■ ENGINE CONTROL SYSTEM

1. General

The engine control system of the 2UZ-FE engine has the following features.

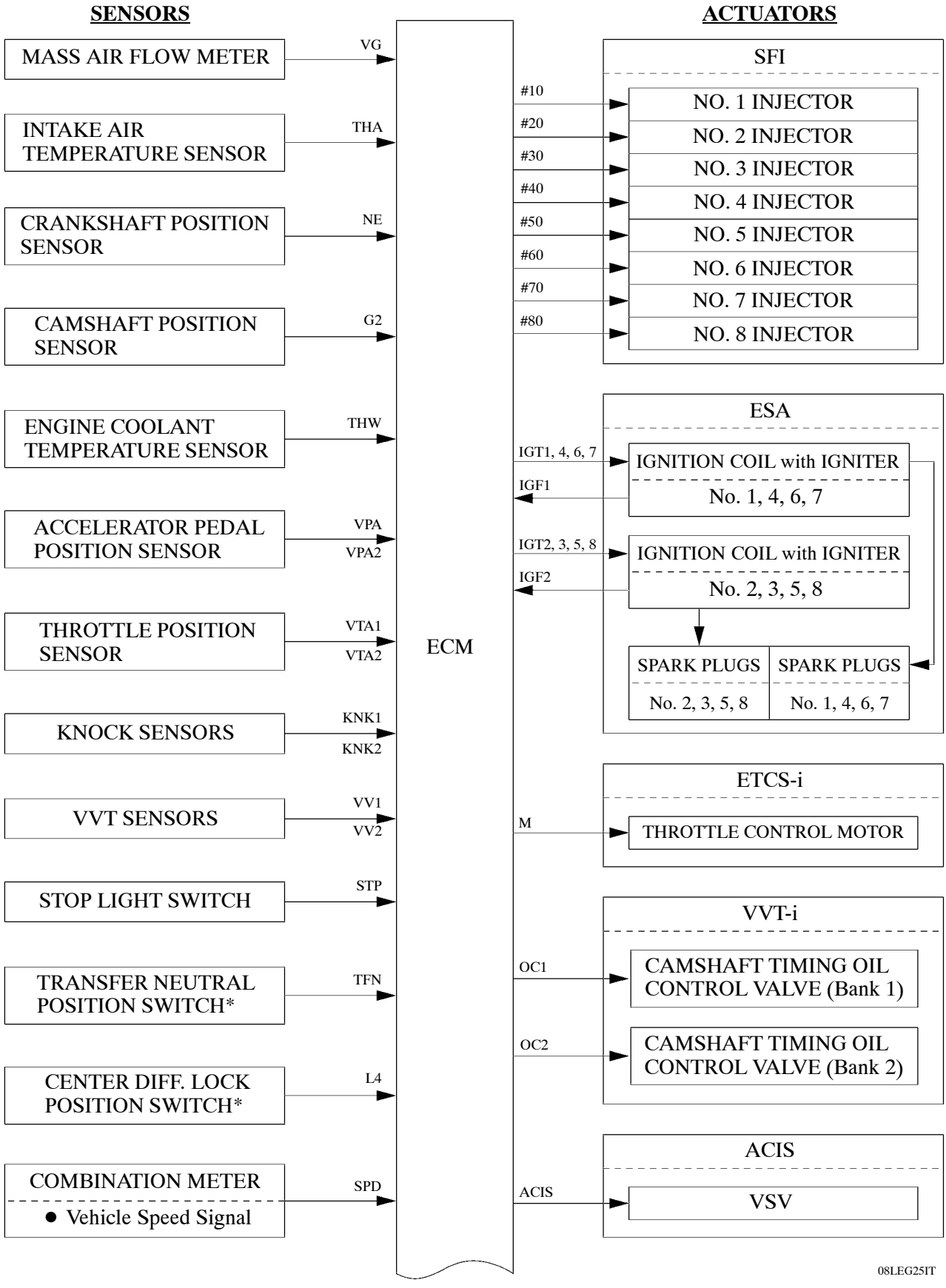
System	Outline
SFI (Sequential Multiport Fuel Injection)	● An L-type SFI system directly detects the intake air mass using a hot wire type air flow meter. ● An independent injection system (in which fuel is injected once into each intake port for each two revolutions of the crankshaft) is used. ● Fuel injection takes two forms: – Synchronous injection, in which injection always occurs at the same timing relative to the firing order. – Non-synchronous injection in which injection is effected regardless of the crankshaft angle.
ESA (Electronic Spark Advance)	● Ignition timing is determined by the ECM based on signals from various sensors. The ECM corrects ignition timing in response to engine knocking. ● This system selects the optimal ignition timing in accordance with the signals received from the sensors and sends the (IGT) ignition signal to the igniter.
ETCS-i (Electronic Throttle Control System-intelligent) [See page EG-49]	Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort and the condition of the engine and the vehicle.
VVT-i (Variable Valve Timing-intelligent) [See page EG-54]	Controls the intake camshaft to optimal valve timing in accordance with the engine condition.
ACIS (Acoustic Control Induction System) [See page EG-58]	The intake air passages are switched according to the engine speed and throttle valve opening angle to provided high performance in all speed ranges.
Fuel Pump Control [See page EG-60]	● Based on signals from the ECM, the fuel pump ECU controls the fuel pump to 3 stages. ● The fuel pump is stopped when the SRS airbag is deployed in a frontal, side, or side rear collision.
Air Injection Control [See page EG-62]	The ECM controls the air injection time based on the signals from the crankshaft position sensor, engine coolant temperature sensor, mass air flow meter and air pressure sensor.
Starter Control (Cranking Hold Function) [See page EG-66]	Once the ignition switch is turned ON, this control continues to operate the starter until the engine started.

(Continued)

System	Outline
Air-fuel Ratio Sensor and Oxygen Sensor Heater Control	Maintains the temperature of the air-fuel ratio sensors or oxygen sensors at an appropriate level to increase the detection accuracy of the exhaust gas oxygen concentration.
Air Conditioning Cut-off Control	By turning the air conditioning compressor ON or OFF in accordance with the engine condition, drivability is maintained.
Evaporative Emission Control [See page EG-68]	● The ECM controls the purge flow of evaporative emission (HC) in the canister in accordance with the engine conditions. ● Approximately five hours after the ignition switch has been turned OFF, the ECM operates the pump module to detect any evaporative emission leakage occurring between the fuel tank and the canister through changes in the fuel tank pressure.
Engine Immobilizer	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid key.
Diagnosis [See page EG-80]	When the ECM detects a malfunction, the ECM records the malfunction and memorizes information related to the fault.
Fail-safe [See page EG-80]	When the ECM detects a malfunction, the ECM stops or controls the engine according to the data already stored in the memory.

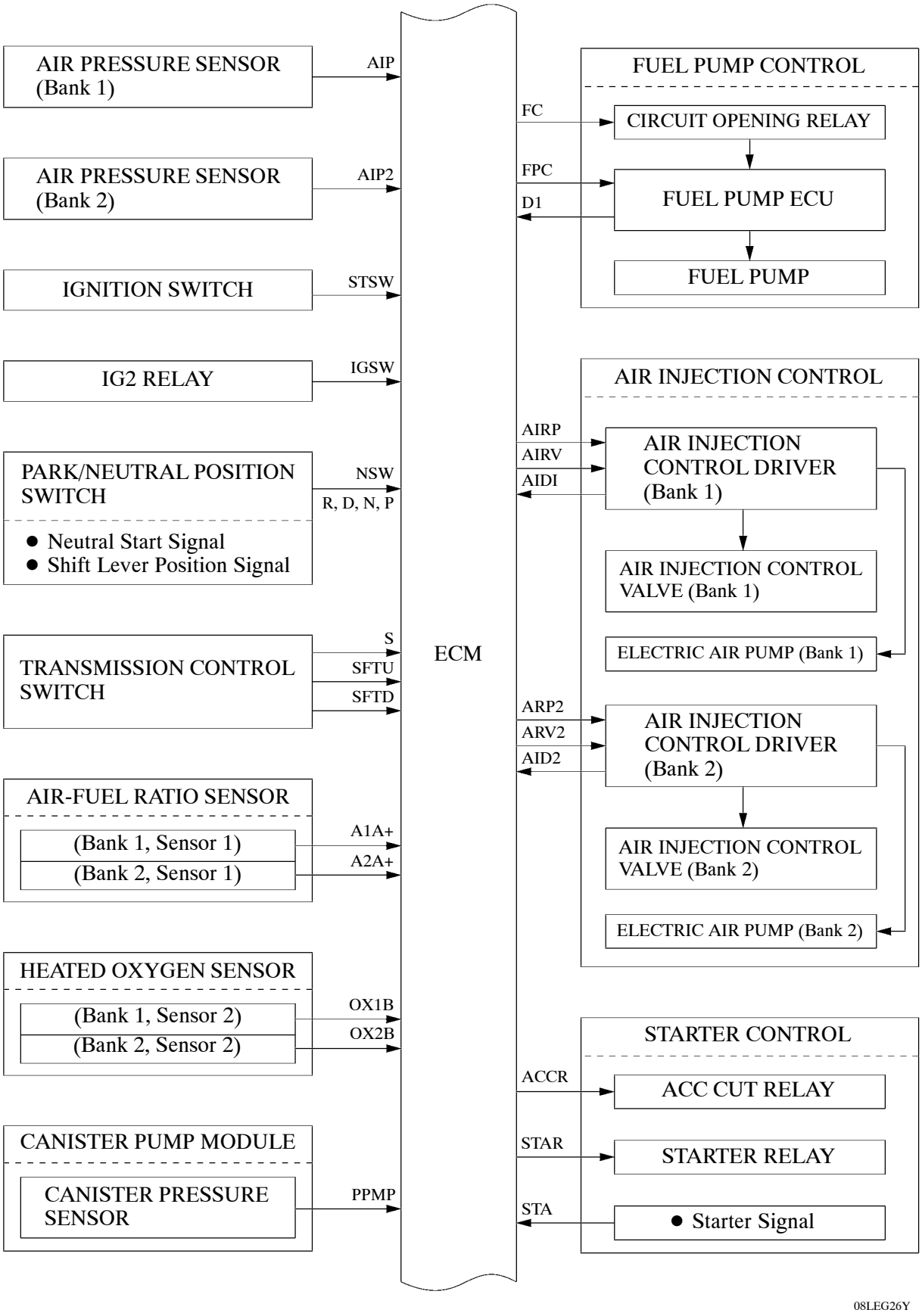
2. Construction

The configuration of the engine control system in the 2UZ-FE engine is as shown in the following chart.

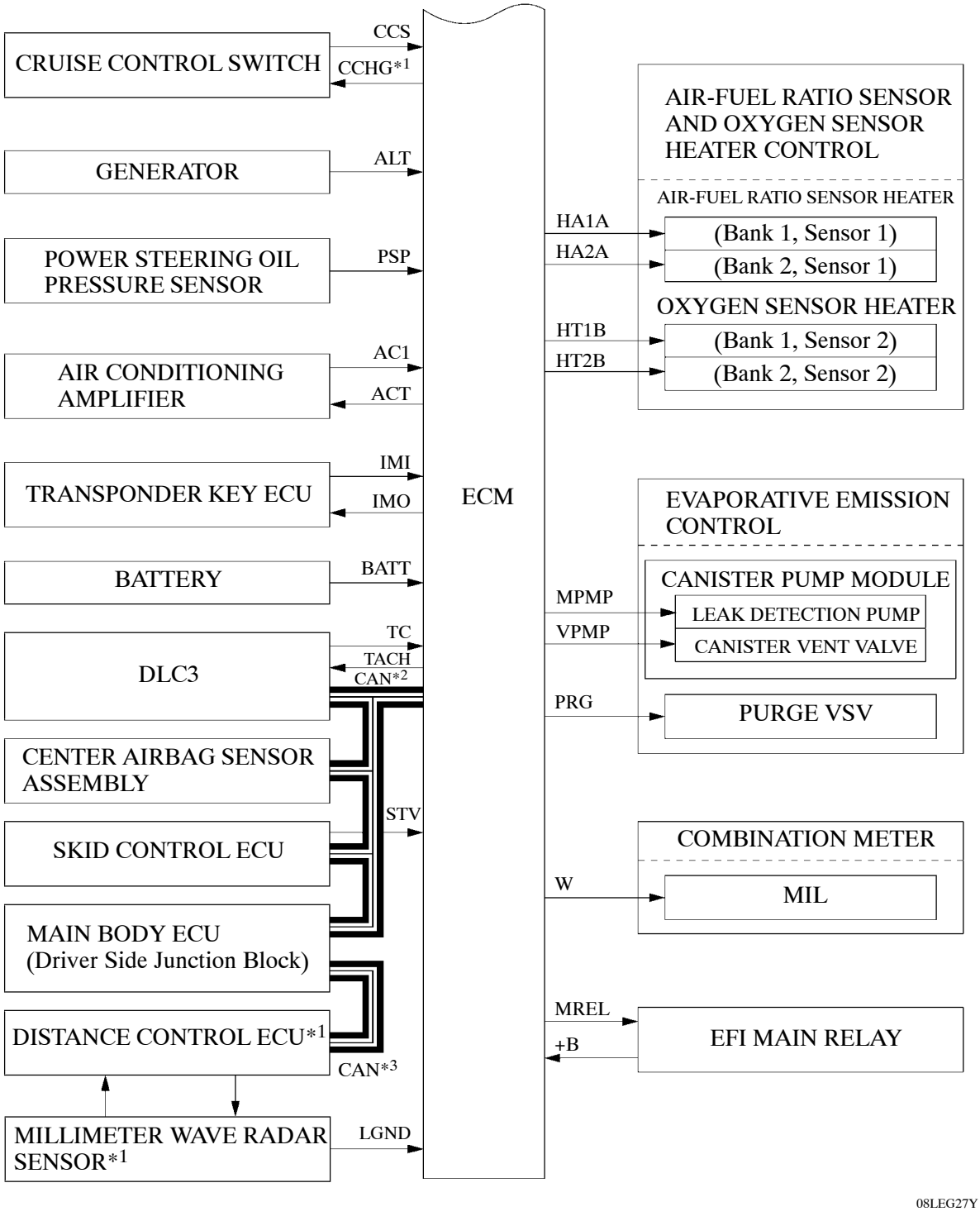


*: 4WD Models

(Continued)


AIR PRESSURE SENSOR (Bank 1)
AIP
AIR PRESSURE SENSOR (Bank 2)
AIP2
IGNITION SWITCH
STSW
IG2 RELAY
IGSW
PARK/NEUTRAL POSITION SWITCH
NSW
R, D, N, P
● Neutral Start Signal
● Shift Lever Position Signal
TRANSMISSION CONTROL SWITCH
S
SFTU
SFTD
AIR-FUEL RATIO SENSOR
(Bank 1, Sensor 1)
(Bank 2, Sensor 1)
A1A+
A2A+
HEATED OXYGEN SENSOR
(Bank 1, Sensor 2)
(Bank 2, Sensor 2)
OX1B
OX2B
CANISTER PUMP MODULE
CANISTER PRESSURE SENSOR
PPMP
ECM
FUEL PUMP CONTROL
FC
CIRCUIT OPENING RELAY
FPC
D1
FUEL PUMP ECU
FUEL PUMP
AIR INJECTION CONTROL
AIRP
AIRV
AIDI
AIR INJECTION CONTROL DRIVER (Bank 1)
AIR INJECTION CONTROL VALVE (Bank 1)
ELECTRIC AIR PUMP (Bank 1)
ARP2
ARV2
AID2
AIR INJECTION CONTROL DRIVER (Bank 2)
AIR INJECTION CONTROL VALVE (Bank 2)
ELECTRIC AIR PUMP (Bank 2)
STARTER CONTROL
ACCR
ACC CUT RELAY
STAR
STARTER RELAY
STA
● Starter Signal
08LEG26Y

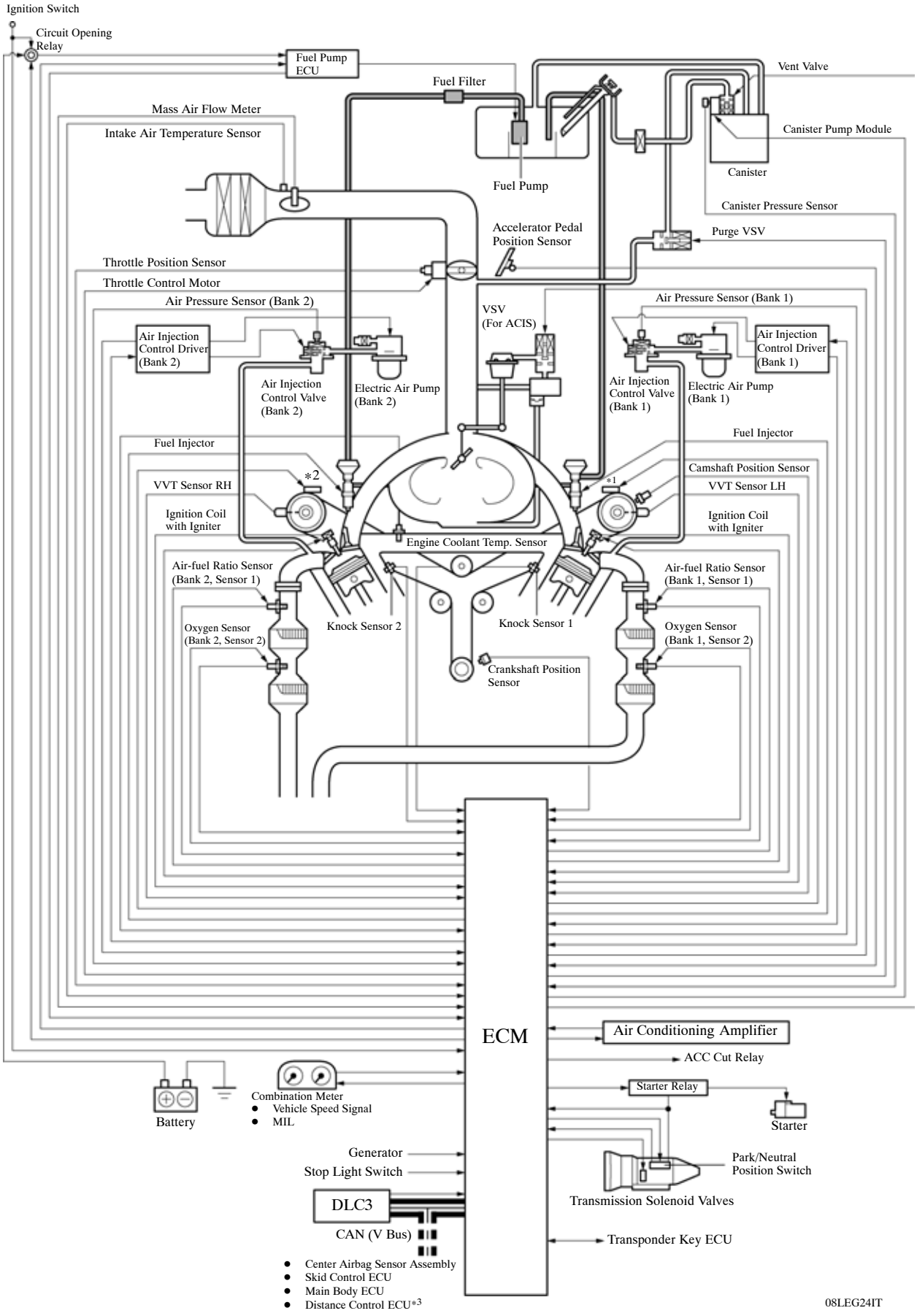
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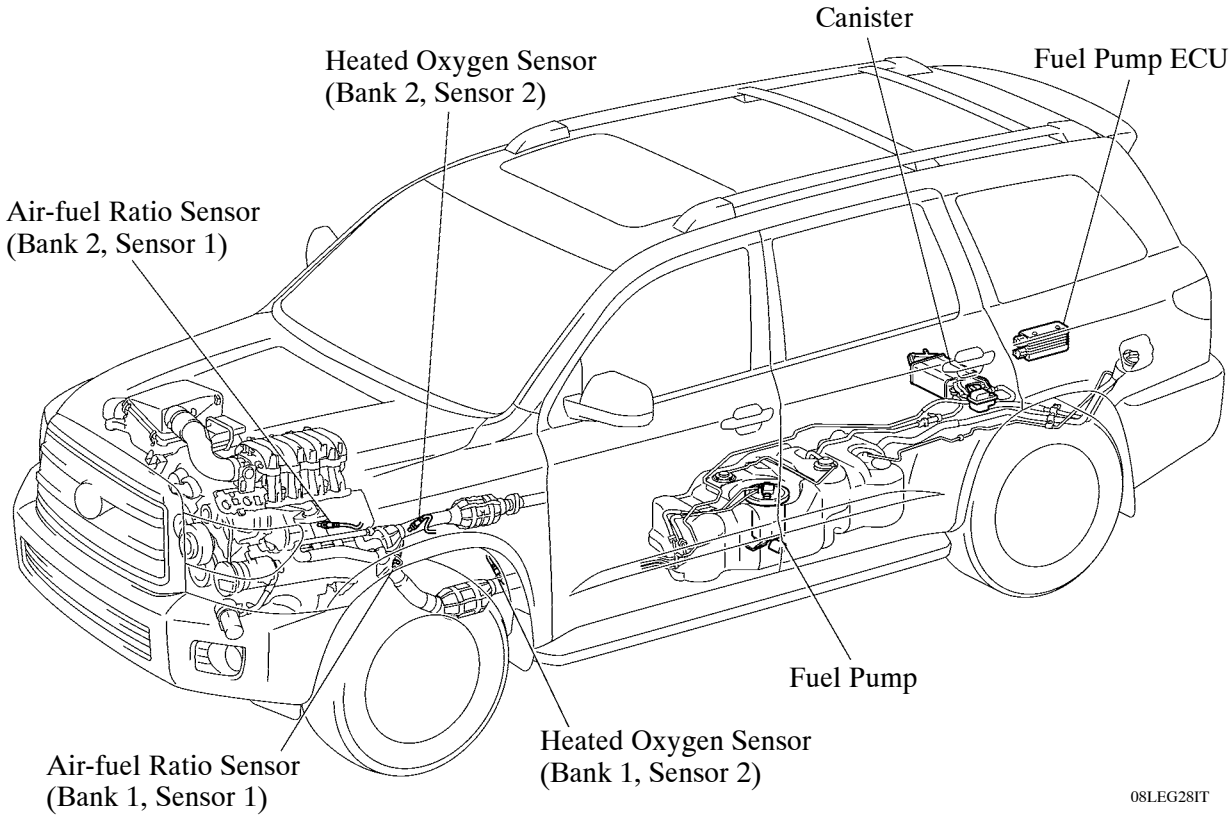
*1: Models with Dynamic Laser Cruise Control System
*2: V Bus
*3: MS Bus

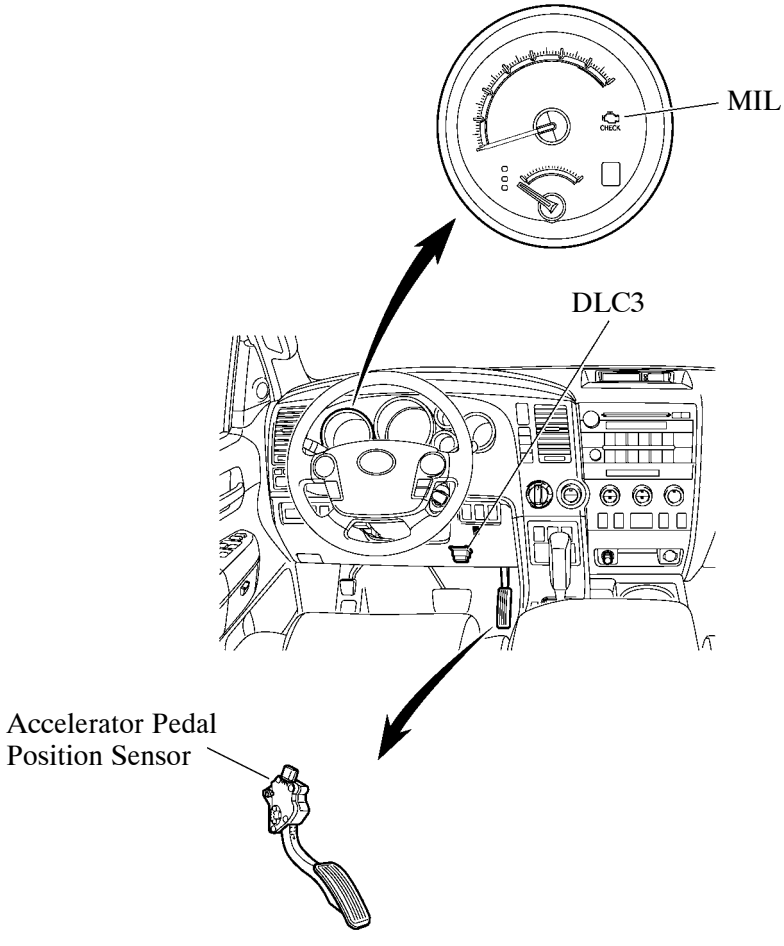
3. Engine Control System Diagram



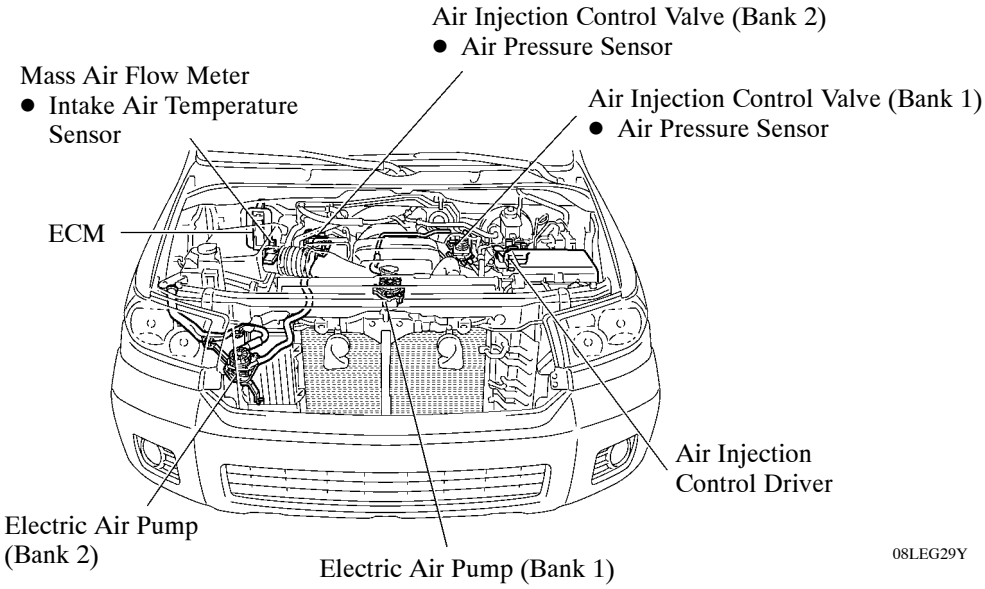
*1: Camshaft Timing Oil Control Valve LH
*2: Camshaft Timing Oil Control Valve RH
*3: Models with Dynamic Laser Cruise Control System

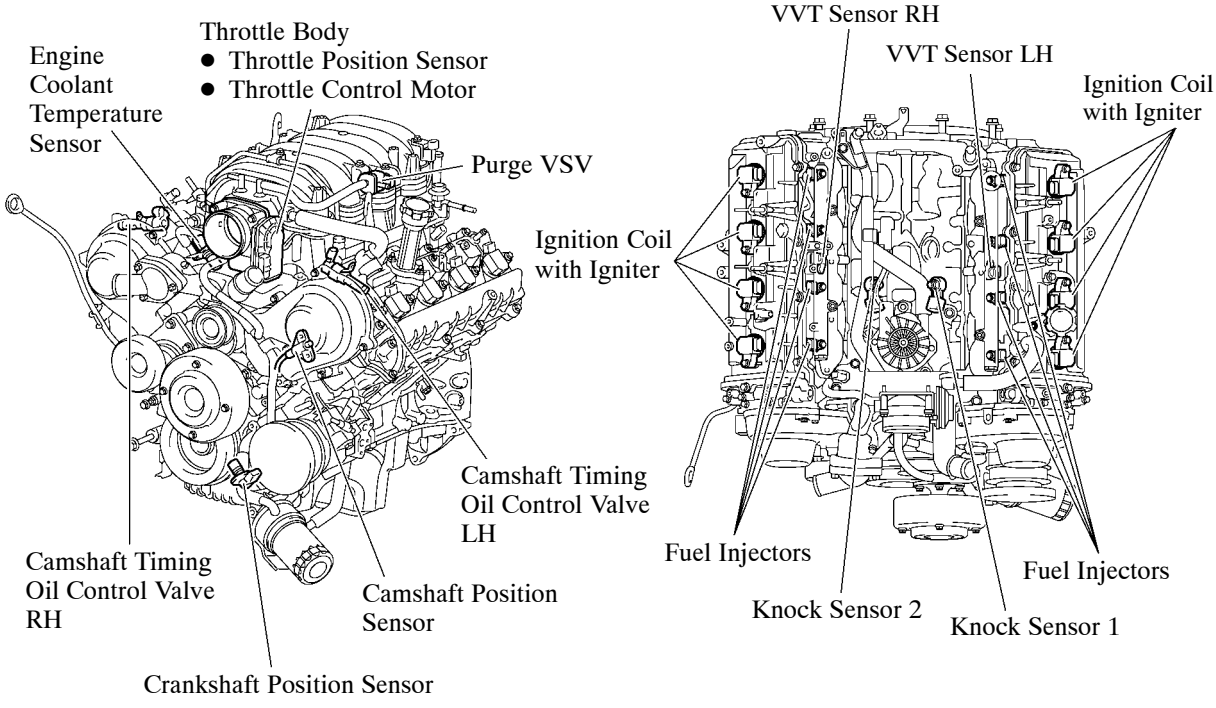
4. Layout of Main Components

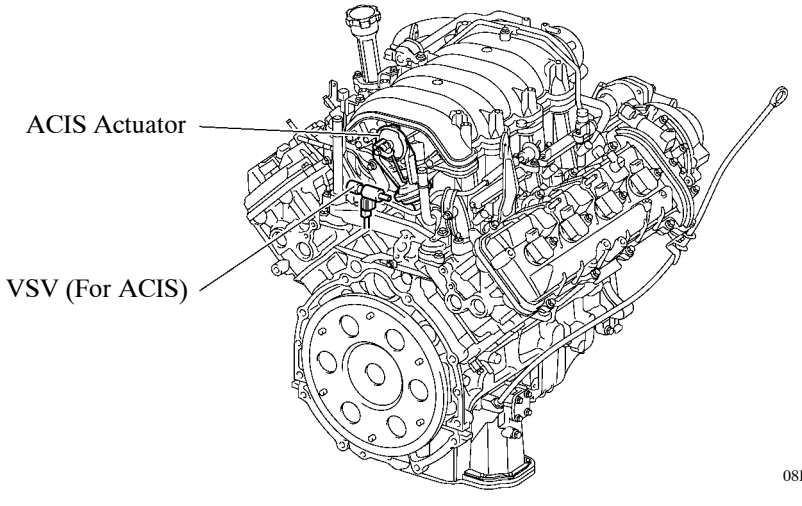




EG


Air Injection Control Valve (Bank 2)
● Air Pressure Sensor
Mass Air Flow Meter
● Intake Air Temperature Sensor
Air Injection Control Valve (Bank 1)
● Air Pressure Sensor
ECM
Air Injection Control Driver
Electric Air Pump (Bank 2)
Electric Air Pump (Bank 1)
08LEG29Y


Throttle Body
● Throttle Position Sensor
● Throttle Control Motor
Engine Coolant Temperature Sensor
Purge VSV
Ignition Coil with Igniter
Camshaft Timing Oil Control Valve LH
Camshaft Timing Oil Control Valve RH
Camshaft Position Sensor
Crankshaft Position Sensor
VVT Sensor RH
VVT Sensor LH
Ignition Coil with Igniter
Fuel Injectors
Fuel Injectors
Knock Sensor 2
Knock Sensor 1


ACIS Actuator
VSV (For ACIS)
08LEG30Y

5. Main Components of Engine Control System

General

The main components of the 2UZ-FE engine control system are as follows:

Components	Outline	Quantity	Function
ECM	32-bit CPU (DENSO)	1	The ECM optimally controls the engine control system to suit the operating conditions of the engine in accordance with the signals provided by the sensors.
Mass Air Flow Meter [See page EG-40]	Hot-wire Type	1	This sensor has a built-in hot-wire to directly detect the intake air mass and flow rate.
Intake Air Temperature Sensor	Thermistor Type	1	This sensor detects the intake air temperature by means of an internal thermistor.
Crankshaft Position Sensor [See page EG-40]	Pick-up Coil Type (Rotor Teeth/36-2)	1	This sensor detects the engine speed and the crankshaft position.
Camshaft Position Sensor [See page EG-41]	MRE Type (Rotor Teeth/3)	1	This sensor detects the camshaft position and performs the cylinder identification.
VVT Sensor [See page EG-42]	Pick-up Coil Type (Rotor Teeth/3)	1 each bank	This sensor detects the actual valve timing.
Accelerator Pedal Position Sensor [See page EG-43]	Non-contact Type	1	This sensor detects the amount of pedal effort applied to the accelerator pedal.
Throttle Position Sensor [See page EG-44]	Non-contact Type	1	This sensor detects the throttle valve opening angle.
Knock Sensor [See page EG-45]	Built-in Piezoelectric Type (Flat Type)	1 each bank	This sensor detects an occurrence of the engine knocking indirectly from the vibration of the cylinder block caused by the occurrence of engine knocking.
Heated Oxygen Sensor [See page EG-47]	Cup Type with Heater	1 each bank	This sensor detects the oxygen concentration in the exhaust gas by measuring the electromotive force which is generated in the sensor itself.
Air-fuel Ratio Sensor [See page EG-47]	Planar Type with Heater	1 each bank	As with the oxygen sensor, this sensor detects the oxygen concentration in the exhaust gas. However, it detects the oxygen concentration in the exhaust gas linearly.
Engine Coolant Temperature Sensor	Thermistor Type	1	This sensor detects the engine coolant temperature by means of an internal thermistor.
Fuel Injector	4-hole Type	8	This fuel injector contains an electro-magnetically operated nozzle to inject fuel into the intake port.

(Continued)

Components	Outline	Quantity	Function
Camshaft Timing Oil Control Valve [See page EG-56]	Electro-magnetic Coil Type	2 each bank	The camshaft timing oil control valve changes the valve timing by switching the oil passage that acts on the VVT-i controller in accordance with the signals received from the ECM.

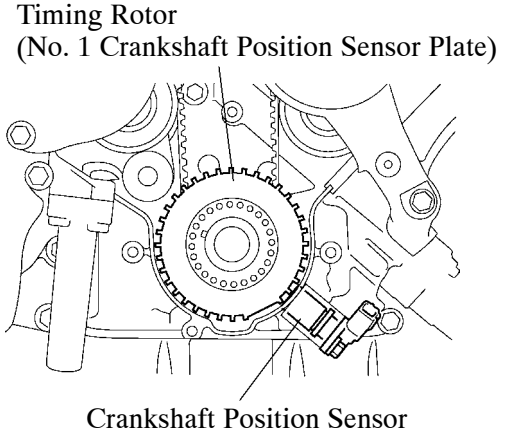
Mass Air Flow Meter

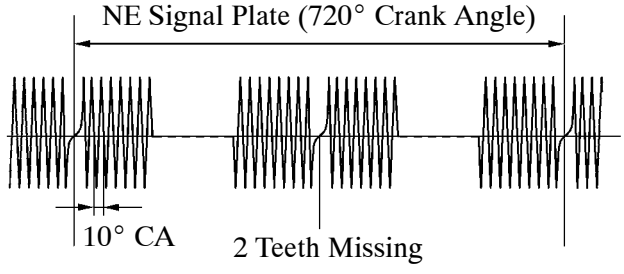
- This mass air flow meter, which is a slot-in type, allows a portion of the intake air to flow through the detection area. By directly measuring the mass and the flow rate of the intake air, the detection precision is improved and the intake air resistance is reduced.
- This mass air flow meter has a built-in intake air temperature sensor.



Crankshaft Position Sensor

The timing rotor of the crankshaft consists of a 34-tooth plate with 2 teeth missing. The crankshaft position sensor outputs a crankshaft rotation signal every 10° of crankshaft rotation, and the change of the signal due to the missing teeth is used to determine top-dead-center.



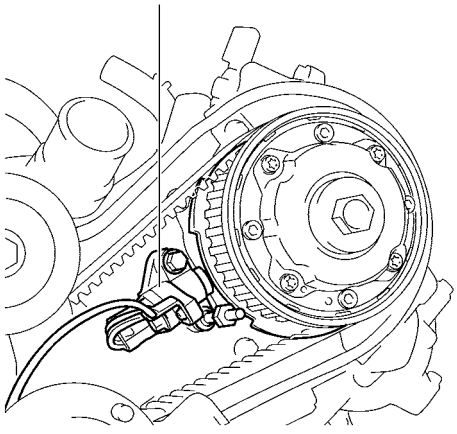


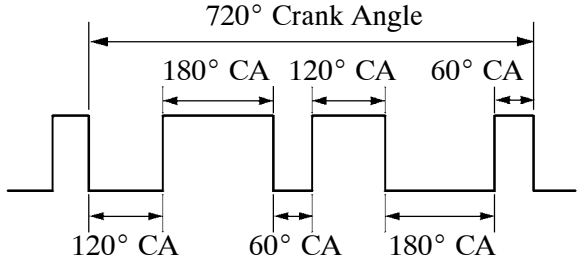
Camshaft Position Sensor

1) General

The camshaft position sensor uses a timing rotor that is provided on the VVT-i controller of the left bank. Based on the timing rotor, the sensor outputs camshaft position signals consisting of 3 (3 Hi output, 3 Lo output) pulses for every 2 revolutions of the crankshaft.

Camshaft Position Sensor





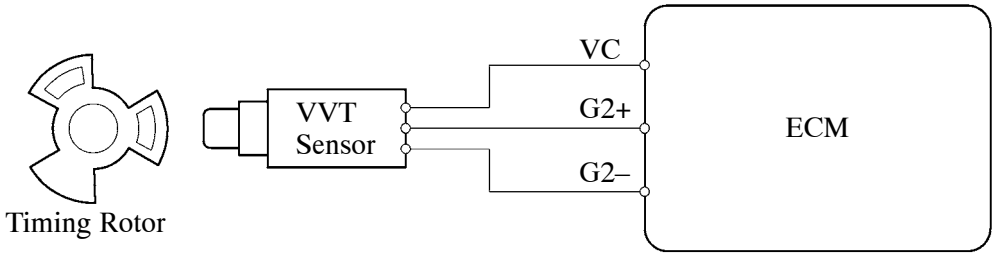
273GX77

2) Construction and Operation

- The MRE type camshaft position sensor consists of an MRE, a magnet and a sensor. The direction of the magnetic field changes due to the different shapes (protruded and non-protruded portions) of the timing rotor, which passes by the sensor. As a result, the resistance of the MRE changes, and the output voltage to the ECM changes to Hi or Lo. The ECM detects the camshaft position based on this output voltage. The ECM compares the camshaft position sensor signal and crankshaft position sensor signals to detect the camshaft position and identify the cylinder.
- The differences between the MRE type camshaft position sensor and the pick-up coil type camshaft position sensor used on the conventional model are as follows.

Item	Sensor Type	
	MRE	Pick-up Coil
Signal Output	Constant digital output starts from low engine speeds	Analog output changes with the engine speed
Camshaft Position Detection	Detection based on the waveforms output throughout the timing rotor speed range	Detection based on the waveforms output as the protruded portion of the timing rotor passes

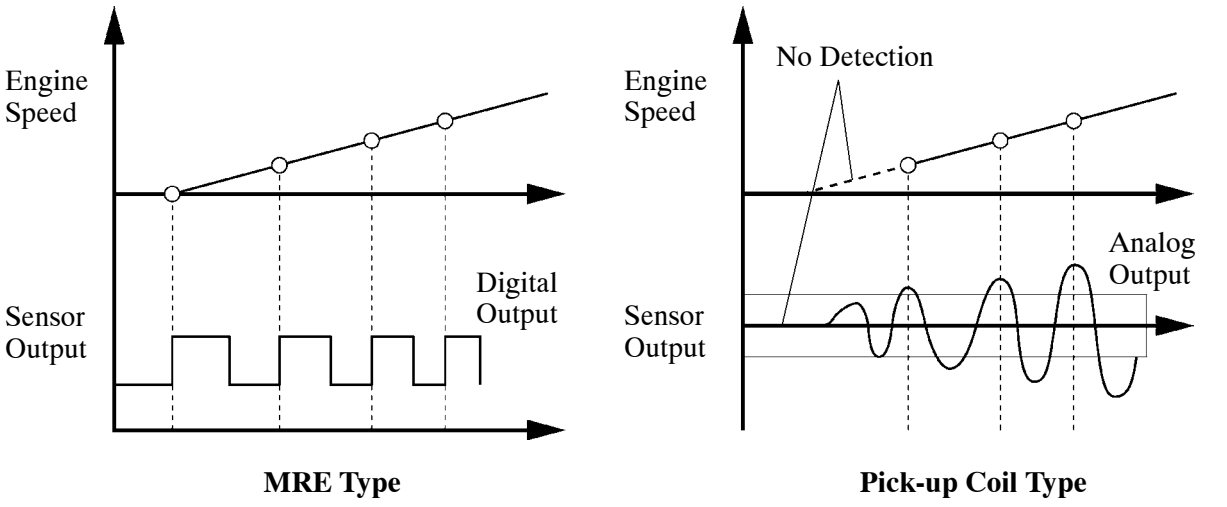
▶ Wiring Diagram ◀



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EG

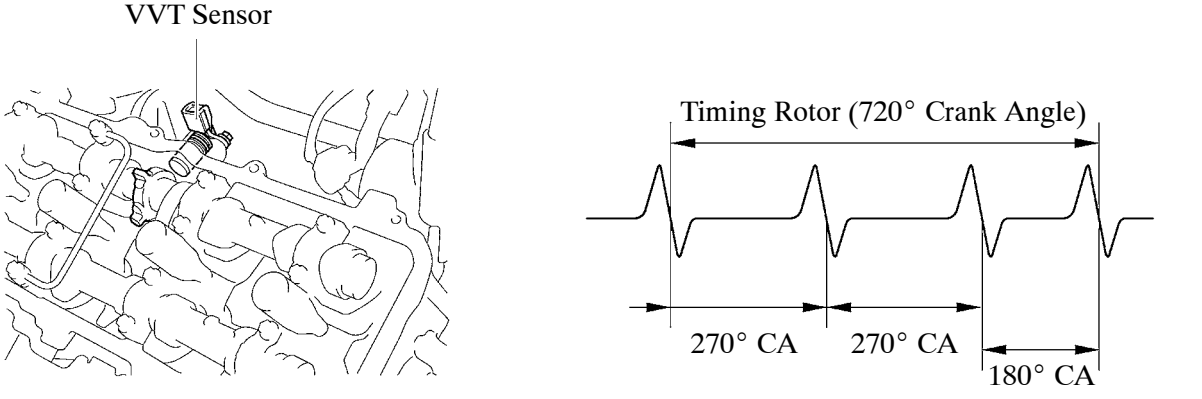
▶ MRE Type and Pick-up Coil Type Output Waveform Image Comparison ◀



232CH41

VVT Sensor

A VVT sensor is mounted on the intake side of each cylinder head. To detect the camshaft position, a timing rotor that is provided on the intake camshaft is used to generate 3 pulses for every 2 revolutions of the crankshaft. The ECM compares these VVT sensor signals and the crankshaft position sensor signal to detect the actual valve timing.

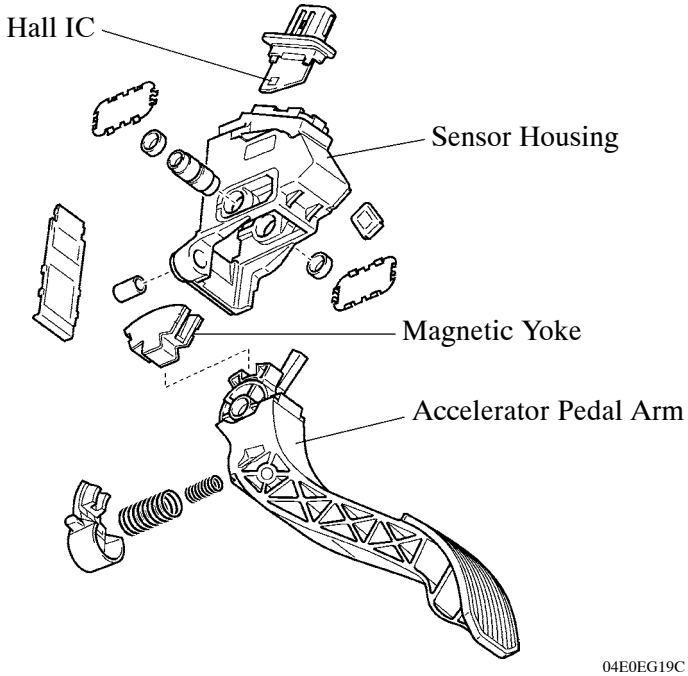


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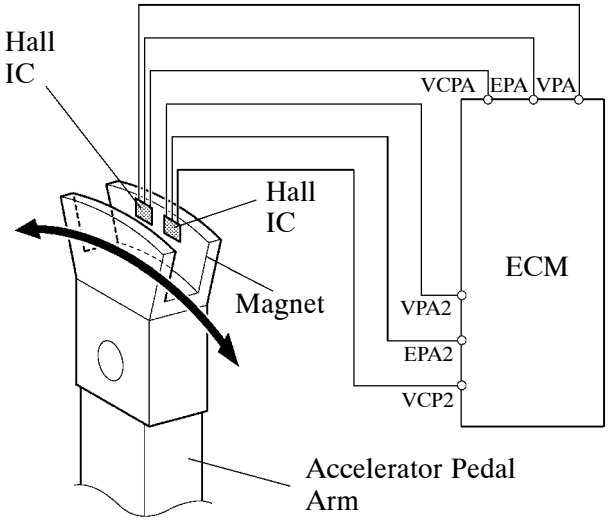
Accelerator Pedal Position Sensor

The non-contact type accelerator pedal position sensor uses a Hall IC, which is mounted on the accelerator pedal arm.

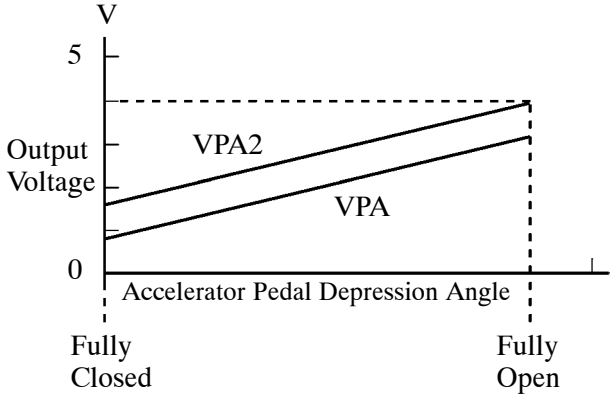
- The magnetic yoke that is mounted at the base of the accelerator pedal arm moves around the Hall IC in accordance with the amount of effort that is applied to the accelerator pedal. The Hall IC converts the changes in the magnetic flux that occur into electrical signals, and outputs them in the form of accelerator pedal position signals to the ECM.
- This accelerator pedal position sensor includes 2 Hall ICs and circuits for the main and sub signals. It converts the accelerator pedal depression angles into two electric signals with differing characteristics and outputs them to the ECM.



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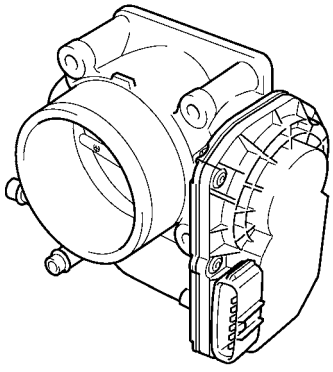


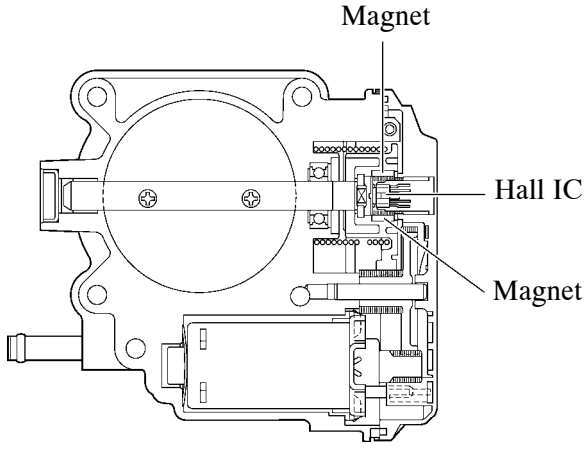
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Throttle position sensor

The non-contact type throttle position sensor is mounted on the throttle body, and it uses a Hall IC.

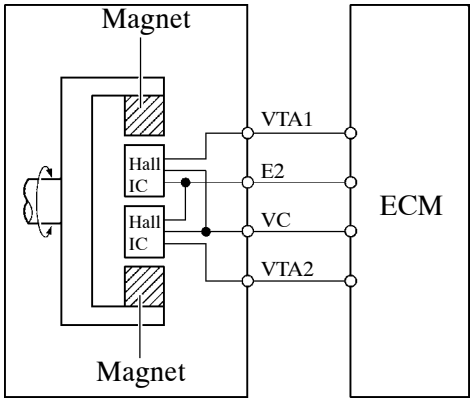
- The Hall IC is surrounded by a magnetic yoke. The Hall IC converts the changes that occur in the magnetic flux into electrical signals, and outputs them in the form of throttle valve position signals to the ECM.
- The Hall IC contains circuits for the main and sub signals. It converts the throttle valve opening angle into two electrical signals that have differing characteristics and outputs them to the ECM.



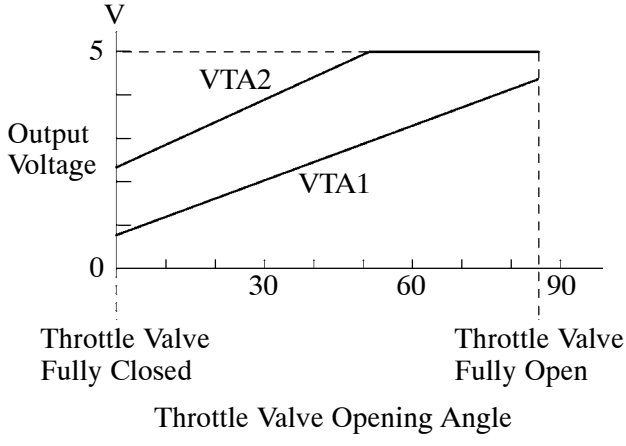


Cross Section

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230LX12



238EG79

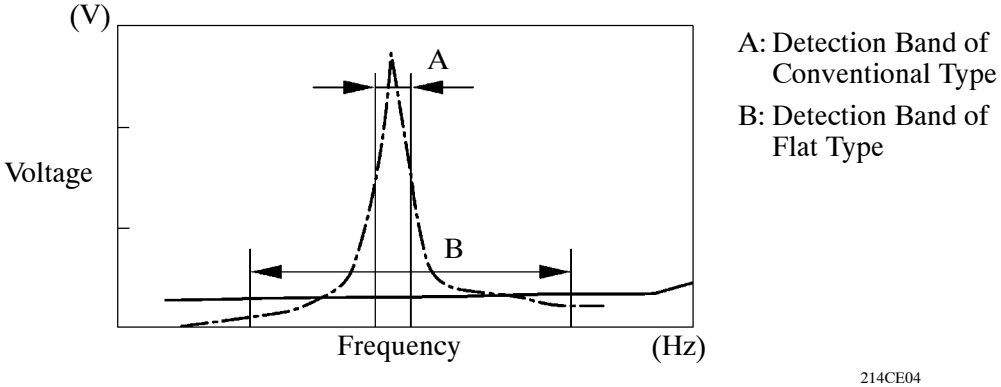
Knock Sensor (Flat Type)

1) General

In a conventional type knock sensor (resonant type), a vibration plate is built into the sensor. This plate has the same resonance point as the knocking frequency of the engine block. This sensor can only detect vibration in this frequency band.
On the other hand, a flat type knock sensor (non-resonant type) has the ability to detect vibration in a wider frequency band (from about 6 kHz to 15 kHz).

- The engine knocking frequency will vary slightly depending on the engine speed. The flat type knock sensor can detect vibration even when the engine knocking frequency changes. Due to the use of the flat type knock sensor, the vibration detection ability is increased compared to a conventional type knock sensor, and more precise ignition timing control is possible.

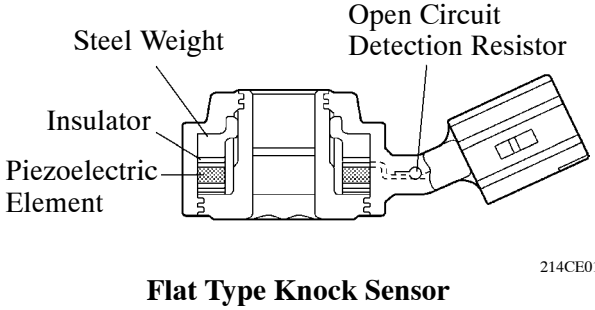
—·— : Resonance Characteristic of Conventional Type
——— : Resonance Characteristic of Flat Type



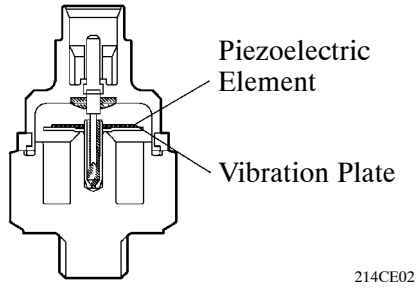
Characteristics of Knock Sensors

2) Construction

- A flat type knock sensor is installed to an engine through the stud bolt installed on the cylinder block. For this reason, a hole for the stud bolt is running through in the center of the sensor.
- In the sensor, a steel weight is located in the upper portion. An insulator is located between the weight and a piezoelectric element.
- An open/short circuit detection resistor is integrated in the sensor.



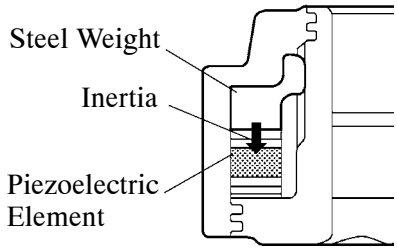
Flat Type Knock Sensor (Non-resonant Type)



Conventional Type Knock Sensor (Resonant Type)

3) Operation

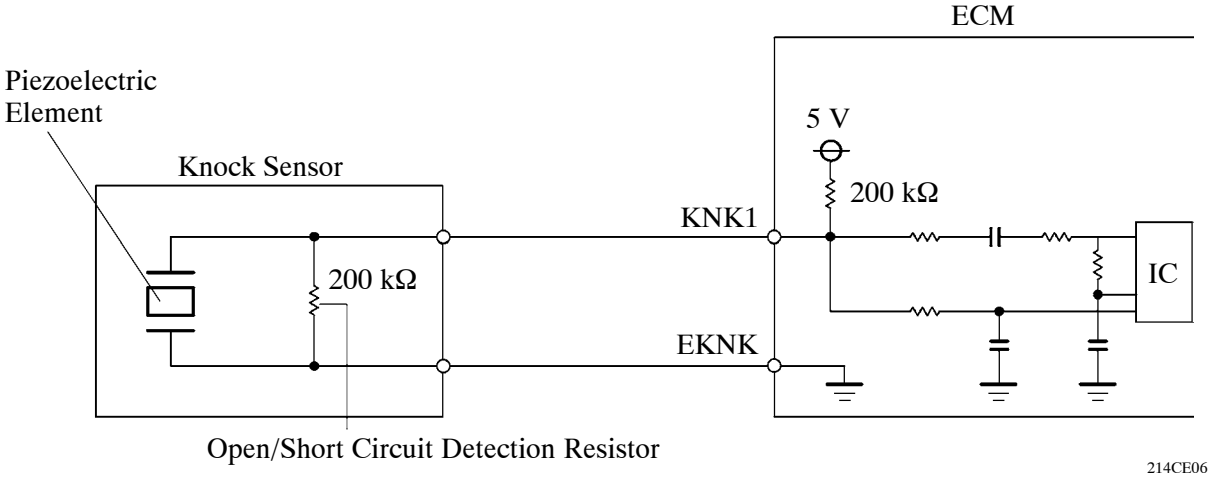
The knocking vibration is transmitted to the steel weight and its inertia applies pressure to the piezoelectric element. This action generates electromotive force (voltage).



214CE08

4) Open/Short Circuit Detection Resistor

When the ignition is ON, the open/short circuit detection resistor in the knock sensor and the resistor in the ECM keep the voltage at the terminal KNK1 of engine constant.
An IC (Integrated Circuit) in the ECM is always monitoring the voltage of the terminal KNK1. If the open/short circuit occurs between the knock sensor and the ECM, the voltage of the terminal KNK1 will change and the ECM detects the open/short circuit and stores a DTC (Diagnostic Trouble Code).



214CE06

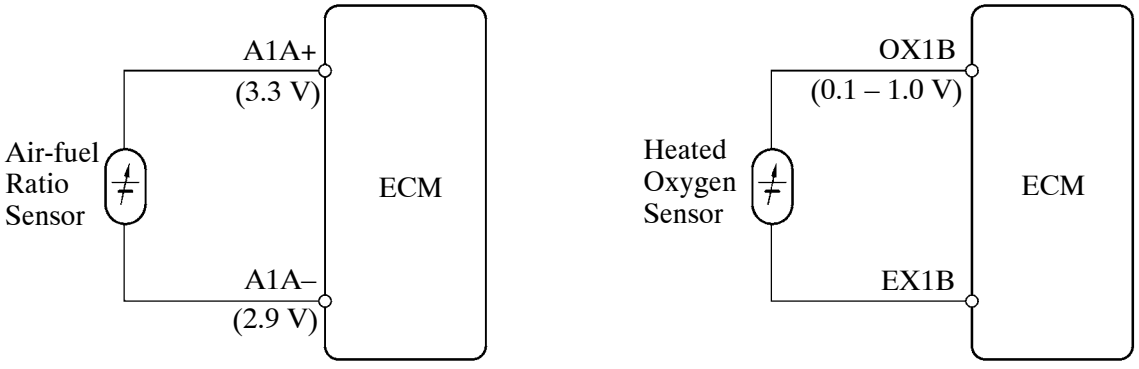
Service Tip

These knock sensors are mounted in specific directions at specific angles. To prevent the right and left bank wiring connectors from being interchanged, make sure to install each sensor in its prescribed direction. For details, refer to the 2008 Sequoia Repair Manual (Pub. No. RM08L0U).

Air-fuel Ratio Sensor and Heated Oxygen Sensor

1) General

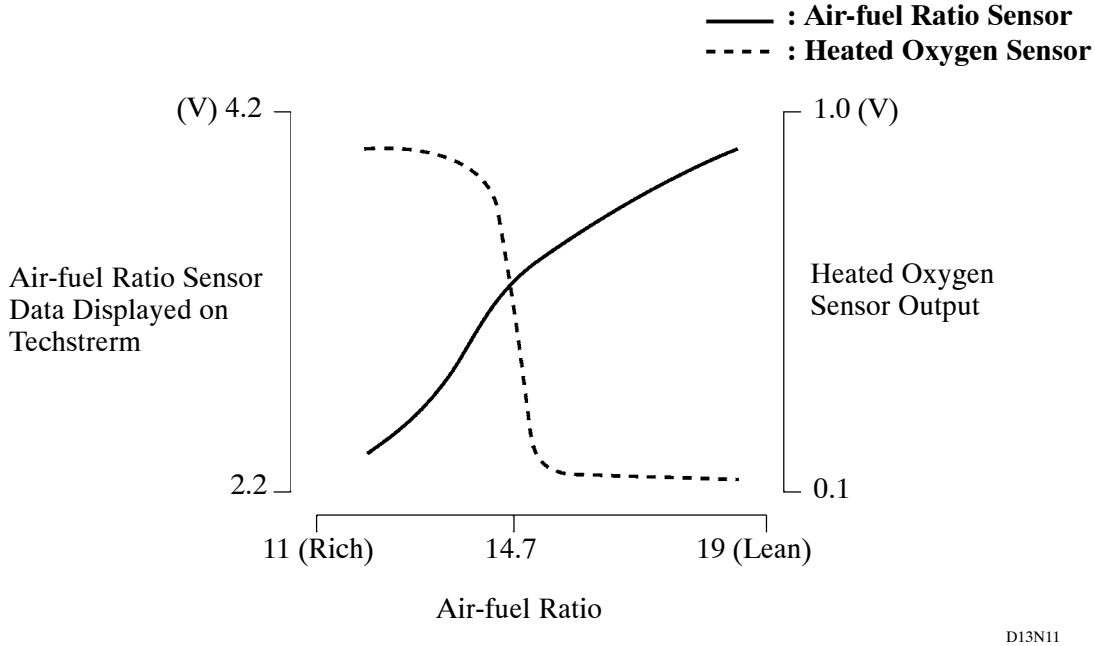
- The heated oxygen sensor and the air-fuel ratio sensor differ in output characteristics.
- The output voltage of the heated oxygen sensor changes in accordance with the oxygen concentration in the exhaust gas. The ECM uses this output voltage to determine whether the present air-fuel ratio is richer or leaner than the stoichiometric air-fuel ratio.
- Approximately 0.4 V is constantly applied to the air fuel ratio sensor, which outputs an amperage that varies in accordance with the oxygen concentration in the exhaust gas. The ECM converts the changes in the output amperage into voltage in order to linearly detect the present air-fuel ratio.



Air-fuel Ratio Sensor Circuit (Bank 1, Sensor 1)

Heated Oxygen Sensor Circuit (Bank 1, Sensor 2)

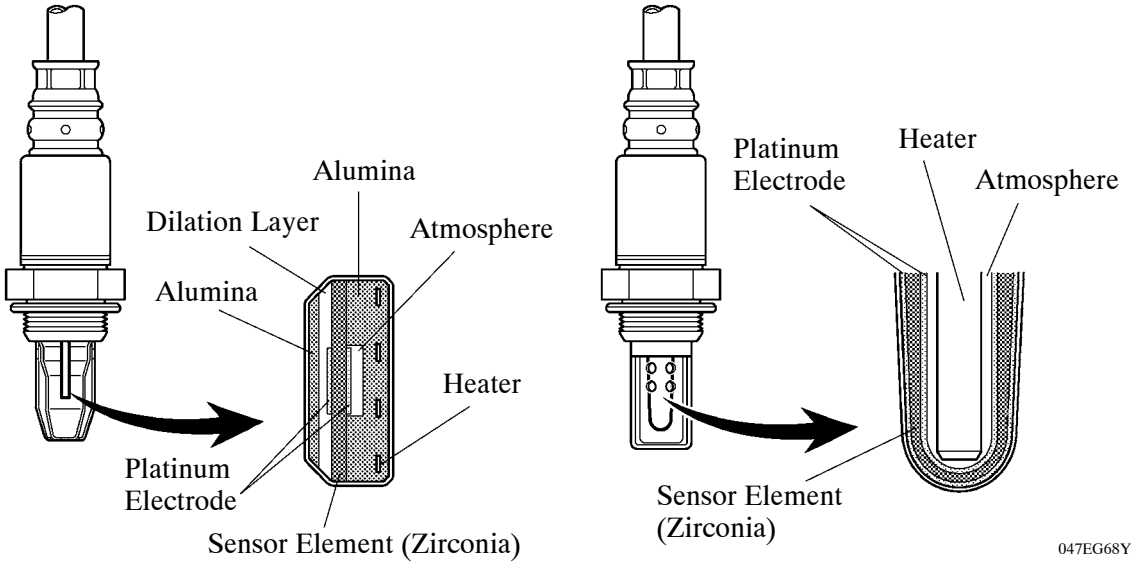
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2) Construction

- The basic construction of the heated oxygen sensor and the air-fuel ratio sensor is the same. However, they are divided into the cup type and the planar type, according to the different types of heater construction that are used.
- The cup type sensor contains a sensor element that surrounds a heater.
- The planar type sensor uses alumina, which excels in heat conductivity and insulation, to integrate a sensor element with a heater, thus improving the warm-up performance of the sensor.



Air-fuel Ratio Sensor (Planar Type) **Heated Oxygen Sensor (Cup Type)**

▶ Warm-up Specification ◀

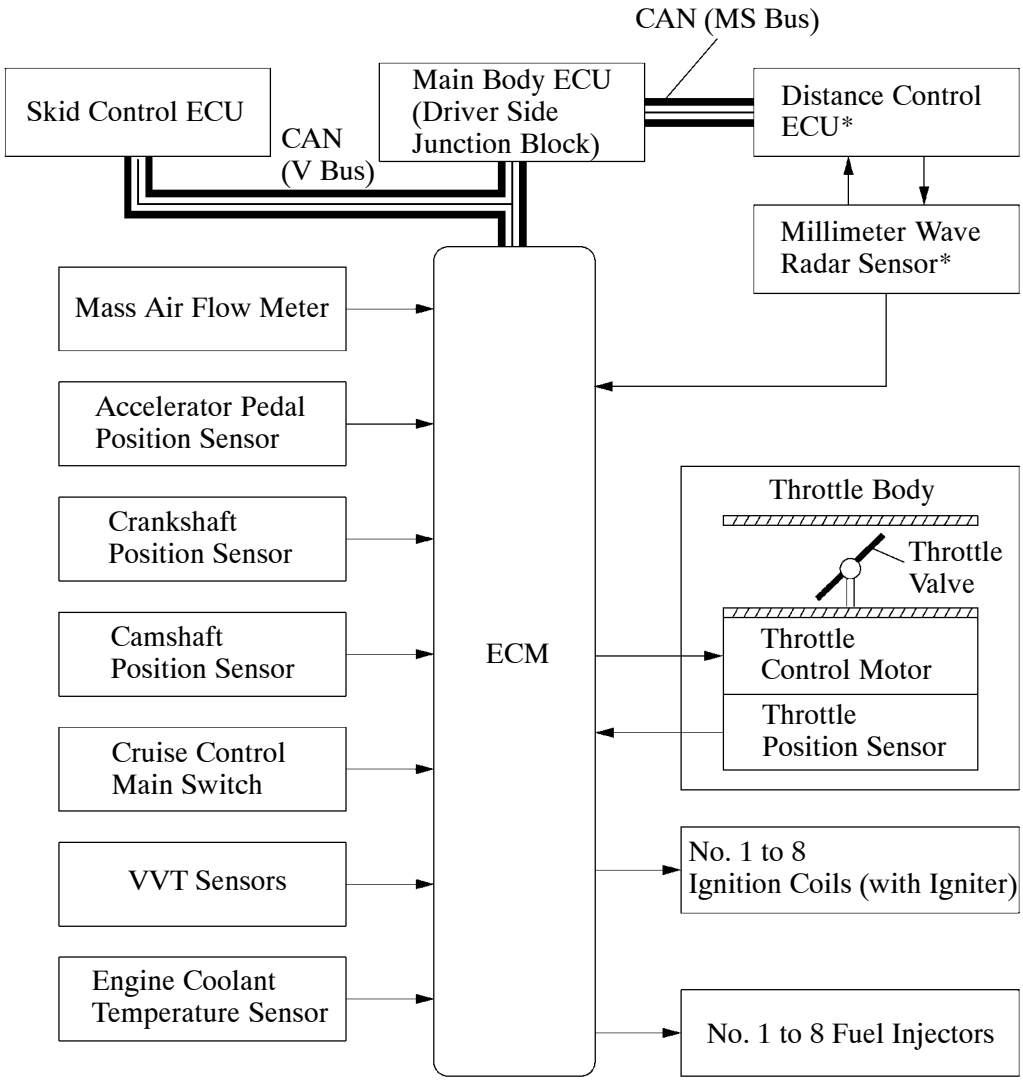
Sensor Type	Planar Type	Cup Type
Warm-up Time	Approx. 10 sec.	Approx. 30 sec.

6. ETCS-i (Electronic Throttle Control System-intelligent)

General

- In the conventional throttle body, the throttle valve angle is determined invariably by the amount of the accelerator pedal effort. In contrast, ETCS-i uses the ECM to calculate the optimal throttle valve angle that is appropriate for the respective driving condition and uses a throttle control motor to control the angle.
- In case of an abnormal condition, this system transfers to the fail-safe mode. For details, see page EG-52.

▶ System Diagram ◀



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*: Models with Dynamic Laser Cruise Control System

Control

1) General

The ETCS-i consists of the following functions:

- Normal Throttle Control (non-linear control)
- ISC (Idle Speed Control)
- A-TRAC (Active Traction Control)*1/TRAC (Traction Control)*2/Auto LSD
- VSC (Vehicle Stability Control) Coordination Control
- Cruise Control
- Dynamic Laser Cruise Control*3

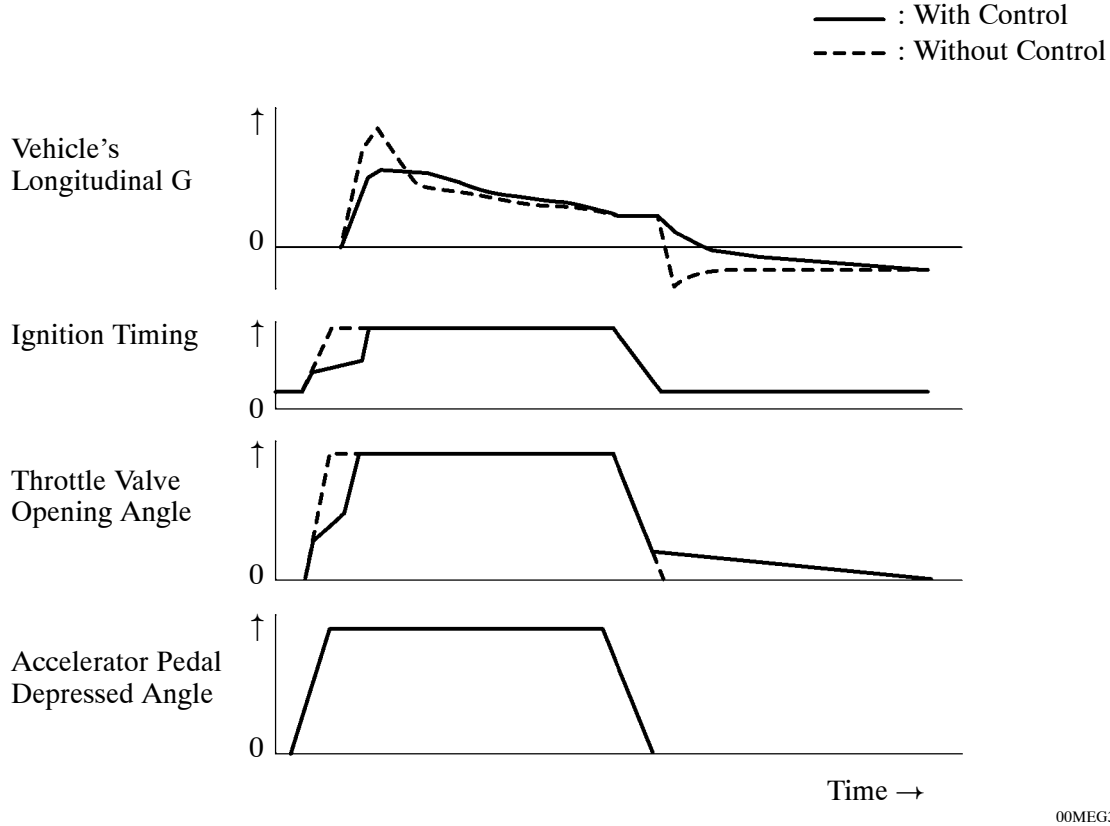
*1: 4WD Models
*2: 2WD Models
*3: Models with Dynamic Laser Cruise Control System

2) Normal Throttle Control (Non-linear Control)

a. General

The normal throttle control controls the throttle to an optimal throttle valve angle that is appropriate for the driving condition such as the amount of the accelerator pedal effort and the engine speed in order to realize excellent throttle control and comfort in all operating ranges.

▶ Conceptual Diagrams of Engine Control During Acceleration and Deceleration ◀



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b. 2nd Start Control

In situations in which low-μ (low friction) road surface conditions can be anticipated, such as when the vehicle is driving in the snow, the rate of throttle valve opening can be controlled to ensure vehicle stability while the vehicle is driving on the slippery surface. This is accomplished by turning on 2nd start control. Pressing the 2nd side of the pattern select switch activates this control. This control modifies the relationship and reaction of the throttle to the accelerator pedal, and assists the driver by reducing the engine output from that of a normal level.

3) Idle Speed Control

The ECM controls the throttle valve in order to constantly maintain an ideal idle speed.

4) A-TRAC*1/TRAC*2/Auto LSD

As part of the A-TRAC*1/TRAC*2/Auto LSD, the throttle valve opening is reduced by a demand signal sent from the skid control ECU to the ECM. This demand signal will be sent if an excessive amount of slippage occurs at a drive wheel, thus ensuring vehicle stability and applying an appropriate amount of power to the road.

5) VSC Coordination Control

In order to bring the effectiveness of the VSC into full play, the throttle valve angle is regulated through a coordination control with the skid control ECU.

6) Cruise Control

The ECM directly actuates the throttle valve for operation of the cruise control.

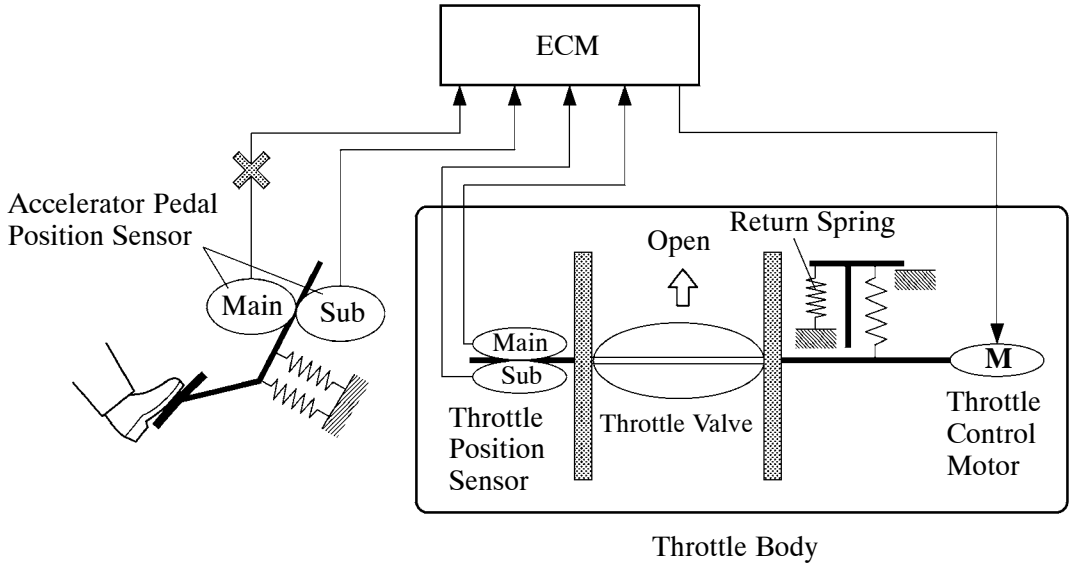
7) Dynamic Laser Cruise Control*3

The dynamic laser cruise control uses a millimeter wave radar sensor and distance control ECU to determine the distance, direction, and relative speed to a vehicle ahead. Thus, the system can effect deceleration control, follow-up control, constant speed control, and acceleration control. To make these controls possible, the ECM controls the throttle valve.

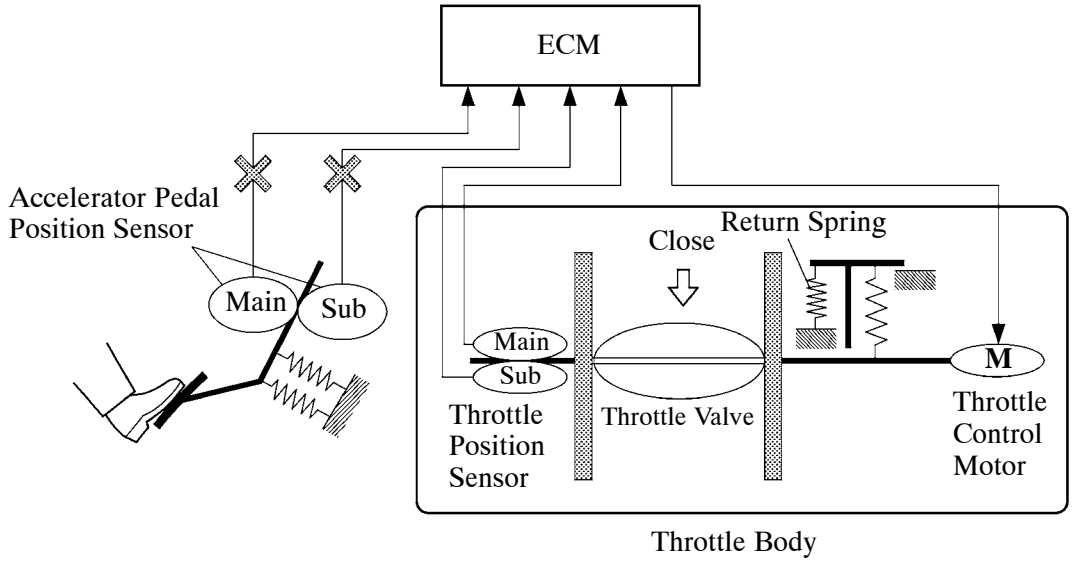
*1: 4WD Models
*2: 2WD Models
*3: Models with Dynamic Laser Cruise Control System

Fail-safe Operation due to Accelerator Pedal Position Sensor Trouble

- The accelerator pedal position sensor comprises two (main, sub) sensor circuits.
- If a malfunction occurs in either of the sensor circuits, the ECM detects the abnormal signal voltage difference between these two sensor circuits and switches into a fail-safe mode. In this fail-safe mode, the remaining circuit is used to calculate the accelerator pedal opening, in order to operate the vehicle under fail-safe mode control.

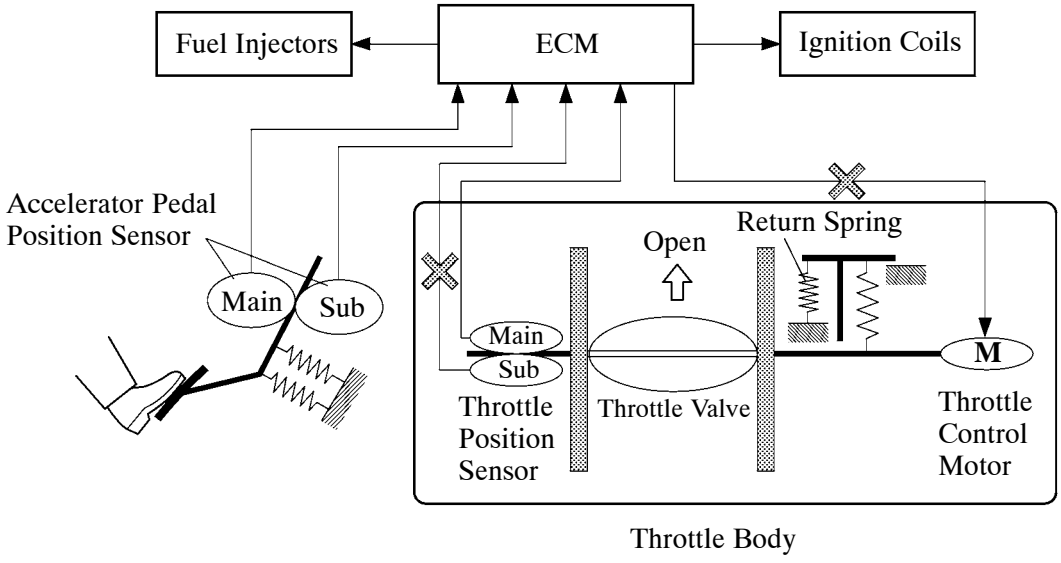


- If both circuits malfunction, the ECM detects the abnormal signal voltage from these two sensor circuits and discontinues the throttle control. At this time, the vehicle can be driven within its idling range.



Fail-safe Operation due to Throttle Position Sensor Trouble

- The throttle position sensor comprises two (main, sub) sensor circuits.
- If a malfunction occurs in either of the sensor circuits, the ECM detects the abnormal signal voltage difference between these two sensor circuits, cuts off the current to the throttle control motor, and switches to a fail-safe mode.
- Then, the force of the return spring causes the throttle valve to return and stay at the prescribed base opening position. At this time, the vehicle can be driven in the fail-safe mode while the engine output is regulated through control of the fuel injection and ignition timing in accordance with the accelerator pedal position.
- The same control as above is effected if the ECM detects a malfunction in the throttle control motor system.



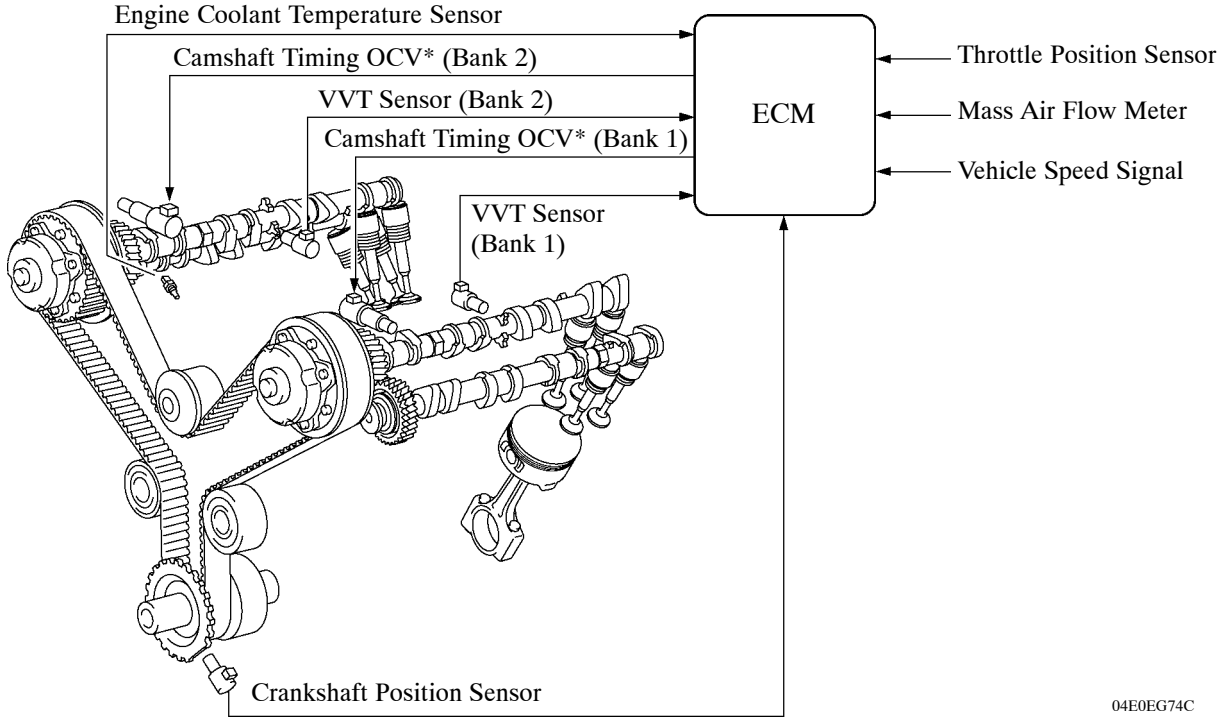
Throttle Body

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7. VVT-i (Variable Valve Timing-intelligent) System

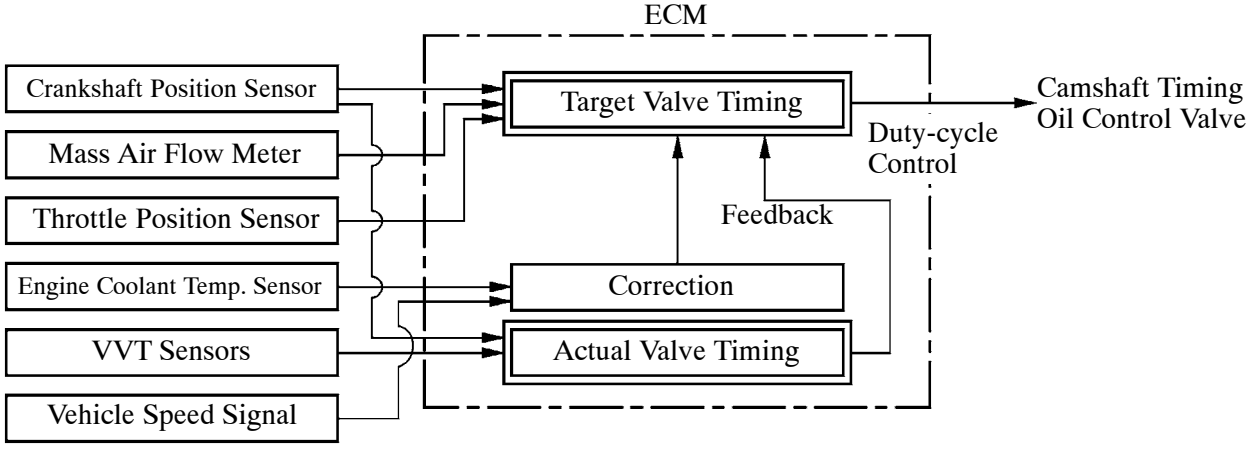
General

- The VVT-i system is designed to control the intake camshaft within a range of 40° (of Crankshaft Angle) to provide valve timing that is optimally suited to the engine condition. This improves torque in all the speed ranges as well as increasing fuel economy, and reducing exhaust emissions.

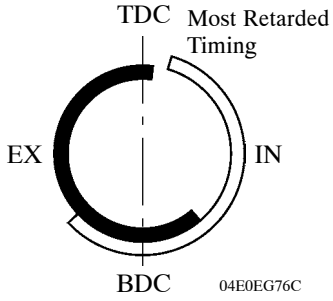
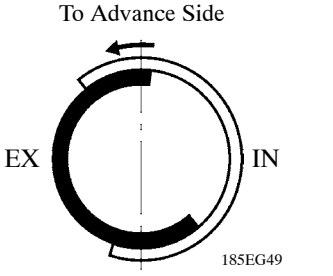
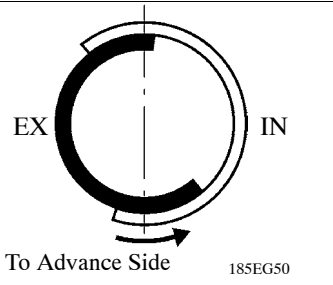
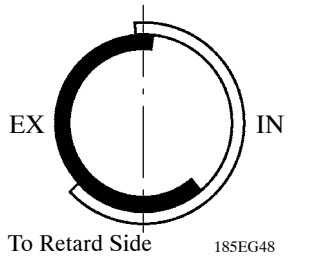
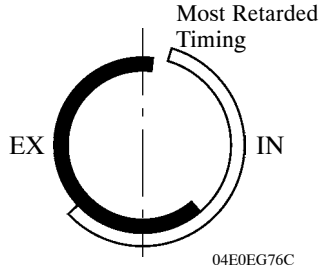
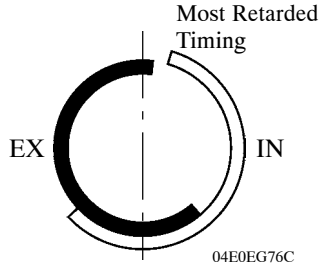


*: Oil Control Valve

- By using the engine speed, intake air mass, throttle position, engine coolant temperature and vehicle speed, the ECM can calculate optimal valve timing for each driving condition and controls the camshaft timing oil control valve. In addition, the ECM uses signals from the VVT sensor and the crankshaft position sensor to detect the actual valve timing, thus providing feedback control to achieve the target valve timing.



Effectiveness of VVT-i System

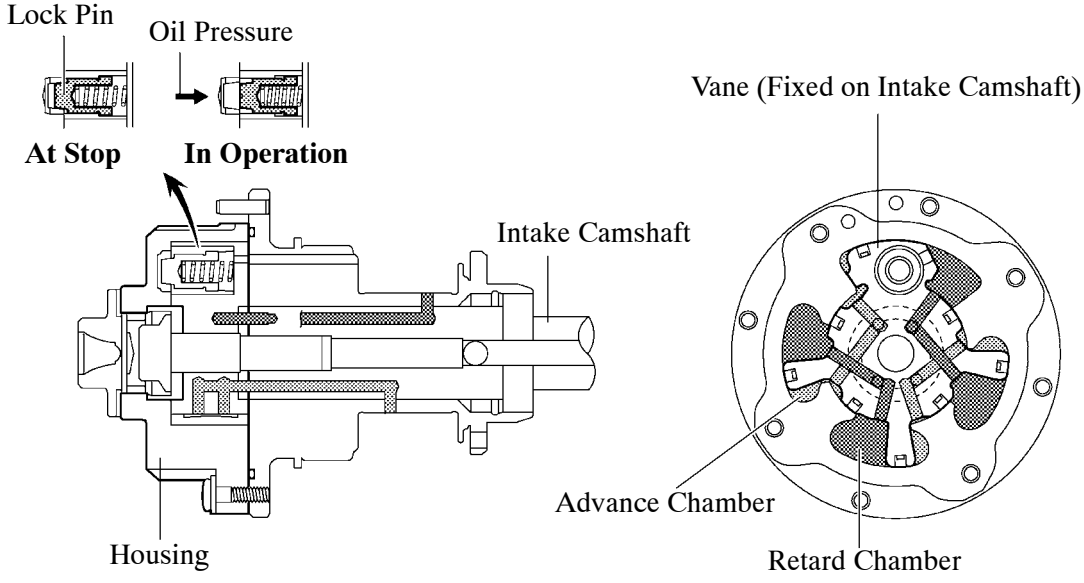
Operation State	Objective	Effect
● During Idling ● At Light Load	 Eliminating overlap to reduce blow back to the intake side	● Stabilized idle speed ● Better fuel economy
At Medium Load	 Increasing overlap to increase internal EGR to reduce pumping loss	● Better fuel economy ● Improved emission control
In Low to Medium Speed Range with Heavy Load	 Advancing the intake valve close timing for volumetric efficiency improvement	Improved torque in low to medium speed range
In High Speed Range with Heavy Load	 Retarding the intake valve close timing for volumetric efficiency improvement	Improved output
At Low Temperatures	 Eliminating overlap to prevent blow back to the intake side and stabilizes the idling speed at fast idle.	● Stabilized fast idle speed ● Better fuel economy
● Upon Starting ● Stopping the Engine	 Eliminating overlap to reduce blow back to the intake side	Improved startability

EG

Construction

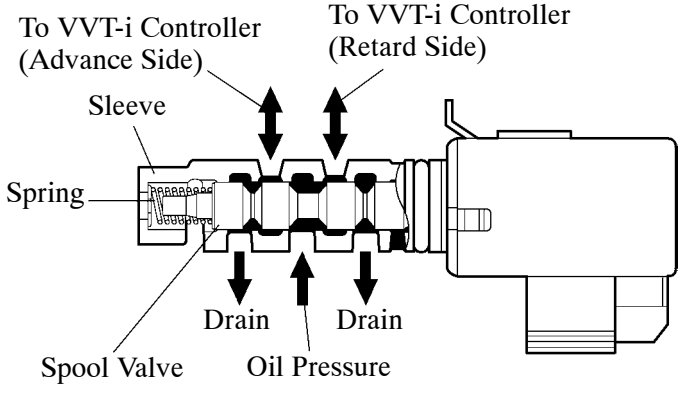
1) VVT-i Controller

VVT-i controller consists of the housing, four vanes, and a lock pin. The oil pressure sent from the advance or retard side path of the intake camshaft causes rotation of the VVT-i controller vane in the circumferential direction to vary the intake valve timing continuously. When the engine is stopped, the intake camshaft will be in the most retarded state to ensure startability. When hydraulic pressure is not applied to the VVT-i controller immediately after the engine has started, the lock pin locks the movement of the VVT-i controller to prevent a knocking noise. Thereafter, when hydraulic pressure is applied to the VVT-i controller, the lock pin is released.



2) Camshaft Timing Oil Control Valve

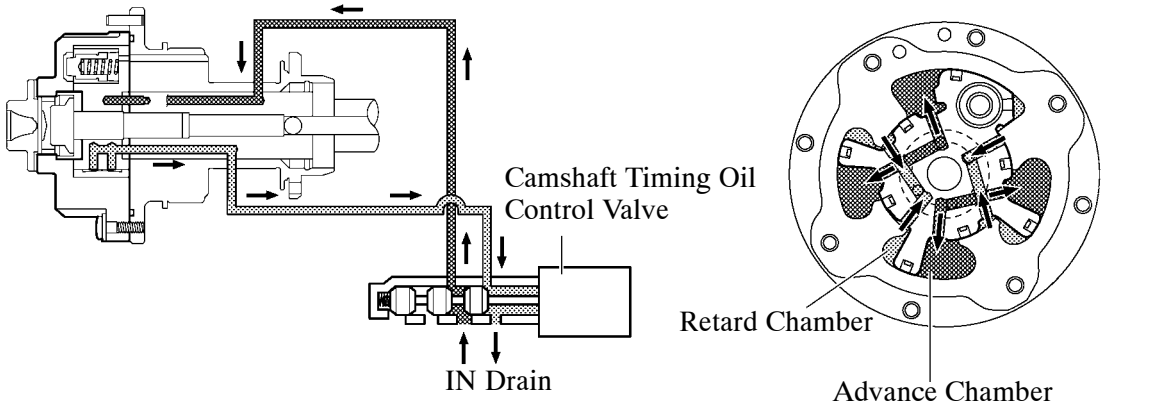
This camshaft timing oil control valve controls the spool valve using duty-cycle control from the ECM. This allows hydraulic pressure to be applied to the VVT-i controller advance or retard side. When the engine is stopped, the camshaft timing oil control valve is in the most retarded position.



Operation

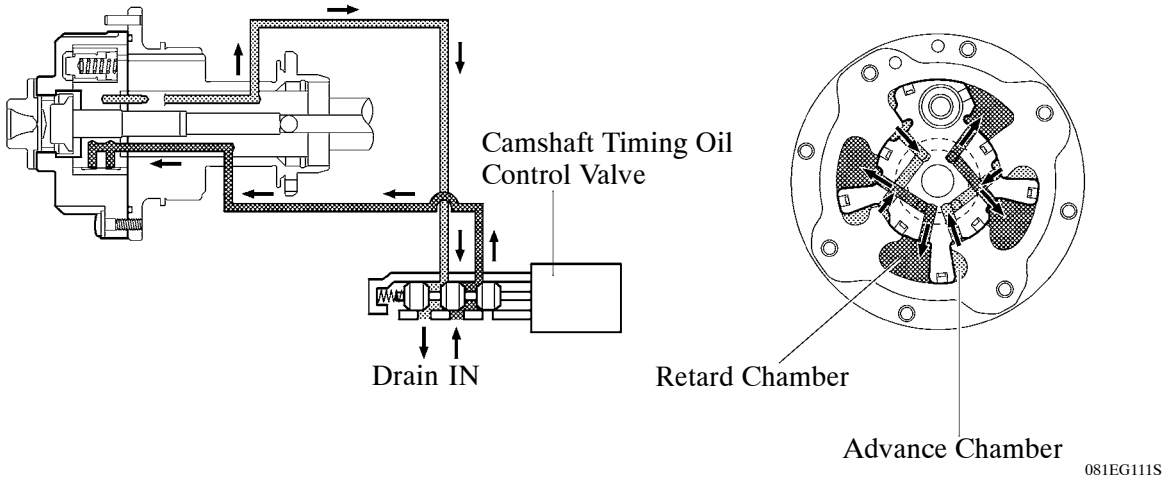
1) Advance

When the camshaft timing oil control valve is positioned as illustrated below by the advance signals from the ECM, the resultant oil pressure is applied to the timing advance side vane chamber to rotate the camshaft in the timing advance direction.



2) Retard

When the camshaft timing oil control valve is positioned as illustrated below by the retard signals from the ECM, the resultant oil pressure is applied to the timing retard side vane chamber to rotate the camshaft in the timing retard direction.



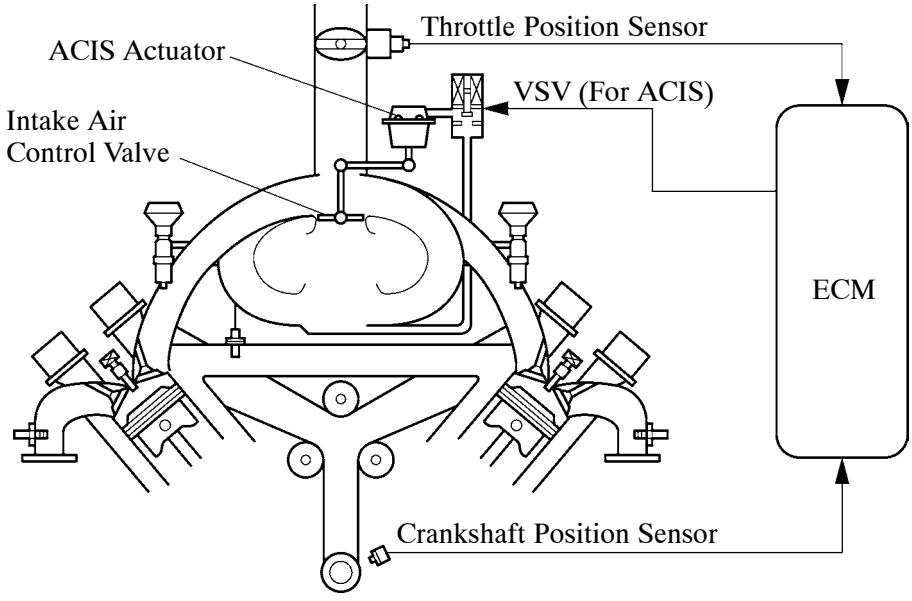
3) Hold

After reaching the target timing, the valve timing is held by keeping the camshaft timing oil control valve in the neutral position unless the traveling state changes.
This adjusts the valve timing at the desired target position and prevents the engine oil from running out when it is unnecessary.

8. ACIS (Acoustic Control Induction System)

General

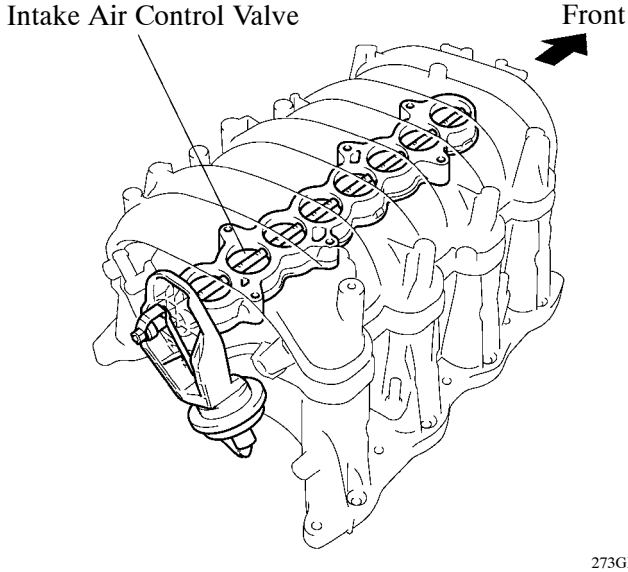
The ACIS uses the intake air control valve as a bulkhead to divide the intake manifold into 2 stages. The intake air control valve is opened and closed to vary the effective length of the intake manifold in accordance with engine speed and throttle valve opening angle. This increases the power output in all ranges from low to high engine speeds.



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Intake Air Control Valve and Actuator

- The intake air control valve and actuator are integrated with the intake manifold.
- The intake air control valve opens and closes to make two effective lengths of the intake manifold possible.



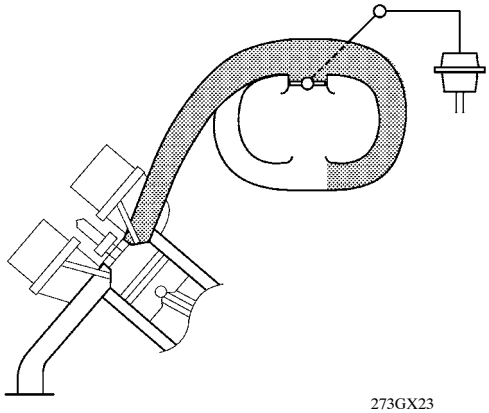
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Operation

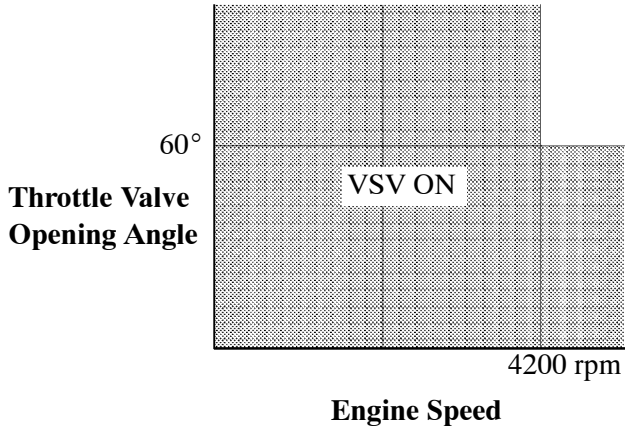
1) Intake Air Control Valve Close (VSV ON)

The ECM activates the VSV so that the negative pressure acts on the diaphragm chamber of the actuator. This closes the control valve to match the longer pulsation cycle. As a result, the effective length of the intake manifold is lengthened and the intake efficiency in the low-to-medium engine speed range is improved due to the dynamic effect of the intake air, thereby increasing the power output.

: Effective Intake Manifold Length



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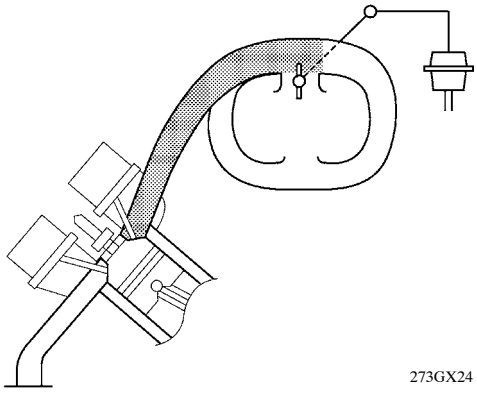


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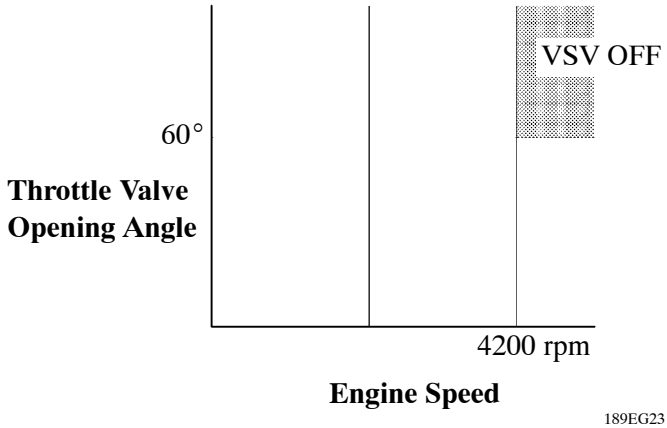
2) Intake Air Control Valve Open (VSV OFF)

The ECM deactivates the VSV so that atmospheric air is led into the diagram chamber of the actuator. This opens the control valve to match the shorter pulsation cycle. When the control valve is open, the effective length of the intake air chamber is shortened and peak intake efficiency is shifted to the high engine speed range, thus providing greater output at high engine speeds

: Effective Intake Manifold Length



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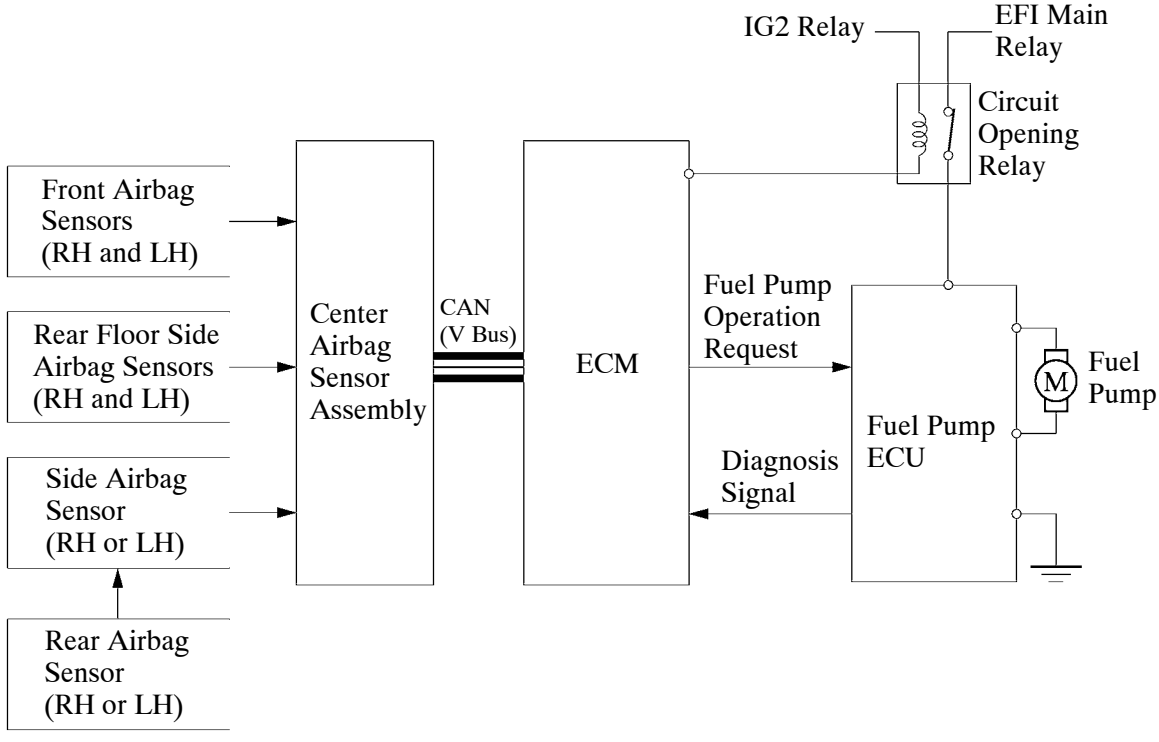
9. Fuel Pump Control

General

In this vehicle, there are 2 types of fuel pump controls. The fuel pump is controlled to an optimum speed to match the engine operating conditions, and the fuel pump operation is stopped when the SRS airbags deploy.

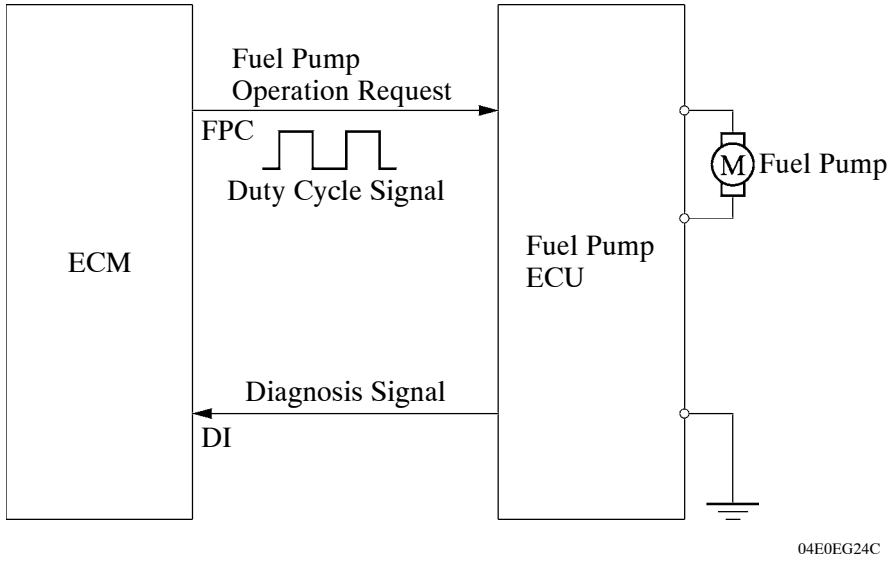
- The ECM transmits a fuel pump operation request signal to the fuel pump ECU that corresponds to the engine operating conditions. The fuel pump ECU receives this request signal and controls the speed of the fuel pump in 3 stages. As a result, under light engine loads, fuel pump speed is kept low to reduce electric power loss.
- A fuel cut control is used to stop the fuel pump when any of the SRS airbags deploys. In this control, if an airbag deployment signal from the center airbag sensor assembly is detected by the ECM, the ECM will turn OFF the circuit opening relay. As a result, the power supply to fuel pump ECU is stopped, causing the fuel pump to stop operating. After the fuel cut control has been activated, turning the ignition switch from OFF to ON cancels the fuel cut control, and the engine can be restarted.

▶ System Diagram ◀

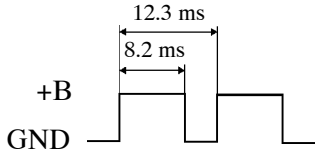
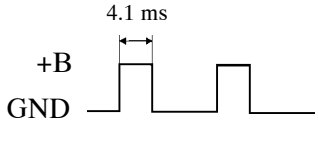
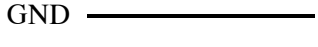


Fuel Pump ECU

- The fuel pump ECU controls fuel pump speed by receiving a duty cycle signal (FPC terminal input) from the ECM, and control is performed in three stages.
- The fuel pump ECU also detects failures in the input and output circuits at the fuel pump ECU and transmits the failure status to the ECM.



▶ FPC Terminal Input ◀

FPC Input Signal (Duty Cycle Signal)	Fuel Pump Speed
	High
	Middle
	Low
	Stop

10. Air Injection System

General

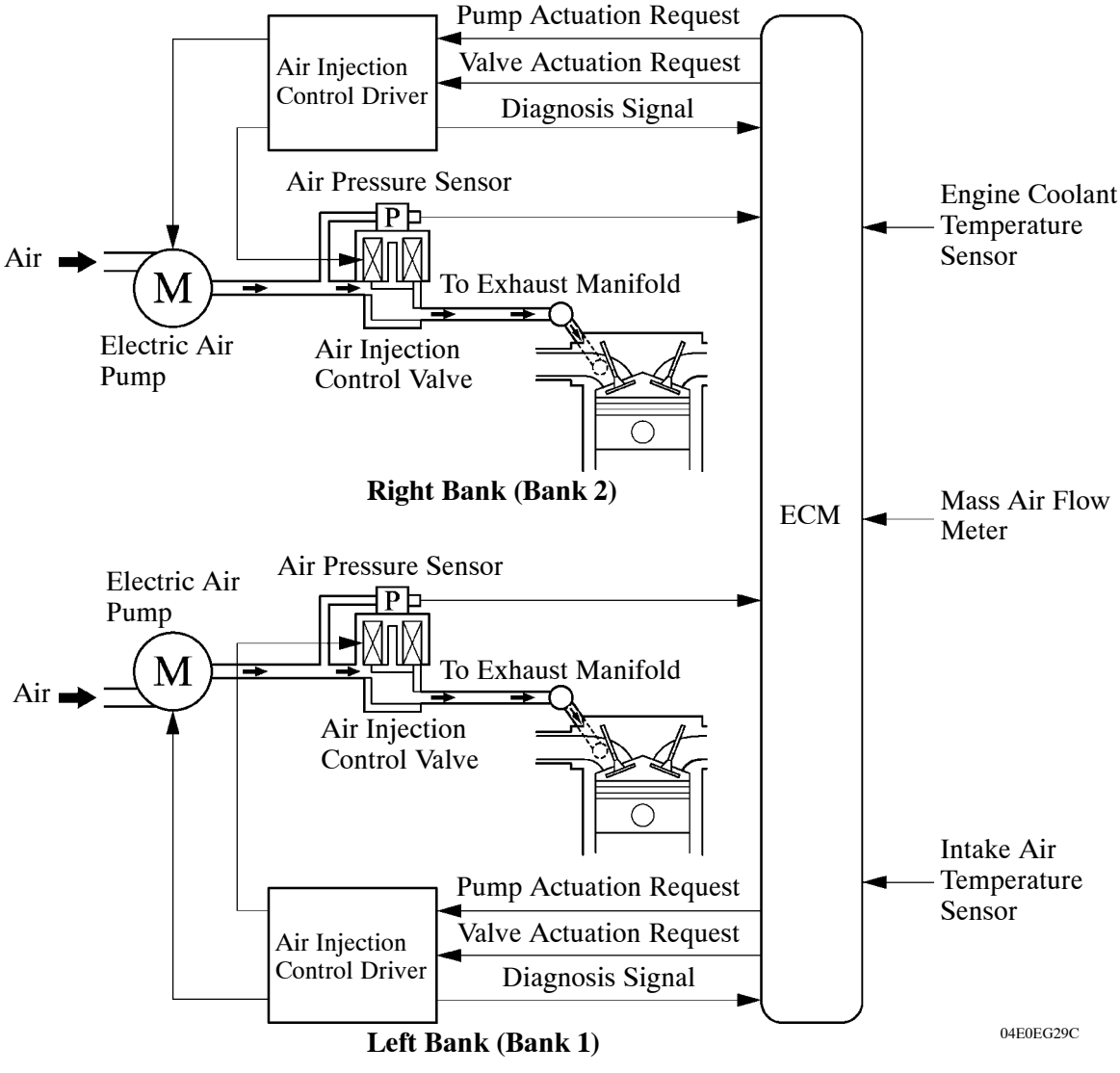
To ensure the proper warm-up performance of the TWCs (Three-Way Catalytic converters) after starting a cold engine, an air injection system is used.

- For this system, each of the right bank (bank 2) and left bank (bank 1) has an electric air pump, air injection control driver, air injection control valve, and air pressure sensor. Control of the right bank and left bank is performed independently. Two pumps are used to increase the amount of air supplied, shortening the catalyst warm-up time.
- The ECM estimates the amount of air injected to the TWCs based on signals from the mass air flow meter in order to regulate the air injection time.
- Air is injected under the following conditions.

▶ Operation Conditions ◀

Engine Coolant Temperature	5 – 45°C (41 – 113°F)
Intake Air Temperature	5°C (41°F) or more

▶ System Diagram ◀

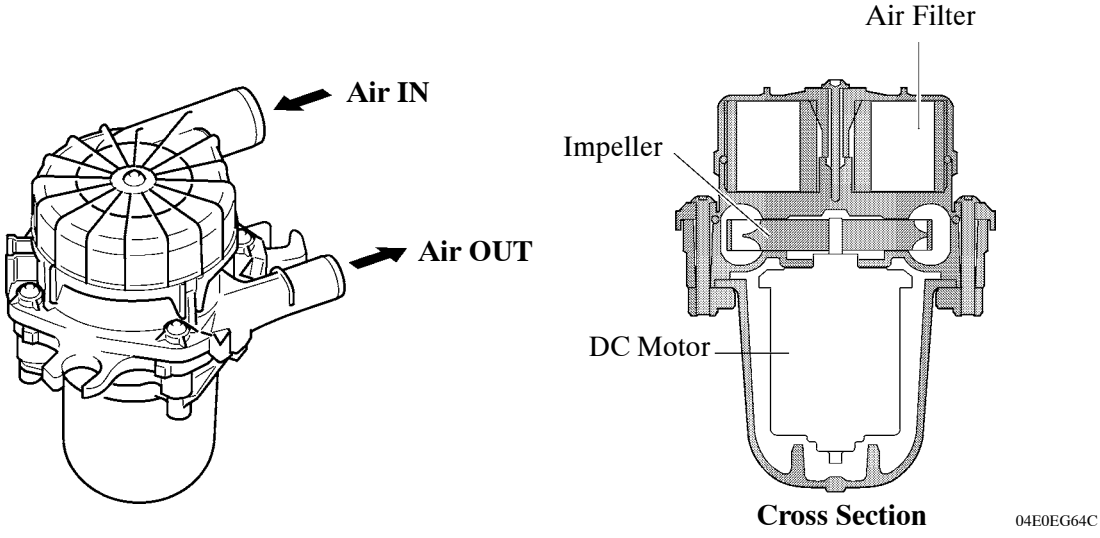


Construction and Function of Main Components

1) Electric Air Pump

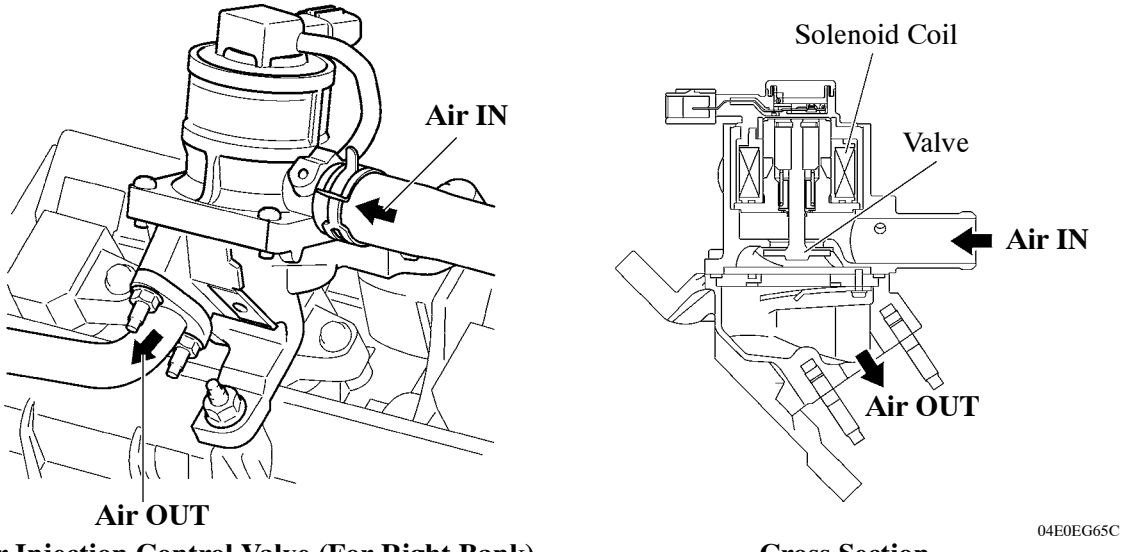
Each electric air pump consists of a DC motor, an impeller and an air filter.

- The electric air pump supplies air into an air injection control valve using its impeller.
- The air filter is maintenance-free.
- The structure and function of the electric air pumps for the right bank and left bank are basically the same.



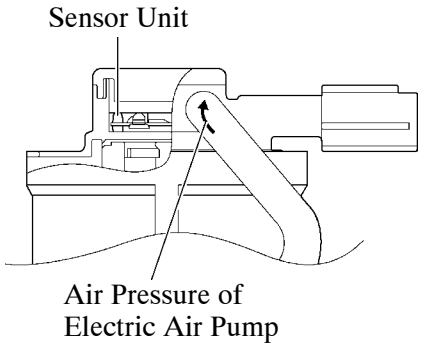
2) Air Injection Control Valve

- The air injection control valve is operated by a solenoid coil to control air injection and prevent back-flow of exhaust gas. Opening timing of the valve is synchronized with the operation timing of the electric air pump.
- Each air pressure sensor is built into the corresponding air injection control valve.
- The structure and function of the air injection control valves for the right bank and left bank are basically the same.

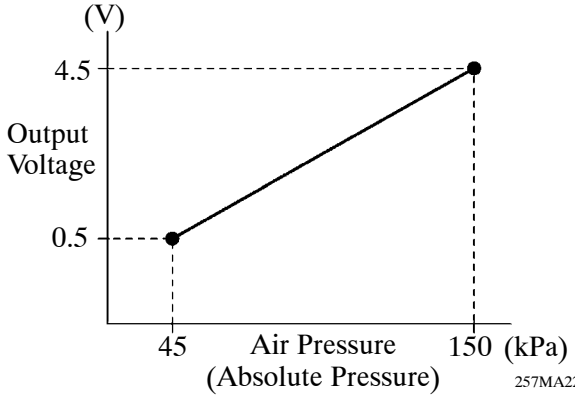


3) Air Pressure Sensor

- The air pressure sensor consists of a semiconductor, which has a silicon chip that changes its electrical resistance when pressure is applied to it. The sensor converts the pressure into an electrical signal, and sends it to the ECM in an amplified form.
- The structure and function of the air pressure sensors for the right bank and left bank are basically the same.



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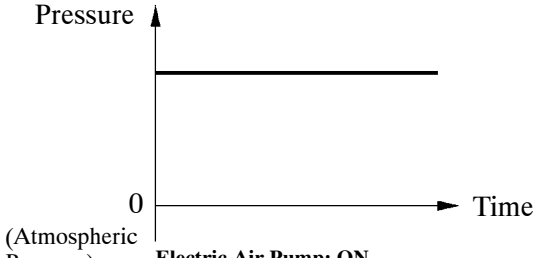


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The ECM detects operation of the air injection system based on signals from the air pressure sensor as follows:

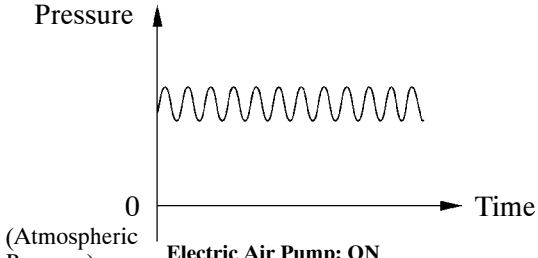
1) When the electric air pump is ON and the air injection control valve is closed, the pressure is stable.
2) When the electric air pump is ON and the air injection control valve is open, the pressure drops slightly and becomes unstable because of exhaust pulses.
3) When the electric air pump is OFF and the air injection control valve is closed, the pressure remains at atmospheric pressure.
4) When the electric air pump is OFF and air injection control valve is open, the pressure drops below atmospheric pressure and becomes unstable because of exhaust pulses.

Example: 1



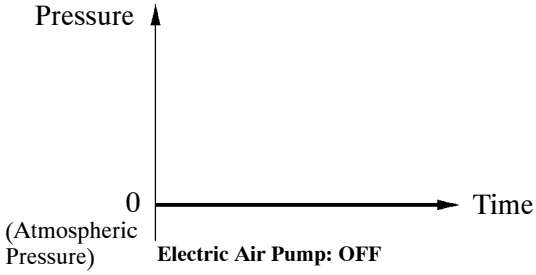
Electric Air Pump: ON
Air Injection Control Valve: Closed

Example: 2



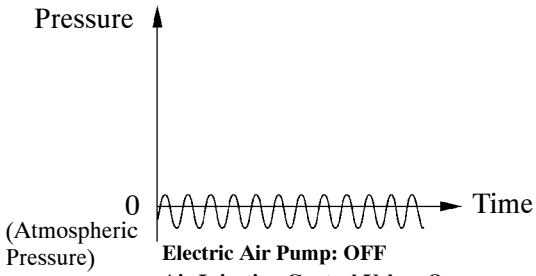
Electric Air Pump: ON
Air Injection Control Valve: Open

Example: 3



Electric Air Pump: OFF
Air Injection Control Valve: Closed

Example: 4

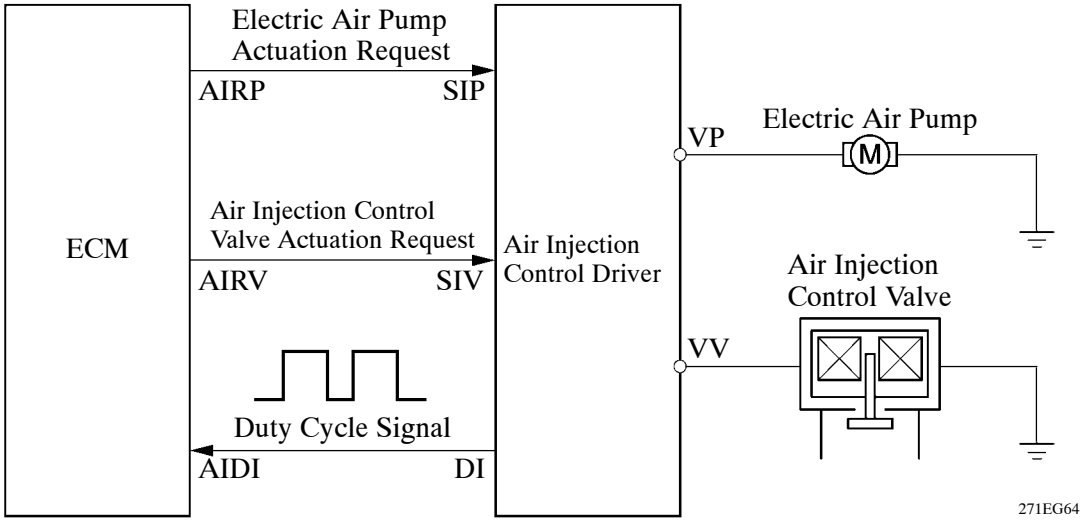


Electric Air Pump: OFF
Air Injection Control Valve: Open

273GX81

4) Air Injection Control Driver

- A semiconductor type air injection control driver is used. Activated by the ECM, this driver actuates the electric air pump and the air injection control valve.
- The air injection control driver also detects failures in the input and output circuits of the air injection control driver and transmits the failure status to the ECM via duty cycle signals.
- The basic functions of the air injection control drivers for the right bank and left bank are the same. The following system chart shows the left bank (bank 1).



▶ DI Terminal Output ◀

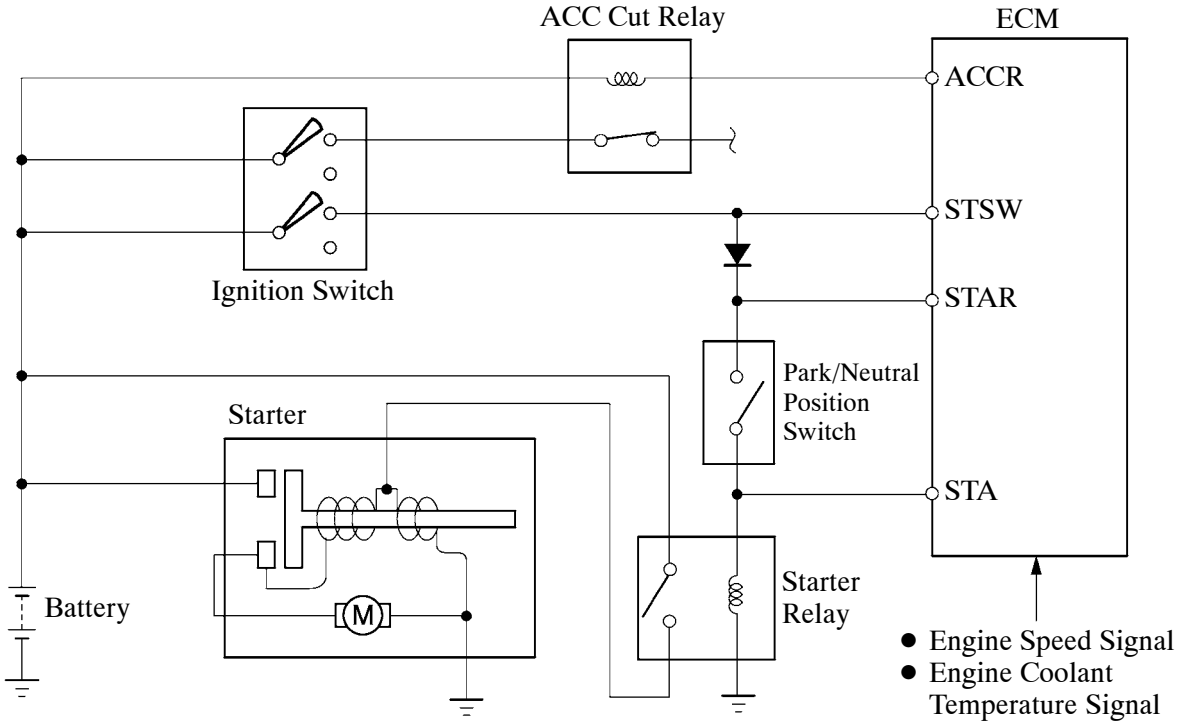
Condition	AIRP	AIRV	Output (Duty Cycle Signal)
Open circuit in line between AIDI and DI terminals.	—	—	GND 273GX28
Failure in line between ECM terminals and air injection control driver.	—	—	GND 273GX29
Output failure at air injection control driver. (Failure in electric air pump actuation circuit)	—	—	200 ms GND 273GX30
Output failure at air injection control driver. (Failure in air switching valve actuation circuit)	—	—	GND 273GX31
Overheat failure of air injection control driver.	—	—	GND 273GX32
Normal	ON	ON	GND 273GX33
	OFF	OFF	GND 273GX29
	ON	OFF	
	OFF	ON	

11. Starter Control (Cranking Hold Function)

General

- Once the ignition switch is turned to the START position, this control continues to operate the starter until the engine starts, without having to hold the ignition switch in the START position. This prevents starting failures.
- When the ECM detects a start signal from the ignition switch, this system monitors the engine speed (NE) signal and continues to operate the starter until it determines that the engine has started.

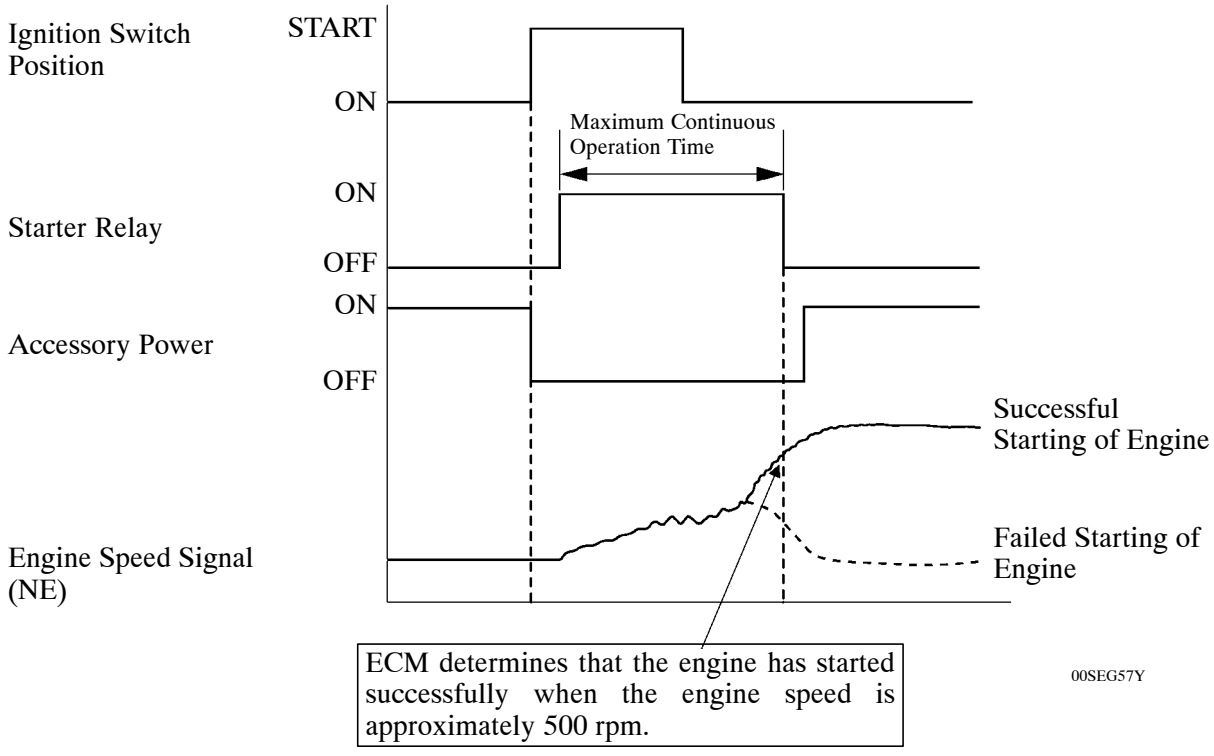
▶ System Diagram ◀



Operation

- As indicated in the following timing chart, when the ECM detects a start signal from the ignition switch, it energizes the starter relay to operate the starter. If the engine is already running, the ECM will not energize the starter relay.
- After the starter operates and the engine speed becomes higher than approximately 500 rpm, the ECM determines that the engine has started and stops the operation of the starter.
- If the engine has any failure and does not work, the starter operates as long as its maximum continuous operation time and stops automatically. The maximum continuous operation time varies depending on the engine coolant temperature condition.
- This system cuts off the current that powers the accessories while the engine is cranking to prevent the accessory illumination from operating intermittently due to the unstable voltage that is associated with the cranking of the engine.
- This system has the following protections.
  - In case that the starter begins to operate, but cannot detect the engine speed signal, the ECM will stop the starter operation immediately. However, if the ignition switch is held in the START position, the starter continues to operate.

▶ Timing Chart ◀



12. Evaporative Emission Control System

General

The evaporative emission control system prevents the fuel vapors that are created in the fuel tank from being released directly into the atmosphere.
The canister stores the fuel vapors that have been created in the fuel tank.

- The ECM controls the purge VSV in accordance with the driving conditions in order to direct the fuel vapors into the engine, where they are burned.
- In this system, the ECM checks for evaporative emission leaks and outputs DTC (Diagnostic Trouble Code) in the event of a malfunction. An evaporative emission leak check consists of an application of vacuum to the evaporative emissions system and monitoring the system for changes in pressure in order to detect a leakage.
- This system consists of the purge VSV, canister, refueling valve, canister pump module, and ECM.
- An ORVR (On-board Refueling Vapor Recovery) function is provided in the refueling valve.
- The canister pressure sensor has been included to the canister pump module.
- A canister filter has been provided on the fresh air line. This canister filter is maintenance-free.
- The followings are the typical conditions necessary to enable an evaporative emission leak check:

Typical Enabling Condition	● Five hours have elapsed after the engine has been turned OFF* ● Altitude: Below 2400 m (8000 feet) ● Battery Voltage: 10.5 V or more ● Power Source: OFF ● Engine Coolant Temperature: 4.4 to 35°C (40 to 95°F) ● Intake Air Temperature: 4.4 to 35°C (40 to 95°F)

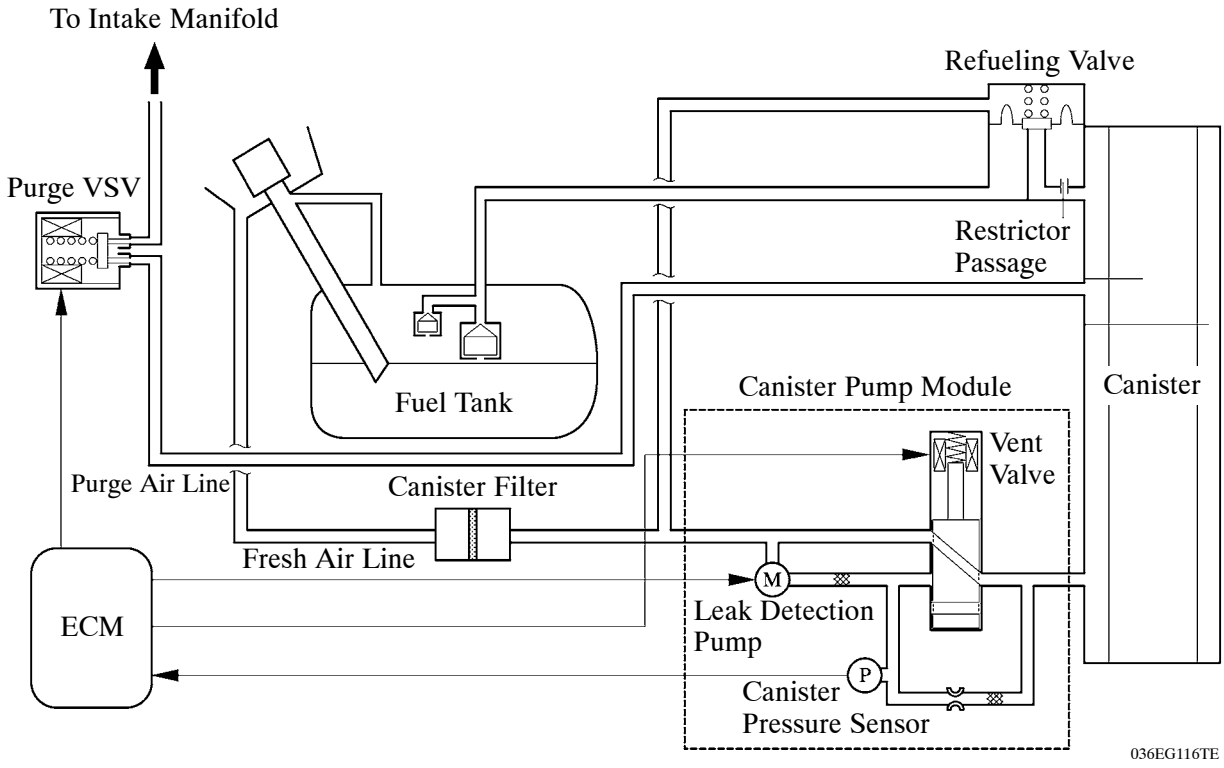
*: If engine coolant temperature does not drop below 35°C (95°F), this time should be extended to 7 hours. Even after that, if the temperature is not less than 35°C (95°F), the time should be extended to 9.5 hours.

Service Tip

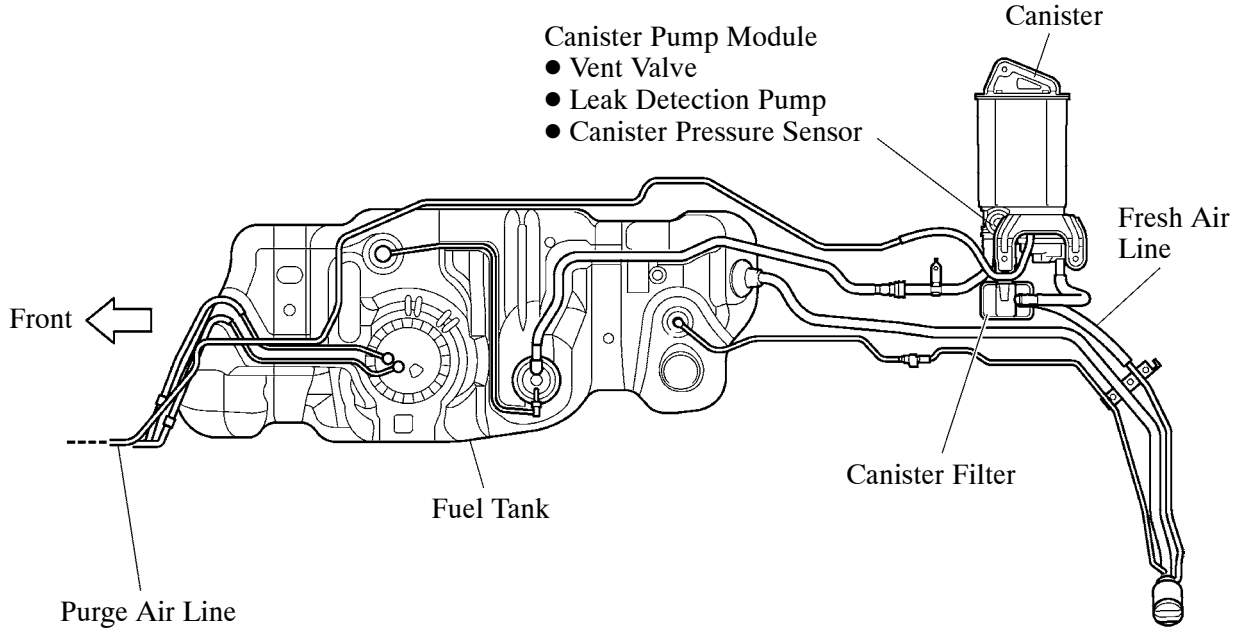
The canister pump module performs a fuel evaporative emission leakage check. This check is done approximately five hours after the engine is turned off. Sound may be heard coming from underneath the luggage compartment for several minutes. This does not indicate a malfunction.

- Pinpoint pressure test procedure is used by pressurizing the fresh air line that runs from the canister pump module to the air filler neck. For details, refer to the 2008 Sequoia Repair Manual (Pub. No. RM08L0U).

System Diagram



Layout of Main Components



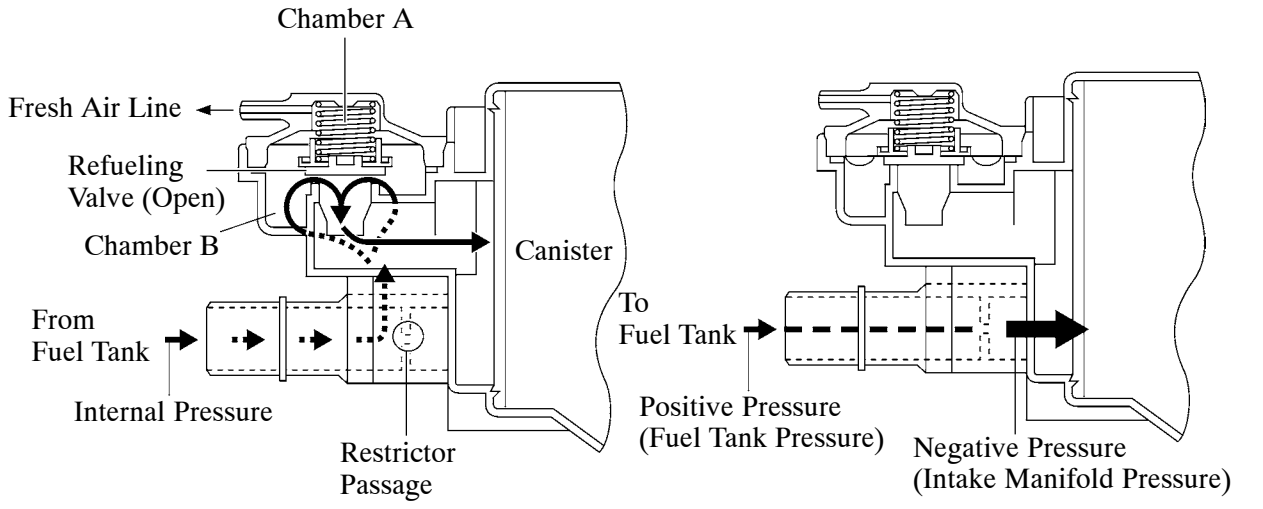
Function of Main Components

Component		Function
Canister		Contains activated charcoal to absorb the fuel vapors that are created in the fuel tank.
Refueling Valve		Controls the flow rate of the fuel vapors from the fuel tank to the canister when the system is purging or during refueling.
	Restrictor Passage	Prevents a large amount of vacuum during purge operation or system monitoring operation from affecting the pressure in the fuel tank.
Fresh Air Line		Fresh air goes into the canister and the cleaned drain air goes out into the atmosphere.
Canister Pump Module	Vent Valve	Opens and closes the fresh air line in accordance with the signals from the ECM.
	Leak Detection Pump	Applies vacuum pressure to the evaporative emission system in accordance with the signals from the ECM.
	Canister Pressure Sensor	Detects the pressure in the evaporative emission system and sends the signals to the ECM.
Purge VSV		Opens in accordance with the signals from the ECM when the system is purging, in order to send the fuel vapors that were absorbed by the canister into the intake manifold. In system monitoring mode, this valve controls the introduction of the vacuum into the fuel tank.
Canister Filter		Prevents dust and debris in the fresh air from entering the system.
ECM		Controls the canister pump module and the purge VSV in accordance with the signals from various sensors, in order to achieve a purge volume that suits the driving conditions. In addition, the ECM monitors the system for any leakage and outputs a DTC if a malfunction is found.

Construction and Operation

1) Refueling Valve

- The refueling valve consists of chamber A, chamber B, and the restrictor passage. A constant atmospheric pressure is applied to chamber A.
- During refueling, the internal pressure of the fuel tank increases. This pressure causes the refueling valve to lift up, allowing the fuel vapors to enter the canister.
- The restrictor passage prevents the large amount of vacuum that is created during purge operation or system monitoring operation from entering the fuel tank, and limits the flow of the fuel vapors from the fuel tank to the canister. If a large volume of fuel vapors enters the intake manifold, it will affect the air-fuel ratio control of the engine. Therefore, the role of the restrictor passage is to help prevent this from occurring.



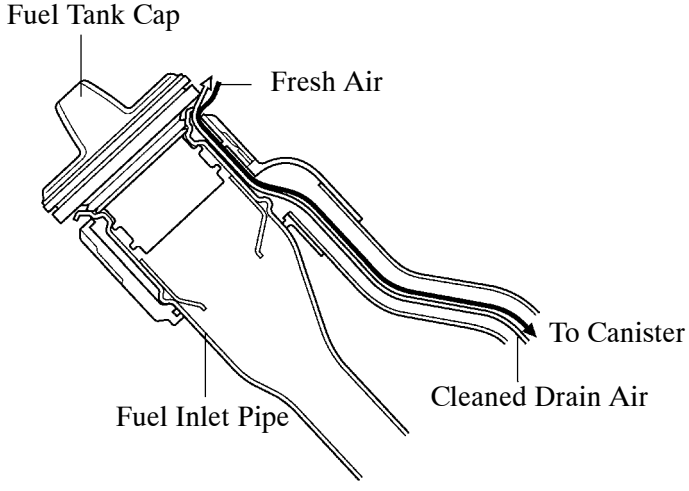
During Refueling

During Purge Operation or System Monitoring Operation

030LS05C

2) Fuel Inlet (Fresh Air Inlet)

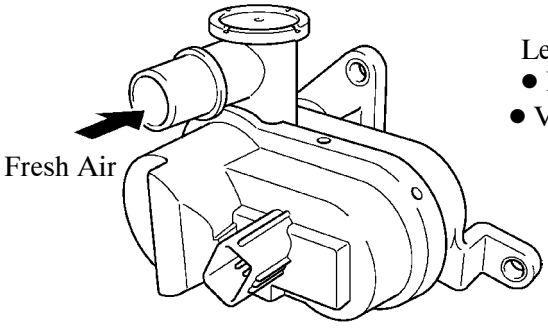
In accordance with the change of structure of the evaporative emission control system, the location of the fresh air line inlet has been changed from the air cleaner to the near the fuel inlet. The fresh air from the atmosphere and drain air cleaned by the canister will go in or out of the system through the passages shown below.



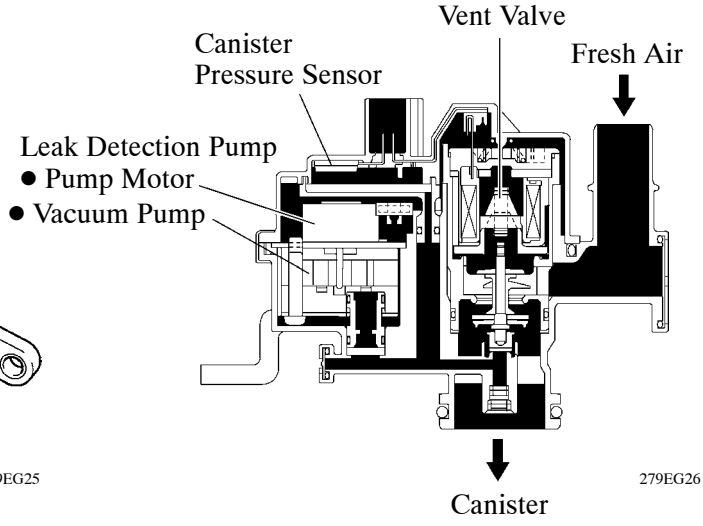
228TU119

3) Canister Pump Module

- The canister pump module consists of the vent valve, canister pressure sensor, and leak detection pump (vacuum pump and pump motor).
- The vent valve switches the passages in accordance with the signals received from the ECM.
- A brushless type DC motor is used for the pump motor.
- A vane type vacuum pump is used.

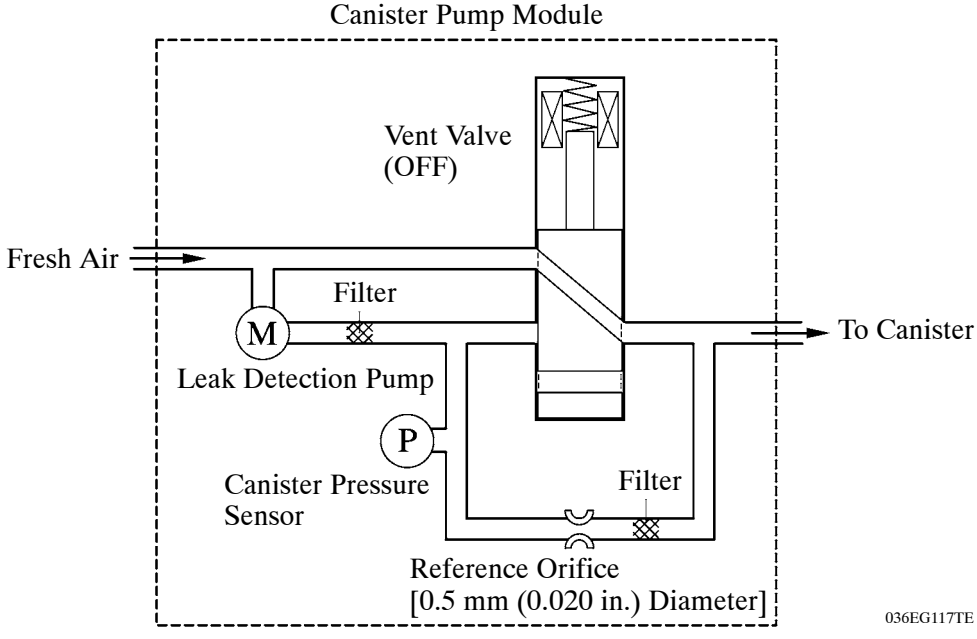


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279EG26

▶ Simple Diagram ◀



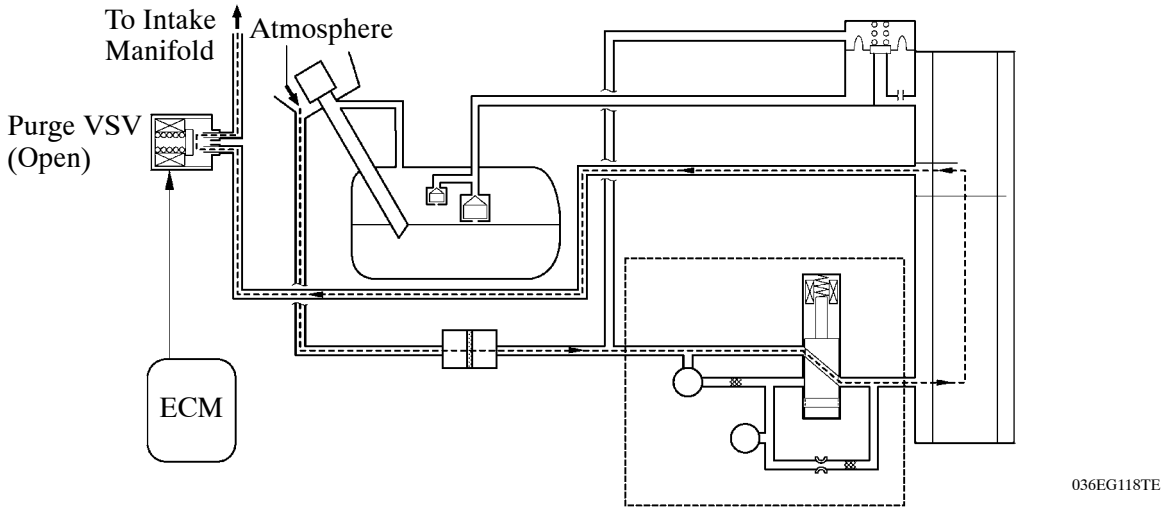
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System Operation

4) Purge Flow Control

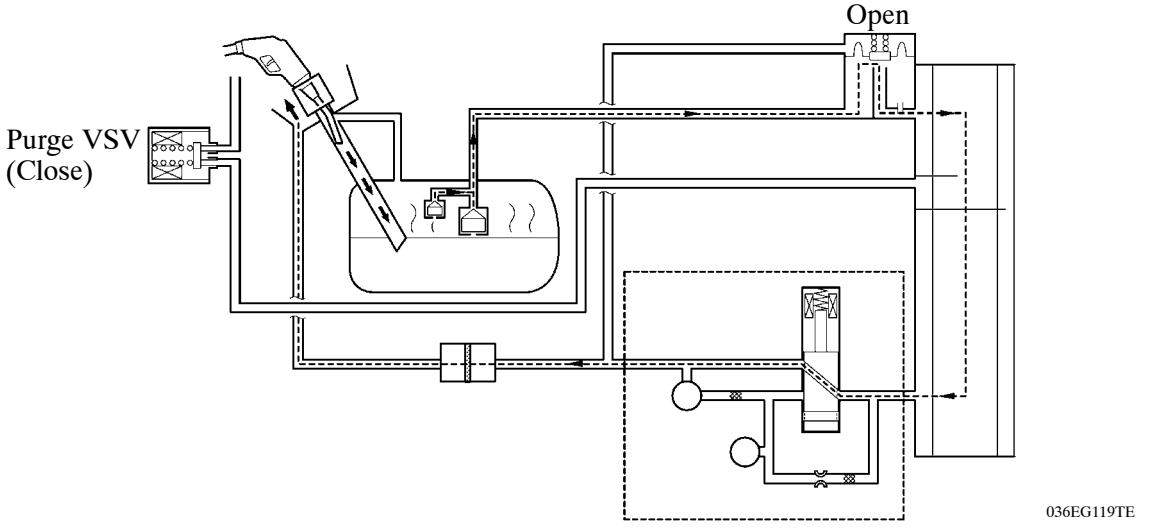
When the engine has reached predetermined parameters (closed loop, engine coolant temp. above 80°C (176°F), etc.), stored fuel vapors are purged from the canister whenever the purge VSV is opened by the ECM.

The ECM will change the duty ratio cycle of the purge VSV, thus controlling purge flow volume. Purge flow volume is determined by intake manifold pressure and the duty ratio cycle of the purge VSV. Atmospheric pressure is allowed into the canister to ensure that purge flow is constantly maintained whenever purge vacuum is applied to the canister.



5) ORVR (On-board Refueling Vapor Recovery)

When the internal pressure of the fuel tank increases during refueling, this pressure causes the diaphragm in the refueling valve to lift up, allowing the fuel vapors to enter the canister. The air that has had the fuel vapors removed from it will be discharged through the fresh air line. The vent valve is used to open and close the fresh air line, and it is always open (even when the engine is stopped) except when the vehicle is in monitoring mode (the valve will be open as long as the vehicle is not in monitoring mode). If the vehicle is refueled in system monitoring mode, the ECM will recognize the refueling by way of the canister pressure sensor, which detects the sudden pressure increase in the fuel tank, and the ECM will open the vent valve.

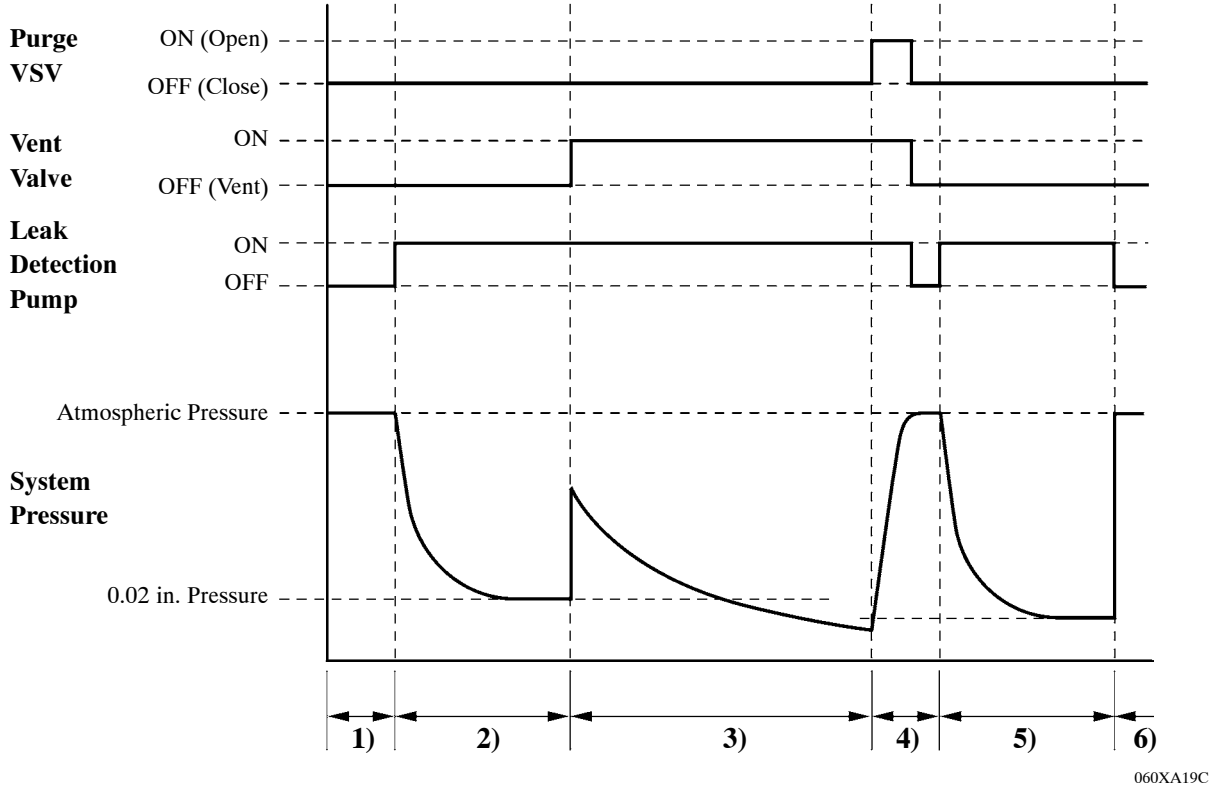


6) EVAP Leak Check

a. General

The EVAP leak check operates in accordance with the following timing chart:

▶ Timing Chart ◀

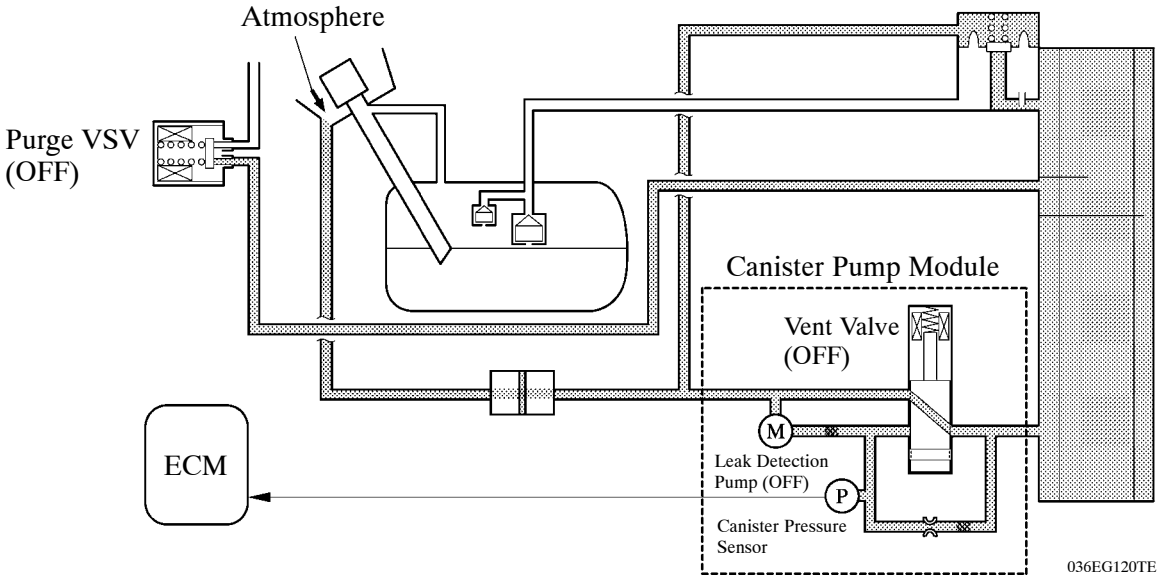


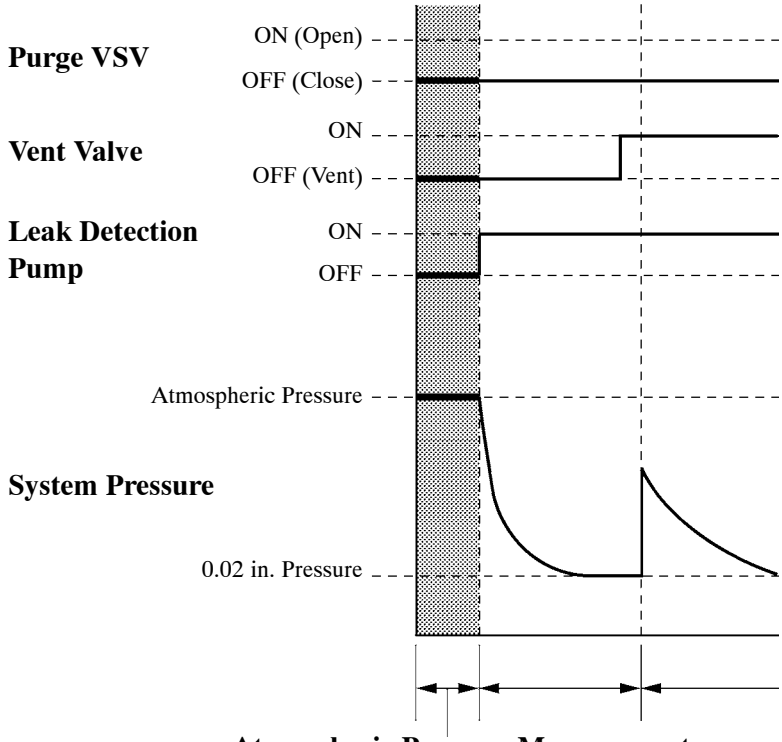
060XA19C

Order	Operation	Description	Time
1)	Atmospheric Pressure Measurement	The ECM turns the vent valve OFF (vent) and measures EVAP system pressure to memorize the atmospheric pressure.	—
2)	0.02 in. Leak Pressure Measurement	The leak detection pump creates negative pressure (vacuum) through a 0.02 in. orifice and the pressure is measured. The ECM determines this as the 0.02 in. leak pressure.	20 sec.
3)	EVAP Leak Check	The leak detection pump creates negative pressure (vacuum) in the EVAP system and the EVAP system pressure is measured. If the stabilized pressure is larger than the 0.02 in. leak pressure, ECM determines that the EVAP system has a leak. If the EVAP pressure does not stabilize within 15 minutes, the ECM cancels EVAP monitor.	Within 15 min.
4)	Purge VSV Monitor	The ECM opens the purge VSV and measures the EVAP pressure increase. If the increase is large, the ECM interprets this as normal.	10 sec.
5)	Repeat 0.02 in. Leak Pressure Measurement	The leak detection pump creates negative pressure (vacuum) through the 0.02 in. orifice and the pressure is measured. The ECM determines this as the 0.02 in. leak pressure.	20 sec.
6)	Final Check	The ECM measures the atmospheric pressure and records the monitor result.	—

b. Atmospheric Pressure Measurement

1) When the ignition switch is turned OFF, the purge VSV and the vent valve are turned OFF. Therefore, atmospheric pressure is introduced into the canister.
2) The ECM measures the atmospheric pressure based on the signals provided by the canister pressure sensor.
3) If the measurement value is out of standards, the ECM actuates the leak detection pump in order to monitor the changes in the pressure.

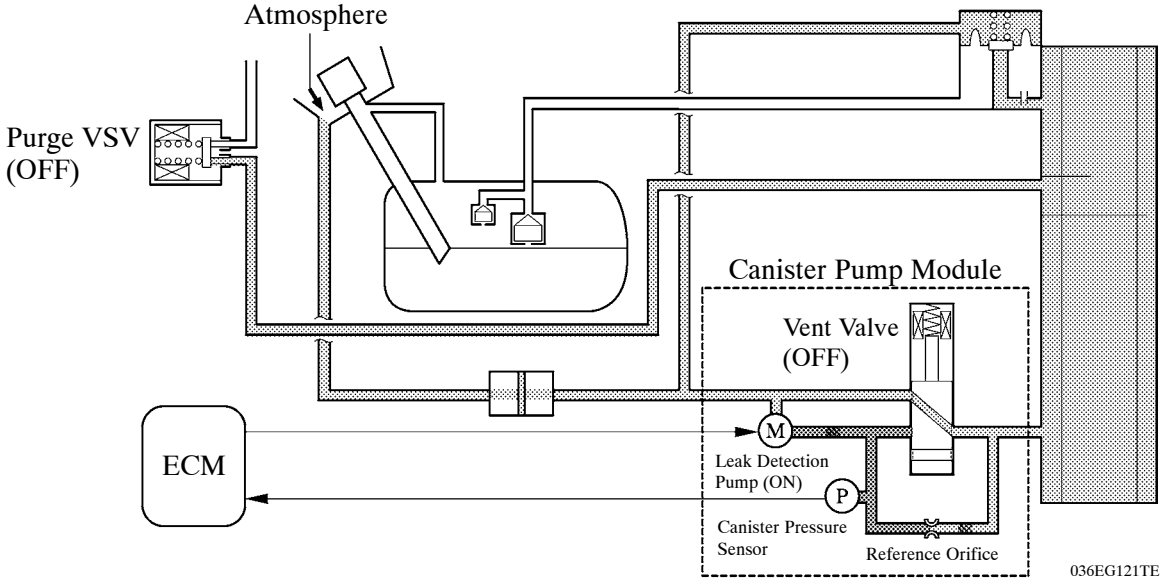


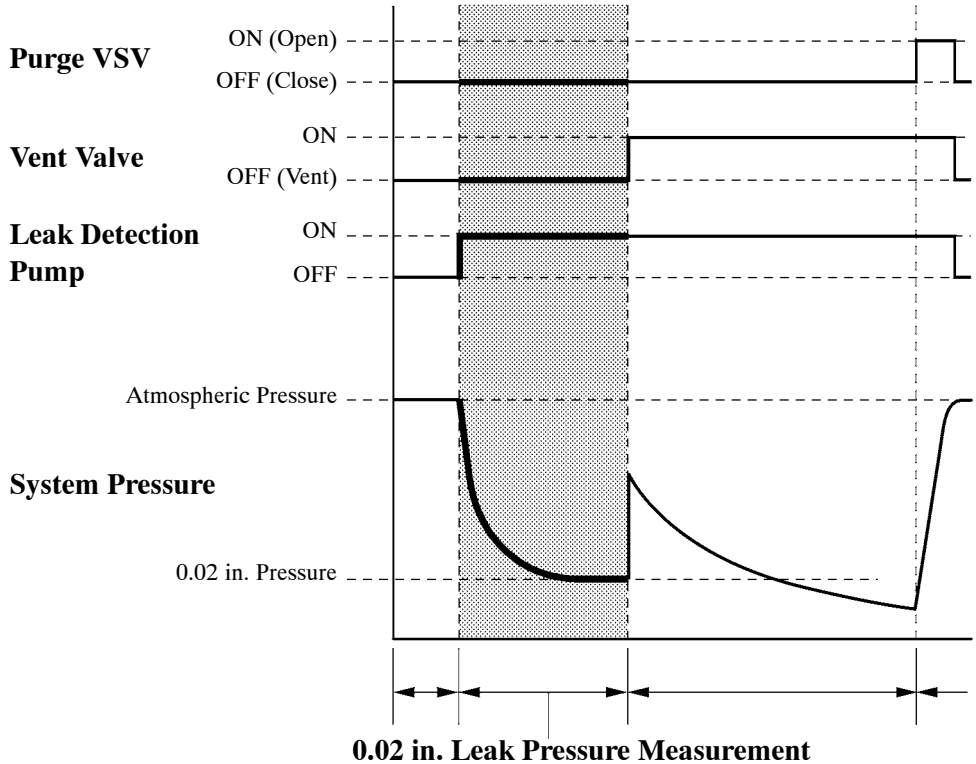


Atmospheric Pressure Measurement

c. 0.02 in. Leak Pressure Measurement

1) The vent valve remains OFF, and the ECM introduces atmospheric pressure into the canister and actuates the leak detection pump in order to create a negative pressure.
2) At this time, the pressure will not decrease beyond a 0.02 in. pressure due to the atmospheric pressure that enters through a 0.02 in. diameter reference orifice.
3) The ECM compares the logic value and this pressure, and stores it as a 0.02 in. leak pressure in its memory.
4) If the measurement value is below the standard, the ECM will determine that the reference orifice is clogged and store DTC P043E in its memory.
5) If the measurement value is above the standard, the ECM will determine that a high flow rate pressure is passing through the reference orifice and store DTC P043F, P2401 and P2402 in its memory.

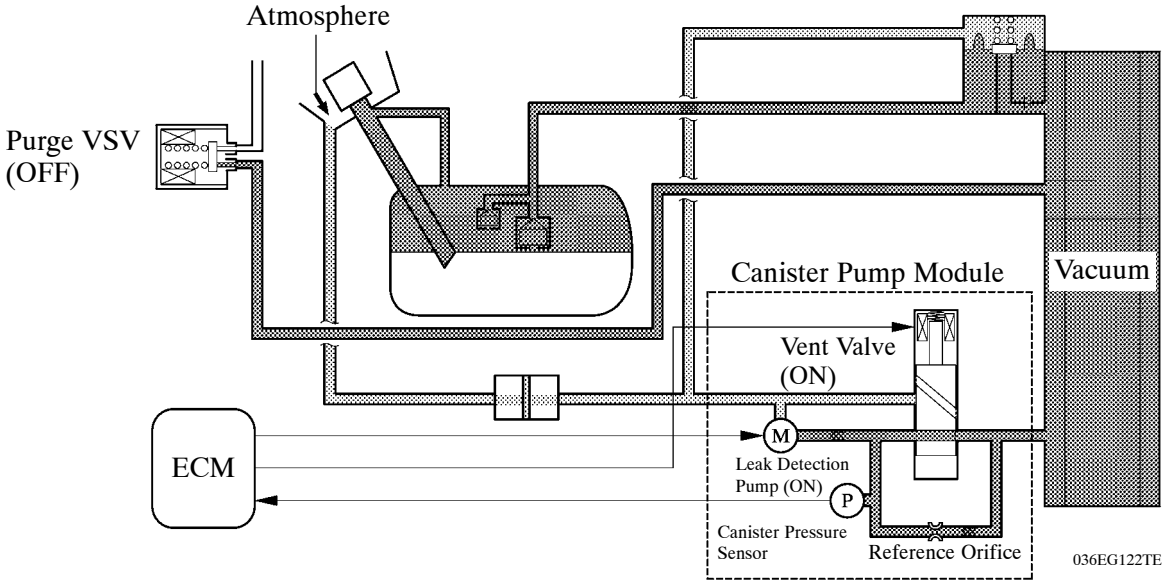


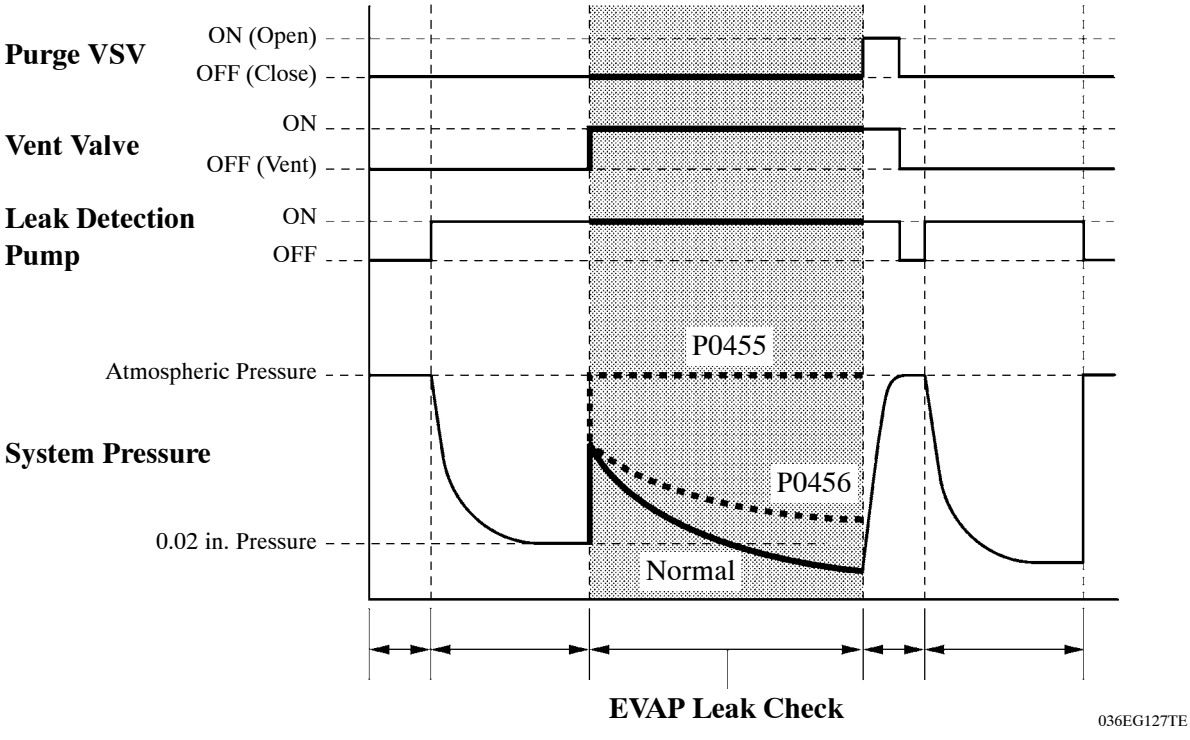


0.02 in. Leak Pressure Measurement 036EG126TE

d. EVAP Leak Check

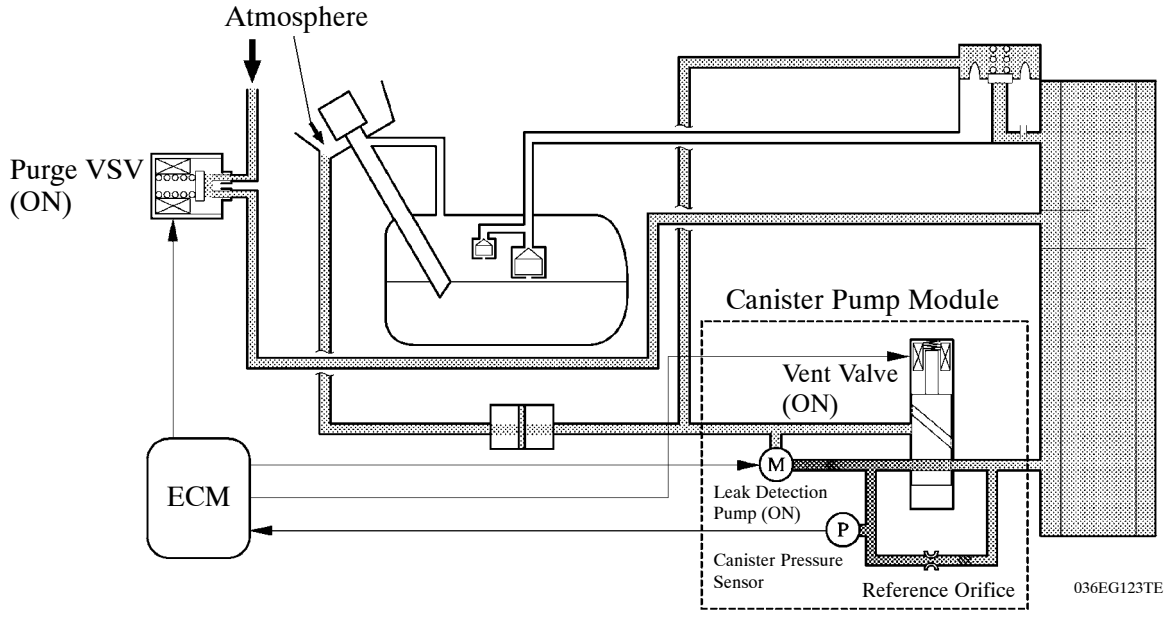
1) While actuating the leak detection pump, the ECM turns ON the vent valve in order to introduce a vacuum into the canister.
2) When the pressure in the system stabilizes, the ECM compares this pressure and the 0.02 in. pressure in order to check for a leakage.
3) If the detection value is below the 0.02 in. pressure, the ECM determines that there is no leakage.
4) If the detection value is above the 0.02 in. pressure and near atmospheric pressure, the ECM determines that there is a gross leakage (large hole) and stores DTC P0455 in its memory.
5) If the detection value is above the 0.02 in. pressure, the ECM determines that there is a small leakage and stores DTC P0456 in its memory.

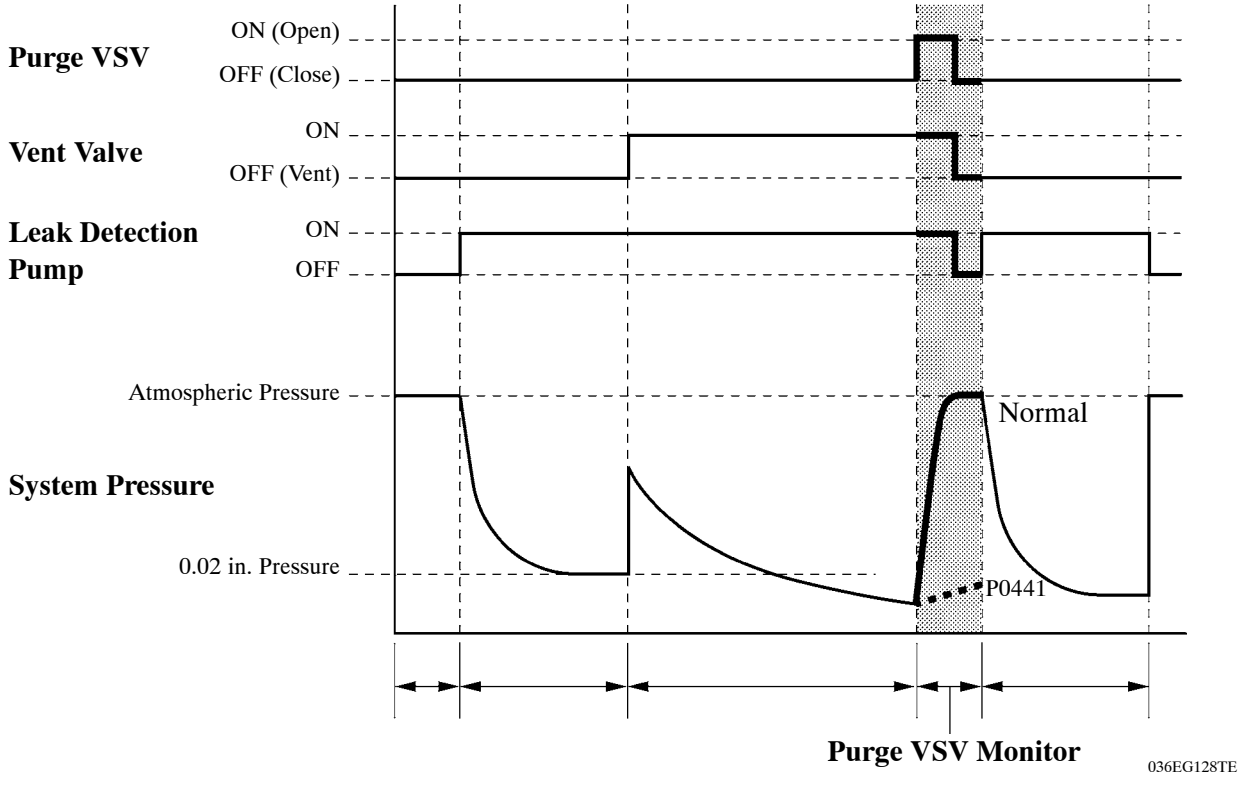




e. Purge VSV Monitor

1) After completing an EVAP leak check, the ECM turns ON the purge VSV with the leak detection pump actuated, and introduces the atmospheric pressure from the intake manifold to the canister.
2) If the pressure change at this time is within the normal range, the ECM determines the condition to be normal.
3) If the pressure is out of the normal range, the ECM will stop the purge VSV monitor and store DTC P0441 in its memory.





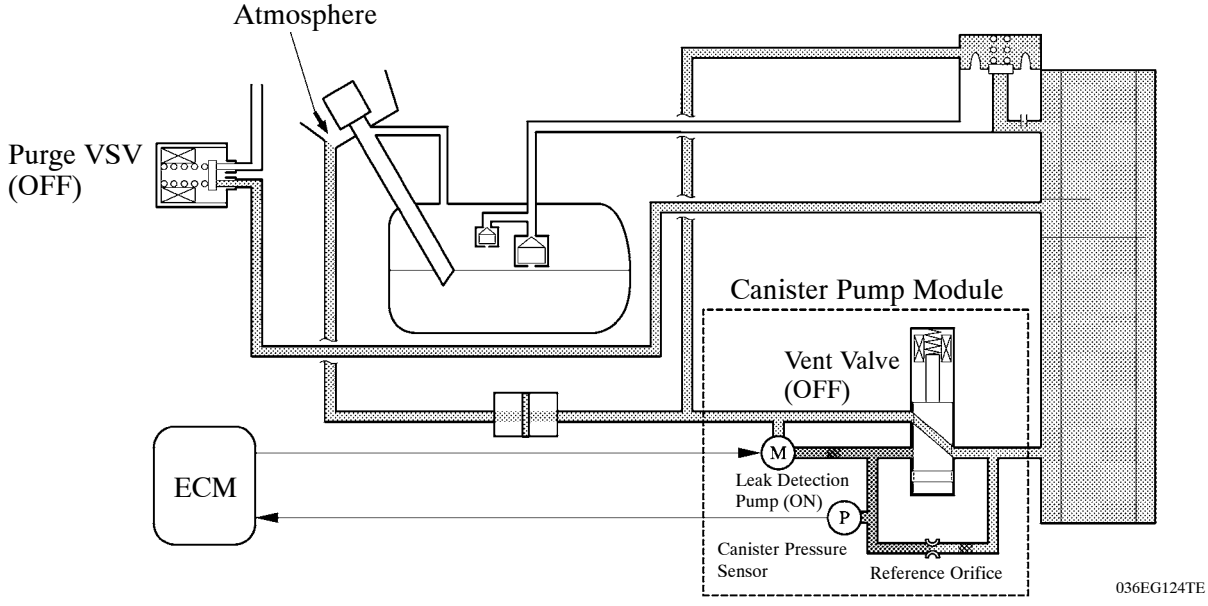
f. Repeat 0.02 in. Leak Pressure Measurement

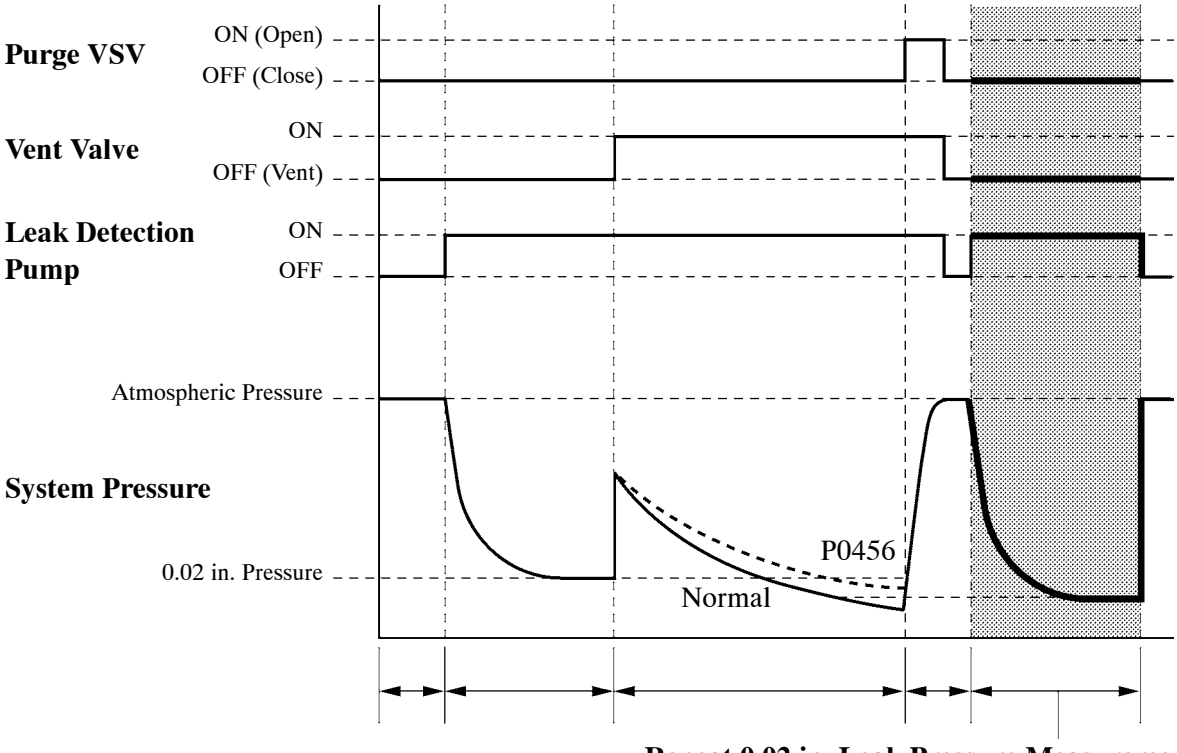
1) While the ECM operates the leak detection pump, the purge VSV and vent valve turn OFF and a repeat 0.02 in. leak pressure measurement is performed.

2) The ECM compares the measured pressure with the pressure during EVAP leak check.

3) If the pressure during the EVAP leak check is below the measured value, the ECM determines that there is no leakage.

4) If the pressure during the EVAP leak check is above the measured value, the ECM determines that there is a small leak and stores DTC P0456 in its memory.





Repeat 0.02 in. Leak Pressure Measurement

036EG129TE

13. Diagnosis

- When the ECM detects a malfunction, the ECM makes a diagnosis and memorizes the failed section. Furthermore, the MIL (Malfunction Indicator Lamp) in the combination meter illuminates or blinks to inform the driver.
- The ECM will also store the DTC (Diagnostic Trouble Code) of the malfunctions. The DTC can be accessed by using the Techstream.
- For details, refer to the 2008 Sequoia Repair Manual (Pub. No. RM08L0U).

Service Tip

To clear the DTC that is stored in the ECM, use the Techstream, disconnect the battery terminal or remove the EFI MAIN fuse and ETCS fuse for 1 minute or longer.

14. Fail-safe

General

When a malfunction is detected at any of the sensors, there is a possibility of an engine or other malfunction occurring if the ECM were to continue to control the engine control system in the normal way. To prevent such a problem, the fail-safe function of the ECM either relies on the data stored in memory to allow the engine control system to continue operating, or stops the engine if a hazard is anticipated. For details, refer to the 2008 Sequoia Repair Manual (Pub. No. RM08L0U).