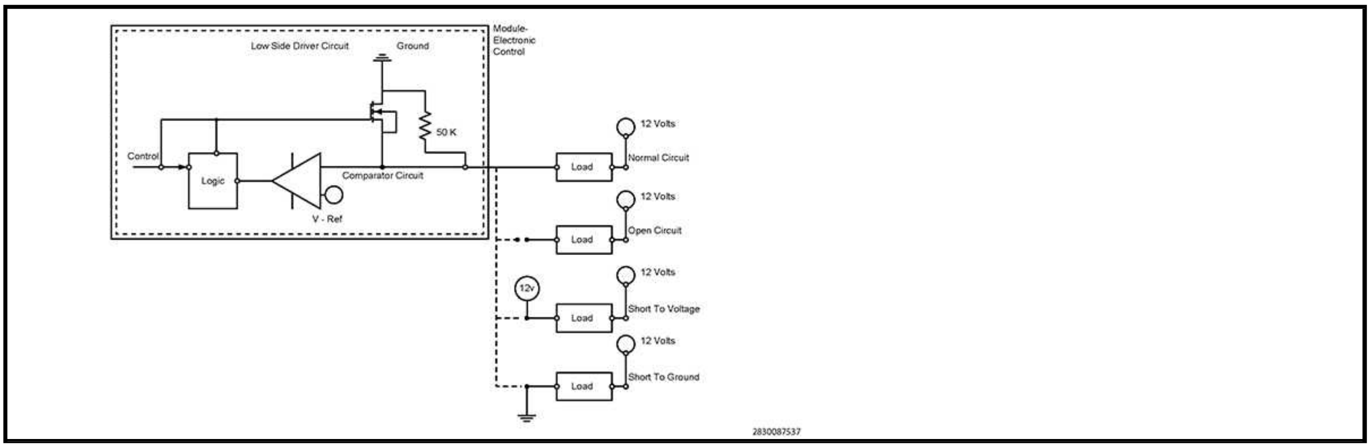
THEORY OF OPERATION

The Powertrain Control Module (PCM) controls the Auto Shutdown (ASD) Relay using a **Low Side Driver** . The ASD Relay Output voltage is supplied to the PCM as well as several engine components. The ASD Relay Output voltage that is supplied to the PCM is used to as the internal actuator supply to power several high side controlled devices. Because the ASD Relay is used for the operation of numerous engine components, the PCM performs diagnostics on both the ASD Relay Control and ASD Relay Output circuits. The PCM operates the ASD Relay Control circuit through a Low Side Driver (LSD).

Typical Low Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver device. The PCM provides a ground to operate the device when switched on. The ground could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device, wiring and internal driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. For diagnostic purposes the PCM uses an internal pull down diagnostic resistor connected in series and a voltage reference (V-Ref) comparator for fault detection:

- **Circuit Open and Circuit Low Detection:** The PCM monitors for an **open circuit** and **short to ground** when the driver is switched off. When switched off, the available voltage passes through the device and the **internal pull down resistor** connected in series. The voltage at the **comparator circuit** should be close to Battery voltage since the majority of the voltage drop occurs through the diagnostic resistor. If the available voltage is less than the V-Ref, a fault is set. In this scenario the V-Ref would be slightly below Battery voltage. **An alternative method of fault detection for an open or short to ground** that is used is to monitor current draw when the internal driver is switched on. If the module does not detect any current draw it determines that the component or circuitry is open. Excessive current draw detected would indicate a short to ground.
- **Circuit High Detection:** The PCM monitors for a **short to voltage** when the driver is switched on. When the driver is switched on providing a path to ground through the transistor, the available voltage should be pulled low, near zero volts since the **comparator circuit** is monitoring the ground side of the device. If the voltage is greater than V-Ref, a fault is detected. In this scenario V-Ref would be slightly above zero volts.

NOTE: **A load that has a resistance that is below manufacturer specification, or a second load device shorted to the low side driver circuit can cause excessive current draw on the internal driver. The driver will be switched off to protect against overheating and damaging the driver. In this instance the Circuit High fault may be detected because the available voltage on the comparator circuit is above V-Ref.**



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage above approximately 10.4 volts.

SET CONDITION

- No voltage sensed on the ASD Control Output circuit at the Powertrain Control Module (PCM) when the ASD relay is energized.

DEFAULT ACTION

- This is a non MIL fault.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
ASD CONTROL OUTPUT CIRCUIT OPEN/HIGH RESISTANCE
ASD RELAY OUTPUT CIRCUIT SHORTED TO GROUND

Possible Causes
AUTO SHUT-DOWN (ASD) RELAY/MAIN RELAY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Is DTC P0685-ASD CONTROL CIRCUIT active or pending?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **CHECK THE BATTERY VOLTAGE SUPPLY TO THE ASD RELAY**
    1. Turn the ignition off.
    2. Remove the ASD Relay from the PDC.
    3. Measure the voltage at the ASD Relay connector (terminal 30) Battery Supply circuit.

        Is the voltage equal to Battery voltage?

        Yes

        - Go To 4

No

- Repair the open voltage supply to the ASD Relay. Check all of the fuses in the PDC. If a fuse is open, check the ASD Relay Output circuit for a short to ground and repair as necessary.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE ASD RELAY (F342) OUTPUT CIRCUIT VOLTAGE AT THE PCM**
   1. Turn the ignition off.
   2. Disconnect the PCM C1 harness connector.

      CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   3. Connect the (special tool #10436, Adapter, GPEC Diagnostic) to the PCM C1 harness connector and the PCM.
   4. Re-install the ASD Relay in the PDC.
   5. Turn the ignition on.
   6. Measure the voltage at all of the Fused ASD Relay Output circuit terminals at the GPEC Adaptor.

   Pick the option that best matches your result:

   The voltage is equal to Battery voltage at each terminal with the ignition on

   - Go To 6

   There is no voltage present on any of the terminals or voltage is less than Battery voltage at all terminals

   - Go To 5

   Voltage is present but is missing from one or more terminals

   - Repair the ASD Relay Output circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK THE ASD RELAY FOR PROPER OPERATION**
   1. Turn the ignition off.
   2. Remove the ASD Relay from the PDC.
   3. Connect a jumper between terminal 30 and terminal 87 at the ASD Relay connector.
   4. Turn the ignition on.
   5. Measure the voltage at all of the Fused ASD Relay Output circuit terminals at the GPEC Adaptor.

   Is the voltage equal to Battery voltage at each terminal with the ignition on?

   Yes

   - Replace the ASD Relay in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

- Repair the ASD Relay Output circuit for an open or high resistance. Check all of the fuses in the PDC. If a fuse is open, check the ASD Relay Output circuit for a short to ground and repair as necessary.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0698-SENSOR REFERENCE VOLTAGE 3 CIRCUIT LOW

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the 5 volt supply circuit is below the minimum acceptable value.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will flash.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT SHORTED TO GROUND
FUEL TANK PRESSURE SENSOR
FUEL PRESSURE SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the Pre-Diagnostic Troubleshooting procedure before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**

    NOTE: **Improperly installed aftermarket accessories can cause this DTC to set.**

1. Refer to the recorded DTCs.

   Are there any improperly installed aftermarket accessories DTCs present?

   Yes

   - Remove the aftermarket accessories and retest for DTC.

   No

   - Go To 3

3. **CHECK THE (K859) SECONDARY 5-VOLT SUPPLY CIRCUIT VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the PCM C1 harness connector.

      CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
   4. Reconnect the PCM C1 harness connector with the GPEC Adaptor connected in-line with the PCM C1 harness connector.
   5. Turn the ignition on.
   6. Measure the voltage on the (K859) Secondary 5-Volt Supply circuit at the GPEC Adaptor.

      Is the voltage between 4.9 and 5.1 volts?

      Yes

      - Go To 6

      No

      - Go To 4

4. **CHECK THE SENSORS THAT SHARE THE SECONDARY 5-VOLT SUPPLY**
   1. **IMPORTANT - FOLLOW THIS PROCEDURE EXACTLY WHEN CHECKING THE FOLLOWING COMPONENTS:** Turn the ignition off before disconnecting each component. After a component has been disconnected, turn the ignition on and measure the voltage on the (K859) Secondary 5-Volt Supply circuit at the GPEC Adaptor. If the 5-Volt Supply voltage returns to 5.0 volts after disconnecting a component, the component that was disconnected is faulty. If the voltage remains low after disconnecting a component, then the disconnected component is not the problem. Leave each component disconnected and move on to the next until the faulty component is discovered or all components have been disconnected. Disconnect only one component at a time during this step.
   2. Disconnect the Fuel Tank Pressure Sensor harness connector and check the Secondary 5-Volt Supply circuit voltage.
   3. Disconnect the Fuel Pressure Sensor harness connector and check the Secondary 5-Volt Supply circuit voltage.

      Were any of the above components determined to be at fault?

      Yes

      - Replace the faulty component in accordance with the Service Information.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK THE (K859) SECONDARY 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO GROUND**
    1. Turn the ignition off.

    NOTE: **All of the components should still be disconnected during this test step.**

    2. Disconnect the PCM C1 harness connector from the PCM.
    3. Check for continuity between ground and the (K859) Secondary 5-Volt Supply circuit at the GPEC Adaptor.

    Is there continuity between ground and the (K859) Secondary 5-Volt Supply circuit(s)?

    Yes

    - Repair the (K859) Secondary 5-Volt Supply circuit for a short to ground.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 6

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.

9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0699-SENSOR REFERENCE VOLTAGE 3 CIRCUIT HIGH

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the 5-Volt supply circuit voltage is above the maximum acceptable value.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will flash.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT SHORTED TO VOLTAGE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the Pre-Diagnostic Troubleshooting procedure before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.

6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**

NOTE: **Improperly installed aftermarket accessories can cause this DTC to set.**

1. Refer to the recorded DTCs.

   Are there any improperly installed aftermarket accessories DTCs present?

   Yes

   - Remove the aftermarket accessories and retest for DTC.

   No

   - Go To 3

3. **CHECK THE (K859) SECONDARY 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO VOLTAGE**

1. Turn the ignition off.
2. Disconnect the PCM C1 harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
4. Reconnect the PCM C1 harness connector with the GPEC Adaptor connected in-line with the PCM C1 harness connector.
5. Disconnect the Fuel Tank Pressure Sensor harness connector.
6. Disconnect the Fuel Pressure Sensor harness connector.
7. Turn the ignition on.
8. Measure the voltage on the (K859) Secondary 5-Volt Supply circuit at the GPEC Adaptor.

   Is the voltage reading above 5.2 volts?

   Yes

   - Repair the (K859) Secondary 5-Volt Supply circuit for a short to voltage.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

- Go To 4

4. **CHECK FOR SENSOR SHORTED INTERNALLY**
    1. **IMPORTANT - FOLLOW THIS PROCEDURE EXACTLY WHEN CHECKING THE FOLLOWING COMPONENTS:** Turn the ignition off before connecting each component. After a component has been connected, turn the ignition on and measure the voltage on the Secondary 5-Volt Supply circuits at the GPEC Adaptor. If the 5-Volt Supply voltage goes above 5.2 volts after connecting a component, the component that was connected is faulty. If the voltage remains at 5.0 volts after connecting a component, then the connected component is not the problem. Leave each component connected and move on to the next until the faulty component is discovered or all components have been connected. Connect only one component at a time during this step.
    2. Connect the connector for each sensor or component, one at a time, and measure the voltage on the 5-Volt Supply circuits at the GPEC Adaptor.

    Does the voltage go above 5.2 volts when connecting any of the sensors?

    Yes

    - Replace the faulty sensor in accordance with the Service Information.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

5. **CHECKING THE PCM POWER AND GROUND CIRCUITS**
    1. Perform the NO RESPONSE FROM THE PCM test procedure. Refer to the appropriate information.

    NOTE: **Check the PCM B+, Fused Ignition, ASD inputs and ground circuits.**

    Were any problems found?

    Yes

    - Repair the PCM power and ground circuit(s) as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 6

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).

- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P06DA-ENGINE OIL PRESSURE CONTROL CIRCUIT

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Dual Stage Engine Oil Pump uses vanes and a moving element that is controlled by a solenoid to produce oil pressure to the engine in two regulated pressure stages (Low/High). In low pressure mode, the oil pressure will increase naturally with engine speed. When switched to high pressure mode the oil pressure is increased and is fairly steady. The Oil Pump Solenoid, mounted on the pump, is used to vary the displacement of the oil pump. The Powertrain Control Module (PCM) controls the solenoid operation. When the solenoid is energized, a bypass oil circuit is opened. This changes the eccentricity of the mechanical pump to lower the oil pressure (low pressure mode). The Engine Oil Pump is operated in low pressure mode during most operating conditions to reduce engine load, increasing the efficiency of the engine. The pump is switched to high pressure mode when engine operating conditions require a higher oil pressure. This is achieved by de-energizing the solenoid.

The minimum engine oil pressure is approximately 82.7 kPa (12 psi) for any operating condition. Anything less than this pressure could result in damage to critical moving parts. The maximum engine oil pressure is limited to 1000 kPa (145 psi) by the pressure relief valve. The oil pressure in the main oil galley of the engine can be checked by monitoring the Engine Oil Pressure (EOP) Sensor on the scan tool or using a mechanical oil pressure gauge.

COMPONENT FUNCTIONAL DESCRIPTION - OIL PUMP SOLENOID

The mechanical Engine Oil Pump operates in two pressure modes described below. The Powertrain Control Module (PCM) switches the pump between modes based on the oil temperature, coolant temperature, and engine operating conditions.

- **Low Mode:** To operate the pump in low pressure mode the PCM commands the High Side Driver (HSD) control on, **energizing** the Oil Pump Solenoid. The Engine Oil Pump is operated in low pressure mode between idle and approximately 3000 RPM.
- **High Mode:** To operate the pump in high pressure mode the PCM commands the HSD control off, de-energizing the Oil Pump Solenoid. The PCM will typically switch the pump from low to high mode when the engine speed increases over approximately 3000 RPM.
- In some instances the system can change to high pressure mode before the engine speed listed when the PCM detects that the engine load increases above a calibrated threshold. This can sometimes be determined by monitoring the oil pressure reading. Typically pressure will increase in relation to engine speed. When the system changes modes the pressure may increase suddenly up or down depending on which mode is being commanded.

NOTE: **The specifications are different between the classic and upgrade 3.6L engines. Choose the appropriated specification chart for the vehicle being diagnosed.**

See the oil pressure specifications in the tables below:

3.6L CLASSIC ENGINES - OIL PRESSURE SPECIFICATIONS		
ENGINE SPEED	OIL PUMP MODE	OIL PRESSURE SPECIFICATION
Idle (650 RPM)	Low Pressure Mode (Solenoid on)	Above 82.7 kPa (Above 12 psi)
1000 - 3000 rpm	Low Pressure Mode (Solenoid on)	200 - 358.5 kPa (29 - 52 psi)
Above 3500 RPM	High Pressure Mode (Solenoid off)	413.7 - 689.5 kPa (60 - 100 psi)
• **NOTE 1:** Values in the table are valid for coolant temperature between 89 - 100B°C. • **NOTE 2:** For Idle (650 RPM approximately) - If vehicle coolant temperature is under 100B°C, it is possible to have the pump working in High pressure mode (solenoid off) and pressure readings above 34 PSI.		

3.6L UPGRADE ENGINES - OIL PRESSURE SPECIFICATIONS		
ENGINE SPEED	OIL PUMP MODE	OIL PRESSURE SPECIFICATION
Idle (650 RPM)	Low Pressure Mode (Solenoid on)	103.4 - 234.4 kPa (15 - 34 psi)
1000 - 3000 rpm	Low Pressure Mode (Solenoid on)	193 - 241.3 kPa (28 - 35 psi)
Above 3500 RPM	High Pressure Mode (Solenoid off)	448.2 - 551.6 kPa (65 - 80 psi)
• **NOTE:** Values in the table are valid for coolant temperature between 89 - 100B°C.		

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the engine running.
- With the Battery voltage above 10.4 volts.

- The Powertrain Control Module (PCM) monitors the Oil Pump Solenoid Control circuit for a short to voltage when the Oil Pump Solenoid is commanded off. The circuit is monitored for an open and short to ground when the Oil Pump Solenoid is commanded on.

SET CONDITION

- With the Oil Pump Solenoid commanded off, the PCM detects voltage on the Oil Pump Solenoid Control circuit.
- With the Oil Pump Solenoid commanded on, the PCM detects one of the following conditions:
  - The current draw is less than 0.1 mA indicating an open circuit.
  - The control circuit temperature is above 160B°C (320B°F) indicating a short to ground.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
OIL PUMP SOLENOID CONTROL CIRCUIT SHORTED TO VOLTAGE
OIL PUMP SOLENOID CONTROL CIRCUIT SHORTED TO GROUND
OIL PUMP SOLENOID CONTROL CIRCUIT OPEN/HIGH RESISTANCE
OIL PUMP SOLENOID GROUND CIRCUIT OPEN/HIGH RESISTANCE
OIL PUMP SOLENOID
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

      Did the DTC return?

      Yes

      - Go To 2

      No

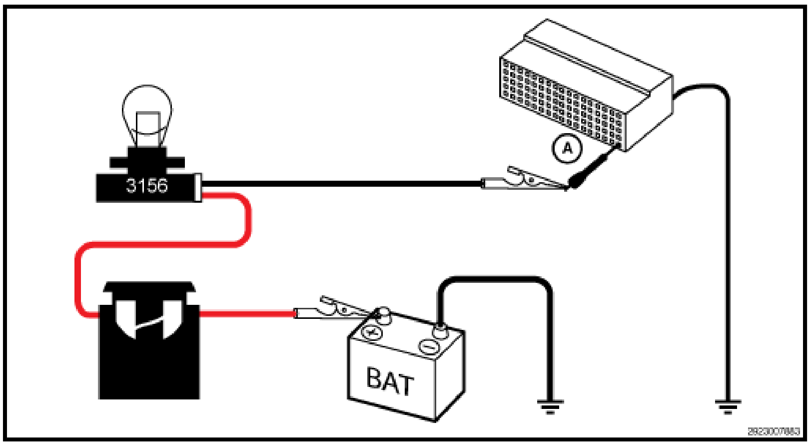
      - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE OIL PUMP SOLENOID (Z907) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**

NOTE: **Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

1. Turn the ignition off.
2. Disconnect the Oil Pump Solenoid harness connector.

CAUTION: **Do not load test any circuits with components still connected to the circuit.**

3. Load test the Oil Pump Solenoid (Z907) Ground circuit at the Oil Pump Solenoid harness connector (A). **Note:** refer to the diagram below.



NOTE: **The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry. Compare the brightness of the bulb in the load test tool to that of a direct connection across Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 3

No

- Repair the Oil Pump Solenoid (Z907) Ground circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **CHECK THE OIL PUMP SOLENOID (G62) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. Disconnect the PCM C2 harness connector.
   2. Check for continuity between ground and the Oil Pump Solenoid (G62) Control circuit at the oil pump solenoid harness connector.

   Is there continuity between ground and the Oil Pump Solenoid (G62) Control circuit?

   Yes

   - Repair the Oil Pump Solenoid (G62) Control circuit for a short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **CHECK THE OIL PUMP SOLENOID (G62) CONTROL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
   2. Measure the resistance of the Oil Pump Solenoid (G62) Control circuit between the Oil Pump Solenoid harness connector and the GPEC Adaptor.

      Is the resistance below 3.0 Ohms?

      Yes

      - Go To 5

      No

      - Repair the Oil Pump Solenoid (G62) Control circuit for an open or high resistance.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK THE OIL PUMP SOLENOID (G62) CONTROL CIRCUIT FOR A SHORT TO ANOTHER VOLTAGE SUPPLY**
   1. Check for continuity between the Oil Pump Solenoid (G62) Control circuit and all other circuits at the GPEC Adaptor.

      Is there continuity between the Oil Pump Solenoid (G62) Control circuit and any other circuit?

      Yes

      - Repair the Oil Pump Solenoid (G62) Control circuit for a short to the circuit that showed continuity.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 6

6. **CHECK THE ABILITY OF THE PCM TO OPERATE THE OIL PUMP SOLENOID CONTROL CIRCUIT**
   1. Reconnect the PCM C2 harness connector.
   2. Turn the ignition on.
   3. Using a 12-volt test light connected to ground, probe the Oil Pump Solenoid (G62) Control circuit at the Oil Pump Solenoid harness connector.

      NOTE: **The test light should be off except for a brief period immediately after turning the ignition on.**

   4. With the scan tool, actuate the Oil Pump Solenoid control to the ON (100%) position.

NOTE: **The test light should be illuminated and bright. Compare the brightness to that of a direct connection to the battery.**

Is the test light illuminated and bright during the actuation and was it off when required?

Yes

- Verify that there is good pin to terminal contact in the Oil Pump Solenoid and Powertrain Control Module connectors. If no problems are found, replace the Oil Pump Solenoid in accordance with the Service Information.

  NOTE: **The 3.6L Dual Stage Oil Pump is released as an assembly. The assembly includes both the pump and the solenoid. There are no serviceable sub-assembly components. In the event the oil pump or solenoid are not functioning or out of specification they must be replaced as an assembly.**

- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

No

- Go To 7

7. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P06DD-ENGINE OIL PRESSURE CONTROL CIRCUIT STUCK OFF

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Dual Stage Engine Oil Pump uses vanes and a moving element that is controlled by a solenoid to produce oil pressure to the engine in two regulated pressure stages (Low/High). In low pressure mode, the oil pressure will increase naturally with engine speed. When switched to high pressure mode the oil pressure is increased and is fairly steady. The Oil Pump Solenoid, mounted on the pump, is used to vary the displacement of the oil pump. The Powertrain Control Module (PCM) controls the solenoid operation. When the solenoid is energized, a bypass oil circuit is opened. This changes the eccentricity of the mechanical pump to lower the oil pressure (low pressure mode). The Engine Oil Pump is operated in low pressure mode during most operating conditions to reduce engine load, increasing the efficiency of the engine. The pump is switched to high pressure mode when engine operating conditions require a higher oil pressure. This is achieved by de-energizing the solenoid.

The minimum engine oil pressure is approximately 82.7 kPa (12 psi) for any operating condition. Anything less than this pressure could result in damage to critical moving parts. The maximum engine oil pressure is limited to 1000 kPa (145 psi) by the pressure relief valve. The oil pressure in the main oil galley of the engine can be checked by monitoring the Engine Oil Pressure (EOP) Sensor on the scan tool or using a mechanical oil pressure gauge.

COMPONENT FUNCTIONAL DESCRIPTION - OIL PUMP SOLENOID

The mechanical Engine Oil Pump operates in two pressure modes described below. The Powertrain Control Module (PCM) switches the pump between modes based on the oil temperature, coolant temperature, and engine operating conditions.

- **Low Mode:** To operate the pump in low pressure mode the PCM commands the High Side Driver (HSD) control on, **energizing** the Oil Pump Solenoid. The Engine Oil Pump is operated in low pressure mode between idle and approximately 3000 RPM.
- **High Mode:** To operate the pump in high pressure mode the PCM commands the HSD control off, de-energizing the Oil Pump Solenoid. The PCM will typically switch the pump from low to high mode when the engine speed increases over approximately 3000 RPM.
- In some instances the system can change to high pressure mode before the engine speed listed when the PCM detects that the engine load increases above a calibrated threshold. This can sometimes be determined by monitoring the oil pressure reading. Typically pressure will increase in relation to engine speed. When the system changes modes the pressure may increase suddenly up or down depending on which mode is being commanded.

NOTE: **The specifications are different between the classic and upgrade 3.6L engines. Choose the appropriated specification chart for the vehicle being diagnosed.**

See the oil pressure specifications in the tables below:

3.6L CLASSIC ENGINES - OIL PRESSURE SPECIFICATIONS		
ENGINE SPEED	**OIL PUMP MODE**	**OIL PRESSURE SPECIFICATION**
Idle (650 RPM)	Low Pressure Mode (Solenoid on)	Above 82.7 kPa (Above 12 psi)
1000 - 3000 rpm	Low Pressure Mode (Solenoid on)	200 - 358.5 kPa (29 - 52 psi)
Above 3500 RPM	High Pressure Mode (Solenoid off)	413.7 - 689.5 kPa (60 - 100 psi)
• **NOTE 1:** Values in the table are valid for coolant temperature between 89 - 100B°C. • **NOTE 2:** For Idle (650 RPM approximately) - If vehicle coolant temperature is under 100B°C, it is possible to have the pump working in High pressure mode (solenoid off) and pressure readings above 34 PSI.		

3.6L UPGRADE ENGINES - OIL PRESSURE SPECIFICATIONS		
ENGINE SPEED	**OIL PUMP MODE**	**OIL PRESSURE SPECIFICATION**
Idle (650 RPM)	Low Pressure Mode (Solenoid on)	103.4 - 234.4 kPa (15 - 34 psi)
1000 - 3000 rpm	Low Pressure Mode (Solenoid on)	193 - 241.3 kPa (28 - 35 psi)
Above 3500 RPM	High Pressure Mode (Solenoid off)	448.2 - 551.6 kPa (65 - 80 psi)
• **NOTE:** Values in the table are valid for coolant temperature between 89 - 100B°C.		

DIAGNOSTIC OVERVIEW - DUAL STAGE ENGINE OIL PUMP SOLENOID

NOTE: **It is important to note that the Stuck On and Stuck Off diagnostic calibrations are reversed from the fault code descriptions. Reading what the diagnostic is checking for as a failure mode will appear to be opposite of what the fault description is calling out. Meaning that the Stuck Off diagnostic test is actually checking for a Stuck On condition, and the Stuck On diagnostic test is actually checking for a Stuck Off condition. This IS NOT incorrect.**

The PCM performs multiple diagnostics for the Dual Stage Engine Oil Pump and solenoid. The HSD control circuit is monitored for opens and shorts. The PCM also performs diagnostics to detect if the pump is stuck in the high or low operating mode. The PCM checks the rationality of the Engine Oil Pressure Sensor before the Oil Pump Solenoid stuck on/off diagnostic runs. Typically a faulty EOP Sensor will set a fault and disable the Oil Pump Solenoid stuck on/off diagnostic.

- **Stuck off Diagnostic:** During higher engine speeds the PCM commands the Oil Pump Solenoid off (high mode). The PCM monitors the engine oil pressure and fails when the pressure is below a calibrated threshold (too low).
- **Stuck on Diagnostic:** At idle, or lower engine speeds the PCM commands the Oil Pump Solenoid on (low mode). The PCM monitors the engine oil pressure and fails when the pressure is above a calibrated threshold (too high).

Component or system rationality diagnostics are typically designed to detect a mechanical failure in the component (solenoid, motor, actuator) or overall system performance issue. A circuit fault against a component or sensor being used to monitor the system should be diagnosed before a rationality fault. However, do not assume that the wiring or circuits are good if you do not have a circuit fault. In some circumstances a circuit issue could also cause a rationality fault to set without a circuit fault. Rationality faults are designed to catch any failure that could be missed in other diagnostics. An example could be a small amount of resistance in the power supply, control or ground circuit to a component, usually at the harness connector terminals, that could cause a component not to energize when commanded on. In many cases a few ohms of resistance at a connector may not cause a circuit fault to set. It is always a good practice to learn and understand how the rationality checks are performed and the faults are detected. Then check the connectors and circuits for the wiring conditions that could cause that failure mode (open or shorted circuit) before replacing any components.

NOTE: **Since the Engine Oil Pump operates in high mode when the solenoid is not energized (off), it is more likely for a P06DE-Engine Oil Pressure Control Circuit Stuck On fault to set due to a wiring or connector issue on this system. The P06DE fault detects a pump stuck in high pressure mode failure (solenoid de-energized).**

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Battery voltage above 11.0 volts.
- The Dual Stage Oil Pump circuit fault or stuck off fault are not active.
- There are no active Engine Oil Pressure Sensor, CKP Sensor, Coolant Temperature Sensor or ASD Relay faults.
- Engine coolant temperature is above 15B°C (59B°F).
- Engine oil temperature is above 20B°C (68B°F).
- The engine speed between approximately 1500 - 5500 rpm.
- Engine running and the Oil Pump Solenoid is commanded off (High oil pressure mode requested).

SET CONDITION

- The PCM detects that the actual oil pressure is too low with the Oil Pump Solenoid commanded off (High pressure mode) for 20.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.
- Vehicle will not be able to exceed 3, 300 RPM when this code is active.

POSSIBLE CAUSES

Possible Causes
LOW ENGINE OIL LEVEL
INCORRECT ENGINE OIL FILTER
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
ENGINE MECHANICAL FAILURE
DUAL STAGE OIL PUMP SOLENOID STUCK ON
DUAL STAGE OIL PUMP SPOOL VALVE STUCK

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

- Perform the applicable repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 2

2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK FOR RELATED DTCS**
    1. Refer to the recorded DTCs.

    Are any of the following related fault codes present: P0520, P0521, P0522, P0523 or P06DA?

    Yes

    - Perform the applicable PCM diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

    No

    - Go To 4
4. **CHECK THE ENGINE OIL/ENGINE MECHANICAL CONDITION**

    NOTE: **Verify that the engine oil is at the proper level and that an OEM specified oil filter is being used. Review the customers oil change history to make sure that the oil is being changed at the correct intervals and that the proper oil viscosity is being used.**

    1. Turn the ignition off.
    2. Check for the following but not limited to:
        - LOW ENGINE OIL LEVEL
        - CONTAMINATED, DIRTY, AERATED OR DETERIORATED ENGINE OIL
        - INCORRECT ENGINE OIL VISCOSITY

- INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)

Were any of the above conditions present?

Yes

- Repair the engine oiling system issue in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK THE DUAL STAGE OIL PUMP**
   1. Check the engine for proper oil pressure.
   2. Check for the following but not limited to:
      - OIL SLUDGE
      - OIL PUMP PICK UP TUBE CRACKED OR MISSING O-RING
      - OIL PUMP PICK UP SCREEN PLUGGED
      - WORN MAIN OR ROD BEARINGS
      - ANYTHING THAT COULD RESTRICT OIL FLOW OR CAUSE LOW OIL PRESSURE

   Were any of the above conditions present?

   Yes

   - Repair as necessary in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Replace the Dual Stage Oil Pump Assembly in accordance with the Service Information. Refer to **PUMP, ENGINE OIL, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P06DE-ENGINE OIL PRESSURE CONTROL CIRCUIT STUCK ON

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Dual Stage Engine Oil Pump uses vanes and a moving element that is controlled by a solenoid to produce oil pressure to the engine in two regulated pressure stages (Low/High). In low pressure mode, the oil pressure will increase naturally with engine speed. When switched to high pressure mode the oil pressure is increased and is fairly steady. The Oil Pump Solenoid, mounted on the pump, is used to vary the displacement of the oil pump. The Powertrain Control Module (PCM) controls the solenoid operation. When the solenoid is energized, a bypass oil circuit is opened. This changes the eccentricity of the mechanical pump to lower the oil pressure (low pressure mode). The Engine Oil Pump is operated in low pressure mode during most operating conditions to reduce engine load, increasing the efficiency of the engine. The pump is switched to high pressure mode when engine operating conditions require a higher oil pressure. This is achieved by de-energizing the solenoid.

The minimum engine oil pressure is approximately 82.7 kPa (12 psi) for any operating condition. Anything less than this pressure could result in damage to critical moving parts. The maximum engine oil pressure is limited to 1000 kPa (145 psi) by the pressure relief valve. The oil pressure in the main oil galley of the engine can be checked by monitoring the Engine Oil Pressure (EOP) Sensor on the scan tool or using a mechanical oil pressure gauge.

COMPONENT FUNCTIONAL DESCRIPTION - OIL PUMP SOLENOID

The mechanical Engine Oil Pump operates in two pressure modes described below. The Powertrain Control Module (PCM) switches the pump between modes based on the oil temperature, coolant temperature, and engine operating conditions.

- **Low Mode:** To operate the pump in low pressure mode the PCM commands the High Side Driver (HSD) control on, **energizing** the Oil Pump Solenoid. The Engine Oil Pump is operated in low pressure mode between idle and approximately 3000 RPM.
- **High Mode:** To operate the pump in high pressure mode the PCM commands the HSD control off, de-energizing the Oil Pump Solenoid. The PCM will typically switch the pump from low to high mode when the engine speed increases over approximately 3000 RPM.
- In some instances the system can change to high pressure mode before the engine speed listed when the PCM detects that the engine load increases above a calibrated threshold. This can sometimes be determined by monitoring the oil pressure reading. Typically pressure will increase in relation to engine speed. When the system changes modes the pressure may increase suddenly up or down depending on which mode is being commanded.

NOTE: **The specifications are different between the classic and upgrade 3.6L engines. Choose the appropriated specification chart for the vehicle being diagnosed.**

See the oil pressure specifications in the tables below:

3.6L CLASSIC ENGINES - OIL PRESSURE SPECIFICATIONS		
ENGINE SPEED	**OIL PUMP MODE**	**OIL PRESSURE SPECIFICATION**
Idle (650 RPM)	Low Pressure Mode (Solenoid on)	Above 82.7 kPa (Above 12 psi)
1000 - 3000 rpm	Low Pressure Mode (Solenoid on)	200 - 358.5 kPa (29 - 52 psi)
Above 3500 RPM	High Pressure Mode (Solenoid off)	413.7 - 689.5 kPa (60 - 100 psi)
• **NOTE 1:** Values in the table are valid for coolant temperature between 89 - 100B°C. • **NOTE 2:** For Idle (650 RPM approximately) - If vehicle coolant temperature is under 100B°C, it is possible to have the pump working in High pressure mode (solenoid off) and pressure readings above 34 PSI.		

3.6L UPGRADE ENGINES - OIL PRESSURE SPECIFICATIONS		
ENGINE SPEED	**OIL PUMP MODE**	**OIL PRESSURE SPECIFICATION**
Idle (650 RPM)	Low Pressure Mode (Solenoid on)	103.4 - 234.4 kPa (15 - 34 psi)
1000 - 3000 rpm	Low Pressure Mode (Solenoid on)	193 - 241.3 kPa (28 - 35 psi)
Above 3500 RPM	High Pressure Mode (Solenoid off)	448.2 - 551.6 kPa (65 - 80 psi)
• **NOTE:** Values in the table are valid for coolant temperature between 89 - 100B°C.		

DIAGNOSTIC OVERVIEW - DUAL STAGE ENGINE OIL PUMP SOLENOID

NOTE: **It is important to note that the Stuck On and Stuck Off diagnostic calibrations are reversed from the fault code descriptions. Reading what the diagnostic is**

checking for as a failure mode will appear to be opposite of what the fault description is calling out. Meaning that the Stuck Off diagnostic test is actually checking for a Stuck On condition, and the Stuck On diagnostic test is actually checking for a Stuck Off condition. This IS NOT incorrect.

The PCM performs multiple diagnostics for the Dual Stage Engine Oil Pump and solenoid. The HSD control circuit is monitored for opens and shorts. The PCM also performs diagnostics to detect if the pump is stuck in the high or low operating mode. The PCM checks the rationality of the Engine Oil Pressure Sensor before the Oil Pump Solenoid stuck on/off diagnostic runs. Typically a faulty EOP Sensor will set a fault and disable the Oil Pump Solenoid stuck on/off diagnostic.

- **Stuck off Diagnostic:** During higher engine speeds the PCM commands the Oil Pump Solenoid off (high mode). The PCM monitors the engine oil pressure and fails when the pressure is below a calibrated threshold (too low).
- **Stuck on Diagnostic:** At idle, or lower engine speeds the PCM commands the Oil Pump Solenoid on (low mode). The PCM monitors the engine oil pressure and fails when the pressure is above a calibrated threshold (too high).

Component or system rationality diagnostics are typically designed to detect a mechanical failure in the component (solenoid, motor, actuator) or overall system performance issue. A circuit fault against a component or sensor being used to monitor the system should be diagnosed before a rationality fault. However, do not assume that the wiring or circuits are good if you do not have a circuit fault. In some circumstances a circuit issue could also cause a rationality fault to set without a circuit fault. Rationality faults are designed to catch any failure that could be missed in other diagnostics. An example could be a small amount of resistance in the power supply, control or ground circuit to a component, usually at the harness connector terminals, that could cause a component not to energize when commanded on. In many cases a few ohms of resistance at a connector may not cause a circuit fault to set. It is always a good practice to learn and understand how the rationality checks are performed and the faults are detected. Then check the connectors and circuits for the wiring conditions that could cause that failure mode (open or shorted circuit) before replacing any components.

NOTE: **Since the Engine Oil Pump operates in high mode when the solenoid is not energized (off), it is more likely for a P06DE-Engine Oil Pressure Control Circuit Stuck On fault to set due to a wiring or connector issue on this system. The P06DE fault detects a pump stuck in high pressure mode failure (solenoid de-energized).**

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Battery voltage above 11.0 volts.
- The Dual Stage Oil Pump circuit fault or stuck off fault are not active.
- There are no active Engine Oil Pressure Sensor, CKP Sensor, Coolant Temperature Sensor or ASD Relay faults.
- Engine coolant temperature is above 15B°C (59B°F).
- Engine oil temperature is above 20B°C (68B°F).
- The engine speed between approximately 1500 - 5500 rpm.
- Engine running and the Oil Pump Solenoid is commanded on (Low oil pressure mode requested).

SET CONDITION

- The PCM detects that the actual oil pressure is too high with the Oil Pump Solenoid commanded on (Low pressure mode) for 20.0 seconds.

DEFAULT ACTION

- This is a non MIL fault.

POSSIBLE CAUSES

Possible Causes
POOR CONNECTION AT THE OIL PUMP SOLENOID HARNESS CONNECTOR
DUAL STAGE OIL PUMP SOLENOID STUCK OFF
DUAL STAGE OIL PUMP SPOOL VALVE STUCK OR PLUGGED

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Go To 3

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK FOR RELATED DTCS**
    1. Refer to the recorded DTCs.

       Are any of the following related fault codes pending, active, or stored: P0520, P0521, P0522, P0523 or P06DA?

       Yes

- Perform the applicable PCM diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

No

- Go To 4

4. **CHECK THE OIL PUMP SOLENOID CONNECTOR AND TERMINALS**
    1. Turn the ignition off.
    2. Check the Oil Pump Solenoid harness connector for proper connection at the Oil Pump Solenoid.
    3. Verify that the connector is completely plugged in and properly locked prior to disconnecting.
    4. Disconnect the Oil Pump Solenoid harness connector and check for any pushed out, damaged or spread terminals.

    Were any issues found with the connector or terminals?

    Yes

    - Repair the damaged terminal or properly connect and lock the Oil Pump Solenoid harness connector and retest for DTCs.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

5. **CHECK THE ENGINE FOR EXCESSIVE SLUDGE**

    NOTE: **Verify that the engine oil is clean and that an OEM specified oil filter is being used. Review the customers oil change history to make sure that the oil is being changed at the correct intervals and that the proper oil viscosity is being used.**

    1. Check the engine for excessive sludge build up before performing any repairs. Excessive sludge can block the bypass in the oil pump causing the pressure to too high.

    Were any of the above conditions present?

    Yes

    - Perform the necessary engine repairs in accordance with the Service Information.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Replace the Dual Stage Oil Pump Assembly in accordance with the Service Information. Refer to **PUMP, ENGINE OIL, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P06E9-ENGINE STARTER PERFORMANCE

For a complete STARTING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

- This diagnostic runs any time an engine crank command is given.

SET CONDITION

- Immediately after reaching the "start" state, a timer begins to check the overall start time. If the Powertrain Control Module (PCM) does not see the engine speed increase to over 750 rpm within five seconds after the start command is given, a fault is set.

DEFAULT ACTION

- The MIL will illuminate.
- The stop/start feature will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
FUEL SYSTEM OR IGNITION SYSTEM FAILURE
STARTER RELAY OUTPUT CIRCUIT OPEN/HIGH RESISTANCE
HIGH RESISTANCE IN THE STARTER CABLE
POOR STARTER CABLE CONNECTION
ENGINE MECHANICAL ISSUE
STARTER MOTOR

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR FUEL SYSTEM OR IGNITION SYSTEM DTCS PRESENT**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs.

        Are there any fuel or ignition system DTCs present?

        Yes

        - Perform the diagnostics for the fuel or ignition system related DTC(s) before proceeding with this diagnostic procedure.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 2
2. **CHECK FOR THE ABILITY OF THE ENGINE TO CRANK**
    1. Attempt to crank or start the engine.

        Does the engine crank?

        Yes

        - Perform the ENGINE CRANKS BUT DOES NOT START diagnostic procedure. Refer to **ENGINE CRANKS BUT DOES NOT START** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

- Perform the ENGINE WILL NOT CRANK diagnostic procedure. Refer to the appropriate information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P06EF-ENGINE RESTART PERFORMANCE

For a complete STARTING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

- This diagnostic runs during an Auto-Restart attempt.

SET CONDITION

- The Powertrain Control Module (PCM) does not detect the engine running 1.5 seconds after an Auto-Restart is commanded on.

DEFAULT ACTION

- This is a non-MIL fault.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
POOR CONNECTION AT THE BATTERY OR STARTER MOTOR
POOR BATTERY CONDITION
FUEL DELIVERY SYSTEM FAILURE
ENGINE MECHANICAL ISSUE
POOR STARTER MOTOR CONDITION (DRAGGING OR OVERHEATING)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. Turn the ignition on.
    2. With the scan tool, erase DTCs.
    3. Test drive the vehicle in Start/Stop mode. Make several complete stops, and Auto-Restart attempts.
    4. Turn the ignition on.
    5. With the scan tool, read DTCs and record on the repair order.

    Is the DTC active or pending?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE FUSES BATTERY CABLES AND STARTER CONNECTIONS**

1. Turn the ignition off.
2. Inspect the Fuses, Battery Cables, Posts and Starter Motor connections for signs of corrosion or a poor connection.

   Were the Fuses, Battery Cables and Starter connections in good condition?

   Yes

   - Go To 3

   No

   - Repair the Battery or Starter connections in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **CHECK THE BATTERY CONDITION**
   1. Use the (special tool #GR8-1220KIT-CHRY, AGM Battery Tester/Charger Station)or equivalent to load test the Battery.
   2. Using the Midtronics Battery Charger/Tester, check the condition of the Battery.

      Did the Battery pass the test?

      Yes

      - Go To 4

      No

      - Replace the Battery in accordance with the Service Information. Refer to **BATTERY, REMOVAL AND INSTALLATION** , and **BATTERY, SUPPLEMENTAL, REMOVAL AND INSTALLATION** .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
4. **CHECK THE FUEL DELIVERY SYSTEM FOR PROPER OPERATION**
   1. Perform the CHECKING THE FUEL DELIVERY SYSTEM diagnostic procedure. Refer to **CHECKING THE FUEL DELIVERY SYSTEM (HARD START)** .

      Were any problems found?

      Yes

      - Repair the Fuel Delivery System in accordance with the Service Information.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 5
5. **CHECK THE ENGINE MECHANICAL CONDITION**
   1. Perform the CHECKING THE ENGINE MECHANICAL CONDITION diagnostic procedure. Refer to the appropriate information.

      NOTE: **Anything that can cause an intermittent no start condition can cause this DTC to set.**

      Were any problems found?

Yes

- Repair the Engine mechanical condition in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Replace the Starter Motor in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P0850-PARK/NEUTRAL SWITCH PERFORMANCE

For a complete TRANSMISSION wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running
- Not equipped with a manual Transmission
- No vehicle speed, Throttle Position (TPS) Sensor, Manifold Absolute Pressure (MAP) Sensor, Barometric Pressure (BARO), or 5-Volt reference DTCs active
- Vehicle speed, engine speed and engine load calculations indicate that the vehicle is not in park or neutral

SET CONDITION

- The Powertrain Control Module (PCM) receives an invalid Park/Neutral switch state message for 0.32 seconds.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
TRANSMISSION RANGE SENSOR (TRS) WIRING ISSUES
COMMUNICATION FAILURE BETWEEN THE PCM AND THE TCM
TRANSMISSION CONTROL MODULE (TCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.

5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR TRANSMISSION CONTROL MODULE (TCM) DTCS**

NOTE: **This DTC could set during towing if the Manual Park Release Cable was not fully pulled and the pawl is in an intermediate position for too long.**

1. With the scan tool, read TCM DTCs.

   Does the TCM have a DTC set for the Park/Neutral Switch or TRS Signal circuits?

   Yes

   - Perform the appropriate diagnostic procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

   No

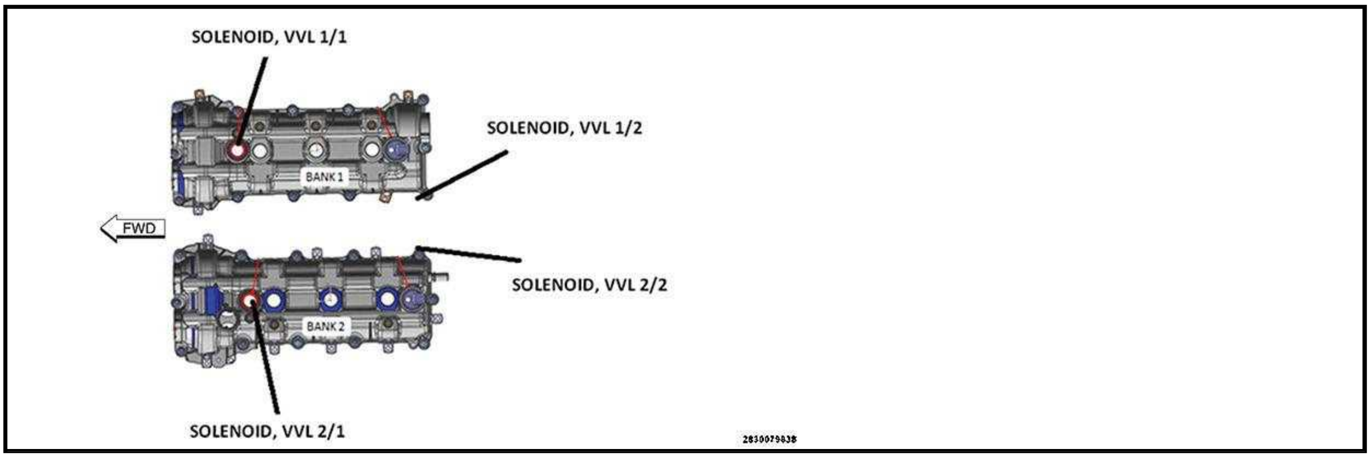
   - Replace the Transmission Control Module in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1050-INTAKE VALVE CONTROL SOLENOID 1 CIRCUIT/OPEN

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:

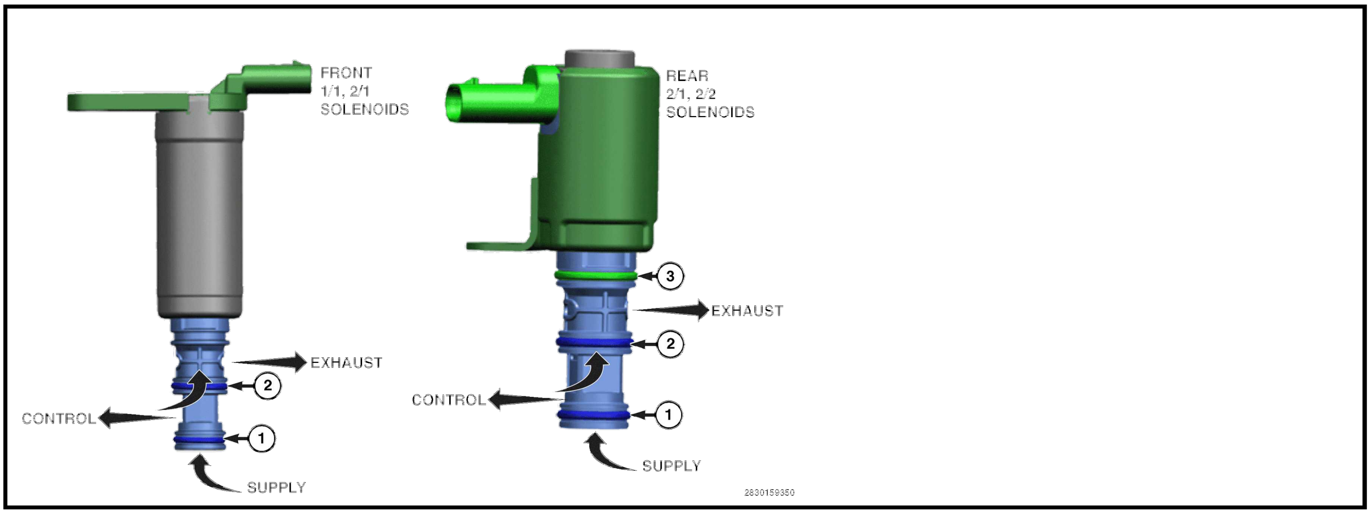


VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073

GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation.

- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure to pass through the solenoid to the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.
- **To enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arm defaults to High Lift mode when no oil pressure is present.

DIAGNOSTICS: The PCM controls each VVL Solenoid with a **High Side Driver (HSD) Circuit** . The PCM performs **circuit diagnostics** on each VVL Solenoid HSD for an open or short in the circuitry.

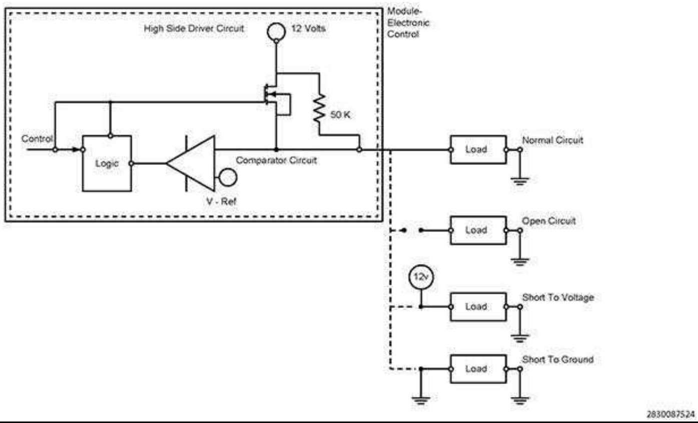


Typical High Side Driver and Fault Detection: This type of driver circuit is generally used for relay control, controlling a solenoid or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The PCM also provides fault detection for the device, wiring and internal driver. In the example below, the PCM uses an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A small amount of amperage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator**

circuit and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect.

- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded off.

SET CONDITION

- The PCM detects an open circuit for the VVL Solenoid 1/1 Control.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVL SOLENOID 1/1 CONTROL CIRCUIT OPEN/HIGH RESISTANCE
VVL SOLENOID 1/1 GROUND CIRCUIT OPEN/HIGH RESISTANCE
VARIABLE VALVE LIFT (VVL) SOLENOID 1/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.

4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE (Z904) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
   1. Disconnect the component harness connector to isolate the ground circuit.
   2. Connect the positive lead of the load test tool to the positive side of the Battery.
   3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
   4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

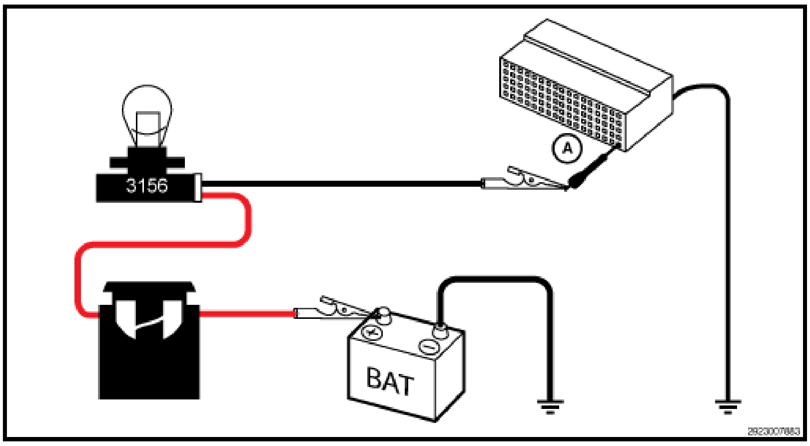
NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 3

   No

   - Repair the ground circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **ISOLATE AND LOAD TEST THE VVL SOLENOID 1/1 (K531) CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
   3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
   4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).

5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

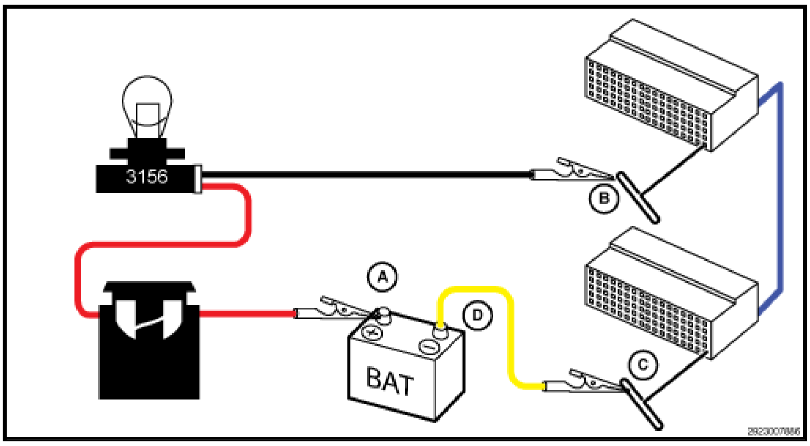
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit.** **Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. **Refer to CIRCUIT LOAD TESTING PROCEDURES .**



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 4

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE VVL SOLENOID RESISTANCE**
   1. Measure the resistance of the VVL Solenoid (component). Remove the VVL Solenoid if necessary to gain access to the terminals and ensure a proper reading.

   NOTE: **The resistance reading through a good VVL Solenoid that is not open or internally shorted is approximately 12.0 Ohms +/- 2.0 Ohms.**

   Is the resistance reading as described above?

   Yes

   - Go To 5

   No

   - Replace the VVL Solenoid in accordance with the Service Information. .

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

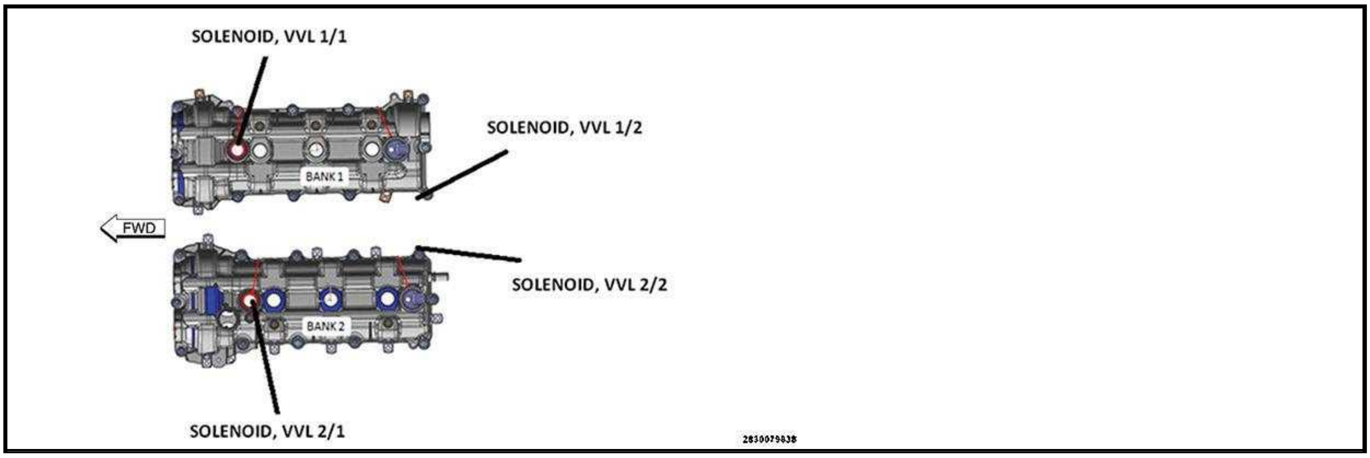
        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1051-INTAKE VALVE CONTROL SOLENOID 1 CIRCUIT LOW

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:

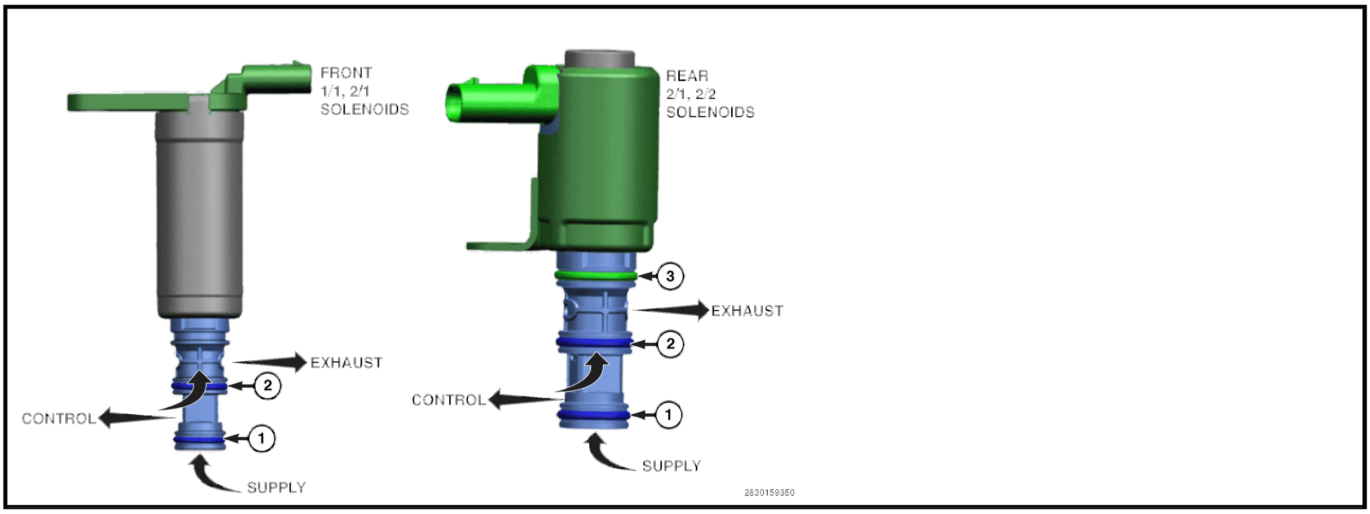


VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073

GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation.

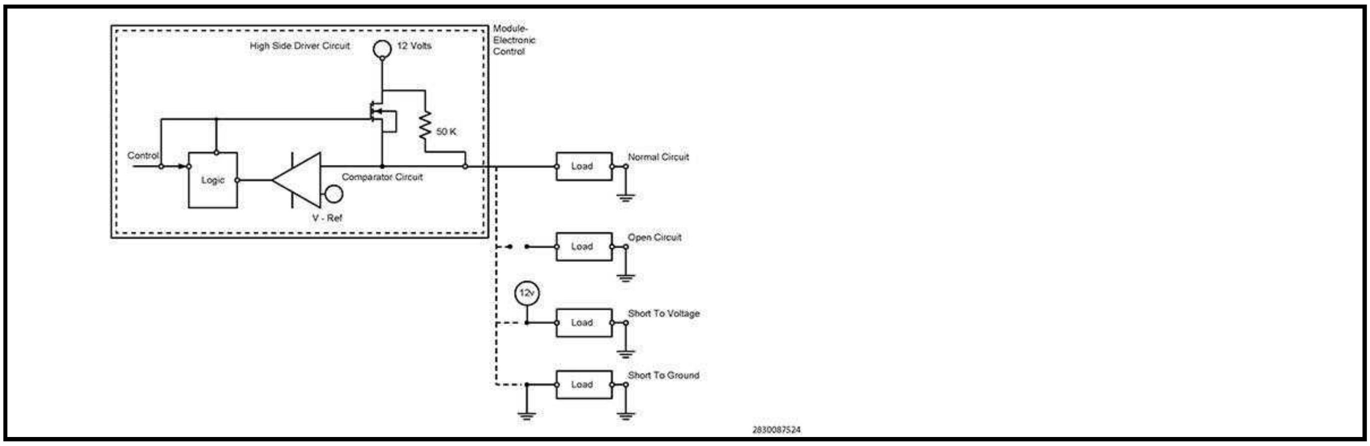
- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure to pass through the solenoid to the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.
- **To enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arm defaults to High Lift mode when no oil pressure is present.

DIAGNOSTICS: The PCM controls each VVL Solenoid with a **High Side Driver (HSD) Circuit** . The PCM performs **circuit diagnostics** on each VVL Solenoid HSD for an open or short in the circuitry.



Typical High Side Driver and Fault Detection: This type of driver circuit is generally used for relay control, controlling a solenoid or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The PCM also provides fault detection for the device, wiring and internal driver. In the example below, the PCM uses an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A small amount of amperage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running above 750 rpm.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded on.

SET CONDITION

- The PCM detects an excessive current draw on the VVL Solenoid 1/1 Control circuit indicating a short to ground.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVL SOLENOID 1/1 CONTROL CIRCUIT SHORTED TO GROUND
VVL SOLENOID 1/1 CONTROL CIRCUIT SHORTED TO THE VVL SOLENOID 1/1 GROUND CIRCUIT
VARIABLE VALVE LIFT (VVL) SOLENOID 1/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **ISOLATE AND CHECK THE VVL SOLENOID 1/1 (K531) CONTROL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to**

pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 3

3. **ISOLATE AND CHECK THE VVL SOLENOID 1/1 (K531) CONTROL CIRCUIT FOR A SHORT TO THE (Z904) GROUND CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between the circuits being tested.**

   Is there continuity between the circuits?

   Yes

   - Repair the short between the circuits.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **CHECK THE VVL SOLENOID RESISTANCE**
   1. Measure the resistance of the VVL Solenoid (component). Remove the VVL Solenoid if necessary to gain access to the terminals and ensure a proper reading.

NOTE: **The resistance reading through a good VVL Solenoid that is not open or internally shorted is approximately 12.0 Ohms +/- 2.0 Ohms.**

Is the resistance reading as described above?

Yes

- Go To 5

No

- Replace the VVL Solenoid in accordance with the Service Information. .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .

- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

No

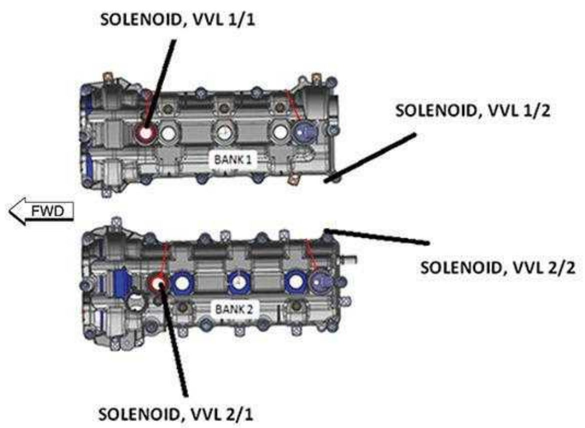
- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

P1052-INTAKE VALVE CONTROL SOLENOID 1 CIRCUIT HIGH

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:



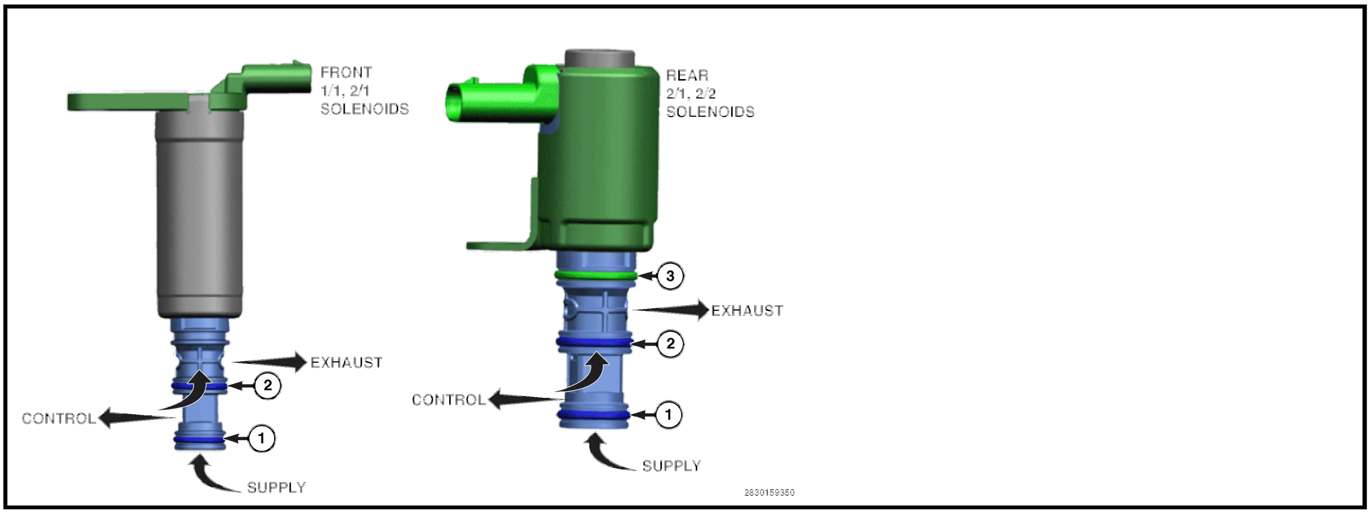
VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073

GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation.

- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure to pass through the solenoid to the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.
- **To enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the

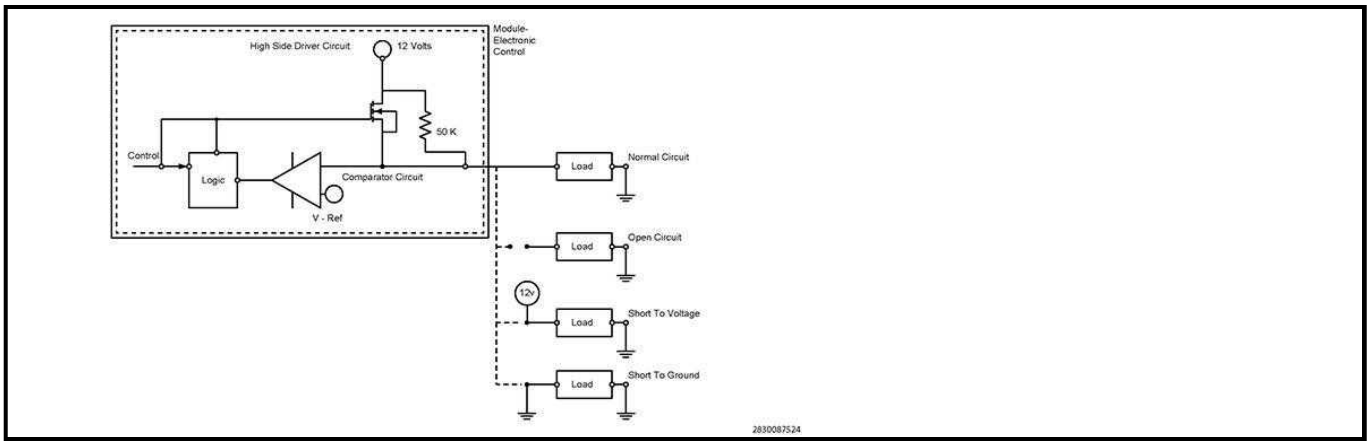
pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arm defaults to High Lift mode when no oil pressure is present.

DIAGNOSTICS: The PCM controls each VVL Solenoid with a **High Side Driver (HSD) Circuit** . The PCM performs **circuit diagnostics** on each VVL Solenoid HSD for an open or short in the circuitry.



Typical High Side Driver and Fault Detection: This type of driver circuit is generally used for relay control, controlling a solenoid or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The PCM also provides fault detection for the device, wiring and internal driver. In the example below, the PCM uses an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A small amount of amperage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded off.

SET CONDITION

- The PCM has detected voltage on the VVL Solenoid 1/1 Control circuit when the solenoid is commanded off and no voltage should be present.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVL SOLENOID 1/1 CONTROL CIRCUIT SHORTED TO VOLTAGE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **ISOLATE AND CHECK THE VVL SOLENOID 1/1 (K531) CONTROL FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

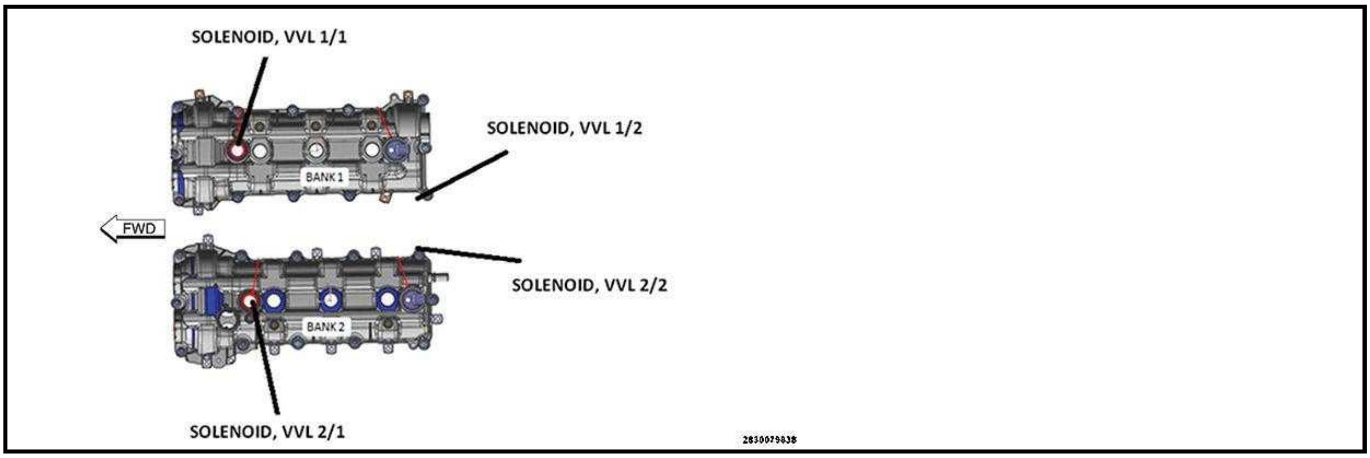
- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1053-INTAKE VALVE CONTROL SOLENOID 2 CIRCUIT/OPEN

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:



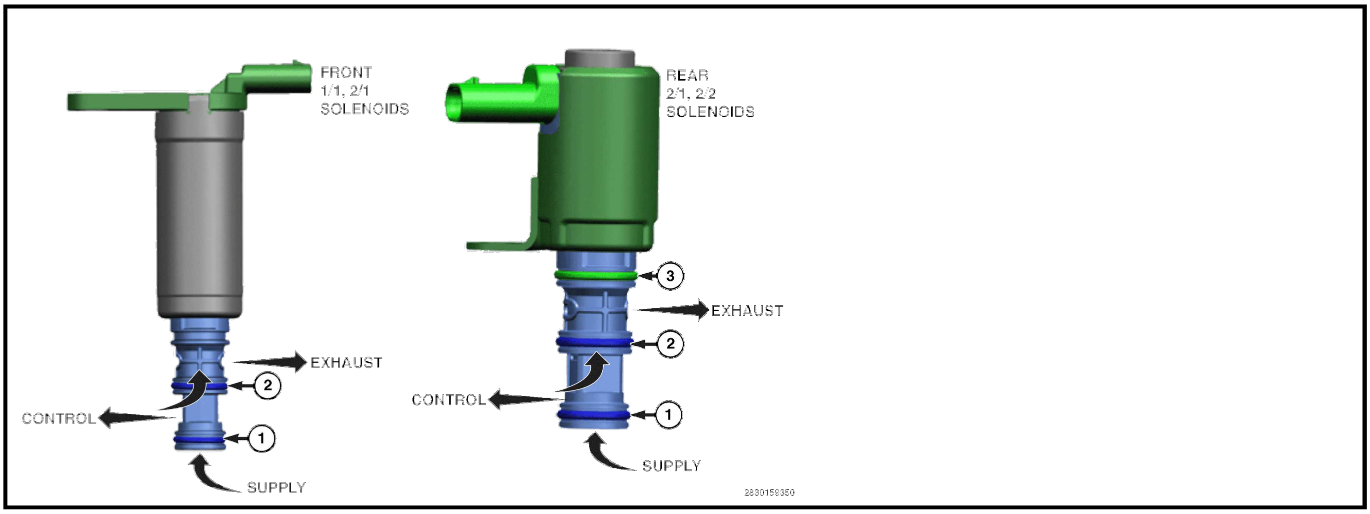
VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073

GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation.

- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure to pass through the solenoid to the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.
- **To enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the

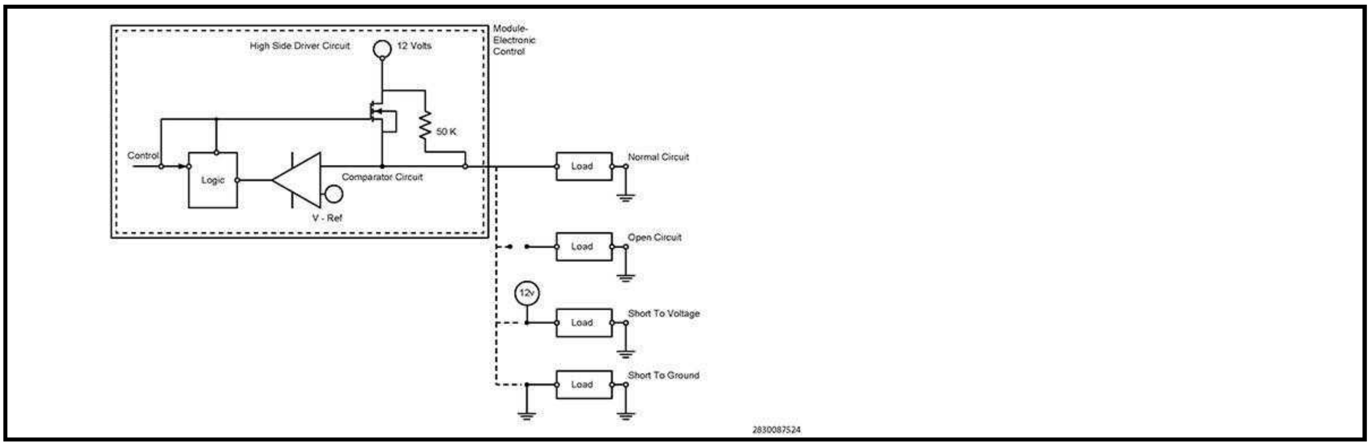
pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arm defaults to High Lift mode when no oil pressure is present.

DIAGNOSTICS: The PCM controls each VVL Solenoid with a **High Side Driver (HSD) Circuit** . The PCM performs **circuit diagnostics** on each VVL Solenoid HSD for an open or short in the circuitry.



Typical High Side Driver and Fault Detection: This type of driver circuit is generally used for relay control, controlling a solenoid or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The PCM also provides fault detection for the device, wiring and internal driver. In the example below, the PCM uses an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A small amount of amperage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded off.

SET CONDITION

- The PCM detects an open on the VVL Solenoid 1/2 Control circuit.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVL SOLENOID 1/2 CONTROL CIRCUIT OPEN/HIGH RESISTANCE
VVL SOLENOID 1/2 GROUND CIRCUIT OPEN/HIGH RESISTANCE
VARIABLE VALVE LIFT (VVL) SOLENOID 1/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE (Z904) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Disconnect the component harness connector to isolate the ground circuit.
    2. Connect the positive lead of the load test tool to the positive side of the Battery.
    3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
    4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

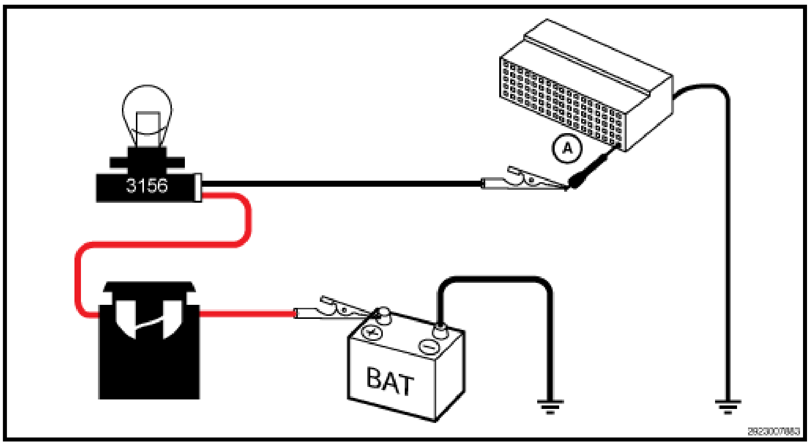
NOTE: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .

NOTE: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 3

No

- Repair the ground circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **ISOLATE AND LOAD TEST THE VVL SOLENOID 1/2 (K532) CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
    3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
    4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
    5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
    6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

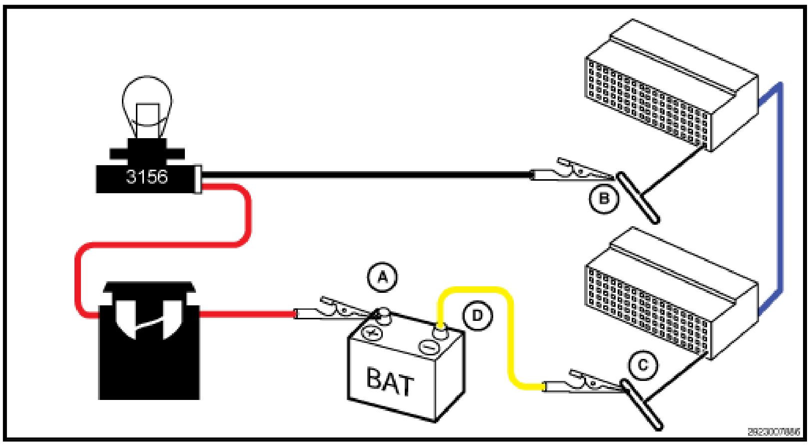
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage**

drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 4

   No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE VVL SOLENOID RESISTANCE**
    1. Measure the resistance of the VVL Solenoid (component). Remove the VVL Solenoid if necessary to gain access to the terminals and ensure a proper reading.

        NOTE: **The resistance reading through a good VVL Solenoid that is not open or internally shorted is approximately 12.0 Ohms +/- 2.0 Ohms.**

        Is the resistance reading as described above?

        Yes

        - Go To 5

        No

        - Replace the VVL Solenoid in accordance with the Service Information. .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

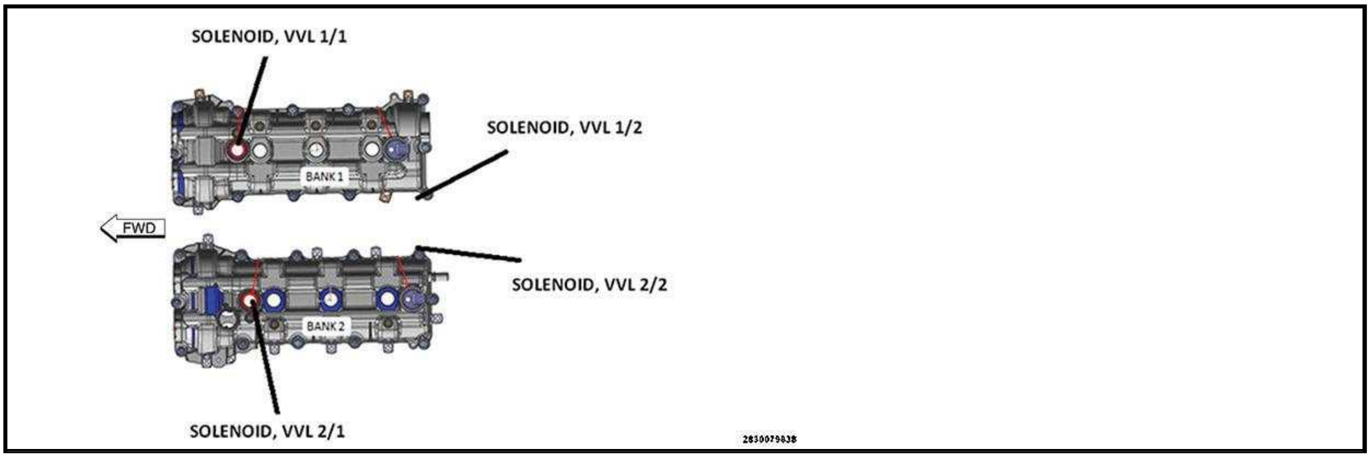
- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1054-INTAKE VALVE CONTROL SOLENOID 2 CIRCUIT LOW

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:



VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073

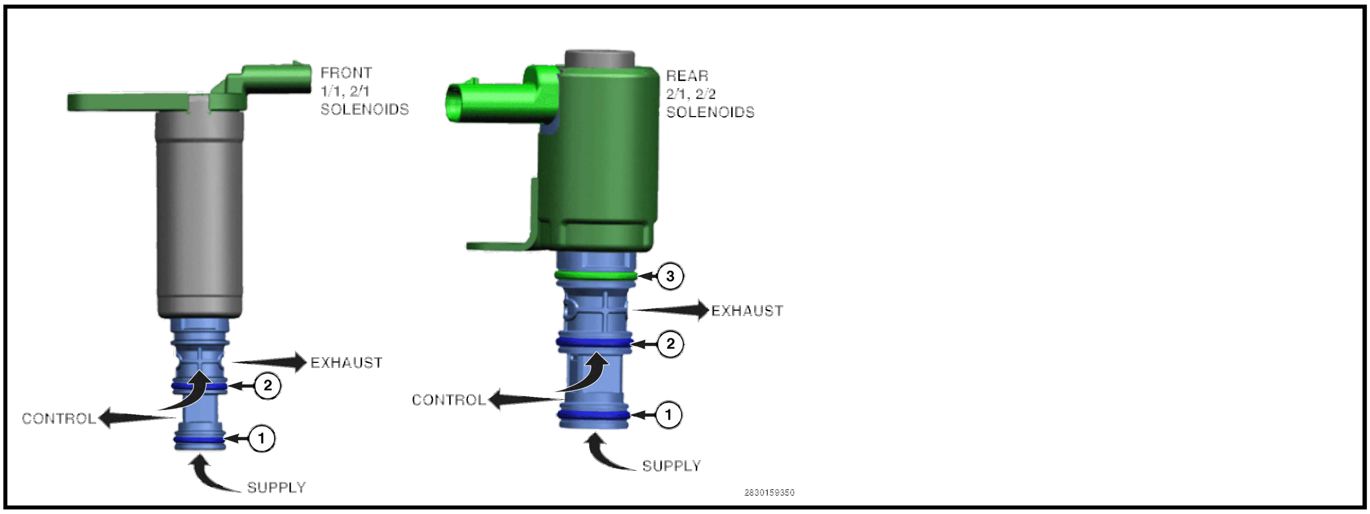
GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation.

- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure to pass through the solenoid to

the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.

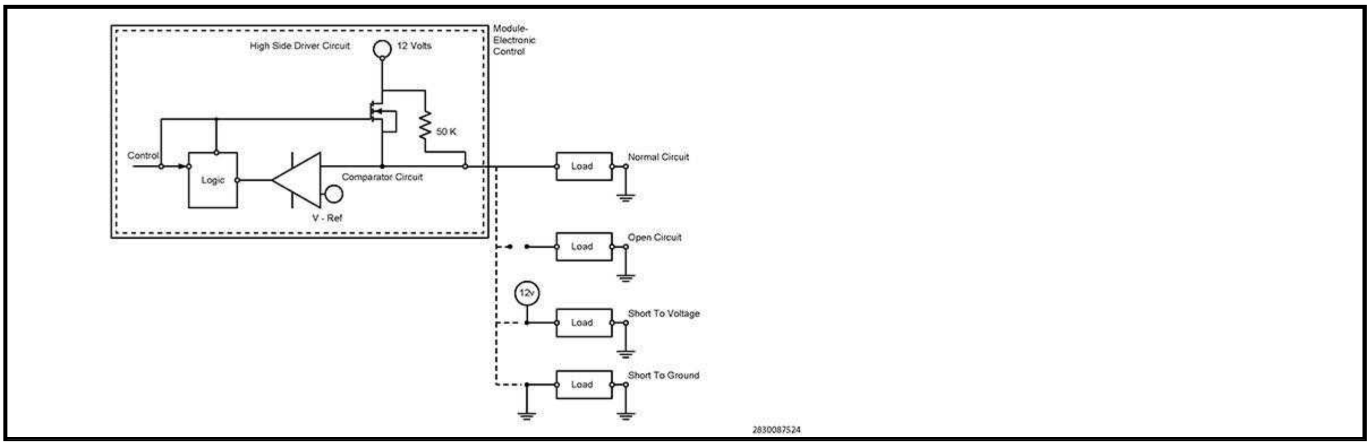
- **To enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arm defaults to High Lift mode when no oil pressure is present.

DIAGNOSTICS: The PCM controls each VVL Solenoid with a **High Side Driver (HSD) Circuit** . The PCM performs **circuit diagnostics** on each VVL Solenoid HSD for an open or short in the circuitry.



Typical High Side Driver and Fault Detection: This type of driver circuit is generally used for relay control, controlling a solenoid or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The PCM also provides fault detection for the device, wiring and internal driver. In the example below, the PCM uses an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A small amount of amperage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running above 750 rpm.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded on.

SET CONDITION

- The PCM detects a short to ground on the VVL Solenoid 1/2 control circuit.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVL SOLENOID 1/2 CONTROL CIRCUIT SHORTED TO GROUND
VVL SOLENOID 1/2 CONTROL CIRCUIT SHORTED TO THE VVL SOLENOID 1/2 GROUND CIRCUIT
VARIABLE VALVE LIFT (VVL) SOLENOID 1/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **ISOLATE AND CHECK THE VVL SOLENOID 1/2 (K532) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.

2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Connect the negative lead of the DVOM to a known good ground.
4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **ISOLATE AND CHECK THE VVL SOLENOID 1/2 (K532) CONTROL CIRCUIT FOR A SHORT TO THE (Z904) GROUND CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between the circuits being tested.**

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **CHECK THE VVL SOLENOID RESISTANCE**
    1. Measure the resistance of the VVL Solenoid (component). Remove the VVL Solenoid if necessary to gain access to the terminals and ensure a proper reading.

       NOTE: **The resistance reading through a good VVL Solenoid that is not open or internally shorted is approximately 12.0 Ohms +/- 2.0 Ohms.**

       Is the resistance reading as described above?

       Yes

       - Go To 5

       No

       - Replace the VVL Solenoid in accordance with the Service Information. .
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

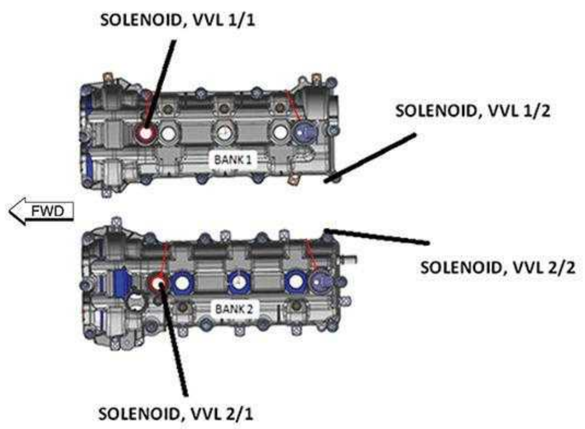
DIAGNOSIS AND TESTING

P1055-INTAKE VALVE CONTROL SOLENOID 2 CIRCUIT HIGH

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:

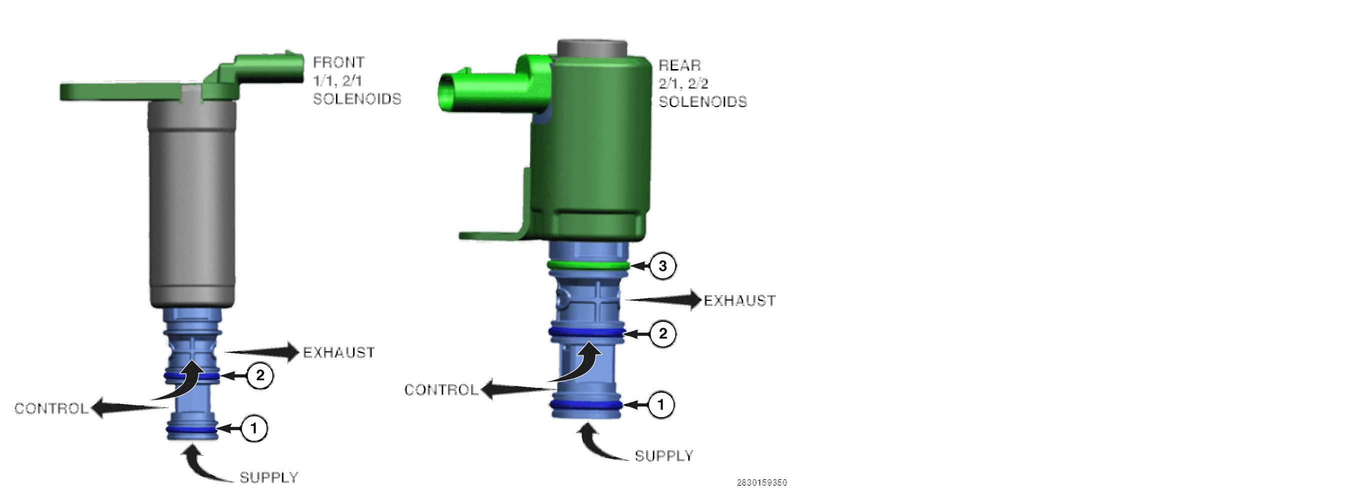


VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073

GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation.

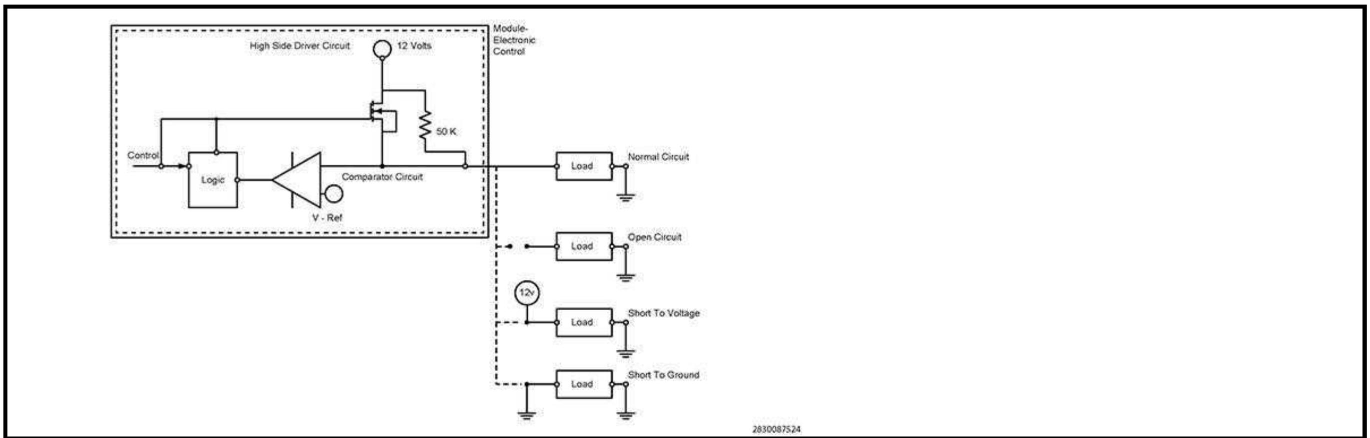
- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure to pass through the solenoid to the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.
- **To enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arm defaults to High Lift mode when no oil pressure is present.

DIAGNOSTICS: The PCM controls each VVL Solenoid with a **High Side Driver (HSD) Circuit** . The PCM performs **circuit diagnostics** on each VVL Solenoid HSD for an open or short in the circuitry.



Typical High Side Driver and Fault Detection: This type of driver circuit is generally used for relay control, controlling a solenoid or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The PCM also provides fault detection for the device, wiring and internal driver. In the example below, the PCM uses an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A small amount of amperage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded off.

SET CONDITION

- The PCM has detected voltage on the VVL Solenoid 1/2 Control circuit when the solenoid is commanded off and no voltage should be present.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVL SOLENOID 1/2 CONTROL CIRCUIT SHORTED TO VOLTAGE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **ISOLATE AND CHECK THE VVL SOLENOID 1/2 (K532) CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .

- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

No

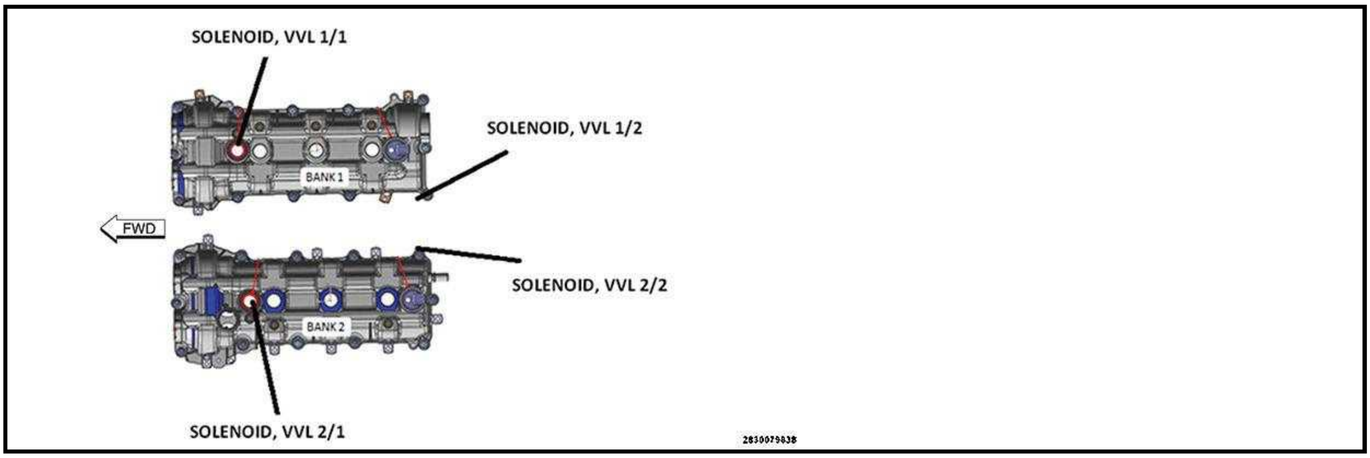
- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

P1056-INTAKE VALVE CONTROL SOLENOID 3 CIRCUIT/OPEN

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:



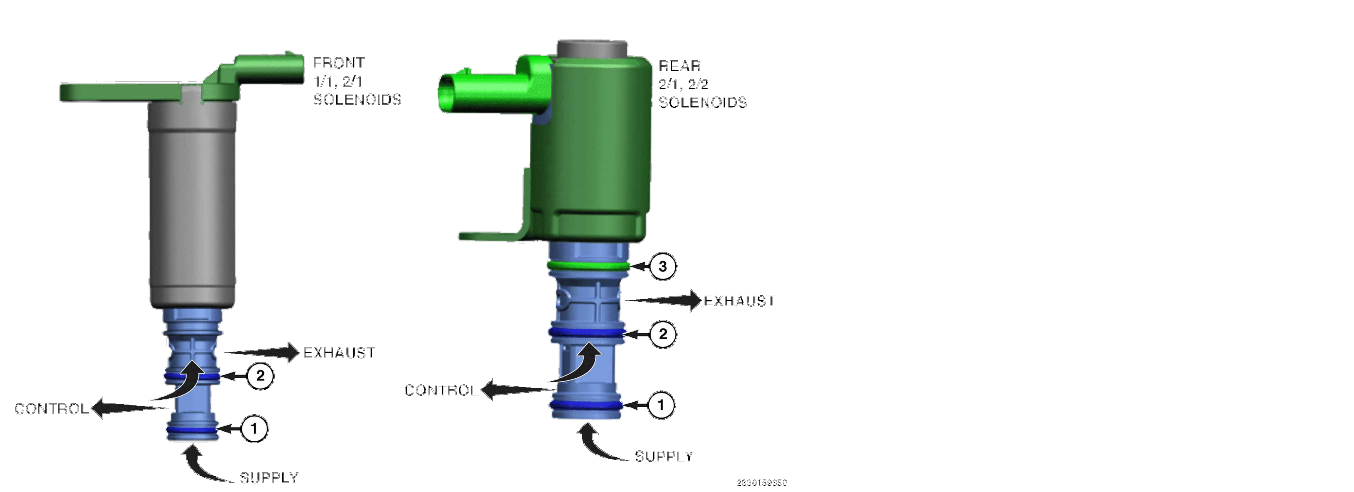
VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073

GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation.

- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure to pass through the solenoid to the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.
- **To enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the

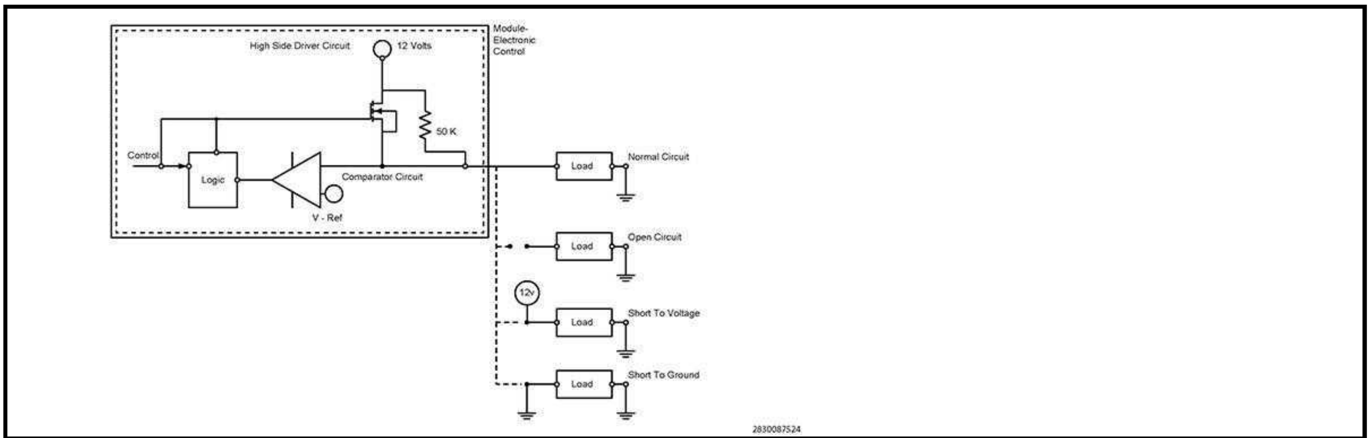
pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arm defaults to High Lift mode when no oil pressure is present.

DIAGNOSTICS: The PCM controls each VVL Solenoid with a **High Side Driver (HSD) Circuit** . The PCM performs **circuit diagnostics** on each VVL Solenoid HSD for an open or short in the circuitry.



Typical High Side Driver and Fault Detection: This type of driver circuit is generally used for relay control, controlling a solenoid or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The PCM also provides fault detection for the device, wiring and internal driver. In the example below, the PCM uses an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A small amount of amperage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded off.

SET CONDITION

- The PCM detects an open on the VVL Solenoid 2/1 Control circuit.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVL SOLENOID 2/1 CONTROL CIRCUIT OPEN/HIGH RESISTANCE
VVL SOLENOID 2/1 GROUND CIRCUIT OPEN/HIGH RESISTANCE
VARIABLE VALVE LIFT (VVL) SOLENOID 2/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE (Z904) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Disconnect the component harness connector to isolate the ground circuit.
    2. Connect the positive lead of the load test tool to the positive side of the Battery.
    3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
    4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

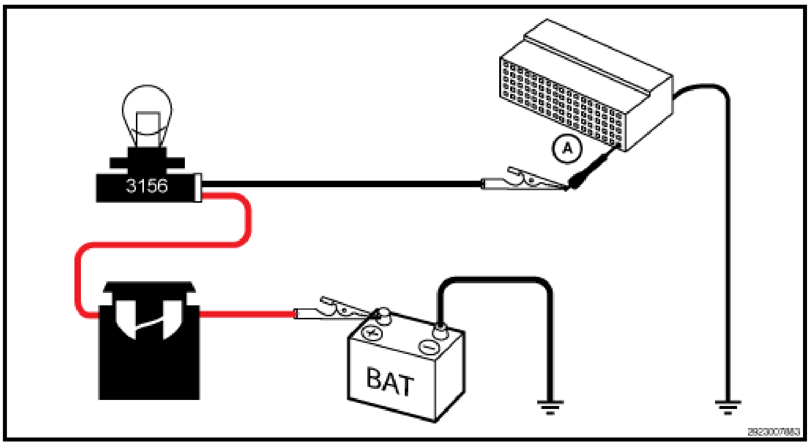
NOTE: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .

NOTE: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 3

No

- Repair the ground circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **ISOLATE AND LOAD TEST THE VVL SOLENOID 2/1 (K533) CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
   3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
   4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
   5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
   6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

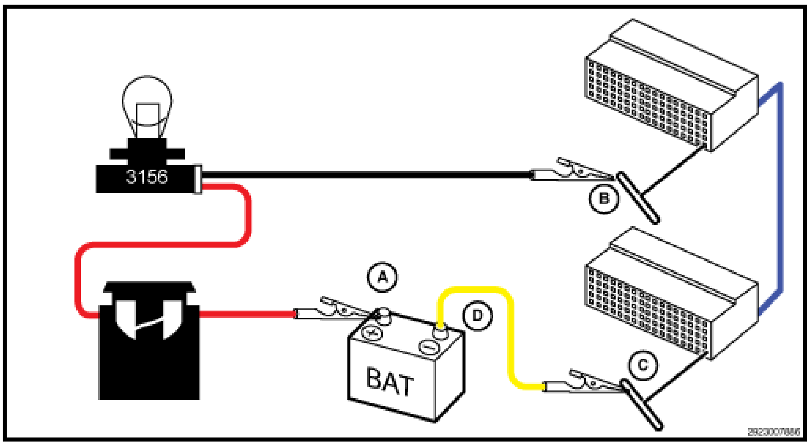
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage**

drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: Do not load test any circuits with components still connected to the circuit.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

   NOTE: Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 4

   No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE VVL SOLENOID RESISTANCE**
   1. Measure the resistance of the VVL Solenoid (component). Remove the VVL Solenoid if necessary to gain access to the terminals and ensure a proper reading.

      NOTE: **The resistance reading through a good VVL Solenoid that is not open or internally shorted is approximately 12.0 Ohms +/- 2.0 Ohms.**

      Is the resistance reading as described above?

      Yes

      - Go To 5

      No

      - Replace the VVL Solenoid in accordance with the Service Information. .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

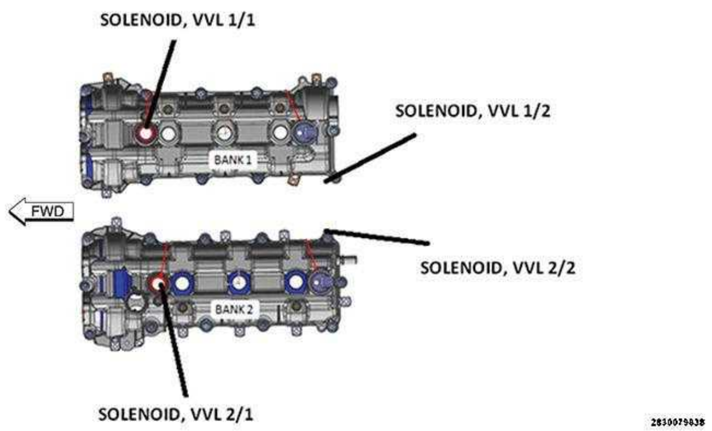
- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1057-INTAKE VALVE CONTROL SOLENOID 3 CIRCUIT LOW

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:



VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073

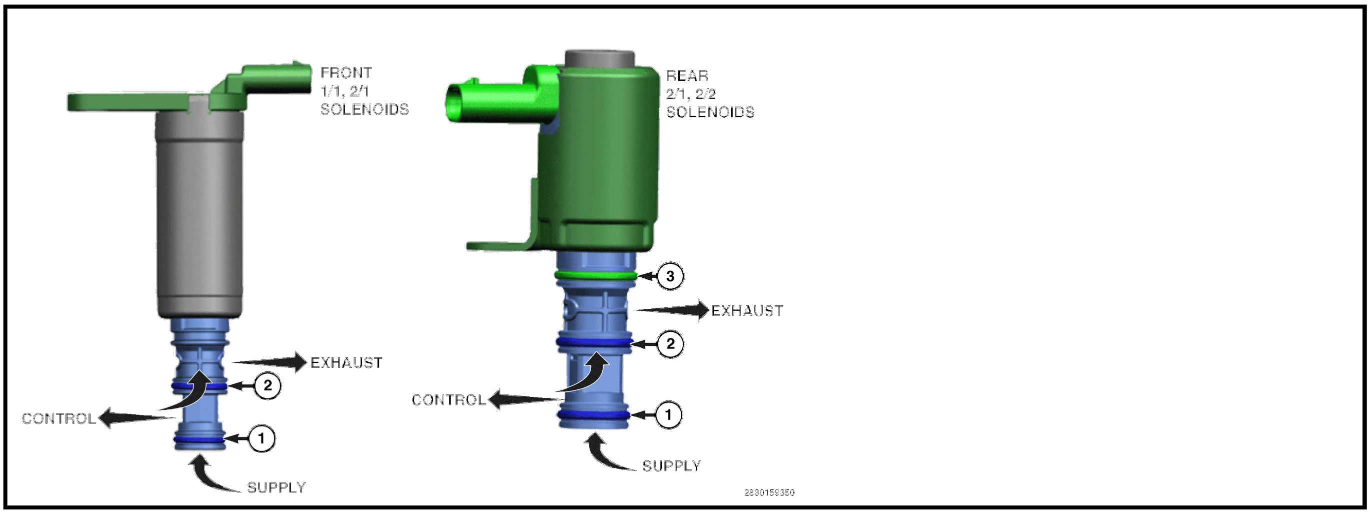
GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation.

- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure to pass through the solenoid to

the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.

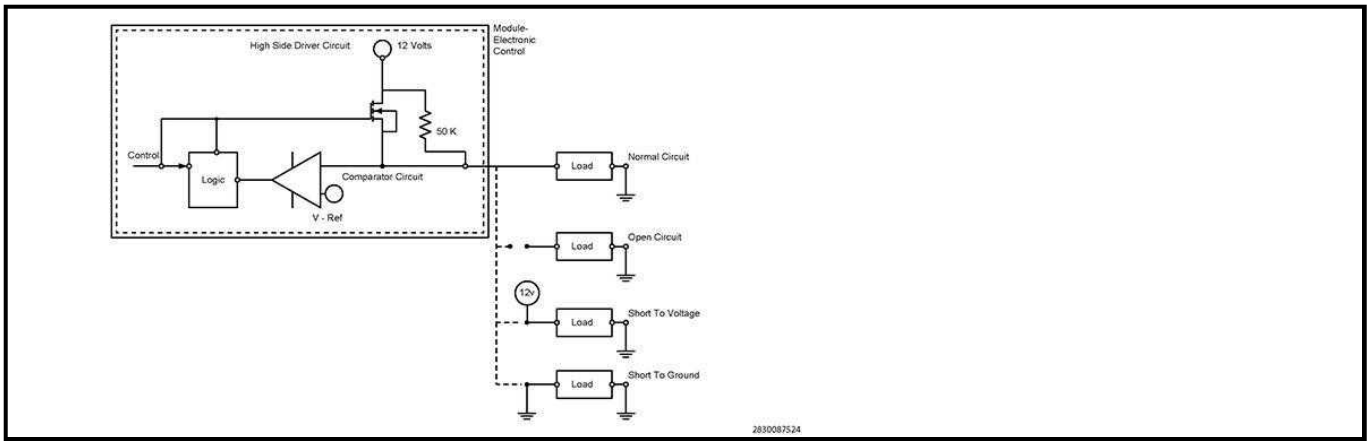
- **To enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arm defaults to High Lift mode when no oil pressure is present.

DIAGNOSTICS: The PCM controls each VVL Solenoid with a **High Side Driver (HSD) Circuit** . The PCM performs **circuit diagnostics** on each VVL Solenoid HSD for an open or short in the circuitry.



Typical High Side Driver and Fault Detection: This type of driver circuit is generally used for relay control, controlling a solenoid or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The PCM also provides fault detection for the device, wiring and internal driver. In the example below, the PCM uses an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A small amount of amperage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running above 750 rpm.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded on.

SET CONDITION

- The PCM detects a short to ground on the VVL Solenoid 2/1 control circuit.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVL SOLENOID 2/1 CONTROL CIRCUIT SHORTED TO GROUND
VVL SOLENOID 2/1 CONTROL CIRCUIT SHORTED TO THE VVL SOLENOID 2/1 GROUND CIRCUIT
VARIABLE VALVE LIFT (VVL) SOLENOID 2/1
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to INTERMITTENT CONDITION .
2. **ISOLATE AND CHECK THE VVL SOLENOID 2/1 (K533) CONTROL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.

2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Connect the negative lead of the DVOM to a known good ground.
4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **ISOLATE AND CHECK THE VVL SOLENOID 2/1 (K533) CONTROL CIRCUIT FOR A SHORT TO THE (Z904) GROUND CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between the circuits being tested.**

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **CHECK THE VVL SOLENOID RESISTANCE**
   1. Measure the resistance of the VVL Solenoid (component). Remove the VVL Solenoid if necessary to gain access to the terminals and ensure a proper reading.

      NOTE: **The resistance reading through a good VVL Solenoid that is not open or internally shorted is approximately 12.0 Ohms +/- 2.0 Ohms.**

      Is the resistance reading as described above?

      Yes

      - Go To 5

      No

      - Replace the VVL Solenoid in accordance with the Service Information. .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.
   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

       Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

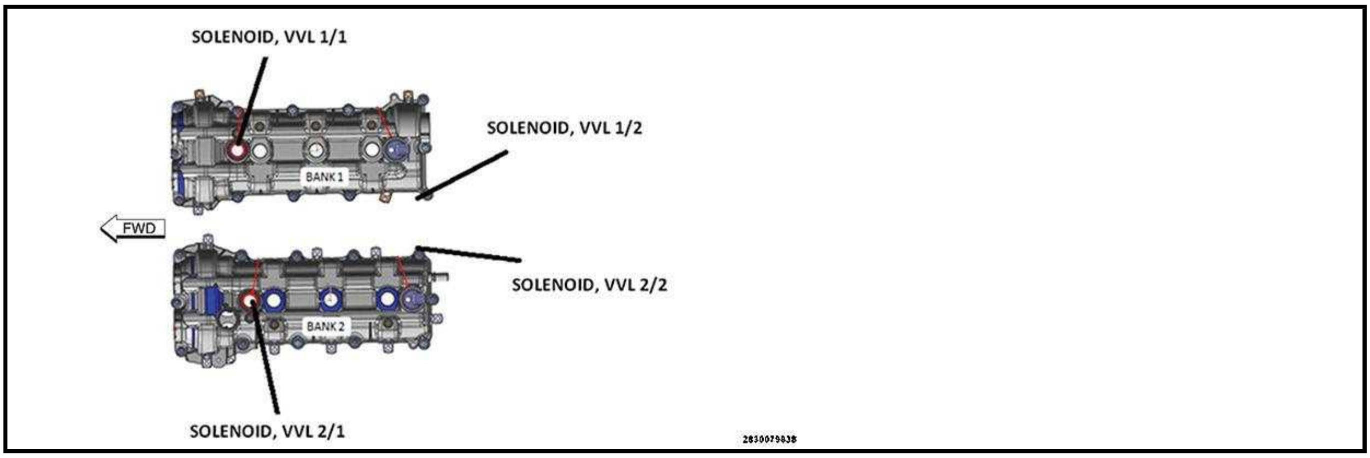
- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1058-INTAKE VALVE CONTROL SOLENOID 3 CIRCUIT HIGH

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:



VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073

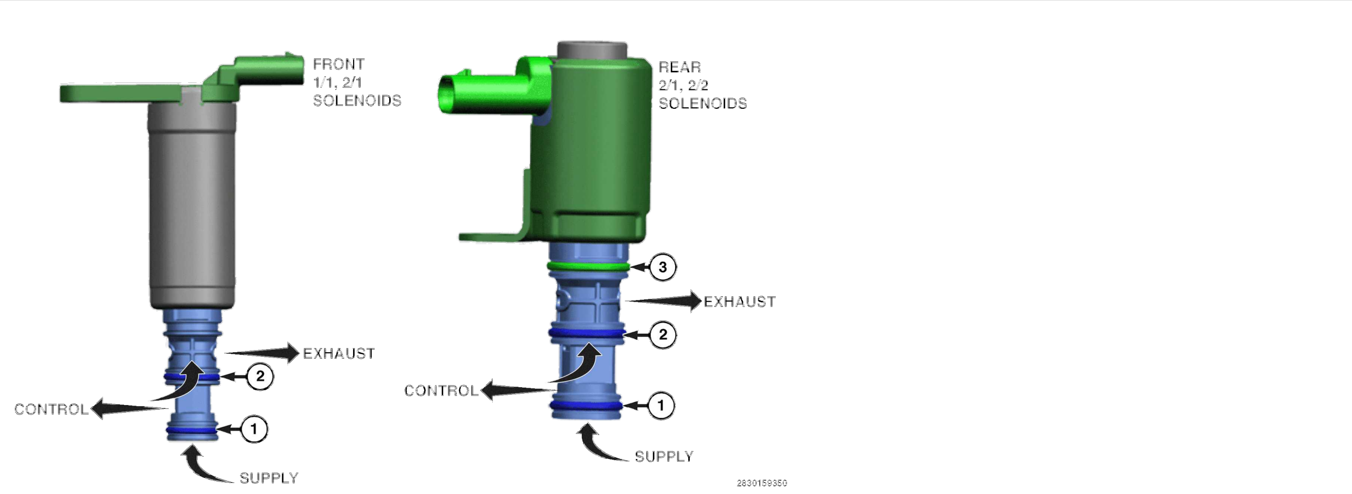
GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation.

- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure to pass through the solenoid to the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in

Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.

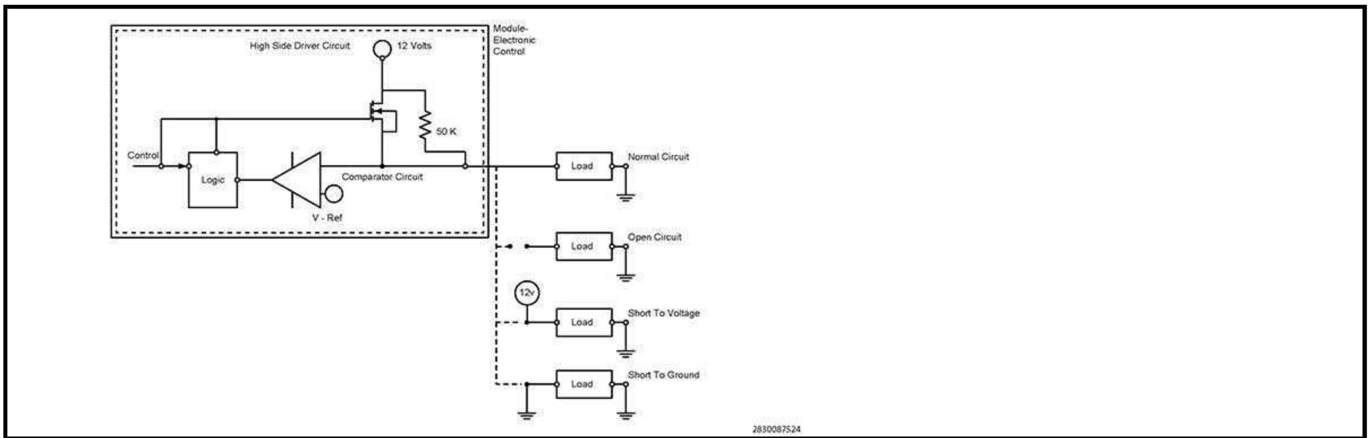
- **To enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arm defaults to High Lift mode when no oil pressure is present.

DIAGNOSTICS: The PCM controls each VVL Solenoid with a **High Side Driver (HSD) Circuit** . The PCM performs **circuit diagnostics** on each VVL Solenoid HSD for an open or short in the circuitry.



Typical High Side Driver and Fault Detection: This type of driver circuit is generally used for relay control, controlling a solenoid or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The PCM also provides fault detection for the device, wiring and internal driver. In the example below, the PCM uses an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A small amount of amperage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded off.

SET CONDITION

- The PCM has detected voltage on the VVL Solenoid 2/1 Control circuit when the solenoid is commanded off and no voltage should be present.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVL SOLENOID 2/1 CONTROL CIRCUIT SHORTED TO VOLTAGE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **ISOLATE AND CHECK THE VVL SOLENOID 2/1 (K533) CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.

4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

   Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

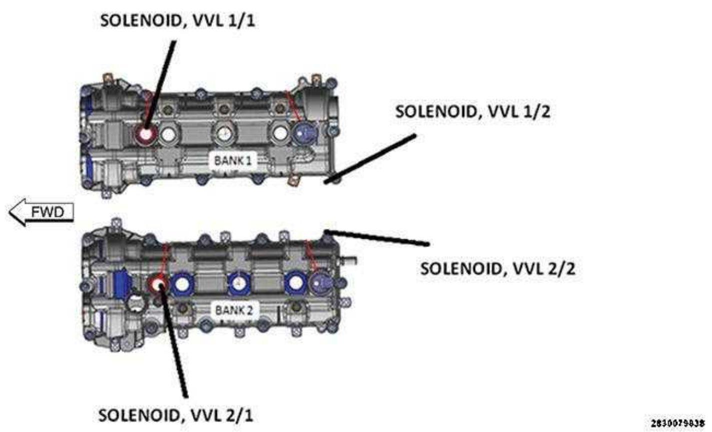
- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1059-INTAKE VALVE CONTROL SOLENOID 4 CIRCUIT/OPEN

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:



VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073

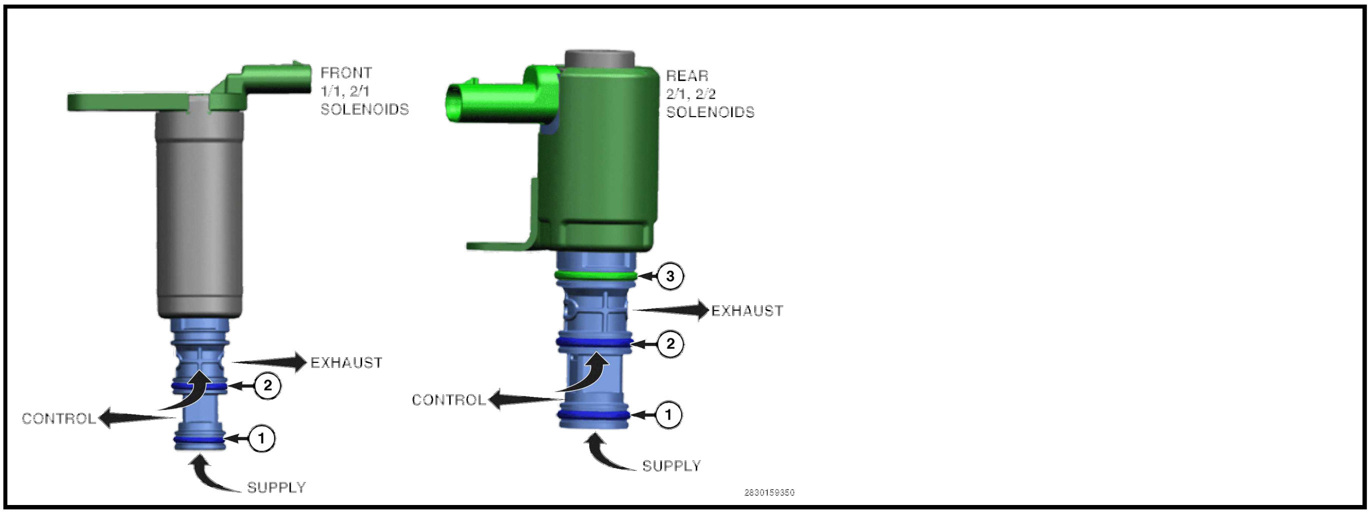
GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation.

- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure to pass through the solenoid to the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in

Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.

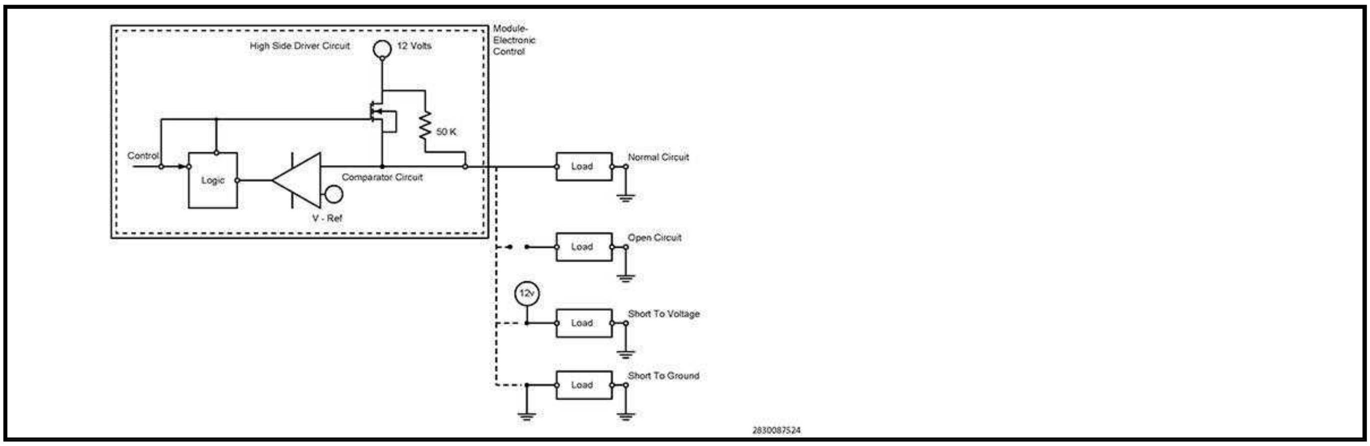
- **To enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arm defaults to High Lift mode when no oil pressure is present.

DIAGNOSTICS: The PCM controls each VVL Solenoid with a **High Side Driver (HSD) Circuit** . The PCM performs **circuit diagnostics** on each VVL Solenoid HSD for an open or short in the circuitry.



Typical High Side Driver and Fault Detection: This type of driver circuit is generally used for relay control, controlling a solenoid or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The PCM also provides fault detection for the device, wiring and internal driver. In the example below, the PCM uses an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A small amount of amperage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded off.

SET CONDITION

- The PCM detects an open on the VVL Solenoid 2/2 Control circuit.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVL SOLENOID 2/2 CONTROL CIRCUIT OPEN/HIGH RESISTANCE
VVL SOLENOID 2/2 GROUND CIRCUIT OPEN/HIGH RESISTANCE
VARIABLE VALVE LIFT (VVL) SOLENOID 2/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE (Z904) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**
    1. Disconnect the component harness connector to isolate the ground circuit.
    2. Connect the positive lead of the load test tool to the positive side of the Battery.

3. Connect the negative lead of the load test tool to the ground circuit at the component harness connector (A). **Note:** refer to the diagram below.
4. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry.

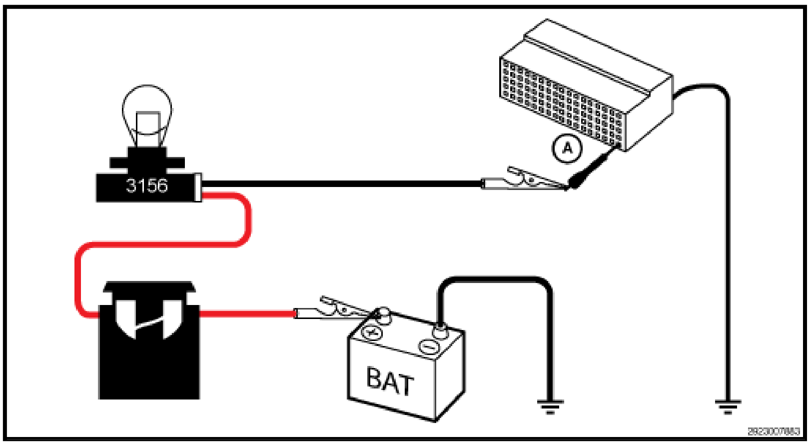
NOTE: **Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to** **CIRCUIT LOAD TESTING PROCEDURES** **.**

NOTE: **A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** **.**



CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 3

No

- Repair the ground circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **ISOLATE AND LOAD TEST THE VVL SOLENOID 2/2 (K534) CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
   3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
   4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
   5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
   6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

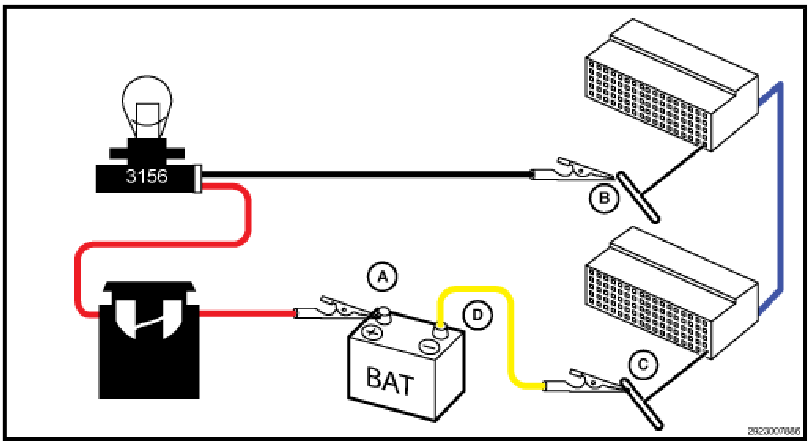
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load**

test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES .**



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

Yes

- Go To 4

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE VVL SOLENOID RESISTANCE**
    1. Measure the resistance of the VVL Solenoid (component). Remove the VVL Solenoid if necessary to gain access to the terminals and ensure a proper reading.

    NOTE: **The resistance reading through a good VVL Solenoid that is not open or internally shorted is approximately 12.0 Ohms +/- 2.0 Ohms.**

    Is the resistance reading as described above?

    Yes

    - Go To 5

    No

    - Replace the VVL Solenoid in accordance with the Service Information. .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.

9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

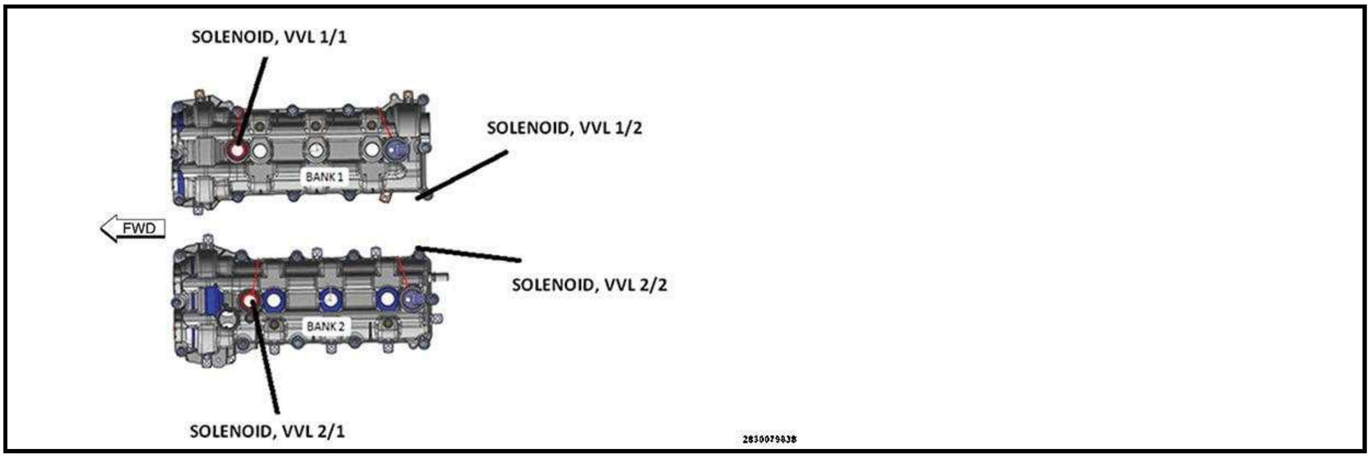
- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P105A-INTAKE VALVE CONTROL SOLENOID 4 CIRCUIT LOW

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:

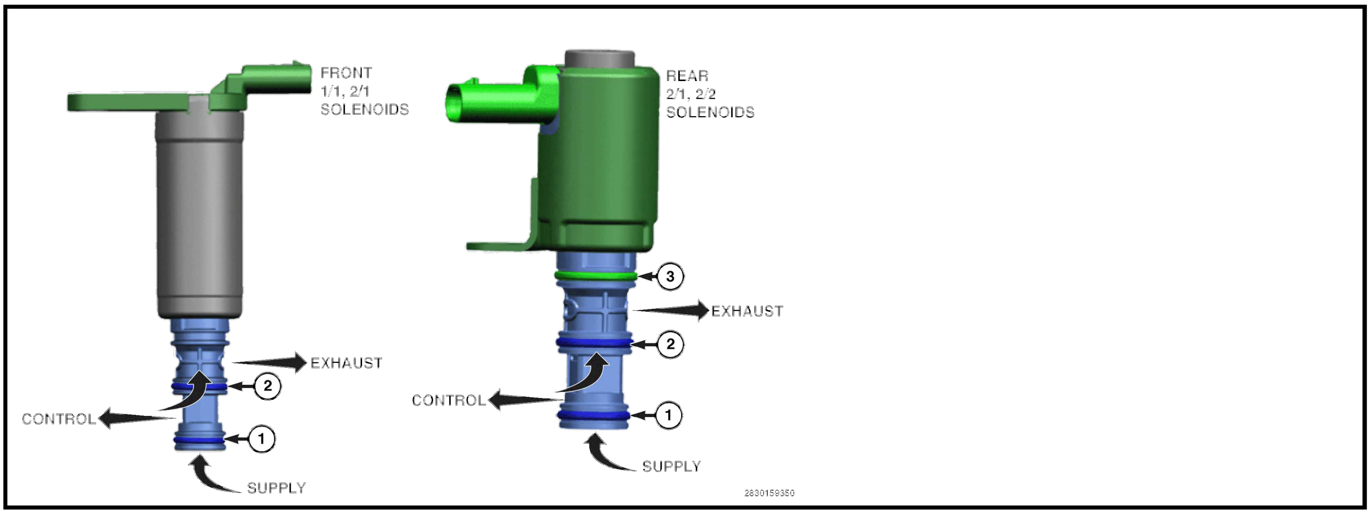


VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073

GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation.

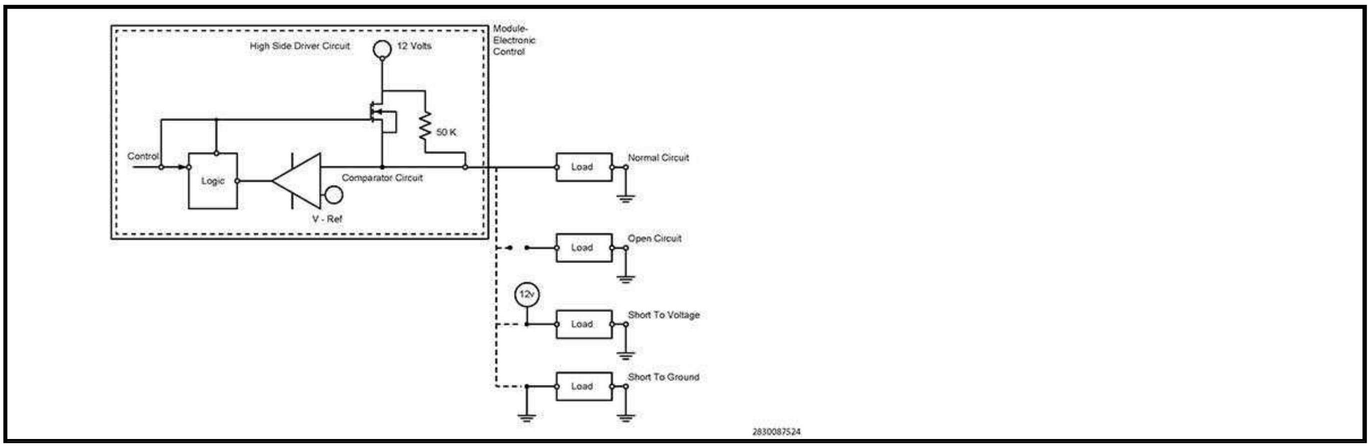
- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure to pass through the solenoid to the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.
- **To enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arm defaults to High Lift mode when no oil pressure is present.

DIAGNOSTICS: The PCM controls each VVL Solenoid with a **High Side Driver (HSD) Circuit** . The PCM performs **circuit diagnostics** on each VVL Solenoid HSD for an open or short in the circuitry.



Typical High Side Driver and Fault Detection: This type of driver circuit is generally used for relay control, controlling a solenoid or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The PCM also provides fault detection for the device, wiring and internal driver. In the example below, the PCM uses an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A small amount of amperage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running above 750 rpm.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded on.

SET CONDITION

- The PCM detects a short to ground on the VVL Solenoid 2/2 Control circuit.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVL SOLENOID 2/2 CONTROL CIRCUIT SHORTED TO GROUND
VVL SOLENOID 2/2 CONTROL CIRCUIT SHORTED TO THE VVL SOLENOID 2/2 GROUND CIRCUIT
VARIABLE VALVE LIFT (VVL) SOLENOID 2/2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **ISOLATE AND CHECK THE VVL SOLENOID 2/2 (K534) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

      NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 3

3. **ISOLATE AND CHECK THE VVL SOLENOID 2/2 (K534) CONTROL CIRCUIT FOR A SHORT TO THE (Z904) GROUND CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to**

pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between the circuits being tested.**

   Is there continuity between the circuits?

   Yes

   - Repair the short between the circuits.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **CHECK THE VVL SOLENOID RESISTANCE**
   1. Measure the resistance of the VVL Solenoid (component). Remove the VVL Solenoid if necessary to gain access to the terminals and ensure a proper reading.

      NOTE: **The resistance reading through a good VVL Solenoid that is not open or internally shorted is approximately 12.0 Ohms +/- 2.0 Ohms.**

      Is the resistance reading as described above?

      Yes

      - Go To 5

      No

      - Replace the VVL Solenoid in accordance with the Service Information. .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.

- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

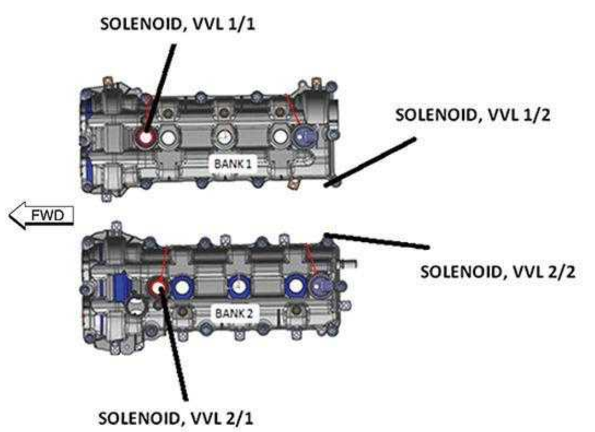
- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P105B-INTAKE VALVE CONTROL SOLENOID 4 CIRCUIT HIGH

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

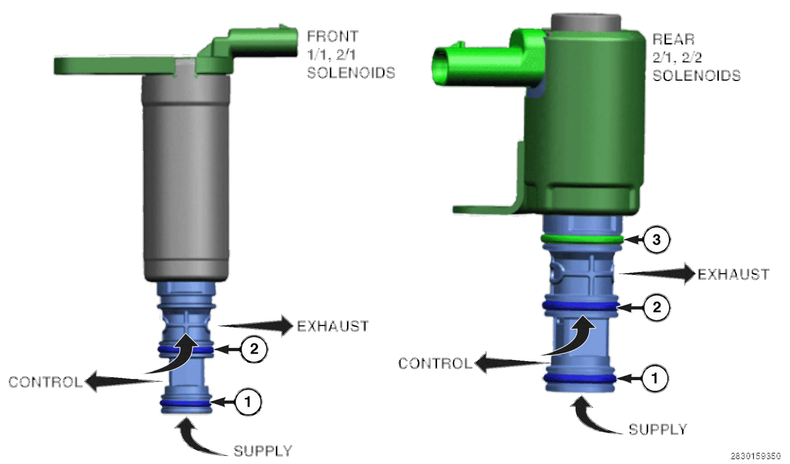
There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:



VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070

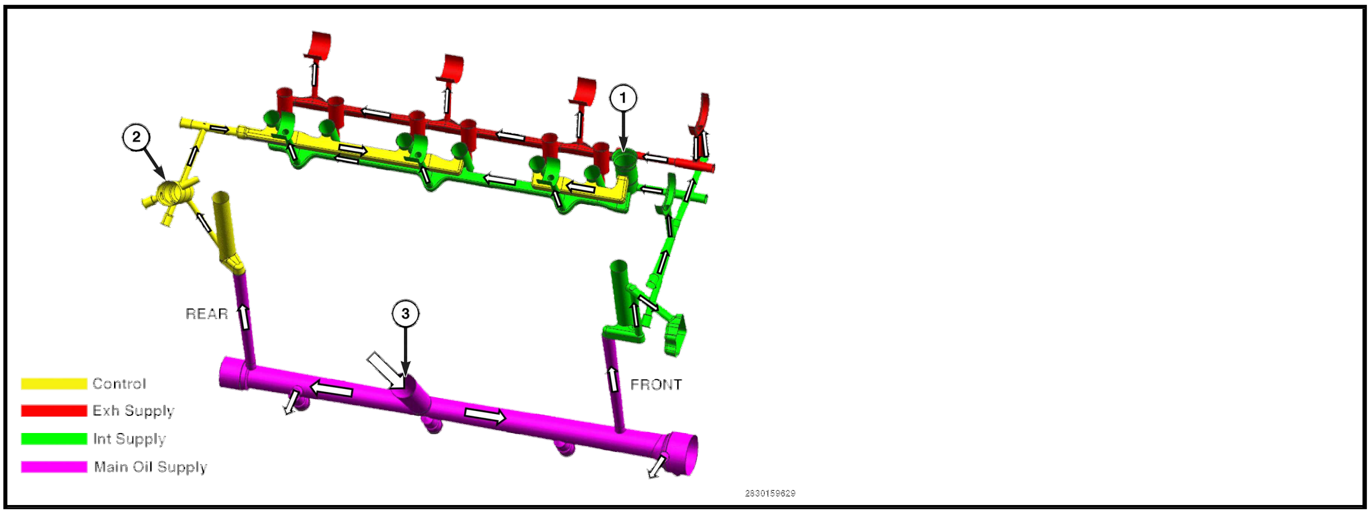
VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073
These faults set when the PCM detects that one or more rockers are stuck in high lift or low lift mode. They are not specific to any of the solenoids. To determine which cylinder is being affected and setting the fault, the intrusive VVL service routine in the scan tool should be run to help determine the affected cylinder(s).			P105C / P105D

GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation. The O-rings on the solenoids prevent oil leakage between passages. The Supply O-ring (1) prevents the pressurized supply oil from entering the control passage when the solenoid is de-energized (off). The Control O-ring (2) prevents the oil from entering the exhaust passage when the solenoid is energized (on). Only the rear solenoid has an Exhaust O-ring (3) preventing an external oil leak. The front solenoid has an external seal to prevent external oil leakage. **If an O-ring is damaged or missing it can cause a Rocker Arm to stick in low lift or high lift mode.**



- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure entering the bottom to pass through the solenoid to the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.
- **To re-enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the oil pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arms default to High Lift mode when no oil pressure is present.

1	Front VVL Solenoid location
2	Rear VVL Solenoid location
3	Oil supply from Oil Filter to the main oil gallery



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded off.

SET CONDITION

- The PCM has detected voltage on the VVL Solenoid 2/2 Control circuit when the solenoid is commanded off and no voltage should be present.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VVL SOLENOID 2/2 CONTROL CIRCUIT SHORTED TO VOLTAGE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **ISOLATE AND CHECK THE VVL SOLENOID 2/2 (K534) CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 3
3. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.

- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

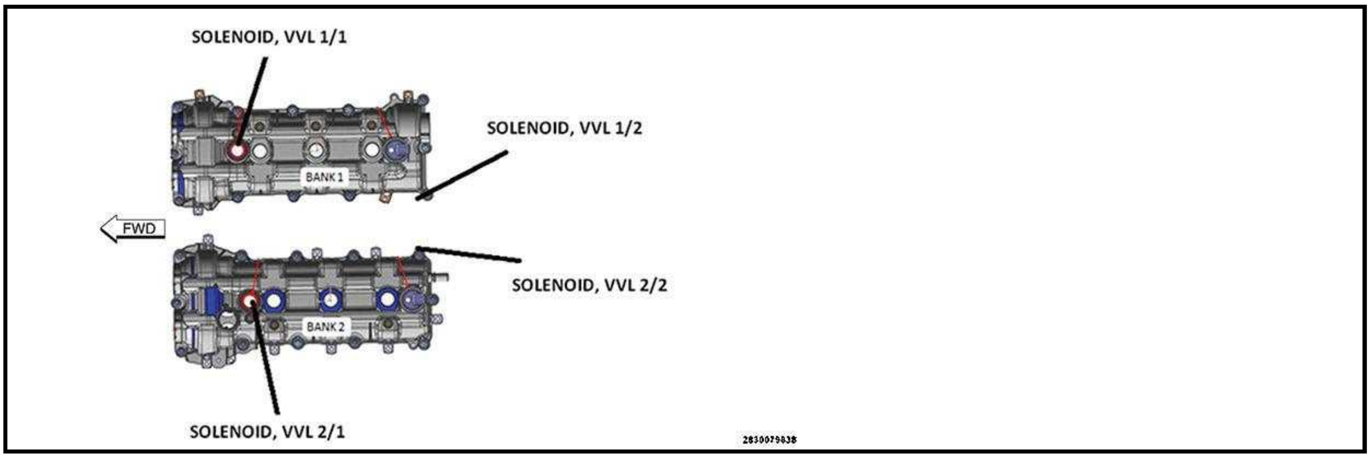
- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P105C-INTAKE VALVE STUCK IN LOW LIFT POSITION

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

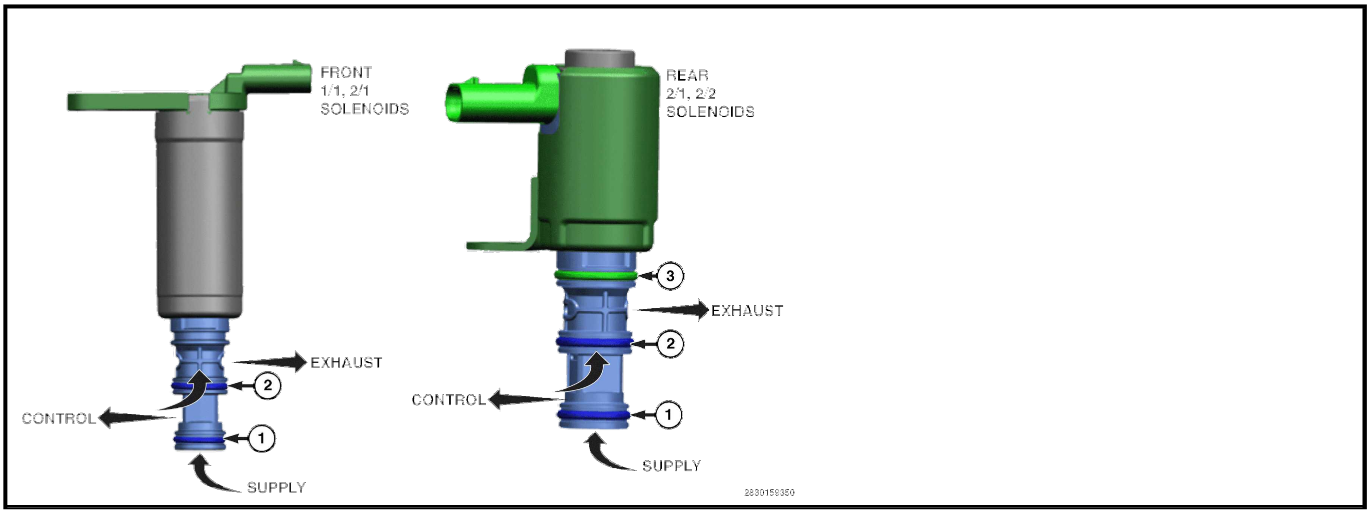
There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:



VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070

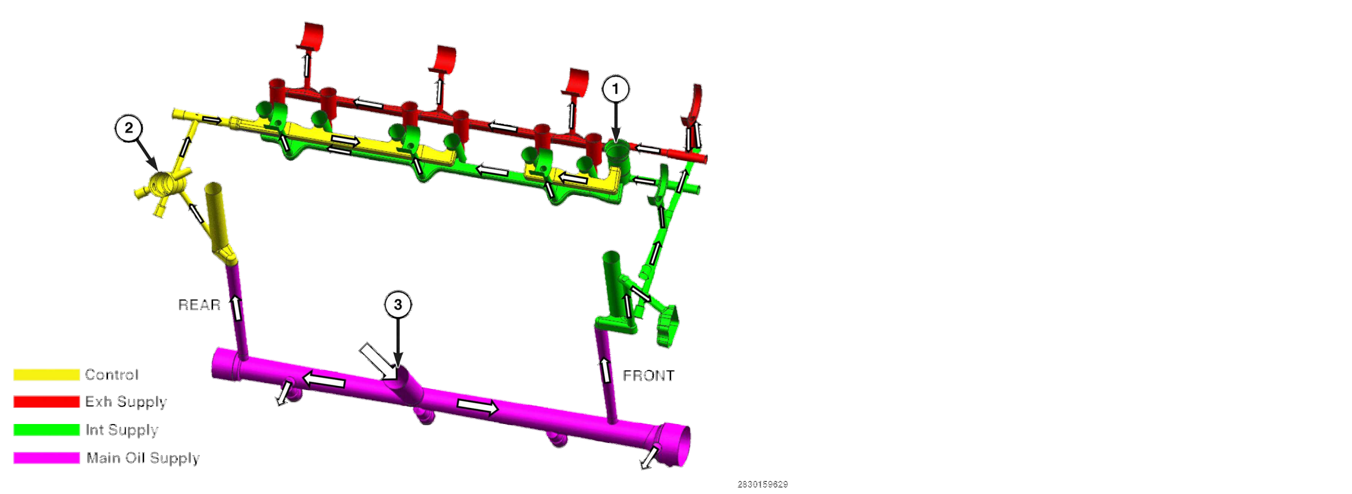
VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073
These faults set when the PCM detects that one or more rockers are stuck in high lift or low lift mode. They are not specific to any of the solenoids. To determine which cylinder is being affected and setting the fault, the intrusive VVL service routine in the scan tool should be run to help determine the affected cylinder(s).			P105C / P105D

GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation. The O-rings on the solenoids prevent oil leakage between passages. The Supply O-ring (1) prevents the pressurized supply oil from entering the control passage when the solenoid is de-energized (off). The Control O-ring (2) prevents the oil from entering the exhaust passage when the solenoid is energized (on). Only the rear solenoid has an Exhaust O-ring (3) preventing an external oil leak. The front solenoid has an external seal to prevent external oil leakage. **If an O-ring is damaged or missing it can cause a Rocker Arm to stick in low lift or high lift mode.**



- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure entering the bottom to pass through the solenoid to the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.
- **To re-enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the oil pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arms default to High Lift mode when no oil pressure is present.

1	Front VVL Solenoid location
2	Rear VVL Solenoid location
3	Oil supply from Oil Filter to the main oil gallery



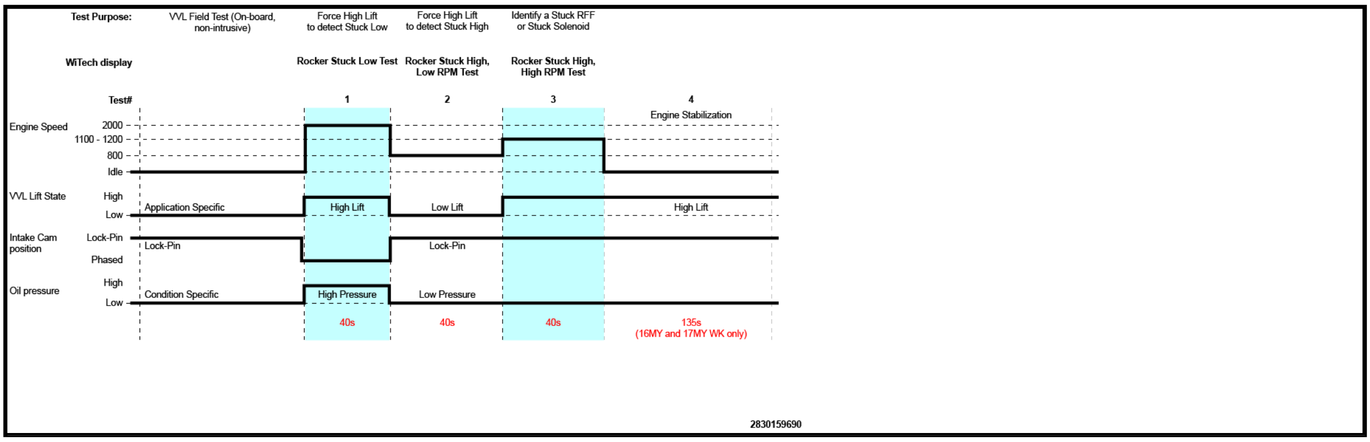
DIAGNOSTIC OVERVIEW - VARIABLE VALVE LIFT (VVL) SYSTEM

PCM DIAGNOSTICS: The PCM performs **diagnostics** for each VVL Solenoid **High Side Driver (HSD) Circuit** to detect an open or short circuit. If no circuit faults are detected the PCM runs a **rationality diagnostic** to detect Rocker Arms that are stuck in the High Lift or Low Lift positions. The PCM monitors for an erratic MAP Sensor signal as well as the Misfire, Knock, and Individual Cylinder Fuel Control (ICFC) monitors to detect a Rocker Arm that is stuck in an incorrect position. A Rocker Arm or arms can stick due to an oil pressure issue, a mechanical failure of a VVL Solenoid (including O-rings) or a faulty Rocker Arm. When a Rocker Arm fault is detected the PCM will begin to record in-field data. If the fault condition goes away during the next drive cycle the data collected will also be cleared.

- **Low Lift stick condition:** A single Rocker Arm that is stuck in low lift may not be detected and the system will continue to operate normally. However, some misfire and engine roughness may be felt. One Rocker Arm stuck in Low Lift mode will cause a misfire at higher engine speeds. Two or more Rocker Arms stuck in Low Lift mode can cause a misfire at any engine speed, including idle. If more than one rocker arm is stuck, the in-field diagnostic will fail, command all Rocker Arms to Low Lift mode and limit the engine speed to approximately 3000 RPM. The PCM will illuminate the MIL on the first trip.
- **High Lift stick condition:** If any Rocker Arm is detected as being stuck in High Lift Mode, the in-field diagnostic will fail and quickly default to commanding all of the Rocker Arms to High Lift mode. The engine will have some roughness and misfire may be felt. A single Rocker Arm stuck in high lift mode typically misfires at idle. The PCM will illuminate the MIL on the second trip.

Tech Tip: Since the two rear cylinders are controlled by the rear solenoid on each bank, a VVL issue that affects both rear cylinders on a bank is most likely a common issue for both cylinders. These would include a damaged or missing O-ring, faulty solenoid, oil supply or control circuit issue. A VVL issue that only affects one of the rear cylinders is more likely going to be a failure of a Rocker Arm or pin for that cylinder.

SCAN TOOL DIAGNOSTICS: The scan tool intrusive VVL Service Routine can be used to verify the VVL system operation as well as a likely possible cause if there is a fault. The routine can only run if the **misfire monitor** is enabled. **If there is an active open circuit fault for a solenoid the routine will run but display all zero's for the results.** When the routine is initiated the scan tool will check the misfire monitor status. If the monitor is enabled the test will continue. If the monitor is disabled, the routine will abort with a message indicating the test has stopped due to misfire disable condition. There are several other conditions that can disable misfire. Some of the common reasons are fuel level (too high or too low), Cam/Crank TLC not learned or ambient temperature too cold. When the test initiates it will run three tests in an attempt to detect a stuck Rocker Arm condition. The on screen display will describe each test being performed and give relevant data. The test will typically take approximately two minutes. The exception is 2016 and 2017 WK/WD vehicles. The test takes approximately four minutes on these vehicles due to an engine stabilization period after the third forced test. See the graph below for details on the routine.



When the routine completes the results will display in a table showing the misfire percentage result for each cylinder during the three tests that were performed. At the top will be a general description of the possible issue or issues. For a more detailed description of the probable causes compare the misfire percentage data recorded to the table in the diagnostic test below. **NOTE: Only count the misfire percentages that are above 75-80% when looking up the results in the table. Any percentage below 75% should not be factored into the result table.**

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running above 750 rpm.
- Battery voltage greater than 11.0 volts.
- Engine Oil Pressure Sensor reading above 20.0 psi.
- High lift mode is requested.
    - VVL Solenoids are commanded off.

SET CONDITION

- The PCM has detected that one or more Rocker Arm is stuck in Low Lift Mode of operation.

DEFAULT ACTION

- The MIL will illuminate.
- If a single Rocker Arm is detected as being stuck in Low Lift Mode, the system will continue to operate normally and switch modes as desired. If more than one Rocker Arm is detected as being stuck in low lift mode, the PCM will default to commanding all of the Rocker Arms to low lift mode.

POSSIBLE CAUSES

Possible Causes
VVL SOLENOID SUPPLY O-RING DAMAGED OR MISSING
VVL SOLENOID STUCK ON/OPEN ALLOWING OIL PRESSURE TO ONE OR MORE ROCKER ARM
ROCKER ARM LOCK PIN STUCK RETRACTED OR BROKEN
ROCKER ARM IMPROPERLY INSTALLED/INCORRECT CLEARANCE BETWEEN A ROCKER ARM AND THE HIGH LIFT (CENTER) CAMSHAFT LOBE
EXCESSIVE WEAR ON A HIGH LIFT (CENTER) CAMSHAFT LOBE
WORN ROCKER ARM

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **PERFORM THE VVL SCAN TOOL DIAGNOSTICS**
    1. Turn the ignition on.
    2. With the scan tool, navigate to Systems Tests, perform the VVL System Diagnostic test and follow the on screen directions.

       NOTE: **Do not erase the DTC before running the routine.**

    3. When the test is complete, compare the results to the table below for the probable failure conditions.

       Scan tool results:

       Compare the results from the routine to the table below.

       - When the routine completes the results will display in a table showing each cylinder and the misfire percentage result for each cylinder during the three tests that were performed. At the top will be a general description of the possible issue or issues. For a more detailed description compare the misfire percentage data recorded to the table below for a detailed list of the probable causes. **NOTE: Only count the misfire percentages that are above 75-80% when looking up the results in the table. Any percentage below 75% should not be factored into the result table.** .

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
Low misfire percentage on (1) Rocker Stuck Low test, (2) Rocker Stuck High, Low RPM test, and (3) Rocker Stuck High, High RPM test	No VVL issue detected	The misfire condition being detected is not caused by the VVL System. Another system is likely causing the misfire
High misfire percentage on (1) Rocker Stuck Low test, (2) Rocker Stuck High, Low RPM test, and (3) Rocker Stuck High, High RPM test	No VVL issue detected	The misfire condition being detected is not caused by the VVL System. Another system is likely causing the misfire
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 1	• VVL Solenoid 1/1 stuck on/open • VVL Solenoid 1/1 control circuit shorted to 12 volts • VVL Solenoid 1/1 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Cylinder 1 rocker arm lash adjuster issue (stuck or broken) • Cylinder 1 rocker arm lock pin stuck retracted • Oil pressure leakage from the supply oil passage to the front control oil passage in the Cylinder Head.	• Verify that the VVL Solenoid 1/1 control circuit is not shorted to 12 volts • Check operation of VVL Solenoid 1/1 for a stuck on/open condition, damaged or missing supply O-ring • Check for broken or stuck Cylinder 1 rocker arms or lock pins • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head.

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 2	• VVL Solenoid 2/1 stuck on/open • VVL Solenoid 2/1 control circuit shorted to 12 volts • VVL Solenoid 2/1 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Cylinder 2 rocker arm lash adjuster issue (stuck or broken) • Cylinder 2 rocker arm lock pin stuck retracted • Oil pressure leakage from the supply oil passage to the front control oil passage in the Cylinder Head.	• Verify that the VVL Solenoid 2/1 control circuit is not shorted to 12 volts • Check operation of VVL Solenoid 2/1 for a stuck on/open condition, damaged or missing supply O-ring • Check for broken or stuck Cylinder 2 rocker arms or lock pins • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step 2 below to check the oil pressure in the Cylinder Head
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 3	• Cylinder 3 rocker arm lash adjuster issue (stuck or broken) • Cylinder 3 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 3 rocker arms or lock pins
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 4	• Cylinder 4 rocker arm lash adjuster issue (stuck or broken) • Cylinder 4 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 4 rocker arms or lock pins
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 5	• Cylinder 5 rocker arm lash adjuster issue (stuck or broken) • Cylinder 5 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 5 rocker arms or lock pins
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 6	• Cylinder 6 rocker arm lash adjuster issue (stuck or broken) • Cylinder 6 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 6 rocker arms or lock pins
(1) Rocker Stuck Low test - high misfire percentage on Cylinder 3 and Cylinder 5	• VVL Solenoid 1/2 stuck on/open • VVL Solenoid 1/2 control circuit shorted to 12 volts • VVL Solenoid 1/2 has missing or damaged	• Check the VVL Solenoid 1/2 control circuit for a short to 12 volts condition • Check operation of VVL Solenoid 1/2 for a stuck on/open condition,

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Oil pressure leakage from the supply oil passage to the rear control oil passage in the Cylinder Head. **NOTE:** **It's less likely but possible for a rocker arm lash adjuster failure (stuck or broken) or lock pin stuck retracted on both Cylinder 3 and Cylinder 5**	damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head.
(1) Rocker Stuck Low test - high misfire percentage on Cylinder 4 and Cylinder 6	• VVL Solenoid 2/2 stuck on/open • VVL Solenoid 2/2 control circuit shorted to 12 volts • VVL Solenoid 2/2 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Oil pressure leakage from the supply oil passage to the rear control oil passage in the Cylinder Head. **NOTE:** **It's less likely but possible for a rocker arm lash adjuster failure (stuck or broken) or lock pin stuck retracted on both Cylinder 4**	• Check the VVL Solenoid 2/2 control circuit for a short to 12 volts condition • Check operation of VVL Solenoid 2/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step 2 below to check the oil pressure in the Cylinder Head

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	and Cylinder 6	
(1) Rocker Stuck Low test - high misfire percentage Cylinder 1, Cylinder 3, and Cylinder 5	• Both bank 1 solenoids have missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage for both bank 1 solenoids • Oil pressure leakage from the supply oil passage to the front and rear control oil passages in the Cylinder Head.	• Check operation of VVL Solenoid 1/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step 2 below to check the oil pressure in the Cylinder Head
(1) Rocker Stuck Low test - high misfire percentage Cylinder 2, Cylinder 4, and Cylinder 6	• Both bank 2 solenoids have missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage for both bank 2 solenoids • Oil pressure leakage from the supply oil passage to the front and rear control oil passages in the Cylinder Head.	• Check operation of VVL Solenoid 2/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step 2 below to check the oil pressure in the Cylinder Head
(1) Rocker Stuck Low test - high misfire percentage for all Cylinders (1 - 6)	• Missing or damaged supply O-rings causing oil pressure leakage from the supply oil passage to the control oil passage for front and rear solenoids on bank 1 and bank 2 • Oil pressure leakage from the supply oil passage to the front and rear control oil passages in both Cylinder Heads.	• Check operation of all VVL Solenoids for a stuck on/open condition, damaged or missing supply O-rings • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace both Cylinder Heads.
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 1	• VVL Solenoid 1/1 control circuit open or shorted to ground • VVL Solenoid 1/1 stuck closed/off	• Check the VVL Solenoid 1/1 control circuit for an open or shorted to ground condition

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	• VVL Solenoid 1/1 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted • Cylinder 1 lash adjuster plugged • Cylinder 1 rocker arm lash adjuster issue (stuck or broken) • Cylinder 1 rocker arm lock pin stuck extended	• Check the VVL Solenoid 1/1 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 1/1 operation. Check for debris on screen • Cylinder 1 lash adjuster plugged • Cylinder 1 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 2	• VVL Solenoid 2/1 stuck closed/off • VVL Solenoid 2/1 control circuit open or shorted to ground • VVL Solenoid 2/1 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted • Cylinder 2 lash adjuster plugged • Cylinder 2 rocker arm lash adjuster issue (stuck or broken) • Cylinder 2 rocker arm lock pin stuck extended	• Check the VVL Solenoid 2/1 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 2/1 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 2/1 operation. Check for debris on screen • Cylinder 2 lash adjuster plugged • Cylinder 2 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 3	• Cylinder 3 lash adjuster plugged • Cylinder 3 rocker arm lash adjuster issue (stuck or broken) • Cylinder 3 rocker arm lock pin stuck extended	• Cylinder 3 lash adjuster plugged • Cylinder 3 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 4	• Cylinder 4 lash adjuster plugged • Cylinder 4 rocker arm lash adjuster issue (stuck or broken) • Cylinder 4 rocker arm lock pin stuck extended	• Cylinder 4 lash adjuster plugged • Cylinder 4 rocker arm stuck failure or lock pin stuck extended

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 5	• Cylinder 5 lash adjuster plugged • Cylinder 5 rocker arm lash adjuster issue (stuck or broken) • Cylinder 5 rocker arm lock pin stuck extended	• Cylinder 5 lash adjuster plugged • Cylinder 5 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 6	• Cylinder 6 lash adjuster plugged • Cylinder 6 rocker arm lash adjuster issue (stuck or broken) • Cylinder 6 rocker arm lock pin stuck extended	• Cylinder 6 lash adjuster plugged • Cylinder 6 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 3 and Cylinder 5	• VVL Solenoid 1/2 stuck closed/off • VVL Solenoid 1/2 control circuit open or shorted to ground • VVL Solenoid 1/2 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted **NOTE:** **It's less likely but possible for a rocker arm lash adjuster issue (stuck or broken) or lock pin stuck retracted on Cylinder 3 and Cylinder 5**	• Check the VVL Solenoid 1/2 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 1/2 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 1/2 operation. Check for debris on screen • Cylinder 3 or 5 lash adjuster plugged • Cylinder 3 or 5 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 4 and Cylinder 6	• VVL Solenoid 2/2 stuck closed/off • VVL Solenoid 2/2 control circuit open or shorted to ground • VVL Solenoid 2/2 has missing or damaged control O-ring causing oil	• Check the VVL Solenoid 2/2 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 2/2 for a missing or damaged control O-ring

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted **NOTE:** **It's less likely but possible for a rocker arm lash adjuster issue (stuck or broken) or lock pin stuck retracted on Cylinder 4 and Cylinder 6**	• Actuate and check the VVL Solenoid 2/2 operation. Check for debris on screen • Cylinder 4 or 6 lash adjuster plugged • Cylinder 4 or 6 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 1, Cylinder 3 and Cylinder 5	• VVL Solenoid 1/1 and 1/2 have missing or damaged control O-rings causing oil pressure leakage from the control oil passage to the exhaust oil passage • Bank 1 oil supply passage blockage or restriction to front and rear oil feeds in the bank 1 Cylinder Head • Large internal leakage in bank 1 Cylinder Head affecting the front and rear oil feeds	• Check the control O-rings on the front and rear bank 1 VVL Solenoids for damage • Check for proper oil pressure at the front and rear bank 1 VVL Solenoids. Proceed to step 2 below to check the oil pressure in the Cylinder Head. It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if the oil pressure is low to both solenoids and all other possible causes are exhausted, replace the Cylinder Head **NOTE:** **Low oil pressure in the Cylinder Head will likely also cause issues/faults for the VVT system**
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck	• VVL Solenoid 2/1 and 2/2 have missing or damaged	• Check the control O-rings on the front and rear bank

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
High, High RPM test - high misfire percentage Cylinder 2, Cylinder 4 and Cylinder 6	control O-rings causing oil pressure leakage from the control oil passage to the exhaust oil passage • Bank 2 oil supply passage blockage or restriction to front and rear oil feeds in the bank 2 Cylinder Head • Large internal leakage in bank 2 Cylinder Head affecting the front and rear oil feeds	2 VVL Solenoids for damage • Check for proper oil pressure at the front and rear bank VVL Solenoids. Proceed to step 2 below to check the oil pressure in the Cylinder Head. It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if the oil pressure is low to both solenoids and all other possible causes are exhausted, replace the Cylinder Head **NOTE:** **Low oil pressure in the Cylinder Head will likely also cause issues/faults for the VVT system**
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage for all Cylinders (1 - 6)	Engine oil pressure too low to both Cylinder Heads due to: • Oil level low • Wrong viscosity oil • Oil Filter restriction • Engine mechanical failure (damaged bearings, pick-up tube or seal, engine block, etc.) • Faulty Oil Pump	• Check for proper oil level, filter and viscosity before checking engine oil pressure • If the engine oil pressure is low check for any mechanical issue that could cause low oil pressure. If there are no issues with the bearings, pick-up tube and engine block replace the Engine Oil Pump Assembly **NOTE:** **Low engine oil pressure will likely also cause issues/faults for the VVT system**

2. **CHECK THE ACTUAL OIL PRESSURE TO THE VVL SOLENOID IN THE CYLINDER HEAD**
    1. Turn the ignition off.
    2. Remove the appropriate VVL Solenoid called out by the scan tool.

3. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the VVL Solenoid.
4. Start the engine and allow it to idle.
5. With the scan tool, monitor the Dual Oil Pump mode.

NOTE: **Let the engine run long enough for the pump to switch to low pump mode.**

6. Read and record the oil pressure reading on the oil pressure gauge. Compare the reading to the main engine oil pressure reading from the Engine Oil Pressure Sensor reading on the scan tool.

NOTE: **The Cylinder Head oil pressure should be within 5.0 psi of main engine oil pressure reading.**

Is the Cylinder Head oil pressure should be within 5.0 psi of main engine oil pressure?

Yes

- Remove and inspect the screen on the VVL Solenoid for debris that can block oil flow through the solenoid. Check the seals on the VVL Solenoid for damage and proper installation. If no debris is found, and the seals appear good replace the VVL Solenoid in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

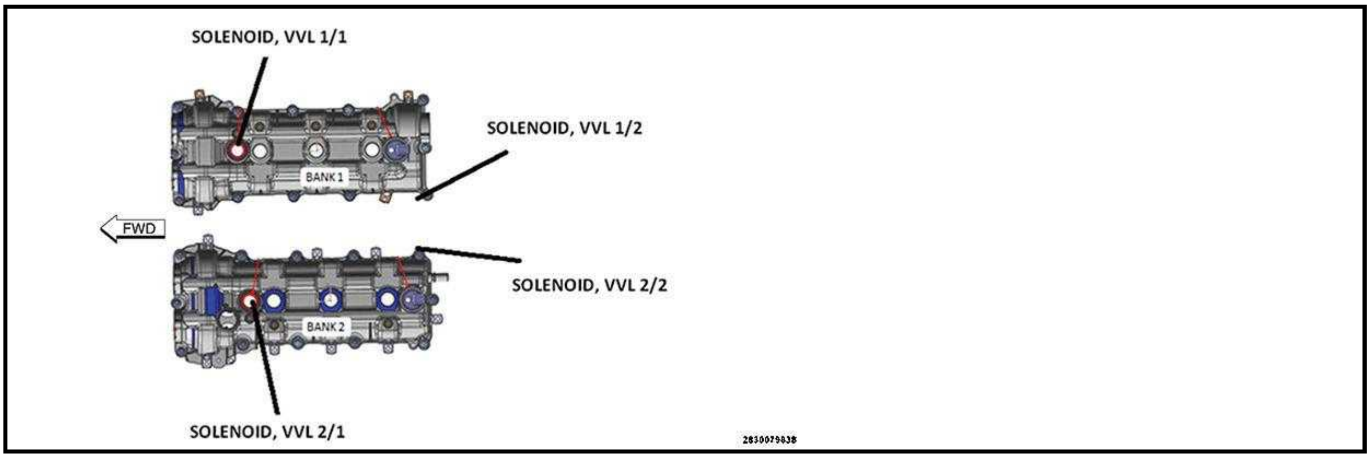
- Diagnose and repair the lack of oil pressure to the VVL Solenoid.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P105D-INTAKE VALVE STUCK IN HIGH LIFT POSITION

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

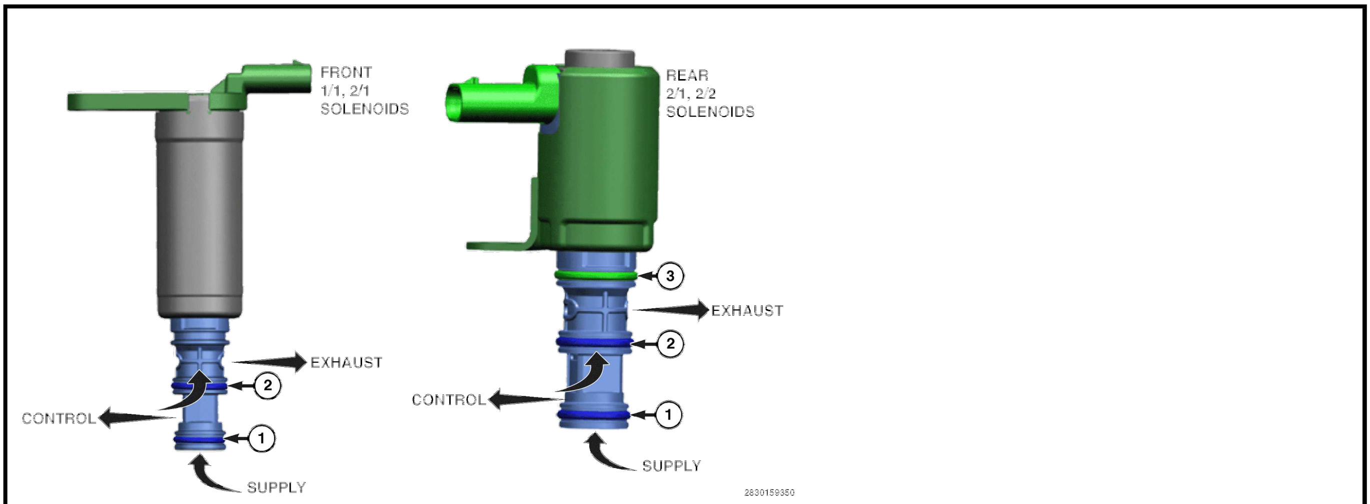
There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:



VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070

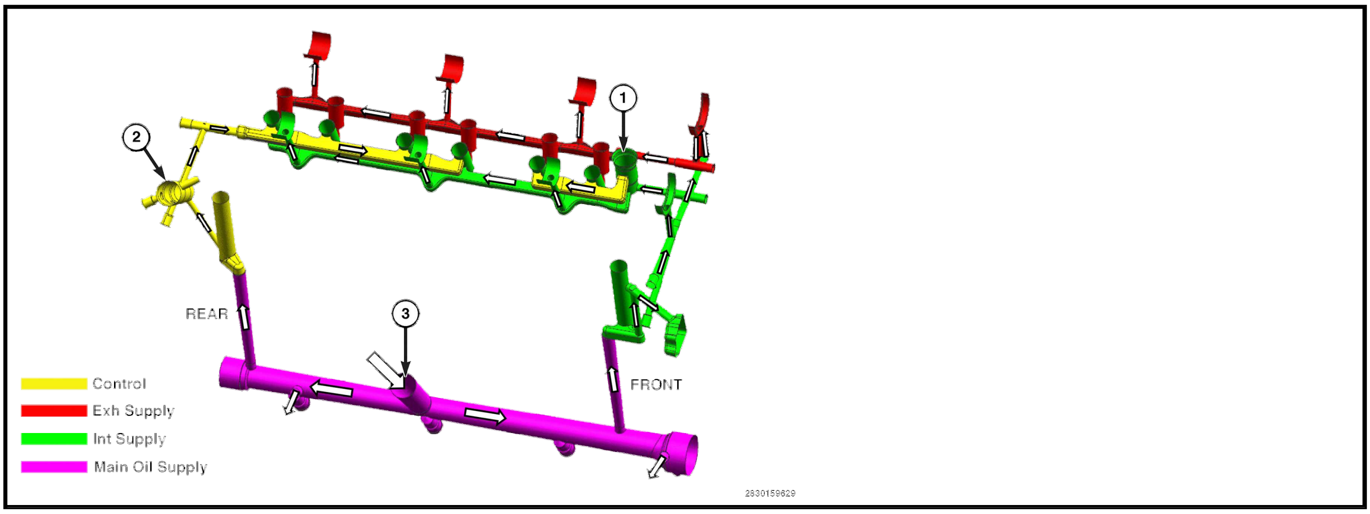
VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073
These faults set when the PCM detects that one or more rockers are stuck in high lift or low lift mode. They are not specific to any of the solenoids. To determine which cylinder is being affected and setting the fault, the intrusive VVL service routine in the scan tool should be run to help determine the affected cylinder(s).			P105C / P105D

GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation. The O-rings on the solenoids prevent oil leakage between passages. The Supply O-ring (1) prevents the pressurized supply oil from entering the control passage when the solenoid is de-energized (off). The Control O-ring (2) prevents the oil from entering the exhaust passage when the solenoid is energized (on). Only the rear solenoid has an Exhaust O-ring (3) preventing an external oil leak. The front solenoid has an external seal to prevent external oil leakage. **If an O-ring is damaged or missing it can cause a Rocker Arm to stick in low lift or high lift mode.**



- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure entering the bottom to pass through the solenoid to the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.
- **To re-enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the oil pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arms default to High Lift mode when no oil pressure is present.

1	Front VVL Solenoid location
2	Rear VVL Solenoid location
3	Oil supply from Oil Filter to the main oil gallery



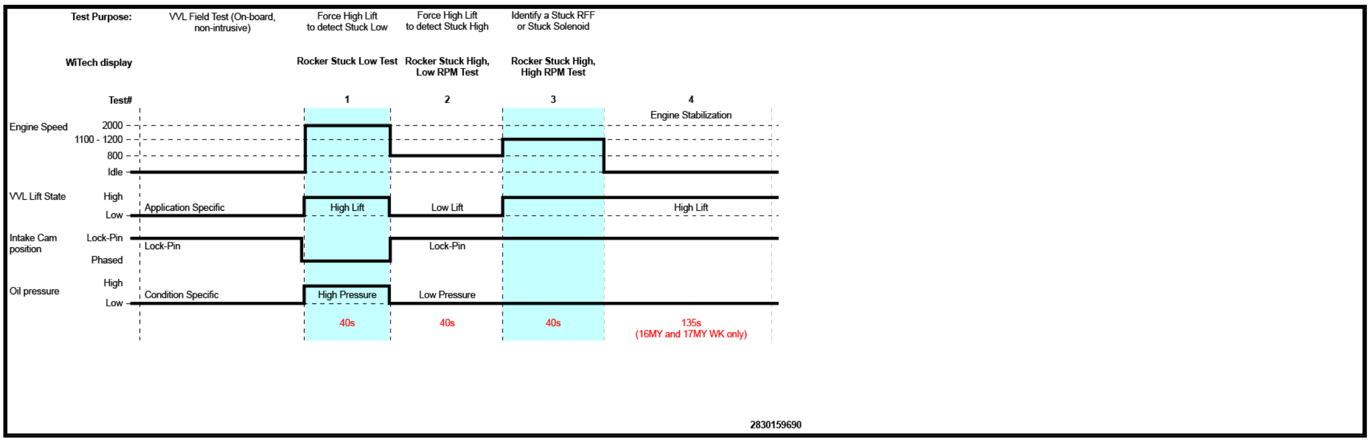
DIAGNOSTIC OVERVIEW - VARIABLE VALVE LIFT (VVL) SYSTEM

PCM DIAGNOSTICS: The PCM performs **diagnostics** for each VVL Solenoid **High Side Driver (HSD) Circuit** to detect an open or short circuit. If no circuit faults are detected the PCM runs a **rationality diagnostic** to detect Rocker Arms that are stuck in the High Lift or Low Lift positions. The PCM monitors for an erratic MAP Sensor signal as well as the Misfire, Knock, and Individual Cylinder Fuel Control (ICFC) monitors to detect a Rocker Arm that is stuck in an incorrect position. A Rocker Arm or arms can stick due to an oil pressure issue, a mechanical failure of a VVL Solenoid (including O-rings) or a faulty Rocker Arm. When a Rocker Arm fault is detected the PCM will begin to record in-field data. If the fault condition goes away during the next drive cycle the data collected will also be cleared.

- **Low Lift stick condition:** A single Rocker Arm that is stuck in low lift may not be detected and the system will continue to operate normally. However, some misfire and engine roughness may be felt. One Rocker Arm stuck in Low Lift mode will cause a misfire at higher engine speeds. Two or more Rocker Arms stuck in Low Lift mode can cause a misfire at any engine speed, including idle. If more than one rocker arm is stuck, the in-field diagnostic will fail, command all Rocker Arms to Low Lift mode and limit the engine speed to approximately 3000 RPM. The PCM will illuminate the MIL on the first trip.
- **High Lift stick condition:** If any Rocker Arm is detected as being stuck in High Lift Mode, the in-field diagnostic will fail and quickly default to commanding all of the Rocker Arms to High Lift mode. The engine will have some roughness and misfire may be felt. A single Rocker Arm stuck in high lift mode typically misfires at idle. The PCM will illuminate the MIL on the second trip.

Tech Tip: Since the two rear cylinders are controlled by the rear solenoid on each bank, a VVL issue that affects both rear cylinders on a bank is most likely a common issue for both cylinders. These would include a damaged or missing O-ring, faulty solenoid, oil supply or control circuit issue. A VVL issue that only affects one of the rear cylinders is more likely going to be a failure of a Rocker Arm or pin for that cylinder.

SCAN TOOL DIAGNOSTICS: The scan tool intrusive VVL Service Routine can be used to verify the VVL system operation as well as a likely possible cause if there is a fault. The routine can only run if the **misfire monitor** is enabled. **If there is an active open circuit fault for a solenoid the routine will run but display all zero's for the results.** When the routine is initiated the scan tool will check the misfire monitor status. If the monitor is enabled the test will continue. If the monitor is disabled, the routine will abort with a message indicating the test has stopped due to misfire disable condition. There are several other conditions that can disable misfire. Some of the common reasons are fuel level (too high or too low), Cam/Crank TLC not learned or ambient temperature too cold. When the test initiates it will run three tests in an attempt to detect a stuck Rocker Arm condition. The on screen display will describe each test being performed and give relevant data. The test will typically take approximately two minutes. The exception is 2016 and 2017 WK/WD vehicles. The test takes approximately four minutes on these vehicles due to an engine stabilization period after the third forced test. See the graph below for details on the routine.



When the routine completes the results will display in a table showing the misfire percentage result for each cylinder during the three tests that were performed. At the top will be a general description of the possible issue or issues. For a more detailed description of the probable causes compare the misfire percentage data recorded to the table in the diagnostic test below. **NOTE: Only count the misfire percentages that are above 75-80% when looking up the results in the table. Any percentage below 75% should not be factored into the result table.**

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running above 750 rpm.
- Battery voltage greater than 11.0 volts.
- Engine Oil Pressure Sensor reading above 20.0 psi.
- Low Lift Mode is requested.
    - VVL Solenoids are commanded on.

SET CONDITION

- The PCM detects that one or more Rocker Arm is stuck in High Lift Mode of operation.

DEFAULT ACTION

- The MIL will illuminate.
- If any Rocker Arm is detected as being stuck in High Lift Mode, the PCM will default to commanding all of the Rocker Arms to high lift mode.

POSSIBLE CAUSES

Possible Causes
INADEQUATE OIL PRESSURE TO ONE OR MORE ROCKER ARM
VVL SOLENOID CONTROL O-RING DAMAGED OR MISSING
VVL SOLENOID STUCK OFF/CLOSED NOT ALLOWING OIL PRESSURE TO ONE OR MORE ROCKER ARM
CONTROL OIL PASSAGE PRESSURE RESTRICTED TO ONE OR MORE ROCKER ARM
ROCKER ARM LOCK PIN STUCK EXTENDED OR BROKEN
ROCKER ARM LASH ADJUSTER PLUGGED
LOW ENGINE OIL PRESSURE/OIL PUMP FAULTY

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **PERFORM THE VVL SCAN TOOL DIAGNOSTICS**
    1. Turn the ignition on.
    2. With the scan tool, navigate to Systems Tests, perform the VVL System Diagnostic test and follow the on screen directions.

       NOTE: **Do not erase the DTC before running the routine.**

    3. When the test is complete, compare the results to the table below for the probable failure conditions.

       Scan tool results:

       Compare the results from the routine to the table below.

       - When the routine completes the results will display in a table showing each cylinder and the misfire percentage result for each cylinder during the three tests that were performed. At the top will be a general description of the possible issue or issues. For a more detailed description compare the misfire percentage data recorded to the table below for a detailed list of the probable causes. **NOTE: Only count the misfire percentages that are above 75-80% when looking up the results in the table. Any percentage below 75% should not be factored into the result table.** .

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
Low misfire percentage on (1) Rocker Stuck Low test, (2) Rocker Stuck High, Low RPM test, and (3) Rocker Stuck High, High RPM test	No VVL issue detected	The misfire condition being detected is not caused by the VVL System. Another system is likely causing the misfire
High misfire percentage on (1) Rocker Stuck Low test, (2) Rocker Stuck High, Low RPM test, and (3) Rocker Stuck High, High RPM test	No VVL issue detected	The misfire condition being detected is not caused by the VVL System. Another system is likely causing the misfire
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 1	• VVL Solenoid 1/1 stuck on/open • VVL Solenoid 1/1 control circuit shorted to 12 volts • VVL Solenoid 1/1 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Cylinder 1 rocker arm lash adjuster issue (stuck or broken) • Cylinder 1 rocker arm lock pin stuck retracted • Oil pressure leakage from the supply oil passage to the front control oil passage in the Cylinder Head.	• Verify that the VVL Solenoid 1/1 control circuit is not shorted to 12 volts • Check operation of VVL Solenoid 1/1 for a stuck on/open condition, damaged or missing supply O-ring • Check for broken or stuck Cylinder 1 rocker arms or lock pins • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head.

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 2	• VVL Solenoid 2/1 stuck on/open • VVL Solenoid 2/1 control circuit shorted to 12 volts • VVL Solenoid 2/1 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Cylinder 2 rocker arm lash adjuster issue (stuck or broken) • Cylinder 2 rocker arm lock pin stuck retracted • Oil pressure leakage from the supply oil passage to the front control oil passage in the Cylinder Head.	• Verify that the VVL Solenoid 2/1 control circuit is not shorted to 12 volts • Check operation of VVL Solenoid 2/1 for a stuck on/open condition, damaged or missing supply O-ring • Check for broken or stuck Cylinder 2 rocker arms or lock pins • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the Cylinder Head
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 3	• Cylinder 3 rocker arm lash adjuster issue (stuck or broken) • Cylinder 3 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 3 rocker arms or lock pins
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 4	• Cylinder 4 rocker arm lash adjuster issue (stuck or broken) • Cylinder 4 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 4 rocker arms or lock pins
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 5	• Cylinder 5 rocker arm lash adjuster issue (stuck or broken) • Cylinder 5 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 5 rocker arms or lock pins
(1) Rocker Stuck Low test - has high misfire percentage on Cylinder 6	• Cylinder 6 rocker arm lash adjuster issue (stuck or broken) • Cylinder 6 rocker arm lock pin stuck retracted	• Check for broken or stuck Cylinder 6 rocker arms or lock pins
(1) Rocker Stuck Low test - high misfire percentage on Cylinder 3 and Cylinder 5	• VVL Solenoid 1/2 stuck on/open • VVL Solenoid 1/2 control circuit shorted to 12 volts • VVL Solenoid 1/2 has missing or damaged	• Check the VVL Solenoid 1/2 control circuit for a short to 12 volts condition • Check operation of VVL Solenoid 1/2 for a stuck on/open condition,

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Oil pressure leakage from the supply oil passage to the rear control oil passage in the Cylinder Head. **NOTE:** **It's less likely but possible for a rocker arm lash adjuster failure (stuck or broken) or lock pin stuck retracted on both Cylinder 3 and Cylinder 5**	damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head.
(1) Rocker Stuck Low test - high misfire percentage on Cylinder 4 and Cylinder 6	• VVL Solenoid 2/2 stuck on/open • VVL Solenoid 2/2 control circuit shorted to 12 volts • VVL Solenoid 2/2 has missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage • Oil pressure leakage from the supply oil passage to the rear control oil passage in the Cylinder Head. **NOTE:** **It's less likely but possible for a rocker arm lash adjuster failure (stuck or broken) or lock pin stuck retracted on both Cylinder 4**	• Check the VVL Solenoid 2/2 control circuit for a short to 12 volts condition • Check operation of VVL Solenoid 2/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the Cylinder Head

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	and Cylinder 6	
(1) Rocker Stuck Low test - high misfire percentage Cylinder 1, Cylinder 3, and Cylinder 5	• Both bank 1 solenoids have missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage for both bank 1 solenoids • Oil pressure leakage from the supply oil passage to the front and rear control oil passages in the Cylinder Head.	• Check operation of VVL Solenoid 1/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the Cylinder Head
(1) Rocker Stuck Low test - high misfire percentage Cylinder 2, Cylinder 4, and Cylinder 6	• Both bank 2 solenoids have missing or damaged supply O-ring causing oil pressure leakage from the supply oil passage to the control oil passage for both bank 2 solenoids • Oil pressure leakage from the supply oil passage to the front and rear control oil passages in the Cylinder Head.	• Check operation of VVL Solenoid 2/2 for a stuck on/open condition, damaged or missing supply O-ring • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace the Cylinder Head. Proceed to step below to check the oil pressure in the Cylinder Head
(1) Rocker Stuck Low test - high misfire percentage for all Cylinders (1 - 6)	• Missing or damaged supply O-rings causing oil pressure leakage from the supply oil passage to the control oil passage for front and rear solenoids on bank 1 and bank 2 • Oil pressure leakage from the supply oil passage to the front and rear control oil passages in both Cylinder Heads.	• Check operation of all VVL Solenoids for a stuck on/open condition, damaged or missing supply O-rings • It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if all other possible causes are exhausted, replace both Cylinder Heads.
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 1	• VVL Solenoid 1/1 control circuit open or shorted to ground • VVL Solenoid 1/1 stuck closed/off	• Check the VVL Solenoid 1/1 control circuit for an open or shorted to ground condition

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	• VVL Solenoid 1/1 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted • Cylinder 1 lash adjuster plugged • Cylinder 1 rocker arm lash adjuster issue (stuck or broken) • Cylinder 1 rocker arm lock pin stuck extended	• Check the VVL Solenoid 1/1 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 1/1 operation. Check for debris on screen • Cylinder 1 lash adjuster plugged • Cylinder 1 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 2	• VVL Solenoid 2/1 stuck closed/off • VVL Solenoid 2/1 control circuit open or shorted to ground • VVL Solenoid 2/1 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted • Cylinder 2 lash adjuster plugged • Cylinder 2 rocker arm lash adjuster issue (stuck or broken) • Cylinder 2 rocker arm lock pin stuck extended	• Check the VVL Solenoid 2/1 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 2/1 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 2/1 operation. Check for debris on screen • Cylinder 2 lash adjuster plugged • Cylinder 2 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 3	• Cylinder 3 lash adjuster plugged • Cylinder 3 rocker arm lash adjuster issue (stuck or broken) • Cylinder 3 rocker arm lock pin stuck extended	• Cylinder 3 lash adjuster plugged • Cylinder 3 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 4	• Cylinder 4 lash adjuster plugged • Cylinder 4 rocker arm lash adjuster issue (stuck or broken) • Cylinder 4 rocker arm lock pin stuck extended	• Cylinder 4 lash adjuster plugged • Cylinder 4 rocker arm stuck failure or lock pin stuck extended

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 5	• Cylinder 5 lash adjuster plugged • Cylinder 5 rocker arm lash adjuster issue (stuck or broken) • Cylinder 5 rocker arm lock pin stuck extended	• Cylinder 5 lash adjuster plugged • Cylinder 5 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 6	• Cylinder 6 lash adjuster plugged • Cylinder 6 rocker arm lash adjuster issue (stuck or broken) • Cylinder 6 rocker arm lock pin stuck extended	• Cylinder 6 lash adjuster plugged • Cylinder 6 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 3 and Cylinder 5	• VVL Solenoid 1/2 stuck closed/off • VVL Solenoid 1/2 control circuit open or shorted to ground • VVL Solenoid 1/2 has missing or damaged control O-ring causing oil pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted **NOTE:** **It's less likely but possible for a rocker arm lash adjuster issue (stuck or broken) or lock pin stuck retracted on Cylinder 3 and Cylinder 5**	• Check the VVL Solenoid 1/2 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 1/2 for a missing or damaged control O-ring • Actuate and check the VVL Solenoid 1/2 operation. Check for debris on screen • Cylinder 3 or 5 lash adjuster plugged • Cylinder 3 or 5 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 4 and Cylinder 6	• VVL Solenoid 2/2 stuck closed/off • VVL Solenoid 2/2 control circuit open or shorted to ground • VVL Solenoid 2/2 has missing or damaged control O-ring causing oil	• Check the VVL Solenoid 2/2 control circuit for an open or shorted to ground condition • Check the VVL Solenoid 2/2 for a missing or damaged control O-ring

SCAN TOOL INTRUSIVE VVL TEST RESULT	PROBABLE CAUSES	REPAIR ACTIONS
	pressure leakage from the control oil passage to the exhaust oil passage • Control oil passage pressure restricted **NOTE:** **It's less likely but possible for a rocker arm lash adjuster issue (stuck or broken) or lock pin stuck retracted on Cylinder 4 and Cylinder 6**	• Actuate and check the VVL Solenoid 2/2 operation. Check for debris on screen • Cylinder 4 or 6 lash adjuster plugged • Cylinder 4 or 6 rocker arm stuck failure or lock pin stuck extended
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage Cylinder 1, Cylinder 3 and Cylinder 5	• VVL Solenoid 1/1 and 1/2 have missing or damaged control O-rings causing oil pressure leakage from the control oil passage to the exhaust oil passage • Bank 1 oil supply passage blockage or restriction to front and rear oil feeds in the bank 1 Cylinder Head • Large internal leakage in bank 1 Cylinder Head affecting the front and rear oil feeds	• Check the control O-rings on the front and rear bank 1 VVL Solenoids for damage • Check for proper oil pressure at the front and rear bank 1 VVL Solenoids. Proceed to step below to check the oil pressure in the Cylinder Head. It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if the oil pressure is low to both solenoids and all other possible causes are exhausted, replace the Cylinder Head **NOTE:** **Low oil pressure in the Cylinder Head will likely also cause issues/faults for the VVT system**
(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck	• VVL Solenoid 2/1 and 2/2 have missing or damaged	• Check the control O-rings on the front and rear bank

<table>
<tr><th>SCAN TOOL INTRUSIVE VVL TEST RESULT</th><th>PROBABLE CAUSES</th><th>REPAIR ACTIONS</th></tr>
<tr><td>High, High RPM test - high misfire percentage Cylinder 2, Cylinder 4 and Cylinder 6</td><td>control O-rings causing oil pressure leakage from the control oil passage to the exhaust oil passage
Bank 2 oil supply passage blockage or restriction to front and rear oil feeds in the bank 2 Cylinder Head
Large internal leakage in bank 2 Cylinder Head affecting the front and rear oil feeds</td><td>2 VVL Solenoids for damage
Check for proper oil pressure at the front and rear bank VVL Solenoids. Proceed to step below to check the oil pressure in the Cylinder Head. It is a very low percentage of the time that an internal crack in a Cylinder Head would cause this issue. However if the oil pressure is low to both solenoids and all other possible causes are exhausted, replace the Cylinder Head
NOTE:
Low oil pressure in the Cylinder Head will likely also cause issues/faults for the VVT system</td></tr>
<tr><td>(2) Rocker Stuck High, Low RPM test, or (3) Rocker Stuck High, High RPM test - high misfire percentage for all Cylinders (1 - 6)</td><td>Engine oil pressure too low to both Cylinder Heads due to:
Oil level low
Wrong viscosity oil
Oil Filter restriction
Engine mechanical failure (damaged bearings, pick-up tube or seal, engine block, etc.)
Faulty Oil Pump</td><td>Check for proper oil level, filter and viscosity before checking engine oil pressure
If the engine oil pressure is low check for any mechanical issue that could cause low oil pressure. If there are no issues with the bearings, pick-up tube and engine block replace the Engine Oil Pump Assembly
NOTE:
Low engine oil pressure will likely also cause issues/faults for the VVT system</td></tr>
</table>

2. **CHECK THE ACTUAL OIL PRESSURE TO THE VVL SOLENOID IN THE CYLINDER HEAD**
    1. Turn the ignition off.
    2. Remove the appropriate VVL Solenoid called out by the scan tool.

3. Install the (special tool #2027300090, Kit, VVL Adapters) in place of the VVL Solenoid.
4. Start the engine and allow it to idle.
5. With the scan tool, monitor the Dual Oil Pump mode.

NOTE: Let the engine run long enough for the pump to switch to low pump mode.

6. Read and record the oil pressure reading on the oil pressure gauge. Compare the reading to the main engine oil pressure reading from the Engine Oil Pressure Sensor reading on the scan tool.

NOTE: The Cylinder Head oil pressure should be within 5.0 psi of main engine oil pressure reading.

Is the Cylinder Head oil pressure should be within 5.0 psi of main engine oil pressure?

Yes

- Remove and inspect the screen on the VVL Solenoid for debris that can block oil flow through the solenoid. Check the seals on the VVL Solenoid for damage and proper installation. If no debris is found, and the seals appear good replace the VVL Solenoid in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

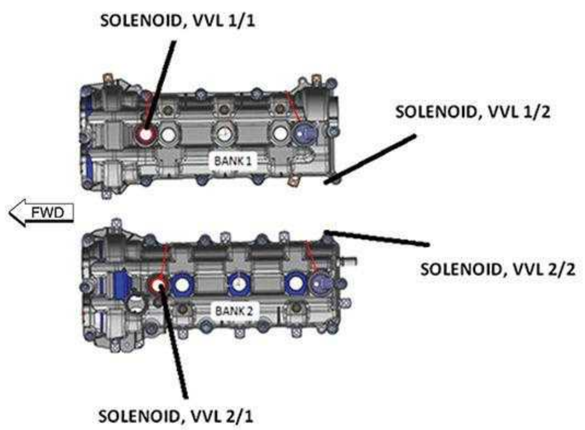
No

- Diagnose and repair the lack of oil pressure to the VVL Solenoid.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

P1070-INTAKE VALVE CONTROL SOLENOID 1 RANGE/PERFORMANCE

THEORY OF OPERATION

There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:



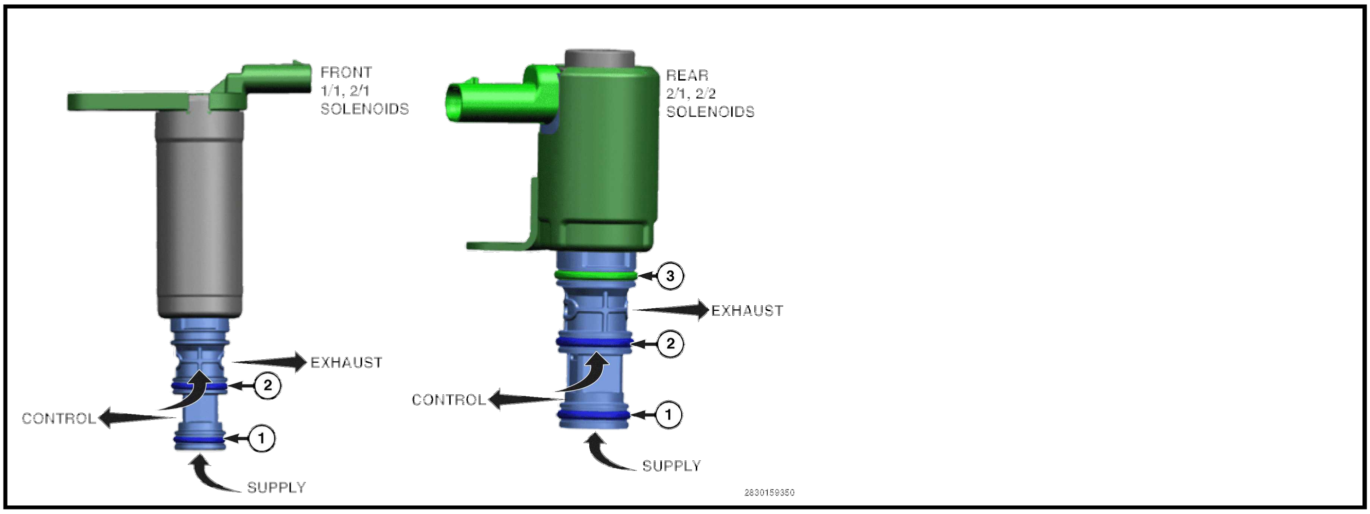
VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071

VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073

GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation.

- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure to pass through the solenoid to the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.
- **To enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arm defaults to High Lift mode when no oil pressure is present.

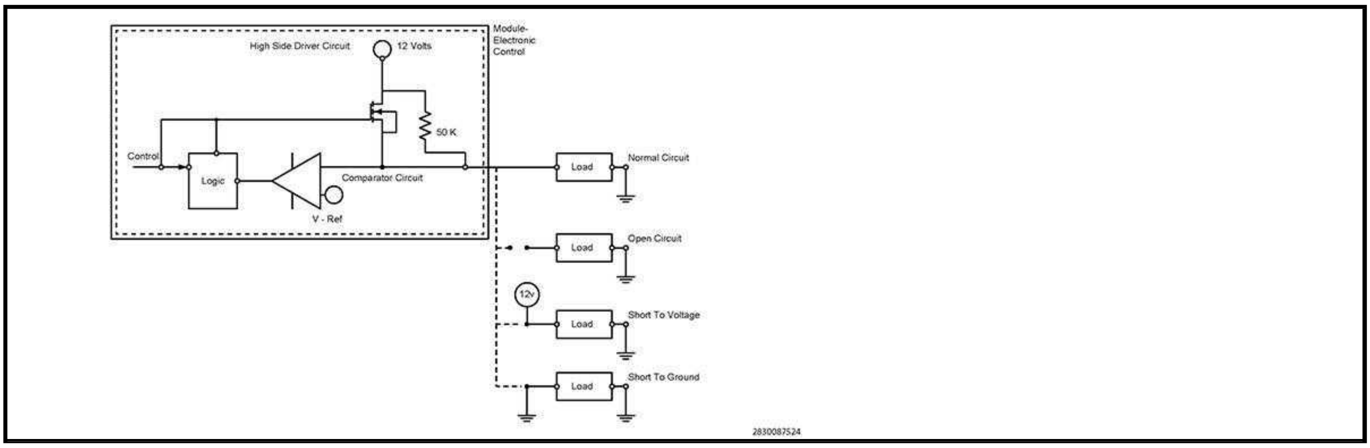
DIAGNOSTICS: The PCM controls each VVL Solenoid with a **High Side Driver (HSD) Circuit** . The PCM performs **circuit diagnostics** on each VVL Solenoid HSD for an open or short in the circuitry.



Typical High Side Driver and Fault Detection: This type of driver circuit is generally used for relay control, controlling a solenoid or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The PCM also provides fault detection for the device, wiring and internal driver. In the example below, the PCM uses an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A small amount of amperage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground

will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded on.

SET CONDITION

- The PCM has detected an under voltage, over voltage or over temperature condition on the internal driver circuit for the VVL Solenoid 1/1 Control circuit.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
CHECK THE PCM POWERS AND GROUNDS
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE PCM POWERS AND GROUNDS**
    1. Perform the CHECKING THE PCM POWERS AND GROUNDS test procedure. Refer to **CHECKING THE PCM POWER AND GROUND CIRCUITS - 3.6L** .

       Were any problems found?

       Yes

       - Perform the appropriate repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 3
3. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.

11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

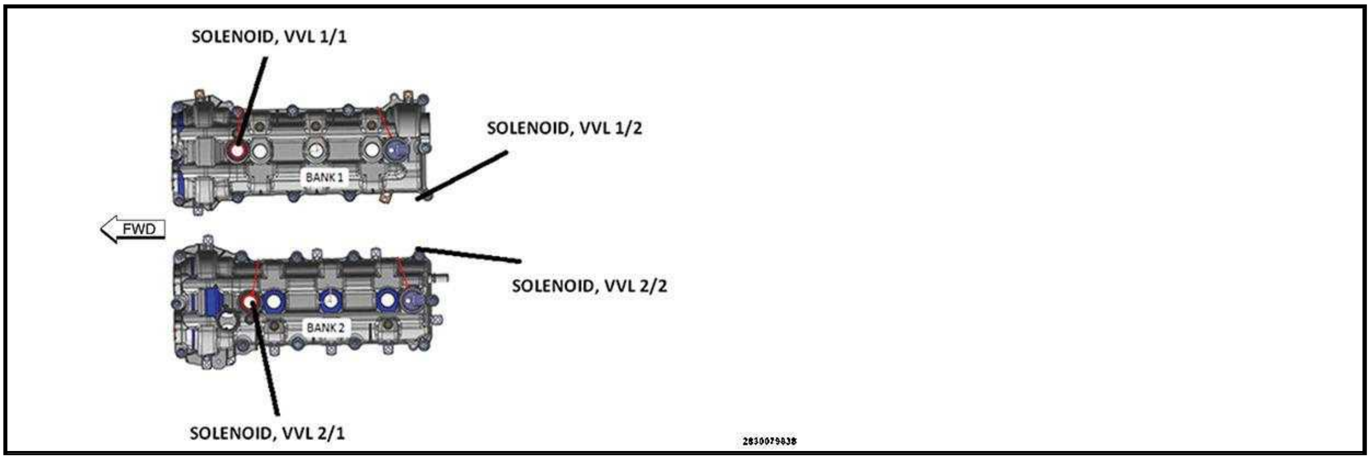
    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1071-INTAKE VALVE CONTROL SOLENOID 2 RANGE/PERFORMANCE

THEORY OF OPERATION

There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:



VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073

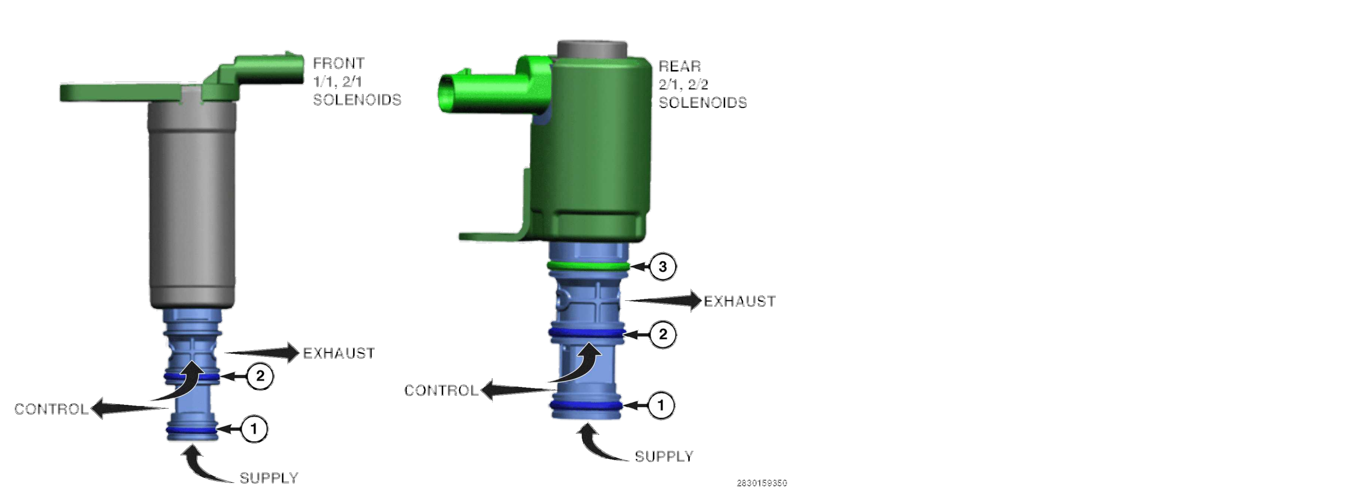
GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation.

- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure to pass through the solenoid to

the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.

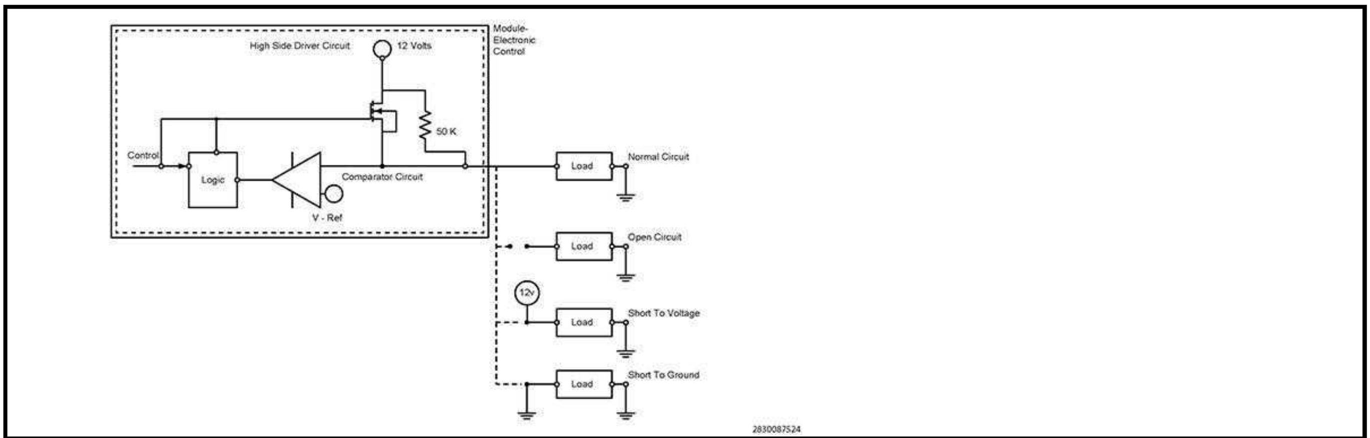
- **To enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arm defaults to High Lift mode when no oil pressure is present.

DIAGNOSTICS: The PCM controls each VVL Solenoid with a **High Side Driver (HSD) Circuit** . The PCM performs **circuit diagnostics** on each VVL Solenoid HSD for an open or short in the circuitry.



Typical High Side Driver and Fault Detection: This type of driver circuit is generally used for relay control, controlling a solenoid or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The PCM also provides fault detection for the device, wiring and internal driver. In the example below, the PCM uses an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A small amount of amperage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded on.

SET CONDITION

- The PCM has detected an under voltage, over voltage or over temperature condition on the internal driver circuit for the VVL Solenoid 1/2 Control circuit.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
CHECK THE PCM POWERS AND GROUNDS
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE PCM POWERS AND GROUNDS**
    1. Perform the CHECKING THE PCM POWERS AND GROUNDS test procedure. Refer to **CHECKING THE PCM POWER AND GROUND CIRCUITS - 3.6L** .

        Were any problems found?

Yes

- Perform the appropriate repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

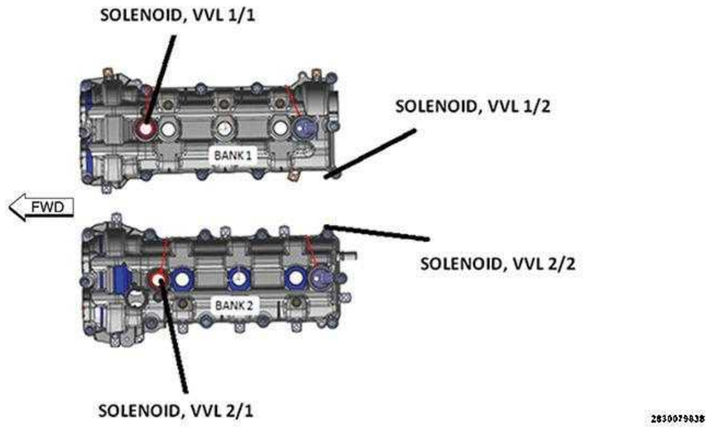
        - The wiring or poor connection problem has been repaired.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

P1072-INTAKE VALVE CONTROL SOLENOID 3 RANGE/PERFORMANCE

THEORY OF OPERATION

There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:

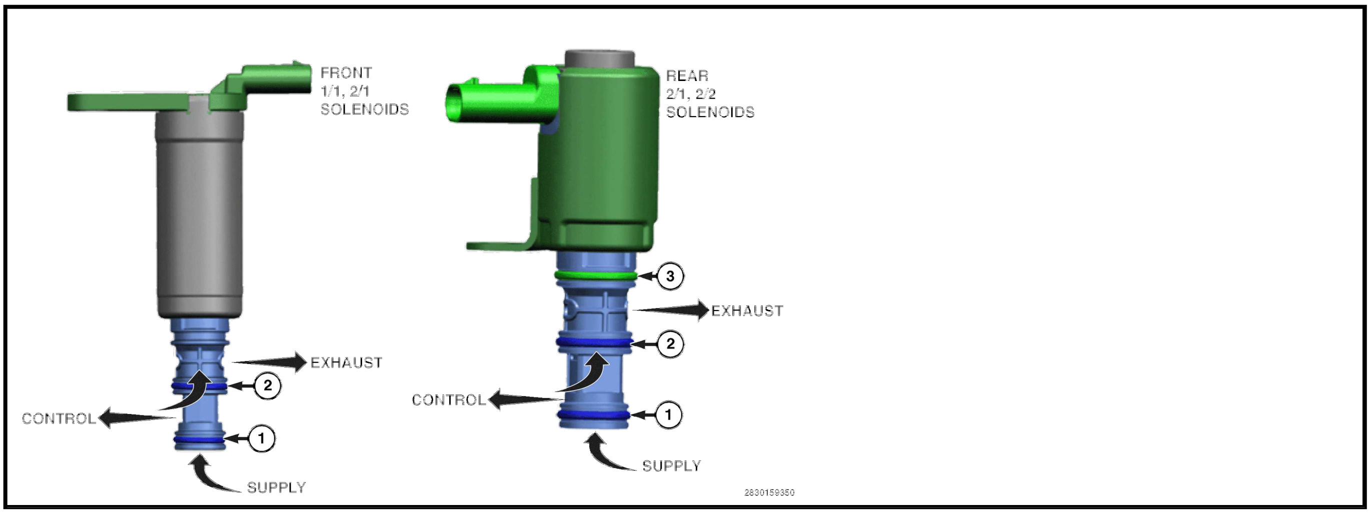


VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073

GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation.

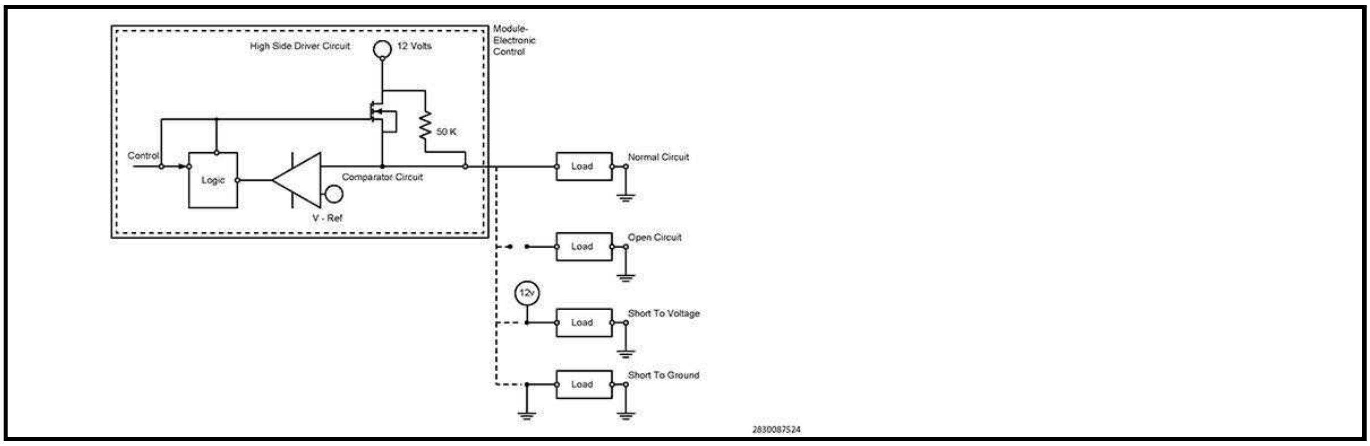
- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure to pass through the solenoid to the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.
- **To enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arm defaults to High Lift mode when no oil pressure is present.

DIAGNOSTICS: The PCM controls each VVL Solenoid with a **High Side Driver (HSD) Circuit** . The PCM performs **circuit diagnostics** on each VVL Solenoid HSD for an open or short in the circuitry.



Typical High Side Driver and Fault Detection: This type of driver circuit is generally used for relay control, controlling a solenoid or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The PCM also provides fault detection for the device, wiring and internal driver. In the example below, the PCM uses an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A small amount of amperage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded on.

SET CONDITION

- The PCM has detected an under voltage, over voltage or over temperature condition on the internal driver circuit for the VVL Solenoid 2/1 Control circuit.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
CHECK THE PCM POWERS AND GROUNDS
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE PCM POWERS AND GROUNDS**
    1. Perform the CHECKING THE PCM POWERS AND GROUNDS test procedure. Refer to **CHECKING THE PCM POWER AND GROUND CIRCUITS - 3.6L** .

        Were any problems found?

        Yes

        - Perform the appropriate repair.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 2
3. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**

1. Perform any Service Bulletins that apply.
2. Disconnect all PCM harness connectors.
3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
   - Proper connector installation.
   - Damaged connector locks.
   - Corrosion.
   - Other signs of water intrusion.
   - Weather seal damage (if equipped).
   - Bent terminals.
   - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
   - Terminals that have been pushed back into the connector cavity.
   - Check for spread terminals and verify proper terminal tension.

   Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

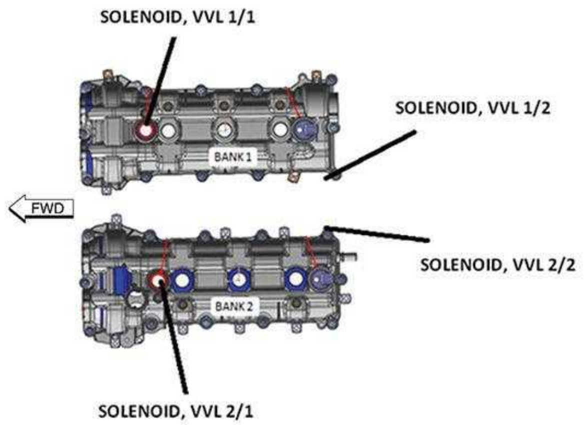
    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1073-INTAKE VALVE CONTROL SOLENOID 4 RANGE/PERFORMANCE

THEORY OF OPERATION

There are four Variable Valve Lift (VVL) Solenoids that control the operation of the Intake Rocker Arms for all six cylinders. See the figure and table below for the VVL Solenoid locations and cylinder control:

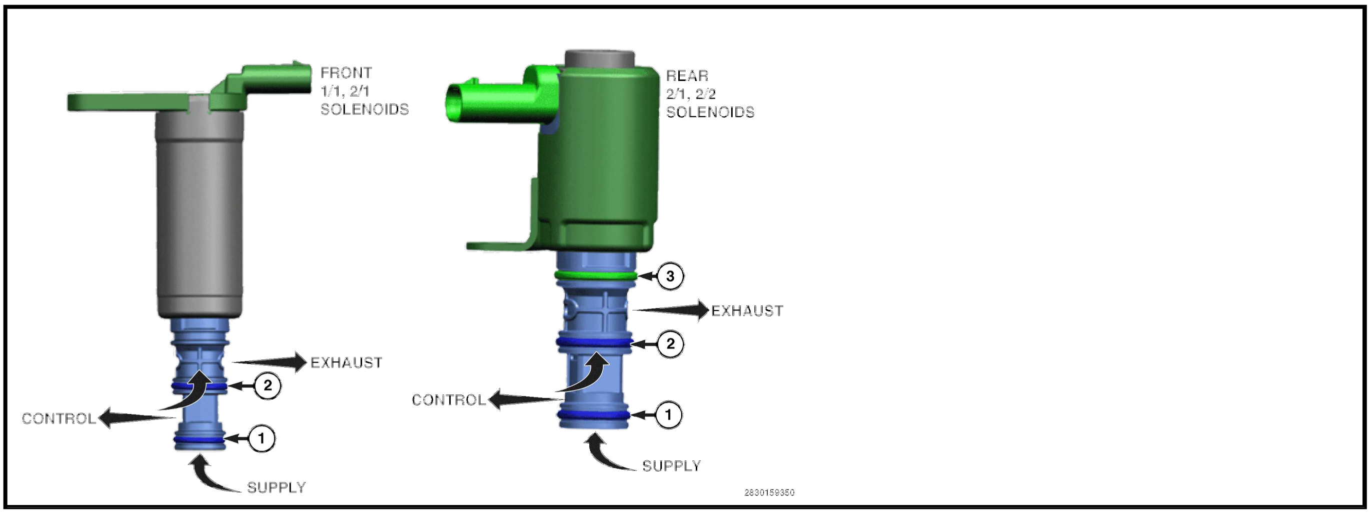


VVL SOLENOID	PHYSICAL LOCATION	CYLINDERS CONTROLLED	RELATED FAULT CODES
VVL SOLENOID 1/1	BANK 1 FRONT SOLENOID	CYLINDER 1 INTAKE VALVES	P1050 / P1051 / P1052 / P1070
VVL SOLENOID 1/2	BANK 1 REAR SOLENOID	CYLINDERS 3 AND 5 INTAKE VALVES	P1053 / P1054 / P1055 / P1071
VVL SOLENOID 2/1	BANK 2 FRONT SOLENOID	CYLINDER 2 INTAKE VALVES	P1056 / P1057 / P1058 / P1072
VVL SOLENOID 2/2	BANK 2 REAR SOLENOID	CYLINDERS 4 AND 6 INTAKE VALVES	P1059 / P105A / P105B / P1073

GENERAL OPERATION: The VVL System is designed to vary the lift and duration of the Intake Valves, to maximize efficiency and engine torque, depending on engine operation. The VVL System consists of 2 step Intake Rocker Arms that are capable of operating in High Lift or Low Lift mode. The PCM energizes and de-energizes the four VVL Solenoids to control the engine oil pressure to the Rocker Arms, controlling low lift and high lift operation.

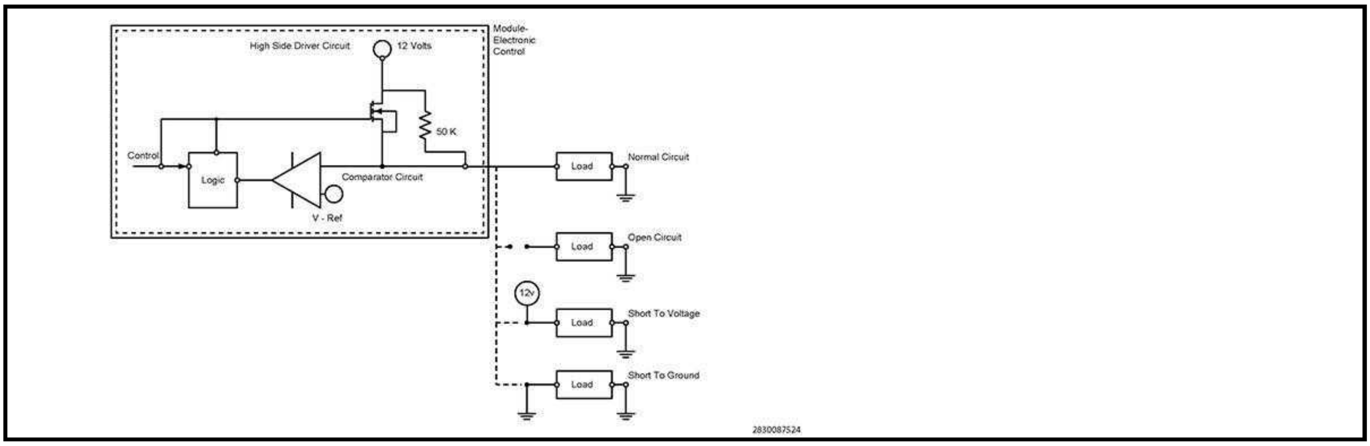
- **To enter Low Lift Mode** the PCM provides 12.0 volts to the VVL Solenoid to energize the solenoid. When energized the VVL Solenoid opens allowing the supply oil pressure to pass through the solenoid to the control oil passage and Rocker Arm. The pressurized oil pushes against the springs in the lock pins forcing the pins to retract. This allows the center of the Rocker Arm to move down freely and operate in Low Lift Mode. It takes approximately 20.0 psi of engine oil pressure at the Rocker Arm to overcome the springs in the lock pins.
- **To enter High Lift Mode** the PCM de-energizes the VVL Solenoid. The solenoid closes and the pressurized oil in the control passage passes through the VVL Solenoid to the exhaust passage. When the pressure is relieved the spring loaded lock pin extends keeping the center of the Rocker Arm in the High Lift position. The Rocker Arm defaults to High Lift mode when no oil pressure is present.

DIAGNOSTICS: The PCM controls each VVL Solenoid with a **High Side Driver (HSD) Circuit** . The PCM performs **circuit diagnostics** on each VVL Solenoid HSD for an open or short in the circuitry.



Typical High Side Driver and Fault Detection: This type of driver circuit is generally used for relay control, controlling a solenoid or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The PCM also provides fault detection for the device, wiring and internal driver. In the example below, the PCM uses an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A small amount of amperage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.
- VVL Solenoid is commanded on.

SET CONDITION

- The PCM has detected an under voltage, over voltage or over temperature condition on the internal driver circuit for the VVL Solenoid 2/2 Control circuit.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
CHECK THE PCM POWERS AND GROUNDS
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **PERFORM THE CHECKING THE PCM POWERS AND GROUNDS TEST PROCEDURE**
    1. Perform the CHECKING THE PCM POWERS AND GROUNDS test procedure. Refer to **CHECKING THE PCM POWER AND GROUND CIRCUITS - 3.6L** .

        Were any problems found?

        Yes

        - Perform the appropriate repair.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 3
3. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**

1. Perform any Service Bulletins that apply.
2. Disconnect all PCM harness connectors.
3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1115-GENERAL TEMPERATURE RATIONALITY

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

This diagnostic runs one time during an ignition cycle when the following conditions are met:

- Battery voltage is greater than 7.5 volts.
- Engine off time is greater than 480 minutes.
- Intake manifold mass flow is greater than 20 grams/sec.
- Ambient temperature is greater than -64Â°C (-83Â°F).
- Vehicle driven over 30 mph for 30 seconds.

SET CONDITION

- Once the vehicle is soaked for a calibrated engine off time and then driven over calibrated speed and load conditions for a calibrated time, the Powertrain Control Module (PCM) compares the Ambient Air Temperature (AAT) Sensor, Engine Coolant Temperature (ECT), and Intake Air Temperature (IAT) sensor values. If the values of all the three sensors are more than 15Â°C (27Â°F) apart, the general temperature sensor rationality test fails.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
HIGH RESISTANCE IN THE SENSOR SIGNAL CIRCUIT
HIGH RESISTANCE IN THE SENSOR GROUND CIRCUIT
SENSOR SIGNAL CIRCUIT SHORTED TO GROUND
SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE
SENSOR SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
TEMPERATURE SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **COMPARE THE TEMPERATURE SENSOR READINGS**

   NOTE: **In cold weather, this DTC could be set by a high powered block heater and no repair would be required.**

   1. Allow the engine to cold soak with the ignition off long enough for the engine temperature to cool to near ambient temperature.
   2. Turn the ignition on.
   3. With the scan tool, read the ECT, IAT, and AAT Sensor temperature values.

      Are the temperature readings within 15Â°C (27Â°F) of each other?

      Yes

      - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

      No

      - Go To 3

3. **CHECK FOR HIGH RESISTANCE IN ONE OF THE TEMPERATURE SENSOR SIGNAL CIRCUITS**
   1. Turn the ignition off.
   2. Disconnect the suspected sensor.
   3. Disconnect the appropriate PCM or Body Control Module (BCM) harness connector depending on the sensor.

      CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   4. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.
   5. Measure the resistance of the Sensor Signal circuit between the suspect sensor harness connector and the GPEC Adaptor or BCM harness connector.

      Is the resistance below 3.0 Ohms?

      Yes

      - Go To 4

      No

      - Repair the high resistance in the Temperature Sensor Signal circuit.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK FOR HIGH RESISTANCE IN ONE OF THE SENSOR GROUND CIRCUITS**
   1. Measure the resistance of the Sensor Ground circuit between the suspect sensor harness connector and the GPEC Adaptor or BCM harness connector.

Is the resistance below 3.0 Ohms?

Yes

- Go To 5

No

- Repair the high resistance in the Sensor Ground circuit.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK FOR A SENSOR SIGNAL CIRCUIT SHORTED TO GROUND**
    1. Check for continuity between ground and the suspect Sensor Signal circuit at the Sensor harness connector.

    Is there continuity between ground and the suspect Sensor Signal circuit?

    No

    - Go To 6

    Yes

    - Repair the Sensor Signal circuit for a short to ground.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK FOR A SENSOR SIGNAL CIRCUIT SHORTED TO A SENSOR GROUND CIRCUIT**
    1. Check for continuity between the Sensor Signal and the Sensor Ground circuit at the Sensor harness connector.

    Is there continuity between Sensor Signal and the Sensor Ground circuit?

    No

    - Go To 7

    Yes

    - Repair the short between the Sensor Signal circuit and the Sensor Ground circuit.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK FOR A SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE**
    1. Turn the ignition on.
    2. Measure the voltage between ground and the Sensor Signal circuit at the Sensor harness connector.

    Is there any voltage present?

    Yes

    - Repair the Sensor Signal circuit for a short to voltage.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 8

8. **DIAGNOSE FOR FAULTY TEMPERATURE SENSOR**
    1. Reconnect the PCM or BCM harness connectors.
    2. Turn the ignition on.
    3. With the scan tool, read the voltage of the suspected Sensor.
    4. Connect a jumper between the Sensor Signal circuit and the Sensor ground circuit of the ECT Sensor, IAT Sensor or AAT Sensor.

       Did the voltage reading start at 4.8 to 5.0 volts and decrease to 0.0 volts when the jumper was installed?

       Yes

       - Verify that there is good pin to terminal contact in the Sensor and Control Module connectors. If no problems are found, replace the appropriate Temperature Sensor.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 9
9. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all BCM or PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
       - Proper connector installation.
       - Damaged connector locks.
       - Corrosion.
       - Other signs of water intrusion.
       - Weather seal damage (if equipped).
       - Bent terminals.
       - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
       - Terminals that have been pushed back into the connector cavity.
       - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.

    5. Connect all BCM or PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

- Replace and program the Body Control Module (BCM) or Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1128-CLOSED LOOP FUELING NOT ACHIEVED - BANK 1 UPSTREAM

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Shortly after engine start up.
- Fuel level above 12%.
- Battery voltage above 11.0 volts.
- No active Bank 1 Fuel Injector, Ignition Coil, or Upstream O2 Sensor circuit faults.

SET CONDITION

- Once the enable time has been reached and all enable conditions are met, the diagnostic will check for closed loop fuel control. If closed loop control is not active by the time the enable timer has expired, the diagnostic will fail.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
RESTRICTED FUEL SUPPLY LINE
FUEL PUMP INLET STRAINER PLUGGED
FUEL PUMP MODULE
O2 SENSOR HEATER OPERATION
O2 SIGNAL CIRCUIT
O2 RETURN CIRCUIT
OXYGEN (O2) SENSOR
ECT SENSOR OPERATION
ENGINE MECHANICAL PROBLEM
FUEL FILTER/PRESSURE REGULATOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any O2 Sensor, Engine Coolant Temperature (ECT), Intake Air Temperature (IAT), or Ambient Air Temperature (AAT) Sensor DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to .

      No

      - Go To 2
2. **CHECK THE ECT SENSOR FOR PROPER OPERATION**

   NOTE: This test works best if performed on a cold engine (cold soak).

   1. Turn the ignition on.
   2. With the scan tool, read the ECT Sensor value. If the engine was allowed to sit overnight (cold soak), the temperature value should be a sensible value that is somewhere close to the ambient temperature.
   3. Compare the ECT Sensor value with the IAT Sensor and AAT Sensor values.

      NOTE: If engine coolant temperature is above 82Â°C (180Â°F), allow the engine to cool until 65Â°C (150Â°F) is reached.

   4. Start the engine and allow it to idle.
   5. During engine warm-up, monitor the ECT Sensor value. The temperature value change should be a smooth transition from start up to normal operating temperature 82Â°C (180Â°F). The value should reach at least 82Â°C (180Â°F).

      Is the ECT Sensor value within a reasonable range with the other sensors at ignition on and did the ECT value increase smoothly and did it reach at least 82Â°C (180Â°F)?

      Yes

      - Go To 3

      No

      - Verify that there is good pin to terminal contact in the Engine Coolant Temperature Sensor and Powertrain Control Module connectors. If OK, replace the Engine Coolant Temperature Sensor. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
3. **CHECK FOR AN ACTIVE DTC**
   1. With the scan tool, read DTCs and record on the repair order.
   2. Test drive or operate the vehicle in accordance with the when monitored and set conditions.

      Is the DTC active or pending?

      Yes

      - Go To 4

      No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

4. **CHECK THE FUEL DELIVERY SYSTEM FOR PROPER OPERATION**
    1. Perform the CHECKING THE FUEL DELIVERY SYSTEM test procedure. Refer to **CHECKING THE FUEL DELIVERY SYSTEM (HARD START)** .

    Were any problems found?

    Yes

    - Perform the appropriate repair.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

5. **CHECK THE ETHANOL CONTENT IN THE FUEL**
    1. Perform the CHECKING FOR PROPER ETHANOL LEVEL IN THE GASOLINE test procedure. Refer to **CHECKING FOR PROPER ETHANOL LEVEL IN THE GASOLINE** .

    Were any issues found with the gasoline?

    Yes

    - Perform the appropriate repair in accordance with the Service Information.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 6

6. **CHECK ENGINE MECHANICAL FOR PROPER OPERATION**
    1. Turn the ignition off.
    2. Check for any of the following conditions/mechanical problems:
        - AIR INDUCTION SYSTEM - must be free from leaks
        - ENGINE VACUUM - must be at least 13 inches in neutral
        - ENGINE VALVE TIMING - must be within specifications
        - ENGINE COMPRESSION - must be within specifications
        - ENGINE EXHAUST SYSTEM - must be free of any restrictions or leaks
        - ENGINE PCV SYSTEM - must flow freely
        - TORQUE CONVERTER STALL SPEED - must be within specifications
        - POWER BRAKE BOOSTER - no internal vacuum leaks
        - FUEL - must be free of contamination
        - FUEL INJECTOR - plugged or restricted injector, control wire not connected to correct injector

    Are there any engine mechanical problems?

    Yes

    - Repair as necessary.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **CHECK THE UPSTREAM O2 SENSOR WIRING**
    1. Disconnect the Upstream O2 Sensor harness connector.
    2. Disconnect the PCM C2 harness connector.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
    4. Check the Upstream O2 Sensor circuits;
        - for a short to ground in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.
        - for an open or high resistance in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.

    Were any problems found?

    Yes

    - Perform the appropriate repair.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 8

8. **REPLACE THE OXYGEN SENSOR AND RETEST FOR DTC**
    1. Replace the Upstream O2 Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. Connect the Bank 1 Upstream O2 Sensor and PCM harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the Freeze Frame Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.

    Did the DTC return?

    Yes

    - Go To 9

    No

    - Replacing the Upstream O2 Sensor repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**

1. Perform any Service Bulletins that apply.
2. Disconnect all PCM harness connectors.
3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.
6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1129-CLOSED LOOP FUELING NOT ACHIEVED - BANK 2 UPSTREAM

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- Shortly after engine start up.
- Fuel level above 12%.
- Battery voltage above 11.0 volts.
- No active Bank 2 Fuel Injector, Ignition Coil, or Upstream O2 Sensor circuit faults.

SET CONDITION

- Once the enable time has been reached and all enable conditions are met, the diagnostic will check for closed loop fuel control. If closed loop control is not active by the time the enable timer has expired, the diagnostic will fail.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
RESTRICTED FUEL SUPPLY LINE
FUEL PUMP INLET STRAINER PLUGGED
FUEL PUMP MODULE
O2 SENSOR HEATER OPERATION
O2 SIGNAL CIRCUIT
O2 RETURN CIRCUIT
OXYGEN (O2) SENSOR
ECT SENSOR OPERATION
ENGINE MECHANICAL PROBLEM
FUEL FILTER/PRESSURE REGULATOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any O2 Sensor DTCs active or pending?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 2
2. **CHECK THE ENGINE COOLANT TEMPERATURE (ECT) SENSOR FOR PROPER OPERATION**

   NOTE: This test works best if performed on a cold engine (cold soak).

    1. Turn the ignition on.

2. With the scan tool, read the ECT Sensor value. If the engine was allowed to sit overnight (cold soak), the temperature value should be a sensible value that is somewhere close to the ambient temperature.
3. Compare the ECT Sensor value with the Intake Air Temperature (IAT) Sensor and Ambient Air Temperature (AAT) Sensor values.

NOTE: **If engine coolant temperature is above 82Â°C (180Â°F), allow the engine to cool until 65Â°C (150Â°F) is reached.**

4. Start the engine and allow it to idle.
5. During engine warm-up, monitor the ECT Sensor value. The temperature value change should be a smooth transition from start up to normal operating temperature 82Â°C (180Â°F). The value should reach at least 82Â°C (180Â°F).

Is the ECT Sensor value within a reasonable range with the other sensors at ignition on and did the ECT value increase smoothly and did it reach at least 82Â°C (180Â°F)?

Yes

- Go To 3

No

- Verify that there is good pin to terminal contact in the Engine Coolant Temperature Sensor and Powertrain Control Module connectors. If OK, replace the Engine Coolant Temperature Sensor. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **CHECK FOR AN ACTIVE DTC**
   1. With the scan tool, read DTCs and record on the repair order.
   2. Test drive or operate the vehicle in accordance with the when monitored and set conditions.

Is the DTC active or pending?

Yes

- Go To 4

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

4. **CHECK THE FUEL DELIVERY SYSTEM FOR PROPER OPERATION**
   1. Perform the CHECKING THE FUEL DELIVERY SYSTEM test procedure. Refer to **CHECKING THE FUEL DELIVERY SYSTEM (HARD START)** .

Were any problems found?

Yes

- Perform the appropriate repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK THE ETHANOL CONTENT IN THE FUEL**
    1. Perform the CHECKING FOR PROPER ETHANOL LEVEL IN THE GASOLINE test procedure. Refer to **CHECKING FOR PROPER ETHANOL LEVEL IN THE GASOLINE** .

       Were any issues found with the gasoline?

       Yes

       - Perform the appropriate repair in accordance with the Service Information.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 6
6. **CHECK ENGINE MECHANICAL FOR PROPER OPERATION**
    1. Turn the ignition off.
    2. Check for any of the following conditions/mechanical problems:
       - AIR INDUCTION SYSTEM - must be free from leaks
       - ENGINE VACUUM - must be at least 13 inches in neutral
       - ENGINE VALVE TIMING - must be within specifications
       - ENGINE COMPRESSION - must be within specifications
       - ENGINE EXHAUST SYSTEM - must be free of any restrictions or leaks
       - ENGINE PCV SYSTEM - must flow freely
       - TORQUE CONVERTER STALL SPEED - must be within specifications
       - POWER BRAKE BOOSTER - no internal vacuum leaks
       - FUEL - must be free of contamination
       - FUEL INJECTOR - plugged or restricted injector, control wire not connected to correct injector

       Are there any engine mechanical problems?

       Yes

       - Repair as necessary.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 7
7. **CHECK THE UPSTREAM O2 SENSOR WIRING**
    1. Disconnect the Upstream O2 Sensor harness connector.
    2. Disconnect the PCM C2 harness connector.

       CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
    4. Check the Upstream O2 Sensor circuits;

- for a short to ground in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.
- for an open or high resistance in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.

Were any problems found?

Yes

- Perform the appropriate repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 8

8. **REPLACE THE OXYGEN SENSOR AND RETEST FOR DTC**
    1. Replace the Upstream O2 Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. Connect the Bank 1 Upstream O2 Sensor and PCM harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the Freeze Frame Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.

    Did the DTC return?

    Yes

    - Go To 9

    No

    - Replacing the Upstream O2 Sensor repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.

- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1205-FUEL PUMP CONTROL MODULE INTERNAL PERFORMANCE

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 10.4 volts.
- The ASD Relay is powered on.

SET CONDITION

- The Fuel Pump Control Module (FPCM) loses the ability to detect short circuits, output state, over voltage, and thermal runaway. When this DTC is set; The FPCM will continue to run the Fuel Pump Module in the normal mode at the duty cycle commanded by the PCM. This is an internal FPCM fault.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
FUEL PUMP CONTROL MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN

1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
2. For future reference, run and save a vehicle Scan Report and all related recorded data.
3. With the scan tool, erase all DTCs.
4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Replace the Fuel Pump Control Module in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

P1206-FUEL PUMP CONTROL MODULE OPEN CIRCUIT TO FUEL PUMP

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
- Battery voltage above 10.4 volts.
- The FPCM is powered on.
- The ASD Relay is energized.
- The Fuel Pump Relay is energized.

SET CONDITION

- The FPCM detects no current draw on Pulse Width Modulated (PWM) Fuel Pump Control circuitry through the Fuel Pump Assembly.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
FPCM PUMP CONTROL CIRCUIT OPEN/HIGH RESISTANCE
FPCM PUMP RETURN CIRCUIT OPEN/HIGH RESISTANCE
FUEL PUMP ASSEMBLY
FUEL PUMP CONTROL MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **ISOLATE AND LOAD TEST THE (N13) FUEL PUMP PWM CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
   3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
   4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
   5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
   6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

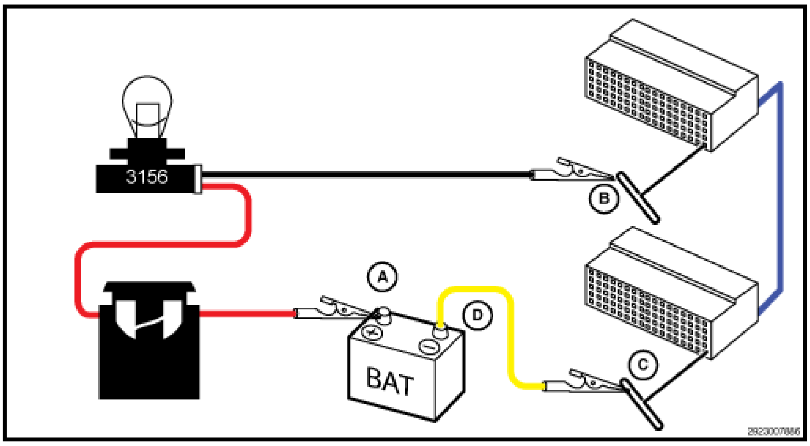
NOTE:	**Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
3. **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between ground and the circuit being tested.**

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 3

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **ISOLATE AND LOAD TEST THE (N14) FUEL PUMP PWM RETURN CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
   3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
   4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
   5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
   6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

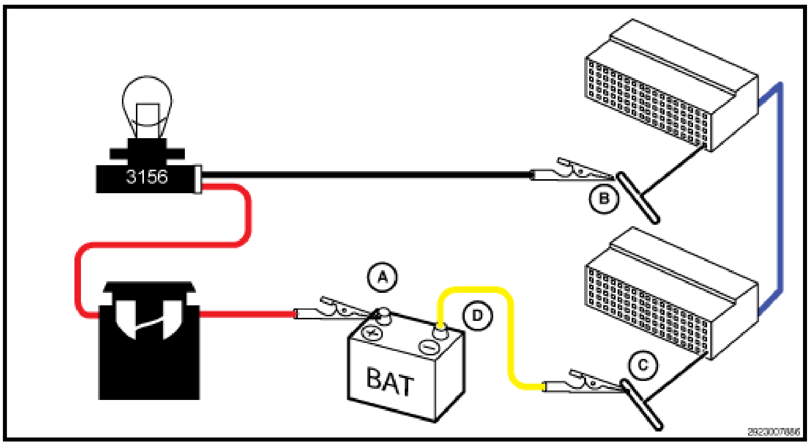
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. 1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
2. 2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. 3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 4

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **REPLACE THE FUEL PUMP ASSEMBLY AND RETEST FOR DTC**
    1. Turn the ignition off.
    2. Replace the Fuel Pump Assembly in accordance with the Service Information. Refer to **ASSEMBLY, FUEL PUMP, REMOVAL AND INSTALLATION** .
    3. Connect the Fuel Pump Assembly and PCM harness connectors.
    4. Turn the ignition on.
    5. With the scan tool, erase DTCs.
    6. Using the recorded Freeze Frame and the When Monitored conditions, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace the Fuel Pump Control Module in accordance with the Service Information. Refer to **ASSEMBLY, FUEL PUMP, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Replacing the Fuel Pump Assembly repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1239-ENGINE OIL TEMPERATURE TOO LOW

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Once the Ambient Air Temperature (AAT), Intake Air Temperature (IAT), and Engine Coolant Temperature (ECT) Sensors have been evaluated the Engine Oil Temperature (EOT) Sensor can be checked. If the ambient, engine coolant, and general temperature sensor rationalities indicate valid sensor readings then the engine oil temperature rationality will assume the AAT and ECT Sensors are correct and therefore can be used to evaluate the EOT Sensor.

To determine failing status, the difference between the starting EOT and starting ECT is compared to a threshold. If the calculated difference is above the threshold, then starting EOT is compared to starting AAT. The diagnostic will check to see if a block heater is being used to determine if larger threshold values are needed. If this rationality test fails, then it is tested again using the updated value of AAT. A failure here will result in a fault being set for EOT sensor.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Battery voltage greater than 7.5 volts.

- The difference between the engine coolant temperature and the actual engine oil temperature is less than 255Â°C (491Â°F) at engine start-up.
- To initiate the monitor, the model predicted engine oil temperature at engine start must be less than approximately 58Â°C (136.4Â°F). The monitor will stop running when the model predicted engine oil temperature becomes greater than 88Â°C (190.4Â°F).

SET CONDITION

- The actual engine oil temperature is below the model predicted temperature by more than 104Â°F (40Â°C) for three minutes.

DEFAULT ACTION

- The MIL light will illuminate.

POSSIBLE CAUSES

Possible Causes
ENGINE OIL
COOLING SYSTEM NOT OPERATING TO SPECIFICATION
HIGH RESISTANCE IN THE EOT SIGNAL CIRCUIT
HIGH RESISTANCE IN THE SENSOR GROUND CIRCUIT
ENGINE OIL TEMPERATURE SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

Are there any EOT Sensor DTCs active or pending?

Yes

- Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

No

- Go To 3

3. **CHECK THE ENGINE OILING AND COOLING SYSTEMS FOR PROPER LEVELS/TYPE/CONDITION AND OPERATION**
    1. The following conditions must be checked:
        - LOW ENGINE OIL
        - ENGINE MECHANICAL TOLERANCES OUT OF SPECIFICATION
        - ENGINE OIL PRESSURE OUT OF SPECIFICATION
        - ENGINE OIL MEETS OEM SPECIFICATION
        - DETERIORATED OR DIRTY OIL
        - ENGINE OIL CONTAMINATED (i.e., coolant and/or fuel)
        - COOLING SYSTEM NOT OPERATING TO SPECIFICATION

    Were any of the above conditions found?

    Yes

    - Repair as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 4

4. **ISOLATE AND CHECK THE EOT SENSOR (G224) TEMP SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 5

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND CHECK THE (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 6

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **REPLACE THE EOT SENSOR AND RETEST FOR DTCS**
   1. Turn the ignition off.
   2. Replace the component in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   3. Connect the component and Electronic Control Unit (ECU) harness connectors.
   4. Turn the ignition on.
   5. With the scan tool, erase all DTCs.
   6. Turn the ignition off for a minimum of 10.0 seconds.
   7. Turn the ignition on.

8. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
9. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 7

No

- Replacing the faulty EOT Sensor repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1300-CRANKSHAFT POSITION LEARN OUT OF RANGE

THEORY OF OPERATION

The Crankshaft Position System learn feature is used to calculate reference errors caused by slight tolerance variations in the Crankshaft, Target Wheel, and the Crankshaft Position (CKP) sensors. The calculated error allows the Powertrain Control Module (PCM) to accurately compensate for reference variations. The Crankshaft Position System variation compensating values are learned and stored in the PCM memory during a Decel Fuel Shutoff event. If the Crankshaft Position System variation values are not learned and stored in the PCM memory, DTC P0315 sets. If the actual Crankshaft variation is not within the Crankshaft Position systems window stored in the PCM, DTC P1300 sets and the values are not learned.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Engine is running but in a Fuel Shutoff Decel condition.
- Engine speed between 1248 rpm and 1344 rpm.
- Vehicle speed between 40 mph and 75 mph.
- Brake Switch 1 is off (i.e. not pressed).
- Engine Coolant Temperature (ECT) Sensor above 60Â°C (140Â°F).

SET CONDITION

- One of the CKP Sensor target windows has more than 2% variance from the reference.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
CAM/CRANK RELEARN PROCEDURE NOT PERFORMED
WIRE HARNESS ISSUE
CRANKSHAFT POSITION SENSOR (CKP)
TARGET WHEEL/PULSE RING

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **PERFORM THE CAM/CRANK RELEARN PROCEDURE**

NOTE: **The Cam/Crank Variation Relearn must be performed anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.**

1. Turn the ignition on.
2. With the scan tool select the "Cam/Crank Relearn" procedure under PCM Miscellaneous Menu Option and follow the on screen instructions.

NOTE: **If a negative response is displayed after the Cam/Crank Relearn procedure is performed, start the engine and perform the Cam/Crank Relearn procedure over until the misfire monitor is cleared.**

Did the PCM complete the Cam/Crank Relearn procedure?

Yes

- Go To 2

No

- Perform the process over until the Relearn procedure is completed.

2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 3

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **INSPECT THE WIRING HARNESS AND CONNECTORS FOR DAMAGE OR POOR FIT**
    1. Turn the ignition off.
    2. Visually inspect the Crankshaft Position (CKP) Sensor wire harness. Look for any chafed, pierced, pinched, or partially broken wires.
    3. Visually inspect the CKP wire harness connectors for broken, bent, pushed out, or corroded terminals.
    4. Verify that there is good pin to terminal contact in the Crank Position Sensor and Powertrain Control Module connectors.
    5. Ensure that the Crankshaft Position Sensor is properly installed and the mounting bolt(s) are torqued to the proper specification.

    Were any of the above conditions present?

    Yes

- Repair as necessary
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **INSPECT THE TARGET WHEEL/FLEX PLATE FOR DAMAGE FOREIGN MATERIAL, OR EXCESSIVE MOVEMENT**
   1. Remove the Crankshaft Position Sensor. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   2. Inspect the Target Wheel/Flex Plate for damage, foreign material, or excessive movement.

      Were any problems found?

      Yes

      - Repair or replace the Target Wheel/Flex Plate as necessary. **The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, Flywheel, Valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.**
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 5
5. **REPLACE THE CRANKSHAFT POSITION SENSOR**

   If there are no possible causes remaining, view repair.

   Repair

   - Replace the Crankshaft Position Sensor. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** . **The "Cam/Crank Relearn" Procedure must be performed every time there has been a repair/replacement made to a CMP Sensor and/or CKP Sensor, Flywheel, Valvetrain, Timing Chain or gears. Failure to do so can cause a misfire fault to set. With the scan tool, perform the "Cam/Crank Relearn" Procedure.**
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1404-EGR CLOSE POSITION PERFORMANCE

THEORY OF OPERATION

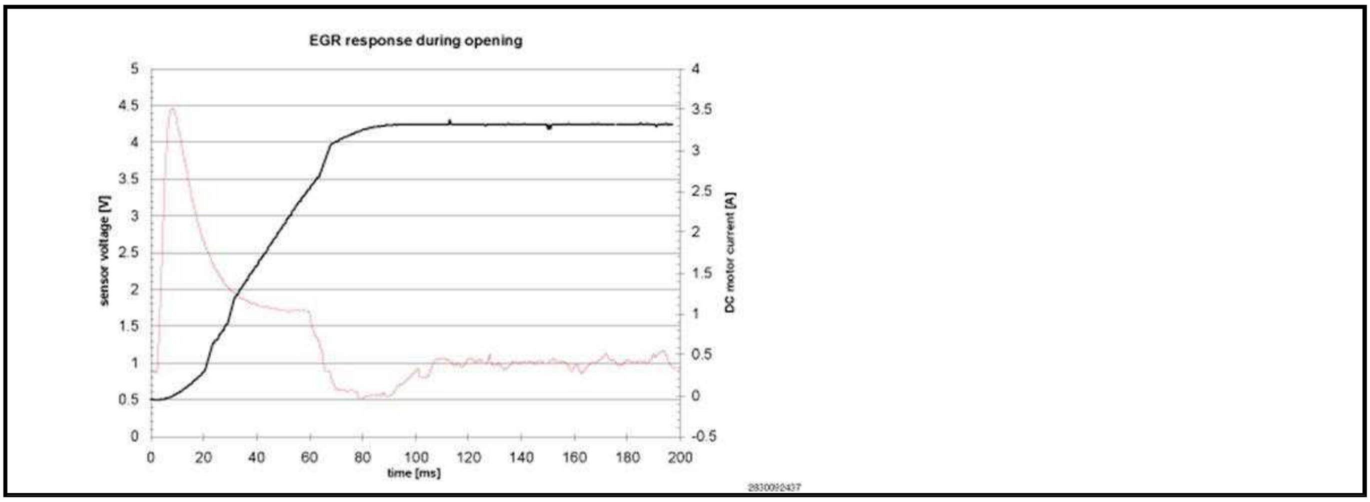
The Cooled Exhaust Gas Recirculation (EGR) Valve Assembly contains an electric Direct Current (DC) Motor and a gear box. An eccentric drive translates the gearbox output from a rotating motion (DC Motor) to a linear stroke (output shaft). The full range of travel of the shaft is approximately 5.0 mm from a fully closed to fully open position. An internal return spring ensures that the valve returns back to its closed position as a fail safe. The EGR Valve is controlled by the Powertrain Control Module (PCM) H-Bridge driver. The H-Bridge operates the DC Motor using a Pulse Width Modulation (PWM) control to help reduce current draw. This helps protect the DC Motor from overheating and reduces electrical load on the system voltage.

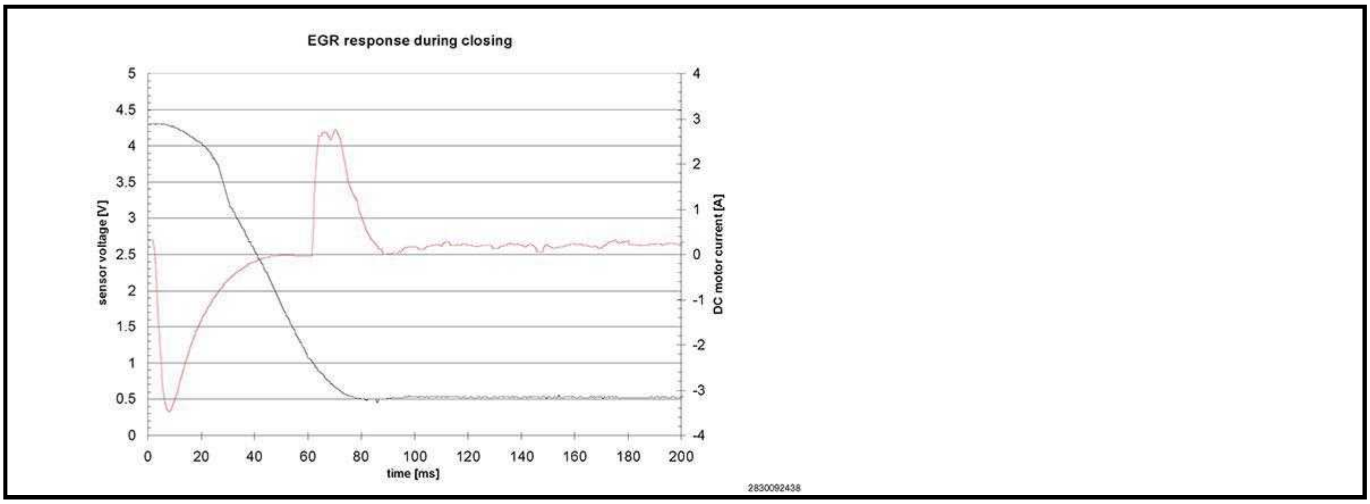
- During initial opening of the EGR Valve the PCM drives the Pulse Width Modulation (PWM) voltage high resulting in a high current draw. After the valve is fully opened the PCM voltage is reduced to maintain the EGR Valve position. This reduces the current draw and protects from overheating the DC Motor.

  - The PCM monitors the temperature and current draw of the DC Motor inside EGR Valve and will adjust the duty cycle to prevent the EGR Valve windings from overheating. Typically, the peak current draw by the EGR Valve occurs during opening and the maximum current load for a typical application is approximately 6.0 amps. The duty cycle is adjusted after opening so that the typical average current draw is approximately 0.5 amps while holding the valve open.
- The PCM also applies a current in the closing direction to fulfill the required dynamic performance. This is done to control the closing speed of the shaft near the stop. This ensures that the valve does not close too fast causing the valve disk to be forced into the stop harshly which may damage the internal gearbox.

There is a position sensor located on the output shaft. The sensor operates as a typical three wire sensor, with a 5-Volt Supply, Sensor Signal, and Sensor Ground circuit. Full range of travel of the output shaft will result in a change of approximately 3.9 volts in the position sensor reading. During normal operation the position sensor signal voltage will range between approximately 0.5 volts (closed) and 4.3 volts (open).

NOTE: **See the figures below for a typical current draw on the DC Motor and voltage reading of the sensor during the EGR Valve opening and closing. The red line represents current draw of the DC Motor and the black line represents the position sensor voltage.**





WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
- Each time the ignition is turned on, with EGR Valve closed, the zero position signal voltage is checked to see if it is within the expected range and compared to the previous zero position signal voltage.

- If the EGR Valve is within the expected range, the signal voltage value is saved as the new zero position voltage.

SET CONDITION

- The PCM will detect a fault for one of the following conditions:
  - The feedback voltage on the position sensor signal is below 0.3 volts.
  - The feedback voltage on the position sensor signal is above 0.8 volts.
  - The difference between the current feedback voltage on the position sensor signal is more that 0.12 volts from the last saved value.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
CARBON DEPOSITS IN EGR VALVE
EGR VALVE ASSEMBLY STICKING/DRAGGING
HIGH RESISTANCE IN THE EGR VALVE POSITION SIGNAL CIRCUIT
HIGH RESISTANCE IN THE SENSOR GROUND CIRCUIT
EGR VALVE ASSEMBLY

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR AN ACTIVE CONDITION**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. With scan tool, read and record the **'EGR Valve Zero Reference Position' or 'EHBVC EE ZERO REF'** value.

   NOTE: **This fault can set due to temporary carbon buildup interfering with the disc closing completely. Many times this DTC is stored because the carbon cleaned itself from the valve and disc allowing the valve to return to the full closed position. Reading the EGR position signal voltage value in the scan tool data display can determine if the valve is sticking or stuck open. As the valve opens, the position sensor signal voltage increases. In the fully closed position the EGR Valve position voltage signal should read approximately 0.5 - 0.52 volts in the scan tool data display.**

   Is the Zero Reference Position voltage above 0.640 volts?

   Yes

   - Go To 2

No

- The condition is not present at this time. There may have been carbon build-up that is cleared. The other possible scenario is possible intermittent connection or resistance in the EGR position sensor circuitry causing an intermittent false voltage feedback reading. Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

    Are there any EGR Valve Position Sensor or EGR Valve Control DTCs active or pending?

    Yes

    - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

    No

    - Go To 3

3. **VEHICLE ROAD TEST**

    NOTE: Perform the following, while maintaining connection with scan tool.

    1. Start the engine and allow vehicle to idle or drive vehicle normally to bring coolant temperature to normal operating range above 71Â°C (160Â°F).
    2. Drive vehicle for at least 3 miles to allow the EGR Valve to open. Turn off ESS so the engine does not shut off at stops. At takeoffs, use moderate acceleration but avoid full throttle accelerations. **Note:** The EGR System does not operate at idle. It typically operates during constant speed driving.
    3. Park the vehicle and shut the engine off for ten seconds.

        NOTE: This will allow the EGR cleaning routine to run at engine shutdown. This can be heard as the EGR Valve will make 5 full stroke actuations.

    4. Turn the ignition on.
    5. With scan tool, read the **Zero Reference Position** and record value.

    Did Zero Reference Position drop by 0.12 volts or return back to the normal closed position?

    Yes

    - The EGR cleaning routine cleared the carbon build-up after test driving the vehicle to operating temperature.

    No

    - Go To 4

4. **CHECK THE EGR POSITION SENSOR CIRCUITS FOR HIGH RESISTANCE**

    NOTE: It is possible for resistance in the position sensor circuits can cause the voltage reading to drift out of range without setting a position sensor signal fault.

    1. Turn the ignition off.

2. Disconnect the EGR Valve harness connector.
3. Disconnect the PCM C2 harness connector

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

4. Connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM connector.
5. Measure the resistance of the:
    - EGR Valve (K683) Position Signal circuit between the EGR Valve harness connector and the GPEC Adaptor.
    - EGR Valve (K900) Sensor Ground circuit between the EGR Valve harness connector and the GPEC Adaptor.

   Is the resistance below 3.0 Ohms for both measurements?

   Yes

    - Go To 5

   No

    - Repair the high resistance in the circuit.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK THE VEHICLE'S REPAIR HISTORY**
    1. Check the history of the vehicle for previous EGR Valve performance related DTCs within the past 90 days.

       Does the repair history show that the vehicle was in dealership for a EGR Valve performance fault within the past 90 days?

       Yes, and the EGR Valve was cleaned during the previous visit:

        - Verify that the connector is completely connected. Check the connector terminals for any pushed out, corroded or spread terminals causing a poor or intermittent connection. If the connector is good, replace the EGR Valve Assembly in accordance with the Service Information. The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       Yes, and the EGR Valve was replaced during the previous visit

        - Verify that the connector is completely connected. Check the connector terminals for any pushed out, corroded or spread terminals causing a poor or intermittent connection. If the connector is good, Clean the valve by running Mopar Combustion Chamber cleaner through the engine. The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine. Test drive the vehicle and verify the DTC does not return. If the fault does not return, check the engine for any fuel or air handling issues that can cause excessive soot or carbon buildup in the engine.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK THE EGR VALVE FOR CARBON OR SOOT BUILD UP**
    1. Turn the ignition off.
    2. Remove the EGR Valve Assembly.
    3. Clean the carbon from the EGR Valve disc and seat. The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine.
    4. Re-install the EGR Valve.
    5. Reconnect the EGR Valve and PCM C2 harness connectors.
    6. Start the engine and allow it to idle.
    7. With scan tool, read the **Zero Reference Position** and record value.

    Did Zero Reference Position return back to the normal closed position voltage (0.50 - 0.52 volts)?

    Yes

    - Cleaning the EGR Valve Assembly repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Replace the EGR Valve Assembly in accordance with the Service Information. The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set. With the scan tool, perform the EGR VALVE REPLACED routine.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P141B-STARTER CONTROL 1 CIRCUIT PERFORMANCE

WHEN MONITORED

This diagnostic runs one time during an ignition cycle when the following conditions are met:

- Ignition on.
- System voltage above 10.38 volts.
- Stop/Start enabled.
- **Condition one:**
    - The Stop/Start Relay is commanded closed (on).
    - Starter Solenoid Relay commanded open (off).
- **Condition two:**
    - The Stop/Start Relay is commanded open (off)
    - Starter Solenoid Relay commanded open (off).

SET CONDITION

- The Powertrain Control Module (PCM) detects voltage is present on the Ignition Crank Sense circuit.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
STARTER SOLENOID RELAY CONTROL CIRCUIT SHORTED TO GROUND
STARTER SOLENOID RELAY CONTROL CIRCUIT SHORTED TO ANOTHER CIRCUIT
IGNITION CRANK SENSE CIRCUIT SHORTED TO ANOTHER CIRCUIT
STARTER SOLENOID RELAY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any Starter Relay circuit DTCs present in the PCM or BCM?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **ISOLATE AND CHECK THE STARTER RELAY (K8) CONTROL CIRCUIT FOR A SHORT TO GROUND**

1. The ignition must be off when checking a circuit for continuity to ground.
2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Connect the negative lead of the DVOM to a known good ground.
4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, (special tool #10436, Adapter, GPEC Diagnostic) connect the to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **ISOLATE AND CHECK THE STARTER RELAY (K8) CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
   4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

   1. If it is necessary to probe a terminal at a PCM harness connector, (special tool #10436, Adapter, GPEC Diagnostic) connect the to the appropriate PCM harness connector.

   NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

   Is there continuity between the circuit being tested and any other circuit?

   Yes

   - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **ISOLATE AND CHECK THE (T753) IGNITION CRANK SENSE CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
   4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **REPLACE THE STARTER SOLENOID RELAY AND RETEST FOR DTCS**
   1. Turn the ignition off.
   2. Replace the component in accordance with the Service Information.
   3. Connect the component and Electronic Control Unit (ECU) harness connectors.
   4. Turn the ignition on.
   5. With the scan tool, erase all DTCs.
   6. Turn the ignition off for a minimum of 10.0 seconds.
   7. Turn the ignition on.
   8. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   9. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 7

No

- Replacing the faulty component repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P141C-STARTER CONTROL 2 CIRCUIT PERFORMANCE

WHEN MONITORED

This diagnostic runs one time during an ignition cycle when the following conditions are met:

- Ignition on.
- System voltage above 10.38 volts.
- Stop/Start enabled.
- **Condition one:**
  - The Stop/Start Relay is commanded open (off).
  - Starter Solenoid Relay commanded closed (on).
- **Condition two:**
  - The Stop/Start Relay is commanded open (off).
  - Starter Solenoid Relay commanded open (off).

SET CONDITION

- The Powertrain Control Module (PCM) detects voltage is present on the Ignition Crank Sense circuit.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
STOP/START RELAY CONTROL CIRCUIT SHORTED TO GROUND
STOP/START RELAY CONTROL CIRCUIT SHORTED TO ANOTHER CIRCUIT
IGNITION CRANK SENSE CIRCUIT SHORTED TO ANOTHER CIRCUIT
STOP/START RELAY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

    Are there any Starter Relay circuit DTCs present in the PCM or BCM?

    Yes

    - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

    No

    - Go To 3

3. **ISOLATE AND CHECK THE STARTER RELAY (K8) CONTROL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, (special tool #10436, Adapter, GPEC Diagnostic) connect the to the appropriate PCM harness connector.

    NOTE: **There should be no continuity between ground and the circuit being tested.**

    Is there continuity between ground and the circuit being tested?

    Yes

    - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 4

4. **ISOLATE AND CHECK THE STOP/START RELAY (K88) CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors

connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.

3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

1. If it is necessary to probe a terminal at a PCM harness connector, (special tool #10436, Adapter, GPEC Diagnostic) connect the to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **ISOLATE AND CHECK THE (T753) IGNITION CRANK SENSE CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
   4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **REPLACE THE STOP/START RELAY AND RETEST FOR DTCS**
    1. Turn the ignition off.
    2. Replace the component in accordance with the Service Information.
    3. Connect the component and Electronic Control Unit (ECU) harness connectors.
    4. Turn the ignition on.
    5. With the scan tool, erase all DTCs.
    6. Turn the ignition off for a minimum of 10.0 seconds.
    7. Turn the ignition on.
    8. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    9. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 7

    No

    - Replacing the faulty component repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
7. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.

10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P141D-STARTER RELAY FEEDBACK OPEN CIRCUIT PERFORMANCE

THEORY OF OPERATION

The Engine Stop/Start (ESS) system utilizes two Starter Relays to operate the Engine Starter Motor. The Body Control Module (BCM) controls one relay with a Low Side Driver (LSD). When the BCM controlled relay is energized, it provides Ground to the other Starter Relay controlled by the Powertrain Control Module (PCM). The PCM controls engine cranking by energizing the second Starter Relay. The Starter Motor can be disengaged by de-energizing either relay. **The relay names and DTC descriptions may not match and can be confusing. In the PCM diagnostics, the relay controlled by the PCM is always considered starter relay 1 and the BCM controlled relay is considered starter relay 2.**

The control circuits for both relays are monitored for circuit faults. The PCM also monitors and performs diagnostics on the output to the Starter Motor on the Ignition Crank Sense circuit. In addition to the control circuit diagnostics for each relay, the PCM also performs diagnostics to detect if one of the relays is stuck in the closed position.

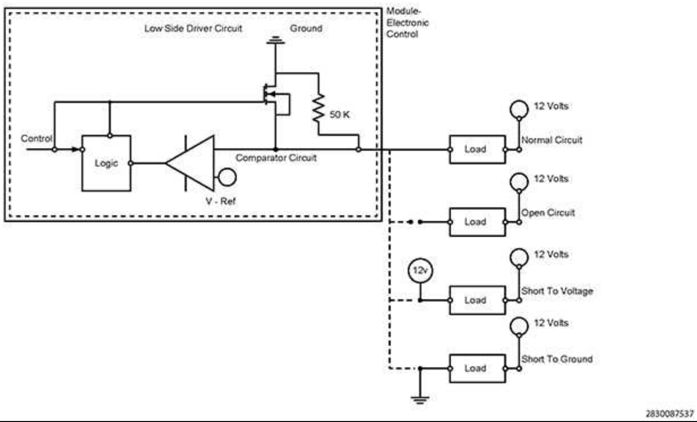
- **Ignition Crank Sense Diagnostics:** The PCM monitors the Ignition Crank Sense circuit voltage when engine cranking is commanded. The Ignition Crank Sense circuit is connected to the Starter Solenoid Feed circuit inside the PDC. During an engine cranking event the PCM expects to see Battery voltage at the Ignition Crank Sense circuit. If no voltage is detected a fault is set.
- **Stuck Relay Diagnostic:** After the engine is initially started, the Powertrain Control Module (PCM) will command one of the Starter Relays closed and the other Starter Relay open and monitor the Ignition Crank Sense circuit for voltage. It will then open the closed relay and close the open relay and monitor the Ignition Crank Sense circuit for voltage. If there is voltage present on the feedback circuit during either of these tests, then the relay that was commanded off when voltage was detected is determined to be stuck closed and a performance fault is set against that relay.

Typical Low Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver device. The PCM provides a ground to operate the device when switched on. The ground could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device, wiring and internal driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. For diagnostic purposes the PCM uses an internal pull down diagnostic resistor connected in series and a voltage reference (V-Ref) comparator for fault detection:

- **Circuit Open and Circuit Low Detection:** The PCM monitors for an **open circuit** and **short to ground** when the driver is switched off. When switched off, the available voltage passes through the device and the **internal pull down resistor** connected in series. The voltage at the **comparator circuit** should be close to Battery voltage since the majority of the voltage drop occurs through the diagnostic resistor. If the available voltage is less than the V-Ref, a fault is set. In this scenario the V-Ref would be slightly below Battery voltage. **An alternative method of fault detection for an open or short to ground** that is used is to monitor current draw when the internal driver is switched on. If the module does not detect any current draw it determines that the component or circuitry is open. Excessive current draw detected would indicate a short to ground.

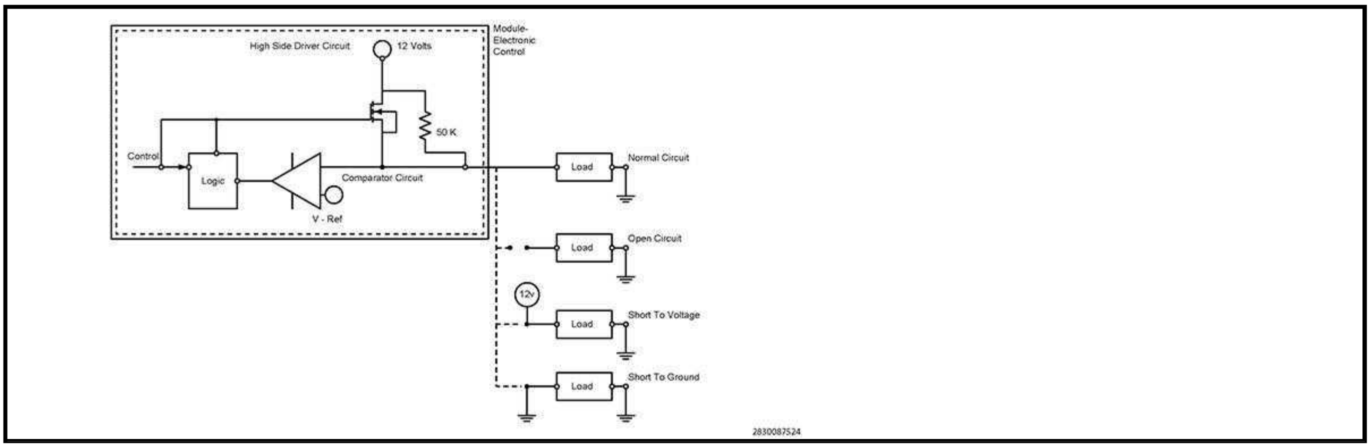
- **Circuit High Detection:** The PCM monitors for a **short to voltage** when the driver is switched on. When the driver is switched on providing a path to ground through the transistor, the available voltage should be pulled low, near zero volts since the **comparator circuit** is monitoring the ground side of the device. If the voltage is greater than V-Ref, a fault is detected. In this scenario V-Ref would be slightly above zero volts.

NOTE: **A load that has a resistance that is below manufacturer specification, or a second load device shorted to the low side driver circuit can cause excessive current draw on the internal driver. The driver will be switched off to protect against overheating and damaging the driver. In this instance the Circuit High fault may be detected because the available voltage on the comparator circuit is above V-Ref.**



Typical High Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver device. The PCM provides 12 volts to operate the device when switched on. The voltage could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device, wiring and internal driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. The graphic shows how the PCM performs diagnostics using an internal pull up diagnostic resistor and calibrated voltage reference (V-Ref) as a comparator for fault detection.

- **Circuit Open and Circuit High Detection:** The PCM monitors for an **open circuit** and **short to voltage** when the internal driver is switched off. A milliampere voltage is provided to the device through the **internal pull up diagnostic resistor** connected in series with the device. The diagnostic voltage is monitored between the pull up resistor and device, and compared to V-Ref. If the resistance in the device or circuitry becomes too large (approaches open) the voltage supply will increase on the **comparator circuit** and become greater than V-Ref, and a fault is detected. A short to Battery voltage will have the same effect. **An alternative method of fault detection for an open** that is used is to monitor current draw when the internal driver is switched on. If the module does not detect any current draw it determines that the component or circuitry is open.
- **Circuit Low Detection:** The PCM monitors for a **short to ground** when the driver is turned on. When switched on, the voltage to the device should be close to the 12 volt supply voltage. A short to ground will pull the voltage at the **comparator circuit** below V-Ref and a circuit low fault is detected. **An alternative method of fault detection for a short to ground** that is used is to monitor current draw when the internal driver is switched on. Excessive current draw detected would indicate a short to ground.



WHEN MONITORED AND SET CONDITIONS

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- System voltage above 10.38 volts.
- Engine Starter engagement (crank) commanded.

Set Conditions:

- During an engine cranking event, the PCM expects to see voltage at the Ignition Crank Sense circuit. If no voltage is detected a fault is set.

Default Actions:

- The MIL will illuminate.

Possible Causes
OPEN BATTERY SUPPLY TO THE STARTER RELAYS
IGNITION CRANK SENSE CIRCUIT OR FUSE OPEN/HIGH RESISTANCE
IGNITION CRANK SENSE CIRCUIT SHORTED TO GROUND
STOP/START RELAY
STARTER SOLENOID RELAY
STARTER MOTOR
POWER DISTRIBUTION CENTER (PDC)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE DTC OR FAULT CONDITION**
    1. With the scan tool, read DTCs.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. Attempt to start the engine.
    4. With the scan tool, read DTCs.

    Is the DTC or fault condition active?

    Yes, and the engine cranks;

- Go To 3

Yes, but the engine does not crank;

- Go To 4

No

- Go To 2

2. **STORED DTC DIAGNOSTIC**
    1. When a DTC is stored and can't be duplicated it may be due to several factors. One factor can be the timing of when the diagnostic runs. For example some diagnostics will run after the ignition is off. Others may run during very specific or small windows of operation. Others may not run during every drive cycle. If you determine by monitoring the scan tool data that a failure is present continue with the test procedure to diagnose the issue.
    2. DTCs can be stored and not present due to calibration issues. In many of these cases there will be a PCM flash update to correct the issue. Check for any Service Bulletins or Star Online Cases that may be related to the DTC or failure modes that are present.
    3. In some cases a DTC can be stored due to an intermittent connection at the component or in-line harness connector. Carefully check that the component and any in-line connectors are properly connected and locked together. Disconnect the connectors and carefully inspect for damaged or pushed our terminals. Inspect the terminals for signs of water intrusion, corrosion, or poor pin fit.

        Were any of the above conditions found?

        Yes

        - Continue with the proper repair procedure.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - If there are no Service Bulletins or Star Online Cases with specific repair actions, clean the component and in-line harness connectors with Mopar electrical cleaner. Dry the connector thoroughly with shop air and apply a small amount of dielectric grease to the face of the connector with your finger. If this vehicle has been in previously with the same inactive DTC or condition, replace the Throttle Body Assembly in accordance with the Service Information.
3. **CHECK THE FUSE FOR THE (T753) IGNITION CRANK SENSE CIRCUIT**
    1. Inspect the fuse that supplies (T753) Ignition Crank Sense circuit.

        Is the fuse open?

        Yes

        - Repair the (T753) Ignition Crank Sense circuit for a short to ground and replace the fuse.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Repair the (T753) Ignition Crank Sense circuit for an open or high resistance. If the (T753) Ignition Crank Sense circuit is not open, Go To 5
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE FUSE THAT SUPPLIES THE STOP/START RELAY**
    1. Inspect the fuse that supplies Fused B+ to terminal 30 of the Stop/Start Relay.

        Is the fuse open?

        Yes

        - Repair the (T750) Starter Relay Output circuit for a short to ground and replace the fuse. If the circuit is not shorted to ground, replace the Starter Motor and fuse.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The fault is due to improper battery supply to the relays or one of the Starter Relays is not closing when energized. Diagnose the condition and perform the appropriate repair.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1456-FUEL TANK PRESSURE SENSOR CIRCUIT LOW

For a complete EVAPORATIVE EMISSIONS SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Fuel Tank Pressure (FTP) Sensor provides the Powertrain Control Module (PCM) with information on vapor pressure inside the fuel tank. The FTP Sensor is a transducer that varies resistance according to changes in pressure. The PCM provides a 5-Volt supply and sensor ground. The sensor sends a feedback voltage to the PCM on the signal circuit. As the fuel tank pressure changes, the feedback voltage changes proportionally.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage greater than 10.38 volts.

SET CONDITION

- The Fuel Tank Pressure (FTP) Sensor input voltage is below the minimum acceptable value.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

POSSIBLE CAUSES
FTP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND
FTP SENSOR SIGNAL CIRCUIT SHORTED TO THE SENSOR GROUND CIRCUIT
FUEL TANK PRESSURE SENSOR (FTP)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.

3. With the scan tool, erase all DTCs.
4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any 5-Volt Supply DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3

3. **ISOLATE AND CHECK THE FTP SENSOR (N7) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

      NOTE: **There should be no continuity between ground and the circuit being tested.**

      Is there continuity between ground and the circuit being tested?

      Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **ISOLATE AND CHECK THE FTP SENSOR (N7) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO THE (K917) SENSOR GROUND CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between the circuits being tested.**

   Is there continuity between the circuits?

   Yes

   - Repair the short between the circuits.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **CONNECT A FUSED JUMPER BETWEEN THE FTP SENSOR (N7) PRESSURE SIGNAL CIRCUIT AND THE (K859) 5-VOLT SUPPLY CIRCUIT AT THE FUEL TANK PRESSURE SENSOR HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL CIRCUIT HIGH DTC**
   1. The Electronic Control Module (ECU) harness connectors must be connected to the ECU during this test step.
   2. Disconnect the sensor harness connector.
   3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the 5-Volt Supply circuit at the sensor harness connector.
   4. Turn the ignition on.
   5. With the scan tool, read DTCs.

   Does the scan tool display the SENSOR SIGNAL CIRCUIT HIGH DTC with the jumper in place?

   Yes

- Replace the faulty sensor in accordance with the Service Information. Refer to **SENSOR, FUEL TANK PRESSURE, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1457-FUEL TANK PRESSURE SENSOR CIRCUIT HIGH

For a complete EVAPORATIVE EMISSIONS SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Fuel Tank Pressure (FTP) Sensor provides the Powertrain Control Module (PCM) with information on vapor pressure inside the fuel tank. The FTP Sensor is a transducer that varies resistance according to changes in pressure. The PCM provides a 5-Volt supply and sensor ground. The sensor sends a feedback voltage to the PCM on the signal circuit. As the fuel tank pressure changes, the feedback voltage changes proportionally.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage greater than 10.38 volts.

SET CONDITION

- The FTP Sensor signal voltage is above the maximum voltage threshold.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

POSSIBLE CAUSES
FTP SENSOR SIGNAL CIRCUIT SHORTED TO THE 5-VOLT SUPPLY CIRCUIT
FTP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE
FTP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
FUEL TANK PRESSURE (FTP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any 5-Volt Supply voltage DTCs active or pending?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 3
3. **CHECK THE FTP SENSOR (N7) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

Is the voltage above 5.2 volts?

Yes

- Go To 4

No

- Go To 5

4. **ISOLATE AND CHECK THE FTP SENSOR (N7) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

Is there continuity between the circuit being tested and any other circuit?

Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To

5. **ISOLATE AND CHECK THE FTP SENSOR (N7) PRESSURE SIGNAL CIRCUIT FOR A SHORT TO THE (K859) 5-VOLT SUPPLY**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between the circuits being tested.**

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **ISOLATE AND CHECK THE FTP SENSOR (N7) PRESSURE SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.

5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 7

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **ISOLATE AND CHECK THE (K917) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 8

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CONNECT A FUSED JUMPER BETWEEN THE FTP SENSOR (N7) PRESSURE SIGNAL CIRCUIT AND THE (K917) SENSOR GROUND CIRCUIT AT THE FTP SENSOR HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL CIRCUIT LOW DTC**
    1. The Electronic Control Module (ECU) harness connectors must be connected to the ECU during this test step.
    2. Disconnect the sensor harness connector.
    3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the sensor ground circuit at the sensor harness connector.
    4. Turn the ignition on.
    5. With the scan tool, read DTCs.

    Does the scan tool display the SENSOR SIGNAL CIRCUIT LOW DTC with the jumper in place?

    Yes

    - Replace the faulty sensor in accordance with the Service Information. Refer to **SENSOR, FUEL TANK PRESSURE, REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 9

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.

8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1495-LEFT FRONT SEATBELT SWITCH CIRCUIT HIGH

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) receives a message over the CAN BUS from the Occupant Restraint Controller (ORC) that there is a fault with the left front seat belt switch assembly.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
LEFT FRONT SEAT BELT SWITCH WIRING ISSUE
LEFT FRONT SEAT BELT ASSEMBLY
OCCUPANT RESTRAINT CONTROLLER (ORC)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

CHECK FOR AN ACTIVE DTC

1. With the scan tool, read DTCs and record on the repair order.

   Is the DTC active or pending?

   Yes

- Refer to **OCCUPANT RESTRAINT CONTROLLER (ORC) - DIAGNOSTIC CODE INDEX** and perform the appropriate diagnostics for the Left Front Seat Belt Switch.

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

P1496-LEFT FRONT SEATBELT SWITCH CIRCUIT LOW

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) receives a message over the CAN BUS from the Occupant Restraint Controller (ORC) that there is a fault with the left front seat belt switch assembly.

DEFAULT ACTION

- The MIL will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
LEFT FRONT SEAT BELT SWITCH WIRING ISSUE
LEFT FRONT SEAT BELT ASSEMBLY
OCCUPANT RESTRAINT CONTROLLER (ORC)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

CHECK FOR AN ACTIVE DTC

1. With the scan tool, read DTCs and record on the repair order.

   Is the DTC active or pending?

   Yes

   - Refer to **OCCUPANT RESTRAINT CONTROLLER (ORC) - DIAGNOSTIC CODE INDEX** and perform the appropriate diagnostics for the Left Front Seat Belt Switch.

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

DIAGNOSIS AND TESTING

P1524-OIL PRESSURE OUT OF RANGE - CAMSHAFT ADVANCE/RETARD DISABLED

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Oil temperature is between -10B°C (14B°F) and 188B°C (370.4B°F).
- No active Engine Oil Temperature (EOT) Sensor or Engine Oil Pressure (EOP) Sensor circuit faults.
- No active Camshaft Solenoid circuit or performance faults.

SET CONDITION

- The engine oil pressure never reaches the calibrated specification to allow the Variable Valve Timing (VVT) activation.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
ENGINE OIL LEVEL LOW
ENGINE OIL AERATED OR CONTAMINATED
INCORRECT ENGINE OIL FILTER
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
ENGINE OIL PRESSURE (EOP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any EOT Sensor, EOP Sensor, or Camshaft Position Solenoid DTCs active or pending?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3

3. **CHECK THE ENGINE OIL/ENGINE MECHANICAL FOR PROPER OPERATION**
    1. Turn the ignition off.
    2. The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.
        - LOW ENGINE OIL LEVEL
        - AERATED ENGINE OIL
        - INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)
        - DETERIORATED OR DIRTY OIL
        - CONTAMINATED ENGINE OIL
        - INCORRECT ENGINE OIL VISCOSITY

        Were any of the above conditions present?

        Yes

        - Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 4

4. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**
    1. Connect an oil pressure gauge to the engine.
    2. Start the engine and allow it to idle.
    3. Monitor the engine oil pressure reading on the gauge.

        NOTE: **If the oil pressure is below 14 psi or oscillating excessively, it can cause a delay in Cam Phaser movement sufficient enough to set a slow response DTC.**

        Is the oil pressure reading stable and above 14.0 psi?

Yes

- Go To 5

No

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **COMPARE THE EOP SENSOR READING TO ACTUAL ENGINE OIL PRESSURE**
   1. With the scan tool, monitor the EOP Sensor reading.

      Does the EOP Sensor reading on the scan tool match the actual oil pressure reading?

      Yes

      - Go To 6

      No

      - Replace the Engine Oil Pressure (EOP) Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.
   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.

10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P152C-ENGINE HOOD SWITCH 2 CIRCUIT RANGE/PERFORMANCE

For a complete VEHICLE THEFT SECURITY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) monitors the hood ajar status of both hood ajar switches on Plug-in Hybrid Electric Vehicles (PHEV) and Electronic Stop/Start (ESS) equipped vehicles for proper operation. Hood Ajar Switch 1 is hard-wired to the Body Control Module (BCM). The signal is sent to the PCM over the CAN Bus. Hood Ajar Switch 2 is hard-wired to the PCM. If the PCM detects that either switch is in the open position or is faulted for any reason during a normal drive cycle, ESS will be disabled for the remainder of the drive cycle. This condition will cause the engine to default to a running state on both PHEV and ESS equipped vehicles. If Hood Ajar Switch 2 is faulted or in the open state it will also cause the Remote Start feature to be inoperative.

For additional information on the effect of this DTC to the operation of ESS, proceed to the **ENGINE START/STOP (ESS) INOPERATIVE.** . Refer to **ENGINE STOP/START (ESS) SYSTEM INOPERATIVE** .

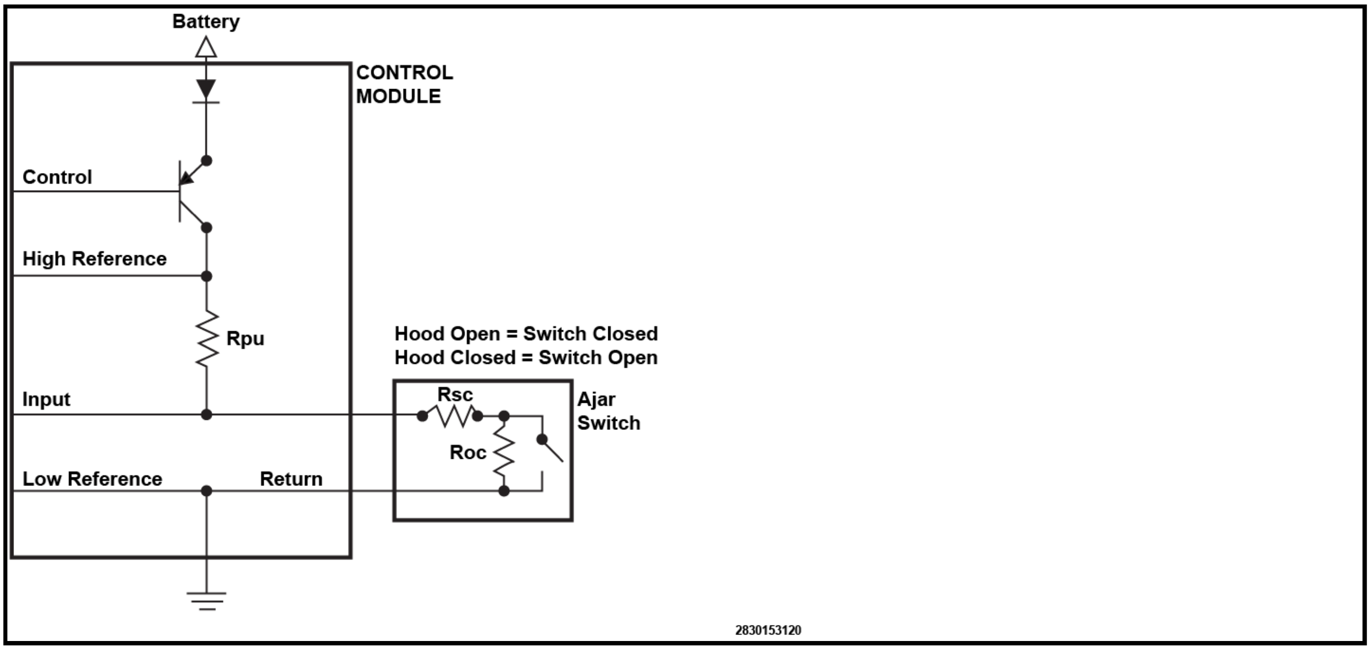
COMPONENT FUNCTIONAL DESCRIPTION - HOOD LATCH/AJAR SWITCH 1

Component Functional Operation: The Hood Ajar Switch 1 is a hard-wired input to the Body Control Module (BCM). For most vehicles it is integrated as part of the Hood Latch assembly. If it is incorporated into the latch assembly there will be an electrical connector on the latch assembly. If the latch does not have an electrical connector, there should be a 2nd plunger switch under the hood. The Hood Ajar Switch 1 receives a Battery voltage signal from the BCM through an internal pull up resistor. When the ajar switch is open the signal passes through both internal resistors and the resistance through the switch should be approximately 1000 Ohms. When the switch is closed the signal passes through only the Rsc resistor and the resistance through the switch should be approximately 500 Ohms.

Technical Data:

Parameter	Nominal	B
Rsc	499 ohms	
Roc	499 ohms	
Rpu	1100 ohms	
Signal reference voltage	Battery/system voltage	

Parameter	Nominal	B
Protection	Short to Ground/Short to Battery	
Detection	Short to Ground/Open Circuit/Short to Battery	



The BCM monitors the Hood Ajar Switch 1 signal circuit and converts the voltage signal into counts to broadcast over the CAN Bus network.

- Electronic Control Modules read an analog signal voltage and converts it to digital counts. Each count is an equal percentage of the signal reference voltage. This can be seen when viewing some sensor or switch voltages and converted values on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts to a Battery voltage reference.
- The resolution of the signal (number of counts) is determined by the required precision of the input by the ECU. Typically, sensor signals are high resolution. This allows the module to read small changes over a wide range in a variable resistance sensor signal. These are typically used on a temperature, pressure, position or MUX type of sensor.
- Switches on the other hand are usually of much lower resolution than sensors. This is because an ECU is generally looking for a switch to be in only a few positions that use fixed resistors. The lower resolution also helps the ECU to overcome some resistance in a circuit and still read the correct state. This also lowers the sensitivity to setting DTCs.

The Hood Ajar Switch 1 signal voltage is typically divided into 15 counts. The table below shows the relation between for the Hood Ajar Switch 1 states. The voltage ranges given are based on a nominal reference voltage of 13.5 volts. The counts and percentage of Battery voltage will remain constant, but the signal voltage will vary as actual Battery voltage changes.

- Using the following method to convert the actual Hood Ajar Switch 1 signal voltage to a percentage of Battery voltage. (Hood Ajar Switch 1 signal voltage / Battery voltage value = % of Battery voltage).
- Examples: (4.7v signal / 14.2v Battery = 33%) 5 counts. (6.7v signal / 12.6v Battery = 53%) 8 counts

VOLTAGE PERCENTAGE/VALUE TO HOOD STATE				
Count Level	**Signal State**	**Signal Voltage @ 13.5 volts nominal**	**Percentage of Battery Voltage**	**Fault Code**
0 - 2	Circuit Shorted Low	Below 1.8v	0 - 13%	P257E

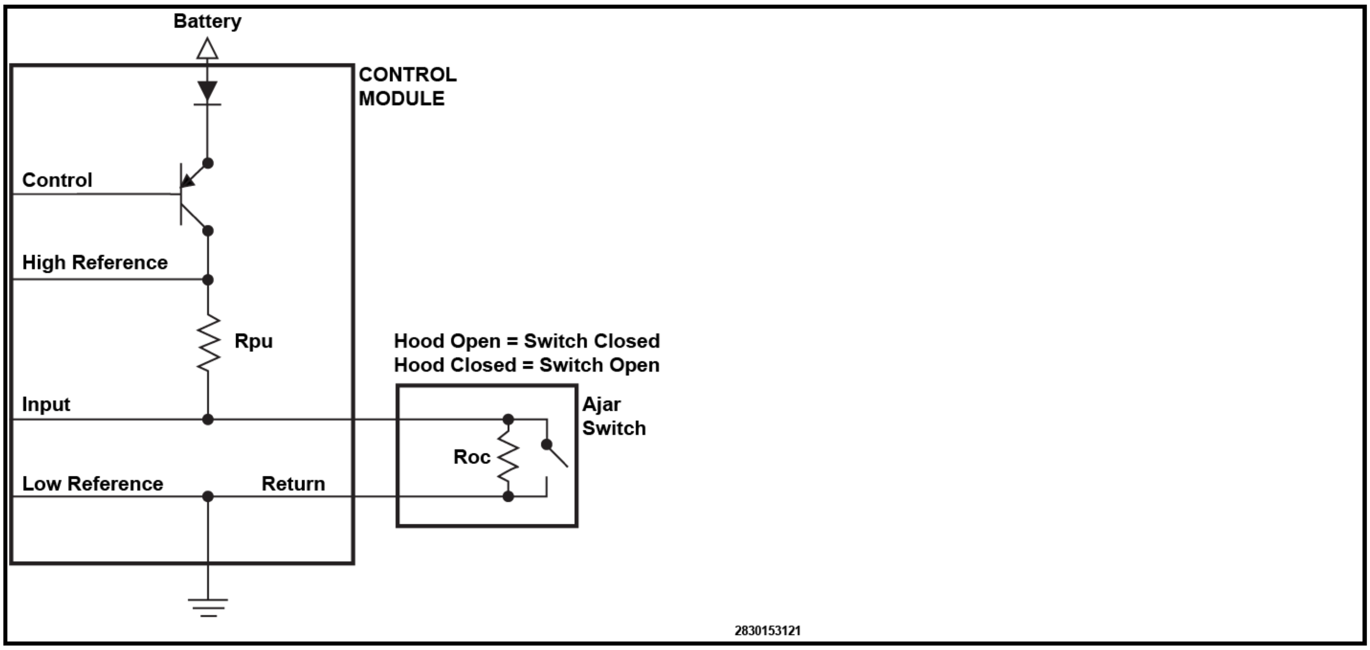
VOLTAGE PERCENTAGE/VALUE TO HOOD STATE					
Count Level	**Signal State**	**Signal Voltage @ 13.5 volts nominal**	**Percentage of Battery Voltage**	**Fault Code**	
3 - 6	Ajar	2.7v - 4.5v	20 - 33%	Normal operating range	B B
7- 10	Not Ajar	5.4v - 8.9v	40 - 66%		B B
11 - 15	Circuit Shorted High/Open	Above 9.0v	73 - 100%	P257F	

COMPONENT FUNCTIONAL DESCRIPTION - HOOD LATCH/AJAR SWITCH 2

Component Functional Operation: The Hood Ajar Switch 2 is a hard-wired input to the Powertrain Control Module (PCM). The switch receives a 5.0 volt signal from the PCM through an internal pull up resistor. When the switch is open the signal passes through the internal resistor and the resistance through the switch should be approximately 1000 Ohms. When the ajar switch is closed the signal passes through the switch directly to the return circuit and the resistance through the switch should read approximately 0.0 Ohms. The resistor inside the Hood Ajar Switch allows the PCM the ability to detect the hood ajar status and diagnose the signal for an open condition. The PCM is not able to detect a short low in the signal since this would be the same input as hood open/ajar. This failure mode would be detected by the rationality fault that compares the signal to the Hood Ajar Switch 1 signal received over the Can Bus from the Body Control Module (BCM).

Technical Data:

Parameter	Nominal	B
Roc	1000 ohms	
Rpu	N/A	
Reference voltage	5.0v DC	
Protection	Short to Ground/Short to Battery	
Detection	Open Circuit/Short to Battery	



DIAGNOSTIC OVERVIEW - HOOD AJAR SWITCHES

The Powertrain Control Module (PCM) must see both Hood Ajar Switches in the open state (hood closed) for the Remote Start and Engine Stop/Start (ESS) systems to operate. The switch states should always match if both switches are functioning properly.

- If the vehicle has a performance or correlation fault, start by determining which switch is not reading the hood states (ajar/not ajar) properly. Use one of the following methods to verify both Hood Ajar Switch states.
  - Read the scan tool data reads.
  - Measure the resistance through each switch in both states (switch open/closed).
  - Check the voltage on the signal circuit in each state.

  Use the technical data information provided in the Component Functional Description and Operation to determine which Hood Switch is reading incorrectly and diagnose the switch and wiring accordingly.

- Typically a performance fault against Hood Ajar Switch 2, or a correlation fault is due to the **total resistance** of a switch or circuitry drifting out of range. On vehicles where Hood Ajar Switch 2 has only the one internal resistor used to detect the **open switch state** , a short to ground in the signal circuit would be interpreted as a closed switch state (hood ajar) at all times by the PCM. This would cause a correlation fault when the hood is closed/not ajar.
- Circuit Low/High faults against one of the Hood Ajar Switches are typically due to an open or short in the switch or wiring.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Electronic Stop/Start (ESS) is enabled.

SET CONDITION

- The PCM detects that the voltage is implausible for 0.32 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
HIGH RESISTANCE IN THE ENGINE HOOD SWITCH 2 SIGNAL CIRCUIT
HIGH RESISTANCE IN THE SENSOR GROUND CIRCUIT
ENGINE HOOD SWITCH 2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.

4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **ISOLATE AND CHECK THE HOOD AJAR SWITCH 2 (K806) SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 3

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **ISOLATE AND CHECK THE (K917) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide

to follow the path of the circuit.

3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 4

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **REPLACE THE ENGINE HOOD SWITCH 2 AND RETEST FOR DTCS**
   1. Replace the component in accordance with the Service Information.
   2. Connect the component and Electronic Control Unit (ECU) harness connectors.
   3. Turn the ignition on.
   4. With the scan tool, erase DTCs.
   5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
   6. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 5

No

- Replacing the faulty component repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED HARNESS CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.

4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
   - Proper connector installation.
   - Damaged connector locks.
   - Corrosion.
   - Other signs of water intrusion.
   - Weather seal damage (if equipped).
   - Bent terminals.
   - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
   - Terminals that have been pushed back into the connector cavity.
   - Check for spread terminals and verify proper terminal tension.

   Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P152D-ENGINE HOOD SWITCH 2 CIRCUIT LOW

For a complete VEHICLE THEFT SECURITY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

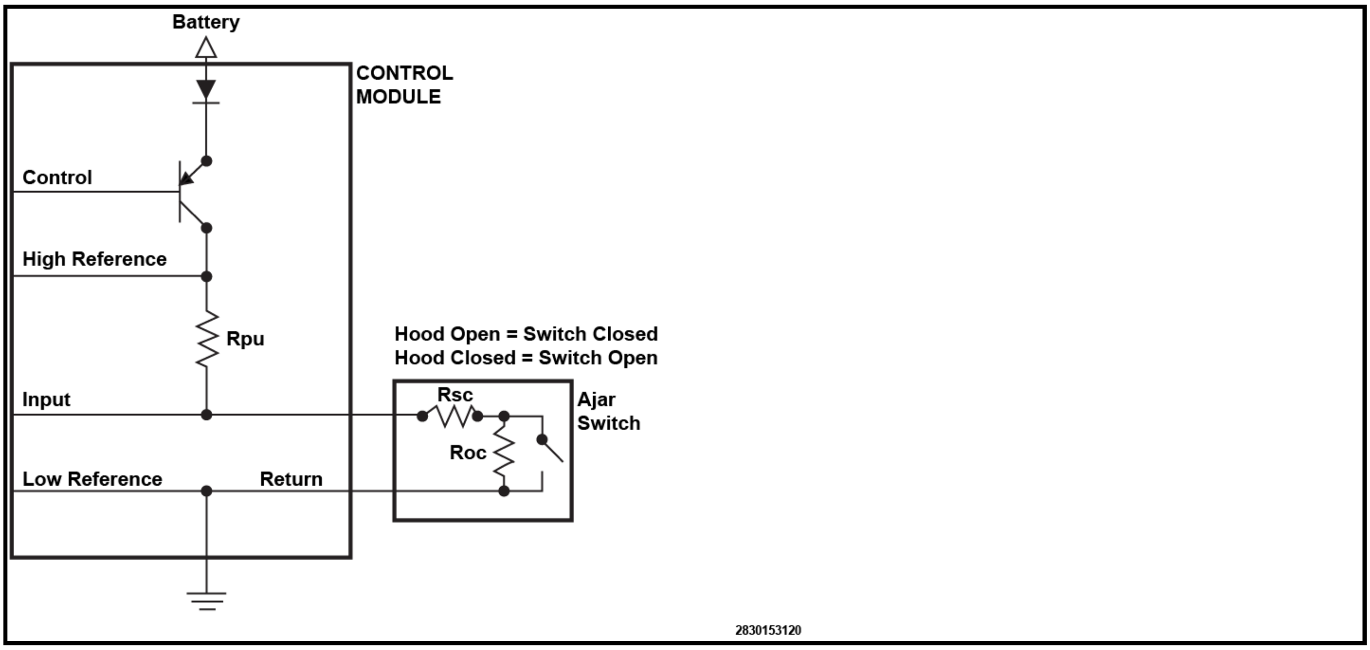
THEORY OF OPERATION

The Powertrain Control Module (PCM) monitors the hood ajar status of both hood ajar switches on Plug-in Hybrid Electric Vehicles (PHEV) and Electronic Stop/Start (ESS) equipped vehicles for proper operation. Hood Ajar Switch 1 is hard-wired to the Body Control Module (BCM). The signal is sent to the PCM over the CAN Bus. Hood Ajar Switch 2 is hard-wired to the PCM. If the PCM detects that either switch is in the open position or is faulted for any reason during a normal drive cycle, ESS will be disabled for the remainder of the drive cycle. This condition will cause the engine to default to a running state on both PHEV and ESS equipped vehicles. If Hood Ajar Switch 2 is faulted or in the open state it will also cause the Remote Start feature to be inoperative.

For additional information on the effect of this DTC to the operation of ESS, proceed to the **ENGINE START/STOP (ESS) INOPERATIVE.** . Refer to **ENGINE STOP/START (ESS) SYSTEM INOPERATIVE** .

COMPONENT FUNCTIONAL DESCRIPTION - HOOD LATCH/AJAR SWITCH 2

Component Functional Operation: The Hood Ajar Switch 2 is a hard-wired input to the Powertrain Control Module (PCM). The switch receives a 5.0 volt signal from the PCM through an internal pull up resistor. When the ajar switch is open the signal passes through the internal resistor and the resistance through the switch should be approximately 1000 Ohms. When the ajar switch is closed the signal passes directly through the switch to the return circuit with no resistance. The resistor inside the Hood Ajar Switch allows the PCM the ability to detect the hood ajar status and diagnose the signal for an open condition. The PCM is not able to detect a short low in the signal since this would be the same input as hood ajar. This failure mode would be detected by the rationality fault that compares the signal to the Hood Ajar Switch 1 signal received over the Can Bus from the Body Control Module (BCM).



Technical Data:

Parameter	Nominal
Rsc	499 ohms
Roc	499 ohms
Rpu	1100 ohms
Reference voltage	5.0v DC
Protection	Short to Ground/Short to Battery
Detection	Short to Ground/Open Circuit/Short to Battery

DIAGNOSTIC OVERVIEW - HOOD AJAR SWITCHES

The Powertrain Control Module (PCM) must see both Hood Ajar Switches in the open state (hood closed) for the Remote Start and Engine Stop/Start (ESS) systems to operate. The switch states should always match if both switches are functioning properly.

- If the vehicle has a performance or correlation fault, start by determining which switch is not reading the hood states (ajar/not ajar) properly. Use one of the following methods to verify both Hood Ajar Switch states.

- Read the scan tool data reads.
- Measure the resistance through each switch in both states (switch open/closed).
- Check the voltage on the signal circuit in each state.

Use the technical data information provided in the Component Functional Description and Operation to determine which Hood Switch is reading incorrectly and diagnose the switch and wiring accordingly.

- Typically a performance fault against Hood Ajar Switch 2, or a correlation fault is due to the **total resistance** of a switch or circuitry drifting out of range. On vehicles where Hood Ajar Switch 2 has only the one internal resistor used to detect the **open switch state** , a short to ground in the signal circuit would be interpreted as a closed switch state (hood ajar) at all times by the PCM. This would cause a correlation fault when the hood is closed/not ajar.
- Circuit Low/High faults against one of the Hood Ajar Switches are typically due to an open or short in the switch or wiring.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
- Engine Stop/Start (ESS) is enabled.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Hood Ajar Switch 2 signal voltage is below the minimum calibrated threshold.

DEFAULT ACTION

- The MIL will illuminate.
- ESS is disabled while the DTC is present.
- The engine will start if not running when the DTC sets.

POSSIBLE CAUSES

Possible Causes
HOOD AJAR SWITCH 2 SIGNAL CIRCUIT SHORT TO GROUND
HOOD AJAR SWITCH 2 SIGNAL CIRCUIT SHORT TO SENSOR GROUND CIRCUIT
HOOD AJAR SWITCH 2
POWERTRAIN CONTROL MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.

6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE HOOD AJAR SWITCH 2 CONNECTOR AND TERMINALS**
    1. Turn the ignition off.
    2. Check the Hood Ajar Switch 2 harness connector for proper connection at the Hood Ajar Switch 2.
    3. Verify that the connector is completely plugged in and properly locked prior to disconnecting.
    4. Disconnect the Hood Ajar Switch 2 harness connector and check for any pushed out, damaged or spread terminals.

    Were any issues found with the connector or terminals?

    Yes

    - Repair the damaged terminal or properly connect and lock the Hood Ajar Switch 2 harness connector and retest for DTCs.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

3. **CHECK THE HOOD AJAR SWITCH 2 FOR PROPER FUNCTION**
    1. Check the Hood Ajar Switch 2 functionality. Use the Hood Ajar Switch 2 diagnostic and technical information provided above.

    Is the Hood Ajar Switch 2 functioning properly?

    Yes

    - Go To 4

    No

    - Replace the Hood Ajar Switch 2 in accordance with the Service Information.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE HOOD AJAR SWITCH 2 (K806) SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.

4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **ISOLATE AND CHECK THE HOOD AJAR SWITCH 2 (K806) SIGNAL CIRCUIT FOR A SHORT TO THE (K917) SENSOR GROUND CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

NOTE: **There should be no continuity between the circuits being tested.**

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.

- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P152E-ENGINE HOOD SWITCH 2 CIRCUIT HIGH

For a complete VEHICLE THEFT SECURITY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) monitors the hood ajar status of both hood ajar switches on Plug-in Hybrid Electric Vehicles (PHEV) and Electronic Stop/Start (ESS) equipped vehicles for proper operation. Hood Ajar Switch 1 is hard-wired to the Body Control Module (BCM). The signal is sent to the PCM over the CAN Bus. Hood Ajar Switch 2 is hard-wired to the PCM. If the PCM detects that either switch is in the open position or is faulted for any reason during a normal drive cycle, ESS will be disabled for the remainder of the drive cycle. This condition will cause the engine to default to a running state on both PHEV and ESS equipped vehicles. If Hood Ajar Switch 2 is faulted or in the open state it will also cause the Remote Start feature to be inoperative.

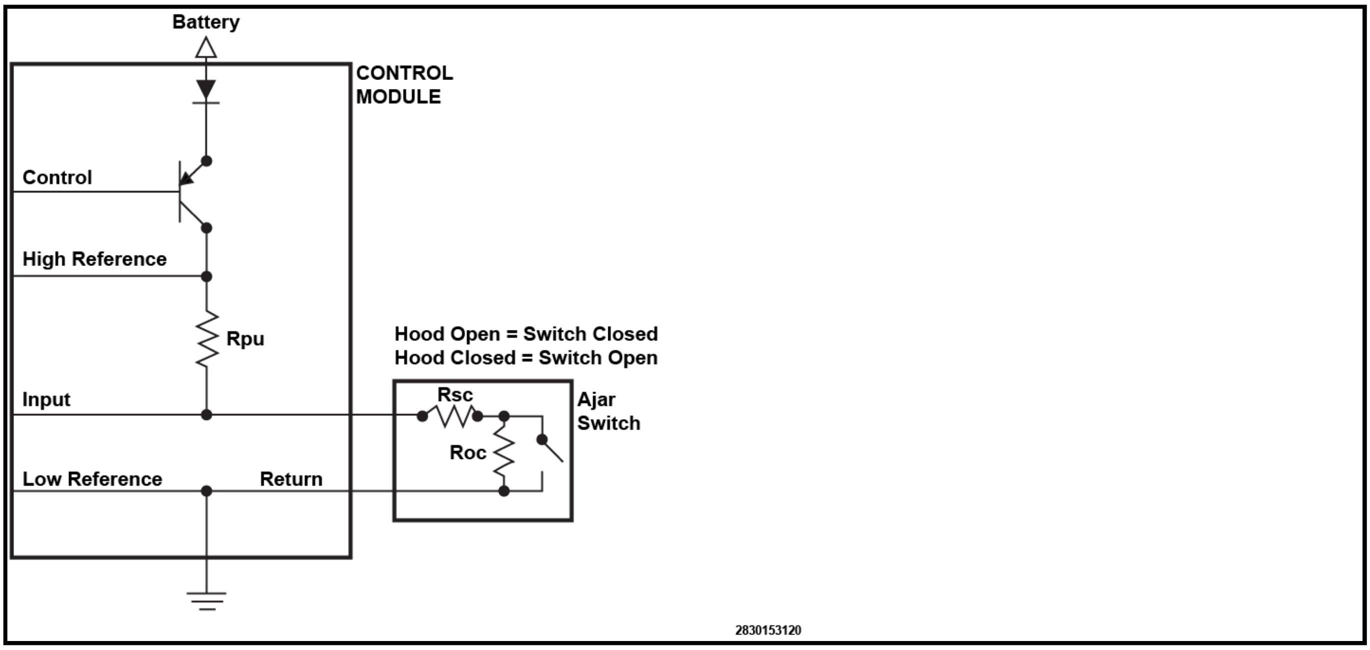
For additional information on the effect of this DTC to the operation of ESS, proceed to the **ENGINE START/STOP (ESS) INOPERATIVE.** . Refer to **ENGINE STOP/START (ESS) SYSTEM INOPERATIVE** .

COMPONENT FUNCTIONAL DESCRIPTION - HOOD LATCH/AJAR SWITCH 1

Component Functional Operation: The Hood Ajar Switch 1 is a hard-wired input to the Body Control Module (BCM). For most vehicles it is integrated as part of the Hood Latch assembly. If it is incorporated into the latch assembly there will be an electrical connector on the latch assembly. If the latch does not have an electrical connector, there should be a 2nd plunger switch under the hood. The Hood Ajar Switch 1 receives a Battery voltage signal from the BCM through an internal pull up resistor. When the ajar switch is open the signal passes through both internal resistors and the resistance through the switch should be approximately 1000 Ohms. When the switch is closed the signal passes through only the Rsc resistor and the resistance through the switch should be approximately 500 Ohms.

Technical Data:

Parameter	Nominal	B
Rsc	499 ohms	
Roc	499 ohms	
Rpu	1100 ohms	
Signal reference voltage	Battery/system voltage	
Protection	Short to Ground/Short to Battery	
Detection	Short to Ground/Open Circuit/Short to Battery	



The BCM monitors the Hood Ajar Switch 1 signal circuit and converts the voltage signal into counts to broadcast over the CAN Bus network.

- Electronic Control Modules read an analog signal voltage and converts it to digital counts. Each count is an equal percentage of the signal reference voltage. This can be seen when viewing some sensor or switch voltages and converted values on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts to a Battery voltage reference.
- The resolution of the signal (number of counts) is determined by the required precision of the input by the ECU. Typically, sensor signals are high resolution. This allows the module to read small changes over a wide range in a variable resistance sensor signal. These are typically used on a temperature, pressure, position or MUX type of sensor.
- Switches on the other hand are usually of much lower resolution than sensors. This is because an ECU is generally looking for a switch to be in only a few positions that use fixed resistors. The lower resolution also helps the ECU to overcome some resistance in a circuit and still read the correct state. This also lowers the sensitivity to setting DTCs.

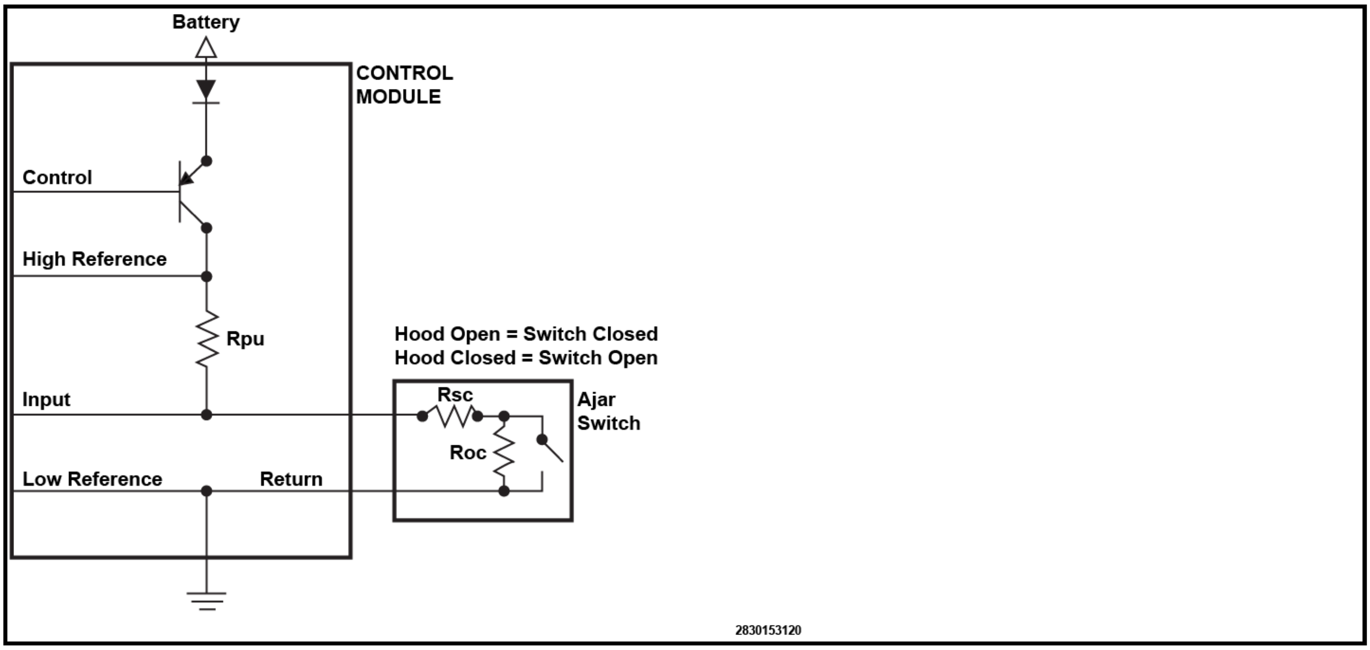
The Hood Ajar Switch 1 signal voltage is typically divided into 15 counts. The table below shows the relation between for the Hood Ajar Switch 1 states. The voltage ranges given are based on a nominal reference voltage of 13.5 volts. The counts and percentage of Battery voltage will remain constant, but the signal voltage will vary as actual Battery voltage changes.

- Using the following method to convert the actual Hood Ajar Switch 1 signal voltage to a percentage of Battery voltage. (Hood Ajar Switch 1 signal voltage / Battery voltage value = % of Battery voltage).
- Examples: (4.7v signal / 14.2v Battery = 33%) 5 counts. (6.7v signal / 12.6v Battery = 53%) 8 counts

VOLTAGE PERCENTAGE/VALUE TO HOOD STATE					
Count Level	**Signal State**	**Signal Voltage @ 13.5 volts nominal**	**Percentage of Battery Voltage**	**Fault Code**	
0 - 2	Circuit Shorted Low	Below 1.8v	0 - 13%	P257E	
3 - 6	Ajar	2.7v - 4.5v	20 - 33%	Normal operating range	B B
7- 10	Not Ajar	5.4v - 8.9v	40 - 66%		B B
11 - 15	Circuit Shorted High/Open	Above 9.0v	73 - 100%	P257F	

COMPONENT FUNCTIONAL DESCRIPTION - HOOD LATCH/AJAR SWITCH 2

Component Functional Operation: The Hood Ajar Switch 2 is a hard-wired input to the Powertrain Control Module (PCM). The switch receives a 5.0 volt signal from the PCM through an internal pull up resistor. When the ajar switch is open the signal passes through the internal resistor and the resistance through the switch should be approximately 1000 Ohms. When the ajar switch is closed the signal passes directly through the switch to the return circuit with no resistance. The resistor inside the Hood Ajar Switch allows the PCM the ability to detect the hood ajar status and diagnose the signal for an open condition. The PCM is not able to detect a short low in the signal since this would be the same input as hood ajar. This failure mode would be detected by the rationality fault that compares the signal to the Hood Ajar Switch 1 signal received over the Can Bus from the Body Control Module (BCM).



Technical Data:

Parameter	Nominal
Rsc	499 ohms
Roc	499 ohms
Rpu	1100 ohms
Reference voltage	5.0v DC
Protection	Short to Ground/Short to Battery

Parameter	Nominal
Detection	Short to Ground/Open Circuit/Short to Battery

DIAGNOSTIC OVERVIEW - HOOD AJAR SWITCHES

The Powertrain Control Module (PCM) must see both Hood Ajar Switches in the open state (hood closed) for the Remote Start and Engine Stop/Start (ESS) systems to operate. The switch states should always match if both switches are functioning properly.

- If the vehicle has a performance or correlation fault, start by determining which switch is not reading the hood states (ajar/not ajar) properly. Use one of the following methods to verify both Hood Ajar Switch states.
  - Read the scan tool data reads.
  - Measure the resistance through each switch in both states (switch open/closed).
  - Check the voltage on the signal circuit in each state.

  Use the technical data information provided in the Component Functional Description and Operation to determine which Hood Switch is reading incorrectly and diagnose the switch and wiring accordingly.
- Typically a performance fault against Hood Ajar Switch 2, or a correlation fault is due to the **total resistance** of a switch or circuitry drifting out of range. On vehicles where Hood Ajar Switch 2 has only the one internal resistor used to detect the **open switch state** , a short to ground in the signal circuit would be interpreted as a closed switch state (hood ajar) at all times by the PCM. This would cause a correlation fault when the hood is closed/not ajar.
- Circuit Low/High faults against one of the Hood Ajar Switches are typically due to an open or short in the switch or wiring.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on
- Engine Stop/Start (ESS) is enabled

SET CONDITION

- The PCM detects that the Hood Ajar Switch 2 voltage is above 4.9 volts for 0.32 seconds.

DEFAULT ACTION

- This is a Non-MIL fault.
- The stop/start feature will be disabled when this DTC is active.
- The engine will start if not running when the DTC sets.

POSSIBLE CAUSES

Possible Causes
HOOD AJAR SWITCH 2 SIGNAL CIRCUIT OPEN
SENSOR GROUND CIRCUIT OPEN
HOOD AJAR SWITCH 2
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE HOOD AJAR SWITCH 2 CONNECTOR AND TERMINALS**
    1. Turn the ignition off.
    2. Check the Hood Ajar Switch 2 harness connector for proper connection at the Hood Ajar Switch 2.
    3. Verify that the connector is completely plugged in and properly locked prior to disconnecting.
    4. Disconnect the Hood Ajar Switch 2 harness connector and check for any pushed out, damaged or spread terminals.

    Were any issues found with the connector or terminals?

    Yes

    - Repair the damaged terminal or properly connect and lock the Hood Ajar Switch 2 harness connector and retest for DTCs.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 3
3. **CHECK THE HOOD AJAR SWITCH 2 FOR PROPER FUNCTION**
    1. Check the Hood Ajar Switch 2 functionality. Use the Hood Ajar Switch 2 diagnostic and technical information provided above.

    Is the Hood Ajar Switch 2 functioning properly?

    Yes

    - Go To 4

    No

    - Replace the Hood Ajar Switch 2 in accordance with the Service Information.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE HOOD AJAR SWITCH 2 (K806) POSITION SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 5

    No

    - Repair the circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND CHECK THE (K917) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 6

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P152F-ENGINE HOOD SWITCH 2 / ENGINE HOOD SWITCH 1 CORRELATION

For a complete VEHICLE THEFT SECURITY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) monitors the hood ajar status of both hood ajar switches on Plug-in Hybrid Electric Vehicles (PHEV) and Electronic Stop/Start (ESS) equipped vehicles for proper operation. Hood Ajar Switch 1 is hard-wired to the Body Control Module (BCM). The signal is sent to the PCM over the CAN Bus. Hood Ajar Switch 2 is hard-wired to the PCM. If the PCM detects that either switch is in the open position or is faulted for any reason during a normal drive cycle, ESS will be disabled for the remainder of the drive cycle. This condition will cause the engine to default to a running state on both PHEV and ESS equipped vehicles. If Hood Ajar Switch 2 is faulted or in the open state it will also cause the Remote Start feature to be inoperative.

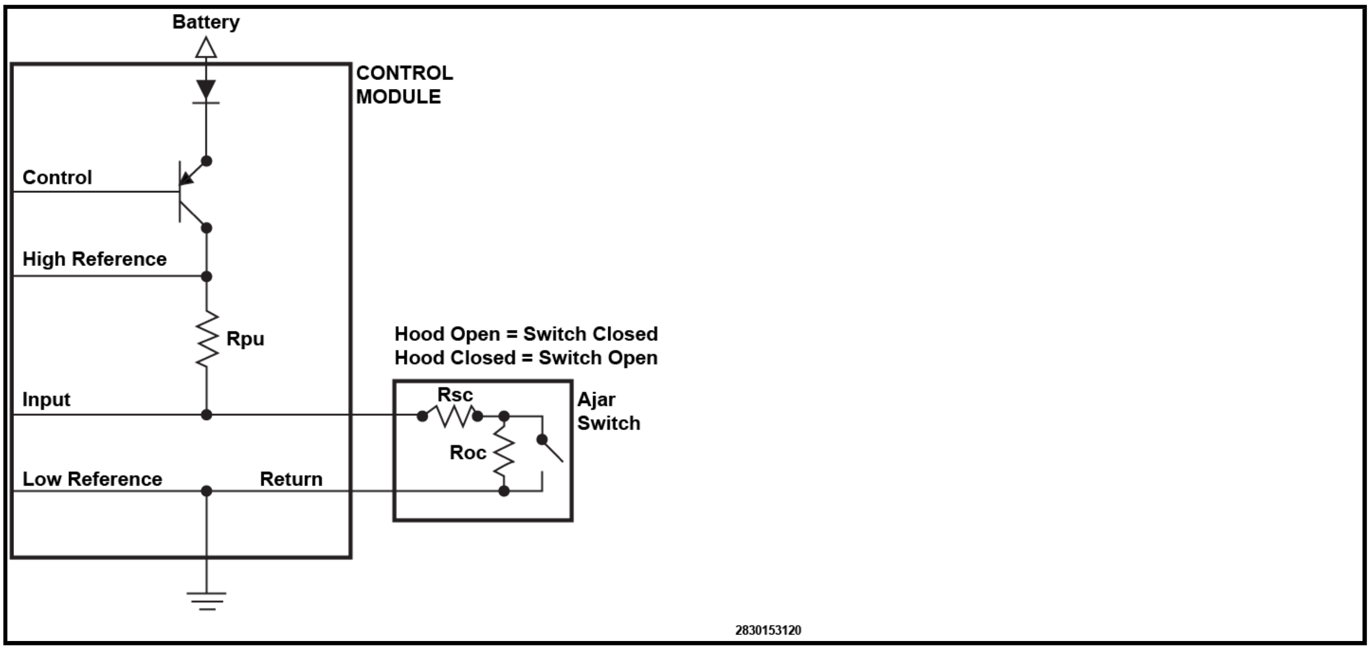
For additional information on the effect of this DTC to the operation of ESS, proceed to the **ENGINE START/STOP (ESS) INOPERATIVE.** . Refer to **ENGINE STOP/START (ESS) SYSTEM INOPERATIVE** .

COMPONENT FUNCTIONAL DESCRIPTION - HOOD LATCH/AJAR SWITCH 1

Component Functional Operation: The Hood Ajar Switch 1 is a hard-wired input to the Body Control Module (BCM). For most vehicles it is integrated as part of the Hood Latch assembly. If it is incorporated into the latch assembly there will be an electrical connector on the latch assembly. If the latch does not have an electrical connector, there should be a 2nd plunger switch under the hood. The Hood Ajar Switch 1 receives a Battery voltage signal from the BCM through an internal pull up resistor. When the ajar switch is open the signal passes through both internal resistors and the resistance through the switch should be approximately 1000 Ohms. When the switch is closed the signal passes through only the Rsc resistor and the resistance through the switch should be approximately 500 Ohms.

Technical Data:

Parameter	Nominal	B
Rsc	499 ohms	
Roc	499 ohms	
Rpu	1100 ohms	
Signal reference voltage	Battery/system voltage	
Protection	Short to Ground/Short to Battery	
Detection	Short to Ground/Open Circuit/Short to Battery	



The BCM monitors the Hood Ajar Switch 1 signal circuit and converts the voltage signal into counts to broadcast over the CAN Bus network.

- Electronic Control Modules read an analog signal voltage and converts it to digital counts. Each count is an equal percentage of the signal reference voltage. This can be seen when viewing some sensor or switch voltages and converted values on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc.). The signal voltage could be anywhere from 5.0 volts to a Battery voltage reference.
- The resolution of the signal (number of counts) is determined by the required precision of the input by the ECU. Typically, sensor signals are high resolution. This allows the module to read small changes over a wide range in a variable resistance sensor signal. These are typically used on a temperature, pressure, position or MUX type of sensor.
- Switches on the other hand are usually of much lower resolution than sensors. This is because an ECU is generally looking for a switch to be in only a few positions that use fixed resistors. The lower resolution also helps the ECU to overcome some resistance in a circuit and still read the correct state. This also lowers the sensitivity to setting DTCs.

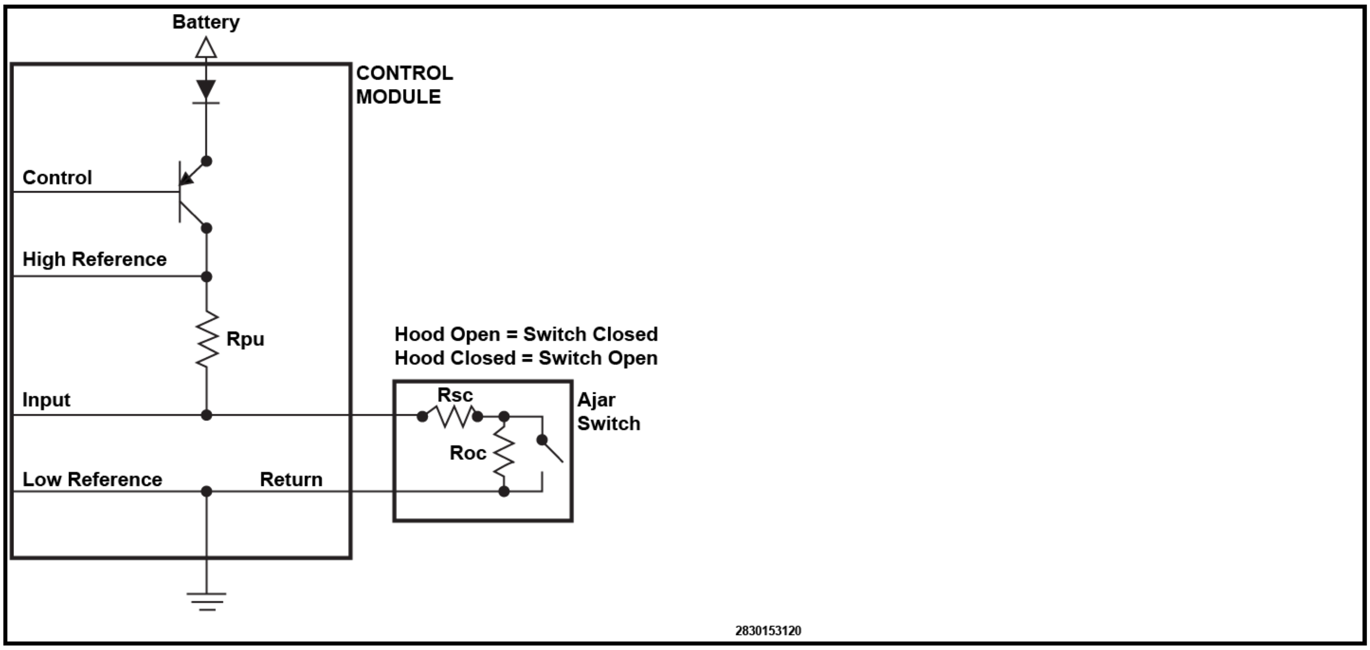
The Hood Ajar Switch 1 signal voltage is typically divided into 15 counts. The table below shows the relation between for the Hood Ajar Switch 1 states. The voltage ranges given are based on a nominal reference voltage of 13.5 volts. The counts and percentage of Battery voltage will remain constant, but the signal voltage will vary as actual Battery voltage changes.

- Using the following method to convert the actual Hood Ajar Switch 1 signal voltage to a percentage of Battery voltage. (Hood Ajar Switch 1 signal voltage / Battery voltage value = % of Battery voltage).
- Examples: (4.7v signal / 14.2v Battery = 33%) 5 counts. (6.7v signal / 12.6v Battery = 53%) 8 counts

VOLTAGE PERCENTAGE/VALUE TO HOOD STATE					
Count Level	**Signal State**	**Signal Voltage @ 13.5 volts nominal**	**Percentage of Battery Voltage**	**Fault Code**	
0 - 2	Circuit Shorted Low	Below 1.8v	0 - 13%	P257E	
3 - 6	Ajar	2.7v - 4.5v	20 - 33%	Normal operating range	B B
7- 10	Not Ajar	5.4v - 8.9v	40 - 66%		B B
11 - 15	Circuit Shorted High/Open	Above 9.0v	73 - 100%	P257F	

COMPONENT FUNCTIONAL DESCRIPTION - HOOD LATCH/AJAR SWITCH 2

Component Functional Operation: The Hood Ajar Switch 2 is a hard-wired input to the Powertrain Control Module (PCM). The switch receives a 5.0 volt signal from the PCM through an internal pull up resistor. When the ajar switch is open the signal passes through the internal resistor and the resistance through the switch should be approximately 1000 Ohms. When the ajar switch is closed the signal passes directly through the switch to the return circuit with no resistance. The resistor inside the Hood Ajar Switch allows the PCM the ability to detect the hood ajar status and diagnose the signal for an open condition. The PCM is not able to detect a short low in the signal since this would be the same input as hood ajar. This failure mode would be detected by the rationality fault that compares the signal to the Hood Ajar Switch 1 signal received over the Can Bus from the Body Control Module (BCM).



Technical Data:

Parameter	Nominal
Rsc	499 ohms
Roc	499 ohms
Rpu	1100 ohms
Reference voltage	5.0v DC
Protection	Short to Ground/Short to Battery
Detection	Short to Ground/Open Circuit/Short to Battery

DIAGNOSTIC OVERVIEW - HOOD AJAR SWITCHES

The Powertrain Control Module (PCM) must see both Hood Ajar Switches in the open state (hood closed) for the Remote Start and Engine Stop/Start (ESS) systems to operate. The switch states should always match if both switches are functioning properly.

- If the vehicle has a performance or correlation fault, start by determining which switch is not reading the hood states (ajar/not ajar) properly. Use one of the following methods to verify both Hood Ajar Switch states.
    - Read the scan tool data reads.
    - Measure the resistance through each switch in both states (switch open/closed).
    - Check the voltage on the signal circuit in each state.

  Use the technical data information provided in the Component Functional Description and Operation to determine which Hood Switch is reading incorrectly and diagnose the switch and wiring accordingly.

- Typically a performance fault against Hood Ajar Switch 2, or a correlation fault is due to the **total resistance** of a switch or circuitry drifting out of range. On vehicles where Hood Ajar Switch 2 has only the one internal resistor used to detect the **open switch state** , a short to ground in the signal circuit would be interpreted as a closed switch state (hood ajar) at all times by the PCM. This would cause a correlation fault when the hood is closed/not ajar.
- Circuit Low/High faults against one of the Hood Ajar Switches are typically due to an open or short in the switch or wiring.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Engine Stop/Start (ESS) has not been disabled due to a hood switch fault.

SET CONDITION

- The Hood Ajar Switch 1 and Hood Ajar Switch 2 states do not match.

DEFAULT ACTION

- The MIL will illuminate.
- ESS is disabled while the DTC is present.
- The engine will start if not running when the DTC sets.

POSSIBLE CAUSES

Possible Causes
HOOD NOT SECURED PROPERLY
HOOD AJAR SWITCH 2 SIGNAL CIRCUIT SHORTED TO GROUND
HIGH RESISTANCE IN THE HOOD AJAR SWITCH 1 SENSE CIRCUIT
HIGH RESISTANCE IN THE HOOD AJAR SWITCH 1 SENSOR GROUND CIRCUIT
DEFECTIVE OR STICKING ENGINE HOOD SWITCH 1 (HOOD LATCH)
DEFECTIVE OR STICKING ENGINE HOOD SWITCH 2
BODY CONTROL MODULE (BCM)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **VERIFY THAT THE HOOD IS SECURED PROPERLY**
   1. Visually inspect that the Hood is secured properly. Also inspect the Hood Ajar Switch and Hood Latch Assembly for proper installation.

      Were any problems found?

      Yes

      - Perform the appropriate repair.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 3
3. **CHECK THE HOOD AJAR SWITCH INPUTS**
   1. Monitor the Hood Ajar Switch 1 and Hood Ajar Switch 2 states on the scan tool to determine which switch is no changing properly.

      Which Hood Ajar Switch is not reading properly?

      Hood Ajar Switch 1

      - Go To 4

      Hood Ajar Switch 2

      - Go To 9
4. **CHECK THE HOOD AJAR SWITCH 1 CONNECTOR AND TERMINALS**
   1. Turn the ignition off.
   2. Check the Hood Ajar Switch 1 harness connector for proper connection at the Hood Latch Assembly.
   3. Verify that the connector is completely plugged in and properly locked prior to disconnecting.
   4. Disconnect the Hood Ajar Switch 1 harness connector and check for any pushed out, damaged or spread terminals.

      Were any issues found with the connector or terminals?

      Yes

      - Repair the damaged terminal or properly connect and lock the Hood Ajar Switch 1 harness connector and retest for DTCs.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

- Go To 5

5. **CHECK THE HOOD AJAR SWITCH 1 FOR PROPER FUNCTION**
    1. Check the Hood Ajar Switch 1 functionality. Use the Hood Ajar Switch 1 diagnostic and technical information provided above.

       Is the Hood Ajar Switch 1 functioning properly?

       Yes

       - Go To 6

       No

       - Replace the Hood Latch Assembly in accordance with the Service Information.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
6. **ISOLATE AND CHECK THE HOOD AJAR SWITCH 1 (G70) SENSE CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the ECU harness connector and measure the resistance of the circuit.

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 7

    No

    - Repair the circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
7. **ISOLATE AND CHECK THE HOOD AJAR SWITCH 1 (G931) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the ECU harness connector and measure the resistance of the circuit.

    Is the resistance below 3.0 Ohms?

    Yes

- Go To 8

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK RELATED BCM AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Body Control Module (BCM) in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM), REMOVAL AND INSTALLATION** .
        - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .
9. **CHECK THE HOOD AJAR SWITCH 2 FOR PROPER FUNCTION**
    1. Check the Hood Ajar Switch 2 functionality. Use the Hood Ajar Switch 2 diagnostic and technical information provided above.

Is the Hood Ajar Switch 2 functioning properly?

Yes

- Go To 10

No

- Replace the Hood Ajar Switch 2 in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **ISOLATE AND CHECK THE HOOD AJAR SWITCH 2 (K806) POSITION SIGNAL CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between ground and the circuit being tested.**

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground or short to the sensor ground circuit. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 11

11. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.

- Corrosion.
- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1572-BRAKE PEDAL STUCK ON

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
  - During In plant testing, the Brake Switch is tested to verify that both switches behave correctly.

SET CONDITION

- The Powertrain Control Module (PCM) determines that the Brake Pedal could not electrically indicate the not applied (OFF) position.

DEFAULT ACTION

- ETC light will illuminate.

POSSIBLE CAUSES

Possible Causes
BRAKE PEDAL POSITION SENSOR OUT OF ADJUSTMENT OR IMPROPERLY INSTALLED
BRAKE PEDAL POSITION (BPP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK THE BRAKE PEDAL POSITION SENSOR INSTALLATION**

   NOTE: **This diagnostic is used for in-plant testing only to verify that the BPP Sensor operates correctly.**

   1. Check the Brake Pedal Position Sensor for proper installation and adjustment.

      Is the Brake Pedal Position Sensor installed properly?

      Yes

      - Go To 2

      No

      - Remove and reinstall the Brake Pedal Position Sensor correctly. Erase the DTC. If the DTC will not clear, Go To 2
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
2. **REPLACE THE BRAKE PEDAL POSITION SENSOR AND CHECK DTCS**
   1. Replace the Brake Pedal Position Sensor in accordance with the Service Information. Refer to **SENSOR, STOP LAMP, REMOVAL AND INSTALLATION** .
   2. Operate the vehicle within the conditions that originally set the DTC or use the When Monitored and Set Conditions.
   3. With the scan tool, read DTCs.

      Did the DTC return?

      Yes

      - Go To 3

      No

      - Replacing the Brake Pedal Position Sensor repaired the fault.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
3. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.

5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1573-BRAKE PEDAL STUCK OFF

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
    - During In plant testing, the Brake Switch is tested to verify that both switches behave correctly.

SET CONDITION

- The Powertrain Control Module (PCM) determines that the Brake Pedal could not electrically indicate the not applied (OFF) position.

DEFAULT ACTION

- ETC light will illuminate.

POSSIBLE CAUSES

Possible Causes
BRAKE PEDAL POSITION SENSOR OUT OF ADJUSTMENT OR IMPROPERLY INSTALLED
BRAKE PEDAL POSITION (BPP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK THE BRAKE PEDAL POSITION SENSOR INSTALLATION**

   NOTE: **This diagnostic is used for in-plant testing only to verify that the BPP Sensor operates correctly.**

   1. Check the Brake Pedal Position Sensor for proper installation and adjustment.

      Is the Brake Pedal Position Sensor installed properly?

      Yes

      - Go To 2

      No

      - Remove and reinstall the Brake Pedal Position Sensor correctly. Erase the DTC. If the DTC will not clear, Go To 2
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
2. **REPLACE THE BRAKE PEDAL POSITION SENSOR AND CHECK DTCS**
   1. Replace the Brake Pedal Position Sensor in accordance with the Service Information. Refer to **SENSOR, STOP LAMP, REMOVAL AND INSTALLATION** .
   2. Operate the vehicle within the conditions that originally set the DTC or use the When Monitored and Set Conditions.
   3. With the scan tool, read DTCs.

      Did the DTC return?

      Yes

      - Go To 3

      No

      - Replacing the Brake Pedal Position Sensor repaired the fault.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
3. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**

1. Perform any Service Bulletins that apply.
2. Disconnect all PCM harness connectors.
3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1593-SPEED CONTROL SWITCH 1/2 STUCK

For a complete SPEED CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Speed Control Switch is hard-wired to the Steering Column Control Module (SCCM). The SCCM includes the steering column shroud, Steering Angle Sensor (SAS), Clockspring, Multi-function Switch, Steering

Column Power Tilt and Telescope Switch (if equipped), and a trim cover. The SCCM is located near the top of the steering column below the steering wheel. The Speed Control Switch voltage inputs and SAS messages are bussed to the Powertrain Control Module (PCM) via the CAN Bus.

WHEN MONITORED

- Continuously with the ignition on.

SET CONDITION

- The switch voltage does not register a valid cruise position.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
SPEED CONTROL SWITCH

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **INSPECT THE WIRING HARNESS AND CONNECTORS BETWEEN THE SPEED CONTROL SWITCH AND STEERING COLUMN CONTROL MODULE (SCCM)**

    WARNING: **Turn the ignition off disconnect the 12-volt battery and wait two minutes before proceeding. Failure to follow these instructions may result in possible serious or fatal injury.**

WARNING: **Do not place an intact non-deployed airbag face down on a hard surface, the airbag propels into the air if accidentally deployed. Failure to follow these instructions may result in possible serious or fatal injury.**

1. Turn the ignition off.
2. Visually inspect the wiring harness between the Speed Control Switch harness connector and the SCCM harness connector for physical damage. Check for damaged wires, connectors, and open/spread terminals.

   Were any issues found with the harness or connectors?

   Yes

   - Repair the damage to the wiring harness or connector in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 3

3. **CHECK THE SPEED CONTROL SWITCH FOR PROPER OPERATION**
   1. Replace the Speed Control Switch in accordance with the Service Information. Refer to **SWITCH, SPEED CONTROL, REMOVAL AND INSTALLATION** .
   2. Turn the ignition on.
   3. Move the Speed Control Switch to each position several times.
   4. With the scan tool, read DTCs.

      Does the scan tool display this DTC as active?

      Yes

      - Replace the Steering Column Control Module (SCCM) in accordance with the Service Information. Refer to **MODULE, STEERING COLUMN CONTROL (SCCM), REMOVAL AND INSTALLATION** .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Replacing the Speed Control Switch repaired the fault. Test Complete.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1609-INTERNAL CONTROL MODULE ENGINE OIL TEMPERATURE PERFORMANCE

WHEN MONITORED

This diagnostic runs continuously when the following condition is met:

- With the ignition on.

SET CONDITION

- When secondary software determines that the Engine Oil Temperature is implausible for a period of time.

DEFAULT ACTION

- The MIL will illuminate.
- ETC lamp will flash.
- Acceleration rate and engine output are limited (Vehicle in Limp mode).

POSSIBLE CAUSES

Possible Causes
PCM SOFTWARE UPDATE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE DTC**

   WARNING: When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.

   1. Turn the ignition on.
   2. With the scan tool, erase DTCs in the Powertrain Control Module (PCM).
   3. Start the engine and allow it to reach operating temperature.
   4. Increase engine speed by pressing the accelerator pedal. Do not exceed 3500 rpm.
   5. With the scan tool, read DTCs.

      Is the DTC active or pending?

      Yes

      - Go To 2

      No

      - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any other DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3
3. **CHECK FOR PCM SOFTWARE UPDATE**
   1. With the scan tool, read and record the PCM part number.
   2. Verify the Powertrain Control Module (PCM) is at the latest calibration (flash level). If not at the latest flash level, update the Powertrain Control Module (PCM) in accordance with the Service

Information. Refer to the appropriate information .

WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

3. Turn the ignition on.
4. With the scan tool, erase DTCs in the PCM.
5. Start the engine and allow it to idle.
6. Operate the accelerator pedal by gradually tipping in and out of the throttle and performing various throttle maneuvers. Do not exceed 3500 rpm.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 4

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

4. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.

11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1618-SENSOR REFERENCE VOLTAGE 1 CIRCUIT ERRATIC

NOTE: **Improperly installed aftermarket accessories can cause this DTC to set. Check for any improperly installed aftermarket accessories before continuing with this test.**

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- When the Powertrain Control Module (PCM) recognizes the Primary 5-Volt Supply circuit voltage is varying too much too quickly.

DEFAULT ACTION

- The MIL will illuminate.
- ETC light will flash.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT INTERMITTENTLY SHORTED TO GROUND
5-VOLT SUPPLY CIRCUIT INTERMITTENTLY SHORTED TO VOLTAGE
5-VOLT SUPPLY CIRCUIT INTERMITTENTLY OPEN
CRANKSHAFT POSITION (CMP) SENSOR
ENGINE OIL PRESSURE (EOP) SENSOR
THROTTLE BODY ASSEMBLY
A/C PRESSURE TRANSDUCER
ACCELERATOR PEDAL POSITION (APP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN INTERMITTENT CONNECTION IN THE ENGINE WIRING HARNESS**

NOTE: **Diagnose any active or pending Sensor Reference High or Sensor Reference Low DTCs before proceeding with this test procedure. If this DTC is present without an active or pending Sensor Reference High or Sensor Reference Low DTC, the most likely cause is an intermittent open or short circuit in the wiring harness between the engine and the PCM.**

1. Turn the ignition off.
2. Disconnect the Throttle Body Assembly harness connector.
3. Connect a voltmeter to the (F855) 5-Volt Supply circuit at the Throttle Body Assembly harness connector.

   NOTE: **Make sure that there is a good positive connection between the voltmeter lead and the Throttle Body Assembly terminal since we are looking for an intermittent connection.**

4. Turn the ignition on.
5. While monitoring the voltage reading on the voltmeter, wiggle test the entire engine wiring harness all the way to the PCM.

   NOTE: **Look for any quick changes in the voltmeter reading. The voltmeter should read steady 5.0 volts +/-.01 or.02 volts with the Throttle Body Assembly harness connector unplugged.**

   Did the voltmeter reading change from 5.0 volts at any time while wiggle testing the wiring?

   Yes

   - Repair the (F855) 5-Volt Supply circuit for an intermittent open or short circuit in the wiring harness. Make sure to check all of the in-line connectors for poor connections or spread terminals.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 2

2. **CHECK FOR AN INTERMITTENT CONNECTION IN THE APP WIRING HARNESS**
   1. Turn the ignition off.
   2. Disconnect the APP Sensor harness connector.
   3. Connect a voltmeter to the (K852) 5-Volt Supply circuit at the APP Sensor harness connector.
   4. Turn the ignition on.
   5. While monitoring the voltage reading on the voltmeter, wiggle test the wiring harness between the APP Sensor and the PCM.

   Did the voltmeter reading change from 5.0 volts at any time while wiggle testing the wiring?

   Yes

   - Repair the (K852) 5-Volt Supply circuit for an intermittent open or short circuit in the wiring harness. Make sure to check all of the in-line connectors for poor connections or spread terminals.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

- Go To 3

3. **CHECK THE PRIMARY SENSORS**
    1. Turn the ignition off.
    2. Reconnect the Throttle Body harness connector.
    3. Reconnect the APP Sensor harness connector.
    4. Disconnect the PCM C2 harness connector and connect the (special tool #10436, Adapter, GPEC Diagnostic) in-line with the PCM C2 harness connector.
    5. Connect a voltmeter to the (F855) 5-Volt Supply circuit at the GPEC Adaptor.
    6. Turn the ignition on.
    7. While monitoring the voltage reading on the voltmeter, lightly tap on each sensor listed in the possible causes table.

        Did the voltmeter reading change from 5.0 volts at any time while tapping on one of the sensors?

        Yes

        - Replace the sensor that caused the voltage to change.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 4

4. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.

10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1628-SENSOR REFERENCE VOLTAGE 2 CIRCUIT ERRATIC

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) recognizes the Secondary 5-Volt Supply circuit voltage is varying much too quickly.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will flash.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT INTERMITTENTLY SHORTED TO GROUND
5-VOLT SUPPLY CIRCUIT INTERMITTENTLY SHORTED TO VOLTAGE
5-VOLT SUPPLY CIRCUIT INTERMITTENTLY OPEN
MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR
CAMSHAFT POSITION (CMP) SENSOR
CAMSHAFT POSITION (CMP) SENSOR 2
ACCELERATOR PEDAL POSITION (APP) SENSOR
FUEL RAIL PRESSURE SENSOR (FRPS)
EXHAUST GAS RECIRCULATION (EGR) VALVE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR OTHER DTCS**

NOTE: **Diagnose any active or pending Sensor Reference High or Sensor Reference Low DTCs before proceeding with this test procedure. If this DTC is present without an active or pending Sensor Reference High or Sensor Reference Low DTC, the most likely cause is an intermittent open or short circuit in the wiring harness between the engine and the PCM.**

1. Turn the ignition on.
2. With the scan tool, read DTCs and record on the repair order.

Are there any active or pending Sensor Reference High or Sensor Reference Low DTCs active or pending?

Yes

- Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

No

- Go To 2

2. **CHECK FOR AN INTERMITTENT CONNECTION IN THE ENGINE WIRING HARNESS**

NOTE: **Diagnose any active or pending Sensor Reference High or Sensor Reference Low DTCs before proceeding with this test procedure. If this DTC is present without an active or pending Sensor Reference High or Sensor Reference Low DTC, the most likely cause is an intermittent open or short circuit in the wiring harness between the engine and the PCM.**

1. Turn the ignition off.
2. Disconnect the MAP Sensor harness connector.
3. Connect a voltmeter to the (F856) 5-Volt Supply circuit at the MAP Sensor harness connector.

NOTE: **Make sure that there is a good positive connection between the voltmeter lead and the MAP Sensor harness connector terminal since we are looking for an intermittent connection.**

4. Turn the ignition on.
5. While monitoring the voltage reading on the voltmeter, wiggle test the entire engine wiring harness all the way to the PCM.

NOTE: **Look for any quick changes in the voltmeter reading. The voltmeter should read steady 5.0 volts +/-.01 or.02 volts with the Throttle Body Assembly harness connector unplugged.**

Did the voltmeter reading change from 5.0 volts at any time while wiggle testing the wiring?

Yes

- Repair the (F856) 5-Volt Supply circuit for an intermittent open or short circuit in the wiring harness. Make sure to check all of the in-line connectors for poor connections or spread terminals.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **CHECK FOR AN INTERMITTENT CONNECTION IN THE APP WIRING HARNESS**
    1. Turn the ignition off.
    2. Disconnect the APP Sensor harness connector.
    3. Connect a voltmeter to the (K854) 5-Volt Supply circuit at the APP Sensor harness connector.
    4. Turn the ignition on.
    5. While monitoring the voltage reading on the voltmeter, wiggle test the wiring harness between the APP Sensor and the PCM.

       Did the voltmeter reading change from 5.0 volts at any time while wiggle testing the wiring?

       Yes

       - Repair the (K854) 5-Volt Supply circuit for an intermittent open or short circuit in the wiring harness. Make sure to check all of the in-line connectors for poor connections or spread terminals.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 4
4. **CHECK THE SECONDARY SENSORS FOR AN INTERMITTENT ISSUE**
    1. Turn the ignition off.
    2. Reconnect the MAP Sensor harness connector.
    3. Reconnect the APP Sensor harness connector.
    4. Disconnect the PCM C2 harness connector and connect the (special tool #10436, Adapter, GPEC Diagnostic) in-line with the PCM C2 harness connector.
    5. Connect a voltmeter to the (F856) 5-Volt Supply circuit at the GPEC Adaptor.
    6. Turn the ignition on.
    7. While monitoring the voltage reading on the voltmeter, lightly tap on each sensor listed in the possible causes table.

       Did the voltmeter reading change from 5.0 volts at any time while tapping on one of the sensors?

       Yes

       - Replace the sensor that caused the voltage to change.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 5
5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.

- Damaged connector locks.
- Corrosion.
- Other signs of water intrusion.
- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1684-BATTERY WAS DISCONNECTED

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- When the engine speed goes above idle speed a bit sets to the run diagnostic.

SET CONDITION

- If the PCM loses battery power without a proper shutdown sequence during the current key cycle. The fault sets on the next key cycle.

DEFAULT ACTION

- This is a non-MIL fault.

POSSIBLE CAUSES

Possible Causes
PCM LOST BATTERY POWER WITHOUT A PROPER KEY OFF SHUTDOWN SEQUENCE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

CHECK THE BATTERY SUPPLY TO THE PCM FOR AN INTERMITTENT CONNECTION

1. Turn the ignition off.
2. This is an information only DTC indicating that the battery supply was temporarily lost to the PCM. The most likely issue is an intermittent connection in the battery supply circuit or PCM ground circuit issue. All of the following should be carefully checked:
    - Check the terminals for (A908) Fused B+ circuit for a proper connection, pushed out, damaged or spread terminals at the PDC, any in-line and the PCM harness connectors.
    - Check the fuse for proper connection in the PDC. Verify the fuse is not corroded or partially burnt.
    - Verify that the PCM ground circuits have a good chassis ground.

P1696-EEPROM MEMORY WRITE DENIED/INVALID

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Diagnostic also runs at power down.

SET CONDITION

- The Powertrain Control Module (PCM) writes to a Electronically Erasable Programmable Read-Only Memory (EEPROM) location and reads it back to confirm equivalence. Nine consecutive differences causes a failure.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
POWERTRAIN CONTROL MODULE (PCM) SOFTWARE UPDATE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.

3. With the scan tool, erase all DTCs.
4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE POWERTRAIN CONTROL MODULE SOFTWARE LEVEL**
   1. Turn the ignition on.
   2. Verify the PCM is at the latest calibration (flash level).

   Is there an update for the PCM software?

   Yes

   - Go To 3

   No

   - Replace and program the Powertrain Control Module in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
3. **PROGRAM THE POWERTRAIN CONTROL MODULE**
   1. Update the PCM in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), MODULE PROGRAMMING** .
   2. Cycle the ignition off and on.
   3. With a scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 4

   No

   - Updating the PCM software repaired the fault.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
4. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).

4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1697-EMR (SRI) MILEAGE NOT STORED

WHEN MONITORED

This diagnostic runs continuously when the following condition is met:

- With the ignition on.

SET CONDITION

- The odometer mileage has not been programmed into the Powertrain Control Module (PCM).

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
PCM ODOMETER MILEAGE NOT PROGRAMMED
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any other PCM DTCs active or pending?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **CHECK THE POWERTRAIN CONTROL MODULE FOR PROPER SOFTWARE LEVEL**
    1. Turn the ignition on.
    2. Verify the PCM is at the latest calibration (flash level).

        Is there an update for the PCM?

Yes

- Go To 4

No

- Go To 5

4. **PROGRAM THE POWERTRAIN CONTROL MODULE**
    1. Update the PCM in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), MODULE PROGRAMMING** .
    2. Cycle the ignition off and on.
    3. With a scan tool, read DTCs.

    Does this DTC reset by itself?

    Yes

    - Go To 5

    No

    - Updating the PCM software repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.

11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1718-EEPROM INTEGRITY FAILURE

WHEN MONITORED

This diagnostic runs continuously when the following condition is met:

- With the ignition on.
- The diagnostic also runs at power down.

SET CONDITION

- An attempt to program/write to the internal Electronically Erasable Programmable Read-Only Memory (EEPROM) failed.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
POWERTRAIN CONTROL MODULE (PCM) SOFTWARE UPDATE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.

6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any other PCM DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3
3. **CHECK THE POWERTRAIN CONTROL MODULE FOR PROPER SOFTWARE LEVEL**
   1. Turn the ignition on.
   2. Verify the PCM is at the latest calibration (flash level).

      Is there an update for the PCM?

      Yes

      - Go To 4

      No

      - Go To 5
4. **PROGRAM THE POWERTRAIN CONTROL MODULE**
   1. Update the PCM in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), MODULE PROGRAMMING** .
   2. Cycle the ignition off and on.
   3. With a scan tool, read DTCs.

      Does this DTC reset by itself?

      Yes

      - Go To 5

      No

      - Updating the PCM software repaired the fault.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1C4E-ABS DTC PRESENT

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.

- Battery voltage greater than 10.0 volts.

SET CONDITION

- An active DTC is stored in the ABS/ESP Module.

DEFAULT ACTION

- This is a non MIL fault.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
DTC PRESENT IN THE ABS MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

DTC PRESENT IN ANTI-LOCK BRAKE MODULE

1. This is an informational DTC to inform you that a DTC is stored in the Anti-Lock Brake Module.
2. Erase this DTC after all ABS DTCs have been repaired.

   View Repair

   - With the scan tool, read the Anti-Lock Brake Module DTCs and perform the appropriate diagnostic procedure. Refer to ANTILOCK BRAKE SYSTEM (ABS) - DIAGNOSTIC CODE INDEX .

P1D83-IMPLAUSIBLE ENGINE OIL TEMPERATURE SIGNAL RECEIVED

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With engine off time greater than 480 minutes.
- Ambient Air Temperature (AAT) sensor value greater than -7B°C (19.4B°F).

SET CONDITION

- After a calibrated amount of cool down time, the Powertrain Control Module (PCM) compares the AAT, Engine Coolant Temperature (ECT) Sensor, and the Intake Air Temperature (IAT) Sensor values. If the general temperature rationality passes, the PCM compares the Engine Oil Temperature (EOT) Sensor value to a threshold based on the other temperature sensor values. If the difference is greater than a calibrated value, the diagnostic fails.

DEFAULT ACTION

- This is a non-MIL fault.

POSSIBLE CAUSES

Possible Causes
HIGH RESISTANCE IN THE EOT SENSOR SIGNAL CIRCUIT
HIGH RESISTANCE IN THE SENSOR GROUND CIRCUIT

Possible Causes
ENGINE OIL TEMPERATURE (EOT) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **COMPARE THE ENGINE OIL TEMPERATURE (EOT) SENSOR VALUE TO OTHER TEMPERATURE SENSORS**
    1. Turn the ignition off.
    2. Allow the vehicle to sit with the ignition off in an environment where the temperature is consistent and above -7B°C (19.4B°F) until the engine coolant temperature is equal to ambient temperature.
    3. Turn the ignition on.
    4. With the scan tool, compare the EOT sensor value to the AAT, ECT, and IAT Sensor values.

    Is the EOT Sensor value within 10B°C (18B°F) of the other sensor values?

    Yes

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to INTERMITTENT CONDITION .

    No

    - Go To 2
2. **ISOLATE AND CHECK THE EOT SENSOR (G224) PRESSURE SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 3

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **ISOLATE AND CHECK THE (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 4

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE EOT SENSOR (G224) POSITION SIGNAL CIRCUIT FOR PROPER VOLTAGE AT THE EOT SENSOR HARNESS CONNECTOR**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
    3. Turn the ignition on.
    4. Set the DVOM to measure DC voltage.
    5. Connect the negative lead of the DVOM to a known good ground.
    6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE: **Normal operating voltage should be between 4.8 and 5.2 volts.**

Does the circuit have the proper voltage present?

Yes

- Replace the Engine Oil Temperature (EOT) Sensor if no problems were found with the connectors. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1E08-STOP/START DISABLED - AIRBAG DEPLOYMENT

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The Occupant Restraint Controller (ORC) sends a CAN BUS message to the Powertrain Control Module (PCM) indicating that the Airbags have been deployed.

DEFAULT ACTION

- This is a non-MIL fault.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
AIRBAG DEPLOYMENT

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

DTC EXPLANATION

NOTE: **This DTC indicates that the vehicle has been in an accident and the Airbag Module has deployed the Airbags.**

Information only DTC

View repair

- Perform the SERVICE AFTER A SUPPLEMENTAL RESTRAINT SYSTEM DEPLOYMENT service procedure. Refer to **SERVICE AFTER A SUPPLEMENTAL RESTRAINT SYSTEM DEPLOYMENT** .

P1E09-CLOSED LOOP FUELING NOT ACHIEVED - BANK 1 DOWNSTREAM

THEORY OF OPERATION

This continuous diagnostic is used to detect when fuel control has not changed from open loop to closed loop control. A count down timer is initiated at engine start. The length of the timer is based on the starting engine coolant temperature. The timer will decrement as long as the enable conditions are met. Once the timer has expired, the fuel control system is expected to be in closed loop operation. If the fuel control system does not go closed loop within the calibrated time, the diagnostic will fail.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Engine speed between 1100 rpm and 4000 rpm.
- Upstream O2 Sensor(s) in closed loop mode.

SET CONDITION

- A condition exists where the Downstream O2 Sensor has remained in open loop fuel control, from a start-up condition, longer than a calibrated amount of time, when conditions would have otherwise expected closed loop operation.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

POSSIBLE CAUSES
FUEL DELIVERY SYSTEM
MAP SENSOR, WIRING, OR CONNECTORS
DOWNSTREAM O2 SENSOR, WIRING, OR CONNECTORS
ENGINE MECHANICAL SYSTEM
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

   No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any Downstream O2 Sensor or MAP Sensor performance or circuit DTCs active or pending?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 3

3. **CHECK THE O2 SENSOR HEATER OPERATION**
    1. Turn the ignition off.

       NOTE: **Wait a minimum of 10 minutes to allow the O2 Sensor to cool down before continuing the test. Allow the O2 Sensor voltage to stabilize at 5.0 volts.**

    2. Turn the ignition on.
    3. With the scan tool, actuate the O2 Sensor 1/1 Heater Test.
    4. With the scan tool, monitor O2 Sensor 1/1 voltage for at least two minutes.

       Does the voltage stay above 4.5 volts?

       Yes

       - Verify that there is good pin to terminal contact in the O2 Sensor and Powertrain Control Module connectors. If no problems are found, replace the O2 Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 4

4. **CHECK THE O2 SENSOR OPERATION**
    1. Start the engine.
    2. With the scan tool, monitor the O2 Sensor 1/2 reading.

       Is the voltage switching between 2.5 and 3.4 volts?

       Yes

       - Go To 5

       No

       - Check the O2 Sensor terminals for pushed out, corroded or spread terminals and verify that the wires for the O2 Sensor are not open or shorted to ground. If no problems are found, replace the O2 Sensor.

5. **CHECK THE MAP SENSOR OPERATION**

1. Turn the ignition off.
2. Connect a Vacuum Gauge to a Manifold Vacuum source.
3. Start the engine.
4. Allow the engine to idle.

NOTE: **If engine will not idle, maintain a constant rpm above idle.**

5. With the scan tool, read the MAP Sensor vacuum value.

Is the scan tool reading within one inch of Hg as compared to the Vacuum Gauge reading?

Yes

- Go To 6

No

- Verify that there is good pin to terminal contact in the MAP Sensor and Powertrain Control Module connectors. If OK, replace the MAP Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE FUEL DELIVERY SYSTEM FOR PROPER OPERATION**
   1. Perform the CHECKING THE FUEL DELIVERY SYSTEM test procedure. Refer to **CHECKING THE FUEL DELIVERY SYSTEM (HARD START)** .

   Were any problems found?

   Yes

   - Repair as necessary in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 7

7. **CHECK THE ENGINE MECHANICAL SYSTEM**
   1. Turn the ignition off.
   2. Check for any of the following conditions/mechanical problems:
      - AIR INDUCTION SYSTEM - must be free from leaks.
      - ENGINE VACUUM - must be at least 13 inches in park/neutral
      - ENGINE VALVE TIMING - must be within specifications
      - ENGINE COMPRESSION - must be within specifications
      - ENGINE EXHAUST SYSTEM - must be free of any restrictions or leaks.
      - ENGINE PCV SYSTEM - must flow freely
      - TORQUE CONVERTER STALL SPEED - must be within specifications
      - POWER BRAKE BOOSTER - no internal vacuum leaks
      - FUEL - must be free of contamination
      - FUEL INJECTOR - plugged or restricted injector; control wire not connected to correct injector

   Are there any engine mechanical problems?

Yes

- Repair as necessary in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 8

8. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1E0A-CLOSED LOOP FUELING NOT ACHIEVED - BANK 2 DOWNSTREAM

THEORY OF OPERATION

This continuous diagnostic is used to detect when fuel control has not changed from open loop to closed loop control. A count down timer is initiated at engine start. The length of the timer is based on the starting engine coolant temperature. The timer will decrement as long as the enable conditions are met. Once the timer has expired, the fuel control system is expected to be in closed loop operation. If the fuel control system does not go closed loop within the calibrated time, the diagnostic will fail.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Engine speed between 1100 rpm and 4000 rpm.
- Upstream O2 Sensor(s) in closed loop mode.

SET CONDITION

- A condition exists where the Downstream O2 Sensor has remained in open loop fuel control, from a start-up condition, longer than a calibrated amount of time, when conditions would have otherwise expected closed loop operation.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

POSSIBLE CAUSES
FUEL DELIVERY SYSTEM
MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR, WIRING, OR CONNECTORS
O2 SENSOR, WIRING, OR CONNECTORS
ENGINE MECHANICAL SYSTEM
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE FUEL DELIVERY SYSTEM FOR PROPER OPERATION**
   1. Perform the CHECKING THE FUEL DELIVERY SYSTEM test procedure. Refer to **CHECKING THE FUEL DELIVERY SYSTEM (HARD START)** .

      Were any problems found?

      Yes

      - Repair as necessary in accordance with the Service Information.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 3
3. **CHECK THE MAP SENSOR FOR PROPER OPERATION**
   1. Perform the CHECKING THE MAP SENSOR OPERATION test procedure. Refer to **CHECKING THE MAP SENSOR OPERATION** .

      Were any problems found?

      Yes

      - Repair as necessary in accordance with the Service Information.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 4
4. **CHECK THE OXYGEN SENSOR FOR PROPER OPERATION**
   1. Perform the CHECKING THE OXYGEN SENSOR OPERATION test procedure. Refer to **CHECKING THE OXYGEN SENSOR OPERATION** .

      Were any problems found?

      Yes

      - Repair as necessary in accordance with the Service Information.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 5
5. **CHECK THE ENGINE MECHANICAL SYSTEM FOR PROPER OPERATION**
   1. Perform the CHECKING THE ENGINE MECHANICAL SYSTEM test procedure. Refer to the appropriate information.

Were any problems found?

Yes

- Repair as necessary in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1E26-INTERNAL CONTROL MODULE COOLED EGR TEMPERATURE PERFORMANCE

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- No Exhaust Gas Recirculation (EGR) Position Sensor circuit DTCs active.

SET CONDITION

- The Powertrain Control Module (PCM) detects an internal torque security fault against the EGR system.

DEFAULT ACTION

- This is a non-MIL fault.

POSSIBLE CAUSES

Possible Causes
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.

3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1E27-EGR 1 HIGH SIDE CONTROL CIRCUIT LOW

For a complete EGR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

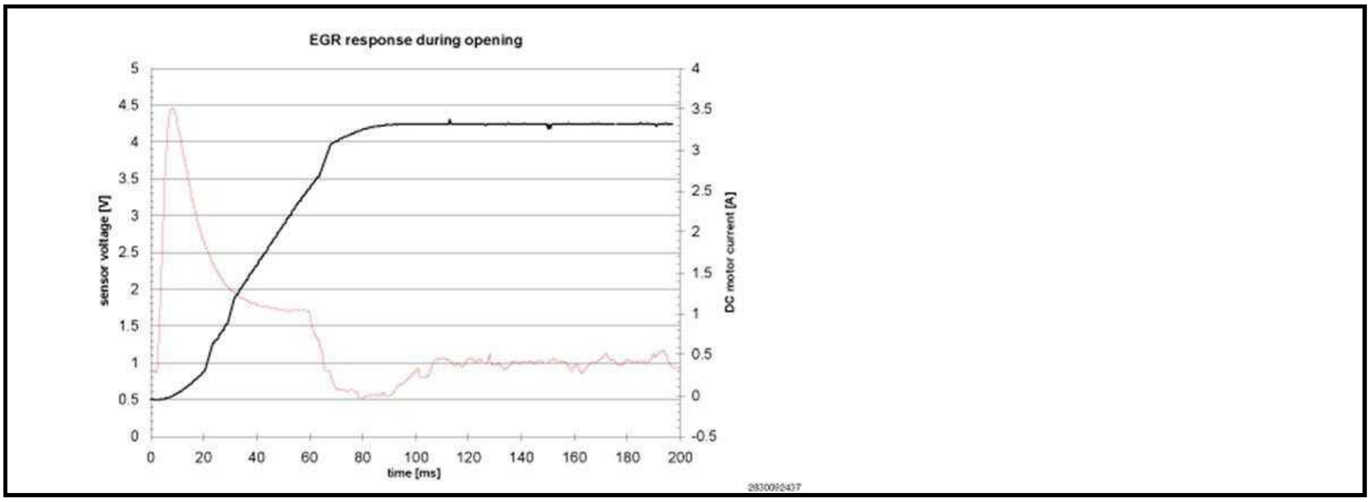
THEORY OF OPERATION

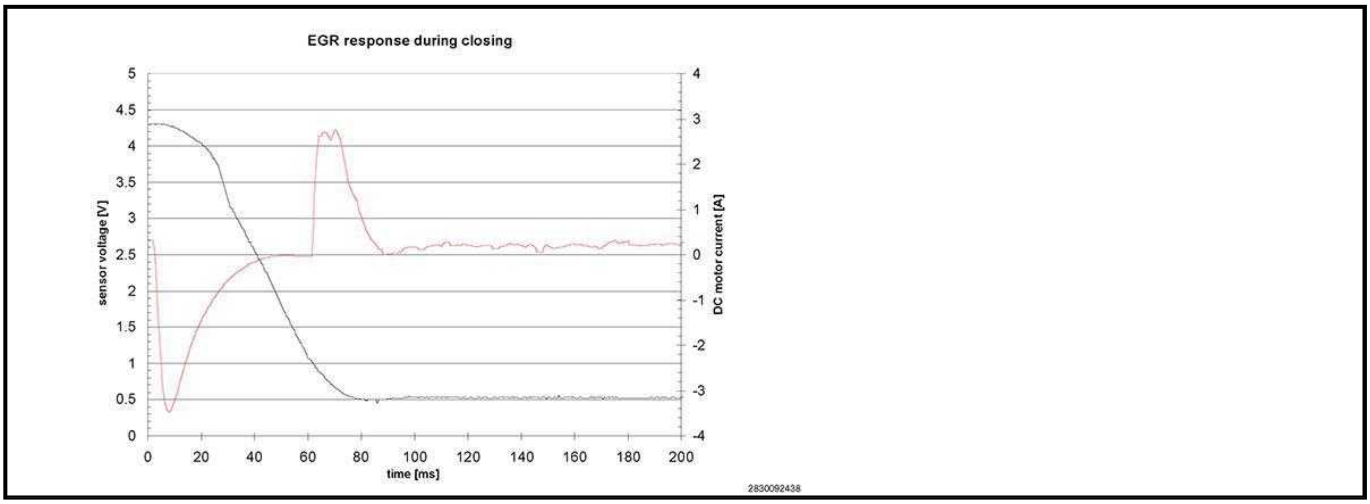
The Cooled Exhaust Gas Recirculation (EGR) Valve Assembly contains an electric Direct Current (DC) Motor and a gear box. An eccentric drive translates the gearbox output from a rotating motion (DC Motor) to a linear stroke (output shaft). The full range of travel of the shaft is approximately 5.0 mm from a fully closed to fully open position. An internal return spring ensures that the valve returns back to its closed position as a fail safe. The EGR Valve is controlled by the Powertrain Control Module (PCM) H-Bridge driver. The H-Bridge operates the DC Motor using a Pulse Width Modulation (PWM) control to help reduce current draw. This helps protect the DC Motor from overheating and reduces electrical load on the system voltage.

- During initial opening of the EGR Valve the PCM drives the Pulse Width Modulation (PWM) voltage high resulting in a high current draw. After the valve is fully opened the PCM voltage is reduced to maintain the EGR Valve position. This reduces the current draw and protects from overheating the DC Motor.
    - The PCM monitors the temperature and current draw of the DC Motor inside EGR Valve and will adjust the duty cycle to prevent the EGR Valve windings from overheating. Typically, the peak current draw by the EGR Valve occurs during opening and the maximum current load for a typical application is approximately 6.0 amps. The duty cycle is adjusted after opening so that the typical average current draw is approximately 0.5 amps while holding the valve open.
- The PCM also applies a current in the closing direction to fulfill the required dynamic performance. This is done to control the closing speed of the shaft near the stop. This ensures that the valve does not close too fast causing the valve disk to be forced into the stop harshly which may damage the internal gearbox.

There is a position sensor located on the output shaft. The sensor operates as a typical three wire sensor, with a 5-Volt Supply, Sensor Signal, and Sensor Ground circuit. Full range of travel of the output shaft will result in a change of approximately 3.9 volts in the position sensor reading. During normal operation the position sensor signal voltage will range between approximately 0.5 volts (closed) and 4.3 volts (open).

NOTE: **See the figures below for a typical current draw on the DC Motor and voltage reading of the sensor during the EGR Valve opening and closing. The red line represents current draw of the DC Motor and the black line represents the position sensor voltage.**





WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage above approximately 10.4 volts.
- The Auto Shutdown (ASD) Relay is energized.

SET CONDITION

- The EGR Valve Motor (+) Control 1 circuit can be driven high or low depending on whether the EGR Valve is being opened or closed by the PCM. The PCM monitors the circuit for excessive current draw in both directions. The PCM will set the P1E27 or P1E28 DTC depending on which direction the EGR Valve is being driven when the fault occurs.
    - For this fault, the PCM detects a current draw above 8.6 amps on the EGR Valve Motor (+) Control 1 circuit when the circuit is being driven low.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EGR VALVE MOTOR (+) CONTROL 1 CIRCUIT SHORTED TO GROUND
EGR VALVE ASSEMBLY
POWERTRAIN CONTROL MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **ISOLATE AND CHECK THE EGR VALVE (K682) CONTROL 1 CIRCUIT FOR A SHORT TO GROUND**

1. The ignition must be off when checking a circuit for continuity to ground.
2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Connect the negative lead of the DVOM to a known good ground.
4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 3

3. **REPLACE THE EGR VALVE AND RETEST FOR DTCS**
   1. Replace the component in accordance with the Service Information. Refer to **VALVE, EXHAUST GAS RECIRCULATION (EGR), REMOVAL AND INSTALLATION** .
   2. Connect the component and Electronic Control Unit (ECU) harness connectors.
   3. Turn the ignition on.
   4. With the scan tool, erase DTCs.
   5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
   6. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 4

   No

   - Replacing the faulty component repaired the fault.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.

2. Disconnect all PCM harness connectors.
3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
   - Proper connector installation.
   - Damaged connector locks.
   - Corrosion.
   - Other signs of water intrusion.
   - Weather seal damage (if equipped).
   - Bent terminals.
   - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
   - Terminals that have been pushed back into the connector cavity.
   - Check for spread terminals and verify proper terminal tension.

   Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P1E28-EGR 1 HIGH SIDE CONTROL CIRCUIT HIGH

For a complete EGR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

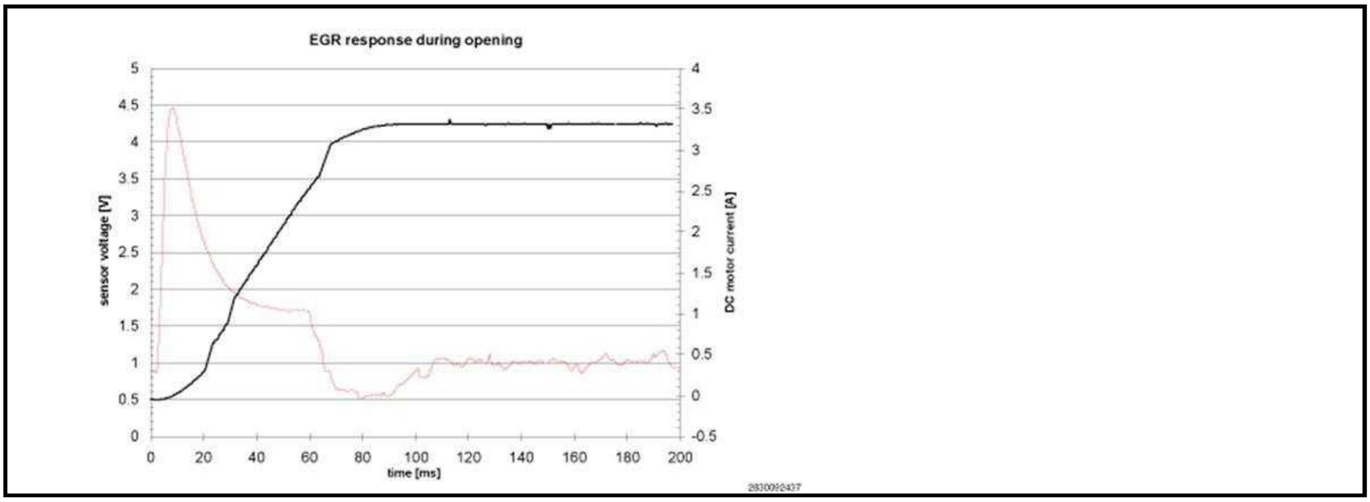
The Cooled Exhaust Gas Recirculation (EGR) Valve Assembly contains an electric Direct Current (DC) Motor and a gear box. An eccentric drive translates the gearbox output from a rotating motion (DC Motor) to a linear stroke (output shaft). The full range of travel of the shaft is approximately 5.0 mm from a fully closed to fully open position. An internal return spring ensures that the valve returns back to its closed position as a fail safe.

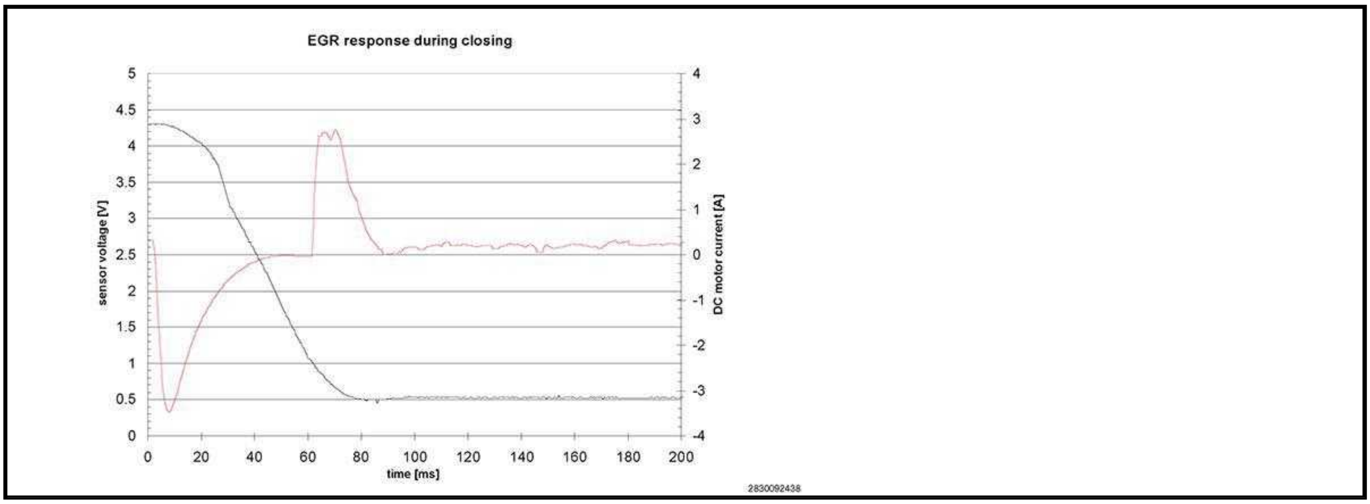
The EGR Valve is controlled by the Powertrain Control Module (PCM) H-Bridge driver. The H-Bridge operates the DC Motor using a Pulse Width Modulation (PWM) control to help reduce current draw. This helps protect the DC Motor from overheating and reduces electrical load on the system voltage.

- During initial opening of the EGR Valve the PCM drives the Pulse Width Modulation (PWM) voltage high resulting in a high current draw. After the valve is fully opened the PCM voltage is reduced to maintain the EGR Valve position. This reduces the current draw and protects from overheating the DC Motor.
  - The PCM monitors the temperature and current draw of the DC Motor inside EGR Valve and will adjust the duty cycle to prevent the EGR Valve windings from overheating. Typically, the peak current draw by the EGR Valve occurs during opening and the maximum current load for a typical application is approximately 6.0 amps. The duty cycle is adjusted after opening so that the typical average current draw is approximately 0.5 amps while holding the valve open.
- The PCM also applies a current in the closing direction to fulfill the required dynamic performance. This is done to control the closing speed of the shaft near the stop. This ensures that the valve does not close too fast causing the valve disk to be forced into the stop harshly which may damage the internal gearbox.

There is a position sensor located on the output shaft. The sensor operates as a typical three wire sensor, with a 5-Volt Supply, Sensor Signal, and Sensor Ground circuit. Full range of travel of the output shaft will result in a change of approximately 3.9 volts in the position sensor reading. During normal operation the position sensor signal voltage will range between approximately 0.5 volts (closed) and 4.3 volts (open).

NOTE: **See the figures below for a typical current draw on the DC Motor and voltage reading of the sensor during the EGR Valve opening and closing. The red line represents current draw of the DC Motor and the black line represents the position sensor voltage.**





WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage above approximately 10.4 volts.
- The Auto Shutdown (ASD) Relay is energized.

SET CONDITION

- The EGR Valve Motor (+) Control 1 circuit can be driven high or low depending on whether the EGR Valve is being opened or closed by the PCM. The PCM monitors the circuit for excessive current draw in both directions. The PCM will set the P1E27 or P1E28 DTC depending on which direction the EGR Valve is being driven when the fault occurs.
    - For this fault, the PCM detects a current draw above 8.6 amps on the EGR Valve Motor (+) Control 1 circuit when the circuit is being driven high.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EGR VALVE MOTOR (+) CONTROL 1 CIRCUIT SHORTED TO BATTERY VOLTAGE
EGR VALVE MOTOR (+) CONTROL 1 CIRCUIT SHORTED TO THE EGR VALVE CONTROL 2 CIRCUIT
EXHAUST GAS RECIRCULATION (EGR) VALVE ASSEMBLY
POWERTRAIN CONTROL MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE EGR VALVE (K682) CONTROL 1 CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

    Is Battery voltage present?

    Yes

    - Go To 3

    No

    - Go To 4
3. **ISOLATE AND CHECK THE EGR VALVE (K682) CONTROL 1 CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 6
4. **ISOLATE AND CHECK THE EGR VALVE (K682) CONTROL 1 CIRCUIT FOR A SHORT TO THE EGR VALVE (K684) CONTROL 2 CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

NOTE: **There should be no continuity between the circuits being tested.**

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **REPLACE THE EGR VALVE AND RETEST FOR DTCS**

   NOTE: **The EGR VALVE REPLACED routine must be performed after replacing or cleaning the EGR Valve to reset the zero learn position. Failure to do so will cause a false failure and the P1404 DTC to set.**

   1. Replace the component in accordance with the Service Information. Refer to **VALVE, EXHAUST GAS RECIRCULATION (EGR), REMOVAL AND INSTALLATION** .
   2. Connect the component and Electronic Control Unit (ECU) harness connectors.
   3. Turn the ignition on.
   4. With the scan tool, erase DTCs.
   5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
   6. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 6

   No

   - Replacing the faulty component repaired the fault.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Disconnect all PCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).

- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

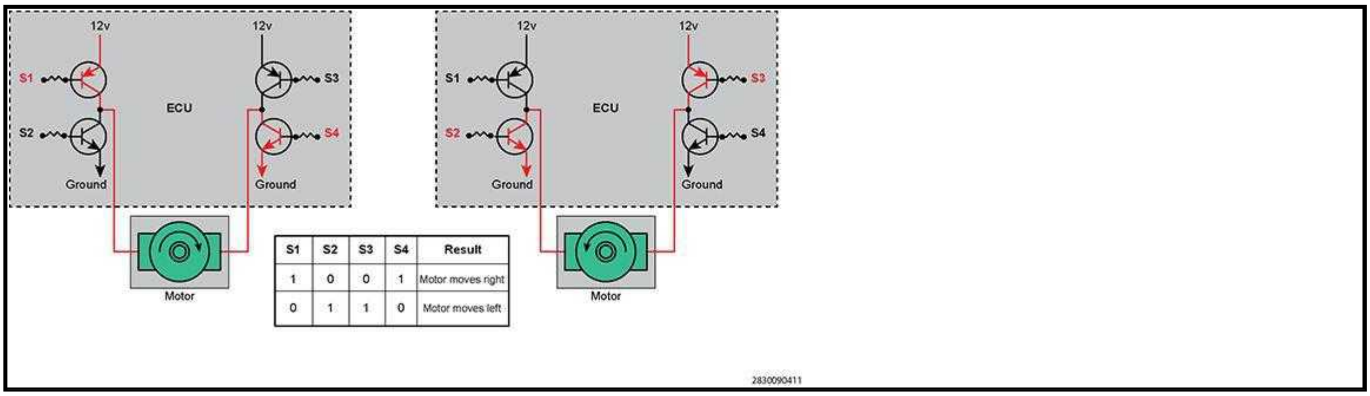
- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2072-ELECTRONIC THROTTLE CONTROL SYSTEM - ICE BLOCKAGE

For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

GENERAL OPERATION: The Electronic Throttle Control (ETC) Motor is controlled using an H-Bridge circuit inside the Powertrain Control Module (PCM). An H-Bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. The H-Bridge arrangement is generally used to reverse the polarity/direction of the Direct Current (DC) motor which allows the DC motor to run forward and backwards. The DC motor located in the Throttle Body drives the throttle blade. In order to decrease engine speed, along with spark and fuel delivery changes, the PCM commands the throttle blade closed reducing air flow into the engine and the engine speed decreases. In order to increase engine speed, the PCM commands the throttle blade open, increasing air flow and engine speed. On a normally functioning Throttle Body, the duty cycle of the ETC Motor should not go above approximately 40%. **See the figure below for a general configuration and operation of an H-Bridge:**



ETC MOTOR DIAGNOSTICS: The PCM performs diagnostics on the DC Motor and circuits. If the PCM detects that the current draw or Pulse Width Modulation (PWM) to the DC Motor is too high or low for a calibrated period of time, then the PCM determines that the motor or circuitry is faulted and not operating properly.

NOTE:	**The PCM can detect a circuit high or circuit low fault during operation of the component, whereas open circuit detection can only occur when the component is not being commanded. If an open occurs in the component or circuits during operation, the PCM will normally detect the failure during the performance diagnostic for the system that component is being used to control.**

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
- Ambient temperature below 7B°C (44.6B°F).

SET CONDITION

- The PCM determines that the Throttle plate is stuck during a cold start and cold ambient temperature. The throttle plate goes through a de-icing procedure to break any ice restricting movement. If the throttle blade still doesn't move the fault will set.

DEFAULT ACTION

- This is a non MIL fault.
- The throttle input and vehicle speed are limited.

POSSIBLE CAUSES

Possible Causes
POWERTRAIN CONTROL MODULE (PCM) SOFTWARE UPDATE
LOW BATTERY VOLTAGE
INTERMITTENT LOSS OF CONNECTION AT THE THROTTLE BODY HARNESS CONNECTOR
ETC MOTOR (+) CIRCUIT OPEN/HIGH RESISTANCE
ETC MOTOR (-) CIRCUIT OPEN/HIGH RESISTANCE
COKING OR DEBRIS BLOCKING THE THROTTLE BODY PLATE
THROTTLE PLATE FROZEN
ETC MOTOR/THROTTLE BODY ASSEMBLY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**

   NOTE: Low battery voltage can also cause excessive current draw. Make sure that the battery is fully charged and can pass a load test before continuing.

   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

     NOTE: When this DTC is Active the engine speed, torque and vehicle speed are limited to a Limp in mode. An intermittent loss of power to the PCM without performing an ETC RELEARN procedure may cause this DTC to set.

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any ETC Motor circuit DTCs present?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3
3. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
   1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

      Are there any applicable Service Bulletins or Flash updates?

      Yes

      - Perform the applicable repair.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **CHECK THE THROTTLE BODY HARNESS CONNECTOR AND TERMINALS**
    1. Turn the ignition off.
    2. Check the Throttle Body harness connector for proper connection at the Throttle Body.
    3. Verify that the connector is completely plugged in and properly locked prior to disconnecting.
    4. Disconnect the Throttle Body harness connector and check for any pushed out, damaged or spread terminals.

    NOTE: **An intermittent loss of a signal from one of the sensors may cause this DTC to set without setting a sensor fault.**

    Were any issues found with the connector or terminals?

    Yes

    - Repair the damaged terminal or properly connect and lock the Throttle Body harness connector and retest for DTCs.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

5. **ISOLATE AND LOAD TEST THE THROTTLE BODY (K124) MOTOR (+) CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
    3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
    4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
    5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
    6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

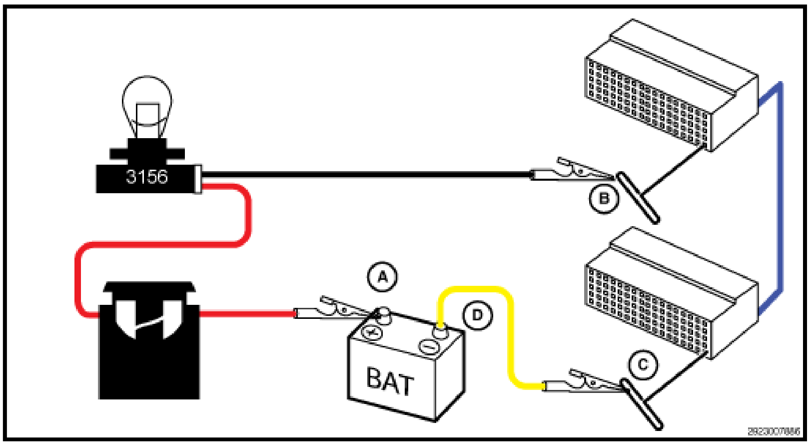
    NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Note: Why perform a voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: Do not load test any circuits with components still connected to the circuit.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 6

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND LOAD TEST THE THROTTLE BODY (K126) MOTOR (-) CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
    3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
    4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
    5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
    6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

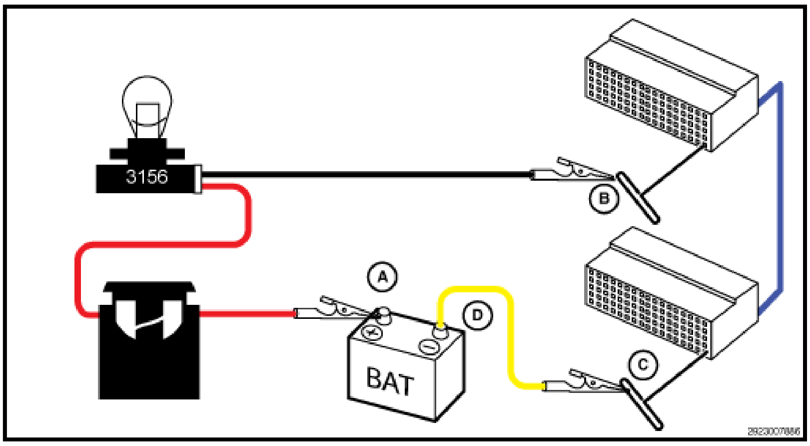
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**

3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 7

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **INSPECT THE THROTTLE BODY FOR FOREIGN MATERIAL, SCORING OR OTHER DAMAGE THAT COULD CAUSE THE THROTTLE PLATE TO STICK**

1. Turn the ignition off.
2. Remove the Air Cleaner Assembly from the Throttle Body.
3. Check for any signs of a foreign material (ice or dirt) causing the Throttle to stick or damage to the Throttle Body bore or plate.

   Were any problems found?

   Yes

   - Remove the debris and inspect the Throttle Body Assembly for signs of physical damage. If the Throttle Body is damaged or still not functioning properly, replace the Throttle Body in accordance with the Service Information. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** . Disconnect the Battery when replacing the Throttle Body Assembly. After installation is complete, use a scan tool and perform the ETC RELEARN function.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 8

8. **REPLACE THE THROTTLE BODY AND RETEST FOR DTCS**
   1. Replace the Throttle Body in accordance with the Service Information. After installation is complete, with a scan tool perform the ETC RELEARN function. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** .
   2. Connect the Throttle Body and PCM harness connectors.
   3. Turn the ignition on.
   4. With the scan tool, erase DTCs.
   5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
   6. With the scan tool, read DTCs.

      Did the DTC return?

      Yes

      - Go To 9

      No

      - Replacing the faulty Throttle Body repaired the fault.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.

- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2096-DOWNSTREAM FUEL TRIM SYSTEM 1 LEAN

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The intent of this diagnostic is to identify rich or lean fuel system abnormalities which would cause vehicle emissions to exceed 1.5 times any of the standards. The base fuel feedback control will maintain the desired fuel/air mixture by modifying the injected fuel quantity according to the oxygen content of the exhaust gas. The Powertrain Control Module (PCM) makes short term and long term fuel corrections based on feedback from the Upstream Oxygen (O2) Sensors. The PCM monitors feedback from the Downstream O2 Sensors to determine and optimize the efficiency of the Catalytic Converters.

The Upstream Fuel System Trim Diagnostic and Downstream Fuel Trim Diagnostic monitors operate very differently;

- **Upstream Fuel System Diagnostic Monitor**
  - The Upstream Fuel System Monitor diagnostic monitors the Upstream O2 Sensor feedback to determine the actual fuel/air ratio, which is then compared to the desired fuel/air ratio. The error between the two is measured and corrected for. This correction happens "live" and the

instantaneous value of the correction is stored in short term fuel trim. Short term fuel trim is intended to correct temporary or dynamic errors in the air/fuel ratio. If the value of short term fuel trim is large enough for a sufficient period of time, it is assumed that whatever is causing the error is permanent and not temporary and the value in short term fuel trim is moved to long term fuel trim. When this transfer occurs, the short term fuel trim is re-zeroed and continues to look for temporary errors. If the combined value of the total fuel correction stored in short term and long term fuel trim (rich or lean) exceeds a calibrated threshold, for a calibrated period of time, a fuel system monitor fault is recorded.

- **Downstream Fuel Trim Diagnostic Monitor**
  - A Downstream O2 Sensor goal voltage is selected to maintain the optimum catalyst efficiency. Corresponding Upstream O2 Sensor rich/lean switching point thresholds for various operating conditions are also selected which normally result in a Downstream O2 Sensor voltage close to this goal voltage. During normal operation, whenever the upstream rich/lean switching point threshold does not result in the desired downstream goal voltage, the downstream fuel trim feature "trims" (adjusts) the upstream rich/lean switching point threshold up or down appropriately until the desired downstream goal voltage is achieved. The amount of trim adjustment that is added or removed is called "downstream fuel trim." If the trim adjustment to the Upstream O2 Sensor goes beyond a calibrated threshold (rich or lean), a fault is set.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running in downstream closed loop fuel control.
- Battery voltage above 11.0 volts.
- Barometric pressure greater than 75 kPa.
- The ambient temperature above -7B°C (20B°F).
- Fuel level greater than 12%.
- Altitude below 2590.8 m (8500 ft.).

SET CONDITION

- The value of the downstream fuel trim is compared with the lean thresholds. Every time the value exceeds the calibrated threshold, a fail timer increments and mass flow through the exhaust is accumulated. If the fail timer and accumulated mass flow exceed the fail thresholds, the test fails and the diagnostic stops running for that trip. It takes two consecutive failed trips to set a DTC.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EXHAUST SYSTEM LEAK
UPSTREAM O2 SENSOR WIRING ISSUE
UPSTREAM O2 SENSOR
DOWNSTREAM O2 SENSOR WIRING ISSUE
DOWNSTREAM O2 SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. **Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .**

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any O2 Sensor, upstream fuel trim, fuel system or air handling DTCs active or pending?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **CHECK THE EXHAUST SYSTEM FOR LEAKS**
    1. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

        NOTE: **An exhaust leak of any size at or upstream of the Downstream O2 Sensor can cause this DTC to set. It is critical to thoroughly inspect and repair any leak before continuing on and replacing an O2 Sensor.**

        Were any problems found?

        Yes

        - Repair as necessary in accordance with the Service Information.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

- Go To 4

4. **CHECK THE UPSTREAM O2 SENSOR WIRING FOR AN OPEN OR SHORT TO GROUND**

   NOTE: **The Downstream Fuel Trim Diagnostic will fault based on the trim adjustment to the Upstream O2 Sensor being beyond a calibrated threshold. Therefore, if there are no exhaust system leaks, it is more likely that the Upstream O2 Sensor is the cause of any Downstream Fuel Trim System Rich/Lean fault than the Downstream O2 Sensor. For this reason the Upstream O2 Sensor and wiring should be diagnosed before the Downstream O2 Sensor.**

   1. Disconnect the Upstream O2 Sensor harness connector.
   2. Disconnect the PCM C2 harness connector.

      CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
   4. Check the Upstream O2 Sensor circuits;
      - for a short to ground in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.
      - for an open or high resistance in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.

   Were any problems found?

   Yes

   - Repair the wiring for an open or short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **REPLACE THE UPSTREAM O2 SENSOR AND RETEST FOR DTCS**
   1. Verify that there is good pin to terminal contact in the O2 Sensor 1/1 and Powertrain Control Module connectors. Replace the component in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   2. Connect the component and Electronic Control Unit (ECU) harness connectors.
   3. Turn the ignition on.
   4. With the scan tool, erase DTCs.
   5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
   6. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 6

   No

- Replacing the faulty component repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE DOWNSTREAM O2 SENSOR WIRING FOR AN OPEN OR SHORT TO GROUND**
   1. Disconnect the Downstream O2 Sensor harness connector.
   2. Disconnect the PCM C2 harness connector.

      CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
   4. Check the Downstream O2 Sensor circuits;
      - for a short to ground in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.
      - for an open or high resistance in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.

      Were any problems found?

      Yes

      - Repair the wiring for an open or short to ground.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 7

7. **REPLACE THE DOWNSTREAM O2 SENSOR AND RETEST FOR DTCS**
   1. Verify that there is good pin to terminal contact in the O2 Sensor 1/2 and Powertrain Control Module connectors. Replace the component in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   2. Connect the component and Electronic Control Unit (ECU) harness connectors.
   3. Turn the ignition on.
   4. With the scan tool, erase DTCs.
   5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
   6. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 8

   No

   - Replacing the faulty component repaired the fault.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**

1. Perform any Service Bulletins that apply.
2. Disconnect all PCM harness connectors.
3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
   - Proper connector installation.
   - Damaged connector locks.
   - Corrosion.
   - Other signs of water intrusion.
   - Weather seal damage (if equipped).
   - Bent terminals.
   - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
   - Terminals that have been pushed back into the connector cavity.
   - Check for spread terminals and verify proper terminal tension.

   Repair any conditions that are found.
6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2097-DOWNSTREAM FUEL TRIM SYSTEM 1 RICH

THEORY OF OPERATION

The intent of this diagnostic is to identify rich or lean fuel system abnormalities which would cause vehicle emissions to exceed 1.5 times any of the standards. The base fuel feedback control will maintain the desired fuel/air mixture by modifying the injected fuel quantity according to the oxygen content of the exhaust gas. The Powertrain Control Module (PCM) makes short term and long term fuel corrections based on feedback from the Upstream Oxygen (O2) Sensors. The PCM monitors feedback from the Downstream O2 Sensors to determine and optimize the efficiency of the Catalytic Converters.

The Upstream Fuel System Trim Diagnostic and Downstream Fuel Trim Diagnostic monitors operate very differently;

- **Upstream Fuel System Diagnostic Monitor**
  - The Upstream Fuel System Monitor diagnostic monitors the Upstream O2 Sensor feedback to determine the actual fuel/air ratio, which is then compared to the desired fuel/air ratio. The error between the two is measured and corrected for. This correction happens "live" and the instantaneous value of the correction is stored in short term fuel trim. Short term fuel trim is intended to correct temporary or dynamic errors in the air/fuel ratio. If the value of short term fuel trim is large enough for a sufficient period of time, it is assumed that whatever is causing the error is permanent and not temporary and the value in short term fuel trim is moved to long term fuel trim. When this transfer occurs, the short term fuel trim is re-zeroed and continues to look for temporary errors. If the combined value of the total fuel correction stored in short term and long term fuel trim (rich or lean) exceeds a calibrated threshold, for a calibrated period of time, a fuel system monitor fault is recorded.
- **Downstream Fuel Trim Diagnostic Monitor**
  - A Downstream O2 Sensor goal voltage is selected to maintain the optimum catalyst efficiency. Corresponding Upstream O2 Sensor rich/lean switching point thresholds for various operating conditions are also selected which normally result in a Downstream O2 Sensor voltage close to this goal voltage. During normal operation, whenever the upstream rich/lean switching point threshold does not result in the desired downstream goal voltage, the downstream fuel trim feature "trims" (adjusts) the upstream rich/lean switching point threshold up or down appropriately until the desired downstream goal voltage is achieved. The amount of trim adjustment that is added or removed is called "downstream fuel trim." If the trim adjustment to the Upstream O2 Sensor goes beyond a calibrated threshold (rich or lean), a fault is set.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running in downstream closed loop fuel control.
- Battery voltage above 11.0 volts.
- Barometric pressure greater than 75 kPa.
- The ambient temperature above -7B°C (20B°F).
- Fuel level greater than 12%.
- Altitude below 2590.8 m (8500 ft.).

SET CONDITION

- The value of the downstream fuel trim is compared with the rich thresholds. Every time the value exceeds the calibrated threshold, a fail timer increments and mass flow through the exhaust is accumulated. If the fail timer and accumulated mass flow exceed the fail thresholds, the test fails and the diagnostic stops running for that trip. It takes two consecutive failed trips to set a DTC.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EXHAUST SYSTEM LEAK
ENGINE MECHANICAL/LOW CYLINDER COMPRESSION

Possible Causes
UPSTREAM O2 SENSOR WIRING ISSUE
UPSTREAM O2 SENSOR
DOWNSTREAM O2 SENSOR WIRING ISSUE
DOWNSTREAM O2 SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Go To 2

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any O2 Sensor, upstream fuel trim, misfire, fuel system or air handling DTCs active or pending?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 3
3. **CHECK THE EXHAUST SYSTEM FOR LEAKS**

   NOTE: **An exhaust leak of any size at or upstream of the Downstream O2 Sensor can cause this DTC to set. It is critical to thoroughly inspect and repair any leak before continuing on and replacing an O2 Sensor.**

1. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

   Were any problems found?

   Yes

   - Repair as necessary in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **CHECK THE UPSTREAM O2 SENSOR WIRING FOR AN OPEN OR SHORT TO GROUND**

NOTE: **The Downstream Fuel Trim Diagnostic will fault based on the trim adjustment to the Upstream O2 Sensor being beyond a calibrated threshold. Therefore, if there are no exhaust system leaks, it is more likely that the Upstream O2 Sensor is the cause of any Downstream Fuel Trim System Rich/Lean fault than the Downstream O2 Sensor. For this reason the Upstream O2 Sensor and wiring should be diagnosed before the Downstream O2 Sensor.**

1. Disconnect the Upstream O2 Sensor harness connector.
2. Disconnect the PCM C2 harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
4. Check the Upstream O2 Sensor circuits;
   - for a short to ground in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.
   - for an open or high resistance in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.

   Were any problems found?

   Yes

   - Repair the wiring for an open or short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **CHECK THE DOWNSTREAM O2 SENSOR WIRING FOR AN OPEN OR SHORT TO GROUND**
   1. Disconnect the Downstream O2 Sensor harness connector.
   2. Disconnect the PCM C2 harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
4. Check the Downstream O2 Sensor circuits;
    - for a short to ground in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.
    - for an open or high resistance in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.

   Repair the wiring for an open or short to ground?

   Yes

    - Perform the appropriate repair.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

    - Go To 6

6. **CHECK THE ENGINE COMPRESSION TO CHECK FOR VALVETRAIN OR COMBUSTION CHAMBER ISSUES**

NOTE: **Low compression on a cylinder can cause unburned fuel to collect in the Catalytic Converter using up stored Oxygen. this will cause the Downstream O2 Sensor to stay in the rich state. If not severe enough it may not cause a misfire DTC but observing the misfire monitor may show some counts on one or more of the cylinders on the affected bank which may help in determining which cylinder or cylinders has an issue.**

1. Perform a cylinder compression test on all of the bank 1 cylinders and compare the results with the specifications. Refer to **CYLINDER COMPRESSION TEST** .

   Are any cylinders not within specification?

   Yes

    - Perform a Cylinder Leak Down Test to determine if the cause is from the valvetrain or combustion chambers and repair as necessary.
    - For a combustion chamber issue check the following:
        - Check the cylinder head for cracks
        - Check the pistons for cracks
        - Check for broken piston rings
        - Check for scoring on the cylinder walls
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
    - For a valvetrain issue check the following:
        - Check for broken valve springs
        - Check for proper valve lash clearance. If the valve clearance is out of specification, replace the faulty components (rocker arms, tappets, valves, springs, etc.)
        - Check the Camshaft lobes for excessive wear

        - Check for bent valves
        - Check the valves and seats for pits or improper sealing
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 7

7. **REPLACE THE UPSTREAM O2 SENSOR AND RETEST FOR DTC**
    1. Verify that there is good pin to terminal contact in the O2 Sensor 1/1 and Powertrain Control Module connectors. Replace the O2 Sensor 1/1 if no problems were found with the connectors. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. Reconnect all harness connectors.
    3. With the scan tool, erase DTCs.
    4. Using the recorded data along with the When Monitored and Set Conditions above, operate the vehicle in the conditions that set the DTC.
    5. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 8

    No

    - Replacing the O2 Sensor 1/1 repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
8. **REPLACE THE DOWNSTREAM O2 SENSOR AND RETEST FOR DTC**
    1. Verify that there is good pin to terminal contact in the O2 Sensor 1/2 and Powertrain Control Module connectors. Replace the O2 Sensor 1/2 if no problems were found with the connectors. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. Reconnect all harness connectors.
    3. With the scan tool, erase DTCs.
    4. Using the recorded data along with the When Monitored and Set Conditions above, operate the vehicle in the conditions that set the DTC.
    5. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 9

    No

    - Replacing the O2 Sensor 1/2 repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.

3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2098-DOWNSTREAM FUEL TRIM SYSTEM 2 LEAN

THEORY OF OPERATION

The intent of this diagnostic is to identify rich or lean fuel system abnormalities which would cause vehicle emissions to exceed 1.5 times any of the standards. The base fuel feedback control will maintain the desired fuel/air mixture by modifying the injected fuel quantity according to the oxygen content of the exhaust gas. The Powertrain Control Module (PCM) makes short term and long term fuel corrections based on feedback from the Upstream Oxygen (O2) Sensors. The PCM monitors feedback from the Downstream O2 Sensors to determine and optimize the efficiency of the Catalytic Converters.

The Upstream Fuel System Trim Diagnostic and Downstream Fuel Trim Diagnostic monitors operate very differently;

- **Upstream Fuel System Diagnostic Monitor**
  - The Upstream Fuel System Monitor diagnostic monitors the Upstream O2 Sensor feedback to determine the actual fuel/air ratio, which is then compared to the desired fuel/air ratio. The error between the two is measured and corrected for. This correction happens "live" and the instantaneous value of the correction is stored in short term fuel trim. Short term fuel trim is intended to correct temporary or dynamic errors in the air/fuel ratio. If the value of short term fuel trim is large enough for a sufficient period of time, it is assumed that whatever is causing the error is permanent and not temporary and the value in short term fuel trim is moved to long term fuel trim. When this transfer occurs, the short term fuel trim is re-zeroed and continues to look for temporary errors. If the combined value of the total fuel correction stored in short term and long term fuel trim (rich or lean) exceeds a calibrated threshold, for a calibrated period of time, a fuel system monitor fault is recorded.
- **Downstream Fuel Trim Diagnostic Monitor**
  - A Downstream O2 Sensor goal voltage is selected to maintain the optimum catalyst efficiency. Corresponding Upstream O2 Sensor rich/lean switching point thresholds for various operating conditions are also selected which normally result in a Downstream O2 Sensor voltage close to this goal voltage. During normal operation, whenever the upstream rich/lean switching point threshold does not result in the desired downstream goal voltage, the downstream fuel trim feature "trims" (adjusts) the upstream rich/lean switching point threshold up or down appropriately until the desired downstream goal voltage is achieved. The amount of trim adjustment that is added or removed is called "downstream fuel trim." If the trim adjustment to the Upstream O2 Sensor goes beyond a calibrated threshold (rich or lean), a fault is set.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running in downstream closed loop fuel control.
- Battery voltage above 11.0 volts.
- Barometric pressure greater than 75 kPa.
- The ambient temperature above -7B°C (20B°F).
- Fuel level greater than 12%.
- Altitude below 2590.8 m (8500 ft.).

SET CONDITION

- The value of the downstream fuel trim is compared with the lean thresholds. Every time the value exceeds the calibrated threshold, a fail timer increments and mass flow through the exhaust is accumulated. If the fail timer and accumulated mass flow exceed the fail thresholds, the test fails and the diagnostic stops running for that trip. It takes two consecutive failed trips to set a DTC.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EXHAUST SYSTEM LEAK
UPSTREAM O2 SENSOR WIRING ISSUE
UPSTREAM O2 SENSOR
DOWNSTREAM O2 SENSOR WIRING ISSUE
DOWNSTREAM O2 SENSOR

Possible Causes
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**

    NOTE: **Check for contaminants that may have damaged an O2 Sensor: contaminated fuel, unapproved silicone, oil or coolant in the exhaust system.**

    1. Refer to the recorded DTCs.

        Are there any O2 Sensor DTCs active or pending?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **CHECK THE EXHAUST SYSTEM FOR LEAKS**
    1. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

    NOTE: **An exhaust leak of any size at or upstream of the Downstream O2 Sensor can cause this DTC to set. It is critical to thoroughly inspect**

and repair any leak before continuing on and replacing an O2 Sensor.

Were any problems found?

Yes

- Repair as necessary in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **CHECK THE UPSTREAM O2 SENSOR WIRING FOR AN OPEN OR SHORT TO GROUND**

   NOTE: **The Downstream Fuel Trim Diagnostic will fault based on the trim adjustment to the Upstream O2 Sensor being beyond a calibrated threshold. Therefore, if there are no exhaust system leaks, it is more likely that the Upstream O2 Sensor is the cause of any Downstream Fuel Trim System Rich/Lean fault than the Downstream O2 Sensor. For this reason the Upstream O2 Sensor and wiring should be diagnosed before the Downstream O2 Sensor.**

   1. Disconnect the Upstream O2 Sensor harness connector.
   2. Disconnect the PCM C2 harness connector.

      CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
   4. Check the Upstream O2 Sensor circuits;
      - for a short to ground in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.
      - for an open or high resistance in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.

   Were any problems found?

   Yes

   - Repair the wiring for an open or short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **REPLACE THE UPSTREAM O2 SENSOR AND RETEST FOR DTCS**
   1. Verify that there is good pin to terminal contact in the O2 Sensor 2/1 and Powertrain Control Module connectors. Replace the component in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   2. Connect the component and Electronic Control Unit (ECU) harness connectors.

3. Turn the ignition on.
4. With the scan tool, erase DTCs.
5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
6. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 6

No

- Replacing the faulty component repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE DOWNSTREAM O2 SENSOR WIRING FOR AN OPEN OR SHORT TO GROUND**
   1. Disconnect the Downstream O2 Sensor harness connector.
   2. Disconnect the PCM C2 harness connector.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
   4. Check the Downstream O2 Sensor circuits;
      - for a short to ground in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.
      - for an open or high resistance in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.

   Were any problems found?

   Yes

   - Repair the wiring for an open or short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 7

7. **REPLACE THE DOWNSTREAM O2 SENSOR AND RETEST FOR DTCS**
   1. Verify that there is good pin to terminal contact in the O2 Sensor 2/2 and Powertrain Control Module connectors. Replace the component in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   2. Connect the component and Electronic Control Unit (ECU) harness connectors.
   3. Turn the ignition on.
   4. With the scan tool, erase DTCs.
   5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.

6. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 8

No

- Replacing the faulty component repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2099-DOWNSTREAM FUEL TRIM SYSTEM 2 RICH

THEORY OF OPERATION

The intent of this diagnostic is to identify rich or lean fuel system abnormalities which would cause vehicle emissions to exceed 1.5 times any of the standards. The base fuel feedback control will maintain the desired fuel/air mixture by modifying the injected fuel quantity according to the oxygen content of the exhaust gas. The Powertrain Control Module (PCM) makes short term and long term fuel corrections based on feedback from the Upstream Oxygen (O2) Sensors. The PCM monitors feedback from the Downstream O2 Sensors to determine and optimize the efficiency of the Catalytic Converters.

The Upstream Fuel System Trim Diagnostic and Downstream Fuel Trim Diagnostic monitors operate very differently;

- **Upstream Fuel System Diagnostic Monitor**
  - The Upstream Fuel System Monitor diagnostic monitors the Upstream O2 Sensor feedback to determine the actual fuel/air ratio, which is then compared to the desired fuel/air ratio. The error between the two is measured and corrected for. This correction happens "live" and the instantaneous value of the correction is stored in short term fuel trim. Short term fuel trim is intended to correct temporary or dynamic errors in the air/fuel ratio. If the value of short term fuel trim is large enough for a sufficient period of time, it is assumed that whatever is causing the error is permanent and not temporary and the value in short term fuel trim is moved to long term fuel trim. When this transfer occurs, the short term fuel trim is re-zeroed and continues to look for temporary errors. If the combined value of the total fuel correction stored in short term and long term fuel trim (rich or lean) exceeds a calibrated threshold, for a calibrated period of time, a fuel system monitor fault is recorded.
- **Downstream Fuel Trim Diagnostic Monitor**
  - A Downstream O2 Sensor goal voltage is selected to maintain the optimum catalyst efficiency. Corresponding Upstream O2 Sensor rich/lean switching point thresholds for various operating conditions are also selected which normally result in a Downstream O2 Sensor voltage close to this goal voltage. During normal operation, whenever the upstream rich/lean switching point threshold does not result in the desired downstream goal voltage, the downstream fuel trim feature "trims" (adjusts) the upstream rich/lean switching point threshold up or down appropriately until the desired downstream goal voltage is achieved. The amount of trim adjustment that is added or removed is called "downstream fuel trim." If the trim adjustment to the Upstream O2 Sensor goes beyond a calibrated threshold (rich or lean), a fault is set.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running in downstream closed loop fuel control.
- Battery voltage above 11.0 volts.
- Barometric pressure greater than 75 kPa.
- The ambient temperature above -7B°C (20B°F).
- Fuel level greater than 12%.
- Altitude below 2590.8 m (8500 ft.).

SET CONDITION

- The value of the downstream fuel trim is compared with the rich thresholds. Every time the value exceeds the calibrated threshold, a fail timer increments and mass flow through the exhaust is accumulated. If the fail timer and accumulated mass flow exceed the fail thresholds, the test fails and the diagnostic stops running for that trip. It takes two consecutive failed trips to set a DTC.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EXHAUST SYSTEM LEAK
ENGINE MECHANICAL/LOW CYLINDER COMPRESSION
UPSTREAM O2 SENSOR WIRING ISSUE
UPSTREAM O2 SENSOR
DOWNSTREAM O2 SENSOR WIRING ISSUE
DOWNSTREAM O2 SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Go To 2

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to INTERMITTENT CONDITION .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any O2 Sensor, upstream fuel trim, misfire, fuel system or air handling DTCs active or pending?

       Yes

- Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

No

- Go To 3

3. **CHECK THE EXHAUST SYSTEM FOR LEAKS**

NOTE: **An exhaust leak of any size at or upstream of the Downstream O2 Sensor can cause this DTC to set. It is critical to thoroughly inspect and repair any leak before continuing on and replacing an O2 Sensor.**

1. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

Were any problems found?

Yes

- Repair as necessary in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **CHECK THE UPSTREAM O2 SENSOR WIRING FOR AN OPEN OR SHORT TO GROUND**

NOTE: **The Downstream Fuel Trim Diagnostic will fault based on the trim adjustment to the Upstream O2 Sensor being beyond a calibrated threshold. Therefore, if there are no exhaust system leaks, it is more likely that the Upstream O2 Sensor is the cause of any Downstream Fuel Trim System Rich/Lean fault than the Downstream O2 Sensor. For this reason the Upstream O2 Sensor and wiring should be diagnosed before the Downstream O2 Sensor.**

1. Disconnect the Upstream O2 Sensor harness connector.
2. Disconnect the PCM C2 harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
4. Check the Upstream O2 Sensor circuits;
   - for a short to ground in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.
   - for an open or high resistance in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.

Were any problems found?

Yes

- Repair the wiring for an open or short to ground.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK THE DOWNSTREAM O2 SENSOR WIRING FOR AN OPEN OR SHORT TO GROUND**
   1. Disconnect the Downstream O2 Sensor harness connector.
   2. Disconnect the PCM C2 harness connector.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   3. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
   4. Check the Downstream O2 Sensor circuits;
      - for a short to ground in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.
      - for an open or high resistance in the wiring between the O2 Sensor harness connector and the PCM C2 harness connector.

   Were any problems found?

   Yes

   - Repair the wiring for an open or short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6

6. **CHECK THE ENGINE COMPRESSION TO CHECK FOR VALVETRAIN OR COMBUSTION CHAMBER ISSUES**

   NOTE: **Low compression on a cylinder can cause unburned fuel to collect in the Catalytic Converter using up stored Oxygen. this will cause the Downstream O2 Sensor to stay in the rich state. If not severe enough it may not cause a misfire DTC but observing the misfire monitor may show some counts on one or more of the cylinders on the affected bank which may help in determining which cylinder or cylinders has an issue.**

   1. Perform a cylinder compression test on all of the bank 2 cylinders and compare the results with the specifications. Refer to **CYLINDER COMPRESSION TEST** .

   Are any cylinders not within specification?

   Yes

   - Perform a Cylinder Leak Down Test to determine if the cause is from the valvetrain or combustion chambers and repair as necessary.
   - For a combustion chamber issue check the following:
     - Check the cylinder head for cracks

        - Check the pistons for cracks
        - Check for broken piston rings
        - Check for scoring on the cylinder walls
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
    - For a valvetrain issue check the following:
        - Check for broken valve springs
        - Check for proper valve lash clearance. If the valve clearance is out of specification, replace the faulty components (rocker arms, tappets, valves, springs, etc.)
        - Check the Camshaft lobes for excessive wear
        - Check for bent valves
        - Check the valves and seats for pits or improper sealing
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 7

7. **REPLACE THE UPSTREAM O2 SENSOR AND RETEST FOR DTC**
    1. Verify that there is good pin to terminal contact in the O2 Sensor 2/1 and Powertrain Control Module connectors. Replace the O2 Sensor 2/1 if no problems were found with the connectors. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. Reconnect all harness connectors.
    3. With the scan tool, erase DTCs.
    4. Using the recorded data along with the When Monitored and Set Conditions above, operate the vehicle in the conditions that set the DTC.
    5. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 8

    No

    - Replacing the O2 Sensor 2/1 repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **REPLACE THE DOWNSTREAM O2 SENSOR AND RETEST FOR DTC**
    1. Verify that there is good pin to terminal contact in the O2 Sensor 2/2 and Powertrain Control Module connectors. Replace the O2 Sensor 2/2 if no problems were found with the connectors. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. Reconnect all harness connectors.
    3. With the scan tool, erase DTCs.
    4. Using the recorded data along with the When Monitored and Set Conditions above, operate the vehicle in the conditions that set the DTC.
    5. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

- Go To 9

No

- Replacing the O2 Sensor 2/2 repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

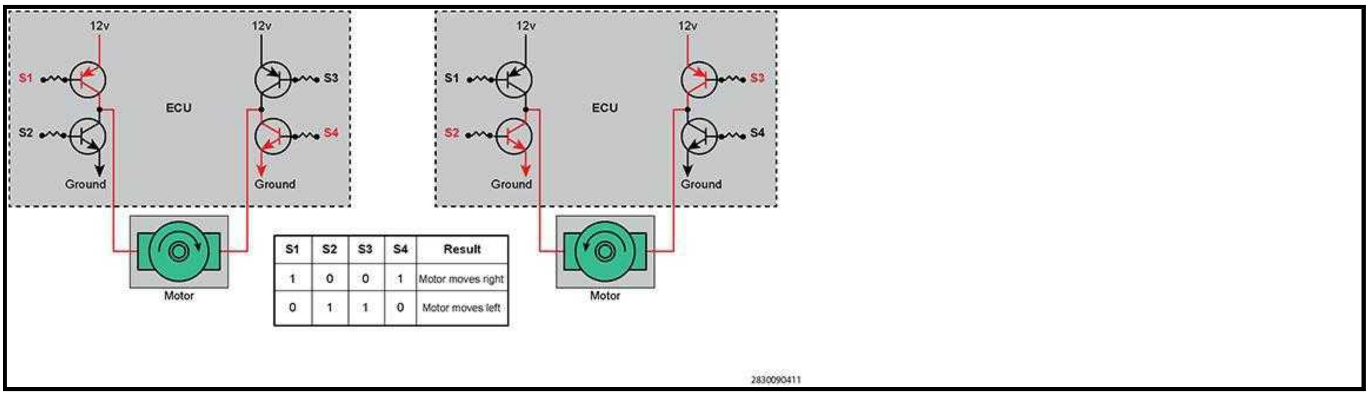
DIAGNOSIS AND TESTING

P2100-ELECTRONIC THROTTLE CONTROL MOTOR CIRCUIT

For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

GENERAL OPERATION: The Electronic Throttle Control (ETC) Motor is controlled using an H-Bridge circuit inside the Powertrain Control Module (PCM). An H-Bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. The H-Bridge arrangement is generally used to reverse the polarity/direction of the Direct Current (DC) motor which allows the DC motor to run forward and backwards. The DC motor located in the Throttle Body drives the throttle blade. In order to decrease engine speed, along with spark and fuel delivery changes, the PCM commands the throttle blade closed reducing air flow into the engine and the engine speed decreases. In order to increase engine speed, the PCM commands the throttle blade open, increasing air flow and engine speed. On a normally functioning Throttle Body, the duty cycle of the ETC Motor should not go above approximately 40%. **See the figure below for a general configuration and operation of an H-Bridge:**



ETC MOTOR DIAGNOSTICS: The PCM performs diagnostics on the DC Motor and circuits. If the PCM detects that the current draw or Pulse Width Modulation (PWM) to the DC Motor is too high or low for a calibrated period of time, then the PCM determines that the motor or circuitry is faulted and not operating properly.

NOTE: **The PCM can detect a circuit high or circuit low fault during operation of the component, whereas open circuit detection can only occur when the component is not being commanded. If an open occurs in the component or circuits during operation, the PCM will normally detect the failure during the performance diagnostic for the system that component is being used to control.**

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- The ETC Motor not in Limp Home mode.

SET CONDITION

- When the Powertrain Control Module (PCM) detects a short in the ETC Motor (+) and ETC Motor (-) circuits of the ETC Motor Driver circuit.

DEFAULT ACTION

- The ETC light will flash.
- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
LOW BATTERY VOLTAGE
ETC MOTOR (+) CIRCUIT SHORTED TO 5.0 VOLTS
ETC MOTOR (-) CIRCUIT SHORTED TO 5.0 VOLTS
ETC MOTOR (+) CIRCUIT SHORTED TO GROUND
ETC MOTOR (-) CIRCUIT SHORTED TO GROUND
ETC MOTOR (+) CIRCUIT SHORTED TO THE ETC MOTOR (-) CIRCUIT
ETC MOTOR/THROTTLE BODY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
    1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

       Are there any applicable Service Bulletins or Flash updates?

       Yes

       - Perform the applicable repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

- Go To 3

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

NOTE:	**If the P2100 is intermittent, it is possible that Low battery voltage is causing excessive current draw in very hot or cold ambient temperatures. This is considered a normal protection operation and no repair is necessary.**

3. **ISOLATE AND CHECK THE THROTTLE BODY (K124) MOTOR (+) CIRCUIT FOR A SHORT TO THE (F855) 5-VOLT SUPPLY CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION:	**Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE:	**There should be no continuity between the circuits being tested.**

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **ISOLATE AND CHECK THE THROTTLE BODY (K126) MOTOR (-) CIRCUIT FOR A SHORT TO THE (F855) 5-VOLT SUPPLY CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION:	**Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between the circuits being tested.**

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **ISOLATE AND CHECK THE THROTTLE BODY (K124) MOTOR (+) CIRCUIT FOR A SHORT TO THE THROTTLE BODY (K126) MOTOR (-) CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between the circuits being tested.**

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **ISOLATE AND CHECK THE THROTTLE BODY (K124) MOTOR (+) CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, (special tool #10436, Adapter, GPEC Diagnostic) connect the to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 7

7. **ISOLATE AND CHECK THE THROTTLE BODY (K126) MOTOR (-) CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, (special tool #10436, Adapter, GPEC Diagnostic) connect the to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 8

8. **REPLACE THE THROTTLE BODY AND RETEST FOR DTCS**
    1. Turn the ignition off.
    2. Replace the component in accordance with the Service Information. After installation is complete, with a scan tool perform the ETC RELEARN function. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** .
    3. Connect the component and Electronic Control Unit (ECU) harness connectors.
    4. Turn the ignition on.
    5. With the scan tool, erase all DTCs.
    6. Turn the ignition off for a minimum of 10.0 seconds.
    7. Turn the ignition on.
    8. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    9. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 9

    No

    - Replacing the faulty component repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.

9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

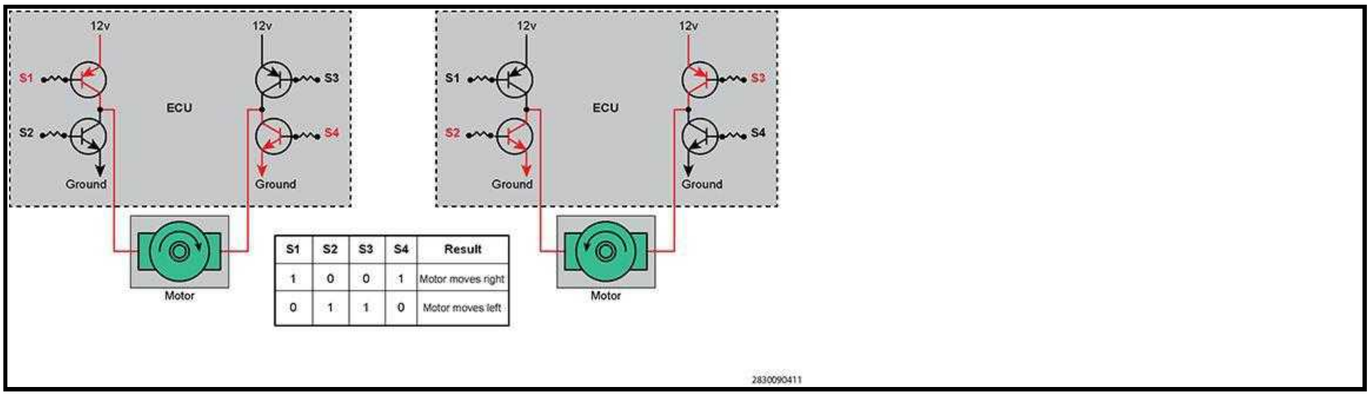
- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2101-ELECTRONIC THROTTLE CONTROL MOTOR PERFORMANCE

For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

GENERAL OPERATION: The Electronic Throttle Control (ETC) Motor is controlled using an H-Bridge circuit inside the Powertrain Control Module (PCM). An H-Bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. The H-Bridge arrangement is generally used to reverse the polarity/direction of the Direct Current (DC) motor which allows the DC motor to run forward and backwards. The DC motor located in the Throttle Body drives the throttle blade. In order to decrease engine speed, along with spark and fuel delivery changes, the PCM commands the throttle blade closed reducing air flow into the engine and the engine speed decreases. In order to increase engine speed, the PCM commands the throttle blade open, increasing air flow and engine speed. On a normally functioning Throttle Body, the duty cycle of the ETC Motor should not go above approximately 40%. **See the figure below for a general configuration and operation of an H-Bridge:**



S1	S2	S3	S4	Result
1	0	0	1	Motor moves right
0	1	1	0	Motor moves left

ETC MOTOR DIAGNOSTICS: The PCM performs diagnostics on the DC Motor and circuits. If the PCM detects that the current draw or Pulse Width Modulation (PWM) to the DC Motor is too high or low for a calibrated period of time, then the PCM determines that the motor or circuitry is faulted and not operating properly.

NOTE: **The PCM can detect a circuit high or circuit low fault during operation of the component, whereas open circuit detection can only occur when the component is not being commanded. If an open occurs in the component or**

circuits during operation, the PCM will normally detect the failure during the performance diagnostic for the system that component is being used to control.

WHEN MONITORED

- This diagnostic runs with the ignition on.

SET CONDITION

- When the error between the actual position and the desired position of the ETC Motor Driver, based on the rate of change, exceeds a calibrated threshold for one second.

DEFAULT ACTION

- The ETC light will flash.
- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
LOW BATTERY VOLTAGE
ETC MOTOR (+) CIRCUIT OPEN
ETC MOTOR (-) CIRCUIT OPEN
ETC MOTOR (+) CIRCUIT SHORTED TO 12 VOLTS
ETC MOTOR (-) CIRCUIT SHORTED TO 12 VOLTS
THROTTLE BODY ASSEMBLY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

NOTE: **If the P2100 is intermittent, it is possible that Low battery voltage is causing excessive current draw, in very hot or very cold ambient temperatures and this is considered a normal protection operation. No repair is necessary.**

2. **ISOLATE AND CHECK THE THROTTLE BODY (K124) ETC MOTOR (+) CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 3

    No

    - Repair the circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **ISOLATE AND CHECK THE THROTTLE BODY (K126) MOTOR (-) CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 4

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK FOR THE THROTTLE BODY MOTOR CIRCUITS SHORTED TO 12.0 VOLTS**
   1. Reconnect the Throttle Body harness connector.
   2. Reconnect the PCM C2 harness connector with the GPEC Adaptor still connected in-line.
   3. Turn the ignition on.
   4. With the scan tool, actuate the Throttle Follower Test.
   5. Slowly press and release the Accelerator Pedal while monitoring the voltage.
   6. Measure the voltage on the Throttle Body (K124) Motor (+) circuit at the GPEC Adaptor.
   7. Measure the voltage on the Throttle Body (K126) Motor (-) circuit at the GPEC Adaptor.

   NOTE: **The voltage reading should change as the valve position is changed. A reading that stays at 12.0 volts would indicate a short to voltage.**

   Is the voltage reading steady at 12.0 volts for either circuit?

   Yes

   - Repair the Throttle Body (K124) Motor (+) circuit or Throttle Body (K126) Motor (-) circuit for a short to voltage.

     NOTE: **A short to voltage can cause the H-Bridge driver in the PCM to be damaged. After repairing the short to voltage, verify that the PCM was not damaged.**

     Go To 5

   No

   - Go To 5

5. **CHECK THE THROTTLE BODY MOTOR FOR PROPER OPERATION**
   1. Connect the voltmeter positive lead to the Throttle Body (K124) Motor (+) circuit.
   2. Connect the voltmeter negative lead to the Throttle Body (K126) Motor (-) circuit.
   3. With the scan tool, actuate the Throttle Follower Test.

4. Slowly press and release the Accelerator Pedal while monitoring the voltage.

   Is the voltage changing as the Throttle Body Valve position changes?

   Yes

   - If a short to voltage has been repaired on either of the ETC Motor circuits in the previous step, repair is complete. If not, replace the Throttle Body Assembly in accordance with the Service Information. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** . Disconnect the Battery when replacing the Throttle Body Assembly. After installation is complete, use a scan tool and perform the ETC RELEARN function.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND**

INSTALLATION .

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2107-ELECTRONIC THROTTLE CONTROL MODULE PROCESSOR

For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

- This diagnostic runs continuously with the engine running.

SET CONDITION

- The Powertrain Control Module (PCM) detects an internal error.

DEFAULT ACTION

- The ETC light will flash.
- The MIL light will illuminate.

POSSIBLE CAUSES

Possible Causes
POWERTRAIN CONTROL MODULE (PCM) SOFTWARE UPDATE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    NOTE: **An intermittent loss of power to the PCM without performing an ETC Relearn procedure may cause this DTC to set.**

    Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE POWERTRAIN CONTROL MODULE SOFTWARE LEVEL**
    1. Turn the ignition on.
    2. Verify the PCM is at the latest calibration (flash level).

    Is there an update for the PCM software?

    Yes

    - Go To 3

    No

    - Go To 4
3. **PROGRAM THE POWERTRAIN CONTROL MODULE**
    1. Update the PCM in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), MODULE PROGRAMMING** .
    2. Cycle the ignition off and on.
    3. With a scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 4

    No

    - Updating the PCM software repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
4. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).

- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

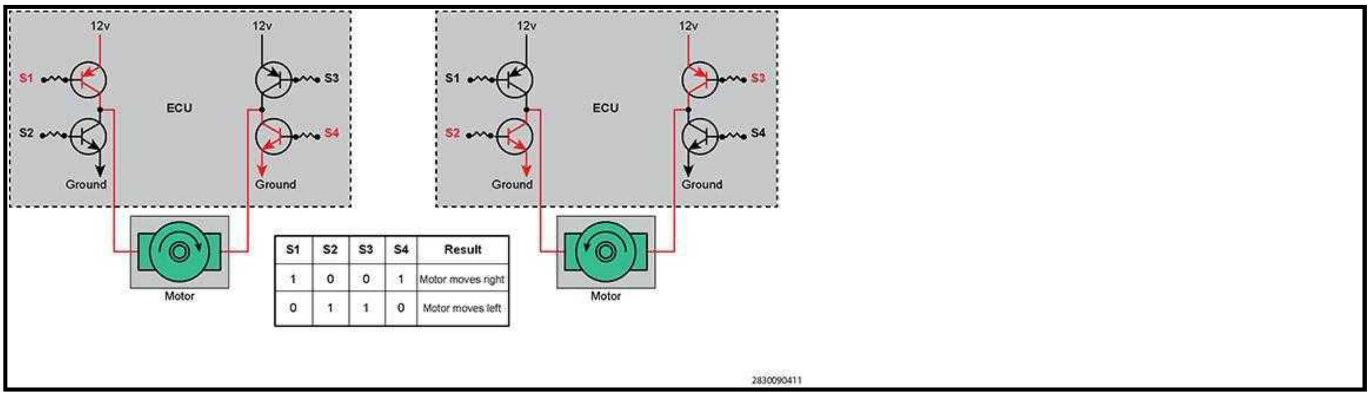
    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2110-ELECTRONIC THROTTLE CONTROL - FORCED LIMITED RPM

For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

GENERAL OPERATION: The Electronic Throttle Control (ETC) Motor is controlled using an H-Bridge circuit inside the Powertrain Control Module (PCM). An H-Bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. The H-Bridge arrangement is generally used to reverse the polarity/direction of the Direct Current (DC) motor which allows the DC motor to run forward and backwards. The DC motor located in the Throttle Body drives the throttle blade. In order to decrease engine speed, along with spark and fuel delivery changes, the PCM commands the throttle blade closed reducing air flow into the engine and the engine speed decreases. In order to increase engine speed, the PCM commands the throttle blade open, increasing air flow and engine speed. On a normally functioning Throttle Body, the duty cycle of the ETC Motor should not go above approximately 40%. **See the figure below for a general configuration and operation of an H-Bridge:**



ETC MOTOR DIAGNOSTICS: The PCM performs diagnostics on the DC Motor and circuits. If the PCM detects that the current draw or Pulse Width Modulation (PWM) to the DC Motor is too high or low for a calibrated period of time, then the PCM determines that the motor or circuitry is faulted and not operating properly.

NOTE: **The PCM can detect a circuit high or circuit low fault during operation of the component, whereas open circuit detection can only occur when the component is not being commanded. If an open occurs in the component or circuits during operation, the PCM will normally detect the failure during the performance diagnostic for the system that component is being used to control.**

WHEN MONITORED

- This diagnostic runs with the engine running.

SET CONDITION

- When the Powertrain Control Module (PCM) requests to limit engine speed and ETC PWM is too high for 1.2 seconds and before P2118 sets.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will illuminate.
- If the ETC PWM stays above 80%, P2110 will set first, and if the fault persists P2118 will follow. Root cause is common for both faults.

POSSIBLE CAUSES

Possible Causes
POWERTRAIN CONTROL MODULE (PCM) SOFTWARE UPDATE
LOW BATTERY VOLTAGE
INTERMITTENT LOSS OF CONNECTION AT THE THROTTLE BODY HARNESS CONNECTOR
ETC MOTOR (+) CIRCUIT OPEN/HIGH RESISTANCE
ETC MOTOR (-) CIRCUIT OPEN/HIGH RESISTANCE
COKING OR DEBRIS BLOCKING THE THROTTLE BODY PLATE
THROTTLE BODY PLATE BINDING INSIDE THE BORE
ETC MOTOR/THROTTLE BODY ASSEMBLY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**

   NOTE: **Low battery voltage can also cause excessive current draw. Make sure that the battery is fully charged and can pass a load test before continuing.**

   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

     NOTE: **When this DTC is Active the engine speed, torque and vehicle speed are limited to a Limp in mode. An intermittent loss of power to the PCM without performing an ETC RELEARN procedure may cause this DTC to set.**

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any ETC Motor circuit DTCs present?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3
3. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
   1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

      Are there any applicable Service Bulletins or Flash updates?

      Yes

      - Perform the applicable repair.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **CHECK THE THROTTLE BODY HARNESS CONNECTOR AND TERMINALS**
    1. Turn the ignition off.
    2. Check the Throttle Body harness connector for proper connection at the Throttle Body.
    3. Verify that the connector is completely plugged in and properly locked prior to disconnecting.
    4. Disconnect the Throttle Body harness connector and check for any pushed out, damaged or spread terminals.

    NOTE: **An intermittent loss of a signal from one of the sensors may cause this DTC to set without setting a sensor fault.**

    Were any issues found with the connector or terminals?

    Yes

    - Repair the damaged terminal or properly connect and lock the Throttle Body harness connector and retest for DTCs.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

5. **ISOLATE AND LOAD TEST THE THROTTLE BODY (K124) MOTOR (+) CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
    3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
    4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
    5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
    6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

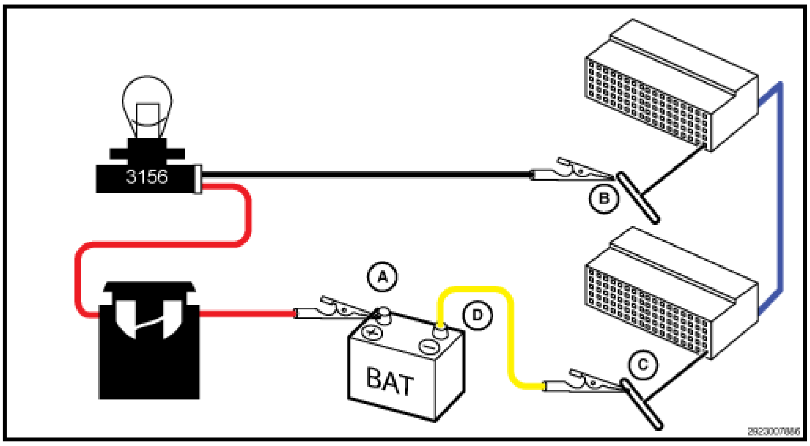
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Note: Why perform a voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: Do not load test any circuits with components still connected to the circuit.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 6

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND LOAD TEST THE THROTTLE BODY (K126) MOTOR (-) CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
    3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
    4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
    5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
    6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

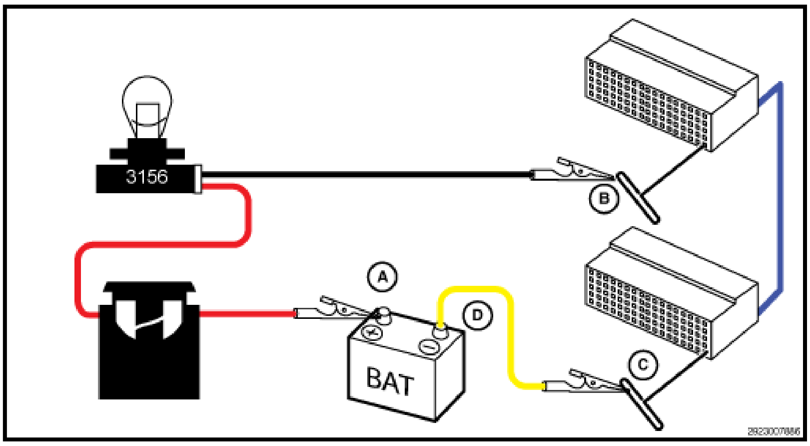
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**

3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 7

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **INSPECT THE THROTTLE BODY FOR FOREIGN MATERIAL, SCORING OR OTHER DAMAGE THAT COULD CAUSE THE THROTTLE PLATE TO STICK**

1. Turn the ignition off.
2. Remove the Air Cleaner Assembly from the Throttle Body.
3. Check for any signs of a foreign material (ice or dirt) causing the Throttle to stick or damage to the Throttle Body bore or plate.

   Were any problems found?

   Yes

   - Remove the debris and inspect the Throttle Body Assembly for signs of physical damage. If the Throttle Body is damaged or still not functioning properly, replace the Throttle Body in accordance with the Service Information. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** . Disconnect the Battery when replacing the Throttle Body Assembly. After installation is complete, use a scan tool and perform the ETC RELEARN function.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 8

8. **REPLACE THE THROTTLE BODY AND RETEST FOR DTCS**
   1. Replace the Throttle Body in accordance with the Service Information. After installation is complete, with a scan tool perform the ETC RELEARN function. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** .
   2. Connect the Throttle Body and PCM harness connectors.
   3. Turn the ignition on.
   4. With the scan tool, erase DTCs.
   5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
   6. With the scan tool, read DTCs.

      Did the DTC return?

      Yes

      - Go To 9

      No

      - Replacing the faulty Throttle Body repaired the fault.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.

- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

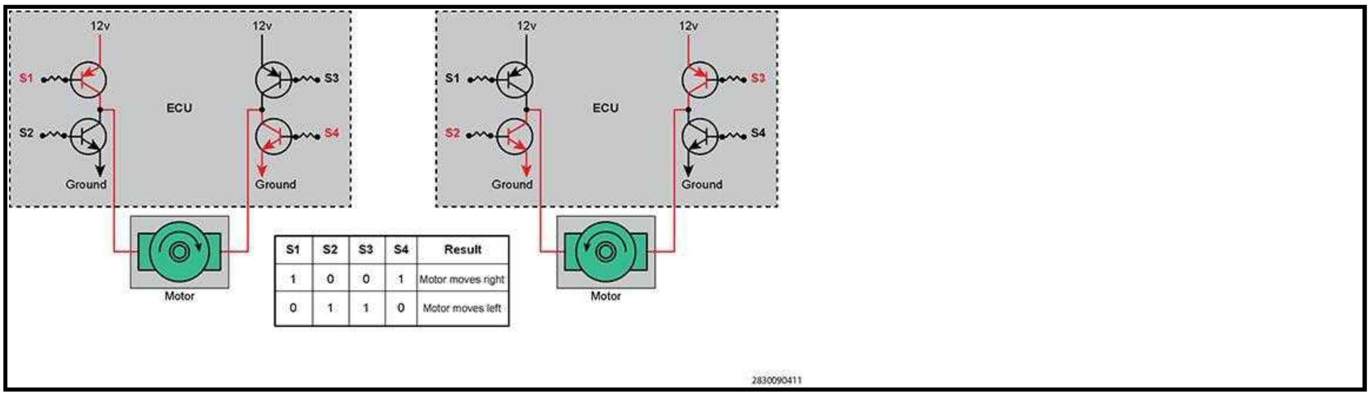
- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2111-ELECTRONIC THROTTLE CONTROL - UNABLE TO CLOSE

For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

GENERAL OPERATION: The Electronic Throttle Control (ETC) Motor is controlled using an H-Bridge circuit inside the Powertrain Control Module (PCM). An H-Bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. The H-Bridge arrangement is generally used to reverse the polarity/direction of the Direct Current (DC) motor which allows the DC motor to run forward and backwards. The DC motor located in the Throttle Body drives the throttle blade. In order to decrease engine speed, along with spark and fuel delivery changes, the PCM commands the throttle blade closed reducing air flow into the engine and the engine speed decreases. In order to increase engine speed, the PCM commands the throttle blade open, increasing air flow and engine speed. On a normally functioning Throttle Body, the duty cycle of the ETC Motor should not go above approximately 40%. **See the figure below for a general configuration and operation of an H-Bridge:**



ETC MOTOR DIAGNOSTICS: The PCM performs diagnostics on the DC Motor and circuits. If the PCM detects that the current draw or Pulse Width Modulation (PWM) to the DC Motor is too high or low for a calibrated period of time, then the PCM determines that the motor or circuitry is faulted and not operating properly.

NOTE: **The PCM can detect a circuit high or circuit low fault during operation of the component, whereas open circuit detection can only occur when the component is not being commanded. If an open occurs in the component or circuits during operation, the PCM will normally detect the failure during the performance diagnostic for the system that component is being used to control.**

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- The ETC Motor Self-Learn procedure has been completed.

SET CONDITION

- When the PCM detects that the Throttle Body blade is not in the correct position for one second during the opening spring return test.

DEFAULT ACTION

- The ETC light will flash.
- The MIL light will illuminate.

POSSIBLE CAUSES

Possible Causes
POWERTRAIN CONTROL MODULE (PCM) SOFTWARE UPDATE
PCM FLASH WAS PERFORMED OR BATTERY VOLTAGE WAS LOST AND THE THROTTLE BODY SELF LEARN WAS NOT PERFORMED
COKING OR BLOCKAGE OF THE THROTTLE PLATE
ELECTRONIC THROTTLE CONTROL (ETC) MOTOR/THROTTLE BODY

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **VERIFY THE PCM WAS NOT REPLACED OR FLASH UPDATES PERFORMED**

NOTE: **This DTC can set when the PCM Non-volatile RAM is reset (can occur when programming the PCM or when Battery voltage to the PCM is very low or lost completely) and an engine start was attempted before cycling the ignition switch from on to off. The Electronic Throttle Body Position Learn procedure must be allowed to run before starting the engine under these conditions.**

1. Check the repair history to determine if the PCM was replaced or any Flash updates were performed.

   Was the PCM was replaced or any Flash updates performed?

   Yes

   - Go To 2

   No

   - Go To 3

2. **PERFORM THE THROTTLE BODY Self-Learn PROCEDURE**
   1. Turn the ignition on for 10.0 seconds to allow the Throttle Body Self-Learn procedure to run to completion or Perform Throttle Body Self-Learn procedure with the scan tool.
   2. With the scan tool, erase DTCs.
   3. Cycle the ignition off for 10.0 seconds.
   4. Cycle the ignition on for 10.0 seconds.
   5. With the scan tool, read DTCs

      Did the DTC return?

      Yes

      - Go To 3

      No

      - Performing the Throttle Body Self-Learn procedure repaired the issue.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **CHECK FOR ANY SERVICE BULLETINS OR FLASH UPDATES THAT APPLY**
   1. Before proceeding with this test procedure, perform any Service Bulletins or PCM Flash updates that relate to this fault code.

      Are there any Service Bulletins or PCM Flash updates available?

      Yes

      - Perform the applicable Service Bulletin or PCM Flash update.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 4

4. **CHECK FOR OTHER DTCS**
   1. Turn the ignition on.

2. With the scan tool, read and record DTCs and Freeze Frame Data.

   Are there any Throttle Body, Crankshaft Position (CKP) Sensor, Camshaft Position (CMP) Sensor, Engine Coolant Temperature (ECT), Intake Air Temperature (IAT) Sensor, Ambient Air Temperature (AAT) Sensor, or Vehicle Speed Sensor DTCs active or pending?

   Yes

   - Refer to the appropriate information .

   No

   - Go To 5

5. **VISUALLY INSPECT THE THROTTLE BODY ASSEMBLY**
   1. Turn the ignition off.
   2. Remove the Air Cleaner Assembly from the Throttle Body.
   3. Check for any signs of a foreign material (ice or dirt) on the Throttle Plate or in the bore causing the Throttle Plate to stick.
   4. Inspect for any signs of coking or a foreign material (ice or dirt) on the Throttle Plate or in the bore causing the Throttle Plate to stick. Turn the ignition on and use the scan tool to actuate the Throttle Plate and check for any sticking.

      Were any signs of foreign material or scoring of the Throttle Plate or bore found?

      Yes

      - Clean the Throttle Blade and bore if possible or replace the Throttle Body Assembly in accordance with the Service Information if necessary.
      - Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** .

        .

      No

      - Go To 6

6. **CHECK THE THROTTLE BODY WRING HARNESS CONNECTOR**
   1. Disconnect the Throttle Body harness connector.
   2. Check the connector for any corroded, pushed out, spread, or damaged terminals.

      Were any problems found?

      Yes

      - Perform the appropriate repair.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

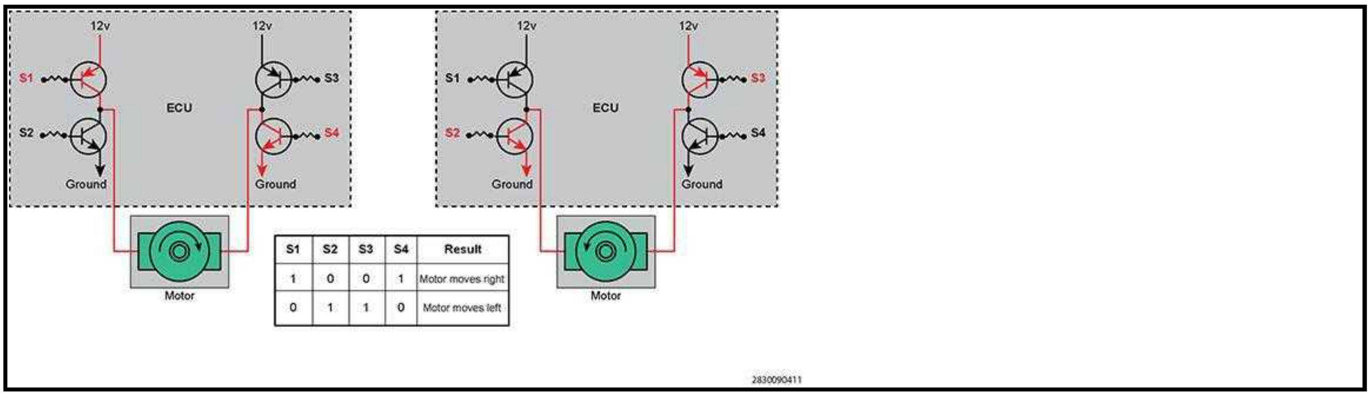
      - Replace the Throttle Body Assembly in accordance with the Service Information. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2112-ELECTRONIC THROTTLE CONTROL - UNABLE TO OPEN

For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

GENERAL OPERATION: The Electronic Throttle Control (ETC) Motor is controlled using an H-Bridge circuit inside the Powertrain Control Module (PCM). An H-Bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. The H-Bridge arrangement is generally used to reverse the polarity/direction of the Direct Current (DC) motor which allows the DC motor to run forward and backwards. The DC motor located in the Throttle Body drives the throttle blade. In order to decrease engine speed, along with spark and fuel delivery changes, the PCM commands the throttle blade closed reducing air flow into the engine and the engine speed decreases. In order to increase engine speed, the PCM commands the throttle blade open, increasing air flow and engine speed. On a normally functioning Throttle Body, the duty cycle of the ETC Motor should not go above approximately 40%. **See the figure below for a general configuration and operation of an H-Bridge:**



ETC MOTOR DIAGNOSTICS: The PCM performs diagnostics on the DC Motor and circuits. If the PCM detects that the current draw or Pulse Width Modulation (PWM) to the DC Motor is too high or low for a calibrated period of time, then the PCM determines that the motor or circuitry is faulted and not operating properly.

NOTE: **The PCM can detect a circuit high or circuit low fault during operation of the component, whereas open circuit detection can only occur when the component is not being commanded. If an open occurs in the component or circuits during operation, the PCM will normally detect the failure during the performance diagnostic for the system that component is being used to control.**

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
- The ETC Motor Self-Learn procedure has been completed.

SET CONDITION

- When the Powertrain Control Module (PCM) detects that the Throttle Body blade is not in the correct position when checked during the closing spring return test for 0.5 seconds.

DEFAULT ACTION

- The ETC light will flash.
- The MIL light will illuminate.

POSSIBLE CAUSES

Possible Causes
COKING OR BLOCKAGE OF THE THROTTLE PLATE
ELECTRONIC THROTTLE CONTROL (ETC) MOTOR/THROTTLE BODY

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    NOTE: **The PCM tests the Throttle Body Assembly by opening and closing the Throttle Body plate before starting the engine.**

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **INSPECT THE THROTTLE BODY FOR FOREIGN MATERIAL, SCORING, OR OTHER DAMAGE THAT COULD CAUSE THE THROTTLE PLATE TO STICK**
    1. Turn the ignition off.
    2. Remove the Air Cleaner Assembly from the Throttle Body.
    3. Check for any signs of a foreign material (ice or dirt) on the Throttle Plate or in the bore causing the Throttle Plate to stick.
    4. Inspect for any signs of coking or a foreign material (ice or dirt) on the Throttle Plate or in the bore causing the Throttle Plate to stick. Turn the ignition on and use the scan tool to actuate the Throttle Plate and check for any sticking.

        Were any signs of foreign material or scoring of the Throttle Plate or bore found?

        Yes

        - Clean the throttle blade and bore if possible or replace the Throttle Body Assembly in accordance with the Service Information if necessary. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** . Disconnect the Battery when replacing the Throttle Body Assembly. After installation is complete, use a scan tool and perform the ETC RELEARN function.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **CHECK THE THROTTLE BODY CONNECTOR FOR DAMAGE OR POOR FIT**
   1. Disconnect the Throttle Body harness connector.
   2. Check the connector for any corroded, pushed out, spread or damaged terminals.

   Were any problems found?

   Yes

   - Repair the Throttle Body connector or wiring.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Replace the Throttle Body Assembly in accordance with the Service Information. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** . Disconnect the Battery when replacing the Throttle Body Assembly. After installation is complete, use a scan tool and perform the ETC RELEARN function.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2115-ACCELERATOR PEDAL POSITION SENSOR 1 MINIMUM STOP PERFORMANCE

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
  - During in-plant testing, the Accelerator Pedal Position (APP) Sensor is checked to make sure the minimum and maximum values can be reached. The Powertrain Control Module (PCM) performs the diagnostic test for this DTC after the diagnostic test for P2166 has passed.

SET CONDITION

- APP Sensor 1 has failed to achieve the required minimum value during In-Plant testing.

DEFAULT ACTION

- The Electronic Throttle Control (ETC) light will illuminate.
- This is a non-MIL fault.
- The Throttle input and vehicle speed are limited.

POSSIBLE CAUSES

POSSIBLE CAUSES
ETC RELEARN
ACCELERATOR PEDAL POSITION (APP) SENSOR

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    NOTE: **This DTC is set when the APP Sensor values are learned in-plant but do not reach the minimum or maximum voltage range.**

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any APP Sensor out of range or 5-Volt Supply DTCs active or pending?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **PERFORM THE ETC RELEARN FUNCTION AND RETEST FOR DTC**
    1. With a scan tool perform the ETC RELEARN function.
    2. With the scan tool, erase DTCs.
    3. Start the engine.
    4. With the scan tool, read DTCs.

        Is the DTC active or pending?

        Yes

        - Replace the APP Sensor in accordance with the Service Information. After installation is complete, perform the ETC RELEARN function.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Performing the ETC RELEARN function repaired the fault.

P2116-ACCELERATOR PEDAL POSITION SENSOR 2 MINIMUM STOP PERFORMANCE

WHEN MONITORED

This diagnostic runs when the following condition is met:

- With the ignition on.
    - During in-plant testing, the Accelerator Pedal Position (APP) Sensor is checked to make sure the minimum and maximum values can be reached. The Powertrain Control Module (PCM) performs the diagnostic test for this DTC after the diagnostic test for P2167 has passed.

SET CONDITION

- APP Sensor 2 has failed to achieve the required minimum value during In-Plant testing.

DEFAULT ACTION

- The Electronic Throttle Control (ETC) light will illuminate.
- This is a non-MIL fault.
- The Throttle input and vehicle speed are limited.

POSSIBLE CAUSES

POSSIBLE CAUSES
ETC RELEARN
ACCELERATOR PEDAL POSITION (APP) SENSOR

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    NOTE: **This DTC is set when the APP Sensor values are learned in-plant but do not reach the minimum or maximum voltage range.**

    Did the DTC return?

    Yes

    - Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any APP Sensor out of range or 5-Volt Supply DTCs active or pending?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 3
3. **PERFORM THE ETC RELEARN FUNCTION AND RETEST FOR DTC**
    1. With a scan tool perform the ETC RELEARN function.
    2. With the scan tool, erase DTCs.
    3. Start the engine.
    4. With the scan tool, read DTCs.

       Is the DTC active or pending?

       Yes

       - Replace the APP Sensor in accordance with the Service Information. After installation is complete, perform the ETC RELEARN function.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

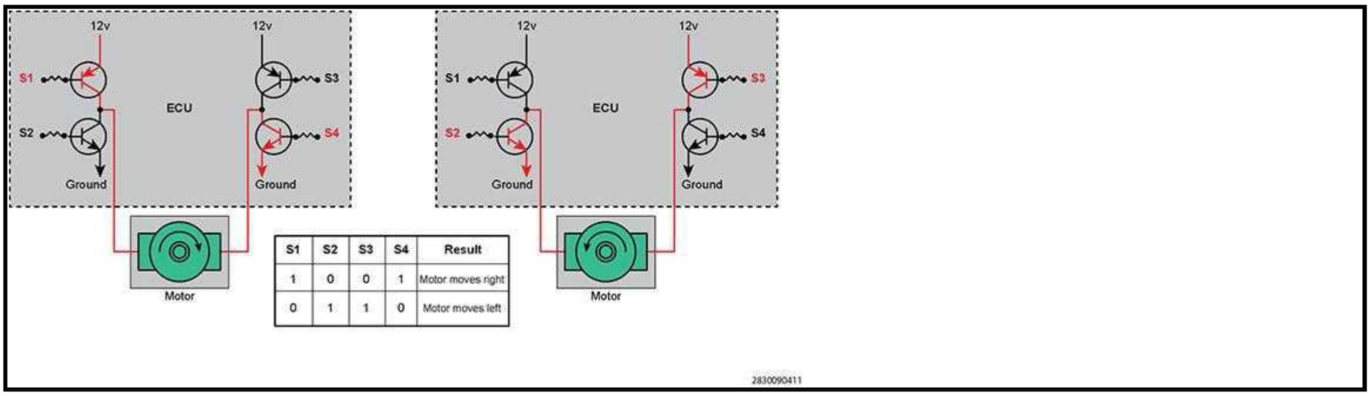
       - Performing the ETC RELEARN function repaired the fault.

P2118-ELECTRONIC THROTTLE CONTROL MOTOR CURRENT PERFORMANCE - BANK 1

For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

GENERAL OPERATION: The Electronic Throttle Control (ETC) Motor is controlled using an H-Bridge circuit inside the Powertrain Control Module (PCM). An H-Bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. The H-Bridge arrangement is generally used to reverse the polarity/direction of the Direct Current (DC) motor which allows the DC motor to run forward and backwards. The DC motor located in the Throttle Body drives the throttle blade. In order to decrease engine speed, along with spark and fuel delivery changes, the PCM commands the throttle blade closed reducing air flow into the engine and the engine speed decreases. In order to increase engine speed, the PCM commands the throttle blade open, increasing air flow and engine speed. On a normally functioning Throttle Body, the duty cycle of the ETC Motor should not go above approximately 40%. **See the figure below for a general configuration and operation of an H-Bridge:**



ETC MOTOR DIAGNOSTICS: The PCM performs diagnostics on the DC Motor and circuits. If the PCM detects that the current draw or Pulse Width Modulation (PWM) to the DC Motor is too high or low for a calibrated period of time, then the PCM determines that the motor or circuitry is faulted and not operating properly.

NOTE: **The PCM can detect a circuit high or circuit low fault during operation of the component, whereas open circuit detection can only occur when the component is not being commanded. If an open occurs in the component or circuits during operation, the PCM will normally detect the failure during the performance diagnostic for the system that component is being used to control.**

WHEN MONITORED

- This diagnostic runs with the engine running.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the ETC Motor Driver duty cycle is over 80% for more than five seconds.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will flash.
- If the PWM stays above 80%, P2110 will set first, and if the fault persists P2118 will follow. Root cause is common for both faults.

POSSIBLE CAUSES

Possible Causes
POWERTRAIN CONTROL MODULE (PCM) SOFTWARE UPDATE
LOW BATTERY VOLTAGE
INTERMITTENT LOSS OF CONNECTION AT THE THROTTLE BODY HARNESS CONNECTOR
ETC MOTOR (+) CIRCUIT OPEN/HIGH RESISTANCE
ETC MOTOR (-) CIRCUIT OPEN/HIGH RESISTANCE
COKING OR DEBRIS BLOCKING THE THROTTLE BODY PLATE
THROTTLE BODY PLATE BINDING INSIDE THE BORE
ETC MOTOR/THROTTLE BODY ASSEMBLY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**

   NOTE: **Low battery voltage can also cause excessive current draw. Make sure that the battery is fully charged and can pass a load test before continuing.**

   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

     NOTE: **When this DTC is Active the engine speed, torque and vehicle speed are limited to a Limp in mode. An intermittent loss of power to the PCM without performing an ETC RELEARN procedure may cause this DTC to set.**

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any ETC Motor circuit DTCs present?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3
3. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
   1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

      Are there any applicable Service Bulletins or Flash updates?

      Yes

      - Perform the applicable repair.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **CHECK THE THROTTLE BODY HARNESS CONNECTOR AND TERMINALS**
    1. Turn the ignition off.
    2. Check the Throttle Body harness connector for proper connection at the Throttle Body.
    3. Verify that the connector is completely plugged in and properly locked prior to disconnecting.
    4. Disconnect the Throttle Body harness connector and check for any pushed out, damaged or spread terminals.

    NOTE: **An intermittent loss of a signal from one of the sensors may cause this DTC to set without setting a sensor fault.**

    Were any issues found with the connector or terminals?

    Yes

    - Repair the damaged terminal or properly connect and lock the Throttle Body harness connector and retest for DTCs.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

5. **ISOLATE AND LOAD TEST THE THROTTLE BODY (K124) MOTOR (+) CIRCUIT TO CHECK FOR HIGH RESISTANCE**
    1. The ignition must be off when performing a load test on a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
    3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
    4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
    5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
    6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

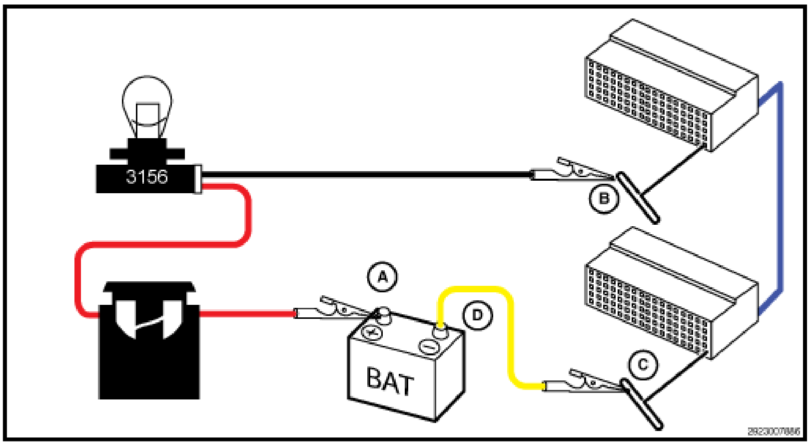
NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

NOTE: Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.

NOTE: Note: Why perform a voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:

1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.
2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.
3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: Do not load test any circuits with components still connected to the circuit.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 6

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND LOAD TEST THE THROTTLE BODY (K126) MOTOR (-) CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
   3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
   4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors (B).
   5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at the other component harness connector (C and D).
   6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

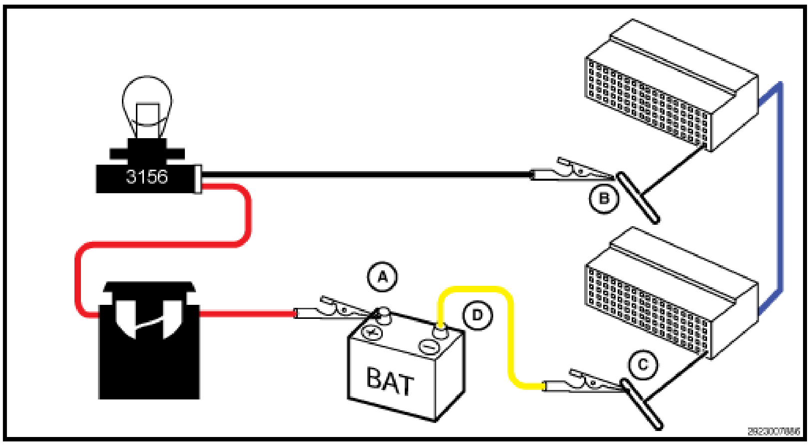
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effectively load test the circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a circuit. To perform a proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. To do so perform the following:**

1. **Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in series with the circuit.**
2. **Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**

3. **The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% less than when compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resistance of 8.0 Ohms. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 7

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

7. **INSPECT THE THROTTLE BODY FOR FOREIGN MATERIAL, SCORING OR OTHER DAMAGE THAT COULD CAUSE THE THROTTLE PLATE TO STICK**

1. Turn the ignition off.
2. Remove the Air Cleaner Assembly from the Throttle Body.
3. Check for any signs of a foreign material (ice or dirt) causing the Throttle to stick or damage to the Throttle Body bore or plate.

   Were any problems found?

   Yes

   - Remove the debris and inspect the Throttle Body Assembly for signs of physical damage. If the Throttle Body is damaged or still not functioning properly, replace the Throttle Body in accordance with the Service Information. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** . Disconnect the Battery when replacing the Throttle Body Assembly. After installation is complete, use a scan tool and perform the ETC RELEARN function.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 8

8. **REPLACE THE THROTTLE BODY AND RETEST FOR DTCS**
   1. Replace the Throttle Body in accordance with the Service Information. After installation is complete, with a scan tool perform the ETC RELEARN function. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** .
   2. Connect the Throttle Body and PCM harness connectors.
   3. Turn the ignition on.
   4. With the scan tool, erase DTCs.
   5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
   6. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 9

   No

   - Replacing the faulty Throttle Body repaired the fault.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.

- Weather seal damage (if equipped).
- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2122-ACCELERATOR PEDAL POSITION SENSOR 1 CIRCUIT LOW

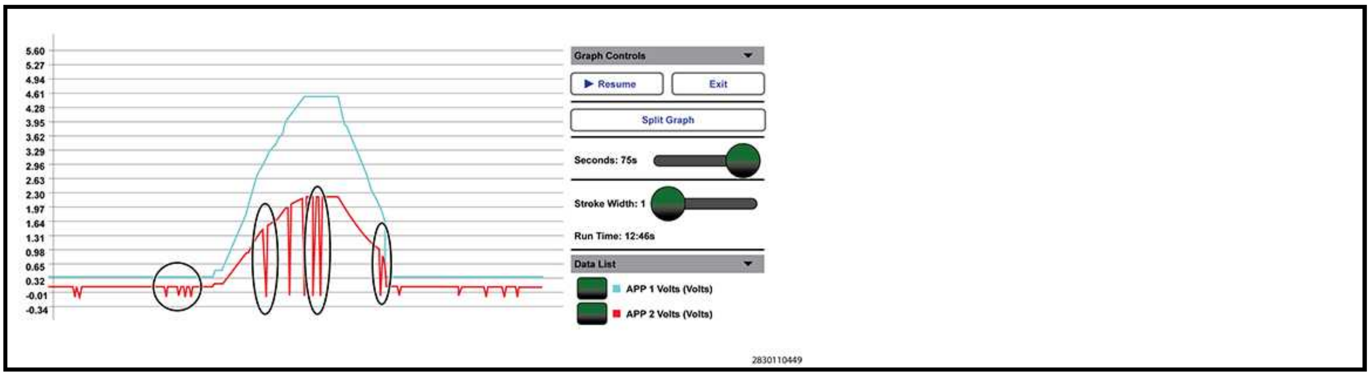
For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Accelerator Pedal Position (APP) Sensor applications today use Induction/Hall Sensors (non-contact).

The Electronic Throttle Control (ETC) system uses two Accelerator Pedal Position (APP) Sensors to monitor the accelerator pedal position. The APP Sensors 1 and 2 are integrated into one assembly located at the pedal assembly. Each sensor has a 5 volt reference circuit, a low reference circuit, and a signal circuit. The Powertrain Control Module (PCM) reads the two signals individually and then compares the two signals as a redundant check of the pedal position. The APP 1 signal will fluctuate somewhere between 0 volts and 5.0 volts. The APP 2 signal will fluctuate somewhere between 0 volts and 2.5 volts. The fluctuation of the two sensors should move proportionately. When operating properly, the voltage reading of the APP 2 will always be approximately half of the voltage reading of the APP 1.

The signal for APP 2 is also used by the PCM for an internal ground check. This test runs a couple of times per second and is the reason why the APP 2 signal spikes to ground regularly during normal operation. If graphing the APP 1 and APP 2 signals for diagnostic purposes, view the figure below to see how the signals will look on a normally functioning APP system.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the APP Sensor 1 input voltage is below the minimum acceptable value.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will flash.
- The Throttle input and vehicle speed are limited.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
APP SENSOR 1 SIGNAL CIRCUIT SHORTED TO GROUND
APP SENSOR 1 SIGNAL CIRCUIT SHORTED TO THE APP SENSOR 1 GROUND CIRCUIT
APP SENSOR 1 SIGNAL CIRCUIT SHORTED TO THE APP SENSOR 2 GROUND CIRCUIT
APP SENSOR 1 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
APP SENSOR 1 GROUND CIRCUIT OPEN/HIGH RESISTANCE
ACCELERATOR PEDAL POSITION (APP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.

6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any 5-Volt Sensor supply voltage DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3
3. **CHECK THE APP SENSOR HARNESS CONNECTOR AND TERMINALS**
   1. Turn the ignition off.
   2. Check the APP Sensor harness connector for proper connection at the APP Sensor.
   3. Verify that the connector is completely plugged in and locked prior to disconnecting.
   4. Disconnect the APP Sensor harness connector and check for pushed out or spread terminals, brineling on terminals, discoloration from excessive heat, or corrosion and water intrusion.

      Were any issues found with the connector or terminals?

      Yes

      - Repair the found issues in accordance with the service information or properly connect and lock the APP Sensor harness connector.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 4
4. **CHECK THE (K852) 5-VOLT SUPPLY CIRCUIT FOR PROPER VOLTAGE AT THE APP SENSOR HARNESS CONNECTOR**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
   3. Turn the ignition on.
   4. Set the DVOM to measure DC voltage.
   5. Connect the negative lead of the DVOM to a known good ground.

6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **Normal operating voltage should be between 4.8 and 5.2 volts.**

   Does the circuit have the proper voltage present?

   Yes

   - Go To 5

   No

   - Repair the (K852) 5-Volt Supply circuit for an open or short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND CHECK THE APP SENSOR (K23) POSITION SIGNAL 1 CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

- Go To 6

6. **ISOLATE AND CHECK THE APP SENSOR (K23) POSITION SIGNAL 1 CIRCUIT FOR A SHORT TO THE (K400) SENSOR GROUND 2 CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

      NOTE: **There should be no continuity between the circuits being tested.**

      Is there continuity between the circuits?

      Yes

      - Repair the short between the circuits.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 7

7. **ISOLATE AND CHECK THE APP SENSOR (K23) POSITION SIGNAL 1 CIRCUIT FOR A SHORT TO THE (K167) SENSOR GROUND 1 CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

      NOTE: **There should be no continuity between the circuits being tested.**

      Is there continuity between the circuits?

      Yes

      - Repair the short between the circuits.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 8

8. **ISOLATE AND CHECK THE APP SENSOR (K23) POSITION SIGNAL 1 FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 9

    No

    - Repair the circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **ISOLATE AND CHECK THE (K167) SENSOR GROUND 1 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to

pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 10

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CHECK RELATED PCM AND APP SENSOR CONNECTIONS**
    1. Disconnect all related in-line harness connections (if equipped).
    2. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
       - Proper connector installation.
       - Damaged connector locks.
       - Corrosion.
       - Other signs of water intrusion.
       - Weather seal damage (if equipped).
       - Brineling on terminals of sensor or harness connector.
       - Bent terminals.
       - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
       - Terminals that have been pushed back into the connector cavity.
       - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.

       NOTE: **Before reconnecting the harness connectors, clean the terminals with Mopar electrical connector cleaner and apply a light application of dielectric grease to the face of the connector with your finger. This will aid in preventing any future issues with the sensor terminals and connector pins; excessive amounts of dielectric grease can cause damage to the sensor terminals, connector pins, and weather seals.**

    3. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    4. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    5. Reconnect the APP Sensor harness connector. Be certain that the connectors is fully seated and the connector locks are fully engaged.
    6. With the scan tool, erase DTCs.
    7. Test drive or operate the vehicle in accordance with the when monitored and set conditions.

8. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 11

   No

   - The wiring or poor connection problem has been repaired.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **CONNECT A FUSED JUMPER BETWEEN THE APP SENSOR (K23) POSITION SIGNAL 1 CIRCUIT AND THE (K852) 5-VOLT SUPPLY CIRCUIT AT THE APP SENSOR HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL CIRCUIT HIGH DTC**
    1. The Electronic Control Module (ECU) harness connectors must be connected to the ECU during this test step.
    2. Disconnect the sensor harness connector.
    3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the 5-Volt Supply circuit at the sensor harness connector.
    4. Turn the ignition on.
    5. With the scan tool, read APP Sensor data.

       Does the scan tool display approximately 5 volts?

       Yes

       - Replace the APP Sensor in accordance with the Service Information. After installation is complete, perform the ETC RELEARN function.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2123-ACCELERATOR PEDAL POSITION SENSOR 1 CIRCUIT HIGH

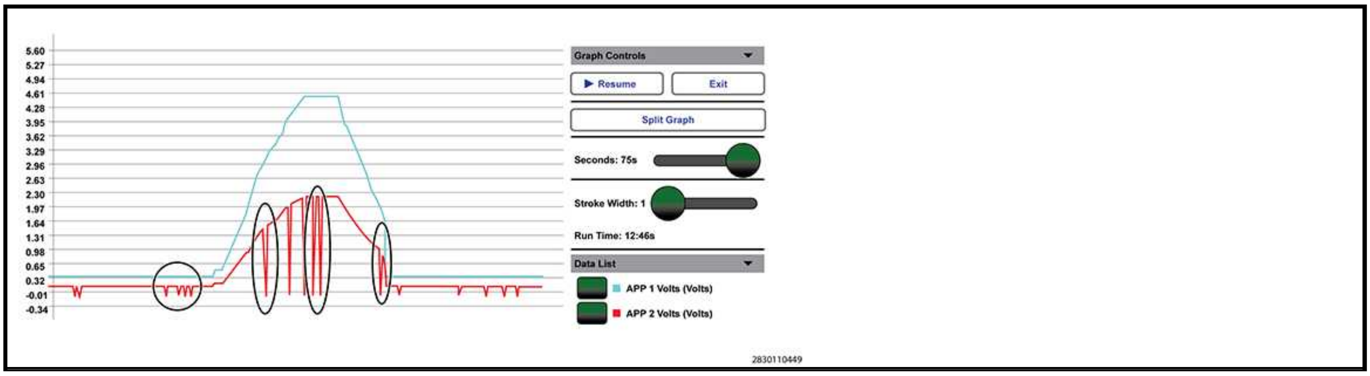
For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Accelerator Pedal Position (APP) Sensor applications today use Induction/Hall Sensors (non-contact).

The Electronic Throttle Control (ETC) system uses two Accelerator Pedal Position (APP) Sensors to monitor the accelerator pedal position. The APP Sensors 1 and 2 are integrated into one assembly located at the pedal assembly. Each sensor has a 5 volt reference circuit, a low reference circuit, and a signal circuit. The Powertrain Control Module (PCM) reads the two signals individually and then compares the two signals as a redundant check of the pedal position. The APP 1 signal will fluctuate somewhere between 0 volts and 5.0 volts. The APP 2 signal will fluctuate somewhere between 0 volts and 2.5 volts. The fluctuation of the two sensors should move proportionately. When operating properly, the voltage reading of the APP 2 will always be approximately half of the voltage reading of the APP 1.

The signal for APP 2 is also used by the PCM for an internal ground check. This test runs a couple of times per second and is the reason why the APP 2 signal spikes to ground regularly during normal operation. If graphing the APP 1 and APP 2 signals for diagnostic purposes, view the figure below to see how the signals will look on a normally functioning APP system.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Accelerator Pedal Position (APP) Sensor 1 input voltage is above 4.73 volts for 0.08 seconds.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will flash.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY 1 CIRCUIT SHORTED TO VOLTAGE
APP SENSOR SIGNAL 1 CIRCUIT SHORTED TO VOLTAGE
APP SENSOR SIGNAL 1 CIRCUIT SHORTED TO AN APP SENSOR 5-VOLT SUPPLY CIRCUIT
ACCELERATOR PEDAL POSITION (APP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to **PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .**

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.

4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any system voltage or 5-Volt Reference DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3
3. **CHECK THE APP SENSOR HARNESS CONNECTOR AND TERMINALS**
   1. Turn the ignition off.
   2. Check the APP Sensor harness connector for proper connection at the APP Sensor.
   3. Verify that the connector is completely plugged in and locked prior to disconnecting.
   4. Disconnect the APP Sensor harness connector and check for pushed out or spread terminals, brineling on terminals, discoloration from excessive heat, or corrosion and water intrusion.

      Were any issues found with the connector or terminals?

      Yes

      - Repair the found issues in accordance with the service information or properly connect and lock the APP Sensor harness connector.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 4
4. **CHECK THE (K852) 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Turn the ignition on.
   4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

NOTE: The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.

Is the voltage above 5.2 volts?

Yes

- Go To 5

No

- Go To 6

5. **ISOLATE AND CHECK THE (K852) 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 10
6. **CHECK THE APP SENSOR (K23) POSITION SIGNAL 1 CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Turn the ignition on.
    4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

NOTE: The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.

Is the voltage above 5.2 volts?

Yes

- Go To 7

No

- Go To 8

7. **ISOLATE AND CHECK THE APP SENSOR (K23) POSITION SIGNAL 1 CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 10
8. **ISOLATE AND CHECK THE APP SENSOR (K23) POSITION SIGNAL 1 CIRCUIT FOR A SHORT TO THE (K852) 5-VOLT SUPPLY CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: **There should be no continuity between the circuits being tested.**

    Is there continuity between the circuits?

    Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 9

9. **ISOLATE AND CHECK THE APP SENSOR (K23) POSITION SIGNAL 1 CIRCUIT FOR A SHORT TO THE (K854) 5-VOLT SUPPLY CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between the circuits being tested.**

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 10

10. **CHECK RELATED PCM AND APP SENSOR CONNECTIONS**
    1. Disconnect all related in-line harness connections (if equipped).
    2. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Brineling on terminals of sensor or harness connector.
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

NOTE: **Before reconnecting the harness connectors, clean the terminals with Mopar electrical connector cleaner and apply a light application of dielectric grease to the face of the connector with your finger. This will aid in preventing any future issues with the sensor terminals and connector pins; excessive amounts of dielectric grease can cause damage to the sensor terminals, connector pins, and weather seals.**

3. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
4. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
5. Reconnect the APP Sensor harness connector. Be certain that the connectors is fully seated and the connector locks are fully engaged.
6. With the scan tool, erase DTCs.
7. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
8. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 11

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **CONNECT A FUSED JUMPER BETWEEN THE APP SENSOR (K23) POSITION SIGNAL 1 CIRCUIT AND THE (K167) SENSOR GROUND 1 CIRCUIT AT THE APP SENSOR HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL CIRCUIT LOW DTC**
    1. The Electronic Control Module (ECU) harness connectors must be connected to the ECU during this test step.
    2. Disconnect the sensor harness connector.
    3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the sensor ground circuit at the sensor harness connector.
    4. Turn the ignition on.
    5. With the scan tool, read DTCs.

Does the scan tool display the SENSOR SIGNAL CIRCUIT LOW DTC with the jumper in place?

Yes

- Replace the APP Sensor in accordance with the Service Information. After installation is complete, perform the ETC RELEARN function.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2127-ACCELERATOR PEDAL POSITION SENSOR 2 CIRCUIT LOW

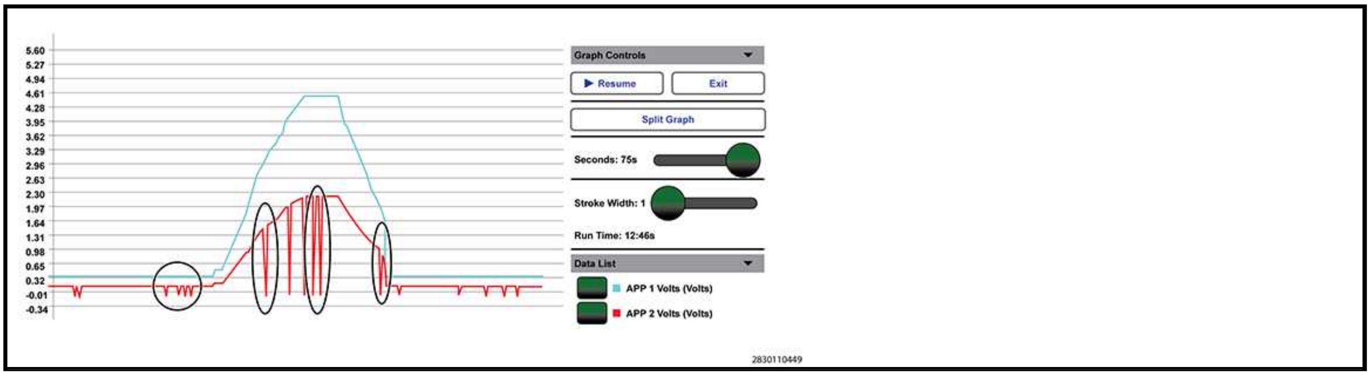
For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Accelerator Pedal Position (APP) Sensor applications today use Induction/Hall Sensors (non-contact).

The Electronic Throttle Control (ETC) system uses two Accelerator Pedal Position (APP) Sensors to monitor the accelerator pedal position. The APP Sensors 1 and 2 are integrated into one assembly located at the pedal assembly. Each sensor has a 5 volt reference circuit, a low reference circuit, and a signal circuit. The Powertrain Control Module (PCM) reads the two signals individually and then compares the two signals as a redundant check of the pedal position. The APP 1 signal will fluctuate somewhere between 0 volts and 5.0 volts. The APP 2 signal will fluctuate somewhere between 0 volts and 2.5 volts. The fluctuation of the two sensors should move proportionately. When operating properly, the voltage reading of the APP 2 will always be approximately half of the voltage reading of the APP 1.

The signal for APP 2 is also used by the PCM for an internal ground check. This test runs a couple of times per second and is the reason why the APP 2 signal spikes to ground regularly during normal operation. If graphing the APP 1 and APP 2 signals for diagnostic purposes, view the figure below to see how the signals will look on a normally functioning APP system.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the APP Sensor 2 input voltage is below the minimum acceptable value.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will flash.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
APP SENSOR 2 SIGNAL CIRCUIT SHORTED TO GROUND

Possible Causes
APP SENSOR 2 SIGNAL CIRCUIT SHORTED TO THE APP SENSOR 1 RETURN CIRCUIT
APP SENSOR 2 SIGNAL CIRCUIT SHORTED TO THE APP SENSOR 2 RETURN CIRCUIT
APP SENSOR 2 SIGNAL CIRCUIT OPEN/HIGH RESISTANCE
APP SENSOR 2 GROUND CIRCUIT OPEN/HIGH RESISTANCE
ACCELERATOR PEDAL POSITION (APP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any 5-Volt Sensor DTCs active or pending?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **CHECK THE APP SENSOR HARNESS CONNECTOR AND TERMINALS**
    1. Turn the ignition off.
    2. Check the APP Sensor harness connector for proper connection at the APP Sensor.
    3. Verify that the connector is completely plugged in and locked prior to disconnecting.

4. Disconnect the APP Sensor harness connector and check for pushed out or spread terminals, brineling on terminals, discoloration from excessive heat, or corrosion and water intrusion.

   Were any issues found with the connector or terminals?

   Yes

   - Repair the found issues in accordance with the service information or properly connect and lock the APP Sensor harness connector.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **CHECK THE (K854) 5-VOLT SUPPLY CIRCUIT FOR PROPER VOLTAGE AT THE APP SENSOR HARNESS CONNECTOR**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
   3. Turn the ignition on.
   4. Set the DVOM to measure DC voltage.
   5. Connect the negative lead of the DVOM to a known good ground.
   6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **Normal operating voltage should be between 4.8 and 5.2 volts.**

   Does the circuit have the proper voltage present?

   Yes

   - Go To 5

   No

   - Repair the (K854) 5-Volt Supply circuit for an open circuit or short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND CHECK THE APP SENSOR (K29) POSITION SIGNAL 2 CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.

4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and ground.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: There should be no continuity between ground and the circuit being tested.

Is there continuity between ground and the circuit being tested?

Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **ISOLATE AND CHECK THE APP SENSOR (K29) POSITION SIGNAL 2 CIRCUIT FOR A SHORT TO THE (K400) SENSOR GROUND 2 CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: There should be no continuity between the circuits being tested.

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **ISOLATE AND CHECK THE APP SENSOR (K29) POSITION SIGNAL 2 CIRCUIT FOR A SHORT TO THE (K167) SENSOR GROUND 1 CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

        NOTE: **There should be no continuity between the circuits being tested.**

        Is there continuity between the circuits?

        Yes

        - Repair the short between the circuits.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - Go To 8
8. **ISOLATE AND CHECK THE APP SENSOR (K29) POSITION SIGNAL 2 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

        NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

        Is the resistance below 3.0 Ohms?

Yes

- Go To 9

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **ISOLATE AND CHECK THE (K400) SENSOR GROUND 2 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 10

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CHECK RELATED PCM AND APP SENSOR CONNECTIONS**
    1. Disconnect all related in-line harness connections (if equipped).
    2. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Brineling on terminals of sensor or harness connector.

- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

NOTE: **Before reconnecting the harness connectors, clean the terminals with Mopar electrical connector cleaner and apply a light application of dielectric grease to the face of the connector with your finger. This will aid in preventing any future issues with the sensor terminals and connector pins; excessive amounts of dielectric grease can cause damage to the sensor terminals, connector pins, and weather seals.**

3. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
4. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
5. Reconnect the APP Sensor harness connector. Be certain that the connectors is fully seated and the connector locks are fully engaged.
6. With the scan tool, erase DTCs.
7. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
8. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 11

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **CONNECT A FUSED JUMPER BETWEEN THE APP SENSOR (K29) POSITION SIGNAL 2 CIRCUIT AND THE (K854) 5-VOLT SUPPLY CIRCUIT AT THE APP SENSOR HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL**
    1. The Electronic Control Module (ECU) harness connectors must be connected to the ECU during this test step.
    2. Disconnect the sensor harness connector.
    3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the 5-Volt Supply circuit at the sensor harness connector.
    4. Turn the ignition on.
    5. With the scan tool, read APP Sensor data.

Does the scan tool display approximately 5 volts?

Yes

- Replace the APP Sensor in accordance with the Service Information. After installation is complete, perform the ETC RELEARN function.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2128-ACCELERATOR PEDAL POSITION SENSOR 2 CIRCUIT HIGH

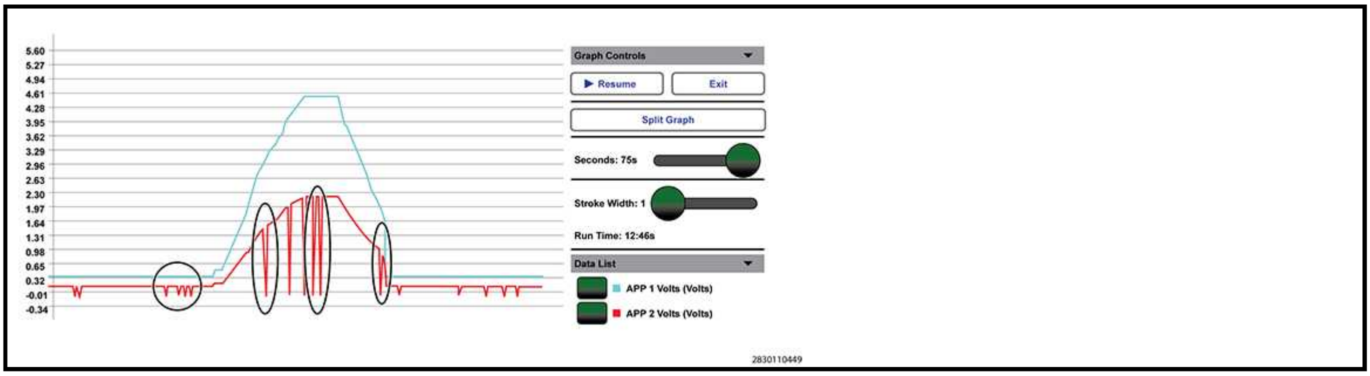
For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Accelerator Pedal Position (APP) Sensor applications today use Induction/Hall Sensors (non-contact).

The Electronic Throttle Control (ETC) system uses two Accelerator Pedal Position (APP) Sensors to monitor the accelerator pedal position. The APP Sensors 1 and 2 are integrated into one assembly located at the pedal assembly. Each sensor has a 5 volt reference circuit, a low reference circuit, and a signal circuit. The Powertrain Control Module (PCM) reads the two signals individually and then compares the two signals as a redundant check of the pedal position. The APP 1 signal will fluctuate somewhere between 0 volts and 5.0 volts. The APP 2 signal will fluctuate somewhere between 0 volts and 2.5 volts. The fluctuation of the two sensors should move proportionately. When operating properly, the voltage reading of the APP 2 will always be approximately half of the voltage reading of the APP 1.

The signal for APP 2 is also used by the PCM for an internal ground check. This test runs a couple of times per second and is the reason why the APP 2 signal spikes to ground regularly during normal operation. If graphing the APP 1 and APP 2 signals for diagnostic purposes, view the figure below to see how the signals will look on a normally functioning APP system.



WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
- Battery voltage greater than 10.4 volts.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the correlation between APP Sensor 1 and APP Sensor 2 is not plausible.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will flash.

- The Throttle input and vehicle speed are limited.

POSSIBLE CAUSES

Possible Causes
5-VOLT SUPPLY CIRCUIT SHORTED TO VOLTAGE
APP SENSOR SIGNAL 2 CIRCUIT SHORTED TO BATTERY VOLTAGE
APP SENSOR SIGNAL 2 CIRCUIT SHORTED TO AN APP SENSOR 5-VOLT SUPPLY CIRCUIT
ACCELERATOR PEDAL POSITION (APP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any system voltage or 5-Volt Reference DTCs active or pending?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **CHECK THE APP SENSOR HARNESS CONNECTOR AND TERMINALS**
    1. Turn the ignition off.
    2. Check the APP Sensor harness connector for proper connection at the APP Sensor.

3. Verify that the connector is completely plugged in and locked prior to disconnecting.
4. Disconnect the APP Sensor harness connector and check for pushed out or spread terminals, brineling on terminals, discoloration from excessive heat, or corrosion and water intrusion.

   Were any issues found with the connector or terminals?

   Yes

   - Repair the found issues in accordance with the service information or properly connect and lock the APP Sensor harness connector.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **CHECK THE (K852) 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Turn the ignition on.
   4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

   NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

   Is the voltage above 5.2 volts?

   Yes

   - Go To 5

   No

   - Go To 6

5. **ISOLATE AND CHECK THE (K852) 5-VOLT SUPPLY CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
   4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

   Is there continuity between the circuit being tested and any other circuit?

   Yes

- Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 10

6. **CHECK THE APP SENSOR (K29) POSITION SIGNAL 2 CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Turn the ignition on.
   4. Using a DVOM, measure the voltage of the circuit being tested at the component harness connector.

   NOTE: **The voltage on a 5.0 volt signal or reference circuit should be between approximately 4.8 and 5.2 volts.**

   Is the voltage above 5.2 volts?

   Yes

   - Go To 7

   No

   - Go To 8

7. **ISOLATE AND CHECK THE APP SENSOR (K29) POSITION SIGNAL 2 CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARNESS CONNECTOR**
   1. The ignition must be off when performing a resistance check to find a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this time leave all in-line connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
   4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

   Is there continuity between the circuit being tested and any other circuit?

   Yes

   - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line connectors to help isolate the location of the short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

- Go To 10

8. **ISOLATE AND CHECK THE APP SENSOR (K29) POSITION SIGNAL 2 CIRCUIT FOR A SHORT TO THE (K852) 5-VOLT SUPPLY CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

    CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: There should be no continuity between the circuits being tested.

    Is there continuity between the circuits?

    Yes

    - Repair the short between the circuits.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 9

9. **ISOLATE AND CHECK THE APP SENSOR (K29) POSITION SIGNAL 2 CIRCUIT FOR A SHORT TO THE (K854) 5-VOLT SUPPLY CIRCUIT**
    1. The ignition must be off when checking for a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

    CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

    NOTE: There should be no continuity between the circuits being tested.

    Is there continuity between the circuits?

    Yes

    - Repair the short between the circuits.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 10

10. **CHECK RELATED PCM AND APP SENSOR CONNECTIONS**
    1. Disconnect all related in-line harness connections (if equipped).
    2. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Brineling on terminals of sensor or harness connector.
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.

       NOTE: **Before reconnecting the harness connectors, clean the terminals with Mopar electrical connector cleaner and apply a light application of dielectric grease to the face of the connector with your finger. This will aid in preventing any future issues with the sensor terminals and connector pins; excessive amounts of dielectric grease can cause damage to the sensor terminals, connector pins, and weather seals.**

    3. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    4. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    5. Reconnect the APP Sensor harness connector. Be certain that the connectors is fully seated and the connector locks are fully engaged.
    6. With the scan tool, erase DTCs.
    7. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    8. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 11

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **CONNECT A FUSED JUMPER BETWEEN THE APP SENSOR (K29) POSITION SIGNAL 2 CIRCUIT AND THE (K400) SENSOR GROUND 2 CIRCUIT AT THE APP SENSOR HARNESS CONNECTOR - VERIFY ABILITY OF THE PCM TO DETECT THE SENSOR SIGNAL CIRCUIT LOW DTC**
    1. The Electronic Control Unit (ECU) harness connectors must be connected to the ECU during this test step.
    2. Disconnect the sensor harness connector.
    3. With the ignition in the off position, connect a fused jumper between the sensor signal circuit and the sensor ground circuit at the sensor harness connector.
    4. Turn the ignition on.
    5. With the scan tool, read DTCs.

    Does the scan tool display the SENSOR SIGNAL CIRCUIT LOW DTC with the jumper in place?

    Yes

    - Replace the APP Sensor in accordance with the Service Information. After installation is complete, perform the ETC RELEARN function.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2135-THROTTLE POSITION SENSOR 1/2 CORRELATION

For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Electronic Throttle Control (ETC) system uses two Throttle Position Sensors (TPS) to monitor the throttle blade position. TPS 1 and TPS 2 are located within the Throttle Body Assembly. The sensors share a common 5-Volt Reference circuit (Supply) and a common Sensor Ground but each sensor has its own Signal circuit (TPS 1 and TPS 2). Each Signal circuit provides the Powertrain Control Module (PCM) with a signal voltage proportionate to throttle blade movement. Normally operating sensor signals are opposing to each other in the following manner:

- **TPS 1** voltage starts low, approximately 0.5 volts at **closed throttle,** and increases to approximately 4.3 volts at **wide open throttle** .
- **TPS 2** voltage starts high, approximately 4.5 volts at **closed throttle,** and decreases to approximately 0.7 volts at **wide open throttle** .

THROTTLE POSITION SENSOR CORRELATION DIAGNOSTIC: Below are examples of how the PCM checks the TPS calculation for any correlation issues by comparing the Absolute Difference between the two TPS signals. Example 1 is showing a sensor correlation that is within specifications and example 2 is a sensor correlation that is outside of specifications. A simple way to calculate the Absolute Difference is to add TPS 1 and TPS 2 voltage values together. The sum of the two values should equal 5.0 volts +/- 0.25 volts. If the sum of the two values is less than 4.75V, or more than 5.25V, the correlation DTC will set.

NOTE: **The values used in the examples are from the table below.**

- **EXAMPLE 1:** Using the voltage readings from the example table below for a **NORMAL SENSOR** at **CLOSED THROTTLE** :
  - Add TPS 1 (0.542V) + TPS 2 (4.456V) = 4.998V for an Absolute Difference of (-0.002). This is a good sensor correlation reading because the difference between 5.0V and 4.998V is less than the +/- 0.25 volt threshold.
- **EXAMPLE 2:** Using the voltage readings from the table below for a **FAULTY SENSOR** at **CLOSED THROTTLE** :
  - Add TPS 1 (0.252V) + TPS 2 (4.456V) = 4.708V for an Absolute Difference of (-0.292). This is a failed sensor correlation reading because the difference between 5.0V and 4.708V is more than the +/- 0.25 volt threshold.

DISCLAIMER: The normal sensor voltage readings in the table below are typical readings for a Throttle Body on a 3.6L engine. The voltage values will vary slightly for different engines. THIS IS INTENDED AS AN EXAMPLE to aid in explaining how the diagnostic performs the Absolute Difference calculation between TPS 1 and TPS 2.				
Â	**THROTTLE POSITION**	**TPS 1 VOLTAGE**	**TPS 2 VOLTAGE**	**(TPS 1) - (TPS 2) ERROR**
NORMAL SENSOR	CLOSED THROTTLE	0.542V	4.456V	-0.002V
	WIDE OPEN THROTTLE	4.313V	0.698V	0.011V
Â				
Â	**THROTTLE POSITION**	**TPS 1 VOLTAGE**	**TPS 2 VOLTAGE**	**(TPS 1) - (TPS 2) ERROR**
FAULTY SENSOR	CLOSED THROTTLE	0.252V	4.456V	Absolute Difference -0.292V
	WIDE OPEN THROTTLE	3.993V	0.698V	Absolute Difference -0.309V

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
- No Throttle Position Sensor (TPS) DTCs present.

SET CONDITION

- The absolute difference between TPS 1 and TPS 2 signals is more than 0.25 volts for between 0.04 and 0.14 seconds depending on calibration.

DEFAULT ACTION

- ETC light will illuminate.
- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
INTERMITTENT WIRING CONNECTION/CONNECTOR ISSUE
TPS 1 SIGNAL CIRCUIT AND TPS 2 SIGNAL CIRCUIT SHORTED TOGETHER
TPS 1 SIGNAL CIRCUIT SHORTED TO THE 5-VOLT SUPPLY CIRCUIT
TPS 2 SIGNAL CIRCUIT SHORTED TO THE 5-VOLT SUPPLY CIRCUIT

Possible Causes
HIGH RESISTANCE IN THE TPS 1 OR TPS 2 SIGNAL CIRCUIT
HIGH RESISTANCE IN THE TPS RETURN CIRCUIT
HIGH RESISTANCE IN THE 5-VOLT SUPPLY CIRCUIT
THROTTLE POSITION SENSOR (TPS)/THROTTLE BODY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **PERFORM THE THROTTLE FOLLOWER TEST**
    1. Turn the ignition on.
    2. With the scan tool, read Powertrain Control Module (PCM) DTCs and Freeze Frame Data and record on the repair order.

        NOTE: **The information provided in the Freeze Frame Data may help when performing the ETC Throttle Follower Test.**

    3. With a scan tool, perform the ETC Throttle Follower Test and monitor the TPS 1 and TPS 2 voltages.

        NOTE: **The absolute difference between TPS 1 and TPS 2 should not be more than 0.25 volts at any time while performing the ETC Throttle Follower Test.**

    4. Slowly operate the throttle pedal to wide open throttle and back to closed throttle. Attempt to duplicate the position recorded in the Freeze Frame Data.
    5. The voltage reading for TPS 1 should start low, approximately 0.5 volts and increase to approximately 4.3 volts.
    6. The voltage reading for TPS 2 should start high, approximately 4.5 volts and decrease to approximately 0.7 volts.

        Do the voltages change proportionately to each other and is the absolute difference of the two sensors less than 0.25 volts during the entire range of travel?

        Yes

        - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

        No

        - Go To 2
2. **CHECK FOR AN INTERMITTENT WIRING/CONNECTOR ISSUE**
    1. With the scan tool, perform the ETC Throttle Follower Test again and wiggle test the wiring harness connector while slowly operating the throttle pedal to wide open throttle and back to closed throttle. Again, attempt to duplicate the position recorded in the Freeze Frame Data. Monitor the TPS 1 and TPS 2 voltages while wiggle testing the connector.
    2. If the absolute difference is still more than 0.25 volts, turn the ignition off, disconnect and reconnect the Throttle Body harness connector and repeat the step above.

        Did the absolute difference of the two sensors become less than 0.25 volts while wiggle testing the connector or after the connector was unplugged and reconnected?

Yes

- Replace the Throttle Body connector if available or perform appropriate repair to the connector for an intermittent connection.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **CHECK FOR AN ACTIVE TPS SENSOR PERFORMANCE DTC**
   1. Refer to the recorded DTCs.

      Are the DTCs P0121 or P0221 also present?

      Yes

      - Perform the applicable PCM diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 4

4. **ISOLATE AND CHECK THE (K22) TPS 1 SIGNAL CIRCUIT FOR A SHORT TO THE (K122) TPS 2 SIGNAL CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

      NOTE: **There should be no continuity between the circuits being tested.**

      Is there continuity between the circuits?

      Yes

      - Repair the short between the circuits.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 5

5. **ISOLATE AND CHECK THE (K22) TPS 1 SIGNAL CIRCUIT FOR A SHORT TO THE (F855) 5-VOLT SUPPLY CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.

2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between the circuits being tested.**

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **ISOLATE AND CHECK THE (K122) TPS 2 SIGNAL CIRCUIT FOR A SHORT TO THE (F855) 5-VOLT SUPPLY CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **There should be no continuity between the circuits being tested.**

Is there continuity between the circuits?

Yes

- Repair the short between the circuits.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **ISOLATE AND CHECK THE (K22) TPS 1 SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

        NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 8

    No

    - Repair the circuit for an open or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **ISOLATE AND CHECK THE (K122) TPS 2 SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

Is the resistance below 3.0 Ohms?

Yes

- Go To 9

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **ISOLATE AND CHECK THE (K922) TPS RETURN CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

Is the resistance below 3.0 Ohms?

Yes

- Go To 10

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **ISOLATE AND CHECK THE (F855) 5-VOLT SUPPLY CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.

3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 11

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **REPLACE THE THROTTLE BODY AND RETEST FOR DTCS**
    1. Replace the component in accordance with the Service Information. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** . Disconnect the Battery when replacing the Throttle Body Assembly. After installation is complete, use a scan tool and select the ETC RELEARN function.
    2. Connect the component and Electronic Control Unit (ECU) harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 12

    No

    - Replacing the faulty Throttle Body Assembly repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

12. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.

3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2138-ACCELERATOR PEDAL POSITION SENSOR 1/2 CORRELATION

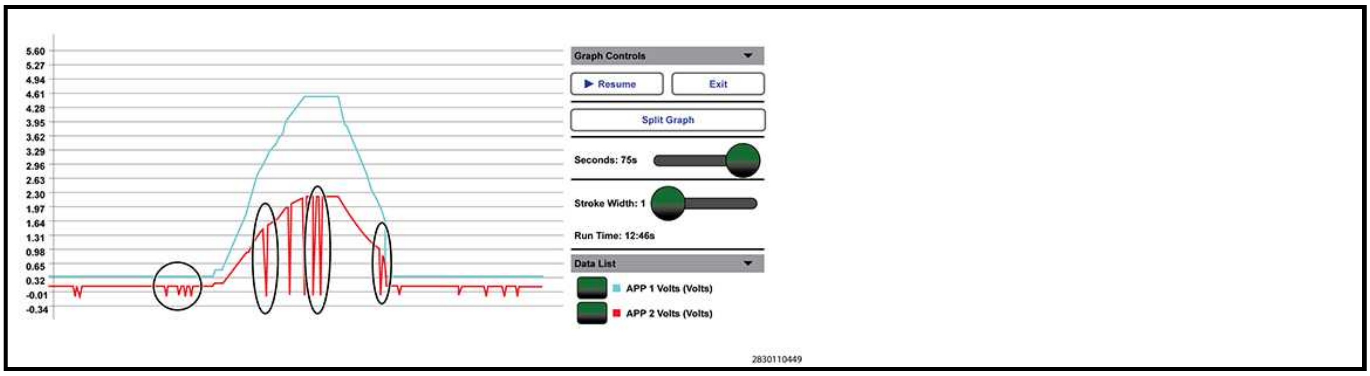
For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

Accelerator Pedal Position (APP) Sensor applications today use Induction/Hall Sensors (non-contact).

The Electronic Throttle Control (ETC) system uses two Accelerator Pedal Position (APP) Sensors to monitor the accelerator pedal position. The APP Sensors 1 and 2 are integrated into one assembly located at the pedal assembly. Each sensor has a 5 volt reference circuit, a low reference circuit, and a signal circuit. The Powertrain Control Module (PCM) reads the two signals individually and then compares the two signals as a redundant check of the pedal position. The APP 1 signal will fluctuate somewhere between 0 volts and 5.0 volts. The APP 2 signal will fluctuate somewhere between 0 volts and 2.5 volts. The fluctuation of the two sensors should move proportionately. When operating properly, the voltage reading of the APP 2 will always be approximately half of the voltage reading of the APP 1.

The signal for APP 2 is also used by the PCM for an internal ground check. This test runs a couple of times per second and is the reason why the APP 2 signal spikes to ground regularly during normal operation. If graphing the APP 1 and APP 2 signals for diagnostic purposes, view the figure below to see how the signals will look on a normally functioning APP system.



WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage greater than 10.4 volts.
- No Accelerator Pedal Position (APP) Sensor 1 DTCs present.
- No Accelerator Pedal Position (APP) Sensor 2 DTCs present.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the correlation between APP Sensor 1 and APP Sensor 2 is not plausible.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will flash.
- The Throttle input and vehicle speed are limited.

POSSIBLE CAUSES

Possible Causes
HIGH RESISTANCE IN A 5-VOLT SUPPLY CIRCUIT
HIGH RESISTANCE IN THE APP SENSOR SIGNAL 1 CIRCUIT
HIGH RESISTANCE IN THE APP SENSOR 1 GROUND CIRCUIT
HIGH RESISTANCE IN THE APP SENSOR SIGNAL 2 CIRCUIT
HIGH RESISTANCE IN THE APP SENSOR 2 GROUND CIRCUIT
ACCELERATOR PEDAL POSITION SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE APP SENSOR HARNESS CONNECTOR AND TERMINALS**
   1. Turn the ignition off.
   2. Check the APP Sensor harness connector for proper connection at the APP Sensor.
   3. Verify that the connector is completely plugged in and locked prior to disconnecting.
   4. Disconnect the APP Sensor harness connector and check for pushed out or spread terminals, brineling on terminals, discoloration from excessive heat, or corrosion and water intrusion.

      Were any issues found with the connector or terminals?

      Yes

      - Repair the found issues in accordance with the service information or properly connect and lock the APP Sensor harness connector.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 3
3. **ISOLATE AND CHECK THE (K852) 5-VOLT SUPPLY CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.

5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 4

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **ISOLATE AND CHECK THE (K23) APP SIGNAL 1 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 5

   No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND CHECK THE (K167) SENSOR GROUND 1 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 6

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND CHECK THE (K854) 5-VOLT SUPPLY CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 7

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **ISOLATE AND CHECK THE (K29) APP SIGNAL 2 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 8

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **ISOLATE AND CHECK THE (K400) SENSOR GROUND 2 CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.

2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 9

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **CHECK RELATED PCM AND APP SENSOR CONNECTIONS**
   1. Disconnect all related in-line harness connections (if equipped).
   2. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Brineling on terminals of sensor or harness connector.
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

   Repair any conditions that are found.

   NOTE: **Before reconnecting the harness connectors, clean the terminals with Mopar electrical connector cleaner and apply a light application of dielectric grease to the face of the connector with your finger. This will aid in preventing any future issues with the sensor terminals and**

connector pins; excessive amounts of dielectric grease can cause damage to the sensor terminals, connector pins, and weather seals.

3. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
4. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
5. Reconnect the APP Sensor harness connector. Be certain that the connectors is fully seated and the connector locks are fully engaged.
6. With the scan tool, erase DTCs.
7. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
8. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 10

   No

   - The wiring or poor connection problem has been repaired.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **REPLACE THE APP SENSOR AND RETEST FOR DTCS**
    1. Replace the APP Sensor in accordance with the Service Information. After installation is complete, perform the ETC RELEARN function.
    2. Connect the component and Electronic Control Unit (ECU) harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Replacing the faulty component repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2166-ACCELERATOR PEDAL POSITION SENSOR 1 MAXIMUM STOP PERFORMANCE

For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

This diagnostic runs one time during an ignition cycle when the following conditions are met:

- With the ignition on.
    - During in-plant testing, the Accelerator Pedal Position (APP) Sensor is checked to make sure the minimum and maximum values can be reached.

SET CONDITION

- APP Sensor 1 has failed to achieve the required maximum value during In-Plant testing.

DEFAULT ACTION

- The ETC light will illuminate.
- This is a non MIL fault.
- The Throttle input and vehicle speed are limited.

POSSIBLE CAUSES

Possible Causes
ELECTRONIC THROTTLE CONTROL (ETC) RELEARN
ACCELERATOR PEDAL POSITION (APP) SENSOR

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

    NOTE: **This DTC is set when the APP Sensor values are learned in-plant but do not reach the minimum or maximum voltage range.**

2. **CHECK FOR OTHER DTCS**

1. Refer to the recorded DTCs.

   Are there any other APP Sensor or 5-Volt Supply DTCs active or pending?

   Yes

   - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

   No

   - Go To 3

3. **PERFORM THE ETC RELEARN FUNCTION AND RETEST FOR DTC**
   1. With a scan tool perform the ETC RELEARN function.
   2. With the scan tool, erase DTCs.
   3. Start the engine.
   4. With the scan tool, read DTCs.

   Is the DTC active or pending?

   Yes

   - Replace the APP Sensor in accordance with the Service Information. After installation is complete, perform the ETC RELEARN function.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Performing the ETC RELEARN function repaired the fault.

P2167-ACCELERATOR PEDAL POSITION SENSOR 2 MAXIMUM STOP PERFORMANCE

For a complete THROTTLE CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
  - During in-plant testing, the Accelerator Pedal Position (APP) Sensors need to be checked to make sure the minimum and maximum values can be reached.

SET CONDITION

- APP Sensor 2 has failed to achieve the required maximum value during In-Plant testing.

DEFAULT ACTION

- The ETC light will illuminate.
- This is a non MIL fault.
- The Throttle input and vehicle speed are limited.

POSSIBLE CAUSES

Possible Causes
ELECTRONIC THROTTLE CONTROL (ETC) RELEARN
ACCELERATOR PEDAL POSITION (APP) SENSOR

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

    NOTE: **This DTC is set when the APP Sensor values are learned in-plant but do not reach the minimum or maximum voltage range.**

2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any other APP Sensor or 5-Volt Supply DTCs active or pending?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **PERFORM THE ETC RELEARN FUNCTION AND RETEST FOR DTC**
    1. With a scan tool perform the ETC RELEARN function.
    2. With the scan tool, erase DTCs.
    3. Start the engine.
    4. With the scan tool, read DTCs and record on the repair order.

Is the DTC active or pending?

Yes

- Replace the APP Sensor in accordance with the Service Information. After installation is complete, perform the ETC RELEARN function.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Performing the ETC RELEARN function repaired the fault.

P2172-HIGH AIRFLOW/VACUUM LEAK DETECTED (INSTANTANEOUS ACCUMULATION)

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) uses the Manifold Absolute Pressure (MAP) Sensor base model and the Electronic Throttle Control (ETC) Motor position value to create a calculated MAP model value. This calculated MAP model is then compared to the actual MAP Sensor Signal input to the PCM. The PCM uses this comparison to detect vacuum leaks or restrictions in the intake air system. The purpose of this monitor is to detect an instantaneous or gradual change in the intake manifold vacuum that exceeds the calibrated high or low thresholds.

NOTE: **Do not use shop air to clean out the MAP Sensor when diagnosing a MAP Sensor related fault as this will cause internal damage to the sensor.**

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Engine speed above approximately 285 rpm.
- No active MAP Sensor, Throttle Position Sensor, CMP/CKP Sensor or 5-Volt Reference DTCs.
- P2173 or P2174 are not present.

SET CONDITION

- The Powertrain Control Module (PCM) monitors and compares the difference between the actual Map Sensor reading and the calculated Map Sensor model over time. The PCM detects an instantaneous difference between these two values beyond a calibrated threshold, indicating that there is an air leak in the intake system.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light is enabled.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
VACUUM LEAK
PCV VALVE OR HOSE LEAKING OR RESTRICTED
RESTRICTION IN THE EXHAUST SYSTEM

Possible Causes
INTERNAL ENGINE MECHANICAL COMPONENTS
RESISTANCE IN THE 5-VOLT SUPPLY CIRCUIT
RESISTANCE IN THE MAP SIGNAL CIRCUIT
RESISTANCE IN MAP SENSOR GROUND CIRCUIT
MAP SENSOR
THROTTLE BODY - OBSTRUCTION OR FOREIGN OBJECT/MATERIAL
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Go To 2

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

       Are there any 5-Volt Reference, Throttle Body, Cam Sensor, Crank Sensor or MAP Sensor DTCs active or pending?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 3
3. **CHECK THE PCV VALVE AND SYSTEM FOR LEAKS OR RESTRICTIONS**
    1. Visually inspect the PCV System for signs of leaks.
    2. Check the PCV Valve and system for restricted air flow.

       Were any issues found with the PCV System?

Yes

- Perform the appropriate repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **COMPARE THE ENGINE VACUUM AND MAP SENSOR READING**
    1. Turn the engine off.
    2. Connect a vacuum gauge to the Intake Manifold.
    3. Start the engine and allow it to idle.
    4. Monitor the reading on the vacuum gauge.
    5. Monitor the MAP Sensor reading on the scan tool.

    Does the scan tool reading match the vacuum gauge reading?

    Yes

    - Check and repair any engine vacuum leaks, exhaust restrictions, or engine mechanical conditions that can cause low engine compression.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

5. **CHECK THE MAP SENSOR AND THROTTLE BODY HARNESS CONNECTORS AND TERMINALS**
    1. Turn the ignition off.
    2. Check the Map Sensor and Throttle Body harness connector for proper connection at the Map Sensor And Throttle Body.
    3. Verify that the connector is completely plugged in and locked prior to disconnecting.
    4. Disconnect the Map Sensor and Throttle Body harness connectors and check for pushed out or spread terminals, brineling on terminals, discoloration from excessive heat, or corrosion and water intrusion.

    Were any issues found with the connectors or terminals?

    Yes

    - Repair the found issues in accordance with the Service Information or properly connect and lock the Map Sensor or Throttle Body harness connector(s).
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 6

6. **CHECK FOR HIGH RESISTANCE IN THE (F856) 5-VOLT SUPPLY CIRCUIT**
    1. Turn the ignition off.
    2. Disconnect the MAP Sensor harness connector.
    3. Disconnect the PCM C2 harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

4. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
5. Measure the resistance of the (F856) 5-Volt Supply circuit between the MAP Sensor harness connector and the GPEC Diagnostic Adaptor.

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 7

   No

   - Repair the (F856) 5-Volt Supply circuit for high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK FOR HIGH RESISTANCE IN THE (K1) MAP SIGNAL CIRCUIT**
   1. Measure the resistance of the (K1) MAP Signal circuit between the MAP Sensor harness connector and the GPEC Diagnostic Adaptor.

      Is the resistance below 3.0 Ohms?

      Yes

      - Go To 8

      No

      - Repair the (K1) MAP Signal circuit for high resistance.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK FOR HIGH RESISTANCE IN THE (K900) SENSOR GROUND CIRCUIT**
   1. Measure the resistance of the (K900) Sensor Ground circuit between the MAP Sensor harness connector and the GPEC Diagnostic Adaptor.

      Is the resistance below 3.0 Ohms?

      Yes

      - Go To 9

      No

      - Repair the excessive (K900) Sensor ground circuit for high resistance.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **CHECK THE MAP SENSOR AND PORT FOR OBSTRUCTIONS**
   1. Remove the MAP Sensor.
   2. Inspect the MAP Sensor and port for any obstructions.

      Were any obstructions found?

      Yes

- Perform the appropriate repairs and retest.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 10

10. **REPLACE THE MAP SENSOR AND RETEST FOR DTC**
    1. Replace the MAP Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle until closed loop fueling is achieved.
    5. With a scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 11

    No

    - Replacing the MAP Sensor repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
11. **REPLACE THE THROTTLE BODY AND RETEST FOR DTCS**
    1. Replace the Throttle Body in accordance with the Service Information. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** .
    2. Connect the Throttle Body and PCM harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 12

    No

    - Replacing the faulty Throttle Body repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
12. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.

5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2173-HIGH AIRFLOW/VACUUM LEAK DETECTED (SLOW ACCUMULATION)

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) uses the Manifold Absolute Pressure (MAP) Sensor base model and the Electronic Throttle Control (ETC) Motor position value to create a calculated MAP model value. This calculated MAP model is then compared to the actual MAP Sensor Signal input to the PCM. The PCM uses this comparison to detect vacuum leaks or restrictions in the intake air system. The purpose of this monitor is to detect an instantaneous or gradual change in the intake manifold vacuum that exceeds the calibrated high or low thresholds.

NOTE: **Do not use shop air to clean out the MAP Sensor when diagnosing a MAP Sensor related fault as this will cause internal damage to the sensor.**

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the engine running.
- Engine speed above approximately 285 rpm.
- No active MAP Sensor, Throttle Position Sensor, CMP/CKP Sensor or 5-Volt Reference DTCs.
- P2172 or P2174 are not present.

SET CONDITION

- The Powertrain Control Module (PCM) monitors and compares the difference between the actual Map Sensor reading and the calculated Map Sensor model over time. The PCM detects a gradual long term increase in the difference between these two values, beyond a calibrated adaptive limit, indicating that there is an air leak in the intake system.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light is enabled.

POSSIBLE CAUSES

Possible Causes
VACUUM LEAK
PCV VALVE OR HOSE LEAKING OR RESTRICTED
RESTRICTION IN THE EXHAUST SYSTEM
INTERNAL ENGINE MECHANICAL COMPONENTS
RESISTANCE IN THE 5-VOLT SUPPLY CIRCUIT
RESISTANCE IN THE MAP SIGNAL CIRCUIT
RESISTANCE IN MAP SENSOR GROUND CIRCUIT
MAP SENSOR
THROTTLE BODY - OBSTRUCTION OR FOREIGN OBJECT/MATERIAL
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

    Are there any 5-Volt Reference, TPS, Cam Sensor, Crank Sensor or MAP Sensor DTCs active or pending?

    Yes

    - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

    No

    - Go To 3
3. **CHECK THE PCV VALVE AND SYSTEM FOR LEAKS OR RESTRICTIONS**
    1. Visually inspect the PCV System for signs of leaks.
    2. Check the PCV Valve and system for restricted air flow.

    Were any issues found with the PCV System?

    Yes

    - Perform the appropriate repair.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 4
4. **COMPARE THE ENGINE VACUUM AND MAP SENSOR READING**
    1. Turn the engine off.
    2. Connect a vacuum gauge to the Intake Manifold.
    3. Start the engine and allow it to idle.
    4. Monitor the reading on the vacuum gauge.
    5. Monitor the MAP Sensor reading on the scan tool.

    Does the scan tool reading match the vacuum gauge reading?

    Yes

    - Check and repair any engine vacuum leaks, exhaust restrictions, or engine mechanical conditions that can cause low engine compression.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

- Go To 5

5. **CHECK THE MAP SENSOR AND THROTTLE BODY HARNESS CONNECTORS AND TERMINALS**
    1. Turn the ignition off.
    2. Check the Map Sensor and Throttle Body harness connector for proper connection at the Map Sensor And Throttle Body.
    3. Verify that the connector is completely plugged in and locked prior to disconnecting.
    4. Disconnect the Map Sensor and Throttle Body harness connectors and check for pushed out or spread terminals, brineling on terminals, discoloration from excessive heat, or corrosion and water intrusion.

    Were any issues found with the connectors or terminals?

    Yes

    - Repair the found issues in accordance with the Service Information or properly connect and lock the Map Sensor or Throttle Body harness connector(s).
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 6

6. **CHECK FOR HIGH RESISTANCE IN THE (F856) 5-VOLT SUPPLY CIRCUIT**
    1. Turn the ignition off.
    2. Disconnect the MAP Sensor harness connector.
    3. Disconnect the PCM C2 harness connector.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    4. Connect the (special tool #10436, Adapter, GPEC Diagnostic).
    5. Measure the resistance of the (F856) 5-Volt Supply circuit between the MAP Sensor harness connector and the GPEC Adaptor.

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 7

    No

    - Repair the (F856) 5-Volt Supply circuit for high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK FOR HIGH RESISTANCE IN THE (K1) MAP SIGNAL CIRCUIT**
    1. Measure the resistance of the (K1) MAP Signal circuit between the MAP Sensor harness connector and the GPEC Adaptor.

    Is the resistance below 3.0 Ohms?

    Yes

- Go To 8

No

- Repair the (K1) MAP Signal circuit for high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK FOR HIGH RESISTANCE IN THE (K900) SENSOR GROUND CIRCUIT**
    1. Measure the resistance of the (K900) Sensor Ground circuit between the MAP Sensor harness connector and the GPEC Adaptor.

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 9

    No

    - Repair the (K900) Sensor Ground circuit for high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **CHECK THE MAP SENSOR AND PORT FOR OBSTRUCTIONS**
    1. Remove the MAP Sensor.
    2. Inspect the MAP Sensor and port for any obstructions.

    Were any obstructions found?

    Yes

    - Perform the appropriate repairs and retest.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 10

10. **REPLACE THE MAP SENSOR AND RETEST FOR DTC**
    1. Replace the MAP Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. Turn the ignition on.
    3. With the scan tool, erase DTCs.
    4. Start the engine and allow it to idle until closed loop fueling is achieved.
    5. With a scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 11

    No

    - Replacing the MAP Sensor repaired the fault.

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

11. **REPLACE THE THROTTLE BODY AND RETEST FOR DTCS**
    1. Replace the Throttle Body in accordance with the Service Information. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** .
    2. Connect the Throttle Body and PCM harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 12

    No

    - Replacing the faulty Throttle Body repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

12. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.

11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2174-LOW AIRFLOW/RESTRICTION DETECTED (INSTANTANEOUS ACCUMULATION)

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) uses the Manifold Absolute Pressure (MAP) Sensor base model and the Electronic Throttle Control (ETC) Motor position value to create a calculated MAP model value. This calculated MAP model is then compared to the actual MAP Sensor Signal input to the PCM. The PCM uses this comparison to detect vacuum leaks or restrictions in the intake air system. The purpose of this monitor is to detect an instantaneous or gradual change in the intake manifold vacuum that exceeds the calibrated high or low thresholds.

NOTE: **Do not use shop air to clean out the MAP Sensor when diagnosing a MAP Sensor related fault as this will cause internal damage to the sensor.**

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- No MAP Sensor, Throttle Body, Camshaft Position (CMP) Sensor, Crankshaft Position (CKP) Sensor, or 5-Volt Reference DTCs.

SET CONDITION

- The PCM detects a long term increase in the difference between the actual MAP Pressure sense and calculated MAP Sensor value, beyond the calibrated limit, due to an increase in vacuum.

DEFAULT ACTION

- The ETC will flash.
- The MIL light will illuminate.

POSSIBLE CAUSES

Possible Causes
RESTRICTION IN THE AIR INLET SYSTEM
RESISTANCE IN THE 5-VOLT SUPPLY CIRCUIT
RESISTANCE IN THE MAP SIGNAL CIRCUIT

Possible Causes
RESISTANCE IN MAP SENSOR GROUND CIRCUIT
MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR
THROTTLE BODY
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Are there any 5-Volt Supply, Throttle Body, Oxygen Sensor, Fuel related or MAP Sensor DTCs active or pending?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **CHECK THE AIR INLET SYSTEM FOR A RESTRICTION**

    NOTE: **The most likely cause of this DTC is a plugged intake air system or dirty Throttle Body.**

    1. Turn the ignition off.
    2. Remove the Air Cleaner Assembly.

3. Remove the Air Filter.
4. Inspect the Throttle Body opening for signs of any foreign materials or excessive carbon build up.
5. Check the intake tube and air cleaner for obstructions; include snow packing questions to customer.

Were any restrictions found?

Yes

- Repair the restriction as necessary.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **COMPARE THE ACTUAL ENGINE VACUUM AND MAP SENSOR READING**
    1. Turn the engine off.
    2. Connect a vacuum gauge to the Intake Manifold.
    3. Start the engine and allow it to idle.
    4. Monitor the reading on the vacuum gauge.
    5. Monitor the MAP Sensor reading on the scan tool.

    Compare the scan tool reading to the vacuum gauge reading?

    Both of the readings match

    - Remove the Air Cleaner Assembly and check for restrictions in the filter or assembly. Check for restriction in the air inlet plumbing. Check the Throttle Body for any signs of binding, sticking or obstructions. Repair as necessary in accordance with the Service Information.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    MAP reading on scan tool does not match the measured vacuum

    - Go To 5

5. **ISOLATE AND CHECK THE (F856) 5-VOLT SUPPLY CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 6

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND CHECK THE MAP SENSOR (K1) PRESSURE SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 7

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **ISOLATE AND CHECK THE (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.

3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance to the measurement value.
4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 8

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK THE MAP SENSOR AND PORT FOR OBSTRUCTIONS**
   1. Remove the MAP Sensor.
   2. Inspect the MAP Sensor and port for any obstructions.

   Were any obstructions found?

   Yes

   - Perform the appropriate repairs and retest.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 9

9. **REPLACE THE MAP SENSOR AND RETEST FOR DTC**
   1. Replace the MAP Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
   2. Turn the ignition on.
   3. With the scan tool, erase DTCs.
   4. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
   5. With a scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 10

No

- Replacing the MAP Sensor repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **REPLACE THE THROTTLE BODY AND RETEST FOR DTCS**
    1. Replace the Throttle Body in accordance with the Service Information. Refer to **THROTTLE BODY, REMOVAL AND INSTALLATION** .
    2. Connect the Throttle Body and PCM harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the Environmental Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 11

    No

    - Replacing the faulty Throttle Body repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
11. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.

7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2181-COOLING SYSTEM PERFORMANCE

For a complete INTAKE AIR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

This diagnostic is used to detect an Engine Coolant Temperature (ECT) Sensor that is in range but reading incorrectly. Unlike the temperature sensor performance diagnostic that runs only on cold starts and compares all of the temperature sensor values, this diagnostic runs continuously. The Powertrain Control Module (PCM) models a predicted ECT Sensor value and compares that model to the actual ECT Sensor. If the difference is too large, a counter starts to increment. When the counter reaches a calibrated threshold, a fault is set.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- The P060B DTC is not active.
- The actual ECT Sensor voltage is somewhere between 0.29 and 4.95 volts.

SET CONDITION

- The difference between the predicted ECT Sensor value and the actual ECT Sensor value is above a calibrated threshold.

DEFAULT ACTION

- The MIL will illuminate.
- The ETC light will illuminate.

POSSIBLE CAUSES

POSSIBLE CAUSES
LOW COOLANT LEVEL
THERMOSTAT
HIGH RESISTANCE IN THE ECT SIGNAL CIRCUIT
HIGH RESISTANCE IN THE SENSOR GROUND CIRCUIT
ENGINE COOLANT TEMPERATURE (ECT) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR OTHER DTCS**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs and record on the repair order.

       Are there any Engine Coolant Temperature (ECT) Sensor DTCs active or pending?

       Yes

       - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 2
2. **CHECK THE ENGINE COOLANT LEVEL AND CONDITION**
    1. Turn the ignition off.

       WARNING: Allow the engine to cool before opening the cooling system. The system may be under pressure. Extreme burns or scalding may result. Failure to follow these instructions can result in possible serious or fatal injury.

    2. Inspect the cooling system for proper coolant level and condition.

       Is the Engine Coolant at the proper level and condition?

       Yes

       - Go To 3

       No

       - Repair the Engine Coolant level or condition problem. Inspect the vehicle for coolant leaks and repair if necessary. Fill the Engine Coolant to the proper level and ensure the proper condition.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
3. **CHECK THE THERMOSTAT OPERATION**

   NOTE: For optimal test results, allow the vehicle to sit outside long enough to cool to ambient temperature in order to start the test with a totally cold soaked engine. With the scan tool, read the Engine Coolant Temperature degree value. If the engine was allowed to sit (cold soak), the temperature

value should be a sensible value that is somewhere close to the ambient temperature.

1. Turn the ignition on.
2. If engine coolant temperature is above 82Â°C (180Â°F), allow the engine to cool until it reaches at least 65Â°C (150Â°F) or cooler before continuing with this test.
3. Start the engine.
4. During engine warm-up monitor the Engine Coolant Temperature degree value on the scan tool. The temperature value change should be a smooth transition from start up to Thermostat opening temperature. Also monitor the actual coolant temperature with a digital thermometer at or near the ECT Sensor and Thermostat positions.

   NOTE: **As the engine warms up to operating temperature, the actual coolant temperature (thermometer reading) and the scan tool Engine Coolant Temperature degree values should stay relatively close to each other. A discrepancy may indicate an inaccurate ECT Sensor signal to the PCM.**

5. As the engine warms to operating temperature, record the temperature at which the Thermostat opens.
6. Using the appropriate Service Information, determine the proper opening temperature of the Thermostat.

   Did the Thermostat open at the proper temperature?

   Yes

   - Go To 4

   No

   - Replace the Thermostat in accordance with the Service Information. Refer to **THERMOSTAT, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE RADIATOR FOR RESTRICTIONS AND FLOW**

   NOTE: **The engine must be running and the Thermostat open to perform this test.**

   1. Check and compare the temperatures at the inlet and outlet of the Radiator. Check for proper operation of the entire cooling system. Be certain to check for proper operation of the Radiator Cap. Check for proper flow through the Radiator and anything that can cause a lack of system pressure or lack of coolant flow in the system which include air in the cooling system, proper operation of the Water Pump and drive belt, restricted Radiator core, collapsed hose restricting flow, etc.

      NOTE: **It is normal to see a lower temperature on the outlet of the Radiator, however a very large difference could indicate a restriction in the Radiator. This condition can cause this DTC to set due to the position of the ETC Sensor in the coolant system. If necessary, compare the temperature difference with a similar vehicle.**

      Was the difference in the temperature readings relatively larger than expected?

      Yes

- Check the cooling system and Radiator for proper flow and repair as necessary.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK FOR HIGH RESISTANCE IN THE ECT SENSOR TEMP SIGNAL CIRCUIT**
    1. Turn the ignition off.
    2. Disconnect the ECT Sensor harness connector.
    3. Disconnect the PCM C2 harness connector.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    4. Connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM connector.

    NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance in the measurement of the circuit.**

    5. Measure the resistance of the ECT Sensor Temp Signal circuit between the ECT Sensor harness connector and the GPEC Adaptor.

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 6

    No

    - Repair the ECT Sensor Temp Signal circuit for an open circuit or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK FOR HIGH RESISTANCE IN THE SENSOR GROUND CIRCUIT**
    1. Measure the resistance of the Sensor Ground circuit between the ECT Sensor harness connector and the GPEC Adaptor.

    Is the resistance below 3.0 Ohms?

    Yes

    - Go To 7

    No

    - Repair the Sensor Ground circuit for an open circuit or high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK THE ABILITY OF THE PCM TO READ THE ECT SENSOR SIGNAL USING A JUMPER**
    1. Turn the ignition off.
    2. Reconnect the PCM C2 harness connector.

3. Turn the ignition on.
4. With the scan tool, read DTCs.

NOTE: **The P0118-ENGINE COOLANT TEMPERATURE SENSOR CIRCUIT HIGH DTC should be active or pending with the connector unplugged.**

5. Connect a jumper between the ECT Sensor Temp Signal circuit and the Sensor Ground circuit at the ECT Sensor harness connector.
6. With the scan tool, read DTCs.

NOTE: **The P0117-ENGINE COOLANT TEMPERATURE SENSOR CIRCUIT LOW DTC should be active or pending with the jumper in place.**

Does the scan tool display as described above?

Yes

- Replace the Engine Coolant Temperature Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 8

8. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.

9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P219A-AIR-FUEL RATIO CYLINDER IMBALANCE BANK 1

THEORY OF OPERATION

The purpose of the Cylinder Imbalance Detection diagnostic monitor is to detect an air/fuel ratio imbalance between the cylinders across an entire cylinder bank.

NOTE: **Although the DTC description does not indicate as such, this fault will set because a specific cylinder on this bank is out of balance with the other cylinders. The fault may not be easily noticeable to the technician. During diagnosis, it is necessary to pay close attention to small differences between the cylinders during each of the test steps.**

This imbalance can be caused by a number of different malfunctions including but not limited to:

- Exhaust Manifold to Cylinder Head leak at a specific cylinder.
- Intake Manifold leak at a specific cylinder.
- Fuel Injector problem.
- Variable cam lift failure.
- Camshaft/ Valvetrain problems.
- Ignition system problems at a specific cylinder.
- Engine mechanical problems relating to cylinder combustion at a specific cylinder.

The Cylinder Imbalance Detection requires that the Upstream Oxygen (O2) Sensors are capable of operating at high frequencies, since an aged O2 Sensors response capability at a higher frequency range can be degraded. Therefore, before this monitor can become active, the O2 Sensor High Frequency Response monitor is performed to see if the sensor is even capable of detecting an imbalance.

Once active, the Cylinder Imbalance Detection monitor matches up the Upstream O2 Sensor signal with the corresponding cylinders on that bank. Each cylinder is monitored and adjustments are made as needed for each cylinder to correct an air/fuel ratio imbalance. If an individual cylinder reaches a calibrated adaptation threshold (15%), the diagnostic monitor will be considered failing.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Closed loop fuel control.
- Engine speed between 1000 - 2700 rpm.
- Engine Coolant Temperature (ECT) Sensor value is between 70Â°C -122Â°C (158Â°F -251Â°F).
- Calculated engine load between 30 - 90%.
- For flex fuel vehicles the Fuel Adaptive Learned must be completed.

SET CONDITION

- The Powertrain Control Module (PCM) detects that one of the cylinders on bank 1 has an air/fuel ratio imbalance of 15% when compared to the other cylinders on the same cylinder bank.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
INTAKE MANIFOLD LEAK AT A SPECIFIC CYLINDER ON BANK 1
EXHAUST MANIFOLD TO CYLINDER HEAD LEAK AT A SPECIFIC CYLINDER ON BANK 1
FUEL INJECTOR ISSUES AT A SPECIFIC CYLINDER ON BANK 1
IGNITION SYSTEM ISSUES AT A SPECIFIC CYLINDER ON BANK 1
CYLINDER COMPRESSION IMBALANCE
CARBON BUILD UP
VARIABLE VALVE TIMING ISSUES
VALVE TRAIN ISSUES
O2 SENSOR

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR AN INTAKE MANIFOLD LEAK AT A SPECIFIC CYLINDER ON BANK 1**
    1. Check for any of the following conditions, but not limited to:
        - Intake manifold seals leaking at a specific cylinder.
        - Intake plenum leak at a specific cylinder.
        - Warped/cracked Intake Manifold or plenum.
        - Vacuum leak at a Fuel Injector O-Rings.

    Were any issues found?

    Yes

    - Perform the appropriate repairs.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 3

3. **CHECK FOR AN EXHAUST MANIFOLD TO CYLINDER HEAD LEAK AT A SPECIFIC CYLINDER ON BANK 1**

    NOTE: **If you are able to determine which cylinder is causing the issue perform the following diagnostics focusing on the suspect cylinder.**

    1. Check the Exhaust Manifold to cylinder head mounting surface for signs of an exhaust leak.
    2. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

    Were any issues found?

    Yes

    - Perform the appropriate repairs.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 4

4. **CHECK FOR FUEL INJECTOR ISSUES AT A SPECIFIC CYLINDER ON BANK 1**
    1. Check for any of the following conditions, but not limited to:
        - Verify correct voltage supply at each Fuel Injector.
        - Verify correct control circuit operation at each Fuel Injector.
        - Verify correct Fuel Injector operation (spray pattern).

    Were any issues found?

    Yes

    - Repair as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK THE CYLINDERS ON BANK 1 FOR LOW COMPRESSION AND IGNITION SYSTEM ISSUES**
    1. Perform a cylinder compression or cylinder leak down test on each cylinder on bank 1.
    2. Check the ignition system for any of the following conditions, but not limited to:
        - Verify correct voltage supply at each Ignition Coil.
        - Verify correct control circuit operation at each Ignition Coil.
        - Verify that the Spark Plugs are matching and are equivalent to OEM specifications.
        - Verify correct Spark Plug gap.
        - Visually inspect the Ignition Coils and Spark Plugs for signs of carbon tracking.
        - Visually inspect the Ignition Coils for signs of damage.

    Were any issues found?

    Yes

    - Repair as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 6
6. **CLEAN THE VALVE TRAIN AND COMBUSTION CHAMBERS**
    1. Using the Mopar Combustion cleaner, de-carbon the engine.
    2. After driving and clearing the combustion cleaner from the engine, erase any DTCs with the scan tool.
    3. Test drive the vehicle in accordance with the when monitored conditions.
    4. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 7

    No

    - Repair is complete.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
7. **CHECK FOR VALVE TRAIN AND VARIABLE VALVE SYSTEM ISSUES**
    1. Check the valvetrain for any of the following conditions, but not limited to:
        - Verify correct operation of the Camshaft Phasers.
        - Verify correct operation of the Oil Control Valves.
        - Check for broken, worn or improperly installed Valve Springs.
        - Check for broken, worn or improperly installed Camshaft followers.
        - Check for worn Camshaft lobes.

    Were any issues found?

Yes

- Repair as necessary.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 8

8. **REPLACE THE UPSTREAM O2 SENSOR AND RETEST FOR DTCS**
    1. Replace the Bank 1 Upstream O2 Sensor. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. With the scan tool, erase DTCs.
    3. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    4. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Anything that can cause an air/fuel ratio imbalance in an individual cylinder will cause this DTC to set. Verify all of the items in this test and any other mechanical items that may cause this DTC to set. Also check for any Service Bulletins that may apply to this fault code.

    No

    - Replacing the O2 Sensor repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P219B-AIR-FUEL RATIO CYLINDER IMBALANCE BANK 2

THEORY OF OPERATION

The purpose of the Cylinder Imbalance Detection diagnostic monitor is to detect an air/fuel ratio imbalance between the cylinders across an entire cylinder bank.

NOTE: **Although the DTC description does not indicate as such, this fault will set because a specific cylinder on this bank is out of balance with the other cylinders. The fault may not be easily noticeable to the technician. During diagnosis, it is necessary to pay close attention to small differences between the cylinders during each of the test steps.**

This imbalance can be caused by a number of different malfunctions including but not limited to:

- Exhaust Manifold to Cylinder Head leak at a specific cylinder.
- Intake Manifold leak at a specific cylinder.
- Fuel Injector problem.
- Variable cam lift failure.
- Camshaft/ Valvetrain problems.
- Ignition system problems at a specific cylinder.
- Engine mechanical problems relating to cylinder combustion at a specific cylinder.

The Cylinder Imbalance Detection requires that the Upstream Oxygen (O2) Sensors are capable of operating at high frequencies, since an aged O2 Sensors response capability at a higher frequency range can be degraded.

Therefore, before this monitor can become active, the O2 Sensor High Frequency Response monitor is performed to see if the sensor is even capable of detecting an imbalance.

Once active, the Cylinder Imbalance Detection monitor matches up the Upstream O2 Sensor signal with the corresponding cylinders on that bank. Each cylinder is monitored and adjustments are made as needed for each cylinder to correct an air/fuel ratio imbalance. If an individual cylinder reaches a calibrated adaptation threshold (15%), the diagnostic monitor will be considered failing.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met

- Engine run time of 90 seconds.
- Engine Coolant Temperature (ECT) Sensor value is between 70Â°C -122Â°C (158Â°F -251Â°F).
- Closed loop fuel control.
- Engine speed between 1000 - 2700 rpm.
- Calculated engine load between 30 - 90%.
- The Upstream O2 Sensor high frequency diagnostic monitor has run and passed this trip, and P113D is not present or pending.
- For flex fuel vehicles the Fuel Adaptive Learned must be completed.

SET CONDITION

- The Powertrain Control Module (PCM) detects that one of the cylinders on bank 2 has an air/fuel ratio imbalance of 15% when compared to the other cylinders on the same cylinder bank.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
INTAKE MANIFOLD LEAK AT A SPECIFIC CYLINDER ON BANK 2
EXHAUST MANIFOLD TO CYLINDER HEAD LEAK AT A SPECIFIC CYLINDER ON BANK 2
FUEL INJECTOR ISSUES AT A SPECIFIC CYLINDER ON BANK 2
IGNITION SYSTEM ISSUES AT A SPECIFIC CYLINDER ON BANK 2
CYLINDER COMPRESSION IMBALANCE
CARBON BUILD UP
VARIABLE VALVE TIMING ISSUES
VALVE TRAIN ISSUES
O2 SENSOR

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.

4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR AN INTAKE MANIFOLD LEAK AT A SPECIFIC CYLINDER ON BANK 2**
   1. Check for any of the following conditions, but not limited to:
      - Intake manifold seals leaking at a specific cylinder.
      - Intake plenum leak at a specific cylinder.
      - Warped/cracked Intake Manifold or plenum.
      - Vacuum leak at a Fuel Injector O-Rings.

   Were any issues found?

   Yes

   - Perform the appropriate repairs.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 3

3. **CHECK FOR AN EXHAUST MANIFOLD TO CYLINDER HEAD LEAK AT A SPECIFIC CYLINDER ON BANK 1**

   NOTE: **If you are able to determine which cylinder is causing the issue perform the following diagnostics focusing on the suspect cylinder.**

   1. Check the Exhaust Manifold to cylinder head mounting surface for signs of an exhaust leak.
   2. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

   Were any issues found?

   Yes

   - Perform the appropriate repairs.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **CHECK FOR FUEL INJECTOR ISSUES AT A SPECIFIC CYLINDER ON BANK 2**
    1. Check for any of the following conditions, but not limited to:
        - Verify correct voltage supply at each Fuel Injector.
        - Verify correct control circuit operation at each Fuel Injector.
        - Verify correct Fuel Injector operation (spray pattern).

    Were any issues found?

    Yes

    - Repair as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5
5. **CHECK THE CYLINDERS ON BANK 2 FOR LOW COMPRESSION AND IGNITION SYSTEM ISSUES**
    1. Perform a cylinder compression or cylinder leak down test on each cylinder on bank 2.
    2. Check the ignition system for any of the following conditions, but not limited to:
        - Verify correct voltage supply at each Ignition Coil.
        - Verify correct control circuit operation at each Ignition Coil.
        - Verify that the Spark Plugs are matching and are equivalent to OEM specifications.
        - Verify correct Spark Plug gap.
        - Visually inspect the Ignition Coils and Spark Plugs for signs of carbon tracking.
        - Visually inspect the Ignition Coils for signs of damage.

    Were any issues found?

    Yes

    - Repair as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 6
6. **CLEAN THE VALVE TRAIN AND COMBUSTION CHAMBERS**
    1. Using the Mopar Combustion cleaner, de-carbon the engine.
    2. After driving and clearing the combustion cleaner from the engine, erase any DTCs with the scan tool.
    3. Test drive the vehicle in accordance with the when monitored conditions.
    4. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 7

    No

- Repair is complete.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK FOR VALVETRAIN AND VARIABLE VALVE SYSTEM ISSUES**
    1. Check the valvetrain for any of the following conditions, but not limited to:
        - Verify correct operation of the Camshaft Phasers.
        - Verify correct operation of the Oil Control Valves.
        - Check for broken, worn or improperly installed valve springs.
        - Check for broken, worn or improperly installed Camshaft followers.
        - Check for worn Camshaft lobes.

    Were any issues found?

    Yes

    - Repair as necessary.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 8

8. **REPLACE THE UPSTREAM O2 SENSOR AND RETEST FOR DTCS**
    1. Replace the Bank 2 Upstream O2 Sensor. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
    2. With the scan tool, erase DTCs.
    3. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    4. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Anything that can cause an air/fuel ratio imbalance in an individual cylinder will cause this DTC to set. Verify all of the items in this test and any other mechanical items that may cause this DTC to set. Also check for any Service Bulletins that may apply to this fault code.

    No

    - Replacing the O2 Sensor repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2226-BAROMETRIC PRESSURE SENSOR

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- No battery related DTC present.

SET CONDITION

- The Barometric Pressure Sensor circuit voltage to the Powertrain Control Module (PCM) is too high.

DEFAULT ACTION

- The MIL light will illuminate.

POSSIBLE CAUSES

Possible Causes
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

CHECK FOR AN ACTIVE DTC

1. Turn the ignition on.
2. Using a scan tool, read DTCs.

   Is the DTC active or pending?

   Yes

   - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

P2228-BAROMETRIC PRESSURE CIRCUIT LOW

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- No battery related DTC present.

SET CONDITION

- The Barometric Pressure Sensor circuit voltage to the Powertrain Control Module (PCM) is too low.

DEFAULT ACTION

- The MIL light will illuminate.
- The ETC light will flash.

POSSIBLE CAUSES

Possible Causes
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN

1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
2. For future reference, run and save a vehicle Scan Report and all related recorded data.
3. With the scan tool, erase all DTCs.
4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Replace and program the Powertrain Control Module in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

P2229-BAROMETRIC PRESSURE CIRCUIT HIGH

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- No battery related DTC present.

SET CONDITION

- The Barometric Pressure Sensor circuit voltage to the Powertrain Control Module (PCM) is too high.

DEFAULT ACTION

- The MIL light will illuminate.
- The ETC light will flash.

POSSIBLE CAUSES

Possible Causes
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN

1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
2. For future reference, run and save a vehicle Scan Report and all related recorded data.
3. With the scan tool, erase all DTCs.
4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Replace and program the Powertrain Control Module in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

P2271-O2 SENSOR 1/2 SIGNAL BIASED RICH

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

For an aged Upstream Oxygen (O2) Sensor, the response rate to the air/fuel change is slower than when it was new. The O2 Sensor tends to move less with the same air/fuel changes in a given time frame. Therefore by observing the activity of voltage readings from the Upstream O2 Sensor, the quality of the O2 Sensor can be detected. The Downstream O2 Sensor is located in the exhaust path behind the Catalytic Converter, and is monitored for proper response to assure optimum Catalytic Converter efficiency. The Downstream O2 Sensor response monitor is intended to diagnose a Downstream O2 Sensor that is not moving or stuck in a voltage window and to insure accurate information for catalyst monitor diagnosis.

WHEN MONITORED

This diagnostic runs after the following enable conditions are met:

- Ambient temperature above -7Â°C (19.4Â°F).
- Battery voltage above 11.0 volts.
- Fuel level above 12%.
- With the engine running for more than 90.0 seconds.
- Engine Coolant Temperature (ECT) Sensor value above 70Â°C (158Â°F).
- Catalytic Converter temperature between 500Â°C (932Â°F) and 850Â°C (1562Â°F).
- Upstream closed loop fuel control active.
- Once the enable conditions are met the vehicle must be driven under the following conditions:
  - Engine speed above 1152 rpm.

- Vehicle speed above 64.4 km/h (60 mph).
- Throttle open for a minimum of 120 seconds.
- Immediately after a closed throttle Decel Fuel Shutoff (DFSO) Event.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Downstream O2 Sensor does not transition from a rich to lean condition within a specific time during a DFSO event.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EXHAUST SYSTEM LEAK
O2 SENSOR 1/2 SIGNAL CIRCUIT
O2 SENSOR 1/2 RETURN CIRCUIT
O2 SENSOR 1/2

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE DTC**

   NOTE: **Check for contaminants that may have damaged the O2 Sensor: contaminated fuel, unapproved silicone, oil and coolant.**

   NOTE: **After any repairs have been made, verify proper O2 Sensor operation. If all the O2 Sensor voltage readings have not returned to normal, follow the diagnostic procedure for the remaining O2 Sensors.**

   1. Start the engine.
   2. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   3. With the scan tool, read DTCs and record on the repair order.

      Is the DTC active or pending?

      Yes

      - Go To 2

      No

      - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE EXHAUST SYSTEM FOR LEAKS**
   1. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

      Were any exhaust leaks found?

      Yes

- Perform the appropriate repairs.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **CHECK THE (K141) O2 1/2 SIGNAL CIRCUIT FOR PROPER VOLTAGE AT THE O2 SENSOR HARNESS CONNECTOR**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
    3. Turn the ignition on.
    4. Set the DVOM to measure DC voltage.
    5. Connect the negative lead of the DVOM to a known good ground.
    6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

NOTE: **Normal operating voltage should be between 4.8 and 5.2 volts.**

Does the circuit have the proper voltage present?

Yes

- Go To 4

No

- Check the (K141) O2 1/2 Signal circuit for a short to ground, open or short to voltage. If OK, replace and program the Powertrain Control Module in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE (K904) O2 RETURN CIRCUIT FOR PROPER VOLTAGE AT THE O2 SENSOR HARNESS CONNECTOR**
    1. Turn the ignition off.
    2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
    3. Turn the ignition on.
    4. Set the DVOM to measure DC voltage.
    5. Connect the negative lead of the DVOM to a known good ground.

6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.

   NOTE: Normal operating voltage should be between 4.8 and 5.2 volts.

   Does the circuit have the proper voltage present?

   Yes

   - Go To 5

   No

   - Check the (K904) O2 1/2 Return circuit for a short to ground, open or short to voltage. If OK, replace and program the Powertrain Control Module in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK THE O2 SENSOR FOR PROPER OPERATION**

NOTE: Check for signs of contaminants that may have damaged the O2 Sensor 1/2, such as contaminated fuel, unapproved silicone, oil and coolant.

1. Using the wiring diagram/schematic as a guide, inspect the wiring and connectors between the O2 Sensor 1/2 and the Powertrain Control Module (PCM).
   - Look for any chafed, pierced, pinched or partially broken wires.
   - Look for broken, bent, pushed out or corroded terminals.
   - Verify that there is good pin to terminal contact in the O2 Sensor 1/2 and Powertrain Control Module connectors.
   - Perform any Service Bulletins that may apply.

   Were any problems found?

   Yes

   - Repair as necessary.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Replace the Oxygen Sensor 1/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2273-O2 SENSOR 2/2 SIGNAL BIASED RICH

For a complete CATALYST MONITOR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

For an aged Upstream Oxygen (O2) Sensor, the response rate to the air/fuel change is slower than when it was new. The O2 Sensor tends to move less with the same air/fuel changes in a given time frame. Therefore by observing the activity of voltage readings from the Upstream O2 Sensor, the quality of the O2 Sensor can be detected. The Downstream O2 Sensor is located in the exhaust path behind the Catalytic Converter, and is monitored for proper response to assure optimum Catalytic Converter efficiency. The Downstream O2 Sensor response monitor is intended to diagnose a Downstream O2 Sensor that is not moving or stuck in a voltage window and to insure accurate information for catalyst monitor diagnosis.

WHEN MONITORED

This diagnostic runs after the following enable conditions are met:

- Ambient temperature above -7Â°C (19.4Â°F).
- Battery voltage above 11.0 volts.
- Fuel level above 12%.
- With the engine running for more than 90.0 seconds.
- Engine Coolant Temperature (ECT) Sensor value above 70Â°C (158Â°F).
- Catalytic Converter temperature between 500Â°C (932Â°F) and 850Â°C (1562Â°F).
- Upstream closed loop fuel control active.
- Once the enable conditions are met the vehicle must be driven under the following conditions:
  - Engine speed above 1152 rpm.
  - Vehicle speed above 64.4 km/h (60 mph).
  - Throttle open for a minimum of 120 seconds.
  - Immediately after a closed throttle Decel Fuel Shutoff (DFSO) Event.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Downstream O2 Sensor does not transition from a lean to rich condition within a specific time during a DFSO event.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
EXHAUST SYSTEM LEAK
O2 SENSOR 1/2 SIGNAL CIRCUIT
O2 SENSOR 1/2 RETURN CIRCUIT
O2 SENSOR 1/2

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE DTC**

   NOTE: **Check for contaminants that may have damaged the O2 Sensor: contaminated fuel, unapproved silicone, oil and coolant.**

   NOTE: **After the repairs have been made, verify proper O2 Sensor operation. If all the O2 Sensor voltage readings have not returned to normal, follow the diagnostic procedure for the remaining O2 Sensors.**

   1. Start the engine.
   2. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   3. With the scan tool, read DTCs and record on the repair order.

      NOTE: **It may be necessary to drive the vehicle to meet the conditions to set this DTC, try to repeat the conditions in which the fault originally set by reviewing the Freeze Frame data.**

   Is the DTC active or pending?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECKING THE EXHAUST SYSTEM FOR LEAKS**
   1. Perform the CHECKING THE EXHAUST SYSTEM FOR LEAKS test procedure. Refer to **CHECKING THE EXHAUST SYSTEM FOR LEAKS** .

   Were any exhaust leaks found?

   Yes

   - Perform the appropriate repairs.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 3
3. **CHECK THE (K243) O2 2/2 SIGNAL CIRCUIT FOR PROPER VOLTAGE AT THE O2 SENSOR HARNESS CONNECTOR**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
   3. Turn the ignition on.
   4. Set the DVOM to measure DC voltage.
   5. Connect the negative lead of the DVOM to a known good ground.
   6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Normal operating voltage should be between 4.8 and 5.2 volts.**

   Does the circuit have the proper voltage present?

   Yes

   - Go To 4

   No

   - Check the (K243) O2 Sensor 2/2 Signal circuit for a short to ground, open, or short to voltage. If no problems are found, replace and program the Powertrain Control Module in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE (K904) O2 2/2 RETURN CIRCUIT FOR PROPER VOLTAGE AT THE O2 SENSOR HARNESS CONNECTOR**
   1. Turn the ignition off.
   2. Disconnect the harness connector at the component of the circuit being tested. **Note:** The ECU harness connector should still be connected during this test step.
   3. Turn the ignition on.
   4. Set the DVOM to measure DC voltage.
   5. Connect the negative lead of the DVOM to a known good ground.
   6. With the positive lead of the DVOM, measure the voltage of the circuit being tested at the component harness connector.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harness connector.

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Normal operating voltage should be between 4.8 and 5.2 volts.**

   Does the circuit have the proper voltage present?

   Yes

- Go To 5

No

- Check the (K904) O2 2/2 Return circuit for a short to ground, open, or short to voltage. If no problems are found, replace and program the Powertrain Control Module in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK THE O2 SENSOR FOR PROPER OPERATION**

NOTE: **Check for signs of contaminants that may have damaged the O2 Sensor, such as contaminated fuel, unapproved silicone, oil and coolant.**

1. Using the wiring diagram/schematic as a guide, inspect the wiring and connectors between the O2 Sensor 2/2 and the Powertrain Control Module (PCM).
   - Look for any chafed, pierced, pinched, or partially broken wires.
   - Look for broken, bent, pushed out or corroded terminals.
   - Verify that there is good pin to terminal contact in the O2 Sensor 2/2 and Powertrain Control Module connectors.
   - Perform any Service Bulletins that may apply.

Were any problems found?

Yes

- Repair as necessary.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Replace the Oxygen Sensor 2/2 in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

DIAGNOSIS AND TESTING

P2299-BRAKE PEDAL POSITION/ACCELERATOR PEDAL POSITION INCOMPATIBLE

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- No Brake or Accelerator Pedal Position Sensor (APPS) faults present.

SET CONDITION

- The PCM recognizes a brake application following the APPS showing a fixed pedal opening. Temporary or permanent.

DEFAULT ACTION

- ETC light will illuminate.
- When this code sets the Accelerator Pedal position in the PCM software will ramp to idle. If the Pedal voltage changes OR the brake pedal is released, the Acceler PCM software will ramp up to the Accelerator Pedal position and the ETC light will go out.

POSSIBLE CAUSES

Possible Causes
CUSTOMER PRESSING ACCELERATOR PEDAL AND BRAKE PEDAL, AND HOLDING THEM DOWN SIMULTANEOUSLY
BRAKE PEDAL OUT OF CALIBRATION
BRAKE PEDAL POSITION (BPP) SENSOR
ACCELERATOR PEDAL POSITION (APP) SENSOR

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE DTC**
   1. With the scan tool, read Anti-Lock Brake (ABS) Module DTCs.

      Are there any DTCs present in the ABS Module?

      Yes

      - Perform the appropriate diagnostic test in the ABS Module.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 2
2. **CHECK THE BPP SENSOR FOR PROPER OPERATION**

   NOTE: **The most likely cause of this DTC is the customer driving with one foot on the Accelerator pedal and the other resting on t Brake Pedal Position Sensor stuck in the pressed state. Ask the driver of the vehicle if this applies to their driving habits b**

   1. With the scan tool, read the Brake Pedal Position Sensor status while pressing and releasing the Brake Pedal.

      Does the scan tool display the Pressed and Released while pressing and releasing the Pedal?

      Yes

      - Go To 3

      No

      - Check the Brake Pedal Position Sensor for proper installation and check the related circuits for opens and shorts using the appropriate wiring diagram found, replace the Brake Pedal Position Sensor in accordance with the Service Information. Refer to **SENSOR, STOP LAMP, REMOVAL AND IN**
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
3. **PERFORM AN APP SENSOR SWEEP AND MONITOR THE VOLTAGE**

   NOTE: **If a Accelerator Pedal assembly becomes mechanically stuck the voltage output will stay fixed, if this is also followed by a the brakes this code will set.**

   1. Turn the ignition on.
   2. With the scan tool, monitor both APP Sensor voltage readings.
   3. Slowly press the accelerator pedal from idle until it reaches the end stop near the floor.
   4. APP Sensor 1 voltage should start at approximately 0.45 volts and increase to approximately 4.6 volts with a smooth transition.
   5. APP Sensor 2 voltage should start at approximately 0.22 volts and increase to approximately 2.3 volts with a smooth transition.

      Does the voltage for the appropriate sensor follow the list specification?

      Yes

      - Go To 4

      No

- Check the Signal and Return circuits for opens and shorts. If no problems are found, Replace the APP Sensor Assembly in accordance with the Servic installation is complete, with a scan tool select the ETC RELEARN function to relearn the APP Sensor values.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **PERFORM THE BRAKE PEDAL CALIBRATION ROUTINE**
   1. With the scan tool, navigate to ABS Module, Misc. Functions, and perform the Brake Pedal Calibration Routine.

      Was the Brake Pedal Calibration Routine successful?

      Yes

      - Test drive the vehicle and verify that the Brake Pedal Calibration fixed the problem.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Visually inspect the BPP Sensor for improper installation, damage or mechanical failure. If no problems are found, replace the Brake Pedal Position S **SENSOR, STOP LAMP, REMOVAL AND INSTALLATION** .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P232A-TCM REQUEST FORCED ENGINE SHUTDOWN

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage greater than 10.0 volts.

SET CONDITION

- The Transmission Control Module (TCM) detects a malfunction in the Transmission. A DTC is stored in the TCM.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
DTC PRESENT IN THE TRANSMISSION CONTROL MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

CHECK FOR AN ACTIVE DTC PRESENT IN TRANSMISSION CONTROL MODULE

NOTE: **The TCM sends a request to the Powertrain Control Module (PCM) to shut the engine off when it detects certain malfunctions in**

1. This is an informational DTC to inform you that there is a DTC stored in the Transmission Control Module.
2. Erase this DTC from the PCM after all TCM DTCs have been repaired.
3. Test drive or operate the vehicle in the conditions that set the original DTC.
4. Using a scan tool, read the TCM DTCs.

   Did any TCM DTCs return?

   Yes

   - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

P2457-EXHAUST GAS RECIRCULATION COOLING SYSTEM PERFORMANCE

For a complete EGR SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Exhaust Gas Recirculation (EGR) Temperature Sensor is positioned between the EGR Cooler and EGR Valve. The feedback signal from the sensor is used to monit of the recirculated exhaust gases passing through the EGR Cooler Assembly. At lower temperatures the signal feedback voltage will read closer to the upper operating p recirculated exhaust gas temperature increases, the signal feedback voltage will decrease toward the lower operating parameter.

There is a sensor rationality monitor that runs after a cold soak condition, at initial engine start up. When certain enable conditions are met, the Powertrain Control Mod the EGR Temperature Sensor reading to the Engine Coolant Temperature (ECT), Ambient Air Temperature (AAT) Sensor readings for plausibility.

A second monitor will run when the EGR system is active to monitor the sensor plausibility. It works as follows: There is a small voltage difference between the upper c the voltage threshold that will set a circuit high fault. The same is also true for the lower operating parameter and the voltage threshold that will set a circuit low fault. T windows are used for checking the coherency of the sensor. If the signal voltage reads in one of these windows, a sensor circuit performance fault will set.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- No Engine Coolant Temperature (ECT) Sensor or Exhaust Gas Recirculation (EGR) Temperature Sensor DTCs active.

- EGR is commanded on.
- Engine is at operating temperature.

SET CONDITION

- When the difference between the PCM modeled temperature and the EGR Temp Sensor is more than 60B°C (140B°F) for 32.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
ENGINE COOLANT LOW
HIGH RESISTANCE IN THE EGR TEMPERATURE SENSOR SIGNAL CIRCUIT
HIGH RESISTANCE IN THE SENSOR GROUND CIRCUIT
EGR COOLER ASSEMBLY RESTRICTED
INTERNAL OR EXTERNAL CRACK IN THE EGR COOLER ASSEMBLY

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **CHECK THE ENGINE COOLANT LEVEL**

   WARNING: Do not remove or loosen the radiator cap with the system hot and under pressure. Serious burns from coolant can occur.

   1. Check the level of the engine coolant.

   Is the cooling system low on coolant?

   Yes

   - Fill the coolant to the proper level. Pressure test and inspect the entire cooling system for signs of coolant leaks.

   No

   - Go To 2
2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 3

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK FOR ENGINE OVERHEATING PROBLEMS**
   1. Start the engine and allow it to reach operating temperature.
   2. Drive the engine under a various load conditions.
   3. Monitor the engine for an overheating condition.

      Is the engine overheating?

      Yes

      - Repair the overheating condition in accordance with the Service Information.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 4
4. **ISOLATE AND CHECK THE EGR TEMPERATURE SENSOR (K932) TEMP SIGNAL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use t diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance t
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

   CAUTION: Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harn

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 5

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND CHECK THE (K900) SENSOR GROUND CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use t diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance t
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harn

NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

Is the resistance below 3.0 Ohms?

Yes

- Go To 6

No

- Repair the circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE EGR COOLER AND HOSES FOR LEAKS**
    1. Pressure test the cooling system and inspect the EGR Cooler Assembly and hoses for signs of a coolant leak.

Were any leaks found?

Yes

- Repair the leak by repairing or replacing the leaking hoses or EGR Cooler Assembly in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 7

7. **CHECK THE EGR COOLER FOR AN INTERNAL LEAK**
    1. Inspect the inside of the exhaust tailpipe for the presence of engine coolant.

NOTE: **A severe leak may also be identified by excessive white smoke from the tailpipe with the engine running resembling t cylinder head gasket. Before condemning a cylinder head gasket, make sure to inspect for coolant inside the EGR Tu**

2. If no coolant was found in the tailpipe, disconnect the EGR Tube that connects between the EGR Valve and the Intake Manifold and inspect the inside of th presence of engine coolant.

Was coolant found inside the exhaust tailpipe or EGR Tube?

Yes

- Replace the EGR Cooler Assembly in accordance with the Service Information. Refer to **COOLER, EXHAUST GAS RECIRCULATION (EGR), INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 8

8. **REPLACE THE EGR TEMPERATURE SENSOR AND RETEST FOR DTCS**
    1. Turn the ignition off.
    2. Replace the EGR Temperature Sensor in accordance with the Service Information. Refer to **SENSOR, EGR TEMPERATURE, REMOVAL AND INSTA**
    3. Connect the component and Electronic Control Unit (ECU) harness connectors.
    4. Turn the ignition on.
    5. With the scan tool, erase all DTCs.
    6. Turn the ignition off for a minimum of 10.0 seconds.
    7. Turn the ignition on.
    8. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.

9. With the scan tool, read DTCs.

Did the DTC return?

Yes

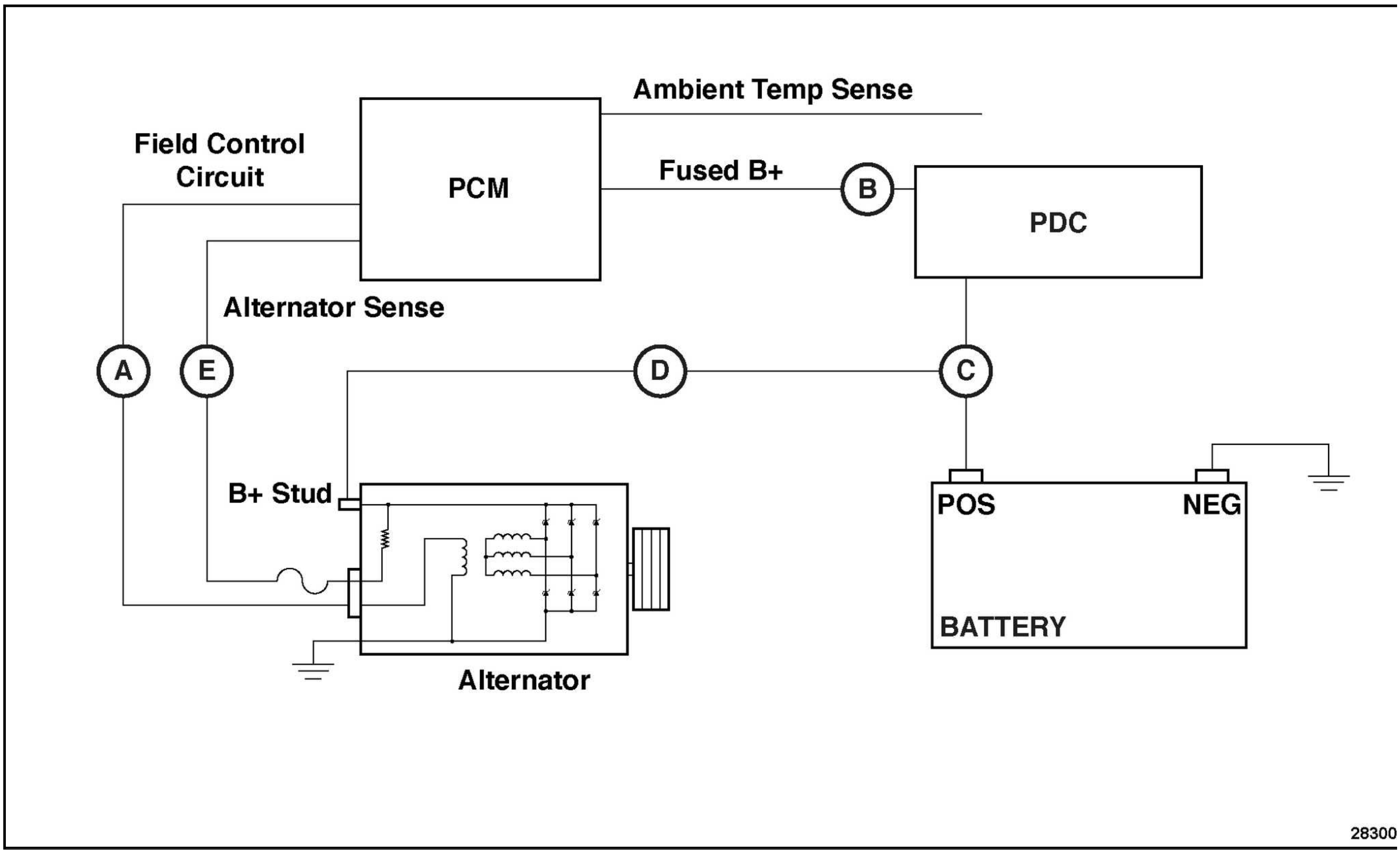
- Replace the EGR Cooler Assembly in accordance with the Service Information. Refer to **COOLER, EXHAUST GAS RECIRCULATION (EGR), REM INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Replacing the EGR Temperature Sensor repaired the fault.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2503-CHARGING SYSTEM OUTPUT LOW

THEORY OF OPERATION



The Electronic Voltage Regulation (EVR) system maintains the system voltage at a desired level by turning the Pulse Width Modulated (PWM) Alternator Field Control When the Alternator field is turned on, the system voltage increases. When the Alternator field is turned off, the system voltage slowly drops. The rate at which this hap the existing electrical loads, ambient under hood temperature, and the engine speed. A constant system voltage (B, C, D) can be maintained only when the Alternator fie at a duty cycle that very accurately emulates the existing electrical loads given the existing ambient under hood temperature and engine speed.

During normal operation: The voltage reading at the Alternator output stud will be very close to the target charging voltage viewed on the scan tool. This is the system the Powertrain Control Module (PCM) through the Fused B+ circuit (B). With the Alternator connector plugged in, the voltage reading on the Alternator Sense circuit w volts less than the voltage at the Alternator output stud due the resistor inside the Alternator. This is the Alternator Sense (E) input to the PCM. These two voltage sense compared during the different diagnostics performed on the EVR System by the PCM.

Diagnostic Mode: When the PCM detects that the output voltage is too high or too low, the PCM runs a series of diagnostics to determine the cause. When the diagnost will change the field control circuit and look for a change in the output voltage. If no reaction is detected, the PCM rationalizes that it has lost control of the Alternator F an open or shorted condition. If the Alternator Field control is active, and the engine speed is above a calibrated threshold, the PCM will run a series of tests that turn the off and on for a brief period of time and monitors the system voltage (B) for a calibrated amount of change in the voltage, to determine a failure of the Alternator. This d repeated failures to insure that an erroneous fault is not set.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the engine running.
- The engine speed high enough (normally above 1157 rpm) to insure sufficient Alternator current output to satisfy the electrical loads.

SET CONDITION

- The Alternator output is sensed to be less than the target charging voltage, during engine operation, for a calibrated amount of time.

DEFAULT ACTION

- This is a non-MIL fault.
- The Battery light will illuminate.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
LOOSE OR BROKEN ACCESSORY DRIVE BELT OR DEFECTIVE TENSIONER
ALTERNATOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

        Is DTC P0622 active or pending?

        Yes

        - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

        No

        - Go To 3
3. **VISUALLY INSPECT THE ALTERNATOR AND BELT**
    1. Turn the ignition off.
    2. Inspect the Alternator belt and Tensioner for proper size and operation.
    3. Check for proper belt routing installation.

        Are the belt and tensioner installed properly and functioning correctly?

        Yes

        - Go To 4

        No

        - Perform the appropriate repair.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
4. **CHECK THE CONDITION OF THE BATTERY**

    NOTE: Inspect the vehicle for aftermarket accessories that may exceed the Alternator System output.

    1. Use the (special tool #GR8-1220KIT-CHRY, AGM Battery Tester/Charger Station)or equivalent to load test the Battery.

        Did the Battery pass or fail?

        Passed

        - Go To 5

        Failed

        - Perform the appropriate repair according to the Battery tester.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **CHECK THE ALTERNATOR OUTPUT AT THE ALTERNATOR OUTPUT STUD**
    1. Start the engine.
    2. Hold the engine speed above 1157 rpm.
    3. With the scan tool, navigate to data display and monitor the target charging voltage.
    4. Using a voltmeter, measure the voltage at the Alternator output stud.

        Is the Alternator output more than 1.0 volt below the target charging voltage?

        Yes

- Verify that there is good pin to terminal contact in the Alternator connector. If no problems are found, replace the Alternator. Refer to **GENERATOR INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK THE ALTERNATOR OUTPUT AT THE PCM**
   1. Turn the ignition off.
   2. Disconnect the PCM C1 harness connector.

      CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals res terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   3. Connect the (special tool #10436, Adapter, GPEC Diagnostic) in line with the PCM C1 harness connector.
   4. Start the engine.
   5. Hold the engine speed above 1157 rpm.
   6. With the scan tool, navigate to data display and monitor the target charging voltage.
   7. Using a voltmeter, measure the voltage between ground and the (A106) Fused B+ circuit at the GPEC Adaptor.

   Is the (A106) Fused B+ circuit voltage more than 1.0 volt below the target charging voltage?

   Yes

   - Use the appropriate wiring diagram/schematic as a guide and inspect the fusible link in the charge wire or fuses in the PDC depending on application fuse is found, perform repair and retest for DTC. If no problems were found, repair the (A106) Fused B+ circuit for excessive resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 7

7. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

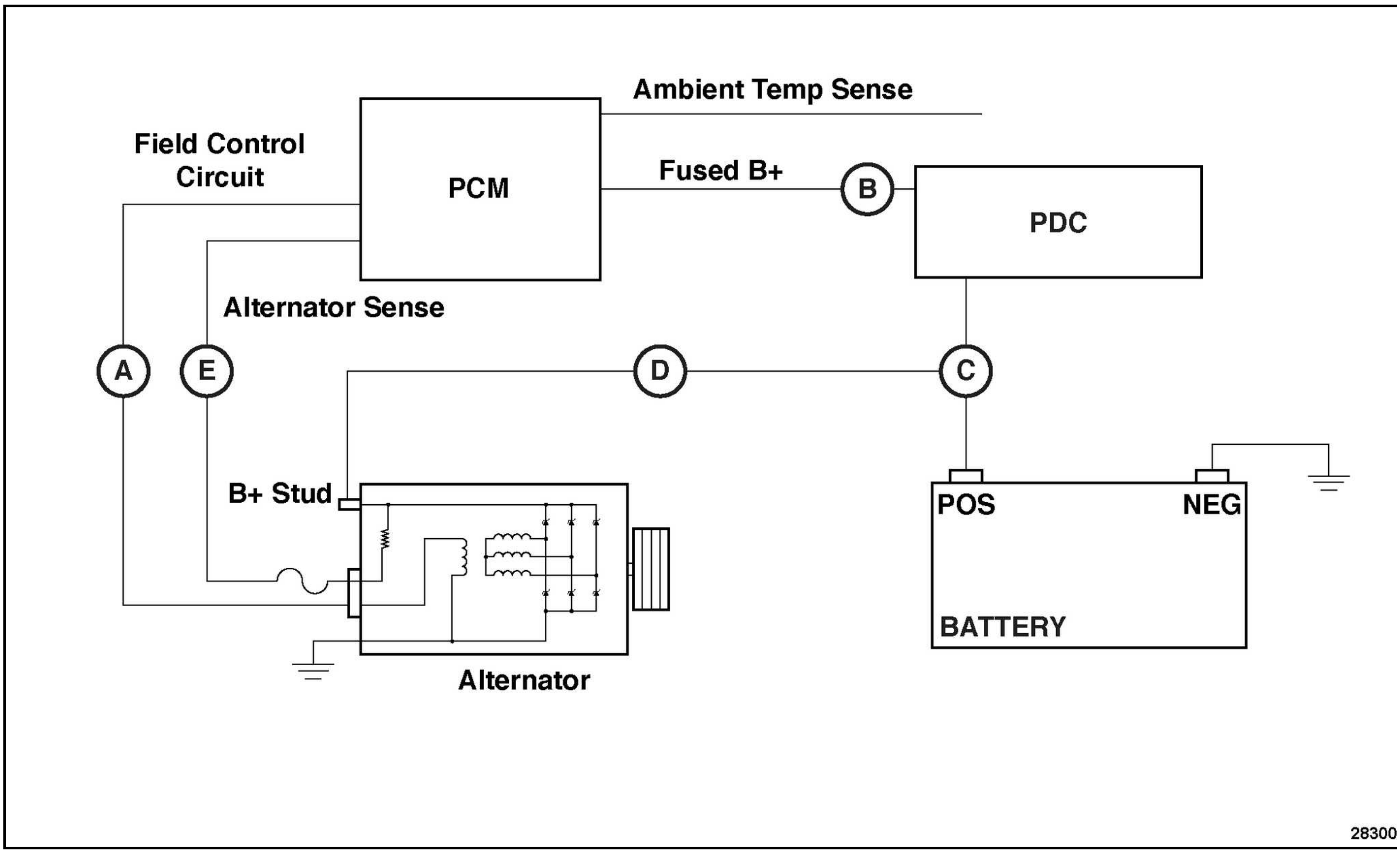
   - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CO REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - The wiring or poor connection problem has been repaired.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2504-CHARGING SYSTEM OUTPUT HIGH

THEORY OF OPERATION



The Electronic Voltage Regulation (EVR) system maintains the system voltage at a desired level by turning the Pulse Width Modulated (PWM) Alternator Field Control When the Alternator field is turned on, the system voltage increases. When the Alternator field is turned off, the system voltage slowly drops. The rate at which this hap the existing electrical loads, ambient under hood temperature, and the engine RPM. A constant system voltage (B, C, D) can be maintained only when the Alternator fie at a duty cycle that very accurately emulates the existing electrical loads given the existing ambient under hood temperature and engine RPM.

During normal operation, the voltage reading at the Alternator output stud will be very close to the target charging voltage viewed on the scan tool. This is the system the Powertrain Control Module (PCM) through the Fused B+ circuit (B). With the Alternator connector plugged in, the voltage reading on the Alternator Sense circuit w volts less than the voltage at the Alternator output stud due the resistor inside the Alternator. This is the Alternator Sense (E) input to the PCM. These two voltage sense compared during the different diagnostics performed on the EVR System by the PCM.

Diagnostic Mode: The PCM will run the **Alternator Voltage High** diagnostic to determine that the Alternator voltage sense (E) is higher than the system voltage (B, C amount. It will give a rapid warning that the Alternator output terminal, Alternator output wiring or the fuse/fuse link in this output wiring had conductivity problems. T permanent or intermittent disconnections, or excessive resistance in the wiring caused by either corrosion or a loose connection.

WHEN MONITORED

- With the engine running.

SET CONDITION

- The Alternator Sense circuit input voltage (E) to the PCM exceeds the direct Fused B+ (B) sensed by the PCM.

DEFAULT ACTION

- This is a non MIL fault.

POSSIBLE CAUSES

Possible Causes
OPEN OR HIGH RESISTANCE BETWEEN THE ALTERNATOR B+ TERMINAL AND THE FUSE ARRAY B+ TERMINAL
RESISTANCE IN THE FUSED B+ CIRCUIT BETWEEN THE FUSE ARRAY AND THE PCM
FUSE ARRAY
ALTERNATOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING P

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE CONDITION OF THE MAIN CRANKING BATTERY**

NOTE: **Inspect the vehicle for aftermarket accessories that may exceed the Alternator System output.**

NOTE: **This DTC does not necessarily indicate an overcharging condition. It merely indicates that the Alternator Sense signal is g Alternator output supplied to the Battery and Fuse Array.**

1. Use the (special tool #GR8-1220KIT-CHRY, AGM Battery Tester/Charger Station)or equivalent to load test the Battery.

   Did the Battery pass or fail?

   Passed

   - Go To 3

   Failed

   - Perform the appropriate repair according to the Battery tester.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

3. **CHECK THE CONDITION OF THE AUXILIARY BATTERY**

NOTE: **Inspect the vehicle for aftermarket accessories that may exceed the Alternator System output.**

NOTE: **This DTC does not necessarily indicate an overcharging condition. It merely indicates that the Alternator Sense signal is g Alternator output supplied to the Battery and Fuse Array.**

1. Use the (special tool #GR8-1220KIT-CHRY, AGM Battery Tester/Charger Station)or equivalent to load test the Battery.

   Did the Battery pass or fail?

   Passed

   - Go To 4

   Failed

   - Perform the appropriate repair according to the Battery tester.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE VOLTAGE AT THE ALTERNATOR OUTPUT STUD**
   1. Start the engine and allow it to idle.
   2. With the scan tool, monitor the Target Charging Voltage.
   3. Measure the voltage at the Alternator output stud.

   Are the voltage readings within 0.2 volts of each other?

   Yes

   - Go To 5

   No

   - Replace the Alternator in accordance with the Service Information. Refer to **GENERATOR, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK THE (A801) FUSED B+ CIRCUIT VOLTAGE AT THE FUSE ARRAY**
   1. Turn the engine off.
   2. Back probe and measure the voltage on the (A801) Fused B+ circuit at the Fuse Array connector.

   NOTE: **Compare the voltage reading to the voltage at the Alternator output stud.**

   Is the voltage within 0.2 volts of the measurement at the Alternator output stud?

   Yes

   - Go To 6

   No

   - Repair the (A801) Fused B+ circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK FOR VOLTAGE DROP THROUGH THE FUSE ARRAY**
   1. Measure the voltage on the (A1) Fused B+ circuit at the Fuse Array.
   2. Compare the voltage reading to the voltage on the (A801) Fused B+ circuit at the Fuse Array.

   Is the voltage within 0.2 volts of the measurement at the Alternator output stud?

Yes

- Go To 7

No

- Check the fuse and Fuse Array terminals for signs of terminal damage, spread terminals, and corrosion. If no problem is found, replace the Fuse Array Service Information. Refer to **FUSE, Z-CASE ARRARY, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK THE (A0) VOLTAGE AT THE FUSE ARRAY**
   1. Measure the voltage on the (A0) Fused B+ circuit at the Fuse Array B+ terminal.

   NOTE: **Compare the voltage reading to the voltage on the (A1) Fused B+ circuit at the Fuse Array.**

   Is the voltage within 0.2 volts of the measurement at the Alternator output stud?

   Yes

   - Go To 8

   No

   - Repair the open or excessive resistance in the (A0) Fused B+ circuit.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
8. **CHECK FOR VOLTAGE DROP THROUGH THE FUSE ARRAY**
   1. Back probe the (A106) Fused B+ circuit at the Fuse Array connector.
   2. Using a voltmeter, measure the voltage on the (A106) Fused B+ circuit.
   3. Compare the voltage reading to the voltage on the (A1) Fused B+ circuit at the Fuse Array.

   Is the voltage within 0.2 volts of the measurement at the Alternator output stud?

   Yes

   - Go To 9

   No

   - Check the fuse and Fuse Array terminals for signs of terminal damage, spread terminals, and corrosion. If no problem is found, replace the Fuse Array Service Information. Refer to **FUSE, Z-CASE ARRARY, REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
9. **CHECK THE (A106) FUSED B+ CIRCUIT VOLTAGE AT THE PCM**
   1. Turn the ignition off.
   2. Disconnect the PCM C1 harness connector.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resu terminal to pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   3. Connect the (special tool #10436, Adapter, GPEC Diagnostic) in-line between the PCM C1 harness connector and the PCM.
   4. Turn the ignition on.
   5. Using a voltmeter, measure the voltage on the (A106) Fused B+ circuit at the GPEC Adaptor.

   Is the (A106) Fused B+ circuit voltage within 0.2 volts of the (A1) Fused B+ circuit at the Fuse Array connector?

   Yes

   - Go To 10

   No

   - Repair the (A106) Fused B+ circuit for high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
10. **CHECK RELATED HARNESS CONNECTIONS**
    1. Disconnect all PCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
       - Proper connector installation.
       - Damaged connector locks.
       - Corrosion.
       - Other signs of water intrusion.
       - Weather seal damage (if equipped).
       - Bent terminals.
       - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
       - Terminals that have been pushed back into the connector cavity.
       - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

    5. Connect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Connect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.

7. Connect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the PCM in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P257E-ENGINE HOOD SWITCH CIRCUIT LOW

For a complete VEHICLE THEFT SECURITY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) monitors the hood ajar status of both hood ajar switches on Plug-in Hybrid Electric Vehicles (PHEV) and Electronic Stop/Start (for proper operation. Hood Ajar Switch 1 is hard-wired to the Body Control Module (BCM). The signal is sent to the PCM over the CAN Bus. Hood Ajar Switch 2 is ha the PCM detects that either switch is in the open position or is faulted for any reason during a normal drive cycle, ESS will be disabled for the remainder of the drive cy cause the engine to default to a running state on both PHEV and ESS equipped vehicles. If Hood Ajar Switch 2 is faulted or in the open state it will also cause the Remo inoperative.

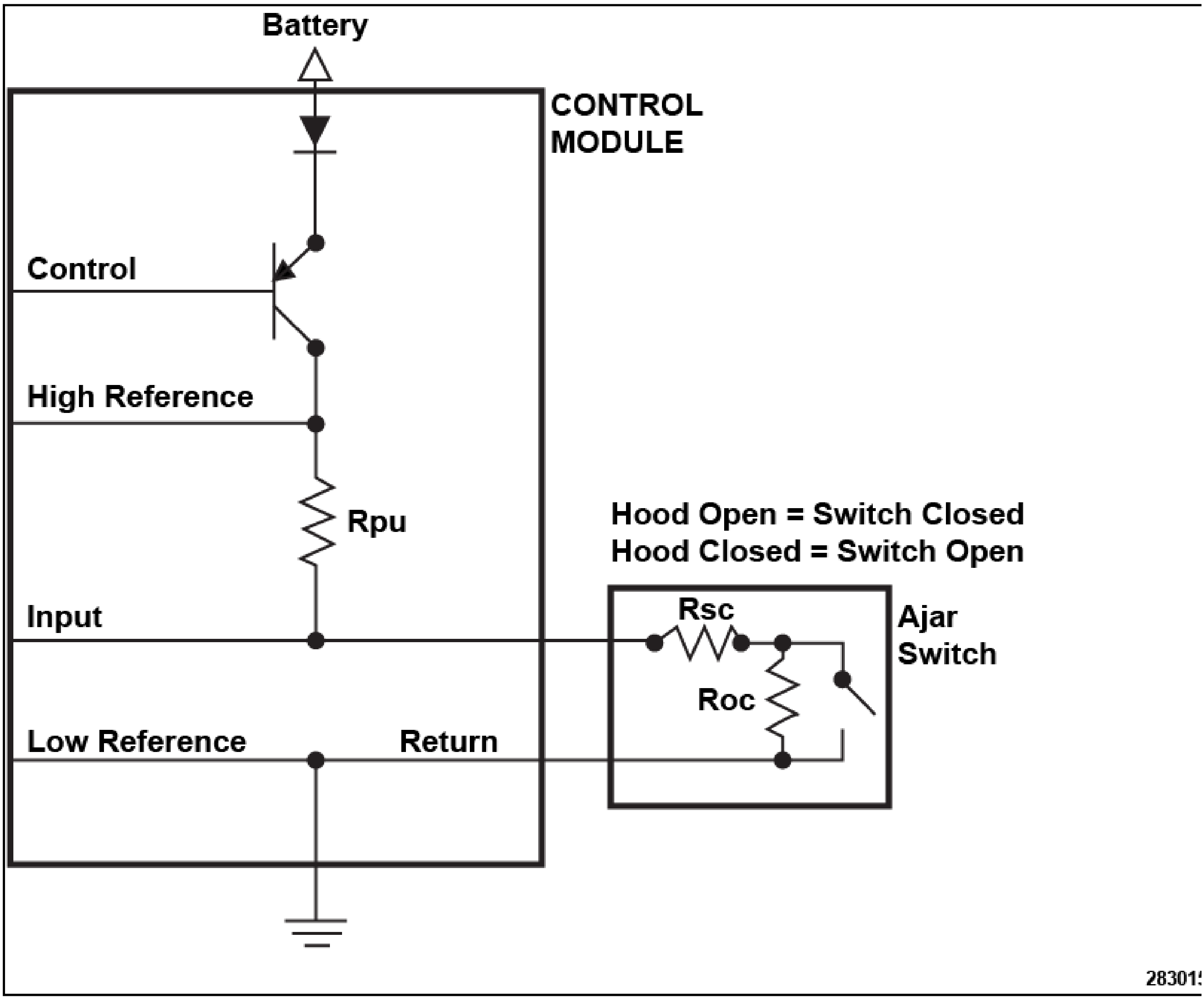
For additional information on the effect of this DTC to the operation of ESS, proceed to the **ENGINE START/STOP (ESS) INOPERATIVE.** . Refer to **ENGINE STO SYSTEM INOPERATIVE** .

COMPONENT FUNCTIONAL DESCRIPTION - HOOD LATCH/AJAR SWITCH 1

Component Functional Operation: The Hood Ajar Switch 1 is a hard-wired input to the Body Control Module (BCM). For most vehicles it is integrated as part of the it is incorporated into the latch assembly there will be an electrical connector on the latch assembly. If the latch does not have an electrical connector, there should be a 2 the hood. The Hood Ajar Switch 1 receives a Battery voltage signal from the BCM through an internal pull up resistor. When the ajar switch is open the signal passes th resistors and the resistance through the switch should be approximately 1000 Ohms. When the switch is closed the signal passes through only the Rsc resistor and the re switch should be approximately 500 Ohms.

Technical Data:

Parameter	Nominal	B
Rsc	499 ohms	
Roc	499 ohms	
Rpu	1100 ohms	
Signal reference voltage	Battery/system voltage	
Protection	Short to Ground/Short to Battery	
Detection	Short to Ground/Open Circuit/Short to Battery	



The BCM monitors the Hood Ajar Switch 1 signal circuit and converts the voltage signal into counts to broadcast over the CAN Bus network.

- Electronic Control Modules read an analog signal voltage and converts it to digital counts. Each count is an equal percentage of the signal reference voltage. This viewing some sensor or switch voltages and converted values on the scan tool. The values will change in blocks (Ex. 0.08v, 0.12v, 0.16v or 8 Pa, 16 Pa, 24 Pa etc. could be anywhere from 5.0 volts to a Battery voltage reference.
- The resolution of the signal (number of counts) is determined by the required precision of the input by the ECU. Typically, sensor signals are high resolution. This read small changes over a wide range in a variable resistance sensor signal. These are typically used on a temperature, pressure, position or MUX type of sensor.
- Switches on the other hand are usually of much lower resolution than sensors. This is because an ECU is generally looking for a switch to be in only a few positio resistors. The lower resolution also helps the ECU to overcome some resistance in a circuit and still read the correct state. This also lowers the sensitivity to settin

The Hood Ajar Switch 1 signal voltage is typically divided into 15 counts. The table below shows the relation between for the Hood Ajar Switch 1 states. The voltage ra nominal reference voltage of 13.5 volts. The counts and percentage of Battery voltage will remain constant, but the signal voltage will vary as actual Battery voltage cha

- Using the following method to convert the actual Hood Ajar Switch 1 signal voltage to a percentage of Battery voltage. (Hood Ajar Switch 1 signal voltage / Batte Battery voltage).
- Examples: (4.7v signal / 14.2v Battery = 33%) 5 counts. (6.7v signal / 12.6v Battery = 53%) 8 counts

VOLTAGE PERCENTAGE/VALUE TO HOOD STATE				
Count Level	**Signal State**	**Signal Voltage @ 13.5 volts nominal**	**Percentage of Battery Voltage**	**Fault (**
0 - 2	Circuit Shorted Low	Below 1.8v	0 - 13%	P25
3 - 6	Ajar	2.7v - 4.5v	20 - 33%	Normal oper
7- 10	Not Ajar	5.4v - 8.9v	40 - 66%	
11 - 15	Circuit Shorted High/Open	Above 9.0v	73 - 100%	P25

DIAGNOSTIC OVERVIEW - HOOD AJAR SWITCHES

The Powertrain Control Module (PCM) must see both Hood Ajar Switches in the open state (hood closed) for the Remote Start and Engine Stop/Start (ESS) systems to should always match if both switches are functioning properly.

- If the vehicle has a performance or correlation fault, start by determining which switch is not reading the hood states (ajar/not ajar) properly. Use one of the follov both Hood Ajar Switch states.
  - Read the scan tool data reads.
  - Measure the resistance through each switch in both states (switch open/closed).

- Check the voltage on the signal circuit in each state.

Use the technical data information provided in the Component Functional Description and Operation to determine which Hood Switch is reading incorrectly and c wiring accordingly.

- Typically a performance fault against Hood Ajar Switch 2, or a correlation fault is due to the **total resistance** of a switch or circuitry drifting out of range. On veh Switch 2 has only the one internal resistor used to detect the **open switch state** , a short to ground in the signal circuit would be interpreted as a closed switch stat by the PCM. This would cause a correlation fault when the hood is closed/not ajar.
- Circuit Low/High faults against one of the Hood Ajar Switches are typically due to an open or short in the switch or wiring.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Engine Stop/Start (ESS) is enabled.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Hood Ajar Switch 1 voltage received over the CAN BUS from the BCM is below the minimum acceptabl

DEFAULT ACTION

- The Hood Ajar Lamp will illuminate.
- This is a non-MIL fault.
- ESS is disabled while the DTC is present.
- The engine will start if not running when DTC sets.

POSSIBLE CAUSES

Possible Causes
HOOD AJAR SWITCH SENSE CIRCUIT SHORT TO GROUND
HOOD AJAR SWITCH SENSE CIRCUIT SHORT TO SENSOR GROUND CIRCUIT
HOOD AJAR SWITCH 1 - LOW INTERNAL RESISTANCE
BODY CONTROL MODULE (BCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE HOOD AJAR SWITCH 1 FOR PROPER FUNCTION**
    1. Check the Hood Ajar Switch 1 functionality. Use the Hood Ajar Switch 1 diagnostic and technical information provided above.

        Is the Hood Ajar Switch 1 functioning properly?

        Yes

        - Go To 3

        No

        - Replace the Hood Latch Assembly in accordance with the Service Information.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
3. **ISOLATE AND CHECK THE HOOD AJAR SWITCH 1 (G70) SENSE CIRCUIT FOR A SHORT TO GROUND**
    1. The ignition must be off when checking a circuit for continuity to ground.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Us diagram as a guide to follow the path of the circuit.
    3. Connect the negative lead of the DVOM to a known good ground.
    4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and grc

    NOTE: **There should be no continuity between ground and the circuit being tested.**

    Is there continuity between ground and the circuit being tested?

    Yes

- Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help isolate
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **ISOLATE AND CHECK THE HOOD AJAR SWITCH 1 (G70) SENSE CIRCUIT FOR A SHORT TO THE (G931) SENSOR GROUND CIRCUIT**
   1. The ignition must be off when checking for a short between circuits.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Us diagram as a guide to follow the path of the circuit.
   3. Connect the test leads of the DVOM and check for continuity between the circuits being tested at the component harness connector.

   NOTE: **There should be no continuity between the circuits being tested.**

   Is there continuity between the circuits?

   Yes

   - Repair the short between the circuits.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 5

5. **CHECK RELATED BCM AND COMPONENT CONNECTIONS**
   1. Disconnect all BCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.
   5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. With the scan tool, erase DTCs.
   9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   10. With the scan tool, read DTCs.

      Did the DTC return?

      Yes

      - Replace and program the Body Control Module (BCM) in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM INSTALLATION** .
      - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

      No

      - The wiring or poor connection problem has been repaired.
      - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

P257F-ENGINE HOOD SWITCH CIRCUIT HIGH

For a complete VEHICLE THEFT SECURITY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) monitors the hood ajar status of both hood ajar switches on Plug-in Hybrid Electric Vehicles (PHEV) and Electronic Stop/Start (for proper operation. Hood Ajar Switch 1 is hard-wired to the Body Control Module (BCM). The signal is sent to the PCM over the CAN Bus. Hood Ajar Switch 2 is ha the PCM detects that either switch is in the open position or is faulted for any reason during a normal drive cycle, ESS will be disabled for the remainder of the drive cy cause the engine to default to a running state on both PHEV and ESS equipped vehicles. If Hood Ajar Switch 2 is faulted or in the open state it will also cause the Remo inoperative.

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Technical Data:

Parameter	**Nominal**	**B**
Rsc	499 ohms	
Roc	499 ohms	
Rpu	1100 ohms	
Signal reference voltage	Battery/system voltage	
Protection	Short to Ground/Short to Battery	
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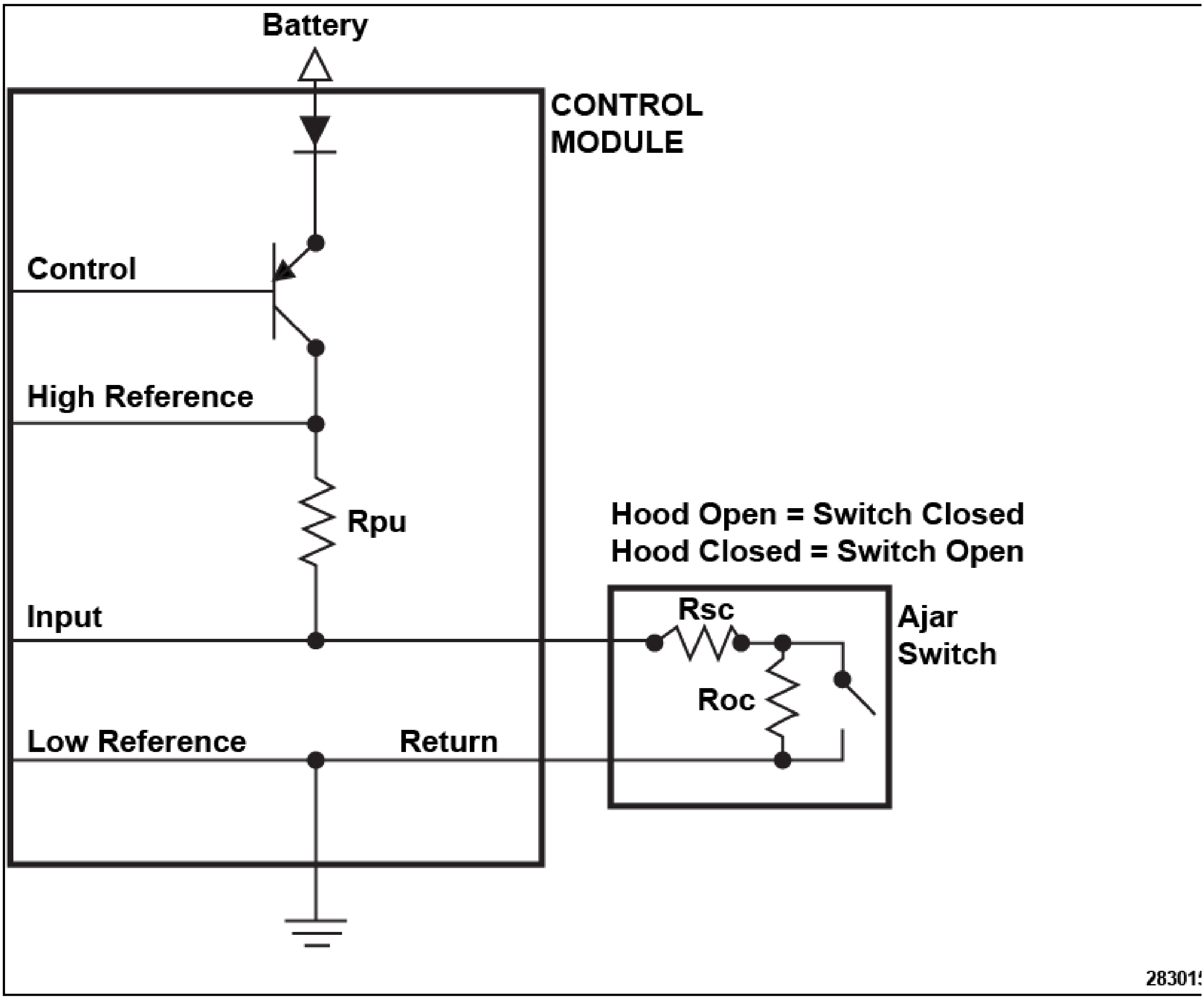

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VOLTAGE PERCENTAGE/VALUE TO HOOD STATE				
Count Level	**Signal State**	**Signal Voltage @ 13.5 volts nominal**	**Percentage of Battery Voltage**	**Fault (**
0 - 2	Circuit Shorted Low	Below 1.8v	0 - 13%	P25'

VOLTAGE PERCENTAGE/VALUE TO HOOD STATE				
Count Level	**Signal State**	**Signal Voltage @ 13.5 volts nominal**	**Percentage of Battery Voltage**	**Fault (**
3 - 6	Ajar	2.7v - 4.5v	20 - 33%	Normal oper
7- 10	Not Ajar	5.4v - 8.9v	40 - 66%	
11 - 15	Circuit Shorted High/Open	Above 9.0v	73 - 100%	P25'

DIAGNOSTIC OVERVIEW - HOOD AJAR SWITCHES

The Powertrain Control Module (PCM) must see both Hood Ajar Switches in the open state (hood closed) for the Remote Start and Engine Stop/Start (ESS) systems to should always match if both switches are functioning properly.

- If the vehicle has a performance or correlation fault, start by determining which switch is not reading the hood states (ajar/not ajar) properly. Use one of the follov both Hood Ajar Switch states.
  - Read the scan tool data reads.
  - Measure the resistance through each switch in both states (switch open/closed).
  - Check the voltage on the signal circuit in each state.

  Use the technical data information provided in the Component Functional Description and Operation to determine which Hood Switch is reading incorrectly and (wiring accordingly.
- Typically a performance fault against Hood Ajar Switch 2, or a correlation fault is due to the **total resistance** of a switch or circuitry drifting out of range. On veh Switch 2 has only the one internal resistor used to detect the **open switch state** , a short to ground in the signal circuit would be interpreted as a closed switch stat by the PCM. This would cause a correlation fault when the hood is closed/not ajar.
- Circuit Low/High faults against one of the Hood Ajar Switches are typically due to an open or short in the switch or wiring.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Engine Stop/Start (ESS) is enabled.

SET CONDITION

- The Powertrain Control Module (PCM) detects that the Hood Ajar Switch 1 Sense voltage received over the CAN BUS from the BCM is above 4.9 volts for 0.32

DEFAULT ACTION

- The Hood Ajar Lamp will illuminate.
- This is a non MIL fault.
- ESS is disabled while the DTC is present.
- The engine will start if it is not running when the DTC sets.

POSSIBLE CAUSES

Possible Causes
HOOD AJAR SWITCH 1 SENSE CIRCUIT OPEN/HIGH RESISTANCE
SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE
HOOD AJAR SWITCH 1 (HOOD LATCH)
BODY CONTROL MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

      Did the DTC return?

      Yes

      - Go To 2

      No

      - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE HOOD AJAR SWITCH 1 CONNECTOR AND TERMINALS**
   1. Turn the ignition off.
   2. Check the Hood Ajar Switch 1 harness connector for proper connection at the Hood Latch Assembly.
   3. Verify that the connector is completely plugged in and properly locked prior to disconnecting.
   4. Disconnect the Hood Ajar Switch 1 harness connector and check for any pushed out, damaged or spread terminals.

      Were any issues found with the connector or terminals?

      Yes

- Repair the damaged terminal or properly connect and lock the Hood Ajar Switch 1 harness connector and retest for DTCs.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 3

3. **CHECK THE HOOD AJAR SWITCH 1 FOR PROPER FUNCTION**
   1. Check the Hood Ajar Switch 1 functionality. Use the Hood Ajar Switch 1 diagnostic and technical information provided above.

      Is the Hood Ajar Switch 1 functioning properly?

      Yes

      - Go To 4

      No

      - Replace the Hood Latch Assembly in accordance with the Service Information.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
4. **CHECK THE HOOD AJAR SWITCH 1 (G70) SENSE CIRCUIT FOR AN OPEN**
   1. Disconnect the appropriate BCM harness connector.
   2. Measure the resistance of the Hood Ajar Switch 1 (G70) Sense circuit between the Hood Ajar Switch harness connector and the BCM A harness connector.

      Is the resistance below 3.0 Ohms?

      Yes

      - Go To 5

      No

      - Repair the Hood Ajar Switch 1 (G70) Sense circuit for an open or high resistance.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **CHECK THE (G931) SENSOR GROUND CIRCUIT FOR AN OPEN**
   1. Measure the resistance of the (G931) Sensor Ground circuit between the Hood Ajar Switch harness connector and the BCM harness connector.

      Is the resistance below 3.0 Ohms?

      Yes

      - Go To 6

      No

      - Repair the (G931) Sensor Ground circuit for an open or high resistance.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
6. **CHECK RELATED BCM AND COMPONENT CONNECTIONS**
   1. Disconnect all BCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.
   5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. With the scan tool, erase DTCs.
   9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   10. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Replace and program the Body Control Module (BCM) in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM INSTALLATION** .
       - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

       No

- The wiring or poor connection problem has been repaired.
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

P258A-ELECTRIC VACUUM PUMP CIRCUIT

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

GENERAL OPERATION: The Electric Vacuum Pump (EVP) system is designed to provide supplemental vacuum during low engine vacuum conditions. The EVP is vacuum in the Brake Vacuum Booster reaches a minimum calibrated threshold. The EVP is especially important on vehicle applications where the engine is not running for hybrid or Stop/Start equipped vehicles. This system maintains a consistent brake pedal feel under all driving conditions. The Vacuum Pump is connected to the engir through a series of hoses and one-way flow check valves. A Vacuum Pressure Sensor mounted in the Brake Vacuum Booster is hard-wired to the Anti-Lock Brake (ABS Program (ESP) Module. The Vacuum Pressure Sensor signal information is then sent to the Powertrain Control Module (PCM) over the CAN Bus. The PCM energizes t through a **Low Side Driver (LSD)** to provide Battery voltage to the vacuum pump and control operation.

COMPONENT FUNCTIONAL DESCRIPTION AND DIAGNOSTIC OVERVIEW - EVP RELAY

Functional Operation of the EVP Relay: Depending on the type of relay being used for the EVP, the approximate resistance of the relay coil should be:

- 72-98 Ohms for a mini relay (larger square relay).
- 94-114 Ohms for a micro relay (smaller rectangular relay).
- 160-225 Ohms for a Printed Circuit Board (PCB) relay.

NOTE: **The coil resistance of a relay or solenoid can vary based on factors like temperature or age of the component. Typically a 10% v a new component at room temperature. Therefore, do not always assume that a component that is measuring slightly outside o is faulty. A faulty component usually will be noticeably out of tolerance.**

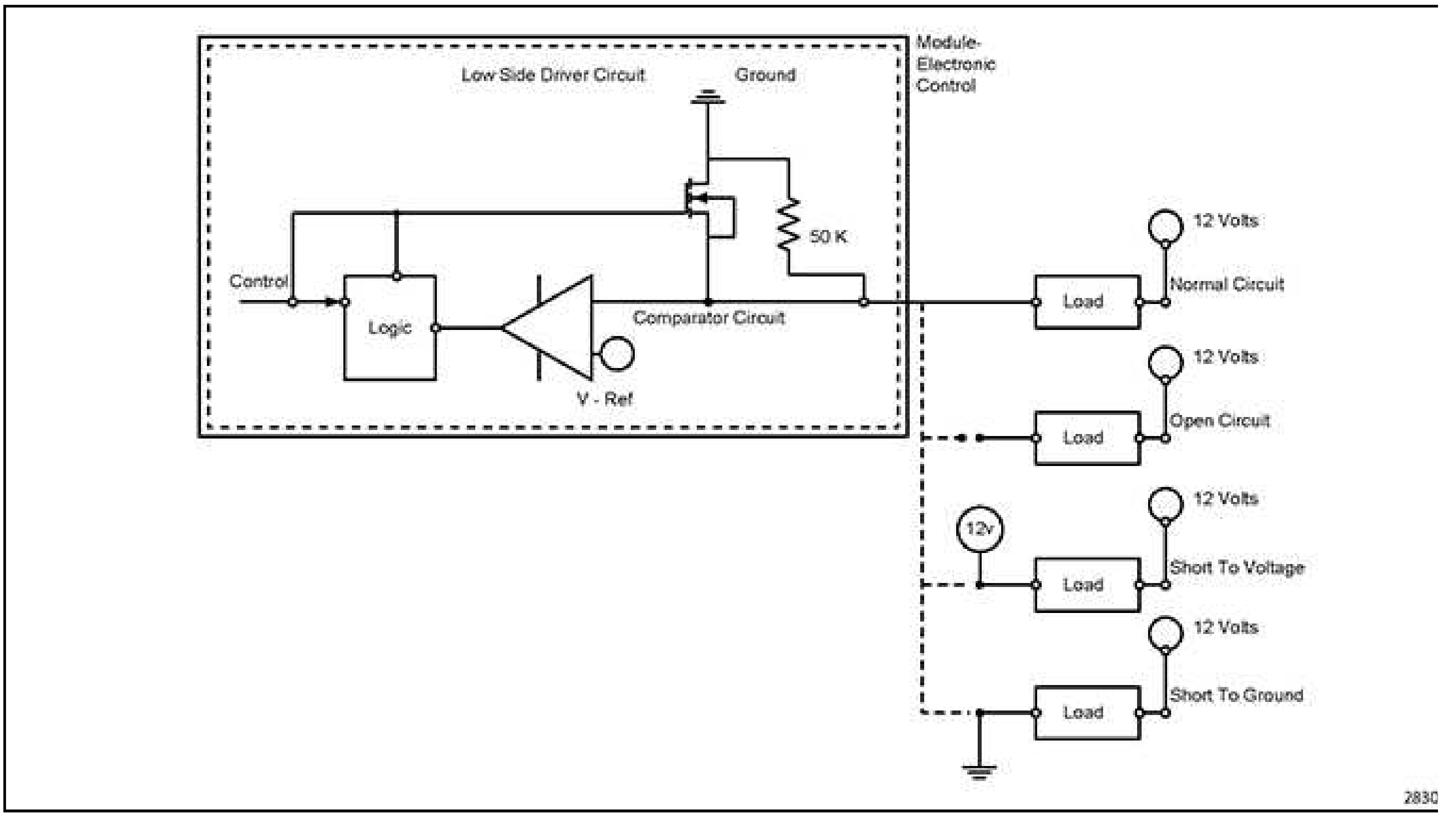
Diagnostic Overview: With the ignition on and the **relay commanded off** , battery voltage should be present at the EVP Relay Control circuit at the PDC output.

- No voltage present would indicate either an open in battery supply somewhere from the source, through the relay coil to the output of the Power Distribution Cent control circuit is grounded and the relay is energized. To determine if the relay is stuck on measure the voltage on the Output circuit with the relay commanded of the output circuit, but not present at the control circuit, it would indicate the control circuit is being grounded. If no voltage is present at the output circuit it would supply circuit path.
- Voltage present would indicate that supply voltage is present. Back probing and jumping the control circuit to ground should cause the relay to close if the coil res specification and the proper battery voltage is being supplied. If the relay doesn't close it would indicate low voltage supply or high coil resistance in the relay. If t indicate an open in the control path.

Typical Low Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver dev ground to operate the device when switched on. The ground could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device, driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. For diagnostic purposes the PCM uses an internal pull d connected in series and a voltage reference (V-Ref) comparator for fault detection:

- **Circuit Open and Circuit Low Detection:** The PCM monitors for an **open circuit** and **short to ground** when the driver is switched off. When switched off, the through the device and the **internal pull down resistor** connected in series. The voltage at the **comparator circuit** should be close to Battery voltage since the m occurs through the diagnostic resistor. If the available voltage is less than the V-Ref, a fault is set. In this scenario the V-Ref would be slightly below Battery volta **method of fault detection for an open or short to ground** that is used is to monitor current draw when the internal driver is switched on. If the module does not determines that the component or circuitry is open. Excessive current draw detected would indicate a short to ground.
- **Circuit High Detection:** The PCM monitors for a **short to voltage** when the driver is switched on. When the driver is switched on providing a path to ground thr available voltage should be pulled low, near zero volts since the **comparator circuit** is monitoring the ground side of the device. If the voltage is greater than V-R this scenario V-Ref would be slightly above zero volts.

NOTE: **A load that has a resistance that is below manufacturer specification, or a second load device shorted to the low side driver circ excessive current draw on the internal driver. The driver will be switched off to protect against overheating and damaging the dı the Circuit High fault may be detected because the available voltage on the comparator circuit is above V-Ref.**



DIAGNOSTIC OVERVIEW - ELECTRIC VACUUM PUMP (EVP) SYSTEM

The PCM performs circuit fault detection on the Electric Vacuum Pump (EVP) Control circuitry and sets the P258A-ELECTRIC VACUUM PUMP CIRCUIT fault if ar condition is detected. The PCM cannot directly monitor the Electric Vacuum Pump Battery Supply or ground circuits. Instead, the PCM performs a system performance EVP Relay is energized **the PCM monitors the Vacuum Pressure Sensor Signal input to make a determination if the Vacuum Pump is functional.** If the PCM doe vacuum for a calibrated period after the relay is energized, the diagnostic fails and the PCM sets the P258B-ELECTRIC VACUUM PUMP PERFORMANCE fault. The will detect any issue that can affect vacuum in the system. There are several electrical and mechanical failures that could cause the diagnostic to fail.

- An electrical or mechanical failure with the vacuum pump or an issue with the vacuum pump circuits.
- A leaking Vacuum Brake Booster assembly.
- Leaking or damaged vacuum tubes or check valve.
- It's also possible for the system to be functioning properly but fail due to a Vacuum Pressure Sensor that is stuck in range and not changing.

NOTE: **It is possible in some cases for pressure sensors to stick mid range if the 5-Volt Supply is missing to the pressure sensor. the type of pressure sensor being used.**

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage above 10.4 volts.

SET CONDITION

- The Powertrain Control Module (PCM) detects an open or short circuit fault on the Vacuum Pump Relay Control circuit.

DEFAULT ACTION

- This is a non MIL fault.

POSSIBLE CAUSES

Possible Causes
FUSED RUN/START CIRCUIT OPEN
VACUUM PUMP RELAY CONTROL CIRCUIT OPEN/HIGH RESISTANCE
VACUUM PUMP RELAY CONTROL CIRCUIT SHORTED TO GROUND
VACUUM PUMP RELAY
POWER DISTRIBUTION CENTER (PDC)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
   1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

      Are there any applicable Service Bulletins or Flash updates?

      Yes

- Perform the applicable repair.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 2

2. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 3

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK FOR OTHER DTCS**

    NOTE: **The Battery supply for the Vacuum Pump Relay coil is supplied by the Run/Start Relay output.**

    1. Refer to the recorded DTCs.

        Are there any Run/Start Relay Control circuit DTCs present in any other modules?

        Yes

        - Perform the applicable diagnostic procedure(s).

        No

        - Go To 4
4. **CHECK THE VACUUM PUMP RELAY CONFIGURATION**
    1. Check the Power Distribution Center layout in the wiring information to determine if the Vacuum Pump Relay is removable or a Printed Circuit Board (PCI

        What type of relay is the vehicle configured with?

        Removable Relay

        - Go To 5

        PCB Relay

        - Go To 6
5. **CHECK THE RUN/START OUTPUT TO THE VACUUM PUMP RELAY CONTROL COIL**
    1. Turn the ignition off.
    2. Remove the Vacuum Pump Relay from the relay connector in the PDC.
    3. Turn the ignition on.
    4. Using a 12-volt test light connected to ground, probe the Battery supply voltage from the Run/Start Relay Output at terminal 85 at the Vacuum Pump Relay

        Is the test light illuminated and bright?

        Yes

        - Go To 7

        No

        - Check all of the fuses in the PDC. If a fuse is open, replace the fuse and retest. If no problems are found with the fuses, check the Battery supply to th of the Run/Start Relay. If no problems are found replace the PDC in accordance with the Service Information.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
6. **CHECK FOR THE RUN/START OUTPUT VOLTAGE TO THE VACUUM PUMP RELAY CONTROL COIL**
    1. Using a DVOM, back probe and measure the voltage on the Vacuum Pump Relay (T110) Control circuit at the PDC connector.

        NOTE: **The relay must be commanded off when checking for voltage on the circuit. With the relay Low Side Driver control ci the voltage should be approximately equal to Battery voltage on the (T110) Vacuum Pump Relay Control circuit.**

        Is the voltage approximately equal to Battery voltage?

        Yes

        - Go To 7

        No

- Check all of the fuses in the PDC. If a fuse is open, replace the fuse and retest. If no problems are found with the fuses, check the Battery supply to th of the Run/Start Relay. If no problems are found replace the PDC in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK THE VACUUM PUMP RELAY FOR PROPER OPERATION**
   1. If the relay is removable, reinstall the Vacuum Pump Relay in the PDC.
   2. Turn the ignition on.
   3. Using a 12-volt test light connected to ground, back probe the Vacuum Pump Relay (T110) Control circuit at the PDC connector.

   NOTE: **The relay should make an audible click when closing. Another way to verify that the relay closed is to back probe anc on the relay output circuit.**

   Did the relay close when connecting the Vacuum Pump Relay (T110) Control circuit to ground through the test light?

   Yes

   - Go To 8

   No

   - If this is a PCB relay, replace the Power Distribution Center (PDC) in accordance with the Service Information.
   - If this is a removable relay and the PDC has an internal PCB and harness connectors, isolate and check the continuity between terminal 86 of the rela output terminal at the PDC connector. If the resistance is below 3.0 Ohms, replace the Vacuum Pump Relay. If the resistance is above 3.0 Ohms, repla Distribution Center (PDC) in accordance with the service information. Refer to **CENTER, POWER DISTRIBUTION (PDC), REMOVAL AND I**
   - If this is a removable relay and the wiring harness is directly hard wired into the PDC, replace the Vacuum Pump Relay.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **ISOLATE AND CHECK THE VACUUM PUMP RELAY (T110) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Us diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and grc

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM har

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help i short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 9

9. **ISOLATE AND CHECK THE VACUUM PUMP RELAY (T110) CONTROL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
   1. The ignition must be off when checking the continuity of a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use t diagram as a guide to follow the path of the circuit.
   3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance t
   4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
   5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM har

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   Is the resistance below 3.0 Ohms?

   Yes

   - Go To 10

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.

5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CO REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P258B-ELECTRONIC VACUUM PUMP PERFORMANCE

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

KNOWN ISSUES - VACUUM PUMP SYSTEM

There are some concerns of unsecured connections:

- Vacuum hose to engine manifold connection.
- Vacuum hose to vacuum pump connection.
- Vacuum pump electrical connection resulting from housing damage, not fully seated, bent or damaged pins.
- Vacuum sensor electrical connection resulting from housing damage, not fully seated, bent or damaged pins.

DESCRIPTION AND OPERATION-VACUUM BOOSTER SYSTEMS

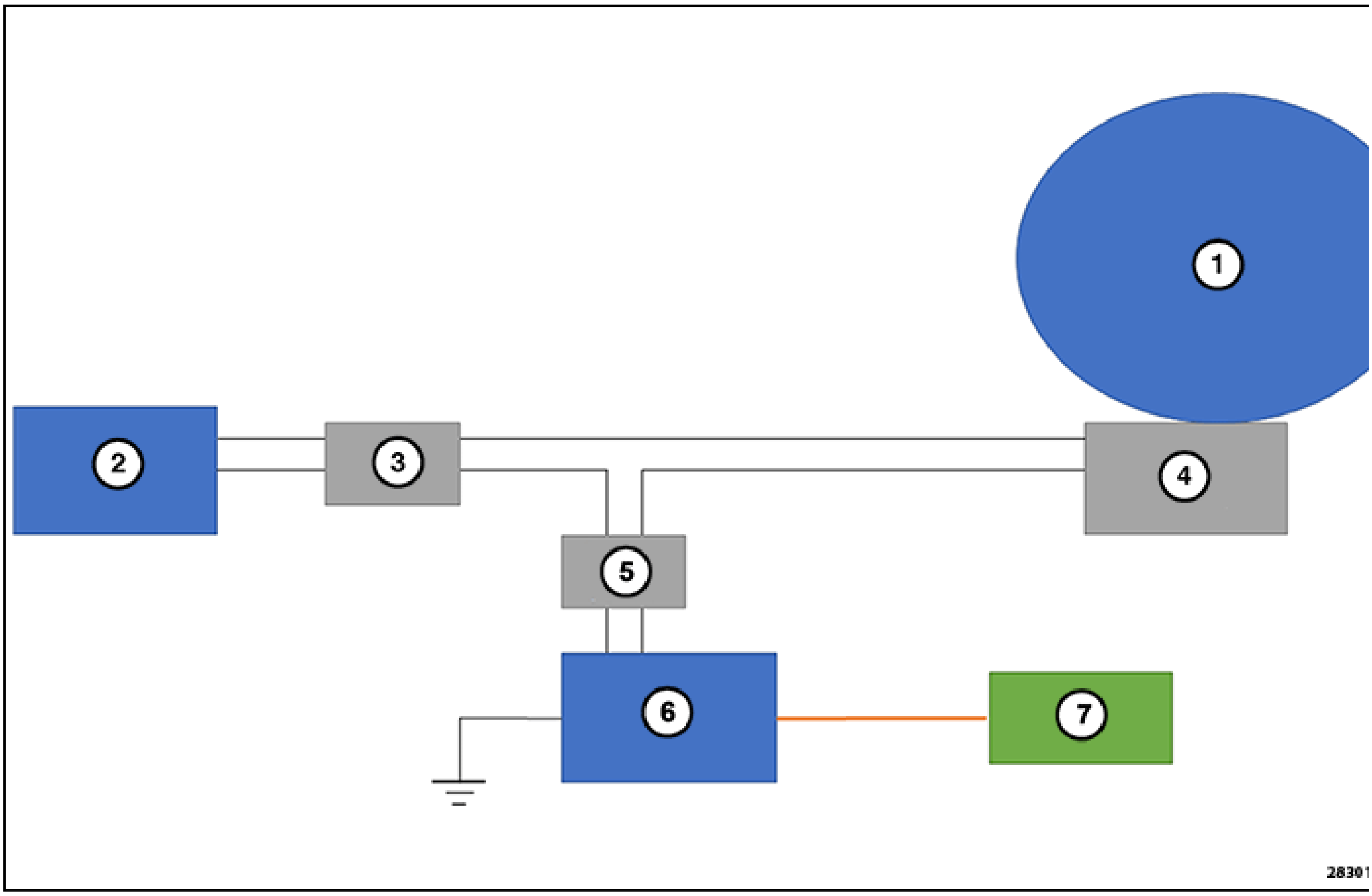
DESCRIPTION

The system consists of the following components:

COMPONENT INDEX

CALLOUT	DESCRIPTION
1.	Brake Booster
2.	Engine Connection
3.	Check Valve
4.	Check Valve/Vacuum Pressure Sensor
5.	Check Valve
6.	Vacuum Pump
7.	Relay

The vacuum boost system consists of a vacuum brake booster and supplemental Electric Vacuum Pump (EVP). The vacuum hose assembly connects in parallel from the EVP and the intake manifold. There is a check valve located in each path of the vacuum hose assembly. The vacuum pressure sensor is located on the brake booster and Lock Brake (ABS)/Electronic Stability Program (ESP) Module. The vacuum hose assembly typically connects to the sensor for most vehicles. The sensor also has an in



GENERAL VACUUM BOOSTER SYSTEM OPERATION:

The Electric Vacuum Pump (EVP) system is designed to provide supplemental vacuum during low engine vacuum conditions. The engine is able to produce approximat EVP is able to produce more vacuum than the engine. This allows the system vacuum to reach the programming turn off of 83% of BARO that is required. When the E\ check valve in the EVP side of the hose assembly is closed by the engine vacuum. When the EVP is operating the check valve in the intake manifold path is closed due t more vacuum than the engine. On a normally operating system, the pump will operate in the following manner:

- **With the engine running and vehicle speed below 7 mph** the EVP is commanded on when the vacuum pressure sensor signal is at or below 55% of BARO. The vacuum pressure sensor signal reaches 65% of BARO.
- **With the engine running and vehicle speed above 8 mph** , the EVP is commanded on at or below 69% of BARO and turns off at 83% of BARO.
- **When the engine is off** , Vacuum pump should not run if the ignition is in acc/run with 0 rpms. The only exception to this is the DT program, which allows the pu ONLY when in an ESS auto stop condition.

The EVP helps maintain the system vacuum between a normal range of 610-850 mbar (61-85 kPa) with the engine running. Anything under approximately 600 mbar (6 pedal condition.

The EVP is especially important on vehicle applications where the engine is not running the entire time, such as for hybrid or Stop/Start equipped vehicles. This system brake pedal feel under all driving conditions. The vacuum pressure sensor signal information is then sent to the Powertrain Control Module (PCM) over the CAN Bus. T vacuum pump relay through a Low Side Driver (LSD) to provide battery voltage to the vacuum pump and control pump operation.

COMPONENT FUNCTIONAL DESCRIPTION - VACUUM PUMP

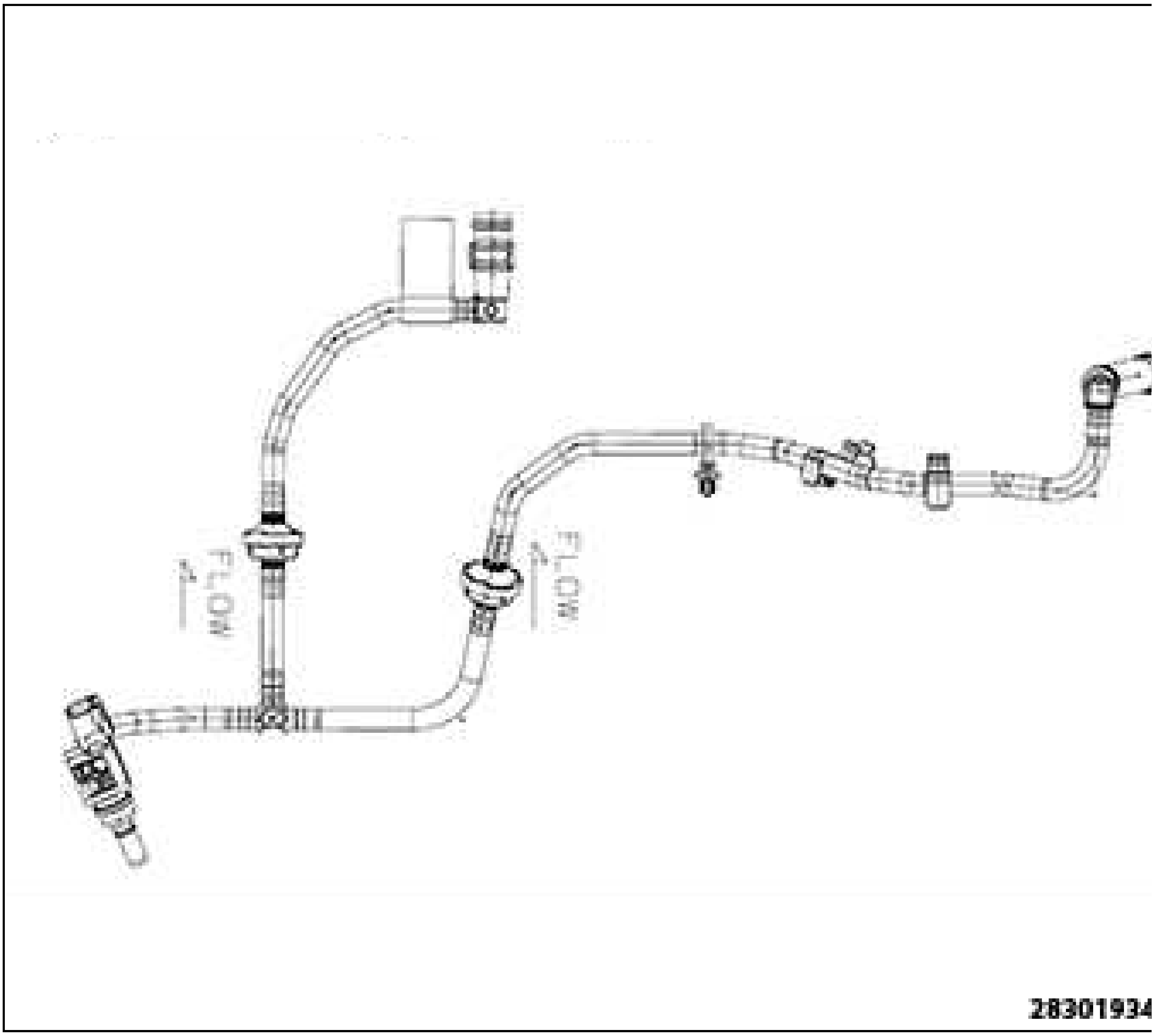
The Electric Vacuum Pump (EVP) is supplied battery voltage from the EVP relay. The pump is grounded using a chassis ground. The EVP relay can be either a removal Circuit Board (PCB) relay inside the Power Distribution Center (PDC).

The engine is able to produce approximately 72% of BARO. The EVP is able to produce more vacuum than the engine. This allows the system vacuum to reach the 83% required.

- Internal resistance is approximately 1.0 ohm
- Vacuum pump amperage draw is around 50-70 on the inrush (Start) and should drop to a nominal 14-15 amps during normal operation.

VACUUM HOSE ASSEMBLY

DESCRIPTION



The vacuum hose assembly consists of:

- vacuum hoses
- check valves
- vacuum pressure sensor/check valve

OPERATION

The vacuum hose assembly connects the Electric Vacuum Pump (EVP) and engine/intake manifold to the brake booster. Each path incorporates a check valve. When the valve in the EVP hose path is closed and engine vacuum is supplied to the brake booster. When the EVP is commanded on, the vacuum create is greater than engine vac in the engine hose path is closed. The booster check valve/pressure sensor is closed when vacuum in the brake booster is greater than the vacuum in the vacuum hose as

ENABLING/SET CONDITIONS AND POSSIBLE CAUSES - VACUUM PUMP

Faults	Monitoring Conditions	Set Conditions	Possible Causes
P258B	1. With the engine running. 2. Minimum MAP reading is 15 kPa (4.4 in hg). 3. Electric Vacuum Pump (EVP) is commanded on.	1. The EVP is operating and the system is not able to increase vacuum at the rate of 1% per second between the thresholds of 69% and 73% of BARO. The system must accumulate 5 fail attempts to set a fault. These fail attempts can be decremented over time by meeting normal operational requirements. 2. The EVP is operating and the system is not able to increase vacuum at the rate of 1% per second when vacuum is under the 69% BARO threshold. A single failed attempt under 69% BARO will result in the P258B DTC.	1. Vacuum hose assembly leaking valve. 2. Brake booster internal leakage. 3. Faulty vacuum pressure sensor. 4. Loss of battery voltage or groun 5. Weak or faulty electric vacuum

Default Actions:

- The MIL will illuminate.

- The stop/start feature is disabled.
- The ESC light will illuminate.

DIAGNOSTIC OVERVIEW - ELECTRIC VACUUM PUMP (EVP) SYSTEM

The PCM performs circuit fault detection on the Electric Vacuum Pump (EVP) relay control circuitry and sets the P258A-ELECTRIC VACUUM PUMP CIRCUIT fault condition is detected. The PCM cannot directly monitor the EVP battery supply or ground circuits. Instead, the PCM performs a system performance diagnostic. When t energized **the PCM compares BARO to the Vacuum Pressure Sensor Signal to make a determination if the Vacuum Pump and system are functional.** The PCM change in vacuum per 1.0 second of vacuum pump run time until a max of 83% of BARO is reached. If the diagnostic accumulates five failed attempts, the PCM sets th VACUUM PUMP PERFORMANCE fault. The performance diagnostic will detect any issue that can affect vacuum in the system. There are several electrical and mech cause the diagnostic to fail:

- Leaking or damaged vacuum tubes or check valves.
- A leaking vacuum brake booster assembly.
- An electrical or mechanical failure with the vacuum pump.
- It's also possible for the system to be functioning properly but fail due to a vacuum pressure sensor that is stuck in range and not changing.

> **NOTE:** **It is possible in some cases for pressure sensors to stick mid range if the 5-Volt Supply is missing to the pressure sensor. the type of pressure sensor being used.**

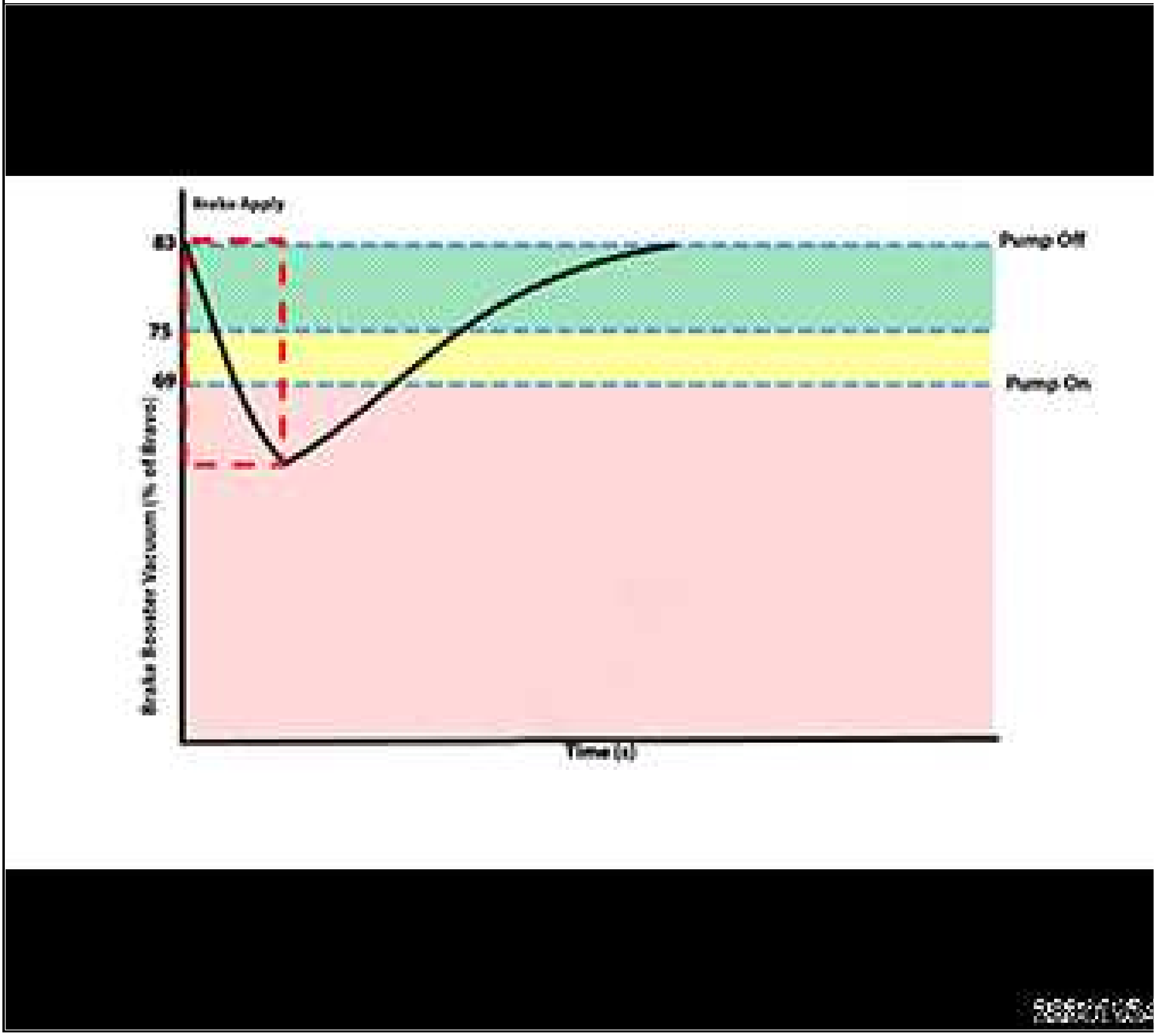
A leak in the vacuum hose assembly or brake booster can cause the EVP to fail prematurely. **If the diagnostics lead to a failed or weak vacuum pump, the entire syst checked for leaks after the EVP is replaced and before releasing the vehicle.** Perform the VACUUM SYSTEM LEAK TEST below after the EVP replacement to ve operating properly.

The table below shows the different stages of the vacuum pump performance diagnostic:

DIAGNOSTIC TABLE
DESCRIPTION
This chart is showing a normally operating system
This chart is showing a system that stops increasing but doesn't reach the maximum threshold. The vacuum pump will turn off to prevent excessive run time which can damage the pump. This system is considered passing because vacuum accumulation is more than75% of BARO (will not set a fault).
This chart is showing a system that stops increasing but doesn't reach the minimum threshold. The vacuum pump will turn off to prevent excessive run time which can damage the pump. This system is considered failing because vacuum accumulation is less than75% of BARO. If the diagnostic accumulates five failed attempts, the PC sets the P258B-ELECTRIC VACUUM PUMP PERFORMANCE fault.
This chart is showing a system that has a gross failure. The vacuum failed to increase by 1% for 5.0 seconds. When this failure occurs once, the PCM sets the P258B-ELECTRIC VACUUM PUMP PERFORMANCE fault.

DIAGNOSTIC TABLE

DESCRIPTION



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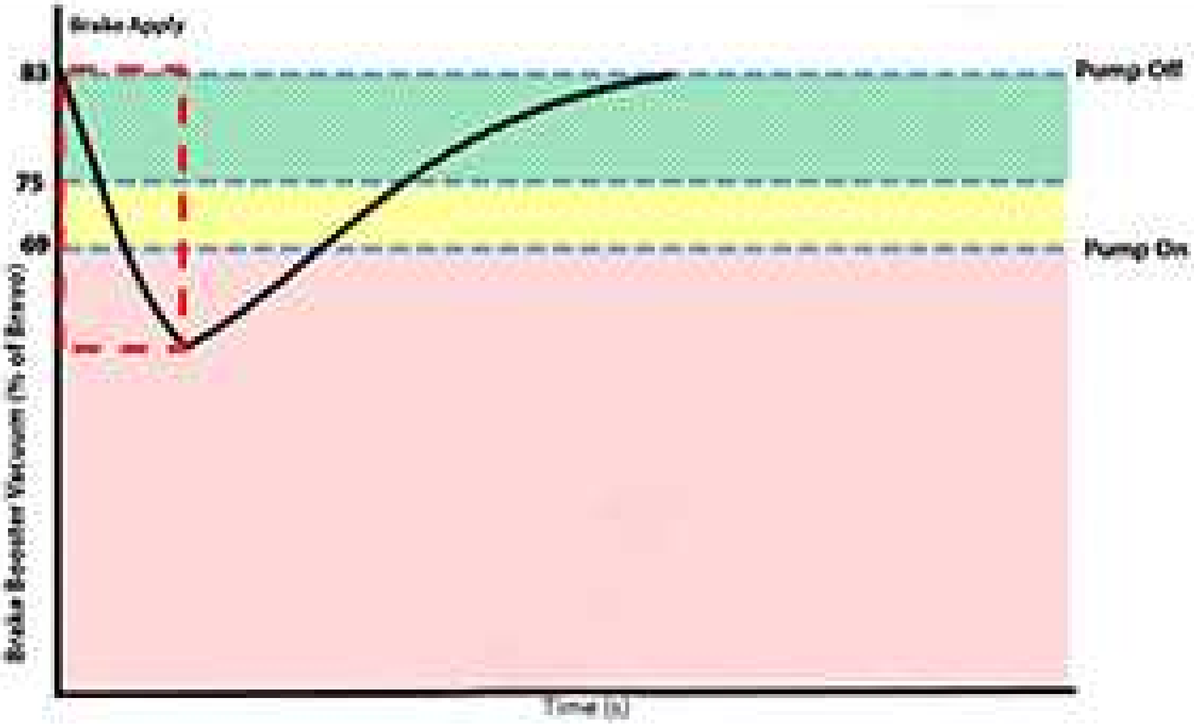

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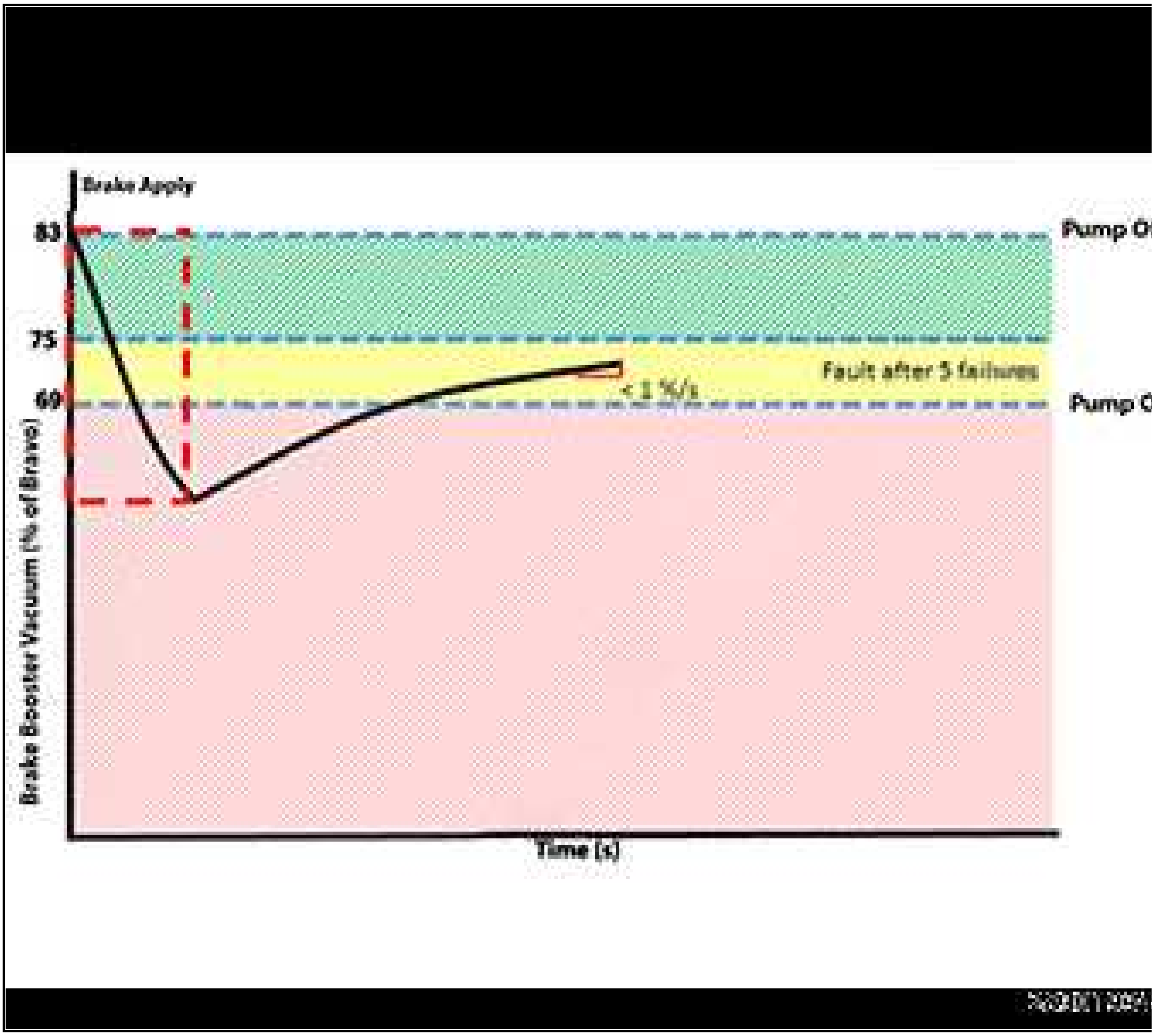
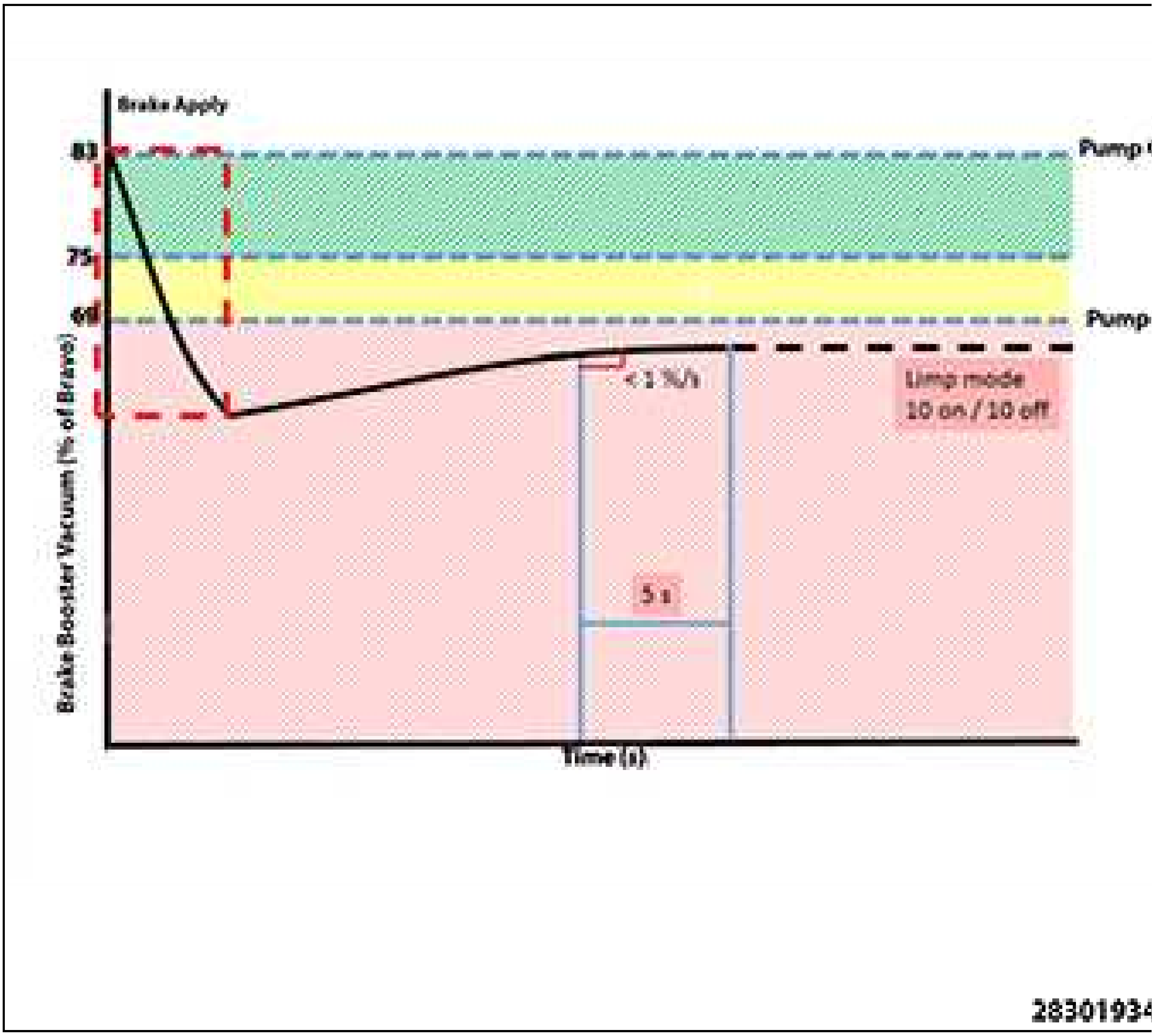


Brake Apply
83
75
69
Pump O
Fault after 5 failures
< 1 %/s
Pump O
Brake Booster Vacuum (% of Brake)
Time (s)



CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the F
Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition.
condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored due to an intermittent connection at the PDC, fuse, Electric Vacuum Pump (EVP) relay terminals or ground connections.
2. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Moni and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some te rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficul cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the syste
3. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode diagnose an intermittent condition.
4. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes throug watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Rev looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or od Battery or Batteries for proper charge and operation along with proper connections. Use the wiring information to identify and check any chassis ground connecti or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pusl burnt, or broken terminals at each connector.
5. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTICS - VACUUM SYSTEM LEAK TEST

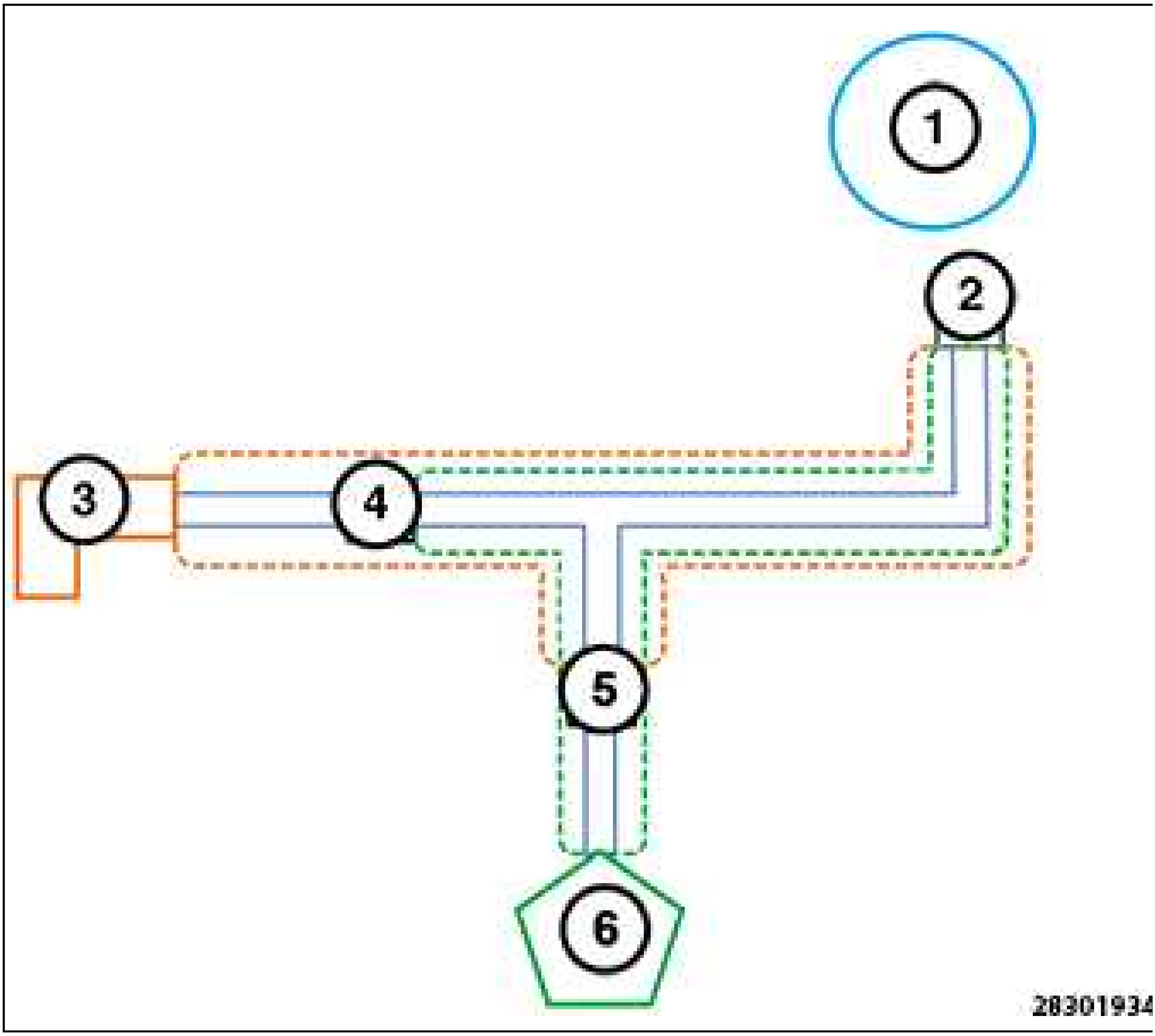
If any leaks are detected, replace the vacuum hose assembly.

Both of the procedures below should be performed in combination as part of any diagnostic for a brake vacuum system performance fault. The procedures should also b
repairs are made to verify the system is not leaking. A leaky system can cause premature electric vacuum pump failure due to over operating the pump.

CHECK THE VACUUM HOSE ASSEMBLY FOR A LEAK:

Steps 1 and 2 require the vacuum hose assembly to be disconnected from the booster, engine, and Electric Vacuum Pump (EVP). If the sensor is not part of the vacuum the sensor from the booster and leave connected to the vacuum hose assembly. Once fully disconnected, the sensor must be plugged as to not allow leakage through the Plug method should be clean to prevent contamination into the sensor check valve.

1. Connect a hand vacuum pump to the EVP connection (6) and pull a vacuum of 8.0 kPa (23.5 In.Hg). Once vacuum is pulled to the correct level, measure vacuum This will check for leakage in the engine check valve and all the vacuum hose assembly inside the green dashed line (4). The vacuum hose assembly should not le (1.3 In.Hg) in one minute.
2. Next connect to the engine connection (3) and pull a vacuum of 8.0 kPa (23.5 In.Hg). Once vacuum is pulled to the correct level, measure vacuum loss over one n for leakage in the EVP connection check valve and all the vacuum hose inside the orange dashed line (5). The vacuum hose assembly should not leak more than 4 minute.
3. Last, remove the plug from the sensor and pull a vacuum directly on the sensor (2) where it would be installed into the booster. Pull a vacuum of 8.0 kPa (23.5 In. pulled to the correct level, measure vacuum loss over one minute. This will check leakage in the sensor check valve (2). The sensor check valve should not leak m In.Hg) in one minute.
    - If any of the above checks fail, the vacuum hose assembly should be replaced as an assembly. The check valves cannot be replaced separately.
    - If the above vacuum checks pass, continue to CHECKING THE BRAKE BOOSTER SIDE FOR A LEAK.



COMPONENT INDEX

1.	Brake Booster
2.	Check Valve/Vacuum Pressure Sensor
3.	Engine Connection
4.	Check Valve - Engine Path
5.	Check Valve - EVP Path
6.	Electric Vacuum Pump

CHECKING THE BRAKE BOOSTER SIDE FOR A LEAK: This procedure checks the brake booster for leakage. Securely install the vacuum hose assembly on the

1. Turn the ignition on and monitor the brake pressure sensor data with the scan tool. **NOTE: The value is multiplied by (-1) so that the reading shows as a positi displayed in the scan tool may need to be converted to metric.**
2. Start and run the engine for at least 30 seconds while monitoring the brake pressure sensor data on the scan tool. Allow the value to stabilize, then immediately cy back to ignition on engine not running. Monitor and record the pressure loss for the initial 15 seconds (the pressure should not drop more than 2.0 kPa (0.60 In.Hg

Monitor and record the pressure loss after an additional 45 seconds (the pressure should not drop more than 2.5 kPa (0.75 In.Hg) over the next 45 seconds).

1. If the pressure drop was less than the thresholds listed above the brake booster and vacuum pressure sensor check valve are operating normally. If the P258 the **VACUUM PUMP** diagnostic.
2. If the pressure drop was more than the thresholds listed above there is a leak at the brake booster. Replace the brake booster and retest.

DIAGNOSTICS - VACUUM PUMP TEST

The following items must be performed before performing this diagnostic procedure:

- If the P258A-EVP Relay Control Circuit DTC or a vacuum pressure sensor circuit DTC is present, diagnose those DTCs before continuing.
- Perform the **VACUUM SYSTEM LEAK TEST** diagnostic before this diagnostic procedure to determine if the system is leaking, and if so which part of the syst performing the diagnostics below.

CHECKING THE OPERATION ON THE VACUUM PUMP: This diagnostic is being performed assuming that the VACUUM SYSTEM LEAK TEST was pe both leak checks or that a repair was done and verified fixed.

NOTE: The value is multiplied by (-1) so that the reading shows as a positive value. The value displayed in the scan tool may need to b metric.

1. Pump the brake pedal to lower the vacuum in the brake booster until pedal is hard. Start the engine and verify the Electric Vacuum Pump (EVP) is running. The v commanded on by the PCM approximately 2 seconds after engine start. **If engine vacuum produces enough vacuum in the booster, the pump may not run.** If monitor the brake pressure sensor reading while the EVP is running. The pressure should steadily increase until the system reaches the maximum threshold or stal off. Max threshold should be 65% BARO in park, or 83% BARO while driving at 8 mph or above.

   NOTE: If the EVP does not run after engine start, while in park, pump the brake pedal 8-10 times rapidly with the engine running. T vacuum and activate the vacuum pump. Do not monitor the scan tool at this time.

   1. If the EVP is showing on in the PCM, but can not physically be seen running or the system cannot build vacuum pressure either the electric vacuum pump i supply or ground circuit issue. **Continue to step 2.**
   2. If the EVP does run but cannot increase the vacuum supply either a gross leak is present, the vacuum pressure sensor is faulty, or the vacuum pump is faulty
      - If the VACUUM SYSTEM LEAK TEST was performed prior to this test and passed, remove the vacuum hose assembly at the brake booster and use apply vacuum directly to the sensor to verify sensor value changes in the scan tool. If the sensor values do not change while using a hand vacuum pu the sensor, replace the vacuum hose assembly with the vacuum pressure sensor. If the system still can not increase vacuum, replace the vacuum pump
      - If the VACUUM SYSTEM LEAK TEST **was not** performed prior to this test, perform that procedure to check for a leak in the system before replaci pump.
   3. If the EVP runs, increases the vacuum supply into a pass threshold and turns off the system is operating properly.
      - If there was a repair made during the VACUUM SYSTEM LEAK TEST the system is fixed.
      - If the system passed both leak checks in the VACUUM SYSTEM LEAK TEST then the issue is intermittent. Verify a good connection at the EVP, PI removable) and ground location. If the DTC is still active, the PCM is faulty.
2. Disconnect the EVP harness connector. Load test the battery supply circuit and ground circuit at the EVP harness connector. Connect one lead of the load test tool and the other lead of the load test tool to the ground circuit. With the ignition on, the load test bulb should be bright if both circuits are good. To verify that there i circuits being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage terminals if there is no resistance in either circuit. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .
   1. If the circuits fail the load test, remove the lead connected to the ground circuit and connect it to a good chassis ground. Check the voltage drop across the 3 tool again. If the voltage drop is still less than battery voltage, repair the battery supply circuit for an open or high resistance. If the voltage drop is now equ repair the ground circuit for an open or high resistance.
   2. If the battery supply and ground circuits check good, replace the electric vacuum pump in accordance with the service information.

P2610-PCM INTERNAL ENGINE OFF TIMER PERFORMANCE

THEORY OF OPERATION

The purpose of the shut down timer diagnostic is to determine if the Powertrain Control Module (PCM) internal clock is running as expected. This engine off timer is us for various OBD monitors. The rationality test consists of two tests used to evaluate shut down time.

During an initial engine start, if it is determined that the engine start is a cold start (determined by comparing the engine coolant temperature versus ambient temperatur

Slow Test

will be run and a long shut down time would be expected. If it is determined that the engine start is not a cold start, the

Fast Test

will be run and a short shut down time is expected because the engine has not been cooled down to cold start conditions.

- The P1607 DTC will set if the Slow Test diagnostic runs and fails.
- The P2610 DTC will set if the Fast Test diagnostic runs and fails.

WHEN MONITORED

This diagnostic runs once per ignition cycle when the following conditions are met:

- Shortly after an initial engine start.
- The difference between the coolant temperature and ambient air temperature is greater than 15B°C (59B°F) at initial engine start.
- The engine coolant temperature recorded at the last engine shut down was above 83B°C (181.4B°F).
  - If the previous engine shut down temperature was not above this value, the shut down diagnostic will not be performed during this ignition cycle.
- There was a minimum of 10B°C (50B°F) temperature drop during the last ignition off.
- If the above monitoring conditions are met, the PCM uses the engine coolant temperature drop to calculate a maximum engine off time threshold. It then compare time to the calibrated maximum threshold.

SET CONDITION

- The PCM determines that the actual previous key off time is above the calculated threshold this fault is set.

DEFAULT ACTION

- MIL is illuminated

POSSIBLE CAUSES

Possible Causes
COOLING SYSTEM ISSUES
AMBIENT AIR TEMPERATURE (AAT) SENSOR
ENGINE COOLANT TEMPERATURE (ECT) SENSOR
POWERTRAIN CONTROL MODULE (PCM) SOFTWARE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **CHECK THE POWERTRAIN CONTROL MODULE (PCM) SOFTWARE LEVEL**

   NOTE: An aftermarket block heater installed may cause this DTC to set.

   1. Turn the ignition on.
   2. With the scan tool, Verify that the PCM is operating at the latest software version available.
   3. Perform any Service Bulletins or PCM flash updates that may apply.

      Were any Service Bulletins or PCM flash updates available for this condition?

      Yes

      - Perform the appropriate repair.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 2
2. **CHECK THE AAT SENSOR FOR PROPER OPERATION**
   1. Turn the ignition off.
   2. Allow the vehicle to sit with the ignition off in an environment where the temperature is consistent and above -7B°C (19.4B°F) until the engine coolant tem to the environmental ambient temperature.
   3. Turn the ignition on.
   4. With a scan tool, compare the AAT Sensor value to the current ambient temperature.

      Is the AAT Sensor value within 10B°C (18B°F) of the current ambient temperature?

      Yes

      - Go To 3

      No

      - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
3. **CHECK THE COOLANT LEVEL AND CONDITION**

   WARNING: Never open the cooling system when the engine is hot. The system is under pressure. Failure to follow these instructions personal injury including extreme burns, scalding, or fatal injury. Allow the engine to cool before opening the cooling syst

   1. Check that the coolant is in good condition and at the proper level. Refer to **COOLING SYSTEM** .

      Is the coolant level and condition OK?

      Yes

      - Go To 4

      No

      - Inspect the vehicle for a coolant leak and add the necessary amount of coolant. Refer to **COOLING SYSTEM LEAKS** .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
4. **CHECK THE COOLING SYSTEM FOR PROPER OPERATION**

   NOTE: If engine coolant temperature is above 65B°C (149B°F), allow the engine to cool until it is below 65B°C (149B°F).

   1. Start the engine.
   2. During engine warm-up monitor the Engine Coolant Temperature degree value. The temperature value change should be a smooth transition from start up t 82B°C (180B°F). Also monitor the actual coolant temperature with a digital thermometer at or near the ECT Sensor and Thermostat positions.

      NOTE: As the engine warms up to operating temperature, the actual coolant temperature (thermometer reading) and the sca Coolant Temperature degree values should stay relatively close to each other.

      Was the digital thermometer readings relatively close to the scan tool reading for the ECT Sensor?

      Yes

      - Go To 5

No

- Replace the Engine Coolant Temperature Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INS**
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CO REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P26E4-STARTER CONTROL 2 CIRCUIT

For a complete STARTING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage above 10.4 volts.

SET CONDITION

- The Powertrain Control Module (PCM) receives a CAN C message from the Body Control Module (BCM) that there is a fault present for the Stop/Start Relay.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
STOP/START RELAY WIRING OPEN OR SHORTED
STOP/START RELAY
BODY CONTROL MODULE (BCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

CHECK FOR AN ACTIVE DTC

1. Attempt to crank the engine, leaving the ignition on.
2. With the scan tool, read DTCs and record on the repair order.

    Is the DTC active or pending?

    Yes

    - Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** and perform the appropriate Starter Relay (Stop/Start Relay) diagnostic

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to INTERMITTENT CONDITION .

P2AF5-STARTER RELAY 3 STUCK ON

For a complete STARTING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

NOTE: **The terminology of the relays in this procedure can be confusing. To add clarity the Power Control Relay is the relay that makes connection between the two Batteries. The PCR Control Relay is in the PDC and is controlled by the Powertrain Control Module Side Driver (LSD). The relay can be removable or a Printed Circuit Board (PCB) relay depending on vehicle configuration. The P provides the power supply to operate the Power Control Relay.**

The Engine Stop/Start (ESS) system uses a **Power Control Relay (PCR)** and two Batteries to eliminate the voltage drop in the system voltage during an Auto-start ev consumer electronics and vehicle modules subsystems to continue to function in a normal manner. The Power Control Relay is connected in-line between the Main (Cra Auxiliary (Vehicle) Battery. The Power Control Relay is normally closed when de-energized, connecting the two Batteries. When the Power Control Relay is energized, breaks the connection between the Batteries.

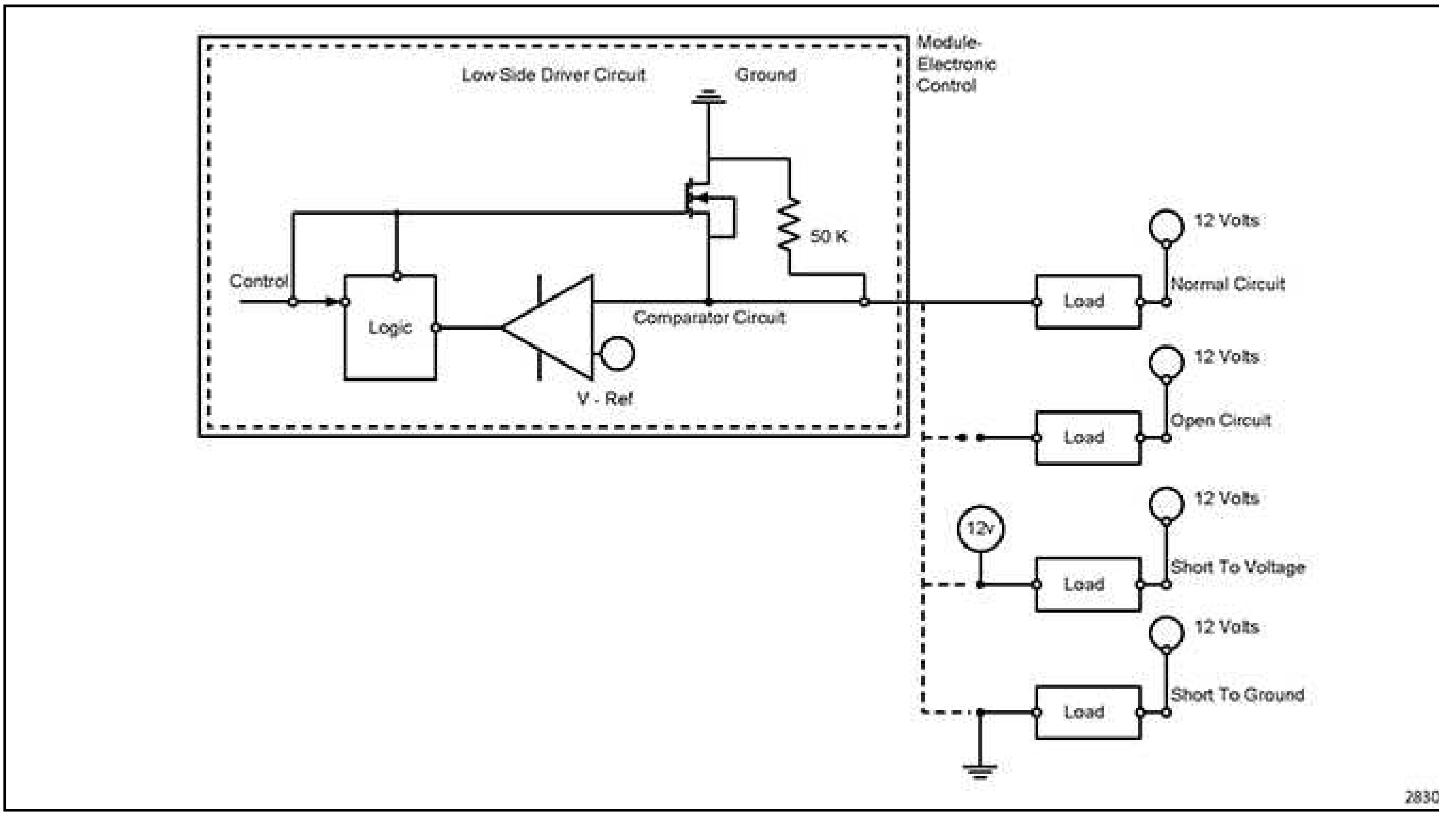
The engine starting and charging systems are connected directly to the Main Battery. When the Power Control Relay is closed (de-energized), the Auxiliary Battery is Battery. Therefore, if the Power Control Relay is stuck on (open), the Auxiliary Battery will not charge.

When ESS is active, and an **Auto-start crank event is initiated** , the **Power Control Relay** is temporarily energized when 12.0 volts is supplied from the output of the **the PDC** . When the Power Control Relay is energized it breaks the connection and allows the Batteries to work independently. When this occurs, the Main Battery is us engine. The Auxiliary Battery, which is now solely connected to the PDC and is not affected by cranking, can maintain full Battery voltage to the rest of the vehicle moc

Typical Low Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver dev ground to operate the device when switched on. The ground could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device, driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. For diagnostic purposes the PCM uses an internal pull d connected in series and a voltage reference (V-Ref) comparator for fault detection:

- **Circuit Open and Circuit Low Detection:** The PCM monitors for an **open circuit** and **short to ground** when the driver is switched off. When switched off, the through the device and the **internal pull down resistor** connected in series. The voltage at the **comparator circuit** should be close to Battery voltage since the m occurs through the diagnostic resistor. If the available voltage is less than the V-Ref, a fault is set. In this scenario the V-Ref would be slightly below Battery volta **method of fault detection for an open or short to ground** that is used is to monitor current draw when the internal driver is switched on. If the module does not determines that the component or circuitry is open. Excessive current draw detected would indicate a short to ground.
- **Circuit High Detection:** The PCM monitors for a **short to voltage** when the driver is switched on. When the driver is switched on providing a path to ground thr available voltage should be pulled low, near zero volts since the **comparator circuit** is monitoring the ground side of the device. If the voltage is greater than V-R this scenario V-Ref would be slightly above zero volts.

NOTE: **A load that has a resistance that is below manufacturer specification, or a second load device shorted to the low side driver circ excessive current draw on the internal driver. The driver will be switched off to protect against overheating and damaging the dı the Circuit High fault may be detected because the available voltage on the comparator circuit is above V-Ref.**



DIAGNOSTIC OVERVIEW - STOP/START SYSTEM AND AUXILIARY BATTERY STATE OF CHARGE (SOC)

PCM DIAGNOSTICS: It is important for the Power Control Relay to operate properly to allow the Auxiliary Battery to charge correctly with the engine running and b Engine Stop/Start (ESS) Auto-start event. The PCM runs continuous diagnostics to determine if the Power Control Relay is stuck in the On (open) or Off (closed) positi

DIAGNOSTIC OVERVIEW OF SYSTEM:

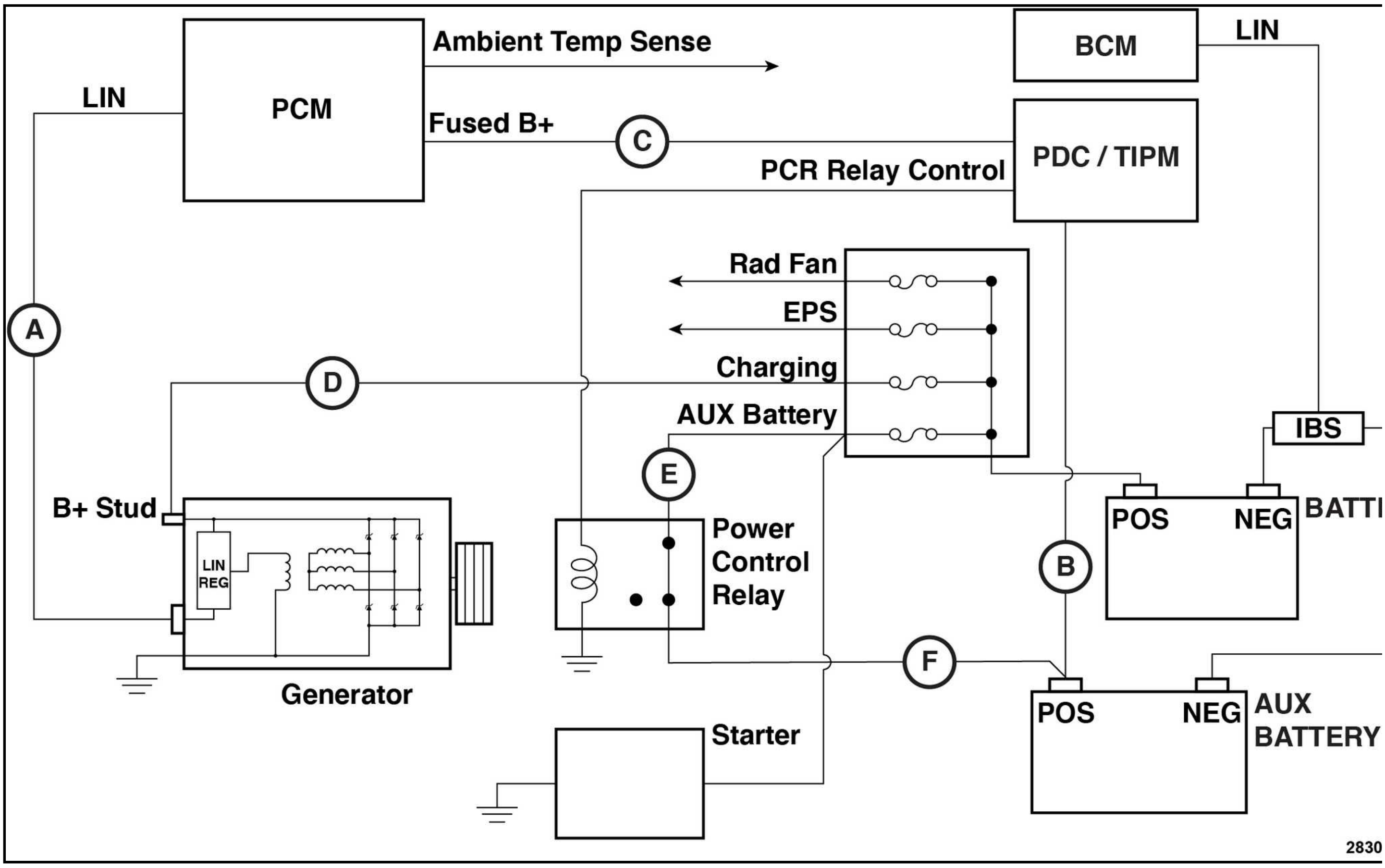
- **Ignition Crank Sense Diagnostic:** The PCM monitors the Ignition Crank Sense circuit voltage when engine cranking is commanded. The Ignition Crank Sense c Starter Solenoid Feed circuit inside the PDC. When engine cranking is commanded the PCM expects to see battery voltage at the Ignition Crank Sense circuit. If 1 fault is set.
  - If the engine is able to crank when the feedback circuit performance fault is active it eliminates the battery supply, Starter Relays and Starter as possible cau If the engine does not crank when the feedback circuit performance fault is active the Ignition Crank Sense circuit is not the possible cause.
- **Stuck Starter Relay Diagnostic:** After the engine is initially started, the Powertrain Control Module (PCM) will command one of the Starter Relays closed and tl open and monitor the Ignition Crank Sense circuit for voltage. It will then open the closed relay and close the open relay and monitor the Ignition Crank Sense cir is voltage present on the feedback circuit during either of these tests, then the relay that was commanded off when voltage was detected is determined to be stuck fault is set against that relay.

POWER CONTROL RELAY DIAGNOSTIC: DISCLAIMER: The generic graphic below is used for reference to show how the components are configured in the sy any particular vehicle. Refer to the wiring and service information for the specific layout of the components for the vehicle that you are working on.

- **Diagnostic 1 - Auxiliary Battery Disconnected:** During an initial key start, the Power Control Relay is commanded on **(open)** and the Auxiliary Battery SOC is B+ voltage (C) to the Powertrain Control Module (PCM) is so low that the PCM experiences a reset during the initial key-on or engine crank event, the **PCM wil will be disabled.**

NOTE: **This will cause a no crank condition. On the next key cycle the DTC will be active. The PCM will de-energize the Power Cor active DTC which will connect the Main Battery to the Auxiliary Battery, allowing the PCM to power up and allow engine cra**

- **Diagnostic 2 - Auxiliary Battery Depleted:** During an ESS Auto-start event, the Power Control Relay is temporarily commanded on (open) disconnecting the M Batteries from each other (E and F). This allows the Auxiliary Battery SOC to be separately monitored by the PCM. If the Auxiliary Battery voltage drops below a (approximately 8.0 volts) during the ESS Auto-start event, the **PCM will set P00FD and ESS will be disabled.**
- **Diagnostic 3 - Auxiliary Battery is Depleting:** During the ESS Auto-start event, if the Auxiliary Battery voltage drops below a calibrated threshold the PCM wil 1. ESS will be disabled for a short period to allow the Auxiliary Battery to charge before being re-enabled and tested again. If the voltage returns above a calibrate Auto-start event, the counter will decrement by 1. If the voltage is still below the calibrated threshold on the next Auto-start event, the counter will increment by 1 reaches 10 counts, the **PCM will set P00FD and ESS will be disabled.**
- **Diagnostic 4 - Power Control Relay Stuck Off:** During the ESS Auto-start event, if the PCM detects little or no difference (delta) between the Auxiliary Battery Battery voltage (C and IBS LIN feedback), the **PCM will set P2AF6 and ESS will be disabled.**
- **Diagnostic 5 - Auxiliary Battery Disconnected from Main Battery:** During normal engine operation, when the vehicle is not in an ESS Auto-start event, the Pc commanded off (closed), connecting the Main and Auxiliary Batteries together (E and F) to allow the Auxiliary Battery to charge. If the difference (delta) betweer voltage and Main Battery voltage (C and IBS LIN feedback) is more than a calibrated threshold, the **PCM will set P2AF5 and ESS will be disabled.**



SIMPLE DIAGNOSTIC STRATEGY:

- **The diagnostic for the P00FD fault** is basically designed to detect a discharging, discharged or disconnected Auxiliary Battery any time there is a disconnect bet detects this if the Fused B+ voltage to the PCM drops low enough to cause a PCM reset when disconnected from the Main/Cranking Battery. This fault will detec Battery, or wiring issue between the Auxiliary Battery, PDC and Battery Supply circuit (B and C) and the PCM.
- **The P2AF5-Power Control Relay Stuck On description can be misleading.** Since the diagnostic is using a comparison of the voltage between the two Batterie more likely to have an issue in the wiring between either Battery and the Power Control Relay (E or F). The only way for the relay to be stuck on **(open)** would be were physically stuck on, or the Fused B+ output from the PCR Control Relay were shorted to voltage. Both of these conditions are possible but not very likely. A **the Power Control Relay being stuck on (open)** would be to measure the voltage at each of the posts at the Power Control Relay with the engine running and th If the Power Control Relay is stuck open the voltage on the Auxiliary Battery side will be lower than the voltage on the Main Battery side of the relay. If the volta sides, the relay is not open. If the voltage is equal to the charging system voltage at both terminals, the wiring issue is most likely on the Auxiliary Battery side of equal to the Auxiliary Battery voltage at both terminals, the wiring issue is most likely on the Main Battery side of the relay.
- **The P2AF6-Power Control Relay Stuck Off diagnostic** is checking for the disconnection between the Batteries to occur when the Power Control Relay is energ Auto-start event. **Anything that can cause the relay not to energize can set this fault,** including a wiring issue with either the Fused B+ output from the PCR C

or the Power Control Relay Ground circuit. These are the two circuits that control the Power Control Relay operation. They do not have separate control circuit fa
If there is an open or short in one of these circuits the stuck off rationality fault sets.

WHEN MONITORED

This diagnostic runs continuously conditions are met:

- With the ignition on.
- Battery voltage above 11.0 volts.
- Vehicle is not in an auto start event.

SET CONDITION

- The PCM determines that the difference between the Auxiliary Battery system voltage and the charging system output voltage is greater than 2.0 volts.

DEFAULT ACTION

- This is a non-MIL fault.
- Engine Start/Stop (ESS) events are disabled.

POSSIBLE CAUSES

Possible Causes
OPEN POWER CONTROL RELAY FUSE (150A) IN THE FUSE ARRAY
PCR CONTROL RELAY OUTPUT CIRCUIT SHORTED TO VOLTAGE
POOR CONNECTION AT THE AUXILIARY BATTERY POSITIVE OR NEGATIVE CABLE ENDS
HIGH RESISTANCE IN THE AUXILIARY BATTERY POSITIVE CABLE
HIGH RESISTANCE IN THE AUXILIARY BATTERY GROUND CABLE OR GROUND LOCATION
HIGH RESISTANCE IN THE FUSED B+ CIRCUIT TO THE PCM
PCR CONTROL RELAY (ON PCB INSIDE PDC) IS STUCK ON
POWER CONTROL RELAY (PCR) STUCK ON (OPEN)
FAULTY AUXILIARY BATTERY
POWER DISTRIBUTION CENTER (PDC)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**
   1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

      Are there any applicable Service Bulletins or Flash updates?

      Yes

      - Perform the applicable repair.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

      No

      - Go To 2
2. **CHECK FOR OTHER DTCS**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.

      Are there any PCR Control Relay Control circuit or Charging system DTCs present?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to 3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX .

      No

      - Go To 3
3. **CHECK THE PCR CONTROL RELAY (T760) OUTPUT CIRCUIT FOR VOLTAGE AT THE POWER CONTROL RELAY**
   1. Turn the ignition off.
   2. Disconnect the Power Control Relay C1 harness connector.
   3. Turn the ignition on, engine not running.
   4. Measure the voltage on the PCR Control Relay (T760) Output circuit at the Power Control Relay C1 harness connector.

      NOTE: **There should be no voltage present since the Power Control Relay is only energized during an auto start event.**

      Is there any voltage present?

      Yes

      - Go To 4

      No

      - Go To 5
4. **CHECK THE PCR CONTROL RELAY (T760) OUTPUT CIRCUIT FOR A SHORT TO ANOTHER VOLTAGE SUPPLY CIRCUIT AT THE PDC COI**
   1. Turn the ignition off.

2. Disconnect the Power Distribution Center (PDC) harness connector.
3. Check for continuity between the PCR Control Relay (T760) Output circuit and all other circuits at the PDC harness connector.

   Is there continuity between the PCR Control Relay (T760) Output circuit and any other circuit?

   Yes

   - Repair the PCR Control Relay (T760) Output circuit for a short to the circuit that showed continuity.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Replace the Power Distribution Center in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK FOR THE POWER CONTROL RELAY STUCK ON (OPEN)**

   NOTE: **There should be direct continuity between the two posts on the normally closed Power Control Relay if the relay is not ene functioning properly.**

   1. Start the engine and allow it to idle.
   2. Measure the voltage at the Power Control Relay C2 post.
   3. Measure the voltage at the Power Control Relay C3 post.

      NOTE: **The voltage measured should be equal to the charging system output voltage at both posts.**

      Is the voltage equal to the charging system at both posts?

      Yes

      - Go To 6

      No, the voltage at both posts is equal to the Auxiliary Battery voltage:

      - Go To 13

      No, the voltage at the post on the Main Battery side is equal to the charging system output and the voltage at the post on the Auxiliary Battery side Auxiliary Battery voltage:

      - Replace the Power Control Relay in accordance with the Service Information.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK THE AUXILIARY BATTERY POSITIVE AND NEGATIVE CABLE CONNECTIONS**
   1. Check for a proper connection between the Battery posts and cable ends at the Auxiliary Battery.

      NOTE: **There should be no voltage drop between the posts and cable ends.**

      Is there a good connector between the posts and cable ends?

      Yes

      - Go To 7

      No

      - Clean the Battery Cables and posts and retest.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

7. **CHECK THE FUSES AND PDC CONNECTIONS**
   1. Check the Fuse(s) that feed the PCM Fused B+ circuit.
   2. Check the Auxiliary Battery cable connection at the PDC for a proper connection.

      Were any issues found with the fuses or connections?

      Yes

      - Make the necessary repairs.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 8

8. **CHECK FOR HIGH RESISTANCE IN THE AUXILIARY BATTERY CABLE**
   1. Perform a voltage drop on the Auxiliary Battery Positive cable between the Auxiliary Battery Positive Cable End and the Power Control Relay.
   2. Perform a voltage drop on the Auxiliary Battery Positive cable between the Auxiliary Battery Positive Cable End and the connection at the PDC.

      Does the Auxiliary Battery Positive Cable have a voltage drop between the Auxiliary Battery and Power Control Relay or PDC?

      Yes

      - Repair or replace the Auxiliary Battery Positive Cable.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 9

9. **CHECK AUXILIARY BATTERY NEGATIVE CABLE AND GROUND LOCATION**

1. Check the Auxiliary Battery Negative Cable for a proper ground at the ground location.
2. Perform a voltage drop on the Auxiliary Battery Negative Cable between the Auxiliary Battery Negative Cable End and the ground location.

   Is the Negative Battery Cable grounded properly?

   Yes

   - Go To 10

   No

   - Repair or replace the Auxiliary Battery Negative Cable or ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CHECK THE AUXILIARY BATTERY STATE OF CHARGE**
    1. Disconnect the Negative Cable from both Batteries.
    2. Use the (special tool #GR8-1220KIT-CHRY, AGM Battery Tester/Charger Station)or equivalent to load test the Auxiliary Battery.

       Did the Auxiliary Battery pass the load test?

       Yes

       - Go To 11

       No

       - Recharge or replace the Auxiliary Battery and retest.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
11. **CHECK (A106) FUSED B+ SUPPLY VOLTAGE TO THE PCM**
    1. Disconnect the PCM C1 harness connector.
    2. Connect the (special tool #10436, Adapter, GPEC Diagnostic) to the PCM harness connector. Reconnect the PCM C1 harness connector in-line with the GP in-line.
    3. Turn the ignition on.
    4. Measure the voltage on the (A106) Fused B+ circuit at the GPEC Adaptor.
    5. Measure the voltage of the Auxiliary Battery.

       Is the voltage on the (A106) Fused B+ circuit within 0.2 volts of the Auxiliary Battery?

       Yes

       - Go To 12

       No

       - Repair the (A106) Fused B+ circuit for high resistance.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
12. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
       - Proper connector installation.
       - Damaged connector locks.
       - Corrosion.
       - Other signs of water intrusion.
       - Weather seal damage (if equipped).
       - Bent terminals.
       - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
       - Terminals that have been pushed back into the connector cavity.
       - Check for spread terminals and verify proper terminal tension.

       Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CO REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

13. **CHECK THE POWER CONTROL RELAY FUSE IN THE BATTERY DISTRIBUTION UNIT (FUSE ARRAY)**
    1. Check the Power Control Relay Fuse in the Battery Distribution Unit (Fuse Array) for continuity.

    Is the Fuse open?

    Yes

    - Replace the open fuse and check the related wiring harnesses and circuits for any conditions that could cause the open fuse.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 14

14. **CHECK FOR HIGH RESISTANCE IN THE MAIN BATTERY CABLE BETWEEN THE MAIN BATTERY AND THE POWER CONTROL RELAY**
    1. Perform a voltage drop on the Main Battery Positive cable between the Main Battery Positive Cable End and the Power Control Relay.

    Does the Main Battery Positive Cable have a voltage drop between the Main Battery and Power Control Relay?

    Yes

    - Repair or replace the Main Battery Positive Cable.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Check the wiring between the Alternator and Main Battery for excessive voltage drop in the circuitry.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2AF6-STARTER RELAY 3 STUCK OFF

For a complete STARTING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

NOTE: **The terminology of the relays in this procedure can be confusing. To add clarity the Power Control Relay is the relay that makes connection between the two Batteries. The PCR Control Relay is in the PDC and is controlled by the Powertrain Control Module Side Driver (LSD). The relay can be removable or a Printed Circuit Board (PCB) relay depending on vehicle configuration. The P provides the power supply to operate the Power Control Relay.**

The Engine Stop/Start (ESS) system uses a **Power Control Relay (PCR)** and two Batteries to eliminate the voltage drop in the system voltage during an Auto-start ev consumer electronics and vehicle modules subsystems to continue to function in a normal manner. The Power Control Relay is connected in-line between the Main (Cra Auxiliary (Vehicle) Battery. The Power Control Relay is normally closed when de-energized, connecting the two Batteries. When the Power Control Relay is energized, breaks the connection between the Batteries.

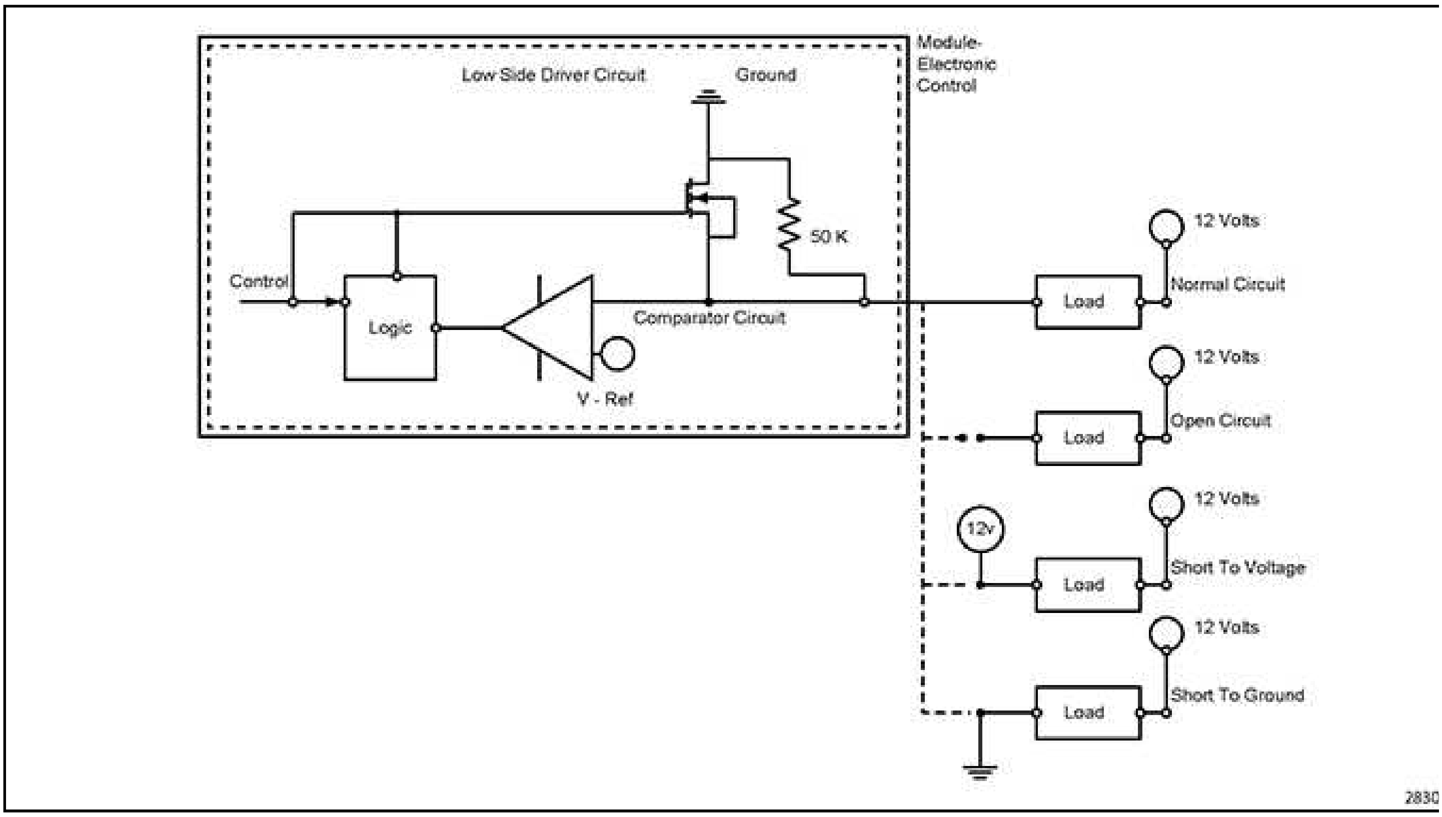
The engine starting and charging systems are connected directly to the Main Battery. When the Power Control Relay is closed (de-energized), the Auxiliary Battery is Battery. Therefore, if the Power Control Relay is stuck on (open), the Auxiliary Battery will not charge.

When ESS is active, and an **Auto-start crank event is initiated** , the **Power Control Relay** is temporarily energized when 12.0 volts is supplied from the output of the **the PDC** . When the Power Control Relay is energized it breaks the connection and allows the Batteries to work independently. When this occurs, the Main Battery is us engine. The Auxiliary Battery, which is now solely connected to the PDC and is not affected by cranking, can maintain full Battery voltage to the rest of the vehicle moc

Typical Low Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver dev ground to operate the device when switched on. The ground could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device, driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. For diagnostic purposes the PCM uses an internal pull d connected in series and a voltage reference (V-Ref) comparator for fault detection:

- **Circuit Open and Circuit Low Detection:** The PCM monitors for an **open circuit** and **short to ground** when the driver is switched off. When switched off, the through the device and the **internal pull down resistor** connected in series. The voltage at the **comparator circuit** should be close to Battery voltage since the m occurs through the diagnostic resistor. If the available voltage is less than the V-Ref, a fault is set. In this scenario the V-Ref would be slightly below Battery volta **method of fault detection for an open or short to ground** that is used is to monitor current draw when the internal driver is switched on. If the module does not determines that the component or circuitry is open. Excessive current draw detected would indicate a short to ground.
- **Circuit High Detection:** The PCM monitors for a **short to voltage** when the driver is switched on. When the driver is switched on providing a path to ground thr available voltage should be pulled low, near zero volts since the **comparator circuit** is monitoring the ground side of the device. If the voltage is greater than V-R this scenario V-Ref would be slightly above zero volts.

NOTE: **A load that has a resistance that is below manufacturer specification, or a second load device shorted to the low side driver circ excessive current draw on the internal driver. The driver will be switched off to protect against overheating and damaging the dı the Circuit High fault may be detected because the available voltage on the comparator circuit is above V-Ref.**



DIAGNOSTIC OVERVIEW - STOP/START SYSTEM AND AUXILIARY BATTERY STATE OF CHARGE (SOC)

PCM DIAGNOSTICS: It is important for the Power Control Relay to operate properly to allow the Auxiliary Battery to charge correctly with the engine running and t Engine Stop/Start (ESS) Auto-start event. The PCM runs continuous diagnostics to determine if the Power Control Relay is stuck in the On (open) or Off (closed) positi

DIAGNOSTIC OVERVIEW OF SYSTEM:

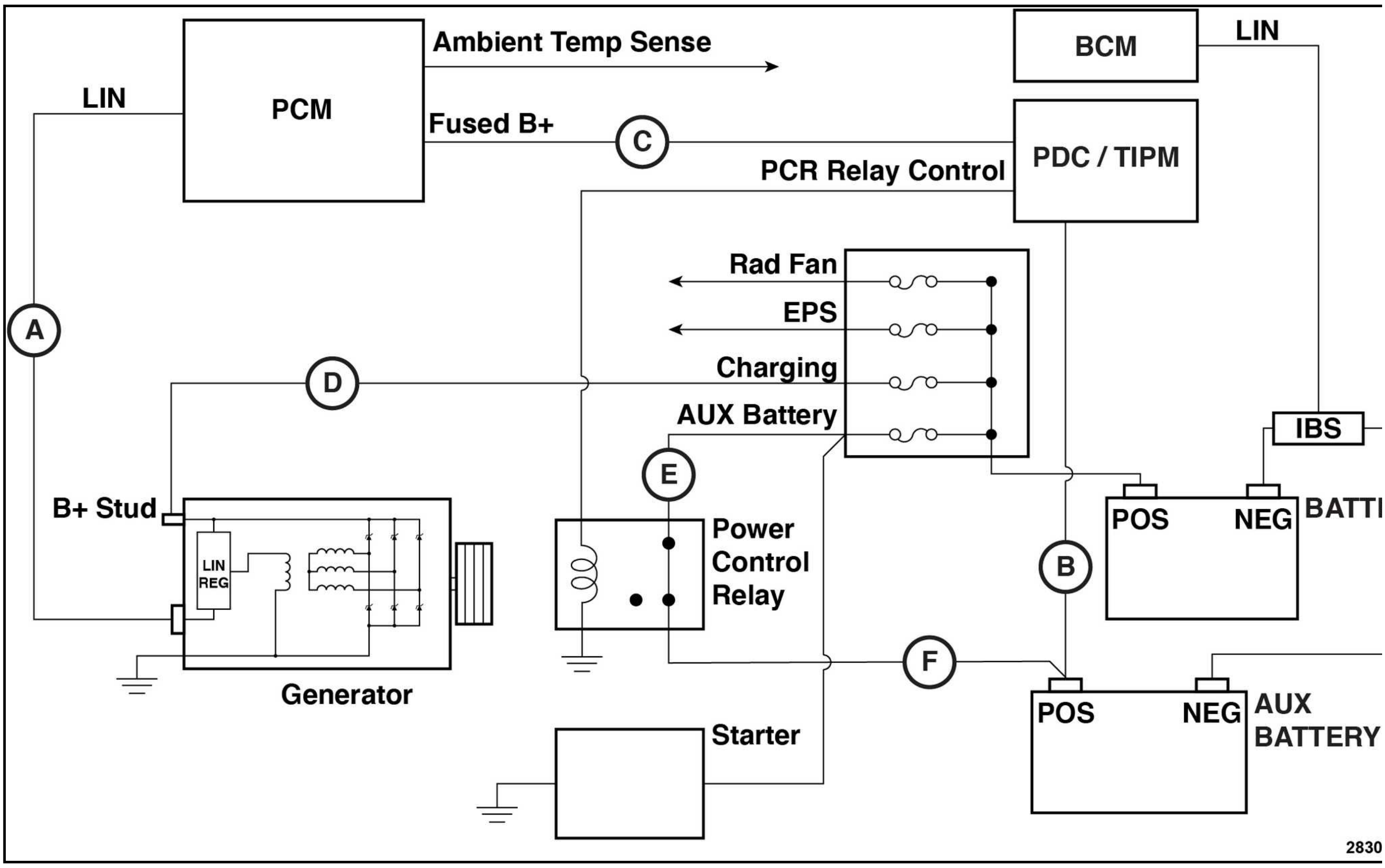
- **Ignition Crank Sense Diagnostic:** The PCM monitors the Ignition Crank Sense circuit voltage when engine cranking is commanded. The Ignition Crank Sense c Starter Solenoid Feed circuit inside the PDC. When engine cranking is commanded the PCM expects to see battery voltage at the Ignition Crank Sense circuit. If r fault is set.
  - If the engine is able to crank when the feedback circuit performance fault is active it eliminates the battery supply, Starter Relays and Starter as possible cau If the engine does not crank when the feedback circuit performance fault is active the Ignition Crank Sense circuit is not the possible cause.
- **Stuck Starter Relay Diagnostic:** After the engine is initially started, the Powertrain Control Module (PCM) will command one of the Starter Relays closed and tl open and monitor the Ignition Crank Sense circuit for voltage. It will then open the closed relay and close the open relay and monitor the Ignition Crank Sense cir is voltage present on the feedback circuit during either of these tests, then the relay that was commanded off when voltage was detected is determined to be stuck fault is set against that relay.

POWER CONTROL RELAY DIAGNOSTIC: DISCLAIMER: The generic graphic below is used for reference to show how the components are configured in the sy any particular vehicle. Refer to the wiring and service information for the specific layout of the components for the vehicle that you are working on.

- **Diagnostic 1 - Auxiliary Battery Disconnected:** During an initial key start, the Power Control Relay is commanded on **(open)** and the Auxiliary Battery SOC is B+ voltage (C) to the Powertrain Control Module (PCM) is so low that the PCM experiences a reset during the initial key-on or engine crank event, the **PCM wil will be disabled.**

NOTE: **This will cause a no crank condition. On the next key cycle the DTC will be active. The PCM will de-energize the Power Cor active DTC which will connect the Main Battery to the Auxiliary Battery, allowing the PCM to power up and allow engine cra**

- **Diagnostic 2 - Auxiliary Battery Depleted:** During an ESS Auto-start event, the Power Control Relay is temporarily commanded on (open) disconnecting the M Batteries from each other (E and F). This allows the Auxiliary Battery SOC to be separately monitored by the PCM. If the Auxiliary Battery voltage drops below a (approximately 8.0 volts) during the ESS Auto-start event, the **PCM will set P00FD and ESS will be disabled.**
- **Diagnostic 3 - Auxiliary Battery is Depleting:** During the ESS Auto-start event, if the Auxiliary Battery voltage drops below a calibrated threshold the PCM wil 1. ESS will be disabled for a short period to allow the Auxiliary Battery to charge before being re-enabled and tested again. If the voltage returns above a calibrate Auto-start event, the counter will decrement by 1. If the voltage is still below the calibrated threshold on the next Auto-start event, the counter will increment by 1 reaches 10 counts, the **PCM will set P00FD and ESS will be disabled.**
- **Diagnostic 4 - Power Control Relay Stuck Off:** During the ESS Auto-start event, if the PCM detects little or no difference (delta) between the Auxiliary Battery Battery voltage (C and IBS LIN feedback), the **PCM will set P2AF6 and ESS will be disabled.**
- **Diagnostic 5 - Auxiliary Battery Disconnected from Main Battery:** During normal engine operation, when the vehicle is not in an ESS Auto-start event, the Pc commanded off (closed), connecting the Main and Auxiliary Batteries together (E and F) to allow the Auxiliary Battery to charge. If the difference (delta) betweer voltage and Main Battery voltage (C and IBS LIN feedback) is more than a calibrated threshold, the **PCM will set P2AF5 and ESS will be disabled.**



SIMPLE DIAGNOSTIC STRATEGY:

- **The diagnostic for the P00FD fault** is basically designed to detect a discharging, discharged or disconnected Auxiliary Battery any time there is a disconnect bet detects this if the Fused B+ voltage to the PCM drops low enough to cause a PCM reset when disconnected from the Main/Cranking Battery. This fault will detec Battery, or wiring issue between the Auxiliary Battery, PDC and Battery Supply circuit (B and C) and the PCM.
- **The P2AF5-Power Control Relay Stuck On description can be misleading.** Since the diagnostic is using a comparison of the voltage between the two Batterie more likely to have an issue in the wiring between either Battery and the Power Control Relay (E or F). The only way for the relay to be stuck on **(open)** would b were physically stuck on, or the Fused B+ output from the PCR Control Relay were shorted to voltage. Both of these conditions are possible but not very likely. A **the Power Control Relay being stuck on (open)** would be to measure the voltage at each of the posts at the Power Control Relay with the engine running and th If the Power Control Relay is stuck open the voltage on the Auxiliary Battery side will be lower than the voltage on the Main Battery side of the relay. If the volta sides, the relay is not open. If the voltage is equal to the charging system voltage at both terminals, the wiring issue is most likely on the Auxiliary Battery side of equal to the Auxiliary Battery voltage at both terminals, the wiring issue is most likely on the Main Battery side of the relay.
- **The P2AF6-Power Control Relay Stuck Off diagnostic** is checking for the disconnection between the Batteries to occur when the Power Control Relay is energ Auto-start event. **Anything that can cause the relay not to energize can set this fault,** including a wiring issue with either the Fused B+ output from the PCR C or the Power Control Relay Ground circuit. These are the two circuits that control the Power Control Relay operation. They do not have separate control circuit fa If there is an open or short in one of these circuits the stuck off rationality fault sets.

WHEN MONITORED

- This diagnostic is run during an Auto Start cranking event.

SET CONDITION

- During an Auto Start cranking event the PCM detects that the difference between the Auxiliary Battery voltage and the Main Battery voltage is less than a calibrat

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
PCR CONTROL RELAY OUTPUT CIRCUIT OPEN/HIGH RESISTANCE
PCR CONTROL RELAY OUTPUT CIRCUIT SHORTED TO GROUND
POWER CONTROL RELAY GROUND CIRCUIT OPEN
POWER CONTROL RELAY IS STUCK OFF (CLOSED)
POOR CONNECTION AT THE MAIN BATTERY POSITIVE OR NEGATIVE CABLE ENDS
HIGH RESISTANCE IN THE MAIN BATTERY POSITIVE CABLE
HIGH RESISTANCE IN THE MAIN BATTERY GROUND
FAULTY AUXILIARY BATTERY
POWER DISTRIBUTION CENTER (PDC)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **CHECK FOR ANY SERVICE BULLETINS OR PCM SOFTWARE UPDATES**

1. Check for any applicable Service Bulletins or Flash updates related to the DTC.

   Are there any applicable Service Bulletins or Flash updates?

   Yes

   - Perform the applicable repair.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 2

2. **CHECK FOR OTHER DTCS**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.

   Are there any Power Control Relay, PCR Control Relay or charging system DTCs present?

   Yes

   - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

   No

   - Go To 3

3. **CHECK THE FUSES AND PDC CONNECTIONS**
   1. Check the Fuse(s) that feed the PCM Fused B+ circuit.
   2. Check the Auxiliary Battery cable connection at the PDC for a proper connection.

   Were any issues found with the fuses or connections?

   Yes

   - Make the necessary repairs.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 4

4. **CHECK THE PCR CONTROL RELAY (T760) OUTPUT CIRCUIT VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the Power Control Relay C1 harness connector.
   3. Using a 12 volt test light connected to ground, back probe PCR Control Relay (T762) Control circuit to energize the relay.
   4. Turn the ignition on.
   5. Measure the voltage on the PCR Control Relay (T762) Control circuit at the Power Control Relay C1 harness connector.

   Is Battery voltage present on the PCR Control Relay (T760) Output circuit?

   Yes

   - Go To 7

   No

   - Go To 5

5. **CHECK THE PCR CONTROL RELAY (T760) OUTPUT CIRCUIT FOR A SHORT TO GROUND**
   1. Turn the ignition off.
   2. Disconnect the PDC C3 harness connector.
   3. Check for continuity between ground and the PCR Control Relay (T760) Output circuit at the Power Control Relay harness connector.

   Is there continuity between ground and the PCR Control Relay (T760) Output circuit?

   Yes

   - Repair the PCR Control Relay (T760) Output circuit for a short to ground and check the fuses in the PDC.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6

6. **ISOLATE AND LOAD TEST THE PCR CONTROL RELAY (T760) OUTPUT CIRCUIT TO CHECK FOR HIGH RESISTANCE**

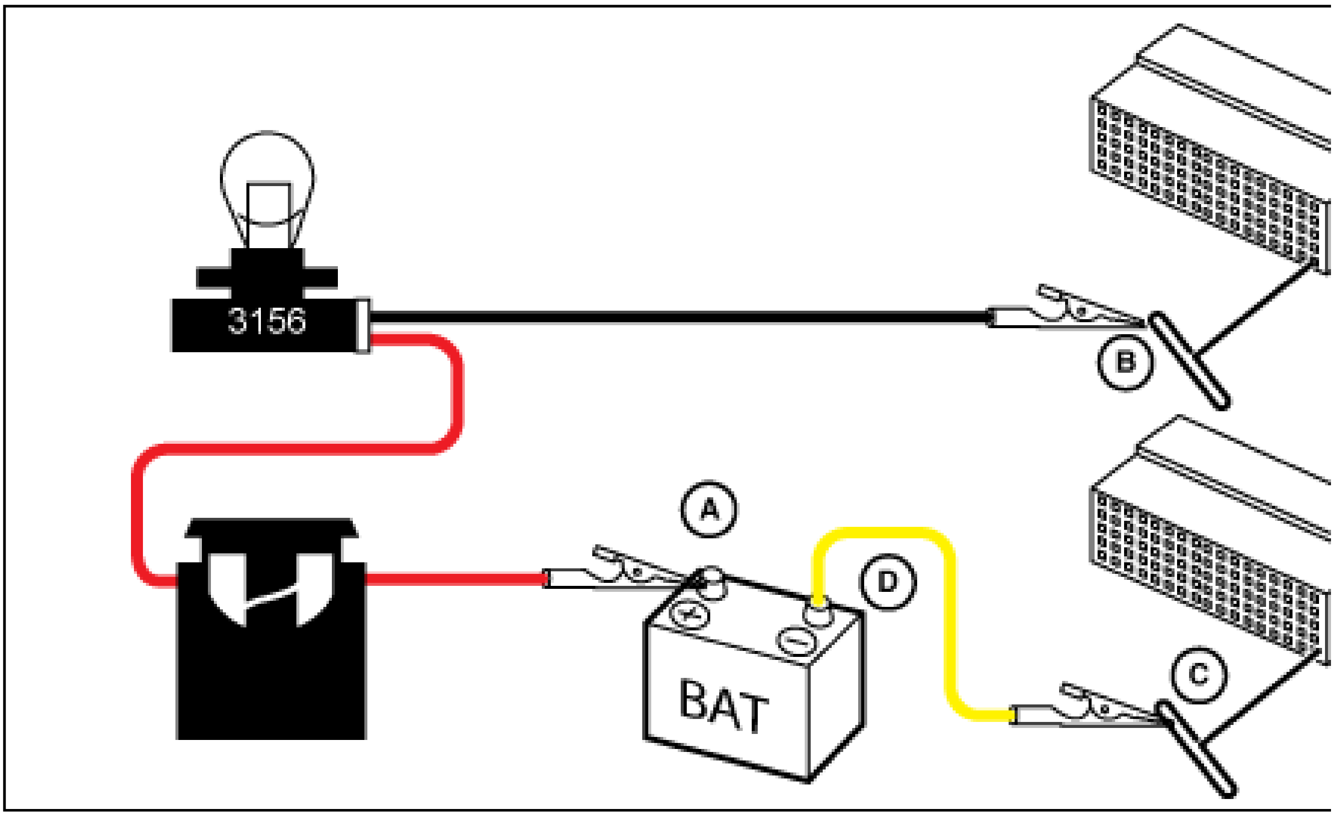
   NOTE: **Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

   CAUTION: **Do not load test any circuits with components still connected to the circuit.**

   1. Disconnect the PDC harness connector.
   2. Connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM connector.

      NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   3. Load test the PCR Control Relay (T760) Output circuit. **Note:** refer to the example illustration.



NOTE: **The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit. Compare the bri in the load test tool to that of a direct connection across Battery.**

Is the load test bulb illuminated and bright?

Yes

- If there were no open fuses in the PDC, replace the PDC in accordance with the Service Information.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

No

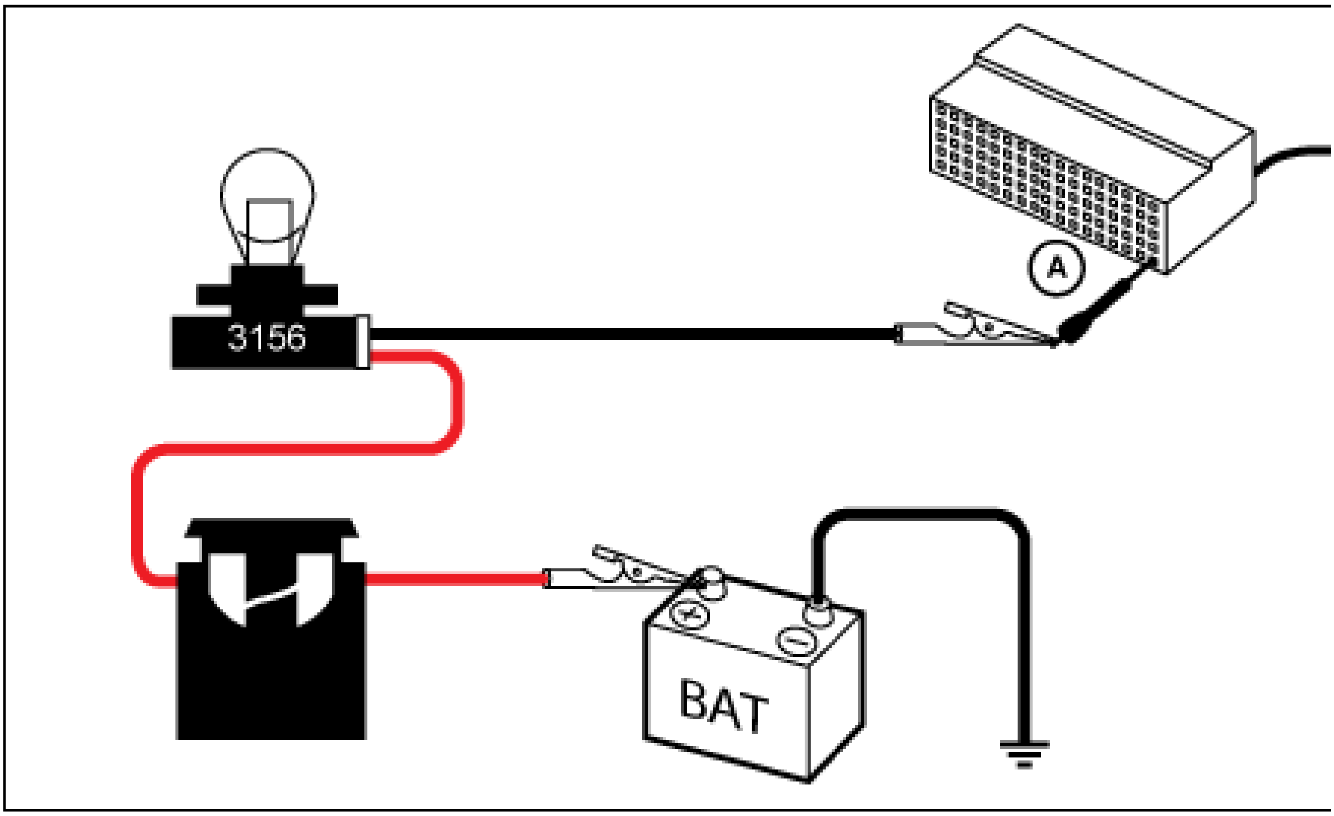
- Repair the PCR Control Relay (T760) Output circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

7. **CHECK THE (Z907) GROUND CIRCUIT FOR HIGH RESISTANCE BY LOAD TESTING THE CIRCUIT**

NOTE: **Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

CAUTION: **Do not load test any circuits with components still connected to the circuit.**

1. Turn the ignition off.
2. Load test the (Z907) Ground circuit at the Power Control Relay harness connector (A). **Note:** refer to the diagram below.



NOTE: **The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry. Compare the b in the load test tool to that of a direct connection across Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 8

No

- Repair the (Z907) Ground circuit for an open or high resistance.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK THE POWER CONTROL RELAY FOR PROPER OPERATION**
   1. Reconnect the Power Control Relay C1 harness connector.

      NOTE: **The Power Control Relay can be checked in one of two ways.**

   2. **Method 1:** Remove the eyelet from the Power Control Relay C2 post. Leave the C3 eyelet connected to the Power Control Relay. **The C2 eyelet is still co Cranking Battery. Be careful to insulate and/or isolate the cable so that it cannot make contact with any engine ground.**
   3. Using a 12 volt test light connected to ground, back probe PCR Control Relay (T762) Control circuit to energize the relay and measure the voltage at the C Control Relay with the C2 eyelet removed and the C3 eyelet still connected.

      NOTE: **The Power Control Relay should be open when energized and there should be no voltage at the C2 post.**

   4. **Method 2:** Start the engine to allow the charging system to become active. Using a 12 volt test light connected to ground, back probe PCR Control Relay (energize the relay and measure the voltage at both of the Power Control Relay posts.

      NOTE: **The Power Control Relay should be open when energized and the voltage on the C2 post should be equal to the Auxi and not charging system output voltage.**

   Is the Power Control Relay functioning properly?

   Yes

   - Go To 9

   No

   - Replace the Power Control Relay in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

9. **CHECK THE AUXILIARY BATTERY POSITIVE AND NEGATIVE CABLE CONNECTIONS**

   NOTE: **A faulty Auxiliary Battery or high resistance in the cables could cause the voltage on the Auxiliary side of the system to dr could appear as though the connection is not being broken between the Batteries when the Power Control Relay is energi start event.**

   1. Check for a proper connection between the Battery posts and cable ends at the Auxiliary Battery.

      NOTE: **There should be no voltage drop between the posts and cable ends.**

Is there a good connector between the posts and cable ends?

Yes

- Go To 10

No

- Clean the Battery Cables and posts and retest.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

10. **CHECK FOR HIGH RESISTANCE IN THE AUXILIARY BATTERY CABLE**
    1. Perform a voltage drop on the Auxiliary Battery Positive cable between the Auxiliary Battery Positive Cable End and the Power Control Relay.
    2. Perform a voltage drop on the Auxiliary Battery Positive cable between the Auxiliary Battery Positive Cable End and the connection at the PDC.

    Does the Auxiliary Battery Positive Cable have a voltage drop between the Auxiliary Battery and Power Control Relay or PDC?

    Yes

    - Repair or replace the Auxiliary Battery Positive Cable.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 11
11. **CHECK AUXILIARY BATTERY NEGATIVE CABLE AND GROUND LOCATION**
    1. Check the Auxiliary Battery Negative Cable for a proper ground.

    Is the Negative Battery Cable grounded properly?

    Yes

    - Go To 12

    No

    - Repair or replace the Auxiliary Battery Negative Cable or ground.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
12. **CHECK THE AUXILIARY BATTERY STATE OF CHARGE**
    1. Turn the ignition off.
    2. Disconnect the Negative Cable from both Batteries.
    3. Use the (special tool #GR8-1220KIT-CHRY, AGM Battery Tester/Charger Station)or equivalent to load test the Battery.

    Did the Auxiliary Battery pass the load test?

    Yes

    - Go To 13

    No

    - Recharge or replace the Auxiliary Battery and retest.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
13. **CHECK (A106) FUSED B+ SUPPLY VOLTAGE TO THE PCM**
    1. Disconnect the PCM C1 harness connector.
    2. Connect the (special tool #10436, Adapter, GPEC Diagnostic) to the PCM harness connector. Reconnect the PCM C1 harness connector in-line with the GP in-line.
    3. Turn the ignition on.
    4. Measure the voltage on the (A106) Fused B+ circuit at the GPEC Adaptor.
    5. Measure the voltage of the Auxiliary Battery.

    Is the voltage on the (A106) Fused B+ circuit within 0.2 volts of the Auxiliary Battery?

    Yes

    - Go To 14

    No

    - Repair the (A106) Fused B+ circuit for high resistance.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
14. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
       - Proper connector installation.
       - Damaged connector locks.
       - Corrosion.
       - Other signs of water intrusion.
       - Weather seal damage (if equipped).

- Bent terminals.
- Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CO REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2AF7-STARTER RELAY "D" CONTROL CIRCUIT/OPEN

For a complete STARTING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

NOTE: **The terminology of the relays in this procedure can be confusing. To add clarity the Power Control Relay is the relay that makes connection between the two Batteries. The PCR Control Relay is in the PDC and is controlled by the Powertrain Control Module Side Driver (LSD). The relay can be removable or a Printed Circuit Board (PCB) relay depending on vehicle configuration. The P provides the power supply to operate the Power Control Relay.**

The Engine Stop/Start (ESS) system uses a **Power Control Relay (PCR)** and two Batteries to eliminate the voltage drop in the system voltage during an Auto-start ev consumer electronics and vehicle modules subsystems to continue to function in a normal manner. The Power Control Relay is connected in-line between the Main (Cra Auxiliary (Vehicle) Battery. The Power Control Relay is normally closed when de-energized, connecting the two Batteries. When the Power Control Relay is energized, breaks the connection between the Batteries.

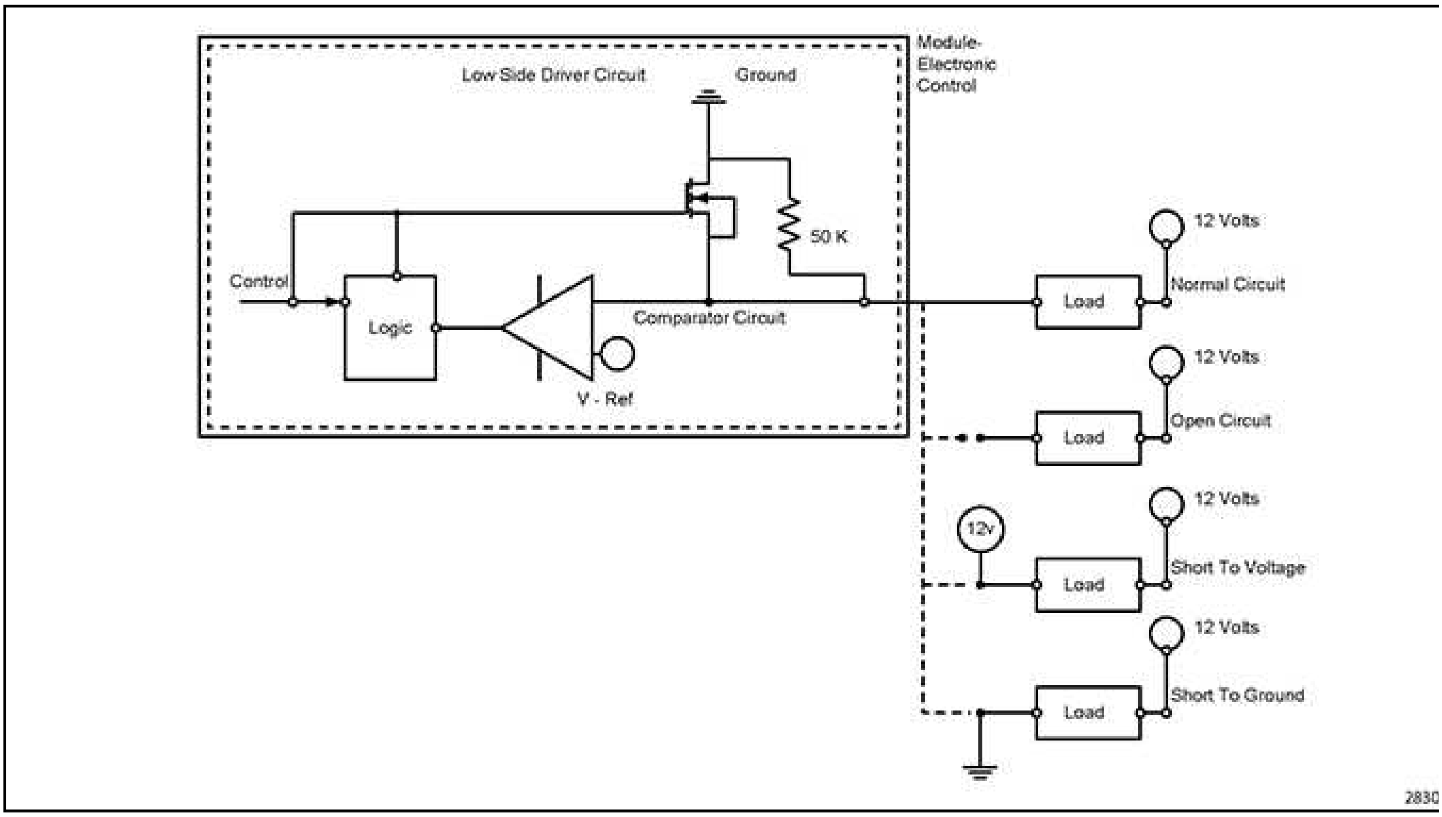
The engine starting and charging systems are connected directly to the Main Battery. When the Power Control Relay is closed (de-energized), the Auxiliary Battery is Battery. Therefore, if the Power Control Relay is stuck on (open), the Auxiliary Battery will not charge.

When ESS is active, and an **Auto-start crank event is initiated** , the **Power Control Relay** is temporarily energized when 12.0 volts is supplied from the output of the **the PDC** . When the Power Control Relay is energized it breaks the connection and allows the Batteries to work independently. When this occurs, the Main Battery is us engine. The Auxiliary Battery, which is now solely connected to the PDC and is not affected by cranking, can maintain full Battery voltage to the rest of the vehicle moc

Typical Low Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver dev ground to operate the device when switched on. The ground could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device, driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. For diagnostic purposes the PCM uses an internal pull d connected in series and a voltage reference (V-Ref) comparator for fault detection:

- **Circuit Open and Circuit Low Detection:** The PCM monitors for an **open circuit** and **short to ground** when the driver is switched off. When switched off, the through the device and the **internal pull down resistor** connected in series. The voltage at the **comparator circuit** should be close to Battery voltage since the m occurs through the diagnostic resistor. If the available voltage is less than the V-Ref, a fault is set. In this scenario the V-Ref would be slightly below Battery volta **method of fault detection for an open or short to ground** that is used is to monitor current draw when the internal driver is switched on. If the module does not determines that the component or circuitry is open. Excessive current draw detected would indicate a short to ground.
- **Circuit High Detection:** The PCM monitors for a **short to voltage** when the driver is switched on. When the driver is switched on providing a path to ground thr available voltage should be pulled low, near zero volts since the **comparator circuit** is monitoring the ground side of the device. If the voltage is greater than V-R this scenario V-Ref would be slightly above zero volts.

NOTE: **A load that has a resistance that is below manufacturer specification, or a second load device shorted to the low side driver circ excessive current draw on the internal driver. The driver will be switched off to protect against overheating and damaging the dı the Circuit High fault may be detected because the available voltage on the comparator circuit is above V-Ref.**



WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
- The PCR Control Relay commanded off.

SET CONDITION

- The Powertrain Control Module (PCM) detects an open condition in the PCR Control Relay Control circuit.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
STARTER RELAY 1 OUTPUT CIRCUIT OPEN
PCR CONTROL RELAY CONTROL CIRCUIT OPEN/HIGH RESISTANCE
PCR CONTROL RELAY
POWER DISTRIBUTION CENTER (PDC)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to INTERMITTENT CONDITION .
2. **CHECK FOR OTHER DTCS**

   NOTE: **The Battery supply for the PCR Control Relay coil is supplied by the (Stop/Start Relay) output.**

   1. Refer to the recorded DTCs.

Are there any Starter Solenoid Relay (Stop/Start Relay) Control circuit DTCs present in the BCM?

Yes

- Perform the applicable diagnostic procedure(s). Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

No

- Go To 3

3. **CHECK THE VOLTAGE SUPPLY FROM THE STOP/START RELAY OUTPUT TO THE PCR CONTROL RELAY CONTROL COIL**
   1. Turn the ignition off.
   2. Remove the PCR Control Relay from the relay connector in the PDC.
   3. Remove the (Stop/Start Relay) from the relay connector in the PDC.
   4. Turn the ignition on.
   5. Connect a fused jumper between terminal 30 and terminal 87 of the (Stop/Start Relay) connector in the PDC.
   6. Using a load test tool connected to ground, probe the Battery supply voltage coming from the (Stop/Start Relay) Output at terminal 86 at the PCR Control F PDC.

   Is the load test tool bulb illuminated and bright?

   Yes

   - Go To 4

   No

   - Check all of the fuses in the PDC. If a fuse is open, replace the fuse and retest. If no problems are found with the fuses, check the Battery supply to th of the Run/Start Relay. If no problems are found replace the PDC in accordance with the Service Information. Refer to **CENTER, POWER DISTRI REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE PCR CONTROL RELAY FOR PROPER OPERATION**
   1. Reinstall the PCR Control Relay in the PDC.
   2. Turn the ignition on.
   3. Using a 12-volt test light connected to ground, back probe the PCR Control Relay (T762) Control circuit at the PDC connector.

   NOTE: **The relay should make an audible click when closing. Another way to verify that the relay closed is to back probe and on the Power Control Relay (T760) Control circuit.**

   Did the relay close when connecting the PCR Control Relay (T762) Control circuit to ground through the test light?

   Yes

   - Go To 5

   No

   - If the PDC has an internal Printed Circuit Board (PCB) and harness connectors, isolate and check the continuity between terminal 85 of the PCR Con the terminal at the PDC connector. If the resistance is below 3.0 Ohms, replace the PCR Control Relay. If the resistance is above 3.0 Ohms, replace tl Center (PDC) in accordance with the service information. Refer to **CENTER, POWER DISTRIBUTION (PDC), REMOVAL AND INSTALLAT**
   - If the wiring harness is directly hard wired into the PDC, replace the PCR Control Relay.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **ISOLATE AND LOAD TEST THE PCR CONTROL RELAY (T762) CONTROL CIRCUIT TO CHECK FOR HIGH RESISTANCE**
   1. The ignition must be off when performing a load test on a circuit.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested.
   3. Connect the positive lead of the load test tool to the positive side of the Battery (A). **Note:** Refer to the diagram below.
   4. Using an approved back probe tool, connect the negative lead of the load test tool to the circuit being tested at the one of the component harness connectors
   5. Using an approved back probe tool and a fused jumper wire, connect the circuit being tested to the negative side of the Battery or a known good ground at t harness connector (C and D).
   6. The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuit.

NOTE: **Note: Why load test a circuit? A load test is used to determine if a circuit is capable of carrying the amperage needed to pe 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has appro of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING F information on building a simple load test tool and for additional load testing information and alternative methods of load t drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

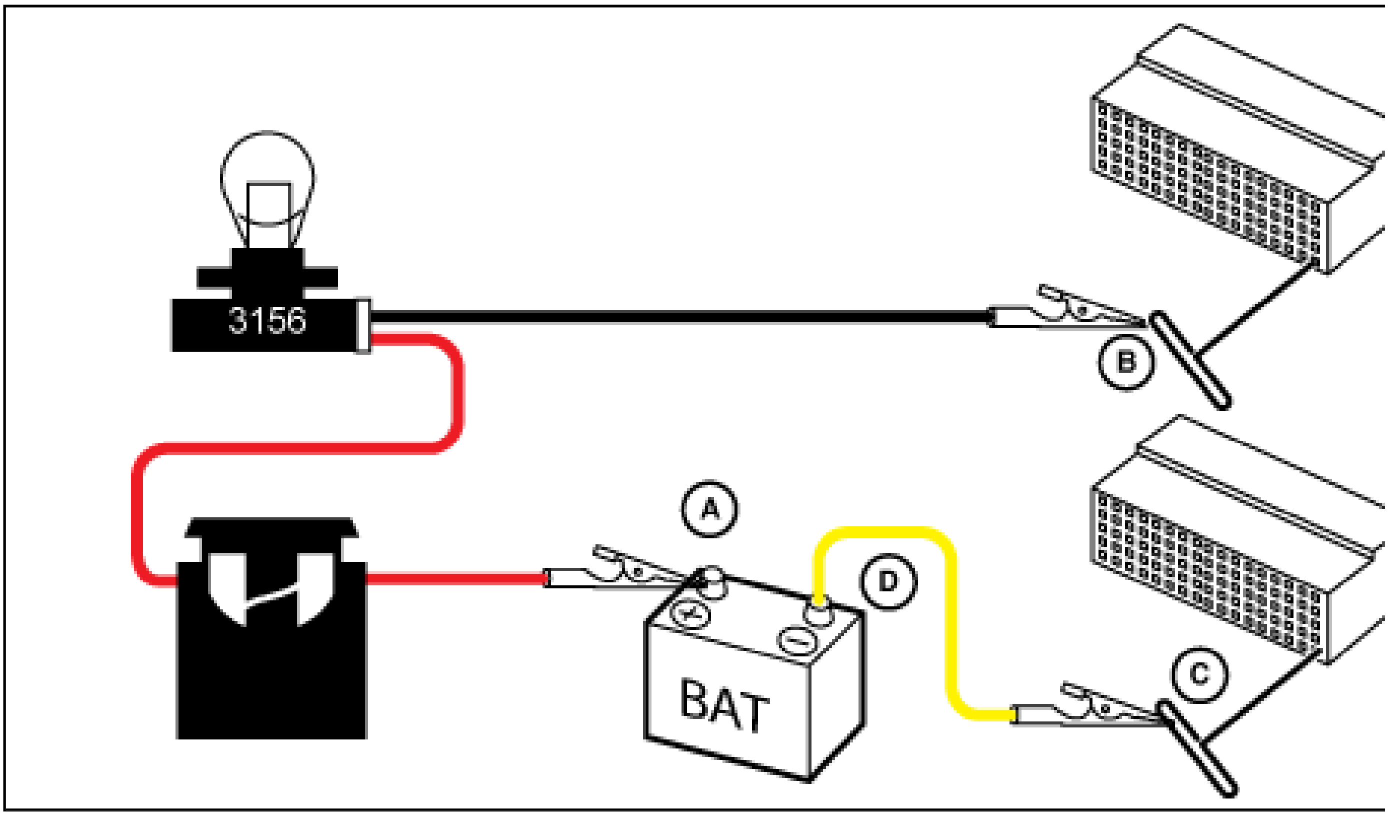
NOTE: **Note: A 12-volt test light can be substituted for the load test tool, but only if the test light draws enough current to effective circuit. Many high impedance test lights draw very little amperage (less than 0.1 amps) and are not reliable to load test a ci proper load test of a circuit, the tool being used should draw more than approximately 0.75 amps.**

NOTE: **Note: Why perform a Voltage Drop Test? To verify with certainty there is not any resistance in the circuit being tested, perf drop test across the 3156 bulb of the load test tool. To do so perform the following:**

- **1. Connect the leads of a DVOM to the alligator clips on the load test tool while the load test tool is connected in serie**
- **2. Compare the voltage drop across the bulb to the voltage reading across the Battery terminals.**
- **3. The voltage dropped across the bulb should be equal to the voltage reading across the Battery terminals if there is circuit being tested.**

Example: 2.0 Ohms of resistance in the circuit being tested will cause the voltage measurement across the bulb to be 25% compared to Battery voltage. The reason for this is that the 2.0 Ohms in the circuit makes up 25% of the total circuit resista

Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .



CAUTION: **Do not load test any circuits with components still connected to the circuit.**

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harı

   NOTE: **The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

   NOTE: **Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

   Is the load test bulb illuminated and bright?

   Yes

   - Go To 6

   No

   - Repair the circuit for an open or high resistance.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.

10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CO REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2AF8-STARTER RELAY "D" CONTROL CIRCUIT LOW

For a complete STARTING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

NOTE: **The terminology of the relays in this procedure can be confusing. To add clarity the Power Control Relay is the relay that makes connection between the two Batteries. The PCR Control Relay is in the PDC and is controlled by the Powertrain Control Module Side Driver (LSD). The relay can be removable or a Printed Circuit Board (PCB) relay depending on vehicle configuration. The P provides the power supply to operate the Power Control Relay.**

The Engine Stop/Start (ESS) system uses a **Power Control Relay (PCR)** and two Batteries to eliminate the voltage drop in the system voltage during an Auto-start ev consumer electronics and vehicle modules subsystems to continue to function in a normal manner. The Power Control Relay is connected in-line between the Main (Cra Auxiliary (Vehicle) Battery. The Power Control Relay is normally closed when de-energized, connecting the two Batteries. When the Power Control Relay is energized, breaks the connection between the Batteries.

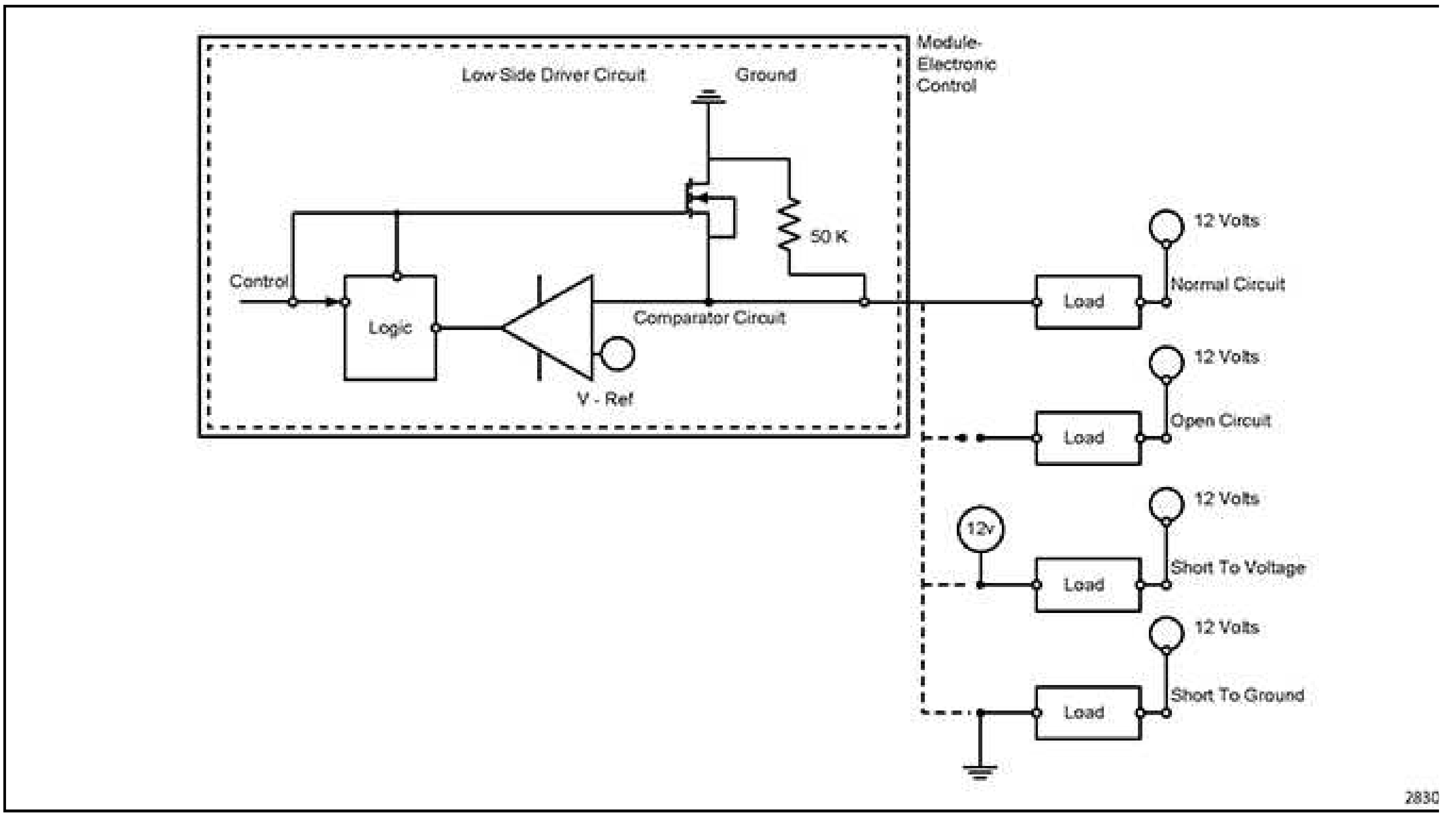
The engine starting and charging systems are connected directly to the Main Battery. When the Power Control Relay is closed (de-energized), the Auxiliary Battery is Battery. Therefore, if the Power Control Relay is stuck on (open), the Auxiliary Battery will not charge.

When ESS is active, and an **Auto-start crank event is initiated** , the **Power Control Relay** is temporarily energized when 12.0 volts is supplied from the output of the **the PDC** . When the Power Control Relay is energized it breaks the connection and allows the Batteries to work independently. When this occurs, the Main Battery is us engine. The Auxiliary Battery, which is now solely connected to the PDC and is not affected by cranking, can maintain full Battery voltage to the rest of the vehicle moc

Typical Low Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver dev ground to operate the device when switched on. The ground could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device, driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. For diagnostic purposes the PCM uses an internal pull d connected in series and a voltage reference (V-Ref) comparator for fault detection:

- **Circuit Open and Circuit Low Detection:** The PCM monitors for an **open circuit** and **short to ground** when the driver is switched off. When switched off, the through the device and the **internal pull down resistor** connected in series. The voltage at the **comparator circuit** should be close to Battery voltage since the m occurs through the diagnostic resistor. If the available voltage is less than the V-Ref, a fault is set. In this scenario the V-Ref would be slightly below Battery volta **method of fault detection for an open or short to ground** that is used is to monitor current draw when the internal driver is switched on. If the module does not determines that the component or circuitry is open. Excessive current draw detected would indicate a short to ground.
- **Circuit High Detection:** The PCM monitors for a **short to voltage** when the driver is switched on. When the driver is switched on providing a path to ground thr available voltage should be pulled low, near zero volts since the **comparator circuit** is monitoring the ground side of the device. If the voltage is greater than V-R this scenario V-Ref would be slightly above zero volts.

NOTE: **A load that has a resistance that is below manufacturer specification, or a second load device shorted to the low side driver circ excessive current draw on the internal driver. The driver will be switched off to protect against overheating and damaging the dr the Circuit High fault may be detected because the available voltage on the comparator circuit is above V-Ref.**



WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
- The PCR Control Relay commanded off.

SET CONDITION

- The Powertrain Control Module (PCM) detects a short to ground on the PCR Control Relay Control circuit.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
STOP/START RELAY OUTPUT CIRCUIT OPEN
PCR CONTROL RELAY CONTROL CIRCUIT SHORTED TO GROUND
PCR CONTROL RELAY CONTROL CIRCUIT OPEN
POWER DISTRIBUTION CENTER (PDC)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING P

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to INTERMITTENT CONDITION .
2. **CHECK FOR OTHER DTCS**

    NOTE: **The Battery supply for the PCR Control Relay coil is supplied by the Stop/Start Relay output.**

    1. Refer to the recorded DTCs.

Are there any Stop/Start Relay Control circuit DTCs present in the BCM?

Yes

- Perform the applicable diagnostic procedure(s). Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

No

- Go To 3

3. **CHECK THE BATTERY SUPPLY VOLTAGE AT THE STOP/START RELAY**
   1. Turn the ignition off.
   2. Remove the Stop/Start Relay from the relay connector in the Power Distribution Center (PDC).
   3. Turn the ignition on.
   4. Measure the voltage at terminal 30 at the Stop/Start Relay connector.

   Is the voltage equal to Battery voltage?

   Yes

   - Go To 4

   No

   - Check the fuse in the PDC. If the fuse is open, check all of the related output circuits for a short to ground and repair as necessary. Replace the fuse a issue. If no problems are found with the fuse, check the Battery supply to the PDC and the operation of the Run/Start Relay. If no problems are found accordance with the Service Information. Refer to **CENTER, POWER DISTRIBUTION (PDC), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK THE PCR CONTROL RELAY COIL AND PDC FOR AN OPEN/HIGH RESISTANCE**
   1. Connect a fused jumper between terminal 30 and terminal 87 at the Stop/Start Relay connector.
   2. Using a load test tool connected to ground, probe the Battery supply voltage coming from the Stop/Start Relay Output at terminal 86 at the PCR Control Re PDC.

   Is the load test tool bulb illuminated and bright?

   Yes

   - Go To 5

   No

   - Replace the PDC in accordance with the Service Information. Refer to **CENTER, POWER DISTRIBUTION (PDC), REMOVAL AND INSTALI**
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK THE PCR CONTROL RELAY FOR PROPER OPERATION**
   1. Remove the load test tool.
   2. Using a 12-volt test light connected to ground, back probe the PCR Control Relay (T762) Control circuit at the PDC connector.

   NOTE: **The relay should make an audible click when closing. Another way to verify that the relay closed is to back probe and on the Power Control Relay (T760) Control circuit.**

   Did the relay close when connecting the PCR Control Relay (T762) Control circuit to ground through the test light?

   Yes

   - Go To 6

   No

   - Replace the PDC in accordance with the service information. Refer to **CENTER, POWER DISTRIBUTION (PDC), REMOVAL AND INSTALL**
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **ISOLATE AND CHECK THE PCR CONTROL RELAY (T762) CONTROL CIRCUIT FOR A SHORT TO GROUND**
   1. The ignition must be off when checking a circuit for continuity to ground.
   2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. **Note:** Us diagram as a guide to follow the path of the circuit.
   3. Connect the negative lead of the DVOM to a known good ground.
   4. With the positive lead of the DVOM, probe the circuit being tested at the component harness connector and check for continuity between the circuit and gro

   CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

   1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM har

   NOTE: **There should be no continuity between ground and the circuit being tested.**

   Is there continuity between ground and the circuit being tested?

   Yes

   - Repair the circuit for a short to ground. Use the appropriate wiring diagram as a guide to trace the circuit and look for any in-line connectors to help i short.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

- Go To 7

7. **ISOLATE AND CHECK THE PCR CONTROL RELAY (T762) CONTROL CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and the component harness connector containing the circuit being tested. **Note:** Use t diagram as a guide to follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance t
    4. Connect one lead of the DVOM to the circuit being tested at the component harness connector.
    5. Connect the other lead to the circuit being tested at the GPEC Adaptor and measure the resistance of the circuit.

    CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting pin connection. Install the GPEC Diagnostic Adaptor to perform the diagnosis.**

    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM har

        NOTE: **IMPORTANT - The GPEC Diagnostic Adaptor can add up to 1.5 Ohms of resistance to the circuit.**

        Is the resistance below 3.0 Ohms?

        Yes

        - Go To 8

        No

        - Repair the circuit for an open or high resistance.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

8. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CO REMOVAL AND INSTALLATION** .
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

        No

        - The wiring or poor connection problem has been repaired.
        - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2AF9-STARTER RELAY "D" CONTROL CIRCUIT HIGH

For a complete STARTING SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

NOTE: **The terminology of the relays in this procedure can be confusing. To add clarity the Power Control Relay is the relay that makes connection between the two Batteries. The PCR Control Relay is in the PDC and is controlled by the Powertrain Control Module Side Driver (LSD). The relay can be removable or a Printed Circuit Board (PCB) relay depending on vehicle configuration. The P provides the power supply to operate the Power Control Relay.**

The Engine Stop/Start (ESS) system uses a **Power Control Relay (PCR)** and two Batteries to eliminate the voltage drop in the system voltage during an Auto-start ev consumer electronics and vehicle modules subsystems to continue to function in a normal manner. The Power Control Relay is connected in-line between the Main (Cra Auxiliary (Vehicle) Battery. The Power Control Relay is normally closed when de-energized, connecting the two Batteries. When the Power Control Relay is energized, breaks the connection between the Batteries.

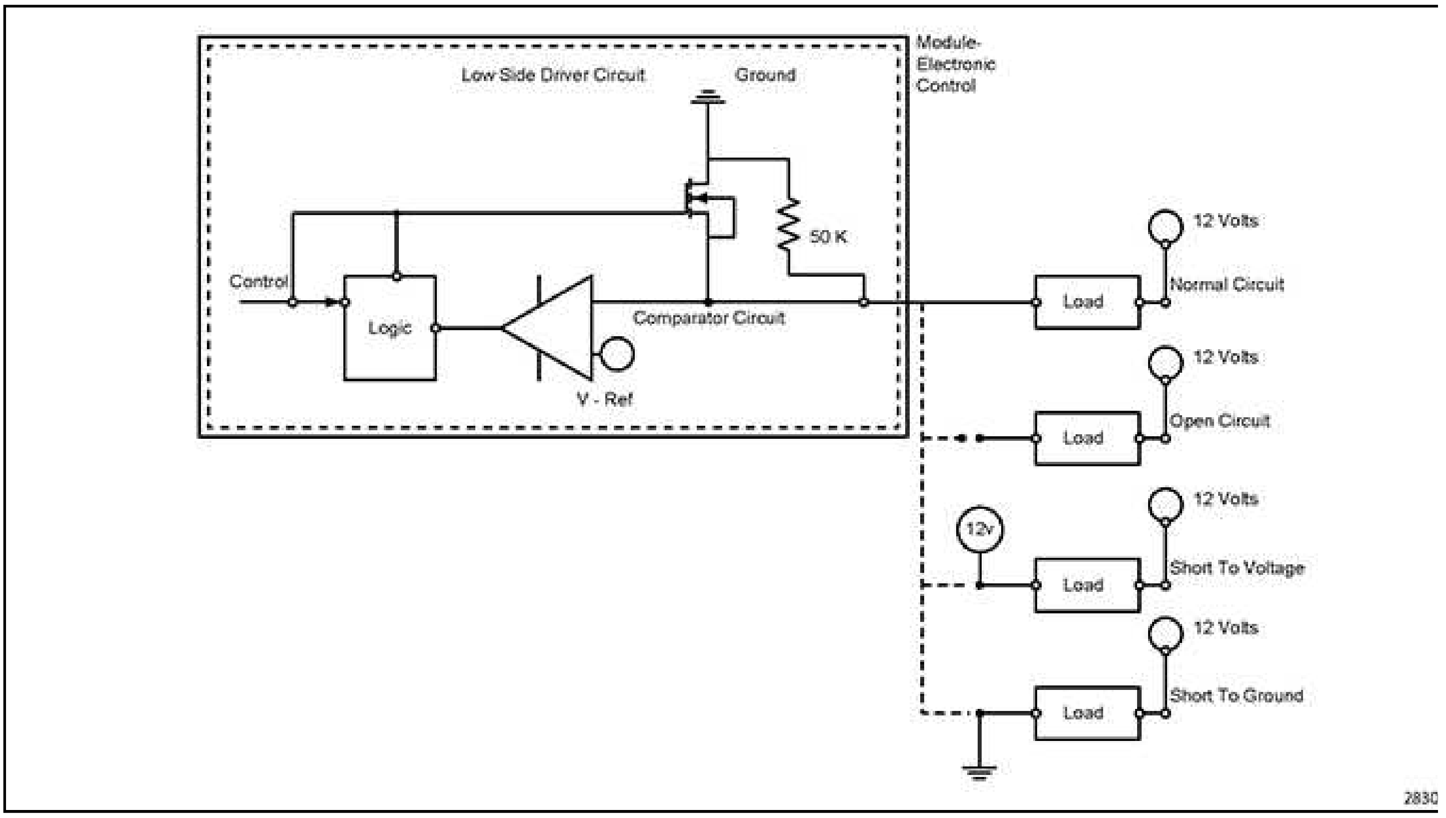
The engine starting and charging systems are connected directly to the Main Battery. When the Power Control Relay is closed (de-energized), the Auxiliary Battery is
Battery. Therefore, if the Power Control Relay is stuck on (open), the Auxiliary Battery will not charge.

When ESS is active, and an **Auto-start crank event is initiated** , the **Power Control Relay** is temporarily energized when 12.0 volts is supplied from the output of the
the PDC . When the Power Control Relay is energized it breaks the connection and allows the Batteries to work independently. When this occurs, the Main Battery is us
engine. The Auxiliary Battery, which is now solely connected to the PDC and is not affected by cranking, can maintain full Battery voltage to the rest of the vehicle moc

Typical Low Side Driver Operation and Fault Detection: This type of driver circuit is generally used for relay control, solenoid control or a similar type of driver dev
ground to operate the device when switched on. The ground could be constant or Pulse Width Modulated (PWM). The PCM also provides fault detection for the device,
driver. Fault detection can be done by monitoring voltage on the circuit, current draw, or a combination of both. For diagnostic purposes the PCM uses an internal pull d
connected in series and a voltage reference (V-Ref) comparator for fault detection:

- **Circuit Open and Circuit Low Detection:** The PCM monitors for an **open circuit** and **short to ground** when the driver is switched off. When switched off, the through the device and the **internal pull down resistor** connected in series. The voltage at the **comparator circuit** should be close to Battery voltage since the m occurs through the diagnostic resistor. If the available voltage is less than the V-Ref, a fault is set. In this scenario the V-Ref would be slightly below Battery volta **method of fault detection for an open or short to ground** that is used is to monitor current draw when the internal driver is switched on. If the module does not determines that the component or circuitry is open. Excessive current draw detected would indicate a short to ground.
- **Circuit High Detection:** The PCM monitors for a **short to voltage** when the driver is switched on. When the driver is switched on providing a path to ground thr available voltage should be pulled low, near zero volts since the **comparator circuit** is monitoring the ground side of the device. If the voltage is greater than V-R this scenario V-Ref would be slightly above zero volts.

NOTE: **A load that has a resistance that is below manufacturer specification, or a second load device shorted to the low side driver circ excessive current draw on the internal driver. The driver will be switched off to protect against overheating and damaging the dı the Circuit High fault may be detected because the available voltage on the comparator circuit is above V-Ref.**



WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
- The PCR Control Relay commanded on.

SET CONDITION

- The Powertrain Control Module (PCM) detects a short to voltage on the PCR Control Relay Control circuit.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
PCR CONTROL RELAY CONTROL CIRCUIT SHORTED TO VOLTAGE
POWER DISTRIBUTION CENTER (PDC)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.

2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
3. With the scan tool, erase all DTCs.
4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **ISOLATE AND CHECK THE PCR CONTROL RELAY (T762) CONTROL CIRCUIT FOR A SHORT TO ANOTHER CIRCUIT AT THE PCM HARN**
    1. The ignition must be off when performing a resistance check to find a short between circuits.
    2. Isolate the circuit by disconnecting the Electronic Control Unit (ECU) and every component harness connector containing the circuit being tested. At this ti connectors connected. **Note:** Use the appropriate wiring diagram as a guide to follow the path of the circuit.
    3. Connect one lead of the DVOM to the circuit being tested at the ECU harness connector.
    4. With the other lead of the DVOM probe all other circuits at the ECU harness connector.
    1. If it is necessary to probe a terminal at a PCM harness connector, connect the (special tool #10436, Adapter, GPEC Diagnostic) to the appropriate PCM harn

    NOTE: **With the circuit isolated there should be no continuity between the circuit being tested and any other circuit.**

    Is there continuity between the circuit being tested and any other circuit?

    Yes

    - Repair the short between the circuits that have continuity. Use the appropriate wiring diagram as a guide to trace the circuits and look for any in-line c the location of the short.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 3

3. **ISOLATE AND CHECK THE PCR CONTROL RELAY COIL CIRCUIT RESISTANCE**
    1. The ignition must be off when checking the continuity of a circuit.
    2. Isolate the circuit by removing the Stop/Start Relay from the PDC and disconnecting the appropriate PDC harness connector. **Note:** Use the appropriate wir follow the path of the circuit.
    3. Before measuring the resistance of any circuit, first measure the resistance between the two leads of the DVOM. **Note:** The meter leads can add resistance t
    4. Connect one lead of the DVOM to terminal 87 at the Stop/Start Relay connector in the PDC.
    5. Connect the other lead to the PDC terminal for the PCR Control Relay (T762) Control circuit and measure the resistance of the circuit.

    NOTE: **Connect the lead to the PDC terminal (component side), not the harness connector.**

    Is the resistance between 160.0 and 250.0 Ohms?

    Yes

    - Go To 4

    No

    - Replace the PDC in accordance with the Service Information. Refer to **CENTER, POWER DISTRIBUTION (PDC), REMOVAL AND INSTALI**
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.

9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CO REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P2B57-LOW ENGINE OIL PRESSURE - CAMSHAFT CONTROL DISABLED

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the engine running.
- Oil temperature is between -10B°C (14B°F) and 188B°C (370.4B°F).
- No active Engine Oil Temperature (EOT) Sensor or Engine Oil Pressure (EOP) Sensor circuit faults.
- No active Variable Valve Lift (VVL) Solenoid circuit or performance faults.

SET CONDITION

- The engine oil pressure never reaches the calibrated specification to allow VVL activation.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
ENGINE OIL LEVEL LOW
ENGINE OIL AERATED OR CONTAMINATED
INCORRECT ENGINE OIL FILTER
INSUFFICIENT OIL PRESSURE DUE TO A MECHANICAL FAILURE IN THE OILING SYSTEM
ENGINE OIL PRESSURE (EOP) SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any Engine Oil Temperature Sensor, Engine Oil Pressure Sensor, or VVL Solenoid DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3
3. **CHECK THE ENGINE OIL CONDITION**
   1. Turn the ignition off.
   2. The following items should be checked before continuing with this procedure. Failure to do so may lead to misdiagnosis.
      - LOW ENGINE OIL LEVEL

- AERATED ENGINE OIL
- INCORRECT ENGINE OIL FILTER (DOES NOT MEET OEM SPECIFICATIONS)
- DETERIORATED OR DIRTY OIL
- CONTAMINATED ENGINE OIL
- INCORRECT ENGINE OIL VISCOSITY

Were any of the above conditions present?

Yes

- Repair the engine oiling or mechanical condition (i.e. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 4

4. **CHECK THE ENGINE OIL PRESSURE AND ENGINE MECHANICAL CONDITION**
   1. Install an oil pressure gauge to the engine.
   2. Start the engine and allow it to idle.
   3. Monitor the engine oil pressure reading on the gauge.

   NOTE: **The oil pressure must be above 20 psi and not oscillating excessively for proper operation of the VVL system and Ro**

   Is the oil pressure reading stable and above 20.0 psi?

   Yes

   - Go To 5

   No

   - Repair the engine oiling or mechanical condition (I.E. improper oil drain back, oil sludge, damaged oil pump, pick-up tube or seal, etc.).
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **COMPARE THE ACTUAL ENGINE OIL PRESSURE TO THE EOP SENSOR READING**
   1. With the scan tool, monitor the EOP Sensor reading.

   Does the EOP Sensor reading on the scan tool match the actual oil pressure reading?

   Yes

   - Go To 6

   No

   - Replace the Engine Oil Pressure Sensor in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.
   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CO REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P3090-UPSTREAM O2 SENSOR RETURN VOLTAGE LOW

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperatu element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heat proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a ca heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater te using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating te output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/f higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negati each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnosti algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 S Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits origina within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sens
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Se separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return ci the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywher Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heate disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that igniti of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (us above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Con High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resista may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High D** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can he diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on t the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or**

Using the Scan Tool for Diagnostics:	
	circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will b 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltag** read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) V Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heate** cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the a to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affecte sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sen affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt inste volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in **Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor re shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shor read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors wil on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and ret voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condit tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, th voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Battery voltage between 11.0 and 15.75 volts.
- With the engine running.

SET CONDITION

- The Upstream O2 Sensor Return circuit voltage is less than 0.9 - 0.96 volts depending on calibration for approximately 9.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
UPSTREAM O2 SENSOR SIGNAL CIRCUIT SHORTED TO GROUND
UPSTREAM O2 SENSOR RETURN CIRCUIT SHORTED TO GROUND
UPSTREAM O2 SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **CHECK FOR ANY APPLICABLE SERVICE BULLETINS**
    1. Check for any Service Bulletins or flash updates that may apply.

       Are there any Service Bulletins or flash updates available?

       Yes

       - Perform the Service Bulletins or flash update.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **CHECK FOR AN ACTIVE DTC**
    1. Start the engine and allow it to idle long enough for the O2 Sensors to enter closed loop operation (approximately 30 seconds).

2. With the scan tool, read DTCs and record on the repair order.

   Is the DTC active or pending?

   Yes

   - Go To 3

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

3. **CHECK THE O2 SENSOR VOLTAGE READINGS WITH THE SCAN TOOL**
   1. With the scan tool select the Data tab and monitor all of the O2 Sensor voltage readings.

      NOTE: Check the voltage readings for all of the O2 Sensors to determine if all of the sensors are switching between 0-1 volt is stuck near 0.0 volts.

      Pick the correct scenario below:

      All O2 Sensors are switching between 0-1 volts on the biased O2 Sensor Signal voltage reading:

      - Go To 4

      One O2 Sensor is reading 0.0 volts and the other O2 Sensors are switching between 0-1 volts on the biased O2 Sensor Signal voltage reading:

      - This indicates a likely short to ground on the signal circuit of the sensor reading near 0.0 volts. Repair the O2 Sensor Signal circuit of the O2 Sensor t volts for a short to ground. If it is determined that the signal circuit is not shorted to ground, the O2 Sensor is likely internally shorted.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

4. **CHECK FOR A SHORTED O2 SENSOR**

   WARNING: When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. clothing. Failure to follow these instructions may result in possible serious or fatal injury.

   1. Disconnect any one of the O2 Sensor harness connectors.
   2. With the scan tool, monitor the voltage readings of the O2 Sensors that are STILL CONNECTED.

      NOTE: If the fault is caused by an O2 Sensor that is internally shorted, the other O2 Sensors should change from switching l switching between 2.5 - 3.5 volts when the faulty O2 Sensor is disconnected.

   3. Reconnect the O2 Sensor harness connector and repeat this step for each of the O2 Sensors on the vehicle.

      Did the voltages change to approximately 2.5 - 3.5 volts for the O2 Sensors STILL CONNECTED when disconnecting any one of the sensors?

      Yes

      - Replace the faulty O2 Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 5

5. **CHECK THE (K902) O2 SENSOR UPSTREAM RETURN CIRCUIT FOR A SHORT TO GROUND**
   1. Turn the ignition off.
   2. Disconnect the PCM C2 harness connector.
   3. Disconnect the O2 Sensor 1/1 harness connector.
   4. Disconnect the O2 Sensor 2/1 harness connector.
   5. Check for continuity between ground and the (K902) O2 Sensor Upstream Return circuit at the O2 Sensor 1/1 or 2/1 harness connector.

      Is there continuity between ground and the (K902) O2 Sensor Upstream Return circuit?

      Yes

      - Repair the (K902) O2 Sensor Upstream Return circuit for a short to ground.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 6

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).

- Terminals that have been pushed back into the connector cavity.
- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CO REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P3091-UPSTREAM O2 SENSOR RETURN VOLTAGE HIGH

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperatu element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heat proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a cal heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater ter using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating te output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/f higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negati each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnosti algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 S Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits origina within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Senso
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Se separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return ci the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywher Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heate disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that igniti of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (us above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Con High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resista may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High D** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can he diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on t the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature**

Using the Scan Tool for Diagnostics:	
	the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will b 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltag** read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) V Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heate** cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the a to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affecte sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sen affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt inste volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned in **Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor re shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shor read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors wil on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and ret voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condit tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, th voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Battery voltage between 11.0 - 15.75 volts.
- With the engine running.

SET CONDITION

- Upstream O2 Sensor Return circuit voltage is above approximately 3.9 volts for 9.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
UPSTREAM O2 SENSOR RETURN CIRCUIT SHORTED TO VOLTAGE
UPSTREAM O2 SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE
UPSTREAM OXYGEN SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **CHECK FOR ANY APPLICABLE SERVICE BULLETINS**
    1. Check for any Service Bulletins or flash updates that may apply.

       Are there any Service Bulletins or flash updates available?

       Yes

       - Perform the Service Bulletins or flash update.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 2
2. **CHECK THE O2 SENSOR VOLTAGE READINGS ON THE SCAN TOOL**
    1. Turn the ignition on, engine not running.
    2. With the scan tool select the Data tab and monitor all of the O2 Sensor raw voltage readings.

       NOTE: Do not use the O2 volts (0-1) data.

    3. Start the engine and allow it to idle long enough for the O2 Sensors to enter closed loop operation (approximately 30 seconds).

       NOTE: The O2 Sensor voltages should normally be switching between approximately 2.5 - 3.5 volts with the engine idling. If or reference circuit is shorted to voltage, the voltage readings will read approximately 5.0 volts.

       Are all of the O2 Sensor voltage readings switching between approximately 2.5 - 3.5 volts?

       Yes

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

       No

       - Go To 3
3. **CHECK FOR A SHORTED O2 SENSOR**

    WARNING: When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. clothing. Failure to follow these instructions may result in possible serious or fatal injury.

    1. Disconnect any one of the O2 Sensor harness connectors.
    2. With the scan tool, monitor the voltage readings of the O2 Sensors that are STILL CONNECTED.

       NOTE: If the fault is caused by an O2 Sensor that is internally shorted or the signal circuit shorted to voltage, the other O2 S change to switching between 2.5 - 3.5 volts when the faulty O2 Sensor is disconnected.

    3. Reconnect the O2 Sensor harness connector and repeat this step for each of the O2 Sensors on the vehicle.

       Did the voltages change to approximately 2.5 - 3.5 volts for the O2 Sensors STILL CONNECTED when disconnecting any one of the sensors?

       Yes

       - Go To 4

       No

       - Go To 5
4. **CHECK THE FAULTY O2 SENSOR SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the affected O2 Sensor harness connector.
    3. Measure the voltage on the O2 Sensor Signal circuit.

       Is the voltage above 5.0 volts?

       Yes

       - Repair the O2 Sensor Signal circuit for a short to voltage.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Replace the faulty O2 Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **CHECK THE UPSTREAM O2 SENSOR (K902) RETURN CIRCUIT FOR A SHORT TO VOLTAGE**
    1. Turn the ignition off.
    2. Disconnect the O2 Sensor 1/1 harness connector.
    3. Disconnect the O2 Sensor 2/1 harness connector.
    4. Turn the ignition on.
    5. Measure the voltage on the Upstream O2 Sensor (K902) Return circuit at the O2 Sensor 1/1 or 2/1 harness connector.

       Is the voltage above 2.75 volts?

Yes

- Repair the Upstream O2 Sensor (K902) Return circuit for a short to voltage.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.
    3. Disconnect all related in-line harness connections (if equipped).
    4. Disconnect the related component harness connectors.
    5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.
    6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    9. With the scan tool, erase DTCs.
    10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CO REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P3092-DOWNSTREAM O2 SENSOR RETURN VOLTAGE LOW

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperatu element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heat proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a ca heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater te using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating te output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/f higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negati each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnosti algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 S Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits origina within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Sens
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Se separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return ci the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywhe Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.

- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heate disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that igniti of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (us above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Con High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resista may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High D** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can he diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on t the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.**
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward sensor heats up.** When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will b 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltag** read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) V Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heate** cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the a to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affecte sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sen affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt inste volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned ir **Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor re shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shor read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors wil on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and ret voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condit

Using the Scan Tool for Diagnostics:	
	tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, th voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Battery voltage between 11.0 and 15.75 volts.
- With the engine running.

SET CONDITION

- The Downstream O2 Sensor Return circuit voltage is less than 0.9 - 0.96 volts depending on calibration for approximately 9.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
DOWNSTREAM O2 SENSOR SIGNAL CIRCUIT SHORTED TO GROUND
DOWNSTREAM O2 SENSOR RETURN CIRCUIT SHORTED TO GROUND
DOWNSTREAM O2 SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **CHECK FOR ANY APPLICABLE SERVICE BULLETINS**
   1. Check for any Service Bulletins or flash updates that may apply.

      Are there any Service Bulletins or flash updates available?

      Yes

      - Perform the Service Bulletins or flash update.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .

      No

      - Go To 2
2. **CHECK FOR AN ACTIVE DTC**
   1. Start the engine and allow it to idle long enough for the O2 Sensors to enter closed loop operation (approximately 30 seconds).
   2. With the scan tool, read DTCs and record on the repair order.

      Is the DTC active or pending?

      Yes

      - Go To 3

      No

      - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to INTERMITTENT CONDITION .
3. **CHECK THE O2 SENSOR VOLTAGE READINGS WITH THE SCAN TOOL**
   1. With the scan tool select the Data tab and monitor all of the O2 Sensor voltage readings.

      NOTE: **Check the voltage readings for all of the O2 Sensors to determine if all of the sensors are switching between 0-1 volt is stuck near 0.0 volts.**

      Pick the correct scenario below:

      All O2 Sensors are switching between 0-1 volts on the biased O2 Sensor Signal voltage reading:

      - Go To 4

      One O2 Sensor is reading 0.0 volts and the other O2 Sensors are switching between 0-1 volts on the biased O2 Sensor Signal voltage reading:

      - This indicates a likely short to ground on the signal circuit of the sensor reading near 0.0 volts. Repair the O2 Sensor Signal circuit of the O2 Sensor t volts for a short to ground. If it is determined that the signal circuit is not shorted to ground, the O2 Sensor is likely internally shorted.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to POWERTRAIN VERIFICATION TEST .
4. **CHECK FOR A SHORTED O2 SENSOR**

   WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

   1. Disconnect any one of the O2 Sensor harness connectors.
   2. With the scan tool, monitor the voltage readings of the O2 Sensors that are STILL CONNECTED.

      NOTE: **If the fault is caused by an O2 Sensor that is internally shorted, the other O2 Sensors should change from switching l switching between 2.5 - 3.5 volts when the faulty O2 Sensor is disconnected.**

3. Reconnect the O2 Sensor harness connector and repeat this step for each of the O2 Sensors on the vehicle.

Did the voltages change to approximately 2.5 - 3.5 volts for the O2 Sensors STILL CONNECTED when disconnecting any one of the sensors?

Yes

- Replace the faulty O2 Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 5

5. **CHECK THE (K904) O2 SENSOR DOWNSTREAM RETURN CIRCUIT FOR A SHORT TO GROUND**
   1. Disconnect the O2 Sensor 1/2 harness connector.
   2. Disconnect the O2 Sensor 2/2 harness connector.
   3. Check for continuity between ground and the (K904) O2 Sensor Downstream Return circuit at the O2 Sensor 1/2 or 2/2 harness connector.

   Is there continuity between ground and the (K904) O2 Sensor Downstream Return circuit?

   Yes

   - Repair the (K904) O2 Sensor Downstream Return circuit for a short to ground.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - Go To 6

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CO REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

   No

   - The wiring or poor connection problem has been repaired.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

P3093-DOWNSTREAM O2 SENSOR RETURN VOLTAGE HIGH

THEORY OF OPERATION

O2 Sensor Heater Operation: For a typical Switching (4 Wire) Oxygen (O2) Sensor output signal to function the sense element must be heated to operating temperatu element is incorporated within the sensor to allow for rapid heating of the sensor to reach operating temperature faster and closed loop fuel control. The O2 Sensor Heat proportional to the heater temperature, meaning that as heater temperature increases, the heater resistance increases. The Powertrain Control Module (PCM) makes a ca heater resistance and temperature. The heater resistance is calculated by measuring the Battery voltage and current draw on the heater control circuit, Then the heater te using the resistance versus temperature characteristic. The heater temperature is monitored continuously and the heating rate is adjusted using Pulse Width Modulation (damaging the heating element. If the PCM detects a fault in the O2 Sensor heater circuitry the internal PCM driver is disabled during the current ignition cycle.

O2 Sensor Output Operation: Normal range of the O2 Sensor output is a 0 to 1.0 volt Analog to Digital (A/D) signal when the sensor is within the normal operating te output voltage is generated by comparing the Oxygen content in the atmosphere, collected in a reference chamber to the Oxygen content in the exhaust stream collected chamber. When the oxygen content is high (caused by a lean air/fuel mixture) the sensor produces a low voltage. When the oxygen content is low (caused by a rich air/f higher voltage. In some instances a negative offset output of up to -1.0 volt may be introduced if the sensor's reference chamber is contaminated. To allow for the negati each O2 Sensor Return circuit has a 2.5 volt bias added to shift the signal voltage to between 2.5 volts and 3.5 volts.

O2 Sensor Diagnostics: The Powertrain Control Module (PCM) performs diagnostics on the heater control, signal and sensor return circuits. The circuit fault diagnosti algorithm based because of how the O2 Sensor operates. This means an open or short in one of the O2 Sensor circuits can cause a fault to set against another of the O2 S Understanding how to interpret the combination of DTCs and O2 Sensor data provided can aid in narrowing down where the fault is in the system.

- **On vehicle/engine combinations that use only the traditional switching O2 Sensors,** both of the Upstream and Downstream O2 Sensor Return circuits origina within the PCM. Because of this, a short anywhere in the wiring in any of the O2 Sensor Return circuits will affect all of the Upstream and Downstream O2 Senso
- **On vehicle/engine combinations that have wide-band Upstream O2 Sensors and switching Downstream O2 Sensors,** the Upstream and Downstream O2 Ser separate within the PCM. In this case a short anywhere in the wiring in the Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s individual diagnostics on the O2 Sensor Return circuit for each wide-band Upstream O2 Sensor.
- **On vehicle/engine combinations that use only the traditional switching O2 Sensors with GPEC 5 PCM,** the Upstream and Downstream O2 Sensor Return ci the PCM. In this case a short anywhere in the wiring in the Upstream O2 Sensor Return circuit(s) will only affect the Upstream O2 Sensor(s) and a short anywher Downstream O2 Sensor Return circuit(s) will only affect the Downstream O2 Sensor(s).

With the scan tool in data display, filter on O2 in the search function and bring up the following info:

- **O2 Sensor signal voltage** - the **biased signal voltage** should switch between 2.5 and 3.5 volts on a normally functioning sensor.
- **O2 Sensor (0-1) signal voltage** - this is the **raw O2 Sensor signal voltage** without the 2.5 volt bias on the return circuit of a normally functioning O2 Sensor.
- **Heater driver operation** - displays the heater duty cycle.
- **Heater temperature** - this is determined by the total heater circuit resistance.
- **Closed loop fuel control state** - displays as open/closed.

Using the Scan Tool for Diagnostics:	
O2 Sensor Heater Diagnosis:	An open circuit or direct short to voltage or ground will cause the PCM to disable the heater PWM control. The heate disabled for the remainder of that ignition cycle, even if the condition is intermittent and heals itself during that igniti of these conditions should set an O2 Sensor Heater Low or High DTC. **Since the heater directly affects the output signal,** and the heater control is disabled, this will cause the affected O2 Sensor biased signal voltage to read high (us above 4.0 volts) and can also eventually set a **Signal Circuit High DTC** . It is not unusual to have both a Heater Con High or Low DTC and a Sensor Signal High DTC for the same sensor. **Important Note: A small amount of resistar may not set a Heater Control Circuit DTC but will affect heater operation and cause the Sensor Signal High D** Monitoring the heater duty cycle and temperature for a sensor that is reading high on the biased signal voltage can he diagnosing this issue. A heater circuit with 4.0 - 5.0 Ohms resistance can increase the heater temperature reading on t the affected sensor by as much as 700B°F when compared to the other Switching (4 wire) O2 Sensors. As little as 2.0 increase the temperature reading approximately 250B°F on the scan tool. **NOTE:** **When a normally operating Switching O2 Sensor is heated to operating temperature the typical duty cycle percentage will range between approximately 30 and 50 percent. The typical heater temperature will range between approximately 1200B°F and 1400B°F on the scan tool. If there is an issue with the O2 Sensor heater or circuitry the PCM will disable the heater driver and the duty cycle will be 0 percent. Any issues in the heater circuitry, even a small amount of resistance, will cause the temperature reading to be noticeably higher than normal.**
O2 Sensor Signal Low Diagnosis:	Monitoring the scan tool and starting the engine with an **O2 Sensor Signal shorted to ground** , and the O2 Sensor is show the biased signal voltage at 0 volts **but the (0-1) raw voltage signal will read -2.5 volts and increase toward**

Using the Scan Tool for Diagnostics:	
	sensor heats up. When the sensor is warm the biased signal voltage reading and the (0-1) raw voltage reading will b 0.0 volts. It will also pull the sensor return bias voltage low through the O2 Sensor. This will cause the **biased voltag** read between the 0-1 volt range on the other O2 Sensors. **This can also cause the O2 Sensor Reference (Return) V Low DTC to set.**
O2 Sensor Signal High Diagnosis:	The O2 Sensor Signal High diagnostic can fail due to several conditions. A open, short or any resistance in the **heate** cause the signal voltage to remain high. Look for abnormalities in the heater duty cycle or heater temperature of the a to help indicate a possible heater control issue causing the signal circuit high fault. An open in a sensor return circuit biased signal voltage to read high, near 5.0 volts, and the (0-1) raw voltage reading to be near 2.5 volts for the affecte sensors. An open in the signal circuit will have the same effect on the sensor. If the Upstream or Downstream O2 Sen affected, it could indicate an open in the return circuit that is before the splice in the harness.
P1621, P3090, and P3092 O2 Sensor Reference (Return) Circuit Low Diagnosis:	The O2 Sensor Reference Circuit Low/High diagnostic is used to monitor the O2 Sensor Return circuits. If any of the circuits are shorted to ground the biased signal voltage readings for all O2 Sensors will switch between 0-1 volt inste volts. This happens because the bias voltage on the return circuit is pulled low for all shared sensors. As mentioned ir **Sensor Signal Low Diagnosis** above, a short to ground in one of the sensor signal circuits will also pull the sensor re shared sensors after the sensor warms up. However, this will cause the voltage reading on the sensor that has the shor read 0.0 volts on both the biased signal voltage and (0-1) raw voltage reading when the sensor is warm.
P1622, P3091, and P3093 O2 Sensor Reference (Return) Circuit High Diagnosis:	A short to voltage in any of the shared **sensor return circuits** will cause the fault to set. The affected O2 Sensors wil on the biased signal voltage. The (0-1) raw voltage reading will be 0.0 volts because the signal circuit voltage and ret voltage are both 5.0 volts. A short to voltage on one of the **O2 Sensor signal circuits** will cause the same fault condit tool readings when the sensor is warm. If the condition is present when the engine is started and the sensor is cold, th voltage reading will start at 2.5 volts and decrease to 0.0 volts as the sensor warms up.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- Battery voltage between 11.0 - 15.75 volts.
- With the engine running.

SET CONDITION

- Downstream O2 Sensor Return circuit voltage is above approximately 3.9 volts for 9.0 seconds.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
DOWNSTREAM O2 SENSOR RETURN CIRCUIT SHORTED TO VOLTAGE
DOWNSTREAM O2 SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE
DOWNSTREAM OXYGEN SENSOR
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

DIAGNOSTIC TEST

1. **CHECK FOR ANY APPLICABLE SERVICE BULLETINS**
    1. Check for any Service Bulletins or flash updates that may apply.

    Are there any Service Bulletins or flash updates available?

    Yes

    - Perform the Service Bulletins or flash update.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 2
2. **CHECK THE O2 SENSOR VOLTAGE READINGS ON THE SCAN TOOL**
    1. Turn the ignition on, engine not running.
    2. With the scan tool select the Data tab and monitor all of the O2 Sensor raw voltage readings.

    NOTE: Do not use the O2 volts (0-1) data.

    3. Start the engine and allow it to idle long enough for the O2 Sensors to enter closed loop operation (approximately 30 seconds).

    NOTE: The O2 Sensor voltages should normally be switching between approximately 2.5 - 3.5 volts with the engine idling. If or reference circuit is shorted to voltage, the voltage readings will read approximately 5.0 volts.

    Are all of the O2 Sensor voltage readings switching between approximately 2.5 - 3.5 volts?

    Yes

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

    No

    - Go To 3
3. **CHECK FOR A SHORTED O2 SENSOR**

WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

1. Disconnect any one of the O2 Sensor harness connectors.
2. With the scan tool, monitor the voltage readings of the O2 Sensors that are STILL CONNECTED.

   NOTE: **If the fault is caused by an O2 Sensor that is internally shorted or the signal circuit shorted to voltage, the other O2 S change to switching between 2.5 - 3.5 volts when the faulty O2 Sensor is disconnected.**

3. Reconnect the O2 Sensor harness connector and repeat this step for each of the O2 Sensors on the vehicle.

   Did the voltages change to approximately 2.5 - 3.5 volts for the O2 Sensors STILL CONNECTED when disconnecting any one of the sensors?

   Yes

   - Go To 4

   No

   - Go To 5

4. **CHECK THE FAULTY O2 SENSOR SIGNAL CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the affected O2 Sensor harness connector.
   3. Measure the voltage on the O2 Sensor Signal circuit.

      Is the voltage above 5.0 volts?

      Yes

      - Repair the O2 Sensor Signal circuit for a short to voltage.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Replace the faulty O2 Sensor in accordance with the Service Information. Refer to **ENGINE SENSORS, REMOVAL AND INSTALLATION** .
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
5. **CHECK THE DOWNSTREAM O2 SENSOR (K904) RETURN CIRCUIT FOR A SHORT TO VOLTAGE**
   1. Turn the ignition off.
   2. Disconnect the O2 Sensor 1/2 harness connector.
   3. Disconnect the O2 Sensor 2/2 harness connector.
   4. Turn the ignition on.
   5. Measure the voltage on the Downstream O2 Sensor (K904) Return circuit at the O2 Sensor 1/2 or 2/2 harness connector.

      Is the voltage above 2.75 volts?

      Yes

      - Repair the Downstream O2 Sensor (K904) Return circuit for a short to voltage.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 6
6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
   1. Perform any Service Bulletins that apply.
   2. Disconnect all PCM harness connectors.
   3. Disconnect all related in-line harness connections (if equipped).
   4. Disconnect the related component harness connectors.
   5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   9. With the scan tool, erase DTCs.
   10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   11. With the scan tool, read DTCs.

       Did the DTC return?

Yes

- Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CO REMOVAL AND INSTALLATION** .
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

U0001-00-CAN C BUS

NOTE: **This DTC may not be listed in the Body Control Module (BCM) diagnostic procedures. If this DTC is not found in the BCM diagn perform the comparable CAN C Bus diagnostic test, such as CAN C BUS-NO SIGNAL, CAN C BUS OFF PERFORMANCE or CAN**

Perform the comparable CAN C Bus diagnostic tests in the BCM. Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

U0101-00-LOST COMMUNICATION WITH TCM

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIA PROCEDURE. Refer to **COMMUNICATION DIAGNOSTIC PROCEDURE** .

U0102-00-LOST COMMUNICATION WITH TRANSFER CASE CONTROL MODULE / AWD

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIA PROCEDURE. Refer to **COMMUNICATION DIAGNOSTIC PROCEDURE** .

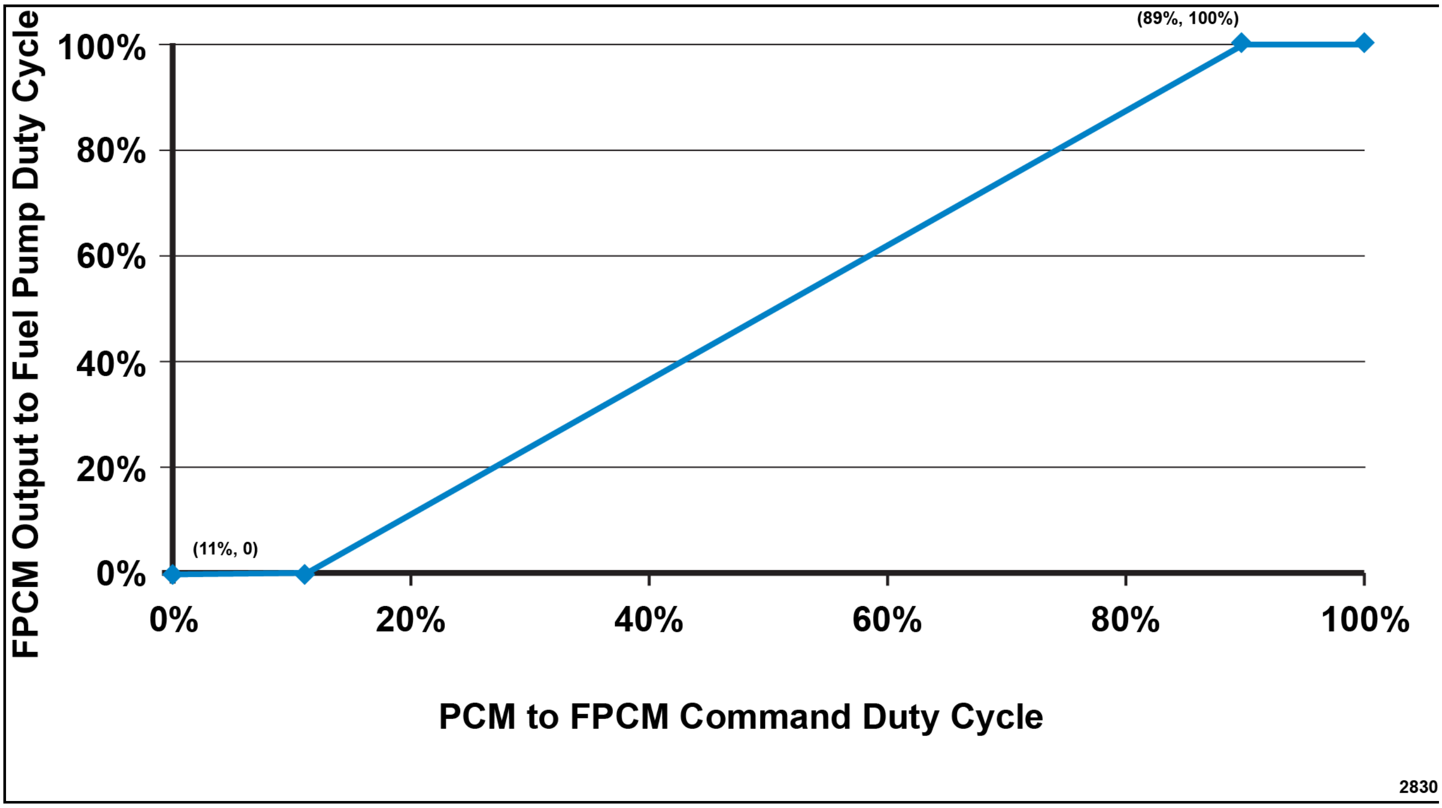
U0109-LOST COMMUNICATION WITH FUEL PUMP CONTROL MODULE

For a complete FUEL DELIVERY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

FPCM SYSTEM DESCRIPTION AND OPERATION

SYSTEM DESCRIPTION: When the Powertrain Control Module (PCM) requires Fuel Pump operation it energizes the Fuel Pump Relay. The Battery voltage output f connect directly to the Fuel Pump like traditional systems. Instead, the Battery voltage is supplied to the Fuel Pump Control Module (FPCM). When the ignition is swit voltage is present for approximately five seconds. Battery voltage should always be present during cranking or when the engine is running. The purpose of FPCM is to c a reduced voltage output to reduce electrical load on the system. Most vehicle/engine combinations operate as a **fixed pressure system** . Vehicles with the 6.2L engine c **pressure system** . It is necessary on some vehicles with the 6.2L engine to have a second Fuel Pump and FPCM to meet engine needs. The second FPCM performs the primary module but uses different DTCs.

SYSTEM OPERATION: To maintain the desired fuel pressure, the PCM sends a Pulse Width Modulated (PWM) duty cycle signal to the FPCM. If there are no systen Pump Control output to the Fuel Pump is based on the duty cycle sent by the PCM. The graph below shows the FPCM output to the Fuel Pump in proportion to the PCM **FPCM output to the fuel pump will not read as a duty cycle when monitoring with a Mopar Scope. It will be a consistent voltage output that is a percentage of**



COMPONENT FUNCTIONAL DESCRIPTION- FUEL PUMP CONTROL MODULE (FPCM) AND FUEL PUMP

The FPCM performs fault detection and reports faults to the PCM through the PWM Feedback circuit. The feedback circuit can be monitored using the Mopar Scope an

- The feedback circuit is a 5.0 volt duty cycle.
- The PCM supplies the 5.0 volts for the feedback circuit.
- The FPCM pulses the low side of the circuit to communicate with the PCM.
- The normal duty cycle operating range is between 3% and 97%.

- When the system is operating normally, the FPCM will send a 50% duty cycle on the feedback circuit to the PCM.
- When the FPCM detects a fault it will send a duty cycle that aligns with the failure mode detected.
- If the duty cycle is 0% or 100% the PCM will set the Loss of Communication fault against the FPCM.

NOTE: **Monitoring the FPCM internal driver with an open feedback circuit using the Mopar Scope will show a pulse width signal with a v (.025v - 0.5v). This is picking up voltage from the internal driver device that is still trying to pulse the duty cycle to the PCM. This performing diagnostics on the feedback circuitry.**

Depending on the failure mode detected by the PCM and FPCM, the FPCM can react by either reducing the PWM output duty cycle, or defaulting to an 80% duty cycle operation. The FPCM reactions are explained further in the PCM/FPCM Reaction column of the Enable Conditions and Failure Modes information.

Fuel Pump: The Fuel Pump operates in the same manner as a typical Brushed DC motor. The only difference is that the speed is reduced due to the PWM output voltag less than 100%. The voltage supplied is based on the command received from the PCM.

Vehicles with Dual Pump Systems: The fuel pumps operate independently, but may be serviced as an assembly on some vehicles. During normal operation both Fuel I the system pressure and volume needed during most engine operating conditions. **The exception is at idle, or idle and purging where there is extremely low fuel den** Fuel Pump 2 is typically turned off. When more fuel demand is needed (typically off idle) Fuel Pump 2 is turned on and both pumps are operated at the same duty cycle the vehicle may still operate normally during most driving conditions but would have performance issues under heavy engine load when both pumps are needed. If a fai Fuel Pump or circuitry, the duty cycle will typically default to 80%. If Fuel Pump 1 (primary) is defaulted to 80%, Fuel Pump 2 may remain off during most operating c **Fuel Pump 2 is defaulted to 80%, the primary pump will continue to operate at the lower duty cycle range. The reason for this is that the primary pump opera fuel from the secondary side of the Fuel Tank and also fills the Fuel Pump assembly reservoir.**

COMPONENT FUNCTIONAL DESCRIPTION - POWERTRAIN CONTROL MODULE (PCM)

The PCM monitors the input signal from the Fuel Rail Pressure Sensor to determine the commanded duty cycle to the FPCM. On a fixed pressure system the PCM varie cycle to maintain a constant pressure. On variable pressure systems the commanded duty cycle is varied to adjust fuel pressure based on engine needs. Ambient tempera can also contribute to fuel pressure changes. The pressure is raised during high ambient temperatures to prevent boiling of the fuel.

NOTE: **On vehicles with diesel engines or high pressure gas fuel systems, the PCM monitors the Fuel Pressure Sensor on the low pres system to determine the commanded duty cycle, not the Fuel Rail Pressure Sensor on the high pressure side.**

The command circuit can be monitored using the Mopar Scope and functions as follows:

- The command circuit is a 12.0 volt duty cycle.
- The FPCM supplies the 12.0 volts for the command circuit.
- The PCM pulses the low side of the circuit to communicate with the DTCM.
- The normal duty cycle operating range is between 11% and 89%.
- If the FPCM does not receive a valid command signal from the PCM it will send a fault message on the feedback circuit and operates the fuel pump at a defaulted

With an open command circuit, the PCM internal driver will show a pulse width signal of approximately 2.5v if checking at the PCM connector with the Mop up voltage from the internal driver device that is still trying to pulse the duty cycle to the FPCM. This can be useful when performing diagnostics on the comm

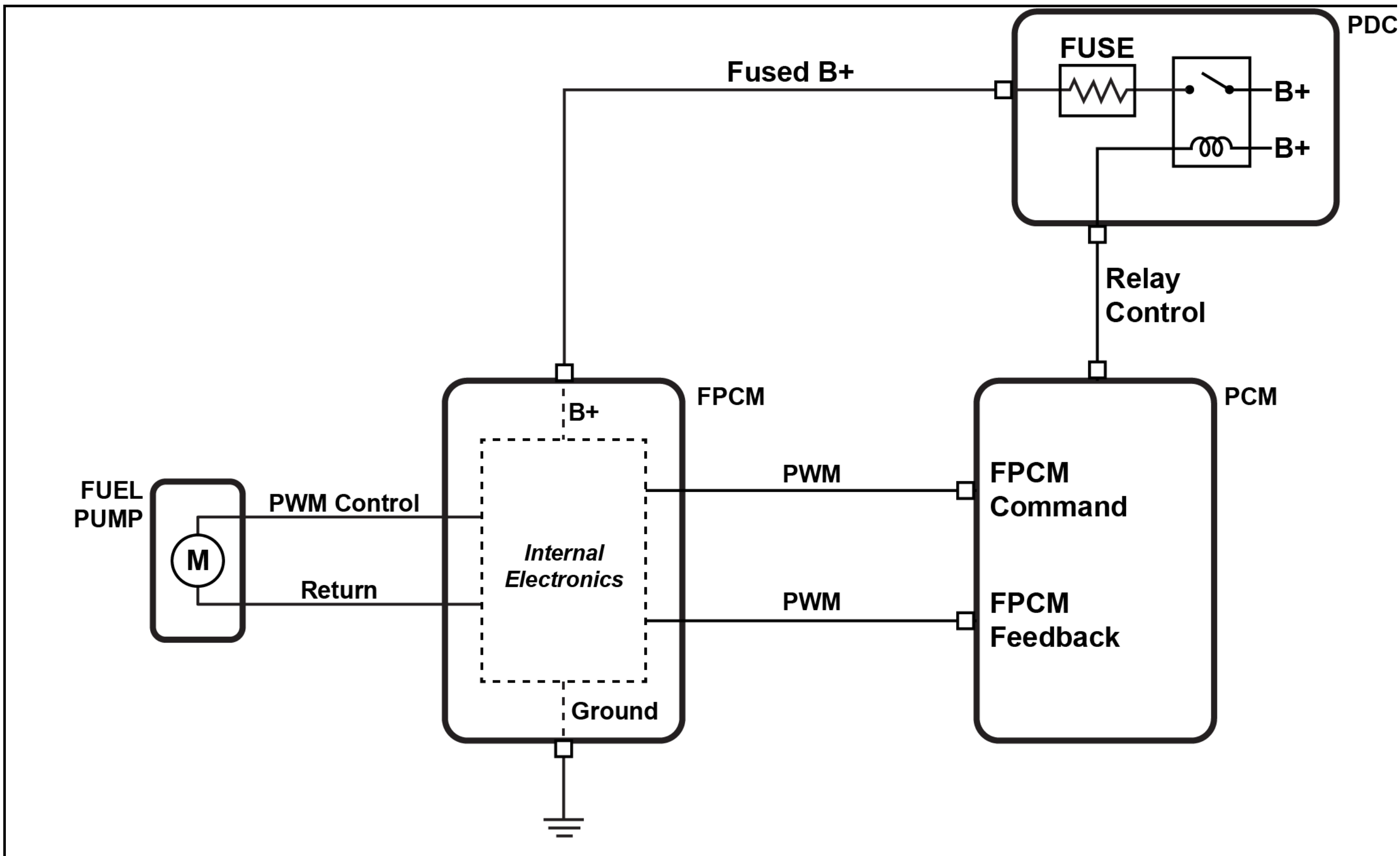
When the PCM loses communication with the FPCM it will default to the highest duty cycle. This will cause the FPCM to provide maximum voltage output to the fuel

TECHNICAL DATA-FUEL SYSTEM PRESSURE SPECIFICATIONS

The table below shows the fuel system pressure specifications.

VARIABLE FUEL PRESSURE SYSTEM SPECIFICATIONS (6.2L ENGINES)		
CRANKING	520 kPa (75.4 psi)	System operates in open loop during cranking
IDLE	340 - 400 kPa (49 - 58 psi)	Normal operating range at idle - Pressure is dependant on ambient and fuel temp. P raised during high temp to prevent boiling
NORMAL RANGE OF OPERATION	340 - 550 kPa (49 - 80 psi)	Normal operating range between idle and high engine demand
100% DUTY CYCLE	600 - 700 kPa (87 - 101.5 psi)	This is regulated by the pressure relief valve in the Fuel Pump. The pressure can va to pump.
B		
4 CYLINDER (1.0L/1.3L GSET / 2.0L GMET ENGINES)		
CRANKING	580 kPa (84.1 psi)	System operates in open loop during cranking
ALL OTHER OPERATING CONDITIONS	520 kPa (75.4 psi)	The fixed pressure systems should maintain approximately 75.0 psi during normal
B		
FIXED PRESSURE SYSTEM SPECIFICATIONS (ALL OTHER ENGINES)		
The fixed pressure systems should maintain approximately 400 kPa (58.0) psi during normal operation		

GENERIC SYSTEM SCHEMATIC:



Pulse Width Modulated (PWM)

KNOWN ISSUES - FPCM SYSTEM

While the FPCM has the capability of detected failure modes, the faults are not always reported out as intended. Some vehicles have incorrect calibrations that will read incorrectly and set the DTCs incorrectly. On these vehicles it is best not to rely on the DTC, or DTC Description when deciding which portion of the system to diagnose to read and understand how the system operates, then diagnose the entire system to determine where the failure lies by performing the **Complete Fuel Pump Control M Diagnostics (Not DTC Specific)** procedure when diagnosing this system. This diagnostic can also be used to diagnose the FPCM command, feedback and fuel pump co with the correct calibration software.

The vehicles listed below will set faults incorrectly for the model years listed and should always be diagnosed using the Not DTC specific system approach.

- DS - model years 2016-2019
- RU - model years 2017-2018
- JL - model year 2018
- JT - model year 2020

The exceptions to the information above are the Loss of Communication, Fuel Rail Pressure Sensor and Fuel Pump Relay Control circuit faults. These faults will typica they are detected by the PCM directly, not the FPCM.

WHEN MONITORED

SET CONDITION

- The Powertrain Control Module (PCM) detects a fault in the Fuel Pump Control System.

DEFAULT ACTION

- The MIL will illuminate.

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PI

The table below shows the FPCM DTCs and the correlating INTENDED failure modes. **NOTE: On some vehicles the faults may not always set as expected which r misdiagnosis (See the know issue information). Therefore, it is usually best to perform the "Complete Fuel Pump Control Module System Testing (Not DTC Sp diagnostic information.**

POSSIBLE CAUSES

FPCM 1 DTC	FPCM 2 DTC	FAILURE MODES	POSSIBLE CAUSES	PCM/FPCM REACTIOI
P025A	P027A	Missing or invalid PWM Command signal from PCM	1. PCM to FPCM Command Signal open 2. PCM to FPCM Command Signal shorted low or high 3. Invalid PWM signal - frequency out of range 4. FPCM 5. PCM	• FPCM defaults the output to the Fu 80% duty cycle **NOTE:** **It is not uncommon for the P025A DTC to set erroneously**

FPCM 1 DTC	FPCM 2 DTC	FAILURE MODES	POSSIBLE CAUSES	PCM/FPCM REACTION
				for several other failure modes
P025B	P027B	Output driver over temp	1. FPCM Output partially shorted to ground 2. Faulty Fuel Pump (high mechanical resistance) 3. Faulty FPCM internal driver	• PCM sets fault, waits a calibrated p commands a safe duty cycle • FPCM output to Fuel Pump to 50% a calibrated period. If over temp co down output driver.
P025C	P027C	System under voltage - Fuel Pump Relay output voltage to FPCM is below a calibrated threshold (approximately 6.0 volts)	1. High resistance in the Fuel Pump Relay output circuit 2. FPCM	• PCM requests 100% Fuel Pump op • FPCM defaults the output to the Fu 80% duty cycle
P025D	P027D	System over voltage - Fuel Pump Relay output voltage to FPCM is above a calibrated threshold (approximately 16.0 volts)	1. Charging system issue	• PCM applies over voltage strategy • FPCM reacts to PCM input comma
P0628	P2633	FPCM output to Fuel Pump shorted to ground	1. Fuel Pump PWM Control circuit shorted to ground	• PCM reduces PWM duty cycle unti • FPCM reacts to PCM input comma
P0629	P2634	FPCM output to Fuel Pump shorted to voltage	1. Fuel Pump PWM Control circuit shorted to voltage	• FPCM output to Fuel Pump to 50% a calibrated period. If condition con down output driver.
P062A	P062A	Actual fuel pressure is above or below the desired fuel pressure by more than a calibrated threshold. • Fixed pressure system - 5.8 psi above or 14.5 psi below • Variable pressure system - 10.9 psi above or below	1. No fuel in the Fuel Tank 2. Fuel supply tube broken/leaking 3. Fuel supply tube pinched/restricted 4. FPCM defaulted to 80% due to another failure detected 5. FPCM duty cycle output reduced due to another failure detected 6. Faulty Fuel Pump	• PCM requests 100% Fuel Pump op • FPCM defaults the output to the Fu 80% duty cycle
P064A	P26EA	Current draw exceeds calibrated threshold	1. Fuel Pump PWM Control circuit shorted to voltage 2. Faulty Fuel Pump - internal short or high mechanical resistance	• PCM reduces PWM duty cycle unti • FPCM reacts to PCM input comma
P1205	P120A	FPCM Micro internal fault	1. Fuel Pump Control Module	• FPCM continues to run in normal m Pump according to PCM command
P1206	P120B	FPCM output to Fuel Pump open circuit	1. Fuel Pump PWM Control circuit open 2. Fuel Pump Return/Ground circuit open 3. FPCM Ground circuit open 4. FPCM	• PCM reduces PWM duty cycle unti • FPCM reacts to PCM input comma
U0109	U016C	PCM Loss of Communication with FPCM	1. FPCM PWM Feedback circuit open 2. FPCM PWM Feedback shorted low or high 3. Fuel Pump Relay output circuit to FPCM open or shorted to ground 4. FPCM Ground circuit open 5. Fuel Pump PWM Control circuit shorted to ground 6. FPCM 7. PCM	• PCM requests 100% Fuel Pump op • FPCM defaults the output to the Fu 80% duty cycle

DIAGNOSTIC OVERVIEW-FUEL PUMP CONTROL MODULE

GENERAL DIAGNOSTIC INFORMATION: There are several faults associated with this system. The failure modes being monitored for are Loss of Communicatio system voltage faults, Thermal Protection, circuit faults, and system performance. **On several vehicles, multiple or incorrect faults** can set which can mislead diagnos reason, it is a good practice to perform a total system diagnosis regardless of the DTC present for most faults. The communication faults are detected directly by the PC correctly. See Communication Diagnostics explanation below.

PCM DIAGNOSTICS: The PCM directly monitors the Fuel Pump Relay Control circuit, FPCM Feedback circuit and the Fuel Pressure Sensor circuits for faults. The signal must be rationalized since the signal is monitored to perform fuel system pressure performance diagnostics. This is done by watching the signal at initial engine s systems. **On the fixed pressure system** the normally stable fuel pressure is dynamic for the first few seconds. The pressure will spike above the set point approximately then drop below the set point approximately 60-70 kPa (8.7-10.2 psi), and quickly dampen and settle at the set point 400kPa (58.0 psi). At initial engine start up, when t approximately 500 rpm, the Powertrain Control Module (PCM) measures the delta pressure change between the highest pressure reading and lowest pressure reading an about sensor rationality. The diagnostic works the same **on the variable pressure system** as the fixed pressure system except that the system is in open loop at start up a commanded to a preset known value to perform the diagnostic.

SYSTEM VOLTAGE DIAGNOSTICS: The FPCM monitors the Battery voltage supply coming from the Fuel Pump Relay to the module. A fault will set if the voltag Typically a voltage high fault would indicate a charging system issue. The voltage low fault could also be a charging system issue, but may also be caused by resistance ground circuit.

COMMUNICATION DIAGNOSTICS: Unlike other system faults, the Loss of Communication fault will typically set correctly. The PCM will set this fault when the duty cycle is below 3% or above 97%. This can occur if the FPCM Battery voltage supply or ground circuits are open, or the FPCM PWM Feedback circuit is open or s

FUEL PUMP PERFORMANCE DIAGNOSTICS: The PCM fails the **P062A** Fuel System Performance diagnostic when the actual fuel pressure is approximately **10 40 kPa (5.8 psi) above the desired fuel pressure.** This fault usually sets along with other faults since the FPCM will default to 80% duty cycle for many failure modes pressure to be higher than the desired set point. The entire system should be examined when this fault is set, including the Fuel Pressure Sensor and circuits. A sensor dr resistance in the signal or sensor ground circuit can cause a false reading on a normally operating system.

- **The dual pump variable pressure systems can be tricky when diagnosing a performance fault.** The fuel pressure may be good with one failed pump during n conditions. The condition may only be present under very heavy engine load conditions when both pumps are needed to produce the pressure and volume needed. tool, monitoring duty cycle for both pumps can help diagnosing the issue. If a failure is detected for either Fuel Pump or circuitry, the duty cycle will typically de Pump 1 (primary) is defaulted to 80%, Fuel Pump 2 may remain off during most operating conditions. However, if Fuel Pump 2 is defaulted to 80%, the primary operate at the lower duty cycle range. The reason for this is that the primary pump operates the jet pump to pull fuel from the secondary side of the Fuel Tank and reservoir.

The FPCM fails the **P064A** Fuel Pump Control Module Performance when excessive current draw is detected on the fuel pump circuitry. The FPCM will default and re fuel pump to the lowest possible duty cycle while the issue is present.

For most vehicles the fuel pressure desired and actual values, as well as the Fuel Pump output duty cycle data can be viewed on the scan tool. These readings can be ver diagnosis of the system.

TECH TIP: A vehicle will typically have one of two issues;

1. The vehicle has no fuel pressure/pump is not operating.
   - The first thing to check for is a Loss of Communication fault. The reason is that the same Battery supply and ground circuit that are used to power up the F Fuel Pump motor to operate. A loss of Battery supply, or a poor chassis ground for the module will cause both issues.
   - The next thing to look for is an output from the FPCM to the pump. This can be done with the scan tool or by checking the duty cycle output from the FPC from the FPCM to the Fuel Pump, the pump should be operating and creating fuel pressure. If the pump is not running then the Fuel Pump and circuits betw Pump should be focused on during diagnostics. If the Loss of Communication fault is not present the Battery supply and chassis ground are most likely goo
2. The vehicle runs normally, has a DTC or DTCs present, and the output duty cycle to the Fuel Pump is defaulted. In most cases, the output is defaulted to 80% and greater than the desired pressure.
   - The first thing to check is for a Loss of Communication fault. If the vehicle is running with a Loss of Communication fault, and an 80% output duty cycle, i an issue with the FPCM PWM Feedback circuit. A loss of Battery supply or a poor chassis ground would usually cause no Fuel Pump operation and a no st
   - If there is no Loss of Communication fault then this condition is most likely present due to an issue with the command circuit, an over current draw or over Fuel Pump.

PRELIMINARY DIAGNOSTIC CHECKS

1. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the ECU. Low Battery voltage can cause a DTC.
3. Circuit faults should typically be diagnosed before rationality/performance faults.
4. Check the component harness connector(s) for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior t testing. Disconnect the component harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the F Monitored and Set Conditions. Erase all DTCs and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. **Since the FPCM monitors the Fuel Pump circuits and motor for excessive current draw and over temperature conditions,** it is possible that the pump may extended period for the condition to be present.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or continuing to diagnose an intermittent condition. If no bulletins apply, check for connection issues by wiggle testing any wiring harnesses and in-line connectors t through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach a lab scope to the circuitry and w Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor battery system voltage or poor ground connections can affect odd ways. Check the battery or batteries for proper charge and operation along with proper connections. Use the wiring information to identify and check any cha related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving. Operate the components through a full range monitoring functionality.

DIAGNOSTIC TEST - COMPLETE FUEL PUMP CONTROL MODULE SYSTEM TESTING (NOT DTC SPECIFIC)

TECH TIP: The FPCM DTCs will set incorrectly for some vehicles/model years due to incorrect calibrations. For those vehicles it is best to perform the "COMPLETE CONTROL MODULE SYSTEM TESTING (NOT DTC SPECIFIC)" diagnostic procedure. Refer to the "KNOW ISSUES" information above for a list of the vehicles calibrations.

COMPLETE FUEL PUMP CONTROL MODULE SYSTEM DIAGNOSTICS:

Using the Mopar Scope is the preferred and best method for diagnosing the FPCM and circuits. The circuits can be monitored one at a time or all together using all four

This test is written with the leads back probed and connected at the FPCM connector unless otherwise specified

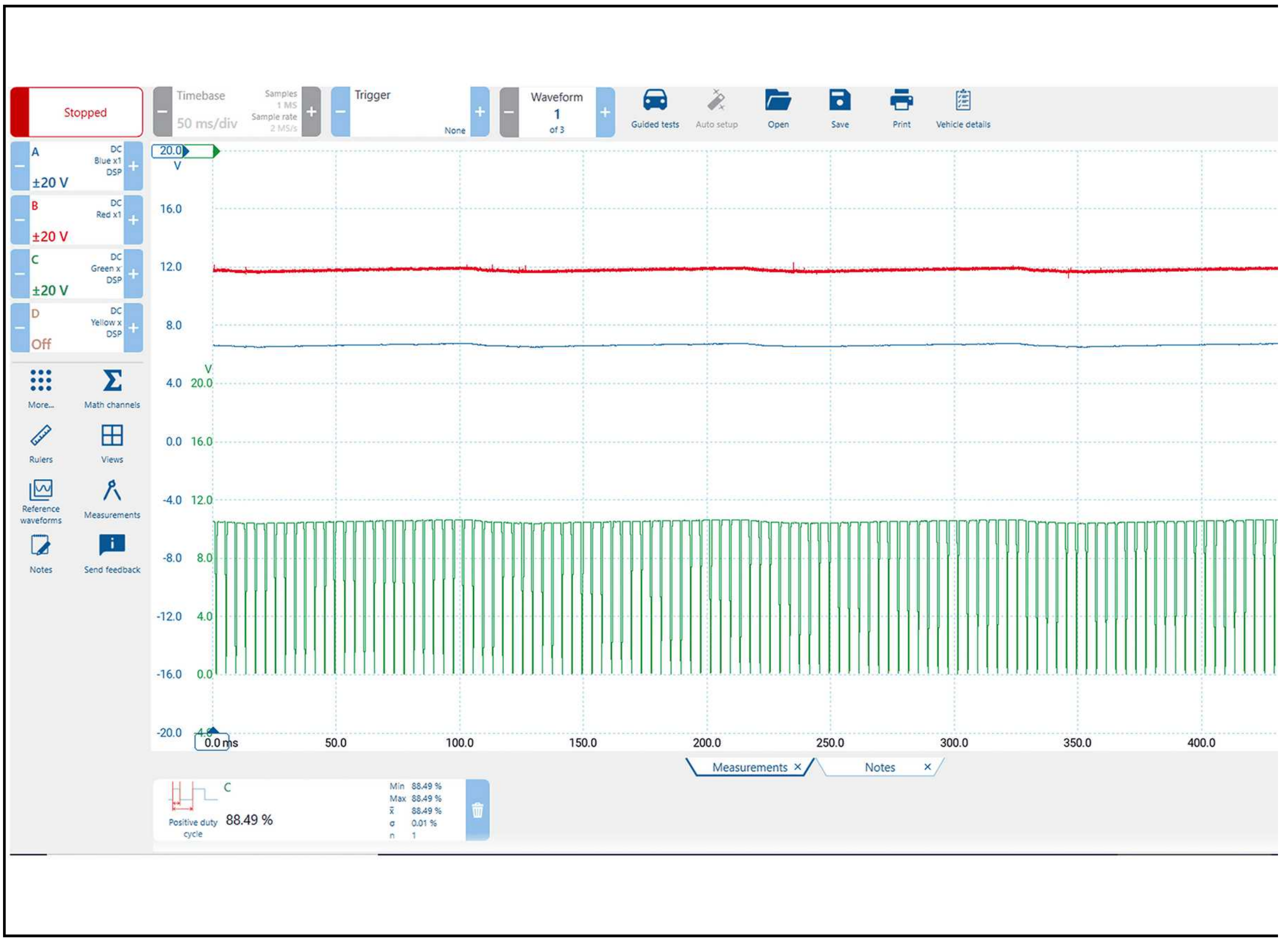
Crank or start the engine while monitoring each of the following circuits:

- PWM Command circuit
- PWM Feedback circuit
- Fuel Pump Control circuit
- Relay output to FPCM (Battery supply)

Below are the expected results along with failure modes for each of the circuits:

1. **BATTERY SUPPLY CIRCUIT:**
    1. The relay output voltage to the FPCM should remain constant and equal to battery voltage during operation.
        - If the voltage is constant battery voltage during cranking, the relay output is not the cause of the issue.
    2. If no voltage is present during cranking there is an open in the relay output circuit.
        - Check the fuse for the circuit. If the fuse is open, check the Fuel Pump Relay Output circuit for a short to ground before replacing the fuse. If the fuse output circuit for an open.
    3. Voltage is present but below battery voltage.
        - Check for resistance in the relay output and FPCM ground circuits.

    NOTE: **An open ground circuit can cause the feedback circuit voltage to change from a 5v duty cycle to a constant volt 6.5v as seen in the figure below.**

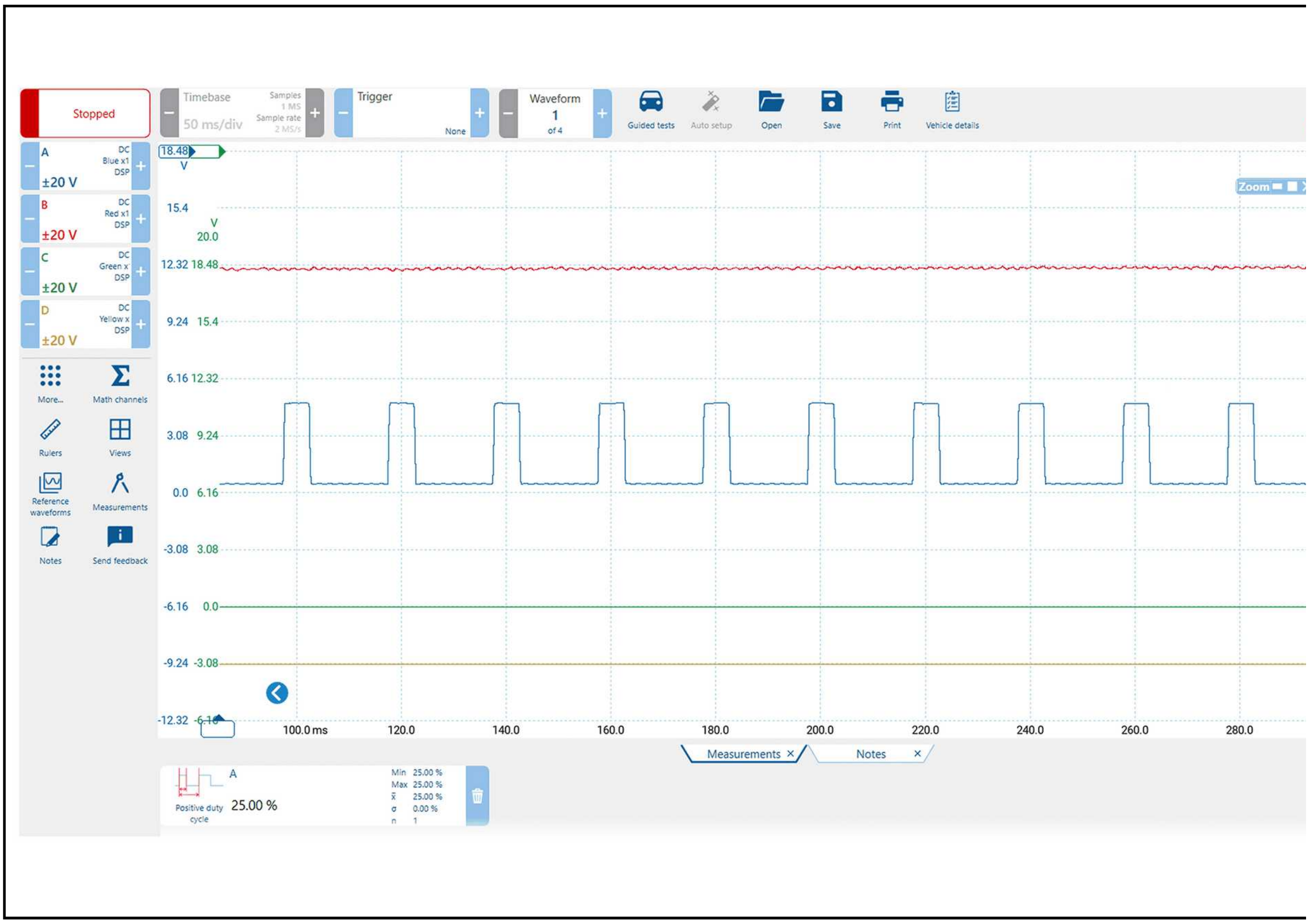
Blue Channel - Feedback circuit	
Red Channel - Fuel pump output circuit	
Green Channel - Command circuit	

2. **FUEL PUMP PWM COMMAND CIRCUIT:**

    For a detailed description on the functionality of the command circuit, read the PCM component functional description information above. The FPCM will still op there is an issue with the command circuit. Typically the output voltage to the fuel pump will be higher than during normal operation. The command circuit can be the PCM using the GPEC Adaptor connected in-line. Both results are described below.

    SCOPE LEAD CONNECTED AT THE FPCM

    1. If the PWM Command circuit is functioning normally the signal should have a 12v duty cycle between 11% and 89%.
        - If the command circuit is functioning as described above the command circuit is not the cause of the issue.
    2. If the PWM Command circuit is reading a constant 0 volts, it would indicate that the control circuit is shorted to ground.



Blue Channel - Feedback circuit	
Red Channel - Fuel pump output circuit	
Green Channel - Command circuit	

- Test and repair the short to ground in the command circuit.

3. If the PWM Command circuit is a reading a constant battery voltage, it would indicate an open in the command circuit or the PCM internal driver is faulty.

Blue Channel - Feedback circuit	
Yellow Channel - Command circuit on the FPCM side of the open	
Green Channel - Command circuit on the PCM side of the open	

- Isolate and measure the resistance of the command circuit. If the circuit is open or has high resistance repair the circuit. If the circuit has less than 5.0 PCM driver is faulty. Replace the powertrain control module in accordance with the service information.

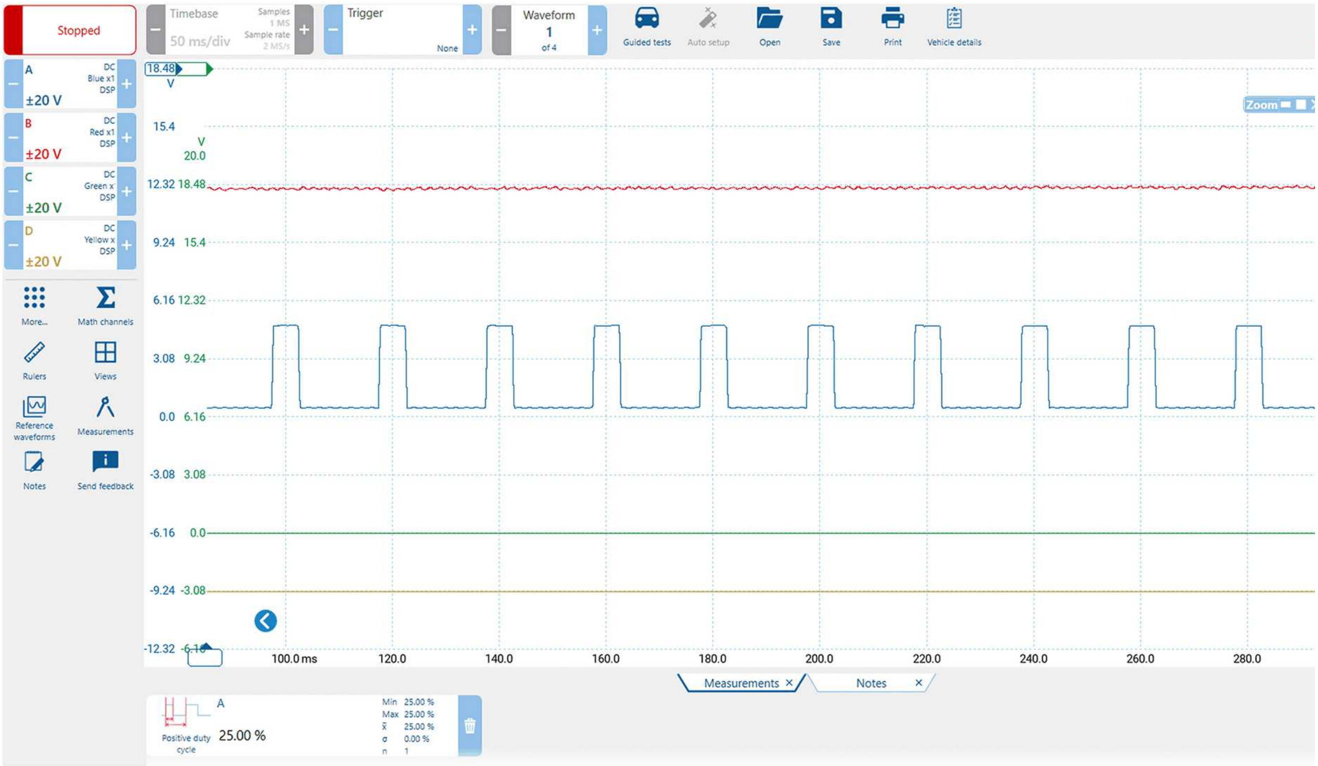
4. If the PWM Command circuit is duty cycling, but the voltage is approximately 2.5v instead of the normal 12v duty cycle, it indicates that the command circ driver are good. The FPCM is not producing the 12v output on the command circuit.

Blue Channel - Feedback circuit	
Yellow Channel - Command circuit on the FPCM side of the open	
Green Channel - Command circuit on the PCM side of the open	

- Verify that the relay output battery supply to the FPCM is constant and the FPCM ground circuit is good. If both circuits test good replace the fuel pu accordance with the service information.

SCOPE LEAD CONNECTED AT THE GPEC ADAPTOR IN-LINE WITH THE PCM

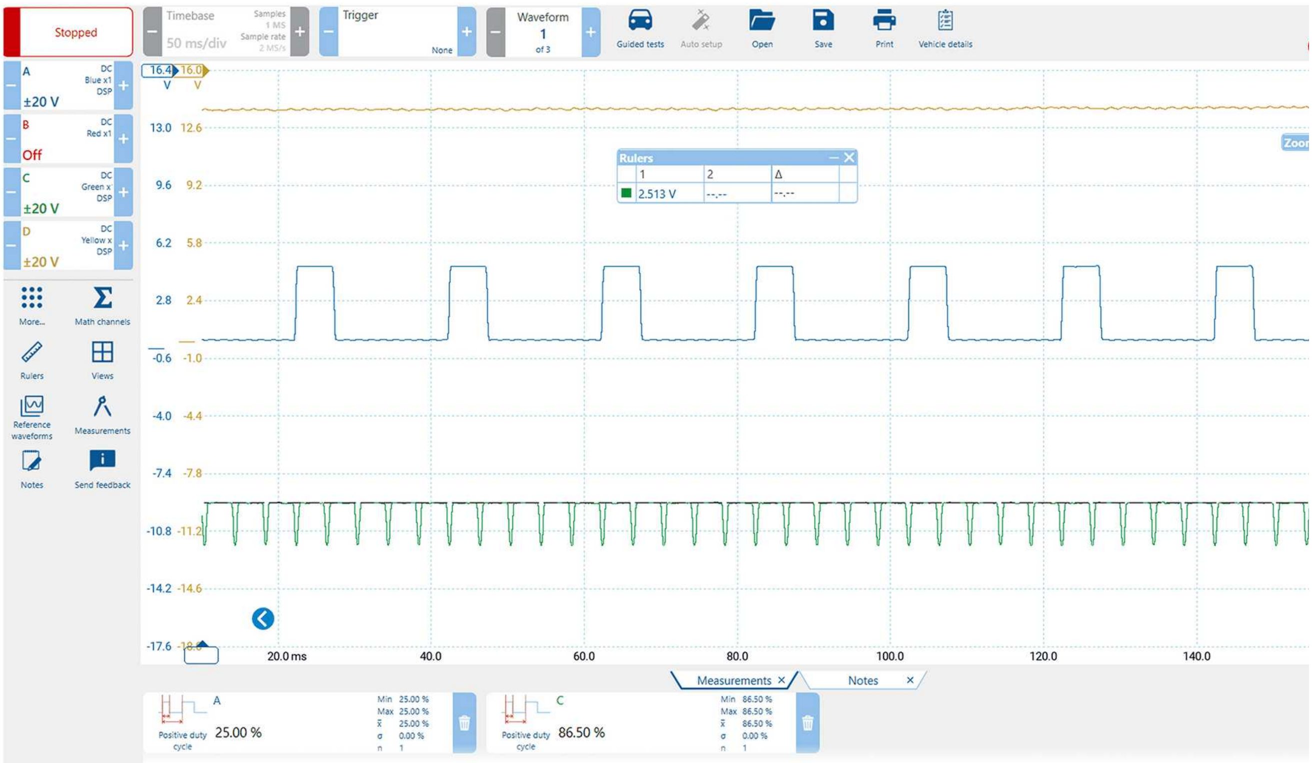
1. If the PWM Command circuit is functioning normally the signal should have a 12v duty cycle between 11% and 89%.
    - If the command circuit is functioning as described above the command circuit is not the cause of the issue.
2. If the PWM Command circuit is reading a constant 0 volts, it would indicate that the command circuit is shorted to ground.



Blue Channel - Feedback circuit	
Red Channel - Fuel pump output circuit	
Green Channel - Command circuit	

- Test and repair the short to ground in the command circuit.

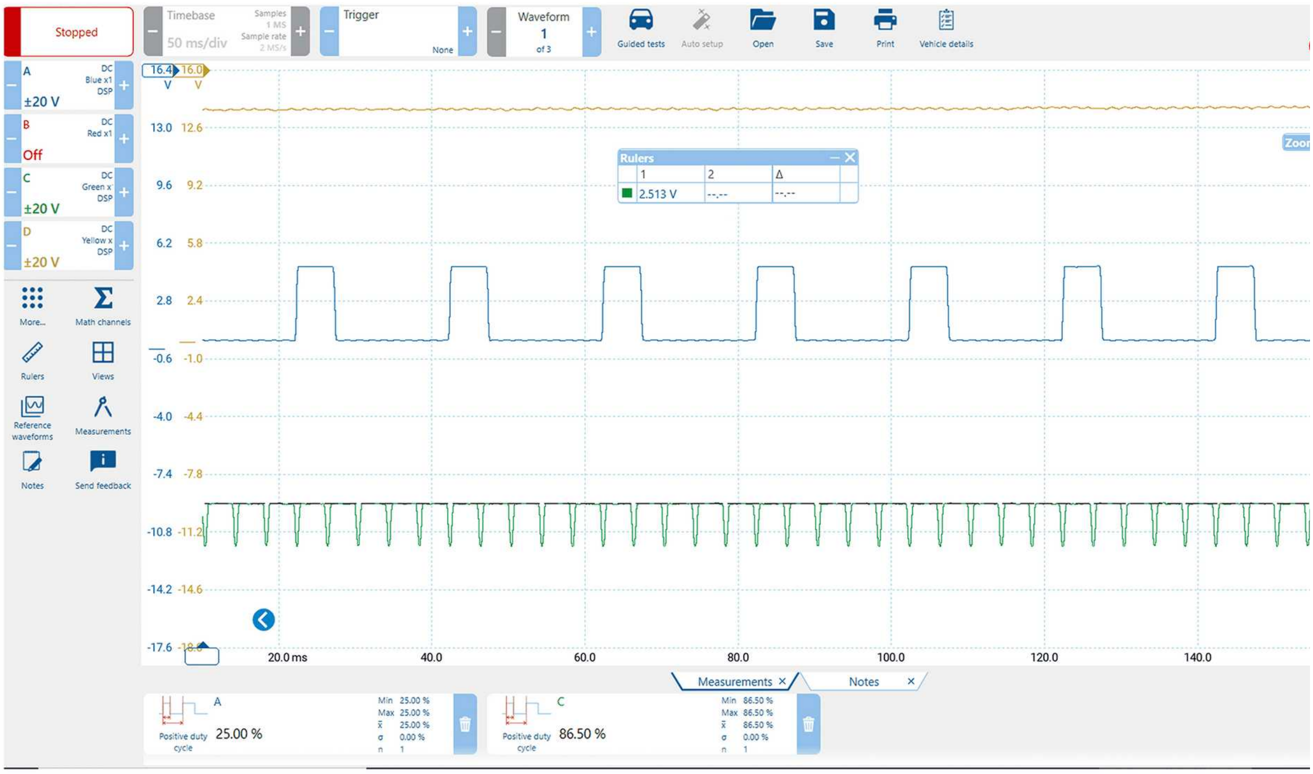
3. If the PWM Command circuit is a reading a constant battery voltage, it indicates the command circuit and FPCM output are good. The PCM internal driver



Blue Channel - Feedback circuit
Yellow Channel - Command circuit on the FPCM side of the open
Green Channel - Command circuit on the PCM side of the open

- Replace the powertrain control module in accordance with the service information.

4. If the PWM Command circuit is duty cycling, but the voltage is approximately 2.5v instead of the normal 12v duty cycle, it indicates that the PCM internal an open in the command circuit or the FPCM is not producing the 12v output on the command circuit.



Blue Channel - Feedback circuit
Yellow Channel - Command circuit on the FPCM side of the open
Green Channel - Command circuit on the PCM side of the open

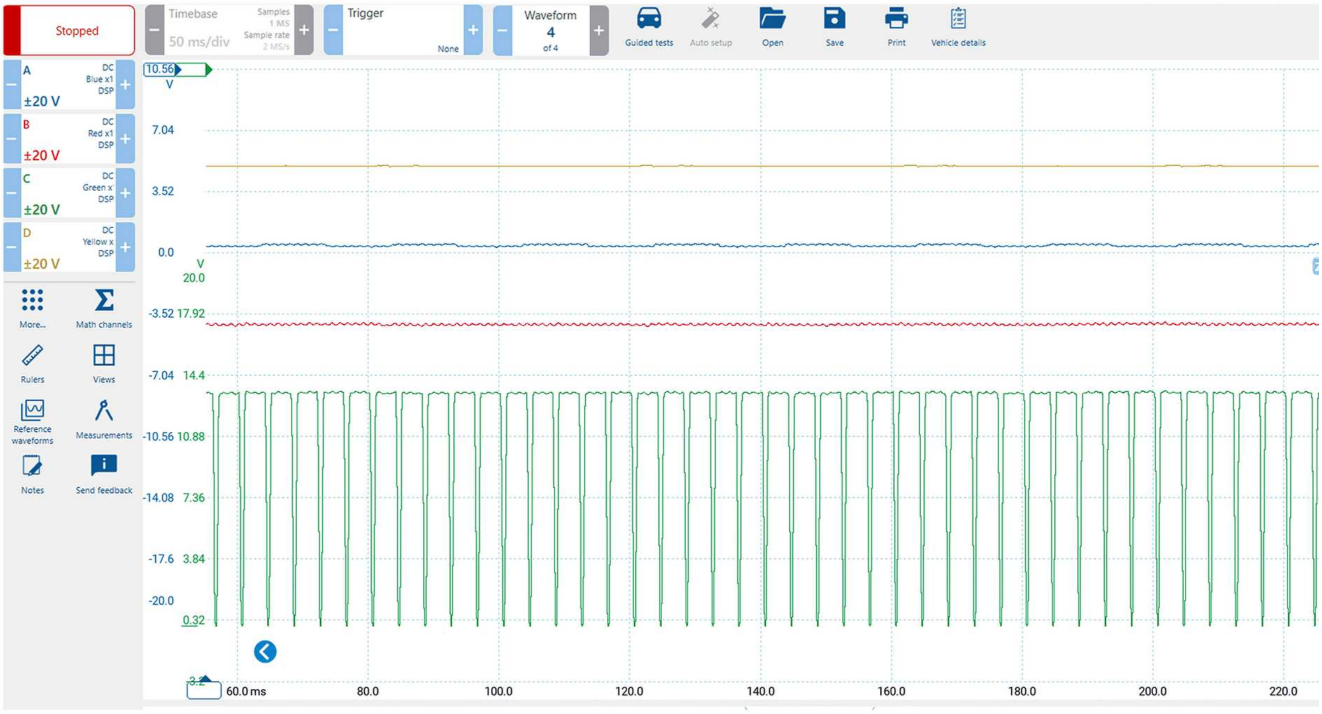
- Isolate and measure the resistance of the command circuit. If the circuit is open or has high resistance repair the circuit. If the circuit has less than 5.0 FPCM output is faulty. Replace the fuel pump control module in accordance with the service information.

3. **FPCM PWM FEEDBACK CIRCUIT:**

For a detailed description on the functionality of the feedback circuit, read the FPCM component functional description information above. The PCM will comma duty cycle when it cannot receive feedback from the FPCM due to an issue with the feedback circuit. The fuel pump should still operate when the communication FPCM and PCM due to a feedback signal circuit issue. Typically the output voltage to the fuel pump will be higher than during normal operation. The feedback ci FPCM or at the PCM using the GPEC Adaptor connected in-line. Both results are described below.

SCOPE LEAD CONNECTED AT THE FPCM

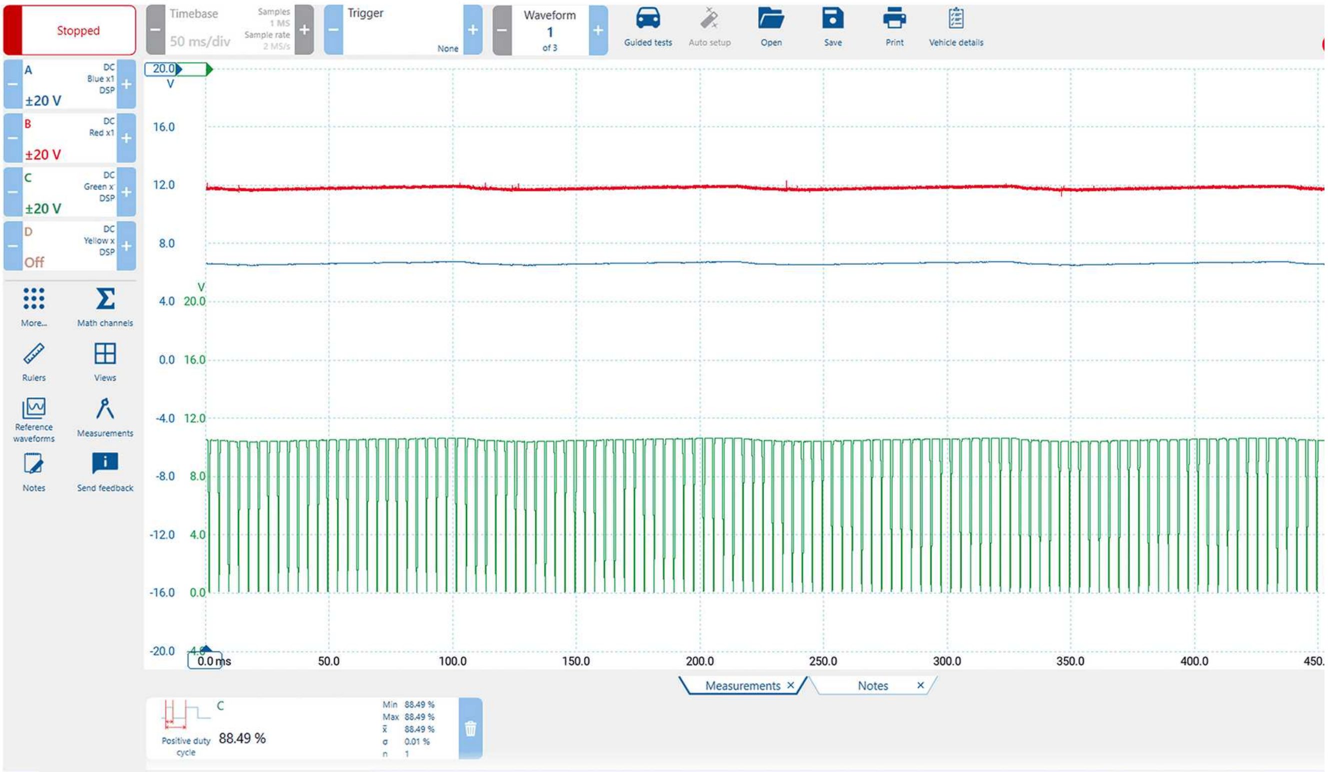
1. If the FPCM PWM Feedback circuit is functioning normally the signal should have a 5v duty cycle between 3% and 97%.
    - If the feedback circuit is functioning as described above the feedback circuit is not the cause of the issue.
2. If the PWM feedback circuit is reading a constant 0 volts, it would indicate that the control circuit is shorted to ground.
    - Test and repair the short to ground in the feedback circuit.
3. If the PWM feedback circuit is reading a constant 5.0 volts, it would indicate that FPCM internal driver is faulty.



Blue Channel - Feedback circuit on the FPCM side of the open
Yellow Channel - Feedback circuit on the PCM side of the open
Green Channel - Command circuit
Red Channel - Fuel pump output circuit

- Replace the fuel pump control module in accordance with the service information.

4. An open or partially open ground circuit can effect the feedback pattern in different ways. The PWM feedback circuit may read a constant voltage approxim
could be a pulsed voltage between 5.0 volts and 8.0 volts when the FPCM ground circuit is open.



Blue Channel - Feedback circuit
Red Channel - Fuel pump output circuit
Green Channel - Command circuit

- Test and repair the FPCM ground circuit for an open or high resistance.

5. If the PWM feedback circuit is duty cycling between approximately 0.3v and 0.6v instead of the normal 5v duty cycle, it indicates that the FPCM internal d feedback circuit is open or the PCM is not producing the 5v output on the feedback circuit.

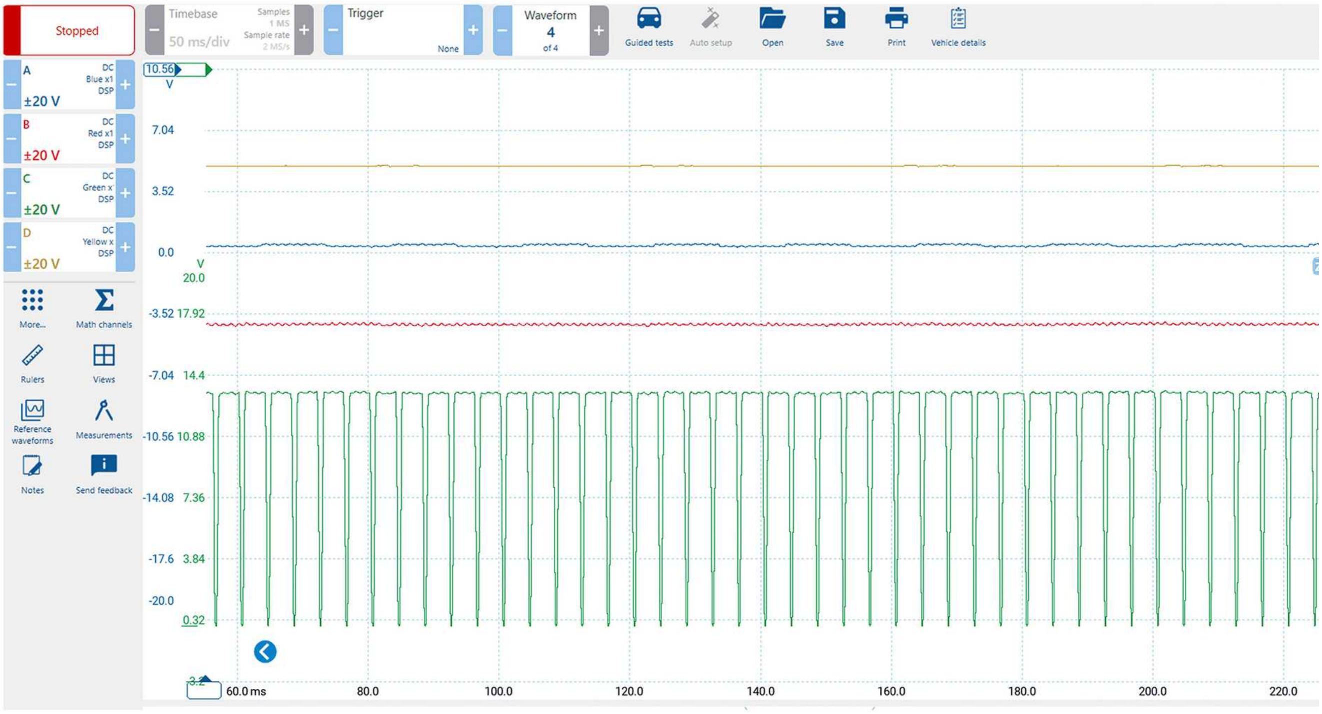
Blue Channel - Feedback circuit on the FPCM side of the open

- If the circuit is open or has high resistance repair the circuit. If the circuit has less than 5.0 Ohms of resistance, the PCM output driver is faulty. Repla module in accordance with the service information.

NOTE: **Another way to test the output and circuit is to connect a scope lead to the PCM connector using the GPEC Ada output is present at the PCM connector, but not at the FPCM, the PCM is good and the feedback circuit is open.**

SCOPE LEAD CONNECTED AT THE GPEC ADAPTOR CONNECTED IN-LINE WITH THE PCM

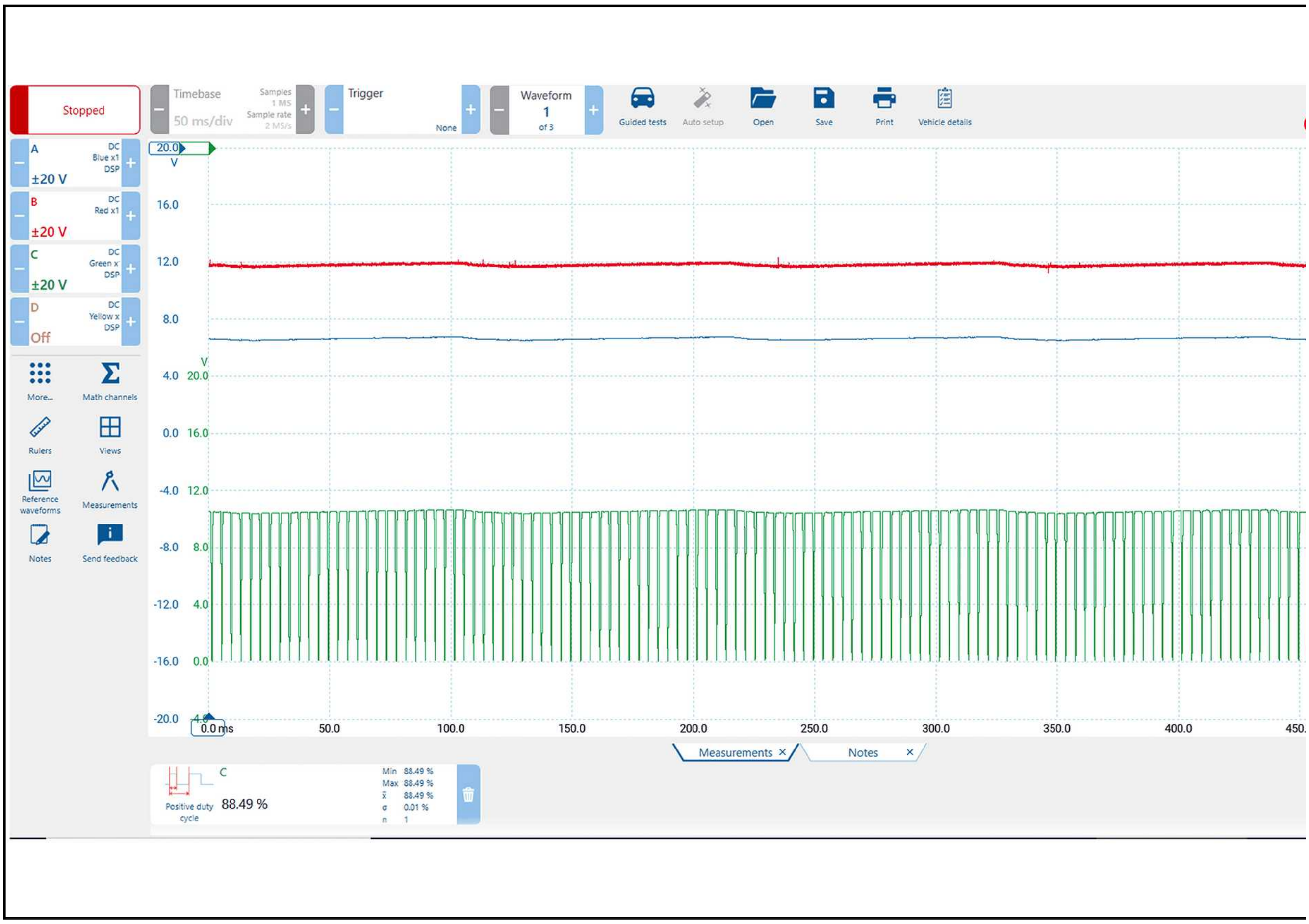
1. If the FPCM PWM Feedback circuit is functioning normally the signal should have a 5v duty cycle between 3% and 97%.
   - If the feedback circuit is functioning as described above the feedback circuit is not the cause of the issue.
2. If the PWM feedback circuit is reading a constant 0 volts, it would indicate that the control circuit is shorted to ground.
   - Test and repair the short to ground in the feedback circuit.
3. If the PWM feedback circuit is reading a constant 5.0 volts, it would indicate that the feedback circuit is open or the FPCM internal driver is faulty.



Blue Channel - Feedback circuit on the FPCM side of the open
Yellow Channel - Feedback circuit on the PCM side of the open
Green Channel - Command circuit
Red Channel - Fuel pump output circuit

- If the circuit is open or has high resistance repair the circuit. If the circuit has less than 5.0 Ohms of resistance, the FPCM driver is faulty. Replace the module in accordance with the service information.

4. If the PWM feedback circuit is reading a constant voltage approximately 6.5 volts, it would indicate that the FPCM ground circuit is open.



Blue Channel - Feedback circuit	
Red Channel - Fuel pump output circuit	
Green Channel - Command circuit	

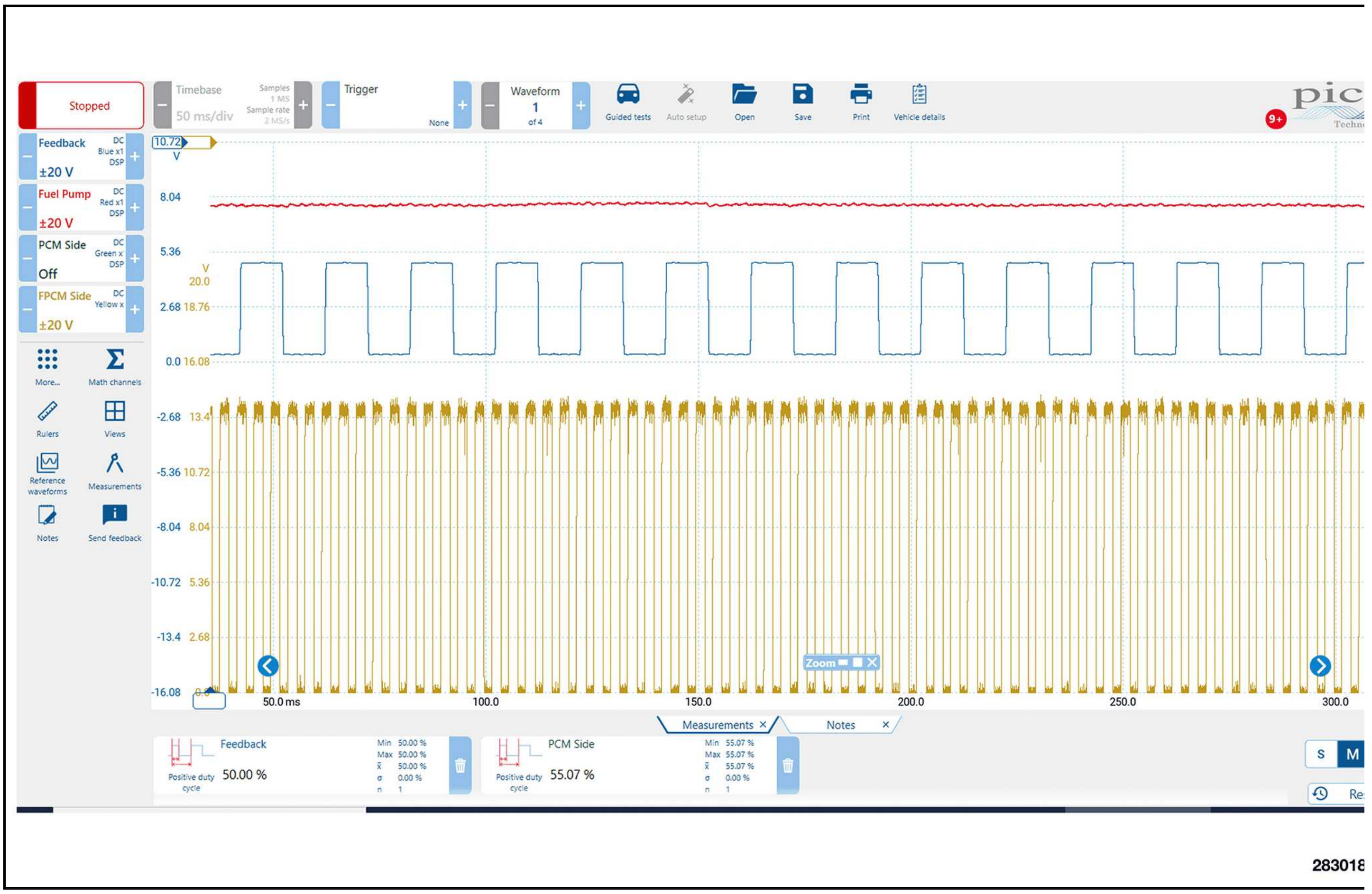
- Test and repair the FPCM ground circuit for an open or high resistance.

5. If the PWM feedback circuit is duty cycling between approximately 0.3v and 0.6v instead of the normal 5v duty cycle, it indicates that the feedback circuit is good. The PCM is not producing the 5v output on the feedback circuit.

Blue Channel - Feedback circuit on the FPCM side of the open

- Replace the powertrain control module in accordance with the service information.

4. **FUEL PUMP AND CONTROL CIRCUITS:** There should be a relatively constant voltage on the fuel pump control circuit. When the system is operating norma output voltage is typically around 7.0 - 9.0 volts. When there is a fault in the system the output is typically higher due to the FPCM defaulting to a higher output (l battery voltage). For this reason the fuel pump output voltage may be high near battery voltage due to an issue in the Fuel Pump circuits or one of the other FPCM Feedback). If one of those circuits indicates an issue, diagnose that circuit before continuing with the diagnosis of the fuel pump circuits.
   1. If the Fuel Pump Control circuit voltage is functioning normally it should be less than battery voltage (between approximately 7.0 - 9.0 volts).
      - If the voltage on the Fuel Pump Control circuit reads as described above, the output from the FPCM is normal.
      - If the voltage on the Fuel Pump Control circuit is reading 0v or near battery voltage, **continue to step b.**
   2. Gain access to the Fuel Pump harness connector. Using the Mopar Scope, back probe the Fuel Pump Control circuit and Fuel Pump Return circuit. Crank or monitor the voltage on each circuit.
      - If the Fuel Pump Control circuit voltage is 0 at the Fuel Pump harness connector, the Fuel Pump Control circuit is open or shorted to ground. Repair t **short to ground in the Fuel Pump PWM Control circuit may open the fuse for the FPCM Battery voltage supply from the relay, which can ca Communication fault also.**
      - If the Fuel Pump Control circuit voltage is the same as the output from the FPCM, the Fuel Pump Return circuit is 0v, and the Fuel Pump does not op faulty.
      - If the Fuel Pump Return circuit voltage matches the Fuel Pump Control circuit at the Fuel Pump harness connector, the Fuel Pump Return circuit is o **The return circuit grounds through the FPCM chassis ground circuit. This will likely lead to a no start with no fuel pump operation.**



Blue Channel - Feedback circuit	
Red Channel - Fuel Pump Control circuit	
Yellow Channel - Command circuit	

U0121-LOST COMMUNICATION WITH ABS

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION-BRAKING SYSTEMS

BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Anti-lock Brake Module (ABS) and Hydraulic Control Unit (HCU). The ABS Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The ABS Module also monitors the pressure sensors to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the C Module receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are h System Control Module. The ABS Module broadcasts the WSS signals on the CAN bus. The ABS Module performs circuit fault diagnostics for the WSS sensors and w and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The W compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the ABS Module monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel locked, the ABS Module cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be re lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being a will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and la (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The ABS Module will open the appropriate Inlet Valves, applying braking to co

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The PCM provides the sensor with a 5-Volt reference, a pul ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the PCM. Th analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pe signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the ABS Module and PCM. **These thresho using the scan tool every time a sensor, ABS Module or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti- control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure senso Outlet Valves. The Brake Pedal Position Sensor is external, and hard-wired to the PCM. The ABS Module in this system is capable of operating the motor/actuato the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There a located in each hydraulic circuit that allow the ABS Module to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wh low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap betwee is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the W against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability cont enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - ANTI-LOCK BRAKE SYSTEM CONTROL MODULE (ABS)

The ABS Module is bolted to the Hydraulic Assembly. The ABS Module monitors several inputs used for normal vehicle braking as well as detection and operation of a and electronic stability controls. The signals that are monitored are listed below. The ABS Module directly monitors the signals for operating the:

- Master Cylinder Pressure Sensor
- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (ABS Module)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The PCM broadcasts the BPP Sensor signal voltage on t the sensor signal is faulty, the PCM sets a fault against t sends a Signal Not Available (SNA) message on the CA
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the ABS fault against the sensor and sends an SNA message on t The PCM will set the implausible data fault (U0418) for message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The ABS Module calculates the sum of the hydraulic pr calipers in all four hydraulic circuits. The signal is broad CAN bus.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.
- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.

- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the ABS with one of the WSS signals. The ABS Module will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY ANT-LOCK BRAKE SYSTEM (ABS) MODULE

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
BRAKE FLUID CONTAMINATION
PINCHED OR BENT BREAK LINE
FAULTY HYDRAULIC ASSEMBLY
FAULTY ANTI-LOCK BRAKE SYSTEM MODULE (ABS)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO ABS OPEN OR SHORTED TO GROUND
ABS GROUND CIRCUIT OPEN/HIGH RESISTANCE
ABS CAN BUS CIRCUITS SHORTED TO VOLTAGE
ABS CAN BUS CIRCUITS SHORTED TO GROUND
ABS CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY ANTI-LOCK BRAKE SYSTEM (ABS) MODULE

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM ABS MODULE
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY ANTI-LOCK BRAKE SYSTEM (ABS) MODULE

DIAGNOSTIC OVERVIEW

ABS BRAKE SYSTEM: When any faults are present against the BPP Sensor in the ABS Module or PCM, the sensor and circuits should always be checked before cor While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and ABS Module should alway connection, burnt, corroded or damaged terminals before condemning the HCU. If the ABS Module is found to be the issue it can be replaced separately. If the HCU is issue, the HCU and ABS Module should be replaced as an ICU assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table w moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other thre RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is tempora
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrat sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the F Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Moni and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some te rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficul cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the syste
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes throug watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Rev looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or od Battery or Batteries for proper charge and operation along with proper connections. Use the wiring information to identify and check any chassis ground connecti or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for push burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the ABS Module. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Suppl properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signa mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disco Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sen Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0 v if available, or the circuit high fault should be active. Next, connect the leads circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0 v if available, or the circuit low fault should be active.

NOTE: **Since the PCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same res**

1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
2. If the voltage remains at 0 v and only the circuit low fault is active, continue to step 4.

4. Disconnect the PCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circui
   1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
   2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
   1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
   2. If the temp sensor signal and ground circuits test good, use the wiring information to check all related harness connectors for pushed out, spread, corroded c condemning ABS Module. If no issues are found, replace the ABS Module in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the ABS M compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the ABS Module. The calculation is bas hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or ABS Module are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the ABS Module is mounted correctly to the HCU. Next, remove the ABS Module and inspect the terminals for signs of damage (pushed out, spread, corro
   - If the ABS Module terminals appear damaged, repair the terminals or replace the ABS Module in accordance with the Service Information.
   - If the ABS Module and terminals appear good, replace the ABS assembly in accordance with the Service Information.

NOTE: **The HCU and ABS Module are separate components, but may be required to be replaced as an Integrated Control Unit (ICU on some vehicles. If the ABS Module is suspected to be the failure, always check to see if the ABS Module can be replaced HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the ABS Module detects a fault against the Brake Pedal Pressure Sensor.

1. There should be a circuit fault set in the PCM, ABS Module or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the ABS Module is mounted correctly to the HCU. Next, remove the ABS Module and inspect the terminals for signs of damage (pushed out, spread, corro
   - If the ABS Module terminals appear damaged, repair the terminals or replace the ABS Module in accordance with the Service Information.
   - If the ABS Module and terminals appear good, replace the HCU in accordance with the Service Information.

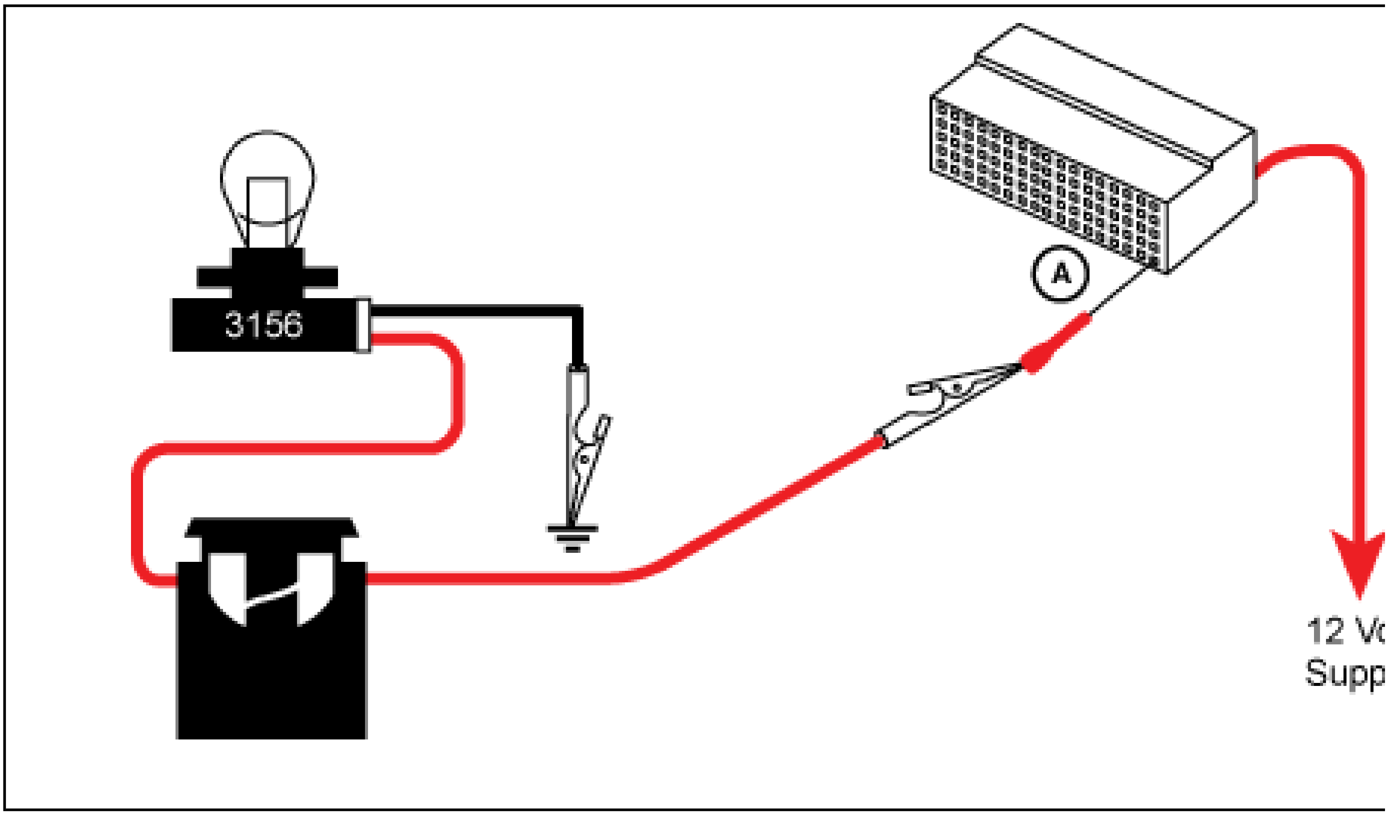
NOTE: **The HCU and ABS Module are separate components, but may be required to be replaced as an Integrated Control Unit (ICU on some vehicles. If the ABS Module is suspected to be the failure, always check to see if the ABS Module can be replaced HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the ABS Module detects a fault against the Master Cylinder Pressure Sensor and send to the PCM.

1. Verify the ABS Module is mounted correctly to the HCU. Next, remove the ABS Module and inspect the terminals for signs of damage (pushed out, spread, corro
   - If the ABS Module terminals appear damaged, repair the terminals or replace the ABS Module in accordance with the Service Information.
   - If the ABS Module and terminals appear good, replace the HCU in accordance with the Service Information.

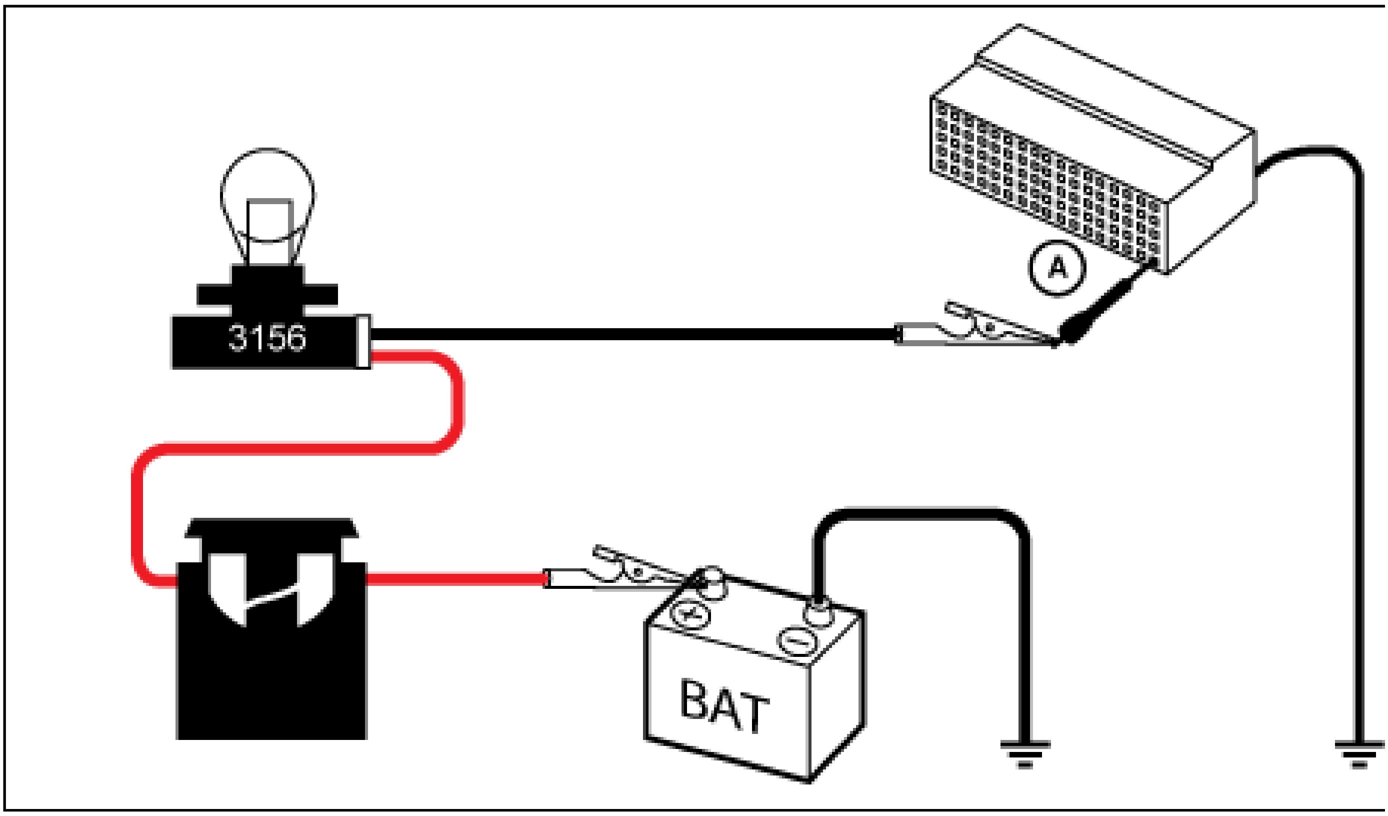
NOTE: **The HCU and ABS Module are separate components, but may be required to be replaced as an Integrated Control Unit (ICU on some vehicles. If the ABS Module is suspected to be the failure, always check to see if the ABS Module can be replaced HCU is suspected, the entire ICU should be replaced.**

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal messa and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake Sy

1. Check for any Service Bulletins, Star On-line Cases, PCM or ABS Module flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the ABS Module. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.
4. Using the wiring information as a guide, check the fuse or fuses that supply power to ABS Module. Verify the fuse(s) are not open and has a good connection witl PDC
   1. If the fuse(s) are good, continue testing in step 5.
   2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

   Disconnect the ABS Module harness connector and load test the Battery Supply and Ignition circuits.

   1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a si method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative m voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .
   2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
      - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
      - If both circuits pass the load test, continue testing in step 6.

6. 

Load test the ABS Module Ground circuit.

  1. If the ground circuit fails load testing, repair the ABS Module chassis ground.
  2. If the ground circuit tests good, continue testing in step 7.
7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the ABS Module. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN approximately 2.4v.
  1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

     NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the connector or the wiring leading to that module.**

  2. If both voltage readings match the values given, the ABS Module is likely faulty. Use the wiring information to check all related harness connectors for pus or dirty terminals before condemning the ABS Module. To check for an intermittent condition, connect a lab scope to both circuits at the ABS Module conn the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the ABS Module in accordance with the service information.

The HCU and ABS Module are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If tl suspected to be the failure, always check to see if the ABS Module can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

ABS MODULE RELATED WHEEL SPEED SENSOR FAULTS - The ABS Module performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the ABS Module. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN ABS Module (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

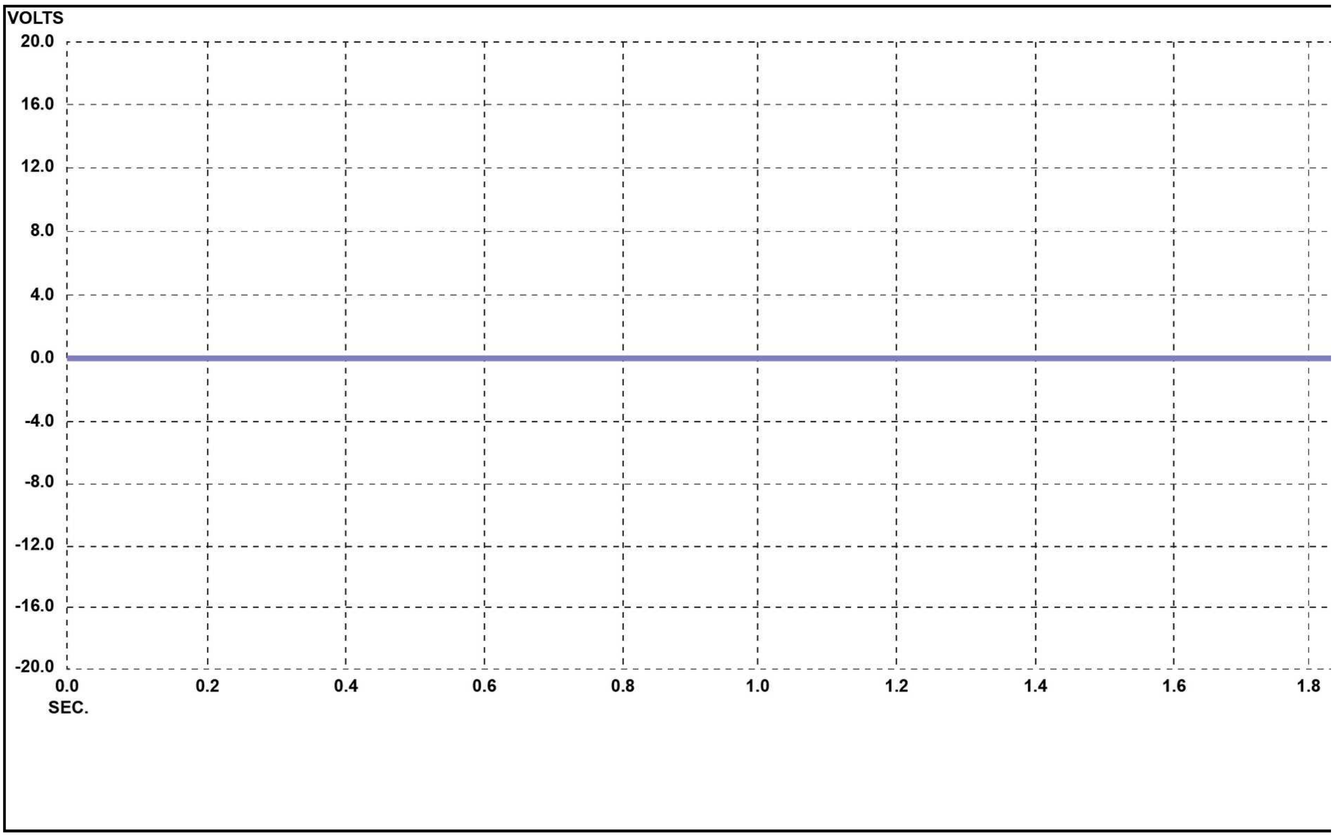
1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle f
  1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
  2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Contı with the Service Information.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS ABS Module SIGNAL AND RA AND ANY PCM WSS FAULTS):

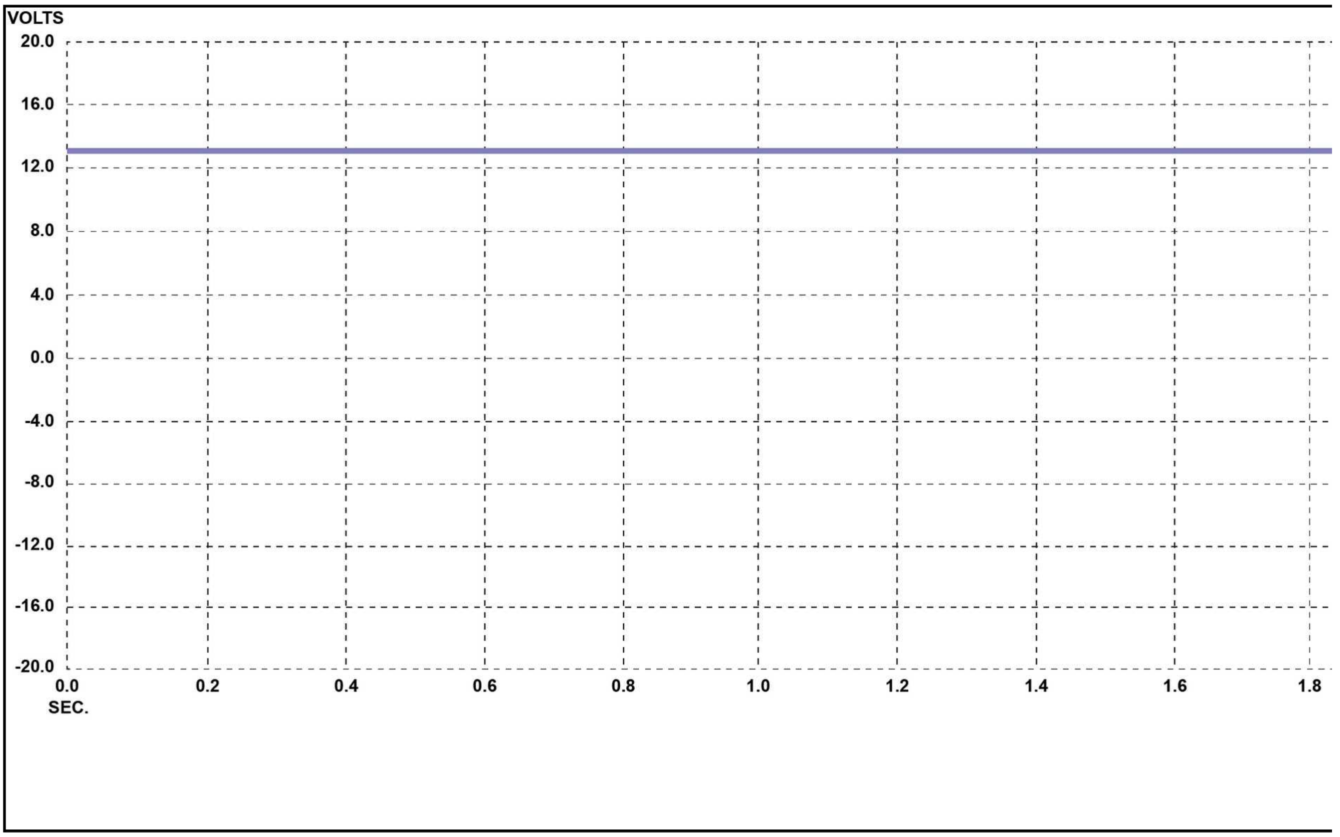
1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. Tl depending on the vehicle. The frequency of the signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the whe

closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is st signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.

1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive t monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that ma the hoist. If the sensor reads correctly during the test drive and the fault is active, the ABS Module is likely faulty. Always check all related harness connect pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a ABS Module.
2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
   - Check the WSS for physical damage and verify it is mounted and fastened properly.
   - If equipped with a tone wheel, inspect the tone wheel for physical damage.
   - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
   - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, use the wiring information to check all related harness connectors in tl spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repa
3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the ABS Module and W and ABS Module harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, use the check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
    1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
    2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and ABS Module har the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, use the wiring information to check all related harness connectors i out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a ABS Module. If no issues are found, the ABS Module is fa

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS ABS Module SIGNAL AND RATIONALITY FAULTS AND AN

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to discon Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be volt
    1. If the voltage reads above 10.0 volts, the ABS Module and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an inte the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WS the circuit tests good (no resistance), the ABS Module internal ground is likely faulty. Use the wiring information to check all related harness connectors in out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a ABS Module. If no issues are found, the ABS Module is fa
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the ABS Module harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit a connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and ABS Module harness connector. There should be less than 3.0 Ohms of res
    1. If the resistance is below 3.0 Ohms, the ABS Module is likely faulty. Use the wiring information to check all related harness connectors in the system for pu corroded or dirty terminals that can cause an intermittent open before condemning a ABS Module. If no issues are found, the ABS Module is faulty.
    2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

U0125-LOST COMMUNICATION WITH DYNAMICS SENSOR

NOTE: **This DTC indicates a communication issue has occurred between the Sending control module (Occupant Restraint Controller - Reporting control module(s) that set this fault.**

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIA PROCEDURE. Refer to COMMUNICATION DIAGNOSTIC PROCEDURE .

U0129-LOST COMMUNICATION WITH BRAKE SYSTEM CONTROL MODULE 1

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and I (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The cal sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it co inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and tl the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure a inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Po monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calip braking input or autonomous braking event.

NOTE: **If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in th allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are ha System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BS rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signal

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is det BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the w longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being ap cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the cond

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the con sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, th the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a perfor**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pe are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically betw

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti- control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure senso Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator insi brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.

- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuat pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes during both vehicle operator input and events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to mo travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the cha circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There a located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wh low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap betwee is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wl against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability cont enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock brak electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)

- Brake Pedal Simulator Pressure Sensor (eBooster System)
- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on If the sensor signal is faulty, the BSCM sets a fault agair and sends a Signal Not Available (SNA) message on the PCM will set the missing message fault (U11BF) for the
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BS(against the sensor and sends an SNA message on the CA PCM will set the implausible data fault (U0418) for the
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure in all four hydraulic circuits. The signal is broadcast on t

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor sig the CAN bus. If one sensor is faulted, the BSCM sets a 1 sensor and sends the input from only the good sensor on The PCM will function normally if only one sensor is fa sensors are faulty, the BSCM sets a fault against both se: a Signal Not Available (SNA) signal on the CAN bus. Tl set the missing message fault (U11BF) for the SNA mes
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, tl fault against the sensor and sends and SNA message on The PCM will set the implausible data fault (U0418) for message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure in all four hydraulic circuits. The signal broadcast on the
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) messag BSCM determines that ESS can be enabled. This is base pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.
- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.

- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSC of the WSS signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before conc the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be th BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection betw should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be repl HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table w moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other thre RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is tempora
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrat sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the F Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Moni and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some te rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficul cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the syste
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes throug watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Rev looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or od Battery or Batteries for proper charge and operation along with proper connections. Use the wiring information to identify and check any chassis ground connecti or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pusl burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Suppl properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signa mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disco Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
   1. If voltage is present, continue to step 3.
   2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead)

to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Ele
the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault shoul
the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault sho

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same r**

1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.

4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circ
    1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
    2. If the temp sensor signal and ground circuits test good, use the wiring information to check all related harness connectors for pushed out, spread, corroded c
    condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM
compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on
pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a
some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If t**

the entire ICU should be replaced.

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rat PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

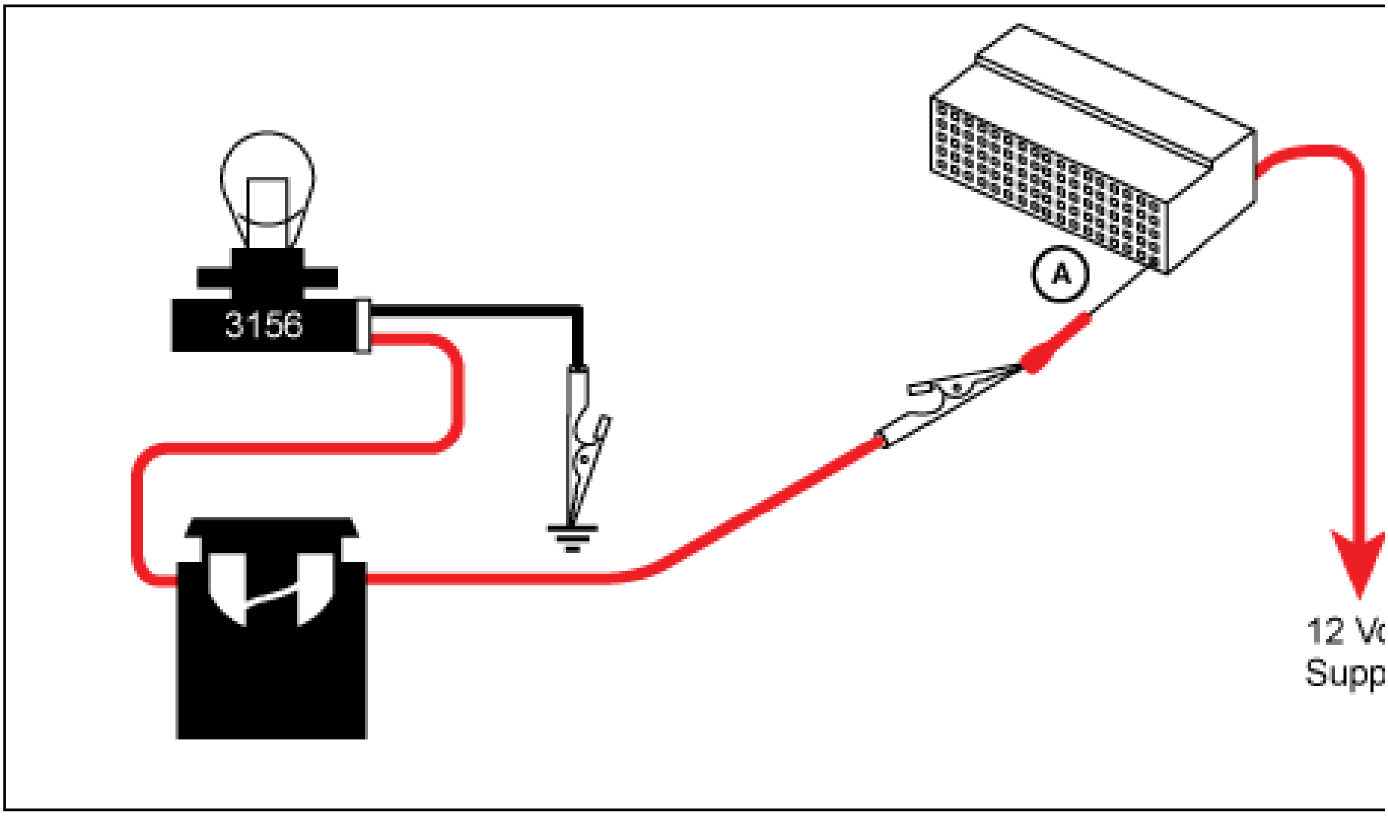
NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If tl the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has nc the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

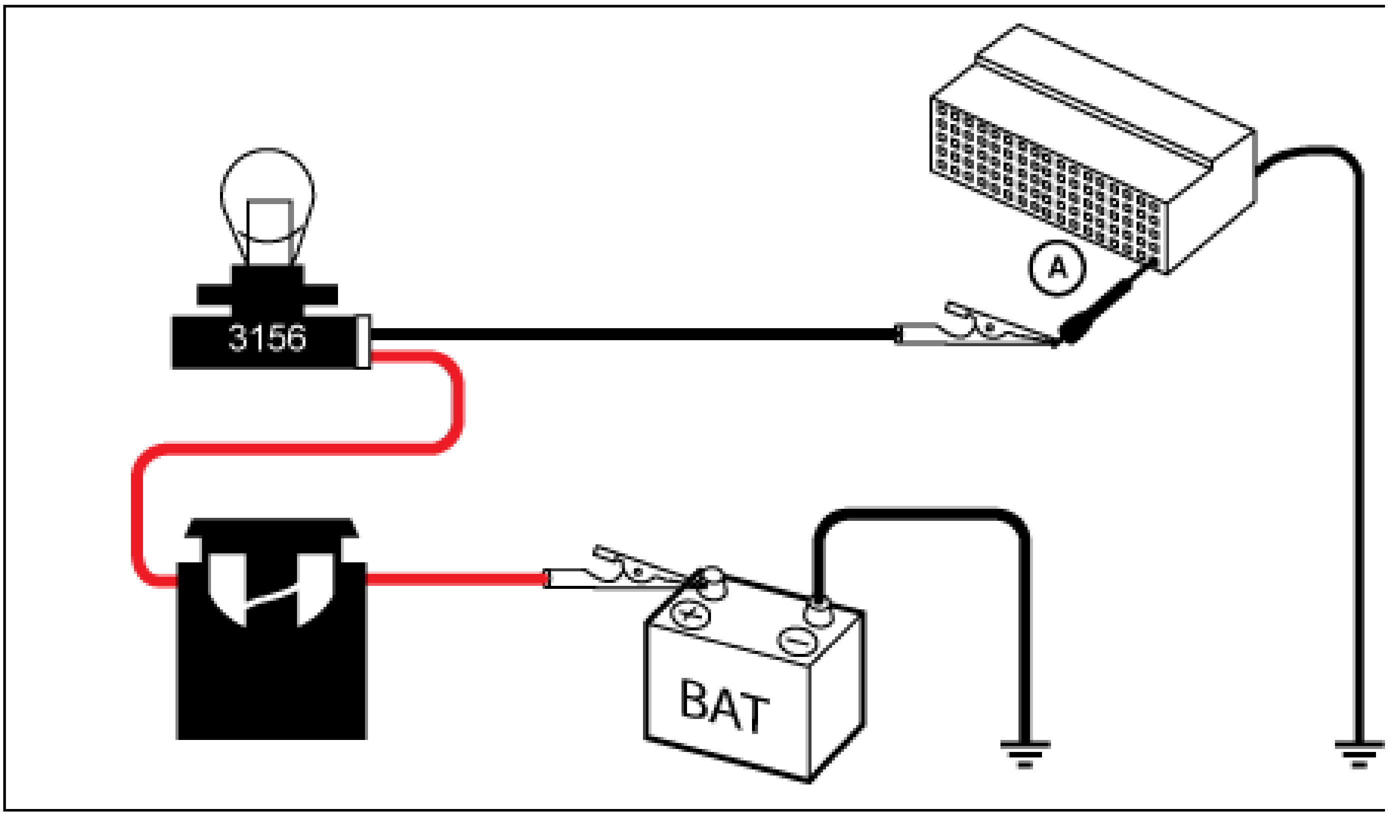
NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If tl the entire ICU should be replaced.**

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal messa the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake Systen

1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.
4. Using the wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the te
   1. If the fuse(s) are good, continue testing in step 5.
   2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

   Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

   1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a si method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative m voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .
   2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
      - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
      - If both circuits pass the load test, continue testing in step 6.

6. 

Load test the BSCM Ground circuit.

1. If the ground circuit fails load testing, repair the BSCM chassis ground.
2. If the ground circuit tests good, continue testing in step 7.

7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (- approximately 2.4v.
   1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

   NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the connector or the wiring leading to that module.**

   2. If both voltage readings match the values given, the BSCM is likely faulty. Use the wiring information to check all related harness connectors for pushed ou dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wigg harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSC failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

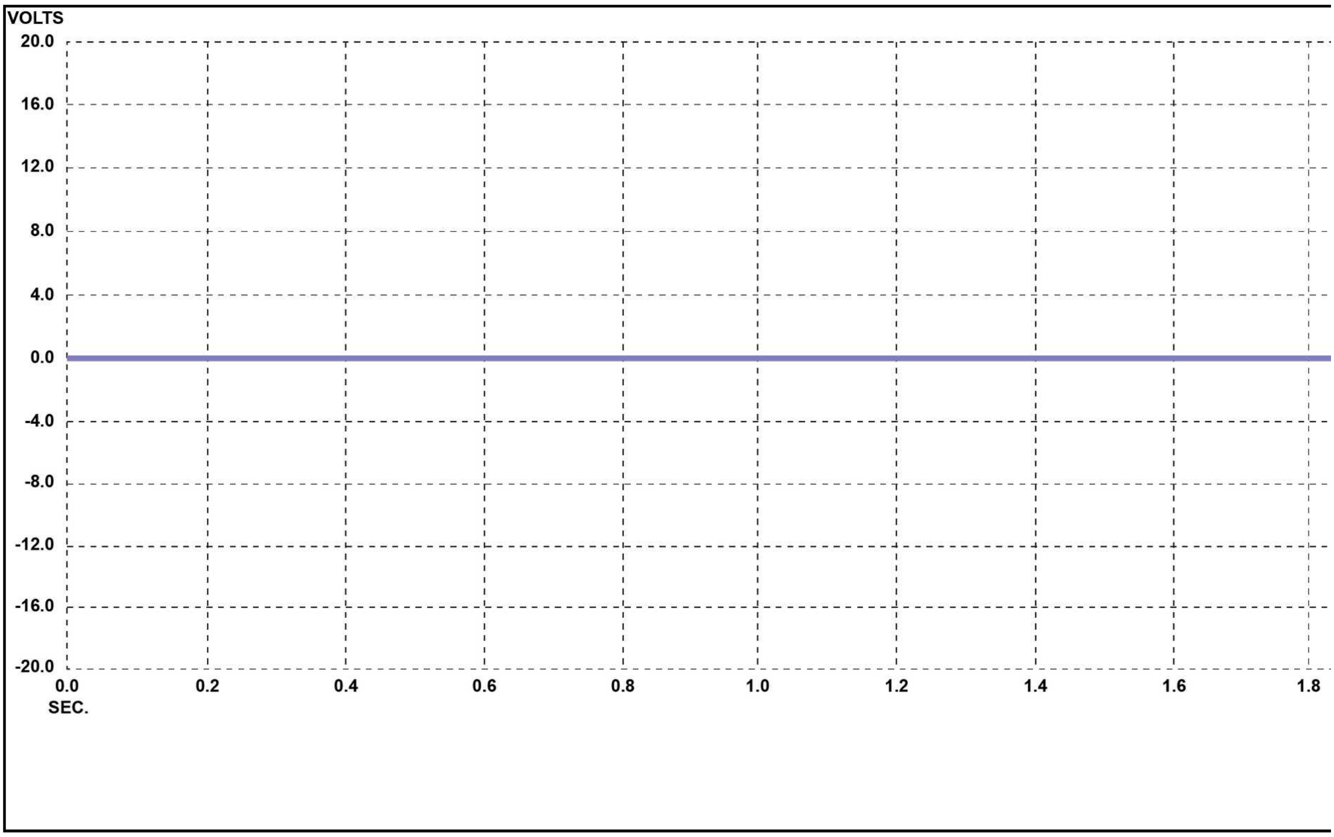
1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle f
   1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
   2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Contr with the Service Information.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATION ANY PCM WSS FAULTS):

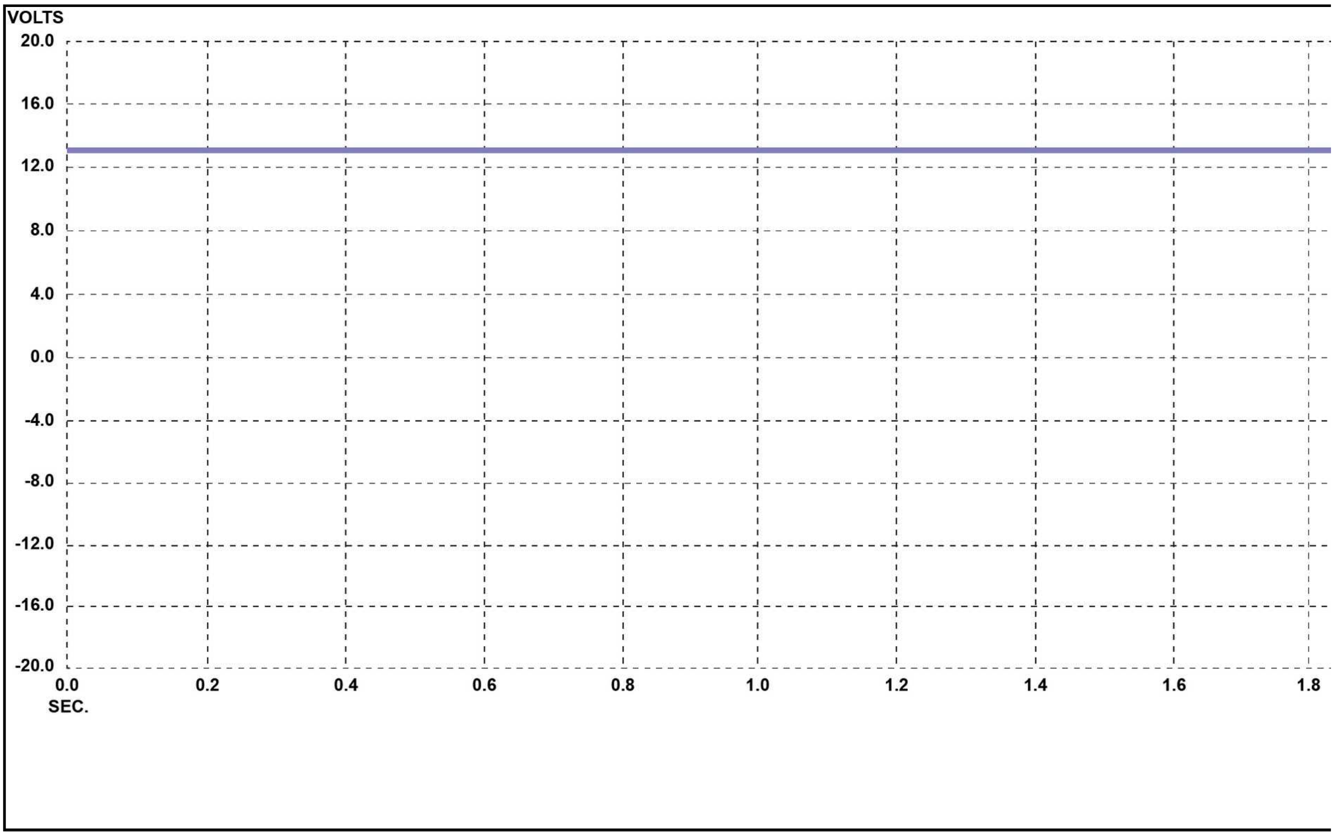
1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. Th depending on the vehicle. The frequency of the signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the whe

closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is st signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.

1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive t monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that ma the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
   - Check the WSS for physical damage and verify it is mounted and fastened properly.
   - If equipped with a tone wheel, inspect the tone wheel for physical damage.
   - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
   - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, use the wiring information to check all related harness connectors in tl spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repa
3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. D BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, use the wiring info related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
    1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
    2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness c Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, use the wiring information to check all related harness connectors in th spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to discon Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be volt
    1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermitte voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WS circuit tests good (no resistance), the BSCM internal ground is likely faulty. Use the wiring information to check all related harness connectors in the systen corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the \
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistanc
    1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. Use the wiring information to check all related harness connectors in the system for pushed dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

DIAGNOSIS AND TESTING

U0140-00-LOST COMMUNICATION WITH BODY CONTROL MODULE

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to COMMUNICATION DIAGNOSTIC PROCEDURE .

U0151-LOST COMMUNICATION WITH OCCUPANT RESTRAINT CONTROLLER

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to COMMUNICATION DIAGNOSTIC PROCEDURE .

U0155-LOST COMMUNICATION WITH CLUSTER/CCN

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to COMMUNICATION DIAGNOSTIC PROCEDURE .

U0164-LOST COMMUNICATION WITH HVAC CONTROL MODULE

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to COMMUNICATION DIAGNOSTIC PROCEDURE .

U0168-LOST COMMUNICATION WITH VEHICLE SECURITY CONTROL MODULE

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to COMMUNICATION DIAGNOSTIC PROCEDURE .

U017E-LOST COMMUNICATION WITH SEATBELT SENSOR 1

NOTE: **This DTC indicates a communication issue has occurred between the Sending control module (Drivers Door Module - DDM) and the Reporting control module(s) that set this fault.**

NOTE: **Treat this DTC as a MISSING MESSAGE DTC when performing the COMMUNICATION DIAGNOSTIC PROCEDURE.**

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to COMMUNICATION DIAGNOSTIC PROCEDURE .

U0212-LOST COMMUNICATION WITH SCM

Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to COMMUNICATION DIAGNOSTIC PROCEDURE .

U0402-IMPLAUSIBLE DATA RECEIVED FROM TCM

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- While the system is active to check for implausible data messages between the Powertrain Control Module (PCM) and Transmission Control Module (TCM).
- During large torque requests from the TCM.

SET CONDITION

- This fault can set if either condition occurs:
  - Data messages received over the bus from the TCM are implausible.
  - The PCM detects a drag during a engine torque request from the TCM. This can occur if the TCM requests engine torque during a shift event.

DEFAULT ACTION

- MIL will illuminate.
- The Transmission will be placed in limp-in.

POSSIBLE CAUSES

POSSIBLE CAUSES
CAN BUS OPEN OR SHORTED CONDITION
TRANSMISSION HARDWARE OR SOFTWARE ISSUE
TRANSMISSION CONTROL MODULE (TCM)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR OTHER DTCS**
   1. Turn the ignition on.
   2. With a scan tool, read and record DTCs and freeze frame data on the repair order.

      NOTE: **This information is important and will be necessary for future reference.**

      Are there any CAN B or CAN C communication DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 2
2. **CHECK THE PCM FOR FLASH UPDATES OR SERVICE BULLETINS**
   1. Perform any **Service Bulletins or flash updates** that may apply for the PCM or TCM.

      Were there any Service Bulletins or flash updates that repaired the issue?

      Yes

      - Repair is complete.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to **STANDARD PROCEDURE** .

NOTE: **Treat this DTC as an IMPLAUSIBLE SIGNAL DTC when performing the COMMUNICATION DIAGNOSTIC PROCEDURE.**

U0405-INVALID DATA RECEIVED FROM CRUISE CONTROL MODULE

NOTE: **Treat this DTC as an IMPLAUSIBLE SIGNAL DTC when performing the COMMUNICATION DIAGNOSTIC PROCEDURE.**

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .

U0416-IMPLAUSIBLE DATA RECEIVED FROM ESP

NOTE: **Treat this DTC as an IMPLAUSIBLE SIGNAL DTC when performing the COMMUNICATION DIAGNOSTIC PROCEDURE.**

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .

U0418-IMPLAUSIBLE DATA RECEIVED FROM BRAKE SYSTEM CONTROL MODULE 1

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE: **If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.

- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)
- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.
- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.

- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan

tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. Use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.

4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

    1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
    2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.
4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.
    1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
    2. If the temp sensor signal and ground circuits test good, Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).

- If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
- If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

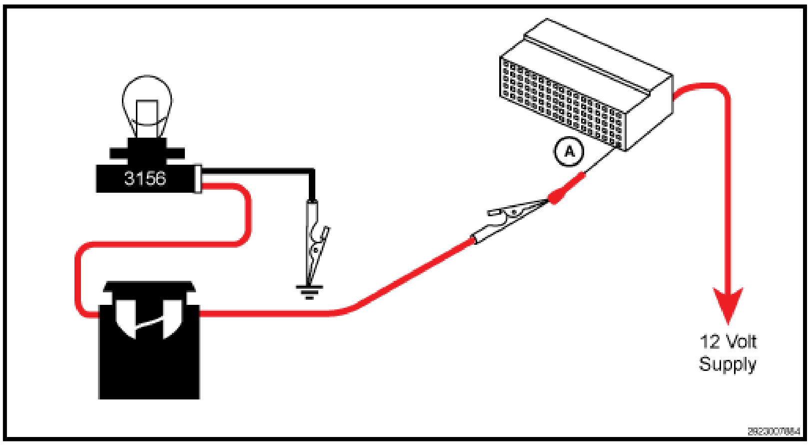
PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

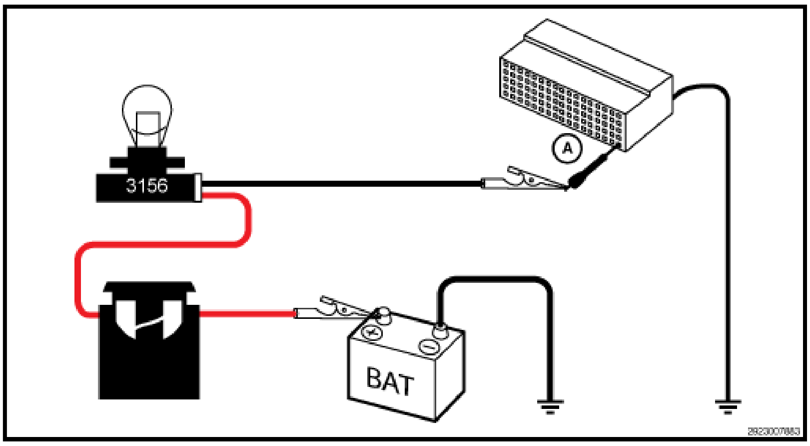
NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.

4. Using the wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
    1. If the fuse(s) are good, continue testing in step 5.
    2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

   Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

    1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .
    2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
        - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
        - If both circuits pass the load test, continue testing in step 6.
6. 

   Load test the BSCM Ground circuit.

    1. If the ground circuit fails load testing, repair the BSCM chassis ground.
    2. If the ground circuit tests good, continue testing in step 7.
7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
    1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

2. If both voltage readings match the values given, the BSCM is likely faulty. Use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

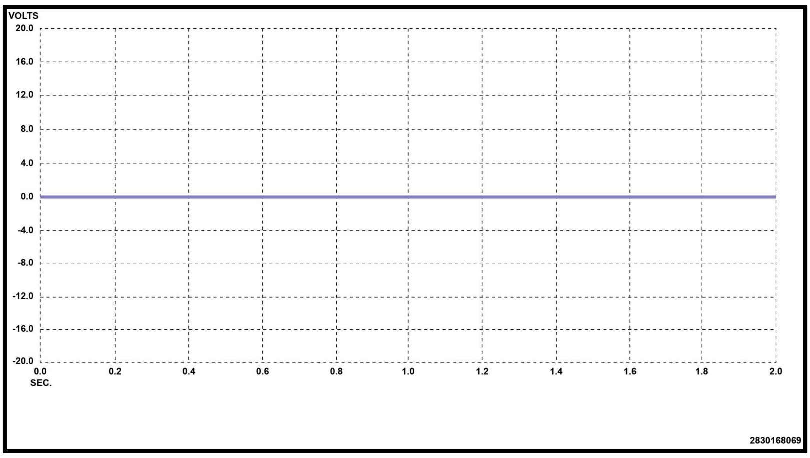
1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
    1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
    2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

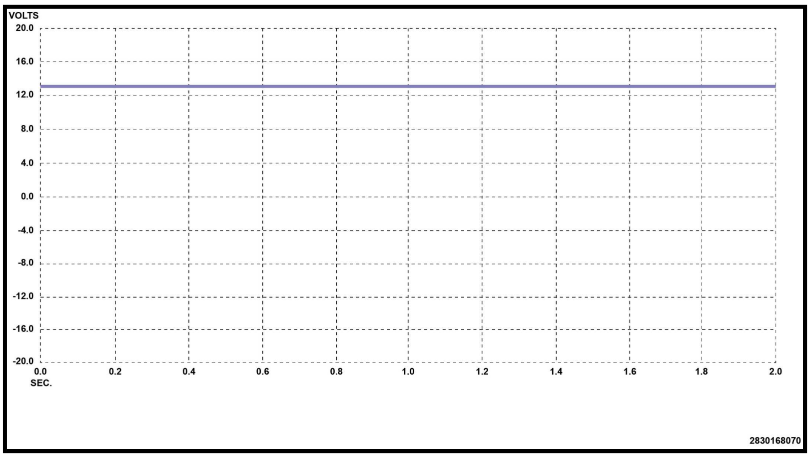
1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the

signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.

1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
   - Check the WSS for physical damage and verify it is mounted and fastened properly.
   - If equipped with a tone wheel, inspect the tone wheel for physical damage.
   - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
   - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.
3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
    1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
    2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.
    1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.

1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. Use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

U0424-IMPLAUSIBLE DATA RECEIVED FROM HVAC CONTROL MODULE

NOTE: **Treat this DTC as an IMPLAUSIBLE SIGNAL DTC when performing the COMMUNICATION DIAGNOSTIC PROCEDURE.**

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to COMMUNICATION DIAGNOSTIC PROCEDURE .

U0426-IMPLAUSIBLE DATA RECEIVED FROM VEHICLE SECURITY CONTROL MODULE

NOTE: **Treat this DTC as an IMPLAUSIBLE SIGNAL DTC when performing the COMMUNICATION DIAGNOSTIC PROCEDURE.**

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to COMMUNICATION DIAGNOSTIC PROCEDURE .

U0427-INVALID DATA RECEIVED FROM VEHICLE SECURITY CONTROL MODULE

NOTE: **Treat this DTC as an IMPLAUSIBLE SIGNAL DTC when performing the COMMUNICATION DIAGNOSTIC PROCEDURE.**

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to COMMUNICATION DIAGNOSTIC PROCEDURE .

U0428-IMPLAUSIBLE DATA RECEIVED FROM STEERING ANGLE SENSOR

NOTE: **Treat this DTC as an IMPLAUSIBLE SIGNAL DTC when performing the COMMUNICATION DIAGNOSTIC PROCEDURE.**

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to COMMUNICATION DIAGNOSTIC PROCEDURE .

U0429-IMPLAUSIBLE DATA RECEIVED FROM STEERING CONTROL MODULE

NOTE: **Treat this DTC as an IMPLAUSIBLE SIGNAL DTC when performing the COMMUNICATION DIAGNOSTIC PROCEDURE.**

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to COMMUNICATION DIAGNOSTIC PROCEDURE .

U0432-INVALID DATA RECEIVED FROM MULTI-AXIS ACCELERATION SENSOR MODULE

NOTE: **Treat this DTC as an INVALID DATA DTC when performing the COMMUNICATION DIAGNOSTIC PROCEDURE.**

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to **COMMUNICATION DIAGNOSTIC PROCEDURE** .

U047F-IMPLAUSIBLE DATA RECEIVED FROM SEATBELT SENSOR 1

WHEN MONITORED

- This diagnostic runs continuously while the system is active.

SET CONDITION

- The Powertrain Control Module (PCM) receives an invalid Seat Belt Pretensioner message over the CAN C bus from the Occupant Restraint Controller (ORC).

DEFAULT ACTION

- MIL light will illuminate.

POSSIBLE CAUSES

Possible Causes
CAN BUS OPEN OR SHORTED CONDITION
OCCUPANT RESTRAINT CONTROLLER (ORC)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Go To 2

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK FOR OTHER DTCS**
    1. Refer to the recorded DTCs.

Are there any CAN B and C communication DTCs active or pending?

Yes

- Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

No

- Go To 3

3. **CHECK FOR ORC COMMUNICATION RELATED DTCS IN OTHER MODULES**
   1. With the scan tool, select Network Diagnostics.

   Is there more than one module with active DTCs "Logged Against" the ORC at this time?

   Yes

   - Replace and program the Occupant Restrain Controller (ORC) in accordance with the Service Information. Refer to **CONTROLLER, OCCUPANT RESTRAINT (ORC), REMOVAL AND INSTALLATION** .
   - Perform the ORC VERIFICATION TEST. Refer to **RESTRAINTS SYSTEM VERIFICATION TEST** .

   No

   - Replace the Powertrain Control Module in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

U110A-LOSS OF COMMUNICATIONS WITH SCM - CAN C

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to **COMMUNICATION DIAGNOSTIC PROCEDURE** .

U110C-LOST FUEL LEVEL MESSAGE

For a complete FUEL DELIVERY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Fuel Level Sensor signal is a direct input to the Body Control Module (BCM). The BCM transmits the fuel level message to the Powertrain Control Module (PCM) over the CAN C bus.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on
- Battery voltage between 9.0 and 16.0 volts
- Engine run time greater than three seconds

SET CONDITION

- The PCM either doesn't receive a bus message or receives an implausible bus message from the Body Control Module (BCM).

POSSIBLE CAUSES

Possible Causes
FUEL LEVEL SENSOR WIRING ISSUE
FUEL LEVEL SENSOR
BODY CONTROL MODULE (BCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Go To 2

        No

        - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **VERIFY THAT THE BCM IS CAPABLE OF SETTING FUEL LEVEL SENSOR FAULTS**
    1. Check the BCM fault code list to verify that the BCM has the capability to set DTCs against the Fuel Level Sensor. Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

        Are there any Fuel Level Sensor faults listed in the DTC list for the BCM?

        Yes

        - Go To 3

        No

        - Go To 4
3. **CHECK THE BCM FOR FUEL LEVEL SENSOR FAULTS**
    1. With the scan tool, read DTCs in the BCM.

        Is the BCM setting any DTCs against the Fuel Level Sensor?

        Yes

- Perform the diagnostic procedure in the BCM. Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

No

- Go To 6

4. **CHECK THE FUEL LEVEL SENSOR WIRING FOR AN OPEN OR SHORTED CONDITION**
    1. Turn the ignition off.
    2. Disconnect the Fuel Level Sensor harness connector.
    3. Disconnect the appropriate BCM harness connector.
    4. Check the Fuel Level Sensor wires:
        - For an open condition.
        - For a short to voltage.
        - For a short to ground.
        - For a short to each other.

    Were any problems found with the wiring?

    Yes

    - Perform the appropriate repair of the wiring.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

5. **REPLACE THE FUEL LEVEL SENSOR AND RETEST FOR DTC**
    1. Replace the Fuel Level Sensor in accordance with the Service Information.
    2. Reconnect all harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the Freeze Frame Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 6

    No

    - Replacing the Fuel Level Sensor repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK RELATED BCM AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.

4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information.
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

U110E-LOST AMBIENT TEMPERATURE MESSAGE

For a complete A/C CONTROL SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

This diagnostic runs when the following conditions are met:

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- The Powertrain Control Module (PCM) either doesn't receive a bus message or receives an implausible bus message from the Body Control Module (BCM).

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
AAT SENSOR WIRING ISSUE
AMBIENT AIR TEMPERATURE (AAT) SENSOR
BODY CONTROL MODULE (BCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Go To 2

        No

        - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **VERIFY THAT THE BCM IS CAPABLE OF SETTING AMBIENT AIR TEMPERATURE SENSOR FAULTS**
    1. Check the BCM fault code list to verify that the BCM has the capability to set DTCs against the AAT Sensor. Refer to **DIAGNOSIS AND TESTING** .

        Are there any AAT Sensor faults listed in the DTC list for the BCM?

        Yes

        - Go To 3

        No

        - Go To 4
3. **CHECK THE BCM FOR AAT SENSOR FAULTS**
    1. With the scan tool, read DTCs in the BCM.

        Is the BCM setting any DTCs against the AAT Sensor?

Yes

- Perform the diagnostic procedure in the BCM. Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

No

- Replace and program the Body Control Module in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM), REMOVAL AND INSTALLATION** .

4. **CHECK THE AAT SENSOR WIRING FOR AN OPEN OR SHORTED CONDITION**
    1. Turn the ignition off.
    2. Disconnect the AAT Sensor harness connector.
    3. Disconnect the appropriate BCM harness connector.
    4. Check the AAT Sensor circuits:
        - For an open condition.
        - For a short to voltage.
        - For a short to ground.
        - For a short to each other.

    Were any problems found with the wiring?

    Yes

    - Perform the appropriate repair of the wiring.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - Go To 5

5. **REPLACE THE AAT SENSOR AND RETEST FOR DTC**
    1. Replace the AAT Sensor in accordance with the Service Information.
    2. Reconnect all harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the Freeze Frame Data or When Monitored Conditions above, operate the vehicle within the conditions that set the DTC.
    6. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 6

    No

    - Replacing the AAT Sensor repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK RELATED PCM AND COMPONENT CONNECTIONS**
    1. Perform any Service Bulletins that apply.
    2. Disconnect all PCM harness connectors.

3. Disconnect all related in-line harness connections (if equipped).
4. Disconnect the related component harness connectors.
5. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

6. Reconnect all PCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
9. With the scan tool, erase DTCs.
10. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
11. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Powertrain Control Module (PCM) in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

U1110-LOST VEHICLE SPEED MESSAGE

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) receives wheel speed and wheel distance CAN C bus messages from the Anti-Lock Brake System (ABS) module.

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The PCM doesn't receive a vehicle speed signal from the Anti-Lock Brake System (ABS) Module over the CAN C bus.

POSSIBLE CAUSES

Possible Causes
CAN C BUS CIRCUIT OPEN OR SHORTED
ANTI-LOCK BRAKE SYSTEM (ABS) MODULE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

        Did the DTC return?

        Yes

        - Go To 2

        No

        - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK PCM FOR U0121- LOST COMMUNICATION WITH ANTI-LOCK BRAKE MODULE**
    1. With a scan tool, read PCM DTCs.

        Is the DTC U0121-LOST COMMUNICATION WITH ANTI-LOCK BRAKE MODULE also set?

        Yes

        - Perform the U0121-Lost Communication with ABS diagnostic procedure. Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

        No

        - Replace the Powertrain Control Module in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .

- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

U1120-LOST WHEEL DISTANCE MESSAGE

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) receives wheel speed and wheel distance CAN C bus messages from the Anti-Lock Brake System (ABS) module.

WHEN MONITORED

- This diagnostic runs continuously with the ignition on.

SET CONDITION

- The PCM doesn't receive a wheel distance traveled signal from the Anti-Lock Brake (ABS) Module over the CAN C bus.

POSSIBLE CAUSES

Possible Causes
CAN C BUS CIRCUIT OPEN OR SHORTED
ANTI-LOCK BRAKE SYSTEM (ABS) MODULE
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK PCM FOR U0121-LOST COMMUNICATION WITH ABS MODULE**

1. With the scan tool, read PCM DTCs.

   Is the U0121-LOST COMMUNICATION WITH ABS MODULE also set?

   Yes

   - Perform the U0121-Lost Communication with ABS diagnostic procedure. Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

   No

   - Replace the Powertrain Control Module in accordance with the Service Information. Refer to **MODULE, POWERTRAIN CONTROL (PCM), REMOVAL AND INSTALLATION** .
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

U1133-LOST STOP/START SWITCH 1 MESSAGE

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on
- Battery voltage between 10.0 and 16.0 volts

SET CONDITION

- The Powertrain Control Module (PCM) either doesn't receive a Stop/Start bus message or receives an implausible bus message from the Body Control Module (BCM).

POSSIBLE CAUSES

Possible Causes
STOP/START SWITCH WIRING ISSUE
STOP/START SWITCH
BODY CONTROL MODULE (BCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

      Did the DTC return?

Yes

- Go To2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **VERIFY THAT THE BODY CONTROL MODULE IS CAPABLE OF SETTING STOP/START SWITCH FAULTS**
    1. Check the BCM fault code list to verify that the BCM has the capability to set DTCs against the Stop/Start Switch. Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

       Are there any Stop/Start Switch faults listed in the DTC list for the BCM?

       Yes

       - Go To 3

       No

       - Go To 4
3. **CHECK THE BODY CONTROL MODULE FOR STOP/START SWITCH FAULTS**
    1. With the scan tool, read DTCs in the BCM.

       Is the BCM setting any DTCs against the Stop/Start Switch?

       Yes

       - Perform the diagnostic procedure in the BCM. Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

       No

       - Go To 6
4. **CHECK THE STOP/START SWITCH WIRING FOR AN OPEN OR SHORT**
    1. Turn the ignition off.
    2. Disconnect the Stop/Start Switch harness connector.
    3. Disconnect the appropriate BCM harness connector.
    4. Check the Stop/Start Switch wiring:
        - For an open condition.
        - For a short to voltage.
        - For a short to ground.
        - For a short to each other.

       Were any problems found with the wiring?

       Yes

       - Perform the appropriate repair of the wiring.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

- Go To 5

5. **REPLACE THE STOP/START SWITCH AND RETEST FOR DTC**
    1. Replace the Stop/Start Switch in accordance with the Service Information.
    2. Reconnect all harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 6

    No

    - Replacing the Stop/Start Switch repaired the fault.
    - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK RELATED BCM AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.
        - Check for spread terminals and verify proper terminal tension.

        Repair any conditions that are found.

    5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
    6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
    7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
    8. With the scan tool, erase DTCs.
    9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
    10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

- Replace and program the Body Control Module (BCM) in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM), REMOVAL AND INSTALLATION** .
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

U1134-LOST STOP/START SWITCH 2 MESSAGE

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on
- Battery voltage between 10.0 and 16.0 volts

SET CONDITION

- The Powertrain Control Module (PCM) either doesn't receive a Stop/Start bus message or receives an implausible bus message from the Body Control Module (BCM).

POSSIBLE CAUSES

Possible Causes
STOP/START SWITCH WIRING ISSUE
STOP/START SWITCH
BODY CONTROL MODULE (BCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.
   5. Turn the ignition on.
   6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
   7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

   No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **VERIFY THAT THE BCM IS CAPABLE OF SETTING STOP/START SWITCH FAULTS**
   1. Check the BCM fault code list to verify that the BCM has the capability to set DTCs against the Stop/Start Switch. Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

      Are there any Stop/Start Switch faults listed in the DTC list for the BCM?

      Yes

      - Go To 3

      No

      - Go To 4
3. **CHECK THE BCM FOR STOP/START SWITCH FAULTS**
   1. With the scan tool, read DTCs in the BCM.

      Is the BCM setting any DTCs against the Stop/Start Switch?

      Yes

      - Perform the diagnostic procedure in the BCM. Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 6
4. **CHECK THE STOP/START SWITCH WIRING FOR AN OPEN OR SHORT**
   1. Turn the ignition off.
   2. Disconnect the Stop/Start Switch harness connector.
   3. Disconnect the appropriate BCM harness connector.
   4. Check the Stop/Start Switch wiring:
      - For an open condition.
      - For a short to voltage.
      - For a short to ground.
      - For a short to each other.

      Were any problems found with the wiring?

      Yes

      - Perform the appropriate repair of the wiring.
      - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

      No

      - Go To 5
5. **REPLACE THE STOP/START SWITCH AND RETEST FOR DTC**
   1. Replace the Stop/Start Switch in accordance with the Service Information.
   2. Reconnect all harness connectors.
   3. Turn the ignition on.

4. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 6

   No

   - Replacing the Stop/Start Switch repaired the fault.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

6. **CHECK RELATED BCM AND COMPONENT CONNECTIONS**
   1. Disconnect all BCM harness connectors.
   2. Disconnect all related in-line harness connections (if equipped).
   3. Disconnect the related component harness connectors.
   4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
      - Proper connector installation.
      - Damaged connector locks.
      - Corrosion.
      - Other signs of water intrusion.
      - Weather seal damage (if equipped).
      - Bent terminals.
      - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
      - Terminals that have been pushed back into the connector cavity.
      - Check for spread terminals and verify proper terminal tension.

      Repair any conditions that are found.

   5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
   6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
   7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
   8. With the scan tool, erase DTCs.
   9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
   10. With the scan tool, read DTCs.

      Did the DTC return?

      Yes

      - Replace and program the Body Control Module (BCM) in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM), REMOVAL AND INSTALLATION** .
      - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

      No

- The wiring or poor connection problem has been repaired.
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

U113E-LOST COMMUNICATION WITH INTELLIGENT BATTERY SENSOR

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on for at least five seconds
- Battery voltage between 10.0 and 16.0 volts

SET CONDITION

- The Body Control Module (BCM) does not receive any information from the Intelligent Battery Sensor (IBS) for more than two seconds.

DEFAULT ACTION

- The MIL is illuminated.
- If the vehicle is equipped with the stop/start feature, the system will be disabled when this DTC is active.

POSSIBLE CAUSES

Possible Causes
FUSED B+ CIRCUIT OPEN/HIGH RESISTANCE
IBS GROUND CIRCUIT OPEN/HIGH RESISTANCE
LIN BUS CIRCUIT OPEN/HIGH RESISTANCE
LIN BUS CIRCUIT SHORTED TO GROUND
INTELLIGENT BATTERY SENSOR (IBS)

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **VERIFY THAT THE BCM IS CAPABLE OF SETTING IBS FAULTS**
    1. Check the BCM fault code list to verify that the BCM has the capability to set DTCs against the IBS. Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

    Are there any IBS faults listed in the DTC list for the BCM?

    Yes

    - Perform the diagnostic procedure in the BCM. Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

    No

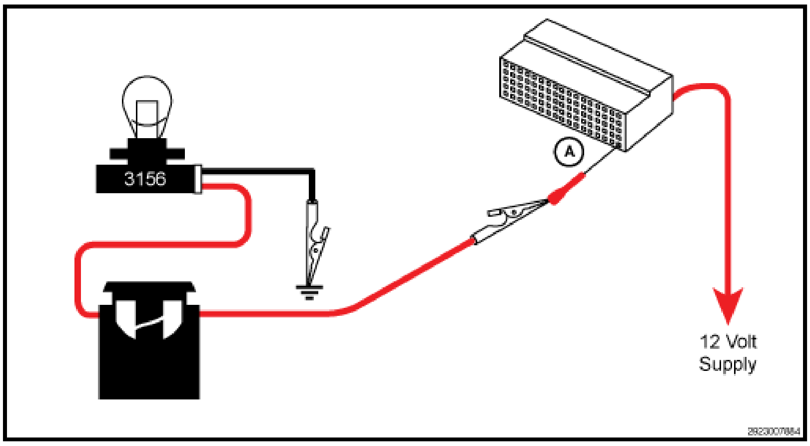
    - Go To 3
3. **ISOLATE AND LOAD TEST THE IBS FUSED B+ CIRCUIT TO CHECK FOR HIGH RESISTANCE**

NOTE: **Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

    1. Disconnect the IBS harness connectors.

    CAUTION: **Do not load test any circuits with components still connected to the circuit.**

    2. Isolate and load test the IBS Fused B+ circuit.



NOTE: **The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry. Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

    Is the load test bulb illuminated and bright?

    Yes

    - Go To 4

    No

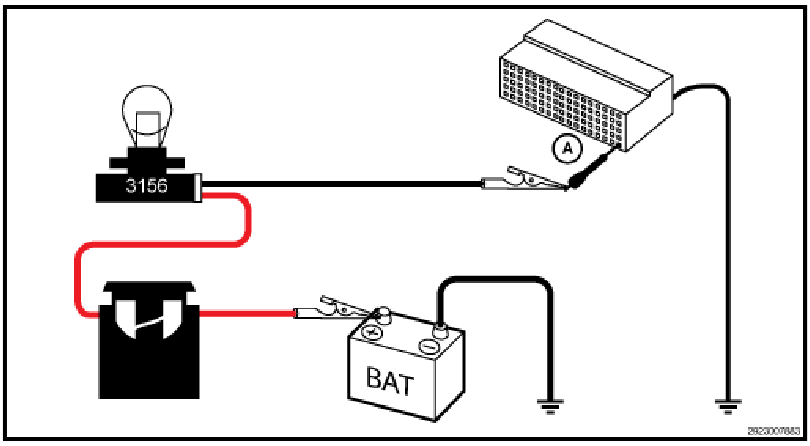
    - Repair the 12.0 volt circuit for an open or high resistance. If the fuse is found to be open, check the circuit for a short to ground.
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

4. **ISOLATE AND LOAD TEST THE IBS GROUND CIRCUIT TO CHECK FOR HIGH RESISTANCE**

NOTE: **Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .**

CAUTION: **Do not load test any circuits with components still connected to the circuit.**

1. Load test the IBS Ground circuit at the IBS harness connector (A). **Note:** refer to the diagram below.



NOTE: **The bulb on the load test tool should be illuminated and bright if there is no resistance in the circuitry. Compare the brightness of the bulb in the load test tool to that of a direct connection to Battery.**

Is the load test bulb illuminated and bright?

Yes

- Go To 5

No

- Repair the ground circuit for an open or high resistance.
- Perform the BODY VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

5. **CHECK THE IBS LIN BUS CIRCUIT FOR A SHORT TO GROUND**
   1. Turn the ignition off.
   2. Disconnect the appropriate BCM harness connector.
   3. Check for continuity between the ground and the IBS LIN Bus circuit at the IBS harness connector.

Is there continuity between ground and IBS LIN Bus circuit?

Yes

- Repair the IBS LIN Bus circuit for a short to ground.
- Perform the BODY VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Go To 6

6. **ISOLATE AND CHECK THE IBS LIN BUS CIRCUIT FOR AN OPEN/HIGH RESISTANCE**
    1. Measure the resistance of the IBS LIN Bus circuit between the IBS harness connector and the BCM harness connector.

       Is the resistance below 3.0 Ohms?

       Yes

       - Go To 7

       No

       - Repair the IBS LIN Bus circuit for an open or high resistance.
       - Perform the BODY VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
7. **REPLACE THE INTELLIGENT BATTERY SENSOR AND RETEST FOR DTC**
    1. Replace the Intelligent Battery Sensor in accordance with the Service Information. Refer to **SENSOR, INTELLIGENT BATTERY (IBS), REMOVAL AND INSTALLATION** .
    2. Connect the Intelligent Battery Sensor and BCM harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, erase DTCs.
    5. Using the recorded Freeze Frame and the When Monitored conditions, operate the vehicle in the conditions that set the DTC.
    6. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Go To 8

       No

       - Replacing the Intelligent Battery Sensor repaired the fault.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
8. **CHECK RELATED BCM AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).
    3. Disconnect the related component harness connectors.
    4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
        - Proper connector installation.
        - Damaged connector locks.
        - Corrosion.
        - Other signs of water intrusion.
        - Weather seal damage (if equipped).
        - Bent terminals.
        - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
        - Terminals that have been pushed back into the connector cavity.

- Check for spread terminals and verify proper terminal tension.

Repair any conditions that are found.

5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Replace and program the Body Control Module (BCM) in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM), REMOVAL AND INSTALLATION** .
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

No

- The wiring or poor connection problem has been repaired.
- Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

U1141-LOST-ESP-TORQUE-REQUEST-MESSAGE

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- When the Anti-Lock Brake System (ABS)/ Electronic Stability Program (ESP) system is active.

SET CONDITION

- The Powertrain Control Module (PCM) has not received a torque request over the bus circuit from the ESP/ ABS Module.

DEFAULT ACTION

- This is a non-MIL fault.

POSSIBLE CAUSES

Possible Causes
WHEEL SPEED SENSOR WIRING ISSUE
WHEEL SPEED SENSOR
ELECTRONIC STABILITY PROGRAM (ESP)/ANTI-LOCK BRAKE (ABS) MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Go To 2

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE ANTI-LOCK BRAKE MODULE FOR WHEEL SPEED SENSOR FAULTS**
    1. With the scan tool, read DTCs in the ABS Module.

       Is the ABS Module setting any DTCs against a Wheel Speed Sensor?

       Yes

       - Perform the diagnostic procedure in the ABS Module. Refer to **ANTILOCK BRAKE SYSTEM (ABS) - DIAGNOSTIC CODE INDEX** .

       No

       - Replace the ABS Module in accordance with the Service Information. Refer to **MODULE, ANTI-LOCK BRAKE SYSTEM (ABS), REMOVAL AND INSTALLATION** .

U115F-LOST COMMUNICATION WITH DRIVER PRESENCE DETECTION MODULE

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to **COMMUNICATION DIAGNOSTIC PROCEDURE** .

DIAGNOSIS AND TESTING

U1186-LOST COMMUNICATION WITH ADAPTIVE CRUISE CONTROL MODULE

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to COMMUNICATION DIAGNOSTIC PROCEDURE .

U1199-LOST HOOD AJAR SWITCH VOLTAGE MESSAGE

For a complete VEHICLE THEFT SECURITY SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on
- Battery voltage between 10.0 and 16.0 volts

SET CONDITION

- The Powertrain Control Module (PCM) receives an implausible Hood Ajar bus message from the Body Control Module (BCM).

POSSIBLE CAUSES

Possible Causes
HOOD AJAR SWITCH WIRING ISSUE
HOOD AJAR SWITCH
BODY CONTROL MODULE (BCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **VERIFY THAT THE BODY CONTROL MODULE IS CAPABLE OF SETTING HOOD AJAR SWITCH FAULTS**
    1. Check the BCM fault code list to verify that the BCM has the capability to set DTCs against the Hood Ajar. Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

       Are there any Hood Ajar Switch faults listed in the DTC list for the BCM?

       Yes

       - Go To 3

       No

       - Go To 4
3. **CHECK THE BODY CONTROL MODULE FOR HOOD AJAR SWITCH FAULTS**
    1. With the scan tool, read DTCs in the BCM.

       Is the BCM setting any DTCs against the Hood Ajar?

       Yes

       - Perform the diagnostic procedure in the BCM. Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

       No

       - Replace and program the Body Control Module (BCM) in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM), REMOVAL AND INSTALLATION** .
4. **CHECK THE HOOD AJAR SWITCH 1 CONNECTOR AND TERMINALS**
    1. Turn the ignition off.
    2. Check the Hood Ajar Switch 1 harness connector for proper connection at the Hood Latch Assembly.
    3. Verify that the connector is completely plugged in and properly locked prior to disconnecting.
    4. Disconnect the Hood Ajar Switch 1 harness connector and check for any pushed out, damaged or spread terminals.

       Were any issues found with the connector or terminals?

       Yes

       - Repair the damaged terminal or properly connect and lock the Hood Ajar Switch 1 harness connector and retest for DTCs.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 5

5. **CHECK THE HOOD AJAR SWITCH 1 FOR PROPER FUNCTION**
    1. Check the Hood Ajar Switch 1 functionality. Use the Hood Ajar Switch 1 diagnostic and technical information provided above.

       Is the Hood Ajar Switch 1 functioning properly?

       Yes

       - Go To 6

       No

       - Replace the Hood Latch Assembly in accordance with the Service Information.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
6. **CHECK THE HOOD AJAR SWITCH WIRING FOR AN OPEN OR SHORTED CONDITION**
    1. Disconnect the appropriate BCM harness connector.
    2. Check the Hood Ajar Switch wiring:
       - For an open condition.
       - For a short to voltage.
       - For a short to ground.
       - For a short to each other.

       Were any problems found with the wiring?

       Yes

       - Perform the appropriate wiring repair.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Go To 7
7. **REPLACE THE HOOD AJAR SWITCH AND RETEST FOR DTCS**
    1. Replace the Hood Ajar in accordance with the Service Information.
    2. Reconnect all harness connectors.
    3. Turn the ignition on.
    4. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Go To 8

       No

       - Replacing the Hood Ajar Switch repaired the fault.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .
8. **CHECK RELATED BCM AND COMPONENT CONNECTIONS**
    1. Disconnect all BCM harness connectors.
    2. Disconnect all related in-line harness connections (if equipped).

3. Disconnect the related component harness connectors.
4. Inspect harness connectors, component connectors, and all male and female terminals for the following conditions:
    - Proper connector installation.
    - Damaged connector locks.
    - Corrosion.
    - Other signs of water intrusion.
    - Weather seal damage (if equipped).
    - Bent terminals.
    - Overheating due to a poor connection (terminal may be discolored due to excessive current draw).
    - Terminals that have been pushed back into the connector cavity.
    - Check for spread terminals and verify proper terminal tension.

    Repair any conditions that are found.

5. Reconnect all BCM harness connectors. Be certain that all harness connectors are fully seated and the connector locks are fully engaged.
6. Reconnect all in-line harness connectors (if equipped). Be certain that all connectors are fully seated and the connector locks are fully engaged.
7. Reconnect all related component harness connectors. Be certain that all connectors are fully seated and the connector locks are fully engaged.
8. With the scan tool, erase DTCs.
9. Test drive or operate the vehicle in accordance with the when monitored and set conditions.
10. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Replace and program the Body Control Module (BCM) in accordance with the Service Information. Refer to **MODULE, BODY CONTROL (BCM), REMOVAL AND INSTALLATION** .
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

    No

    - The wiring or poor connection problem has been repaired.
    - Perform the BODY VERIFICATION TEST. Refer to **BODY VERIFICATION TEST** .

U11BC-LOST BRAKE SWITCH MESSAGE

For a complete wiring diagram, **refer to appropriate SYSTEM WIRING DIAGRAMS article** .

WHEN MONITORED

- This diagnostic runs with the ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) doesn't receive a brake switch signal from the Anti-lock brake (ABS) Module over the CAN C bus.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
BRAKE PEDAL POSITION SENSOR WIRING ISSUES
BRAKE PEDAL POSITION (BPP) SENSOR
ANTI-LOCK BRAKE MODULE (ABS)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Go To 2

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE ANTI-LOCK BRAKE MODULE FOR BPP SENSOR FAULTS**
    1. With the scan tool, read DTCs in the ABS Module.

       Is the ABS Module setting any DTCs against a BPP Sensor?

       Yes

       - Perform the diagnostic procedure in the ABS Module. Refer to **ANTILOCK BRAKE SYSTEM (ABS) - DIAGNOSTIC CODE INDEX** .

       No

       - Replace the ABS Module in accordance with the Service Information. Refer to **MODULE, ANTI-LOCK BRAKE SYSTEM (ABS), REMOVAL AND INSTALLATION** .

U11BF-LOST BRAKE PEDAL POSITION MESSAGE

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE: **If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.

- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)
- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
		four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.
- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.

- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND

POSSIBLE CAUSES
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.

- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

    1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
    2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.
4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.
    1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
    2. If the temp sensor signal and ground circuits test good, use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

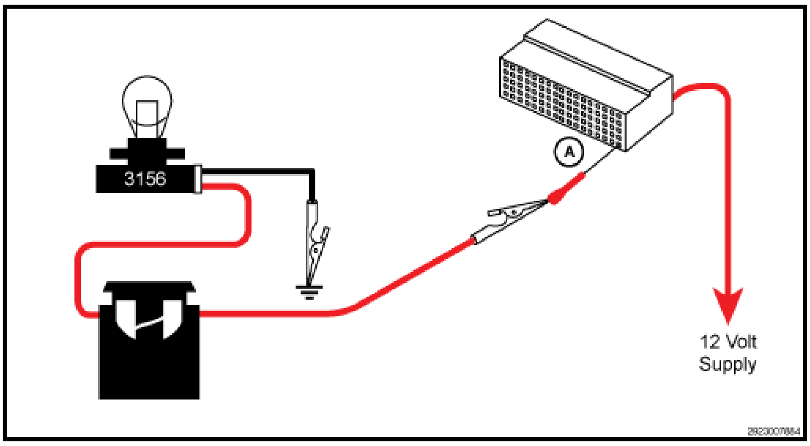
NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

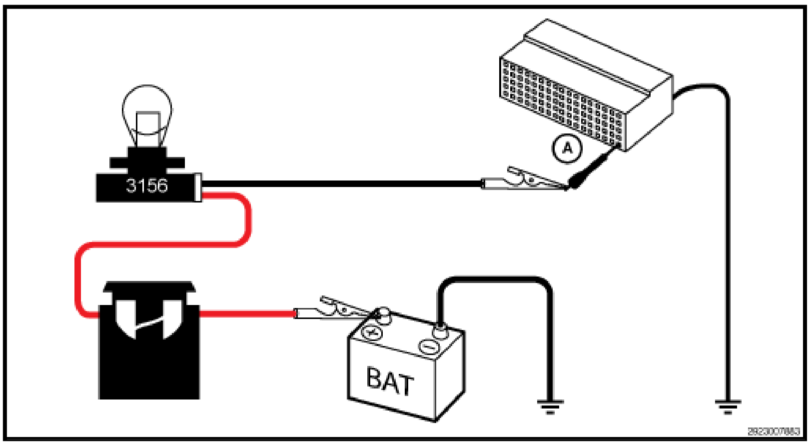
NOTE: The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.
4. Using the appropriate wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
    1. If the fuse(s) are good, continue testing in step 5.
    2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

    Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

    1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to CIRCUIT LOAD TESTING PROCEDURES .
    2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
        - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
        - If both circuits pass the load test, continue testing in step 6.

6. 

Load test the BSCM Ground circuit.

1. If the ground circuit fails load testing, repair the BSCM chassis ground.
2. If the ground circuit tests good, continue testing in step 7.

7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
    1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

    NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

    2. If both voltage readings match the values given, the BSCM is likely faulty. use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.

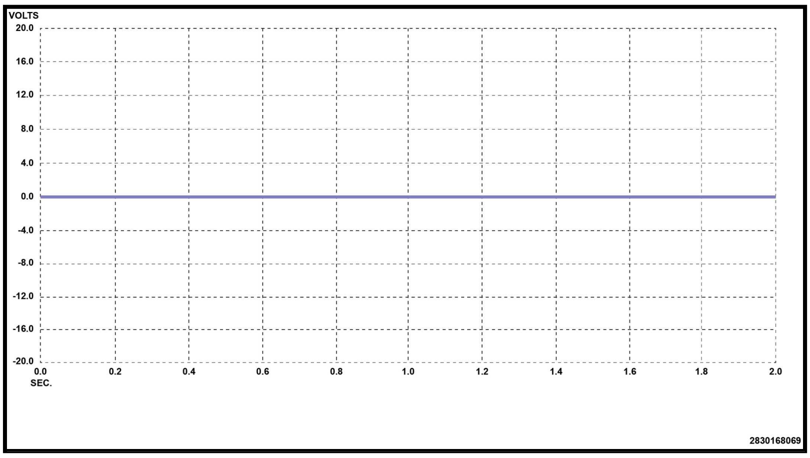
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

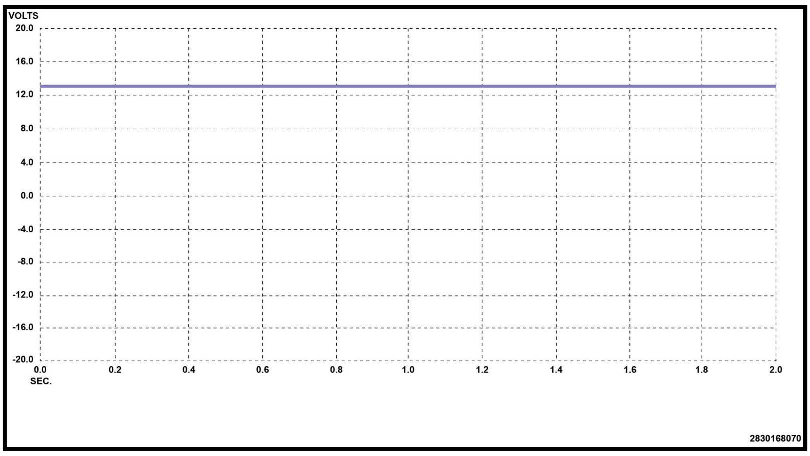
1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
    1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
    2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.
    1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
    2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
        - Check the WSS for physical damage and verify it is mounted and fastened properly.
        - If equipped with a tone wheel, inspect the tone wheel for physical damage.
        - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
        - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.
    3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



    4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
    1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
    2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.
    1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.

   1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
   2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
   1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
   2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.
   1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
   2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

U11C2-LOST TRANSMISSION MESSAGE

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage between 10.0 and 16.0 volts.
- Body Control Module (BCM) is configured correctly.

SET CONDITION

- The Powertrain Control Module (PCM) has not received a Bus message from the Transmission Control Module (TCM) for approximately 500ms.

POSSIBLE CAUSES

Possible Causes
TRANSMISSION CONTROL MODULE (TCM)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
   1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
   2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
   3. With the scan tool, erase all DTCs.
   4. Turn the ignition off for a minimum of 10.0 seconds.

5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

Did the DTC return?

Yes

- Go To 2

No

- Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE TRANSMISSION CONTROL MODULE FOR DTCS**
   1. With the scan tool, read DTCs in the TCM.

      Are there any DTCs set in the TCM?

      Yes

      - Perform the diagnostic procedure in the TCM. Refer to the appropriate information. .

      No

      - Replace the Transmission Control Module in accordance with the Service Information.. Refer to **MODULE, TRANSMISSION CONTROL (TCM), REMOVAL AND INSTALLATION** .

U11DE-LOST SPEED CONTROL MESSAGE

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

- This diagnostic runs continuously when the Speed Control system is active.

SET CONDITION

- The Powertrain Control Module (PCM) does not receive a Speed Control message from the Steering Column Control Module (SCCM) over the CAN Bus.

DEFAULT ACTION

- This is a non MIL fault.

POSSIBLE CAUSES

Possible Causes
LIN BUS OPEN OR SHORTED TO GROUND
SPEED CONTROL SWITCH ASSEMBLY
STEERING COLUMN CONTROL MODULE (SCCM)
POWERTRAIN CONTROL MODULE (PCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

       Did the DTC return?

       Yes

       - Go To 2

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK COMMUNICATION BETWEEN THE SCCM AND THE SPEED CONTROL SWITCH ASSEMBLY**
    1. Turn the ignition on.
    2. With the scan tool, read DTCs in the SCCM.

       Is the SCCM reporting any Speed Control Switch or a Loss of Communication fault with the Speed Control Switch Assembly?

       Yes

       - Refer to **DIAGNOSIS AND TESTING** and perform the appropriate diagnostic test.
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

       No

       - Wiggle test and check the connector at the SCCM for an intermittent loose connection. If the wiring and connector tests good, replace and program the Steering Column Control Module (SCCM) in accordance with the Service Information. Refer to **MODULE, STEERING COLUMN CONTROL (SCCM), REMOVAL AND INSTALLATION** .
       - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

U120C-LOST BRAKE BOOSTER SIGNAL

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

- This diagnostic runs continuously with the Ignition on.

SET CONDITION

- The Powertrain Control Module (PCM) doesn't receive a brake booster vacuum signal from the Anti-lock Brake System (ABS) Module over the CAN C bus.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
BRAKE BOOSTER PRESSURE SENSOR WIRING ISSUES
BRAKE BOOSTER PRESSURE SENSOR
ANTI-LOCK BRAKE SYSTEM (ABS) MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE DTC**
    1. Turn the ignition on.
    2. With the scan tool, read DTCS.

       Is the DTC active or pending?

       Yes

       - Go To 2

       No

       - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **ABS COMMUNICATION RELATED DTCS IN OTHER MODULES**
    1. With the scan tool, read DTCs in the ABS Module.

       Is the ABS Module setting any DTCs against the Brake Booster Pressure Sensor?

       Yes

       - Perform the diagnostic procedure in the ABS Module. Refer to **ANTILOCK BRAKE SYSTEM (ABS) - DIAGNOSTIC CODE INDEX** .
       - Perform the ABS VERIFICATION TEST. Refer to **ABS VERIFICATION TEST** .

       No

       - Replace the ABS Module in accordance with the Service Information. Refer to **MODULE, ANTI-LOCK BRAKE SYSTEM (ABS), REMOVAL AND INSTALLATION** .
       - Perform the ABS VERIFICATION TEST. Refer to **ABS VERIFICATION TEST** .

U120D-LOST ROLLS MODE SIGNAL

NOTE: **Treat this DTC as a MISSING MESSAGE from the BCM when performing the COMMUNICATION DIAGNOSTIC PROCEDURE.**

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to

COMMUNICATION DIAGNOSTIC PROCEDURE .

U12A8-LOST COMMUNICATION WITH MASTER CYLINDER PRESSURE SENSOR

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage above 11.0 volts.

SET CONDITION

- The Master Cylinder Pressure Sensor signal is determined to be invalid by the Anti-Lock Brake System (ABS) Module.

DEFAULT ACTION

- The MIL will illuminate.

POSSIBLE CAUSES

Possible Causes
HYDRAULIC CONTROL UNIT (HCU)
INTEGRATED CONTROL UNIT (ICU)
ANTI-LOCK BRAKE SYSTEM (ABS) MODULE

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.
    3. With the scan tool, erase all DTCs.
    4. Turn the ignition off for a minimum of 10.0 seconds.
    5. Turn the ignition on.
    6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
    7. With the scan tool, read DTCs.

    Did the DTC return?

    Yes

    - Go To 2

    No

    - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK THE ABS MODULE FOR DTCS**
    1. With the scan tool, read DTCs in the ABS Module.

       Are there any DTCs in the ABS Module?

       Yes

       - Perform the diagnostic procedure for the DTC in the ABS Module. Refer to **ANTILOCK BRAKE SYSTEM (ABS) - DIAGNOSTIC CODE INDEX** .
       - Perform the ABS VERIFICATION TEST. Refer to **ABS VERIFICATION TEST** .

       No

       - Replace the ABS Module in accordance with the Service Information. Refer to **MODULE, ANTI-LOCK BRAKE SYSTEM (ABS), REMOVAL AND INSTALLATION** .
       - Perform the ABS VERIFICATION TEST. Refer to **ABS VERIFICATION TEST** .

U1409-IMPLAUSIBLE LEFT FRONT WHEEL SPEED SIGNAL RECEIVED

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE: **If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet

Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.

- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)
- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.
- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)

POSSIBLE CAUSES
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.

4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

   1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
   2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.
4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.
   1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
   2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
   1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
   2. If the temp sensor signal and ground circuits test good, use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).

- If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
- If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

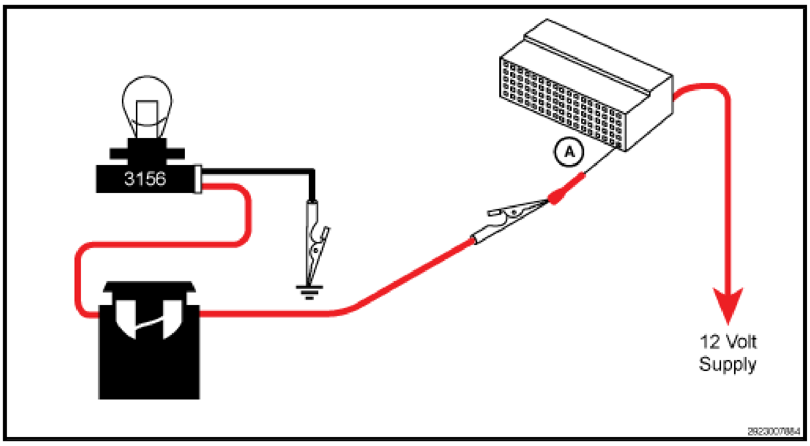
NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

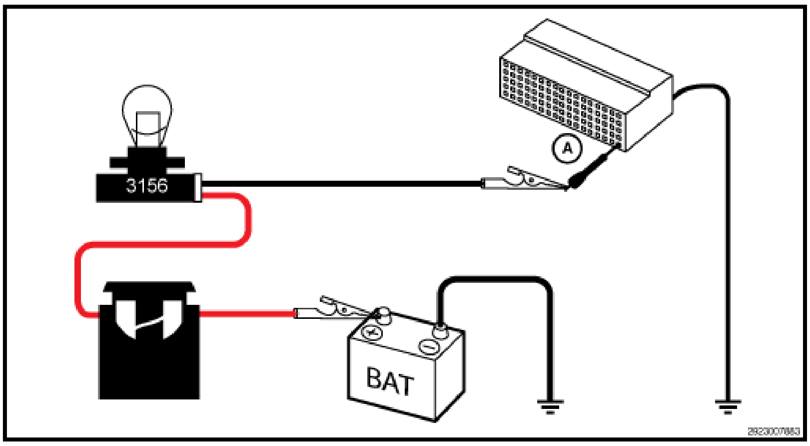
NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.
4. Using the appropriate wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
    1. If the fuse(s) are good, continue testing in step 5.
    2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .
2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
    - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
    - If both circuits pass the load test, continue testing in step 6.

6. 

Load test the BSCM Ground circuit.

1. If the ground circuit fails load testing, repair the BSCM chassis ground.
2. If the ground circuit tests good, continue testing in step 7.

7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
    1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

    NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

    2. If both voltage readings match the values given, the BSCM is likely faulty. use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

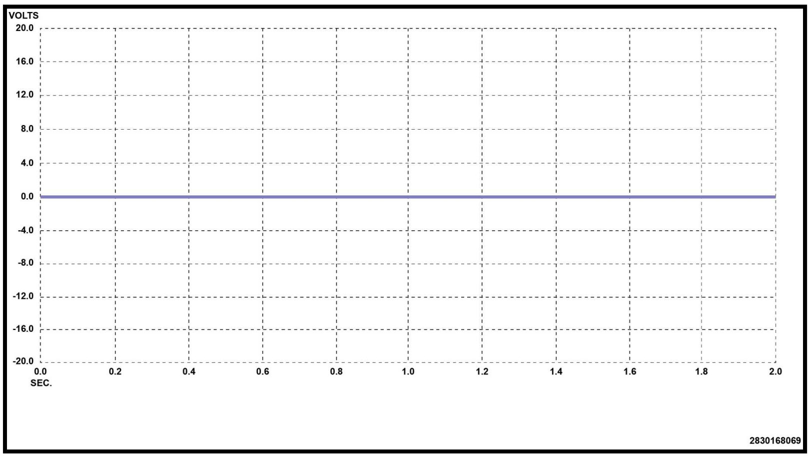
1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
    1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
    2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

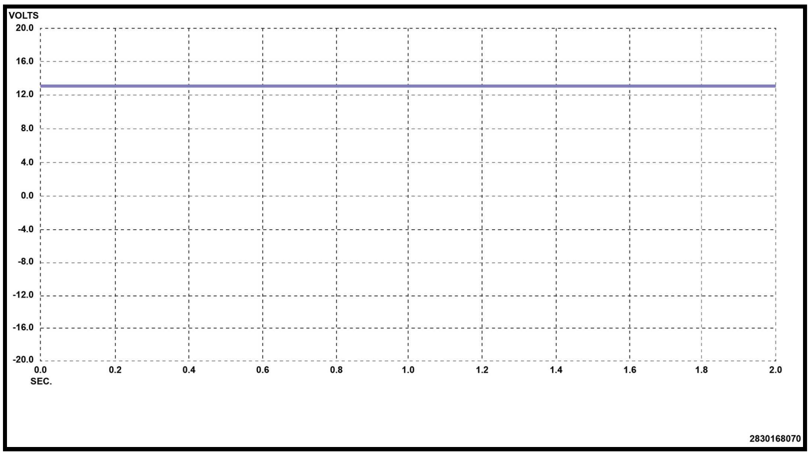
1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.
    1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
    2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
        - Check the WSS for physical damage and verify it is mounted and fastened properly.
        - If equipped with a tone wheel, inspect the tone wheel for physical damage.

- On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
- If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.

3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
   1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
   2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.
    1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.
    1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

U140A-IMPLAUSIBLE RIGHT FRONT WHEEL SPEED SIGNAL RECEIVED

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal

Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE: **If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.

- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)
- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
		and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.
- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the

difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.

- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold

soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.

2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

   1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
   2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.
4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.
   1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
   2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
   1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
   2. If the temp sensor signal and ground circuits test good, use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).

- If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
- If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

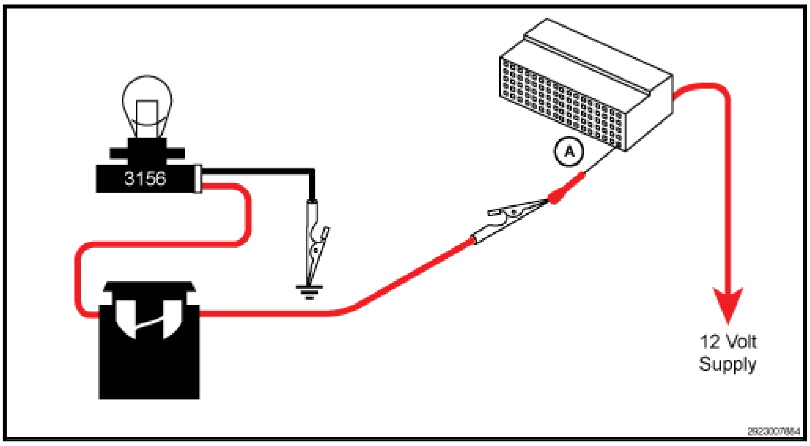
PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

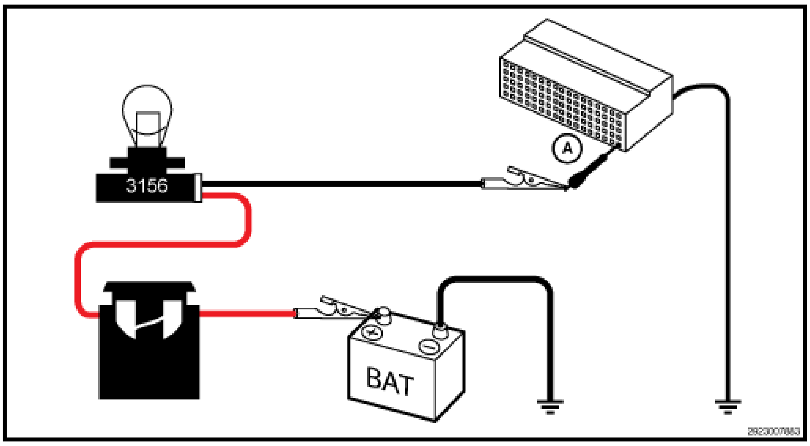
NOTE: The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.

4. Using the appropriate wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
    1. If the fuse(s) are good, continue testing in step 5.
    2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

   Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

    1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .
    2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
        - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
        - If both circuits pass the load test, continue testing in step 6.
6. 

   Load test the BSCM Ground circuit.

    1. If the ground circuit fails load testing, repair the BSCM chassis ground.
    2. If the ground circuit tests good, continue testing in step 7.
7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
    1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

2. If both voltage readings match the values given, the BSCM is likely faulty. use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

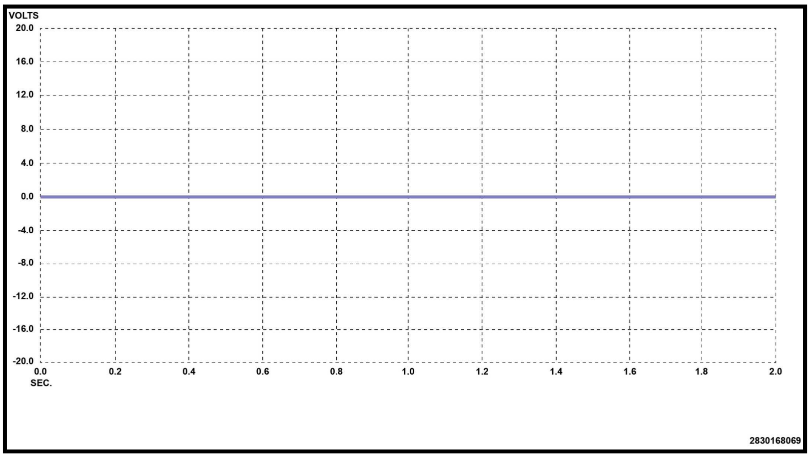
1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
    1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
    2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

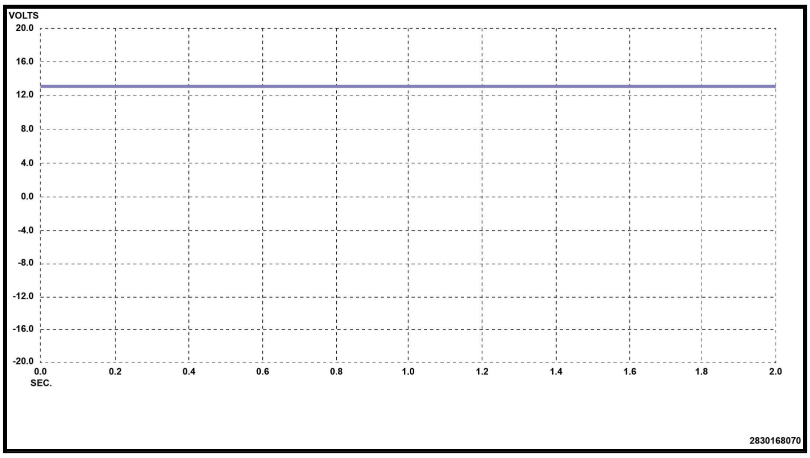
1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the

signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.

1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
   - Check the WSS for physical damage and verify it is mounted and fastened properly.
   - If equipped with a tone wheel, inspect the tone wheel for physical damage.
   - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
   - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.
3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
    1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
    2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.
    1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.

1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

U140B-IMPLAUSIBLE LEFT REAR WHEEL SPEED SIGNAL RECEIVED

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE:	**If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.

- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)
- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
		on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.

- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.

2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

    1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
    2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.
4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.

    1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
    2. If the temp sensor signal and ground circuits test good, use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some**

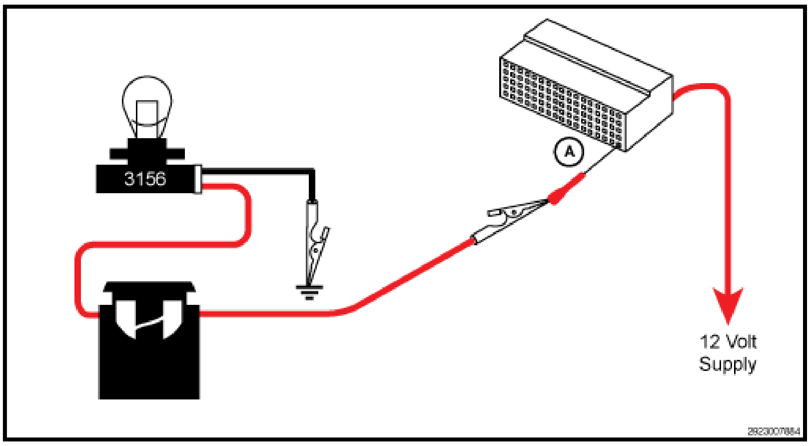
vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

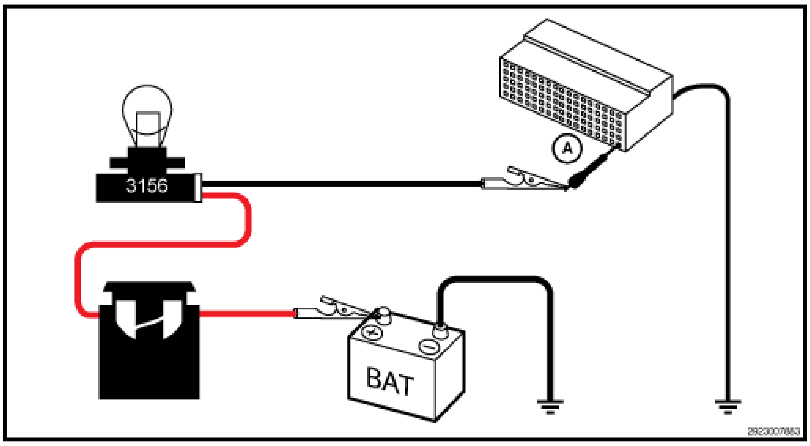
1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.
4. Using the appropriate wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
   1. If the fuse(s) are good, continue testing in step 5.
   2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

   Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

   1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing

information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .

2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
    - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
    - If both circuits pass the load test, continue testing in step 6.

6. 

   Load test the BSCM Ground circuit.

    1. If the ground circuit fails load testing, repair the BSCM chassis ground.
    2. If the ground circuit tests good, continue testing in step 7.

7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
    1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

       NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

    2. If both voltage readings match the values given, the BSCM is likely faulty. use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)

- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

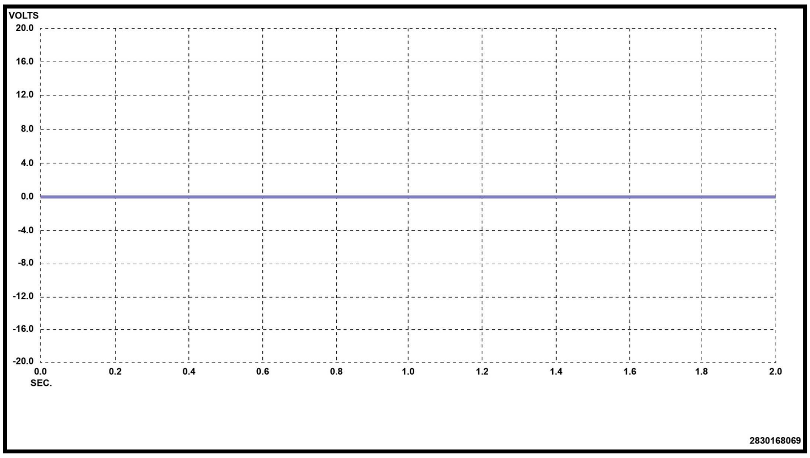
DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
    1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
    2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

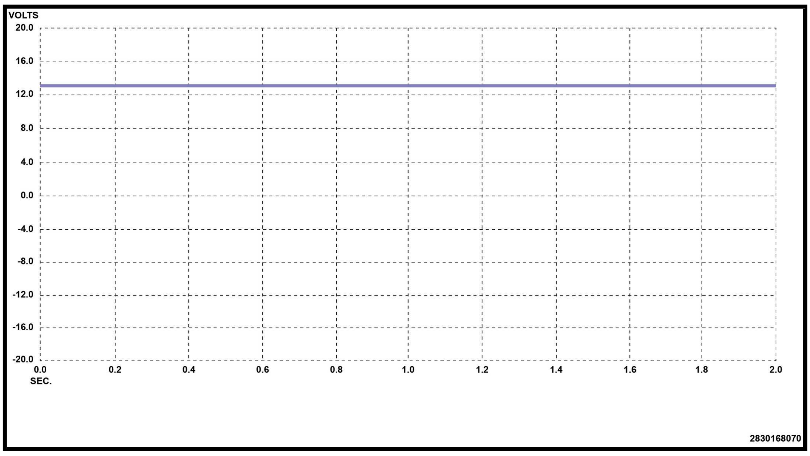
PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.
    1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
    2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
        - Check the WSS for physical damage and verify it is mounted and fastened properly.
        - If equipped with a tone wheel, inspect the tone wheel for physical damage.
        - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
        - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.

3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
    1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
    2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.

1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
2. If no voltage is present, continue testing in step 3.

3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.
    1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

U140C-IMPLAUSIBLE RIGHT REAR WHEEL SPEED SIGNAL RECEIVED

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE: **If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.
- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes

during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)

- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.
- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS

signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU

and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.

2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

   1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
   2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.
4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.
   1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
   2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
   1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
   2. If the temp sensor signal and ground circuits test good, use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).

- If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
- If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

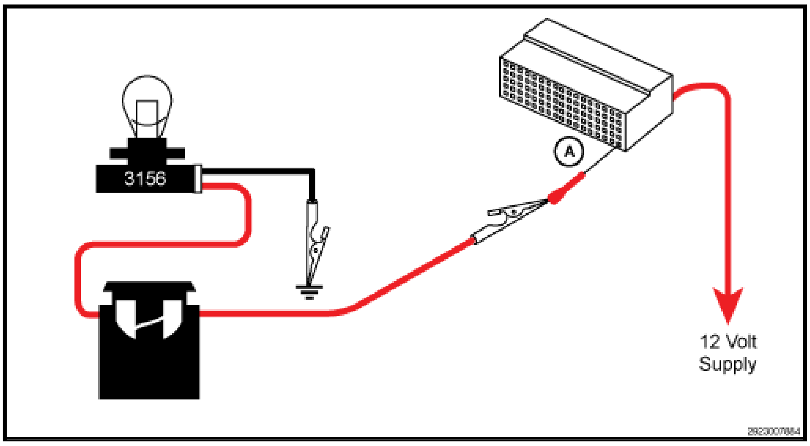
PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

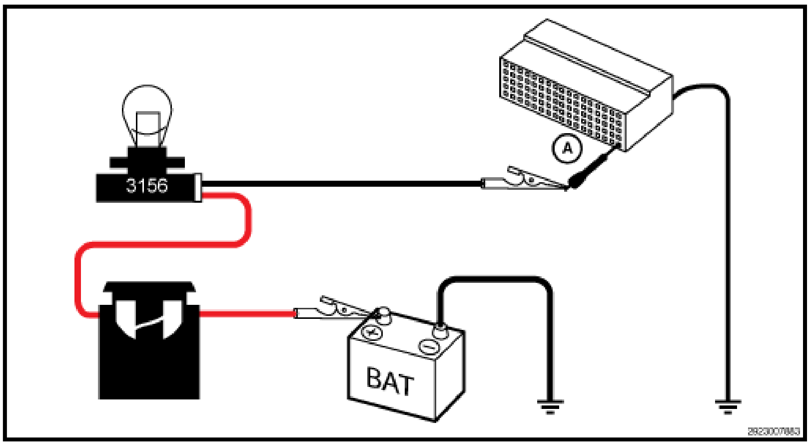
NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.

4. Using the appropriate wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
    1. If the fuse(s) are good, continue testing in step 5.
    2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

   Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

    1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .
    2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
        - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
        - If both circuits pass the load test, continue testing in step 6.
6. 

   Load test the BSCM Ground circuit.

    1. If the ground circuit fails load testing, repair the BSCM chassis ground.
    2. If the ground circuit tests good, continue testing in step 7.
7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
    1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

2. If both voltage readings match the values given, the BSCM is likely faulty. use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

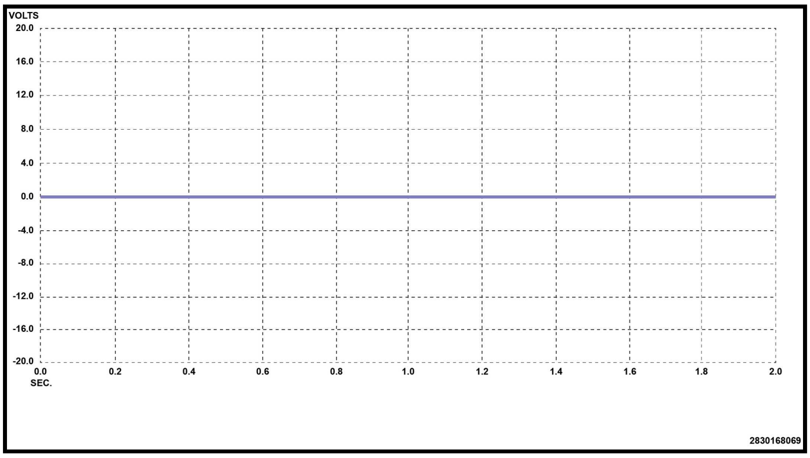
1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
    1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
    2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

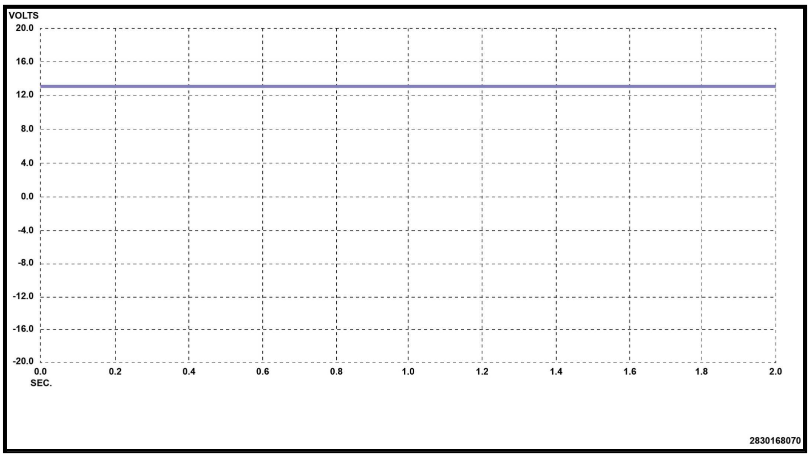
1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the

signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.

1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
   - Check the WSS for physical damage and verify it is mounted and fastened properly.
   - If equipped with a tone wheel, inspect the tone wheel for physical damage.
   - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
   - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.
3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
    1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
    2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.
    1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
    2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.

1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

U1412-IMPLAUSIBLE VEHICLE SPEED SIGNAL RECEIVED

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

THEORY OF OPERATION

The Powertrain Control Module (PCM) receives wheel speed and wheel distance CAN C bus messages from the Anti-Lock Brake System (ABS) module.

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.
- Engine run time greater than three seconds.

SET CONDITION

- The Powertrain Control Module (PCM) either doesn't receive a bus message or receives an implausible bus message from the Anti-Lock Brake System (ABS) Module.

POSSIBLE CAUSES

Possible Causes
WHEEL SPEED SENSOR (WSS) WIRING ISSUE
WHEEL SPEED SENSOR
ANTI-LOCK BRAKE SYSTEM (ABS) MODULE
BODY CONTROL MODULE (BCM)

Always perform the PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE before proceeding. Refer to PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .

DIAGNOSTIC TEST

1. **CHECK FOR AN ACTIVE DTC**
   1. Turn the ignition on.
   2. With the scan tool, read DTCs and record on the repair order.

      Is the DTC active or pending?

      Yes

      - Go To 2

      No

      - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .
2. **CHECK THE ANTI-LOCK BRAKE MODULE FOR WHEEL SPEED SENSOR FAULTS**
   1. With the scan tool, read DTCs in the ABS Module.

Is the ABS Module setting any DTCs against a Wheel Speed Sensor?

Yes

- Perform the diagnostic procedure in the ABS Module. Refer to **ANTILOCK BRAKE SYSTEM (ABS) - DIAGNOSTIC CODE INDEX** .

No

- Replace the ABS Module in accordance with the Service Information. Refer to **MODULE, ANTI-LOCK BRAKE SYSTEM (ABS), REMOVAL AND INSTALLATION** .

U1417-IMPLAUSIBLE LEFT WHEEL DISTANCE SIGNAL RECEIVED

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE: **If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.
- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.

- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)
- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	MESSAGE DESCRIPTION	MESSAGE DEFINITION

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.
- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.
2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.

4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.
    1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
    2. If the temp sensor signal and ground circuits test good, use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE:	**The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
    - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
    - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

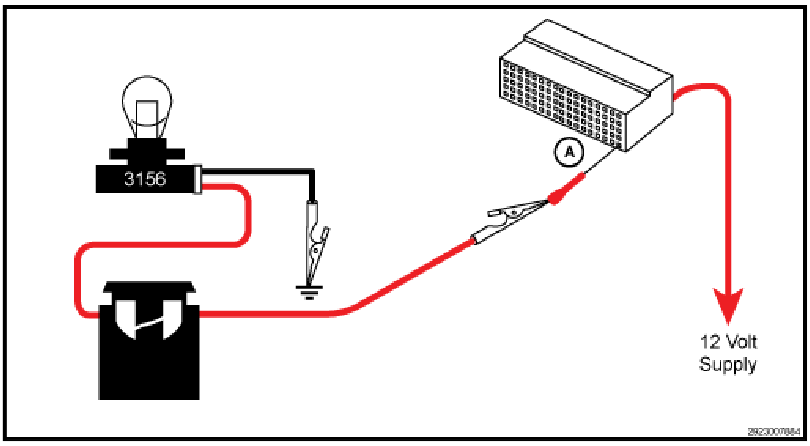
NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: **The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.**

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

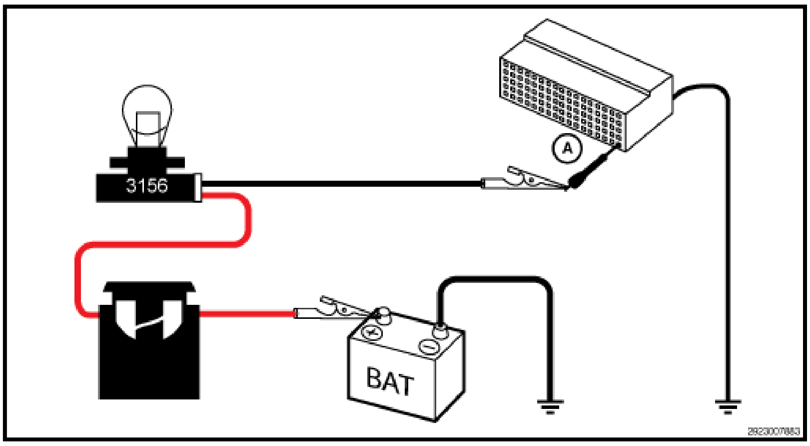
1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.
4. Using the appropriate wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
   1. If the fuse(s) are good, continue testing in step 5.
   2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

   Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

   1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING

PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .

2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
    - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
    - If both circuits pass the load test, continue testing in step 6.

6. 

Load test the BSCM Ground circuit.

1. If the ground circuit fails load testing, repair the BSCM chassis ground.
2. If the ground circuit tests good, continue testing in step 7.

7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
    1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

    NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

    2. If both voltage readings match the values given, the BSCM is likely faulty. use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

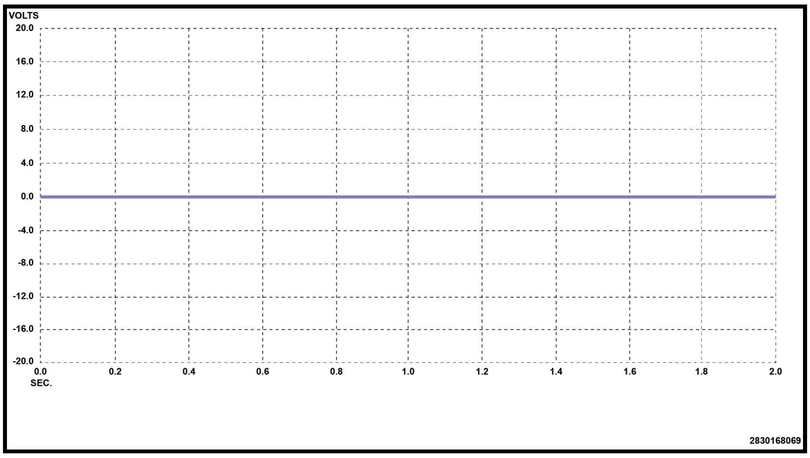
DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
    1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
    2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

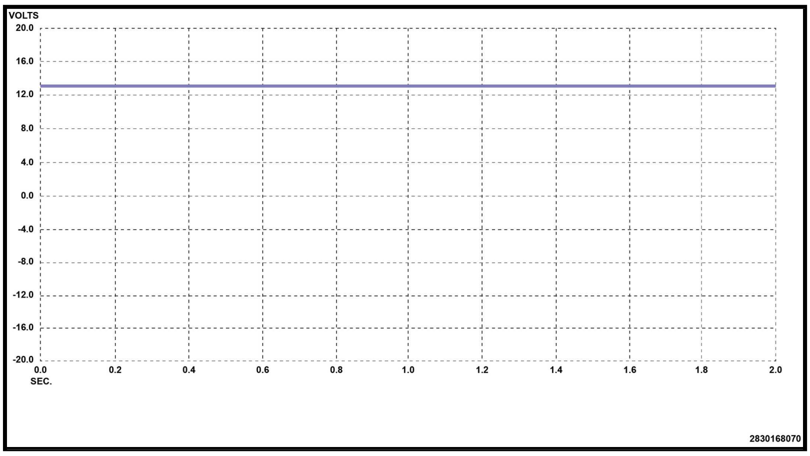
PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.
    1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
    2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
        - Check the WSS for physical damage and verify it is mounted and fastened properly.
        - If equipped with a tone wheel, inspect the tone wheel for physical damage.
        - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
        - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.

3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
    1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
    2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.

1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
2. If no voltage is present, continue testing in step 3.

3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
    1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
    1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
    2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.
    1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

U1418-IMPLAUSIBLE RIGHT WHEEL DISTANCE SIGNAL RECEIVED

For a complete BRAKE SYSTEM wiring diagram, **refer to the appropriate wiring information** .

DESCRIPTION AND OPERATION-BRAKING SYSTEMS

GENERAL NON-eBOOSTER BRAKING SYSTEM OPERATION: The Integrated Control Unit (ICU) consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The BSCM monitors the signal from the Brake Pedal Position (BPP) Sensor mounted on the Brake Pedal assembly and Master Cylinder Pressure (MCP) Sensor signal, mounted inside the HCU to detect when the Brake Pedal is applied. The BSCM also monitors the pressure sensors in each hydraulic circuit to calculate the Brake Torque signal. The calculation is based on the sum of pressure applied to the caliper in each hydraulic circuit. These signals are broadcast on the CAN bus. When the BSCM receives an autonomous brake input it controls a motor/actuator inside the Hydraulic Assembly to apply hydraulic pressure to the calipers to brake the vehicle.

GENERAL eBOOSTER BRAKING SYSTEM OPERATION: The Electronic Booster (eBooster) system consists of the Brake System Control Module (BSCM) and Hydraulic Control Unit (HCU). The system does not use a conventional Master Cylinder mounted on the booster. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. To maintain normal Brake Pedal feel, when the Brake Pedal is pressed it creates hydraulic pressure in a fluid filled chamber inside the HCU. The pressure acts on a cap and spring inside the chamber allowing the pedal to get firm. This system uses a Brake Pedal Simulator Pressure Sensor in place of the MCP Sensor and two unique Brake Pedal Position (BPP) Sensors to monitor for an operator braking input. The BSCM monitors these and other inputs, and controls a motor/actuator inside the HCU to apply hydraulic pressure to the calipers during an operator braking input or autonomous braking event.

NOTE: **If the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.**

WHEEL SPEED SENSOR OPERATION: Wheel Speed Sensors (WSS) are used to monitor vehicle speed and wheel slip conditions. The Wheel Speed Sensors are hard-wired to the Brake System Control Module. The BSCM broadcasts the WSS signals on the CAN bus. The BSCM performs circuit fault diagnostics for the WSS sensors and wiring. The BSCM and PCM perform rationality checks against the outputs from the sensors. **This is described in detail in the DIAGNOSTIC OVERVIEW information below.** The WSS signals are also compared to the Steering Wheel Angle and Dynamic Sensors. Comparing these signals together can determine when the vehicle is in a turning event or if there is a fault in one of the WSS signals.

ANTI-LOCK BRAKING EVENT: During a braking event, the BSCM monitors the WSS signals to detect a wheel lock condition due to a skid event. If a wheel is determined to be locked, the BSCM cycles the Outlet Valve. Cycling the valve off/on relieves and applies the pressure to the wheel to correct the condition. The pressure will be regulated until the wheel lock condition is no longer present.

TRACTION CONTROL AND ELECTRONIC STABILITY CONTROL (ESC): If a wheel spin condition is detected during driving, and the brakes are not being applied, the BSCM will cycle the Inlet Valve in the system, applying braking to the wheel to correct the wheel slip condition. The system monitors the steering wheel angle, yaw rate and lateral acceleration (Dynamic Sensor) and Wheel Speed Sensors to determine an over/under steer condition. The BSCM will open the appropriate Inlet Valves, applying braking to counteract the condition.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE PEDAL POSITION SENSOR

NON-eBOOSTER SYSTEMS: 3-Wire Position Sensor - The Non-eBooster systems use a single Brake Pedal Position Sensor mounted on the Brake Pedal assembly. The BSCM provides the sensor with a 5-Volt reference, a pull down signal and sensor ground circuit. Using a pull down signal means that there will be 0 volts on the signal circuit when the connector is unplugged. The sensor is hard-wired to the BSCM. The BSCM converts the analog voltage signal to a digital signal and broadcasts it on the CAN bus. When the pedal is not pressed, the signal voltage is low. As the driver presses on the Brake Pedal, the voltage on the signal increases. The Minimum (Not pressed) and maximum (Pedal fully pressed) thresholds for the sensors are learned into the BSCM and PCM. **These thresholds must be re-learned using the scan tool every time a sensor, BSCM or PCM is replaced. If these thresholds are not learned, a performance fault will set.**

eBOOSTER SYSTEMS: Single Edge Nibble Transmission (SENT) Sensors - The eBooster system uses two SENT interface protocol sensors used to detect brake pedal travel. These sensors are internal to the Hydraulic Control Unit assembly. As the driver presses on the Brake Pedal, the Brake Pedal Position Sensors send an output only digital signal to the BSCM in percentage of travel. These sensors consist of three circuits, a power supply and ground circuit to function, and a digital output signal circuit. The power supply range is typically between 4.75 and 5.25 volts.

COMPONENT FUNCTIONAL DESCRIPTION - HYDRAULIC CONTROL UNIT (HCU) ASSEMBLY

The HCU Assembly internal components are slightly different depending on the brake system. The functionality of applying the brakes is also different. During an Anti-lock braking, traction control or stability control event, the functionality of the systems is relatively the same.

- **NON-eBOOSTER SYSTEMS:** The HCU on this system incorporates a Master Cylinder Pressure (MCP) Sensor, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The Brake Pedal Position Sensor is external, but hard-wired to the BSCM. The BSCM in this system is capable of operating the motor/actuator inside the HCU to apply the brakes during an autonomous braking event. The vehicle operator can directly brake the vehicle by pressing on the Brake Pedal.
- **eBOOSTER SYSTEMS:** The HCU on this system incorporates a Brake Pedal Simulator Pressure Sensor, two Brake Pedal Position (BPP) Sensors, motor/actuator, hydraulic circuit pressure sensors, Inlet Valves and Outlet Valves. The BSCM in this system operates the motor/actuator to apply the brakes

during both vehicle operator input and autonomous braking events. During normal operation there is no direct link between the Brake Pedal and the hydraulic circuits to the calipers. However, if the BSCM is not able to monitor the Brake Pedal travel or pressure due to a fault in the system, a bypass valve is opened in the chamber which allows a direct connection between the hydraulic pressure in the chamber and the hydraulic circuits to the calipers.

The Inlet Valves allow the fluid and hydraulic pressure to the calipers in each hydraulic circuit. The Outlet Valves are used to relieve the pressure in each circuit. There are two pressure sensors located in each hydraulic circuit that allow the BSCM to monitor the pressure in the system for each circuit.

COMPONENT FUNCTIONAL DESCRIPTION - WHEEL SPEED SENSORS

The Wheel Speed Sensors can be a magnetic pickup type or Hall Effect type sensor depending on the system being used. Each system uses a different type of target. The BSCM provides a signal voltage to the sensor and a ground path. The signal voltage can be 5v or 12v depending on the system.

- The system with magnetic pickup type sensors typically use a metal tone wheel that can be mounted on the hub/bearing assembly or front axle shaft. The tone wheel will have high and low spots equally spaced around the tone wheel. As the wheel is turning the high/low spots on the tone wheel pass the magnet in the sensor causing a square wave 5v or 12v signal.
- The system with Hall Effect sensors use a magnetic pole encoder that is typically incorporated in the wheel bearing assembly. With this system the air gap between the WSS and encoders is not adjustable. As the wheel is turning the magnets in the encoder pass the Hall Effect sensor causing a square wave 5v or 12v signal.

The PCM uses the Wheel Speed Sensor signals and Steering Angle Sensor signal for Engine Stop/Start enabling and oil aeration detection. The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the wheel speed signals are showing vehicle speed present, the PCM will disable ESS mode.
- If the vehicle is in a hard turning event, as determined by the wheel speed signals the oil can be dispersed to one side of the oil pan away from the pickup tube on some vehicles. This can cause oil aeration and affect the valve timing performance fault detection. During a hard turning event the valve timing performance diagnostics will be suspended until the event ends.

COMPONENT FUNCTIONAL DESCRIPTION - STEERING ANGLE SENSOR

Depending on the vehicle, the Steering Angle Sensor (SAS) can be mounted on the Steering Column, or incorporated into the Steering Column Control Module (SCCM) or Steering Gear. The SAS signal is broadcast on the CAN bus. The SAS signal is used by several modules to monitor the Steering Wheel position and rate of change for vehicle stability control, Engine Stop/Start enabling and autonomous operations.

The PCM rationalizes the Wheel Speed Sensor signals against each other and uses the Wheel Speed Sensor signals to rationalize the Steering Angle Sensor signal.

- If the steering angle input is high (wheel turned) when the vehicle comes to a stop, and the vehicle is equipped with Electric Power Steering, the PCM will disable ESS mode. The Electric Power Steering can draw Battery voltage down quickly if the wheel is turned significantly and the engine is turned off.

COMPONENT FUNCTIONAL DESCRIPTION - BRAKE SYSTEM CONTROL MODULE (BSCM)

The BSCM is bolted to the Hydraulic Assembly. The BSCM monitors several inputs used for normal vehicle braking as well as detection and operation of anti-lock braking, traction, and electronic stability controls. The signals that are monitored are listed below. The BSCM directly monitors the signals for operating the:

- Brake Pedal Position Sensor(s)
- Master Cylinder Pressure Sensor (non-eBooster System)
- Brake Pedal Simulator Pressure Sensor (eBooster System)

- Hydraulic pressure sensors in each hydraulic circuit
- Wheel Speed Sensors
- Steering Angle Sensor
- Dynamic Sensor

These inputs are used to control the following output devices:

- Motor/actuator
- Hydraulic pump
- Inlet Check Valves
- Outlet Check Valves

TECHNICAL DATA-BRAKING SYSTEM MESSAGES

NON-eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM broadcasts the BPP Sensor signal voltage on the CAN bus. If the sensor signal is faulty, the BSCM sets a fault against the sensor and sends a Signal Not Available (SNA) message on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.
Master Cylinder Pressure Signal	Actual hydraulic pressure in the Master Cylinder	If the Master Cylinder Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends an SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Torque Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal is broadcast on the CAN bus.

eBOOSTER SYSTEM SIGNALS

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
MESSAGE	**MESSAGE DESCRIPTION**	**MESSAGE DEFINITION**
Brake Pedal Position Signal	Percentage of pedal travel	The BSCM sends the average of the two BPP Sensor signal inputs on the CAN bus. If one sensor is faulted, the BSCM sets a fault against the sensor and sends the input from only the good sensor on the CAN bus. The PCM will function normally if only one sensor is faulty. If both sensors are faulty, the BSCM sets a fault against both sensors and sends a Signal Not Available (SNA) signal on the CAN bus. The PCM will set the missing message fault (U11BF) for the SNA message.

Brake signal messages broadcast by the Brake System Control Module (BSCM)		
Brake Pedal Pressure Signal	Simulated Brake Pedal applied pressure	If the Brake Pedal Simulator Pressure Sensor is faulty, the BSCM sets a fault against the sensor and sends and SNA message on the CAN bus. The PCM will set the implausible data fault (U0418) for the SNA message.
Brake Boost Pressure Signal	Hydraulic line pressure in the braking system to the wheels	The BSCM calculates the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. The signal broadcast on the CAN bus.
BSCM Readiness Flag	Informs PCM that ESS can be performed.	The BSCM sends an ESS readiness flag (TRUE) message when the BSCM determines that ESS can be enabled. This is based on hydraulic pressure to the calipers and road grade calculation.

WHEN MONITORED

This diagnostic runs when the following conditions are met:

Performance Faults (P057B/C053D/C10F5):

- With the ignition on.
- Battery voltage above 10.4 volts.
- No Loss of Communication or implausible/missing message faults active.

Communication Faults (U0121/U0129/U0418/U11BF):

- With the ignition on.
- Battery voltage above 10.4 volts.

Wheel Speed Sensor Signal and Distance Faults (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418):

- With the ignition on.
- Battery voltage between 9.0 and 16.0 volts.

SET CONDITION

- **C053D** - The PCM determines that the Master Cylinder Pressure Sensor signal is irrational.
- **C10F5** - The PCM determines that the Brake Torque signal is irrational.
- **P057B** - The PCM determines that the Brake Pedal Position Sensor signal is irrational.
- **U0121** - The PCM does not receive the Brake Pedal Position Sensor signal.
- **U0129** - The PCM does not receive the Master Cylinder Pressure Sensor signal.
- **U0418** - The PCM receives an SNA message indicating that the has detected a fault in the Master Cylinder Pressure Sensor signal.
- **U11BF** - The PCM receives an SNA message indicating that the has detected a fault in the Brake Pedal Position Sensor signal.
- **(C0501, C0507, C050D, C0513) Wheel Speed Signal Rationality Faults** - When at a stop, one WSS signal is showing vehicles speed output and the other three WSS signals are reading 0 OR When the difference between one WSS signal compared to the other three WSS signals is more than 11 MPH, for 30 seconds.
- **(U1409, U140A, U140B, U140C, U1412, U1417, U1418) Implausible Wheel Speed and Distance Signal Faults** - These faults will typically set when the BSCM detects a fault with one of the WSS

signals. The BSCM will send an SNA or error flag against the sensor.

The (P057B, P057C, P057D, U11BF) BPP Sensor faults can set for any of the following:

DEFAULT ACTION

- The MIL will illuminate.
- ESS System is disabled.

POSSIBLE CAUSES

POSSIBLE CAUSES
5-VOLT SUPPLY CIRCUIT OPEN OR SHORTED TO GROUND
BPP SENSOR SIGNAL CIRCUIT SHORTED TO VOLTAGE (CIRCUIT HIGH)
BPP SENSOR SIGNAL CIRCUIT SHORTED TO GROUND (CIRCUIT LOW)
BPP SENSOR SIGNAL CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
BPP SENSOR GROUND CIRCUIT OPEN/HIGH RESISTANCE (CIRCUIT LOW)
FAULTY BRAKE PEDAL POSITION SENSOR
FAULTY BRAKE SYSTEM MODULE (BSM)

The (C053D, C10F5, U0418) performance and implausible/lost message faults can set for any of the following:

POSSIBLE CAUSES
FAULTY HYDRAULIC ASSEMBLY (BPP AND BRAKE SIMULATOR SENSORS ARE INTERNAL)
FAULTY BRAKE SYSTEM MODULE (BSM)

The (U0121, U0129) Loss of Communication faults can set for any of the following:

POSSIBLE CAUSES
BATTERY OR IGNITION SUPPLY TO BSM OPEN OR SHORTED TO GROUND
BSM GROUND CIRCUIT OPEN/HIGH RESISTANCE
BSM CAN BUS CIRCUITS SHORTED TO VOLTAGE
BSM CAN BUS CIRCUITS SHORTED TO GROUND
BSM CAN BUS CIRCUITS OPEN/HIGH RESISTANCE
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

The Wheel Speed Sensor faults can set for any of the following:

POSSIBLE CAUSES
SNA OR ERROR MESSAGE FROM BSCM
WSS SIGNAL CIRCUITS SHORTED TO VOLTAGE
WSS SIGNAL CIRCUITS SHORTED TO GROUND
WSS SIGNAL CIRCUITS OPEN/HIGH RESISTANCE
WSS GROUND CIRCUIT OPEN/HIGH RESISTANCE
DAMAGED TONE WHEEL
FAULTY WHEEL SPEED SENSOR
FAULTY BRAKE SYSTEM CONTROL MODULE (BSCM)

DIAGNOSTIC OVERVIEW

NON-eBOOSTER SYSTEM: When any faults are present against the BPP Sensor in the BSCM or PCM, the sensor and circuits should always be checked before condemning a module. While the Master Cylinder Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU

and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an ICU assembly.

eBOOSTER SYSTEM: While the BPP Sensors, Brake Pedal Simulator Pressure Sensor and hydraulic circuit pressure sensors are inside the HCU, the connection between the HCU and BSCM should always be checked for proper connection, burnt, corroded or damaged terminals before condemning the HCU. If the BSCM is found to be the issue it can be replaced separately. If the HCU is determined to be the issue, the HCU and BSCM should be replaced as an eBooster assembly.

WHEEL SPEED SENSORS: When the vehicle is moving, the Wheel Speed Sensor signals are rationalized against each other for a stuck sensor. The controller is able to determine difference between a fault and a normal vehicle turning event (explained below).

WHEEL SPEED SENSOR COMPARISONS MONITORED	
Left Front vs Right Front	LF/RF
Left Front vs Left Rear	LF/LR
Left Front vs Right Rear	LF/RR
Right Front vs Left Rear	RF/LR
Right Front vs Right Rear	RF/RR
Left Rear vs Right Rear	LR/RR

The **enable condition threshold** is used as the comparison threshold. The threshold is calculated by taking the average of the six comparison calculations in the table when the vehicle is moving.

- **Driving Straight** - When the vehicle is moving in a straight line (steering wheel angle is near zero) the four sensor signal outputs should be relatively equal. If the LF sensor was stuck, the difference in the three calculations between the LF and other three sensors (LF/RF, LF/LR, LF/RR) will be above the enable condition threshold and the other three calculations (RF/LR, RF/RR, LR/RR) will be below the enable condition threshold, indicating a LF Wheel Speed Sensor failure.
- **Turning** - When the vehicle is turning all of the comparison checks will be different. The differences for all of the comparison checks will increase as the turning radius increases. If all comparison checks are above the calculated enable condition threshold, the vehicle is considered to be in a significant turning event and the diagnostic is temporarily disabled.
- **Vehicle Stopped** - When the vehicle is stopped each Wheel Speed Sensor signal should be 0. If three sensor outputs equal 0 and the forth is above 0 for a calibrated period threshold, the sensor is determined to be irrational.

CHECK FOR AN ACTIVE OR INTERMITTENT CONDITION

Checking for an active DTC or condition: Read and record all DTCs and Freeze Frame Data. Run and save a vehicle scan report for alter use if needed. Review the Freeze Frame data, When Monitored and Set Conditions. Erase all DTCS and operate the vehicle or system in accordance with the these conditions attempting to duplicate the DTC or condition. If a DTC returns or the condition is present continue with the diagnostic procedure. If the DTC or condition is not present, review the Intermittent Condition Testing information.

Intermittent Condition Testing: A DTC can be stored for any number of reasons. If a DTC is not active review and check the following items below;

1. The DTC may be stored because the diagnostic has not run during the current ignition cycle. Review the scan tool Freeze Frame Data, along with the When Monitored and Set Conditions, and attempt to operate the vehicle or system in the similar conditions to allow the diagnostic to run. Some diagnostics may not be easily duplicate, such as some temperature sensor rationality diagnostics which require extended cold soaks. Other diagnostics may require several environmental conditions or extensive enable conditions difficult to duplicate. For these cases it may be best to simply check for proper operation of the components or systems to verify if failure mode is present before attempting to diagnose the system.

2. Electronic Control Modules can be affected by temperature or software issues. Always check for any flash updates that may be related to the DTC or failure mode before continuing to diagnose an intermittent condition.
3. Poor wiring harness connections are a big contributor to intermittent electrical connections. Always check for any Service Bulletins that may apply to the DTC or failure mode before continuing to diagnose an intermittent condition. If no bulletins apply check for connection issues by wiggle testing any wiring harness the circuitry passes through. A good practice is too watch for a DTC to become active or scan tool data to change. An even better method is to attach the Mopar Scope to the circuitry and wiggle test the wiring. Review the scope pattern looking for intermittent opens in the circuitry during the wiggle test. Poor Battery system voltage or poor ground connections can affect systems in different or odd ways. Check the Battery or Batteries for proper charge and operation along with proper connections. use the appropriate wiring information to identify and check any chassis ground connections related to the systems or components being diagnosed. Verify that connectors are locked in properly at the components, modules and any in-line connectors in the system. Look for pushed out, corroded, spread, burnt, or broken terminals at each connector.
4. Mechanical and electrical components can fail intermittently due to temperature changes or vibration during driving.

DIAGNOSTIC TEST - NON-EBOOSTER BRAKE SYSTEM - PCM

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

BRAKE PEDAL POSITION SENSOR CIRCUIT FAULTS (P057C, P057D): TECH TIP: Typical three wire sensors must have voltage present on the 5-Volt Supply circuit to function properly. No voltage on the 5-Volt Supply circuit can cause the sensor to react one of two ways, depending on the type of sensor being used. The first is the sensor signal voltage can be stuck mid range (2.4-2.6 volts), and not change which can cause a performance fault. The second is the signal voltage can be stuck low (0 volts) since the ECU is using a pull-down signal.

1. Check the sensor harness connector for proper connection at the BPP Sensor. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the BPP Sensor harness connector and check for any pushed out, damaged, corroded or spread terminals.
2. Measure the voltage on the 5-Volt Supply circuit with the ignition on. The voltage should measure above 4.9 volts.
    1. If voltage is present, continue to step 3.
    2. If no voltage is present at the harness connector, repair the 5-Volt Supply circuit for an open or high resistance.
3. This step is designed to determine if the fault is being caused by a faulty sensor. Connect the (special tool #2064100080, Kit, Electrical Test Lead) to the BPP Sensor signal and 5-Volt Supply circuit at the BPP Sensor harness connector. A fused jumper can also be used for this step. Move the switch on the Electrical Test Lead Kit to the CLOSED position while either monitoring the voltage or fault screen on the scan tool. The voltage should read 5.0v if available, or the circuit high fault should be active. Next, connect the leads between the signal circuit and the sensor circuit at the BPP Sensor harness connector. The voltage should read 0v if available, or the circuit low fault should be active.

NOTE: **Since the BSCM uses a pull down signal, simply disconnecting the sensor harness connector should also give the same results.**

    1. If the voltage or faults appear as described above, the BPP Sensor is most likely faulty.
    2. If the voltage remains at 0v and only the circuit low fault is active, continue to step 4.
4. Disconnect the BSCM harness connector to isolate the circuits and check the sensor signal circuit for continuity to both chassis ground and the sensor ground circuit.
    1. If there is continuity to either, repair the signal circuit for a short to chassis ground or the sensor ground circuit.
    2. If the signal circuit is not shorted, continue to step 5.
5. Measure the resistance of the sensor signal and sensor ground circuits. Typically the circuit resistance should be less than 5.0 Ohms.
    1. If there is an open or high resistance in either circuit, repair the signal circuit for an open or high resistance.
    2. If the temp sensor signal and ground circuits test good, use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning BSCM. If no issues are found, replace the BSCM in accordance with the service information.

PCM SYSTEM PERFORMANCE FAULTS (P057B, C053D, C10F5): The signal performance faults set when one of the following signals received from the BSCM is irrational when compared to the others. The rationality checks are only done during a driver initiated braking event, not during an autonomous braking event.

- P057B - Brake Pedal Position signal is irrational.
- C053D - Master Cylinder Pressure signal is irrational.
- C10F5 - Brake Torque signal is irrational.

The Master Cylinder Pressure Sensor is internal to the Hydraulic Control Unit (HCU). The Brake Torque signal is calculated by the BSCM. The calculation is based on the sum of the hydraulic pressure to the calipers in all four hydraulic circuits. If one of these signals is irrational, the HCU or BSCM are likely faulty.

1. If the P057B fault is present, perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).

- If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
- If the BSCM and terminals appear good, replace the eBooster assembly in accordance with the Service Information.

NOTE: The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

PCM IMPLAUSIBLE DATA FAULT (U11BF): The lost brake signal fault sets when the BSCM detects a fault against the Brake Pedal Pressure Sensor and has no rational signal to send to the PCM.

1. There should be a circuit fault set in the PCM, BSCM or both. Perform the circuit fault diagnostics for the BPP Sensor before continuing to step 2.
2. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

NOTE: The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

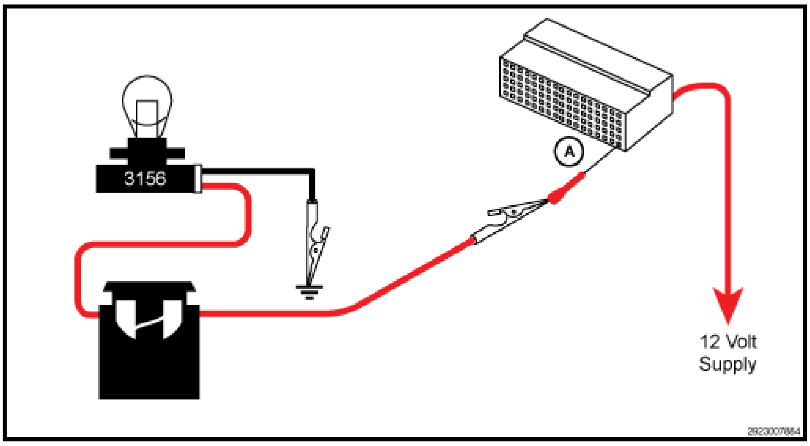
PCM IMPLAUSIBLE DATA FAULT (U0418): The implausible data fault sets when the BSCM detects a fault against the Master Cylinder Pressure Sensor and has no rational signal to send to the PCM.

1. Verify the BSCM is mounted correctly to the HCU. Next, remove the BSCM and inspect the terminals for signs of damage (pushed out, spread, corroded or dirty terminals).
   - If the BSCM terminals appear damaged, repair the terminals or replace the BSCM in accordance with the Service Information.
   - If the BSCM and terminals appear good, replace the HCU in accordance with the Service Information.

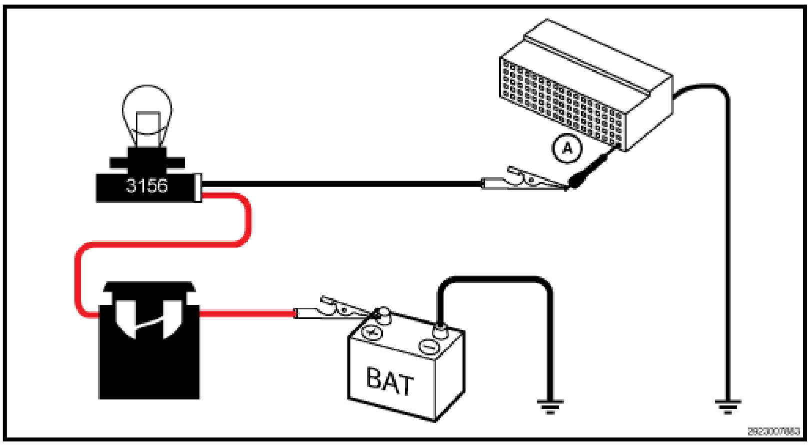
NOTE: The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

PCM LOSS OF COMMUNICATION FAULTS (U0121, U0129): The U0121 fault sets when the PCM does not receive the Brake Pedal Position Sensor signal message from the BSCM and the U0129 fault sets when the PCM does not receive the Master Cylinder Pressure Sensor signal message. Perform the following diagnostic checks for the Brake System Control Module:

1. Check for any Service Bulletins, Star On-line Cases, PCM or BSCM flash updates that apply for the DTC or symptom.
2. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause a DTC.
3. Verify the vehicle modules are configured correctly. An incorrect configuration can cause a Loss of Communication fault.

4. Using the appropriate wiring information as a guide, check the fuse or fuses that supply power to BSCM. Verify the fuse(s) are not open and has a good connection with the terminals in the PDC
    1. If the fuse(s) are good, continue testing in step 5.
    2. If a fuse is open, check the supply circuit for a short to ground before replacing the fuse.
5. 

    Disconnect the BSCM harness connector and load test the Battery Supply and Ignition circuits.

    1. A load test is used to determine if a circuit is capable of carrying the amperage needed to perform properly. The 3156 bulb in the load tool illustrated, is a simple but effective method of testing circuit functionality. A 3156 Bulb has approximately 6.0 Ohms of resistance when the bulb is powered and draws approximately 2.0 amps of current. Read the CIRCUIT LOAD TESTING PROCEDURE for information on building a simple load test tool and for additional load testing information and alternative methods of load testing or voltage drop testing a circuit. Refer to **CIRCUIT LOAD TESTING PROCEDURES** .
    2. To verify that there is no resistance in the circuit being tested, perform a simple voltage drop test across the 3156 bulb of the load test tool. The voltage drop across the bulb should be equal to the voltage reading across the Battery terminals if there is no resistance in the circuit being tested.
        - If either circuit fails the load testing, repair the resistance in the circuit. If the fuse that supplies power to the module is open or damaged
        - If both circuits pass the load test, continue testing in step 6.
6. 

    Load test the BSCM Ground circuit.

    1. If the ground circuit fails load testing, repair the BSCM chassis ground.
    2. If the ground circuit tests good, continue testing in step 7.
7. Check the voltage on the CAN Bus (+) and CAN Bus (-) circuits at the BSCM. Typically the CAN Bus (+) voltage should be approximately 2.6v and CAN Bus (-) voltage should be approximately 2.4v.
    1. If the voltage readings do not match the values given above, check the suspect circuit for opens or shorts.

NOTE: **A short in a Bus circuit would likely cause a Bus Performance fault or affect several modules. If only one module has Loss of Communication faults logged against it due to a wiring issue, it would likely be due to an open in a Bus circuit in the module harness connector or the wiring leading to that module.**

2. If both voltage readings match the values given, the BSCM is likely faulty. use the appropriate wiring information to check all related harness connectors for pushed out, spread, corroded or dirty terminals before condemning the BSCM. To check for an intermittent condition, connect a lab scope to both circuits at the BSCM connector and wiggle test to the wiring harnesses monitoring for a drop in either Bus circuit. If no issues are found, replace the BSCM in accordance with the service information.

The HCU and BSCM are separate components, but may be required to be replaced as an Integrated Control Unit (ICU) for a period of time on some vehicles. If the BSCM is suspected to be the failure, always check to see if the BSCM can be replaced separately. If the HCU is suspected, the entire ICU should be replaced.

DIAGNOSTIC TEST-WHEEL SPEED SENSOR FAULTS

PCM RELATED WHEEL SPEED SENSOR SIGNAL FAULTS (C0501, C0507, C050D, C0513, U1409, U140A, U140B, U140C, U1412, U1417, U1418)

BSCM RELATED WHEEL SPEED SENSOR FAULTS - The BSCM performs the following diagnostic checks on the Wheel Speed Sensors

- Signal circuit continuity check (C0031-1D, C0034-1D, C0036-1D, C0037-1D)
- Erratic signal check (C0031-2F, C0034-2F, C0036-2F, C0037-2F)
- Incorrect component installed check - (C0031-4A, C0034-4A, C0036-4A, C0037-4A) - front and rear sensors are not compatible on some vehicles.
- Rationality check (C0031-62, C0034-62, C0036-62, C0037-62)

PRELIMINARY DIAGNOSTIC CHECKS

1. Check the tire and wheel sizes. Mismatched tires and wheels can cause rationality DTCs to set.
2. Check for any Service Bulletins, Star On-line Cases or ECU flash updates that apply for the DTC or symptom.
3. Check for any Battery voltage DTCs in the BSCM. Low Battery voltage can cause DTCs.
4. Circuit faults should typically be diagnosed before rationality/performance faults.

DIAGNOSING AN INCORRECT COMPONENT INSTALLED FAULT IN BSCM (C0031-4A, C0034-4A, C0036-4A, C0037-4A):

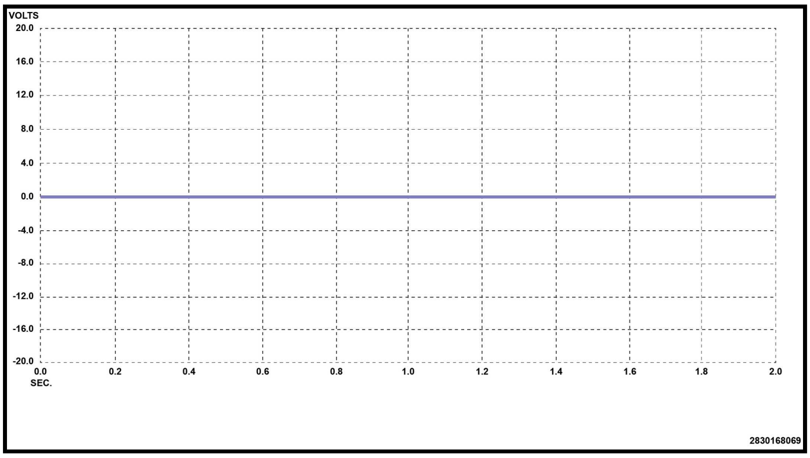
1. Some vehicles use a non-directional front WSS and directional rear WSS. The sensors are not interchangeable. Verify the correct WSS is installed on the vehicle for this fault.
    1. If the wrong part is installed, replace the WSS with the correct part number and verify repair.
    2. If the correct part is installed, replace the WSS. Clear the DTC, test drive the vehicle and confirm repair. If the DTC returns replace the Brake System Control Module in accordance with the Service Information.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A LAB SCOPE - PREFERRED METHOD (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

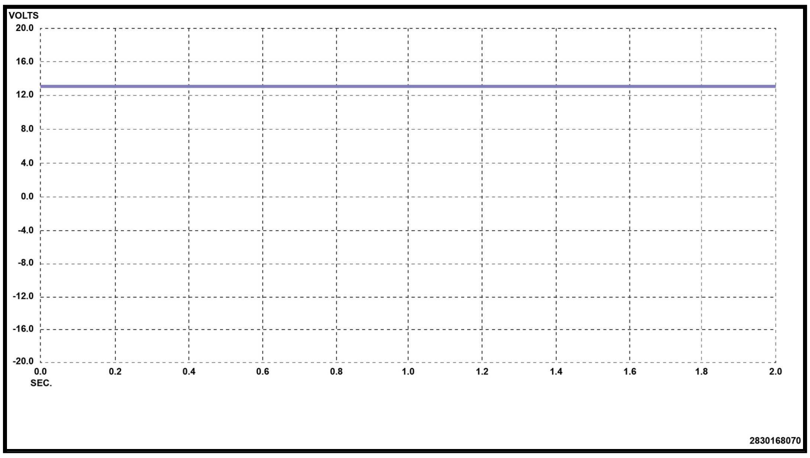
1. Turn the ignition on. At the WSS harness connector, back probe the WSS signal circuit with the lab scope test lead. The harness connector should be plugged into the WSS. Raise the vehicle on a hoist and turn the wheel while monitoring the scope signal. There should be a consistent square wave signal cycling between 0v and some voltage. The voltage may vary depending on the vehicle. The frequency of the

signal will change with the speed of the wheel but the consistency of the pattern should not. While turning the wheel watch the signal closely for the following. Inconsistency in the signal (gaps too large or small) due to a defective tone wheel/encoder or a loose, damaged sensor. A signal that is stuck high or stuck low. A signal that falls off intermittently or at lower speeds. Pick the scenario that best matches the results.

1. **The square wave signal is consistently cycling** - the sensor signal is giving a legitimate reading. The WSS and wiring are performing properly. Test drive the vehicle while monitoring the sensors. If the signal is erratic or dropping off during the test drive, check the sensor, wheel bearing and hub for looseness or damage that may not be showing up on the hoist. If the sensor reads correctly during the test drive and the fault is active, the BSCM is likely faulty. Always check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.
2. **The square wave signal is cycling but has erratic gaps or periodically drops off** - All of the issues listed can cause an erratic signal.
   - Check the WSS for physical damage and verify it is mounted and fastened properly.
   - If equipped with a tone wheel, inspect the tone wheel for physical damage.
   - On vehicles with encoders check the wheel bearing and hub for a worn bearing or excessive runout.
   - If no damage is found in the WSS, tone wheel, hub or wheel bearing assembly, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent circuit issue. If no issues are found, replace the Wheel Speed Sensor and verify repair.
3. **The signal has a constant 0.0 volt reading** - this indicates that the WSS Signal circuit is shorted to ground or has an open between the BSCM and WSS. Disconnect the WSS and BSCM harness connectors. Check the WSS Signal circuit for high resistance or a short to ground. If the WSS Signal circuit checks good, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM.



4. **The signal reading has a constant voltage** - this indicates an open further downstream in the circuitry. Most likely the WSS or the Sensor Ground circuit. Continue testing in step 2.



2. To check the WSS, back probe and attach a scope lead to the Sensor Ground circuit at the WSS harness connector.
   1. **If the Sensor Ground circuit voltage is reading a constant 0.0 volts** - this would indicate an open in, or short across the WSS. The WSS is the faulty.
   2. **If the Sensor Ground circuit has a constant voltage** - this indicates an open in the Sensor Ground circuit path. Disconnect the WSS and BSCM harness connectors. Check the Sensor Ground circuit for high resistance. If the Sensor Ground circuit checks good, use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.

PERFORMING WSS CIRCUIT FAULT DIAGNOSTICS USING A DVOM (THIS COVERS BSCM SIGNAL AND RATIONALITY FAULTS AND ANY PCM WSS FAULTS):

1. Check the WSS harness connector for proper connection at the component. Verify that the connector is completely plugged in and properly locked prior to disconnecting for testing. Disconnect the WSS harness connector and check for water intrusion and any pushed out, damaged, corroded, burnt, or spread terminals.
2. Turn the ignition on and measure the voltage across the WSS (+) and WSS (-) circuits at the WSS harness connector. If both circuits are good there should be voltage present.
   1. If the voltage reads above 10.0 volts, the BSCM and circuits are testing good. Wiggle test the wiring while monitoring the voltage to check for an intermittent connection. If the voltage is steady above 10.0 volts, the Wheel Speed Sensor is likely faulty. Replace the Wheel Speed Sensor and verify repair.
   2. If no voltage is present, continue testing in step 3.
3. Remove the DVOM test lead from the WSS (-) circuit and connect to a good chassis ground. Measure the voltage on the WSS (+) circuit.
   1. If the voltage reads above 10.0 volts with the DVOM connected to chassis ground, the WSS (-) circuit is likely open or has high resistance between the WSS and the BSCM. If the circuit tests good (no resistance), the BSCM internal ground is likely faulty. use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
   2. If no voltage is present on the WSS (+) circuit with the DVOM connected to chassis ground, continue testing in step 4.
4. Turn the ignition off and disconnect the BSCM harness connector. Check the WSS (+) circuit for continuity to both chassis ground and the WSS (-) circuit at the WSS harness connector.
   1. If there is continuity to either, repair the WSS (+) circuit for a short to ground or the WSS (-) circuit.
   2. If the signal circuit is not shorted, continue testing in step 5.
5. Measure the resistance of the WSS (+) circuit between the WSS harness connector and BSCM harness connector. There should be less than 3.0 Ohms of resistance.

    1. If the resistance is below 3.0 Ohms, the BSCM is likely faulty. use the appropriate wiring information to check all related harness connectors in the system for pushed out, spread, corroded or dirty terminals that can cause an intermittent open before condemning a BSCM. If no issues are found, the BSCM is faulty.
    2. If the resistance is above 3.0 Ohms, repair the WSS (+) circuit for an open or high resistance.

U1431-IMPLAUSIBLE DATA RECEIVED FROM CRUISE CONTROL MODULE

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to **COMMUNICATION DIAGNOSTIC PROCEDURE** .

U1440-IMPLAUSIBLE TRANSFER CASE RATIO HIGH RECEIVED

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to **COMMUNICATION DIAGNOSTIC PROCEDURE** .

U1442-IMPLAUSIBLE DATA RECEIVED FROM DRIVER PRESENCE DETECTION MODULE

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to **COMMUNICATION DIAGNOSTIC PROCEDURE** .

U148C-IMPLAUSIBLE DATA RECEIVED FROM STOP/START BUTTON

WHEN MONITORED

This diagnostic runs continuously when the following conditions are met:

- With the ignition on.
- Stop/Start feature enabled.

SET CONDITION

- The Powertrain Control Module (PCM) receives a Stop/Start Off/On button pressed signal for more than five continuous minutes.

DEFAULT ACTION

- This is a non-MIL fault.

POSSIBLE CAUSES

Possible Causes
FAULTY SWITCH BANK MODULE

Always perform the Pre-Diagnostic Troubleshooting procedure before proceeding. Refer to **PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE .**

DIAGNOSTIC TEST

1. **READ AND RECORD DTCS AND ENVIRONMENTAL DATA - ERASE DTCS AND CHECK FOR THE DTC TO RETURN**
    1. With the scan tool, read DTCs in all Electronic Control Units (ECUs) and record on the repair order.
    2. For future reference, with the scan tool, run and save a vehicle Scan Report and all related recorded data.

3. With the scan tool, erase all DTCs.
4. Turn the ignition off for a minimum of 10.0 seconds.
5. Turn the ignition on.
6. Using the When Monitored and Set Conditions above and recorded data, operate the vehicle in the conditions that set the DTC.
7. With the scan tool, read DTCs.

   Did the DTC return?

   Yes

   - Go To 2

   No

   - Perform the INTERMITTENT CONDITION diagnostic procedure. Refer to **INTERMITTENT CONDITION** .

2. **CHECK FOR OTHER DTCS**
   1. Refer to the recorded DTCs.

      Are there any Communication DTCs active or pending?

      Yes

      - Perform the applicable diagnostic procedure(s). Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .

      No

      - Go To 3

3. **CHECK FOR LIN BUS OR CAN BUS DTCS SET IN THE BODY CONTROL MODULE**

   Are there any LIN Bus or CAN Bus DTCs set in the Body Control Module?

   Yes

   - Diagnose the appropriate DTC in the Body Control Module before continuing. Refer to **BODY CONTROL MODULE (BCM) - DIAGNOSTIC CODE INDEX** .

   No

   - Replace the Stop/Start Switch Bank in accordance with the Service Information.
   - Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

U1494-IMPLAUSIBLE DATA SENT FROM ADAPTIVE CRUISE CONTROL MODULE

NOTE: **Treat this DTC as an IMPLAUSIBLE SIGNAL DTC when performing the COMMUNICATION DIAGNOSTIC PROCEDURE.**

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to **COMMUNICATION DIAGNOSTIC PROCEDURE** .

U1504-IMPLAUSIBLE MESSAGE DATA LENGTH RECEIVED FROM STEERING ANGLE SENSOR

The COMMUNICATION DIAGNOSTIC PROCEDURE **MUST** be performed before replacing any component(s) or module(s). Perform the COMMUNICATION DIAGNOSTIC PROCEDURE. Refer to **COMMUNICATION DIAGNOSTIC PROCEDURE** .

STANDARD PROCEDURE

INTERMITTENT CONDITION

DIAGNOSTIC TEST

INTERMITTENT CONDITION

NOTE: **The conditions that set the DTC are not present at this time. Duplicating the conditions under which the stored DTC set is very important when diagnosing an intermittent condition. Review the scan tool Freeze Frame Data information and When Monitored conditions for the DTC being diagnosed. If possible, pay particular attention to the ambient air temperature when the DTC set. Electrical connections, such as wire terminal connections, solder joints, and printed circuit board traces will expand and contract due to temperature changes. If the DTC was set in extreme cold conditions, the vehicle may need to be tested in extreme cold conditions.**

NOTE: **Poor wire harness terminal connections are a big contributor to intermittent electrical connections. Follow the directions below to help identify the source of the intermittent electrical condition.**

1. Record all DTCs on the repair order.
2. Run a Vehicle Scan Report.
3. Perform any Service Bulletins or PCM flash updates that may apply to the DTCs that are present.
4. Use the scan tool to perform a System Test if one applies to a failing component.

   WARNING: **When the engine is operating, do not stand in direct line with the fan. Do not put your hands near the pulleys, belts or fan. Do not wear loose clothing. Failure to follow these instructions may result in possible serious or fatal injury.**

5. With the ignition on or engine running, monitor the scan tool parameters related to the DTC while wiggle testing the wiring harness. Look for parameter values to change and/or a DTC to set.

   NOTE: **Using a data recorder and/or a lab scope may help diagnose intermittent conditions.**

6. If numerous trouble codes were set, use a wire schematic and look for any common sensor supply or ground circuits.
7. Perform a voltage drop test on the related circuits between the suspected inoperative component and the PCM.
8. For Communication DTCs, perform the scan tool LOSS OF COMM TEST. This will force the modules on the CAN C bus to continuously ping each other every one second. Wiggle the applicable wires while reading the NUMBER OF NO RESPONSES. A value above 0 indicates the location of a circuit fault.
9. Turn the ignition off.
10. Visually inspect the related wire harness. Disconnect all of the related component and in-line harness connectors and check for the following:
    - Proper wiring harness routing.
    - Chafed, pierced, pinched, partially broken or open wiring harness insulation.

- Wiring or wiring strands broken inside of the insulation.
- Visually inspect the connector casings, locks, and weatherproof seals for any damage or water intrusion.
- Visually inspect for broken, bent, pushed out, or corroded terminals.
- Visually inspect the connectors and terminals for overheating due to a poor connection (terminals may be discolored due to excessive current draw).
- Verify correct connector pin fit at the related connectors (drag test).
- Connect all the related module, component and in-line wiring harness connectors and verify they are fully seated.

CAUTION: **Do not probe the PCM harness connectors. Probing the PCM harness connectors will damage the PCM terminals resulting in poor terminal to pin connection. Install the PCM Pinout Box and PCM Pinout Box Adapter to perform diagnosis.**

11. Inspect and clean all PCM, engine, and chassis grounds that are related to the DTCs that are present.
12. For any Relay DTCs, actuate the Relay with the scan tool and wiggle the related wire harness to try to interrupt the actuation.
13. For intermittent Evaporative Emission trouble codes perform a visual and physical inspection of the related parts including hoses and the Fuel Filler cap.
14. For intermittent Misfire DTCs check for restrictions in the Intake and Exhaust systems, proper installation of sensors, vacuum leaks, and binding components that are run by the accessory drive belt.
15. Check for any aftermarket accessories and verify they are installed and operate correctly. If needed, disconnect them to verify they are not the cause of the problem.

Were any problems found during the above inspections?

Yes

- Perform the necessary repairs.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Test Complete.

POWERTRAIN VERIFICATION TEST

For a complete wiring diagram, **refer to appropriate SYSTEM WIRING DIAGRAMS article** .

DIAGNOSTIC TEST

POWERTRAIN VERIFICATION TEST

1. Inspect the vehicle to make sure that all engine components are properly installed and connected. Reassemble and reconnect components as necessary.
2. After repairs are complete, erase all DTCs with the scan tool.
3. Refer to the table below to determine if a learn procedure should be performed for the component that was removed or replaced. Not all learn procedures are available for all vehicles. If a component listed in the table is replaced and the correlating learn procedure is present in the scan tool, navigate to "Miscellaneous Functions" and perform the learn procedure before verifying repair. Failure to do so may cause the same, or another DTC to set.

Scan Tool Learn Procedures	Component replaced or removed: Note: (All available Learn procedures should be performed when a PCM is replaced)
Brake Pedal Learn	Brake Pedal Position Sensor, Brake Pedal Assembly
Cam Crank Relearn (NGC/GPEC Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clear Misfire TLC (Magneti Marelli Controllers)	CKP Sensor, CMP Sensor, Flywheel, Valvetrain components (timing chain, gears, tensioners), Cam Phasers
Clutch Pedal Learn	Clutch Pedal Position Sensor, Clutch Pedal, Clutch Assembly (pressure plate and disc)
EGR Valve Replaced	EGR Valve
Learn ETC	Throttle Body
Check PCM Odometer	PCM Replaced
Check PCM VIN	PCM Replaced
PCM Replaced Routine	PCM Replaced
Learn Gear Shift Sensor	Gear Shift Position Sensor, Transmission Shifter components

4. **If the PCM has been replaced** , perform the Module Programming procedure. The PCM Reprogramming procedure is either in PCM Standard Procedure Folder or Electronic Control Modules/PCM Programming Folder depending on the vehicle application. Be certain to program the secret key code, VIN and odometer mileage after programming the PCM.
5. Operate the vehicle in accordance with the parameters and specific information found in the Monitoring Conditions and Theory of Operation of the DTC that was repaired.
6. With the scan tool, verify that no DTCs have returned.

   Are there any DTCs or driveability concerns present?

   Yes

   - Check for any related Service Bulletins and/or and perform the appropriate diagnostic procedure. Refer to 3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX .

   No

   - Repair is complete.

PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE

PRE-DIAGNOSTIC TROUBLESHOOTING PROCEDURE - PCM

1. Before diagnosing the DTC, perform the following checklist:
   - With the scan tool, read all ECU DTCs and record on the repair order.
   - Check for DTCs in other modules that may cause a PCM related DTC to set.
   - With the scan tool, run a Vehicle Scan Report and save the file for future use.
   - Check the vehicle repair history for any recent repairs that may be related to the customer complaint.
   - Verify that the Battery is fully charged and meets OEM specification.
   - With the scan tool, verify that the Battery voltage to the PCM matches the actual Battery voltage of the vehicle.
   - With a scan tool, check the PCM for software updates that are related to the DTC or customer complaint.
     - If a flash update is available, read the Service Bulletin to determine if the software update is applicable to the customer complaint before updating the module.
   - Use the Search function to search for any related information under SERVICE ACTIONS/TIPS.
     - Perform any Service Bulletins or other procedures that may apply.

- Check for aftermarket electrical accessories. Be certain they are installed properly and do not interfere with any related power, ground, or signal circuits. Be certain aftermarket wiring harnesses are routed away from vehicle wiring harness to avoid electromagnetic interference (EMI) where applicable.
- If necessary, check the vehicle build configuration and compare with the OEM Vehicle Build Configuration. Properly configure the vehicle if necessary.
- If multiple DTCs are set in the PCM, and no detectable pattern is evident (i.e. the DTCs are not related to just one or two components or subsystems), diagnose the DTCs in the following order unless instructed to do so by the specific DTC procedure:
    1. ECU Configuration DTCs
    2. PCM High or Low Voltage DTCs
    3. PCM Internal Error DTCs
    4. 5-Volt Sensor Reference High or Low DTCs
    5. Circuit Fault DTCs (Circuit Low, Circuit High, Open Circuit, etc.,)
    6. Performance / Rationality DTCs
    7. Communication DTCs (See below)
    8. Other
- If multiple communication DTCs are set, diagnose the DTCs in the following order unless instructed to do so by the specific DTC procedure:
    1. CAN Bus Off
    2. CAN Bus Off Performance
    3. Lost Communication
    4. Implausible or Invalid Data
    5. Missing Message
    6. Other

Were any of the above conditions found?

Yes

- Perform the appropriate repair procedure.
- Perform the POWERTRAIN VERIFICATION TEST. Refer to **POWERTRAIN VERIFICATION TEST** .

No

- Perform the diagnostic test procedure related to the DTC. and perform the appropriate diagnostic procedure. Refer to **3.6L (GPEC 5) - DIAGNOSTIC CODE INDEX** .