■ ENGINE CONTROL SYSTEM

1. General

The engine control system of the 2GR-FE engine has the following features. The ECM that controls this system is made by DENSO.

System	Outline
SFI (Sequential Multiport Fuel Injection) [See page EG-64]	An L-type SFI system directly detects the intake air volume with a hot-wire type mass air flow meter.
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 (IGT) ignition signals to the igniters.
ETCS-i (Electronic Throttle Control System-intelligent) [See page EG-65]	Optimally controls the opening angle of the throttle valve in accordance with the accelerator pedal input and the engine and vehicle conditions.
Dual VVT-i (Variable Valve Timing-intelligent) [See page EG-67]	Controls the camshafts (intake) and camshafts (exhaust) to an optimal valve timing in accordance with the engine operating conditions.
ACIS (Acoustic Control Induction System) [See page EG-76]	The intake air passages are switched based on engine speed and throttle valve opening angle to provide high performance in all engine speed ranges.
Air Intake Control System [See page EG-78]	The ECM selects between using one, or using both intake air ducts, in order to choose the option that provides the most appropriate balance of noise reduction and airflow for the engine operating conditions.
Fuel Pump Control [See page EG-79]	• Fuel pump operation is controlled by signals from the ECM. • The fuel pump is stopped when an SRS airbag is deployed in a frontal, side, or rear side collision.
Air Conditioning Cut-off Control	By turning the air conditioning compressor ON or OFF in accordance with the engine conditions, drivability is maintained.
Cooling Fan Control [See page EG-80]	The Cooling Fan ECU steplessly controls the speed of the fans in accordance with the engine coolant temperature, vehicle speed, engine speed, and air conditioning operating conditions. As a result, the cooling performance is improved.
Cranking Hold Function* (Starter Control) [See page EG-82]	Once the engine switch is pushed, this control operates the starter until the engine starts.
Air Fuel Ratio Sensor and Heated Oxygen Sensor Heater Control	Maintains the temperature of the air fuel ratio sensors or heated oxygen sensors at an appropriate level to increase the ability of the sensor to accurately detect oxygen concentration.
Evaporative Emission Control [See page EG-84]	• The ECM controls the purge flow of evaporative emissions (HC) from the charcoal canister assembly in accordance with engine conditions. • Approximately five hours after the ignition switch has been turned OFF, the ECM operates the pump module to check for evaporative emission leakage between the fuel tank assembly and the charcoal canister assembly. The ECM can detect leaks by monitoring for changes in the fuel tank pressure.

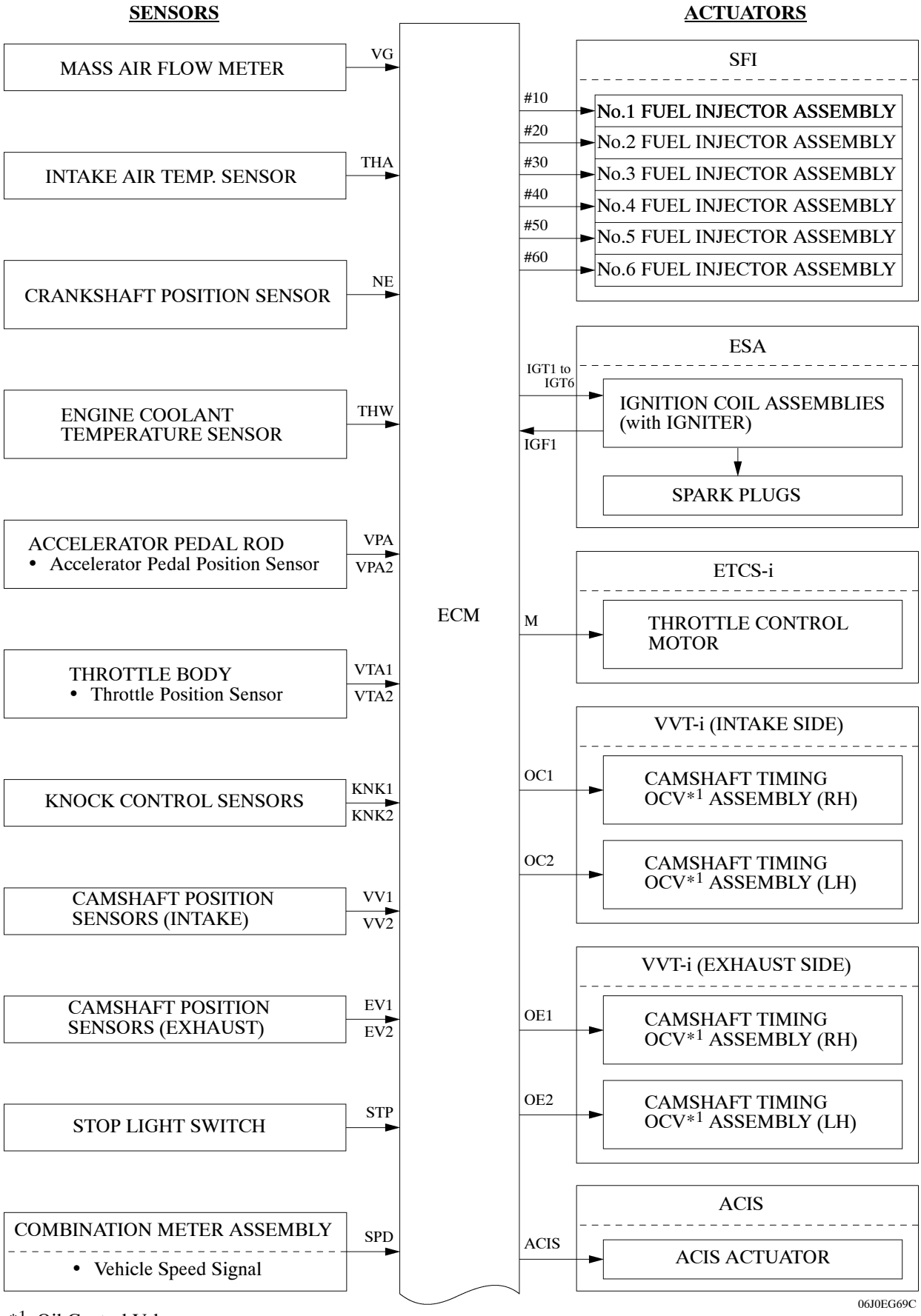
*: Only Models with Smart Key System

(Continued)

System	Outline
Active Control Engine Mount [See page EG-42]	The damping characteristics of the front engine mount are varied to reduce idle vibration.
Engine Immobilizer	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid ignition key.
Diagnosis [See page EG-97]	When the ECM detects a malfunction, the ECM records the malfunction and information that relates to the fault.
Fail-safe [See page EG-97]	When the ECM detects a malfunction, the ECM stops or controls the engine according to the data already stored in the memory.

2. Construction

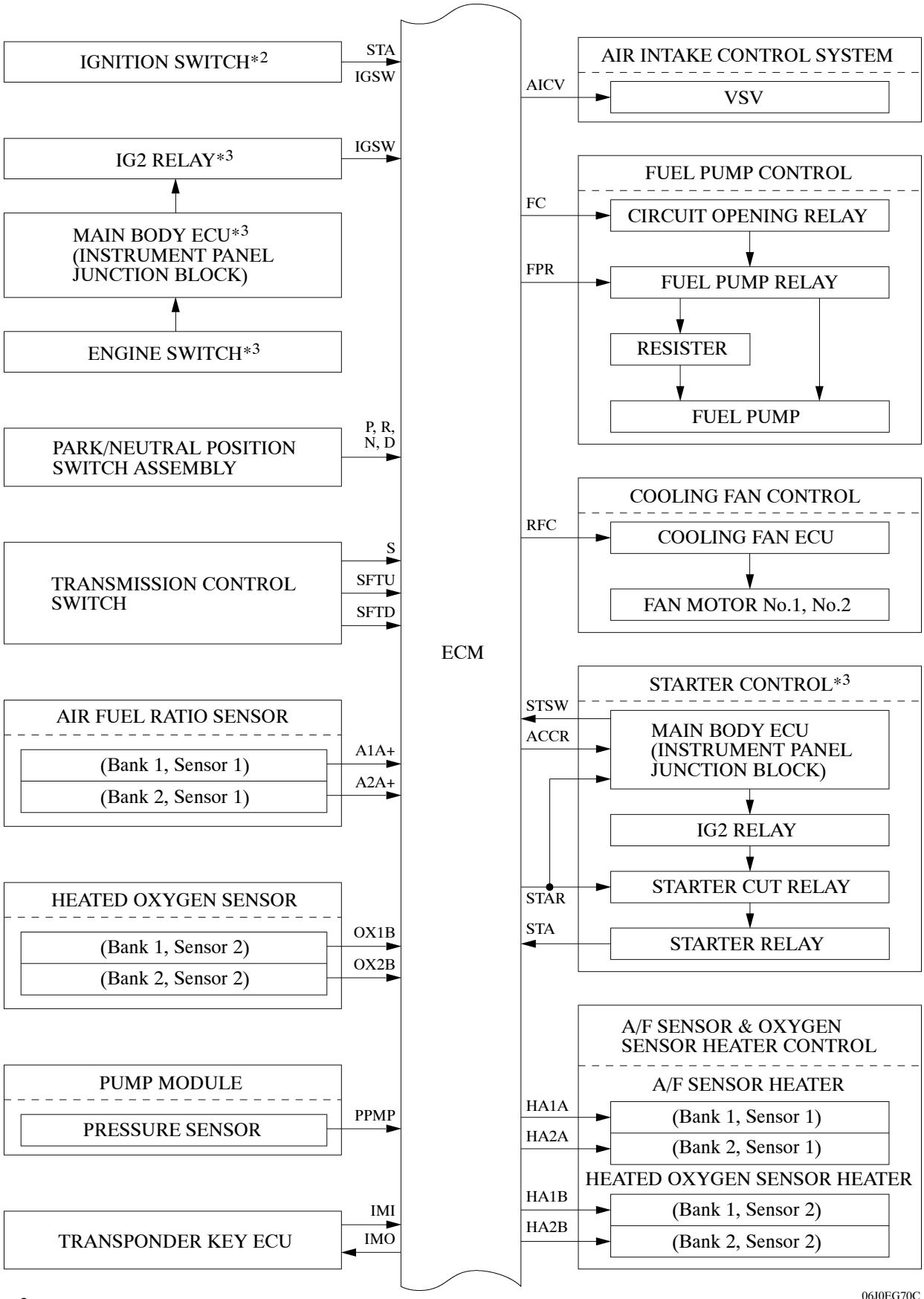
The configuration of the engine control system is as shown in the following chart.



06J0EG69C

*1: Oil Control Valve

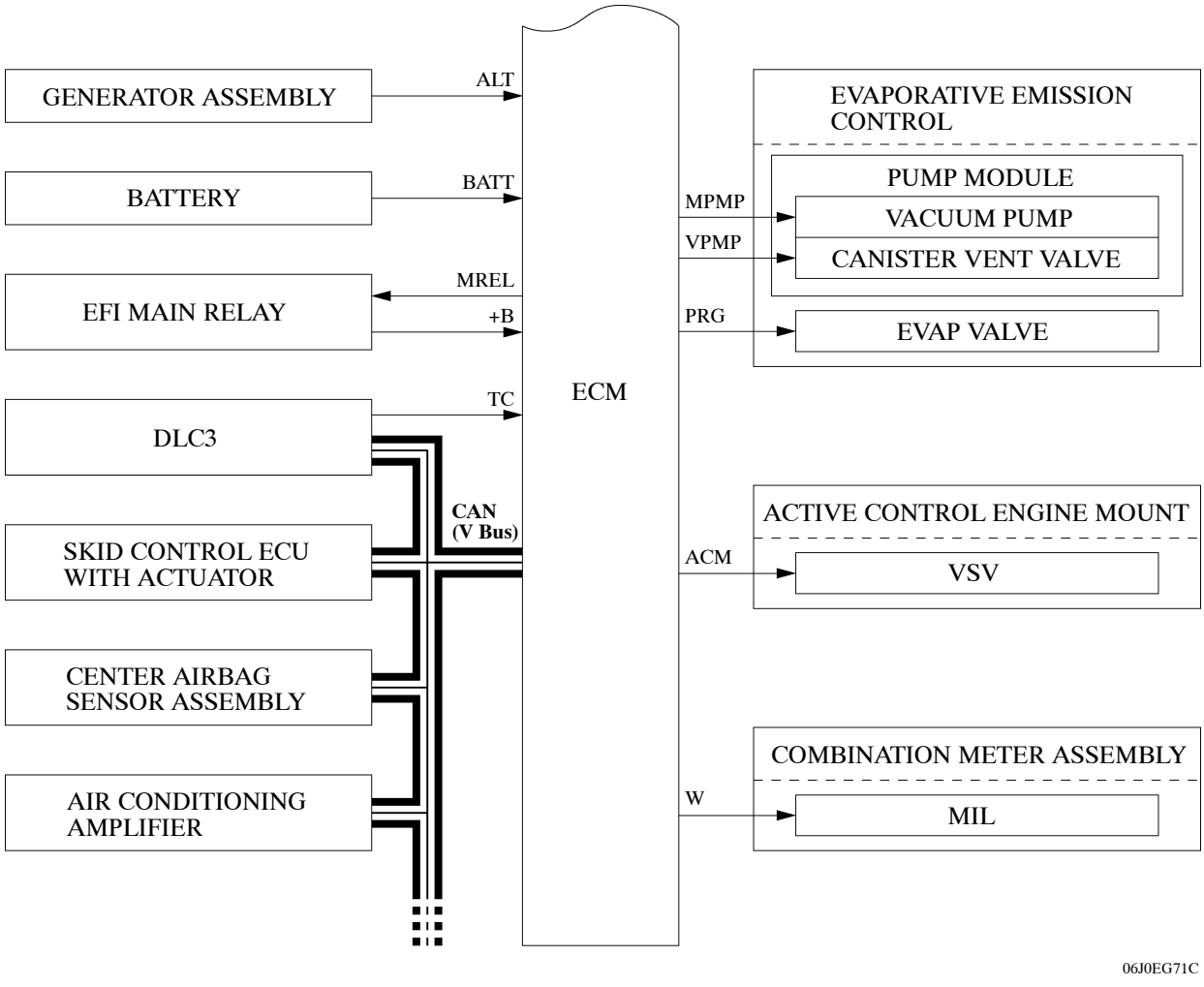
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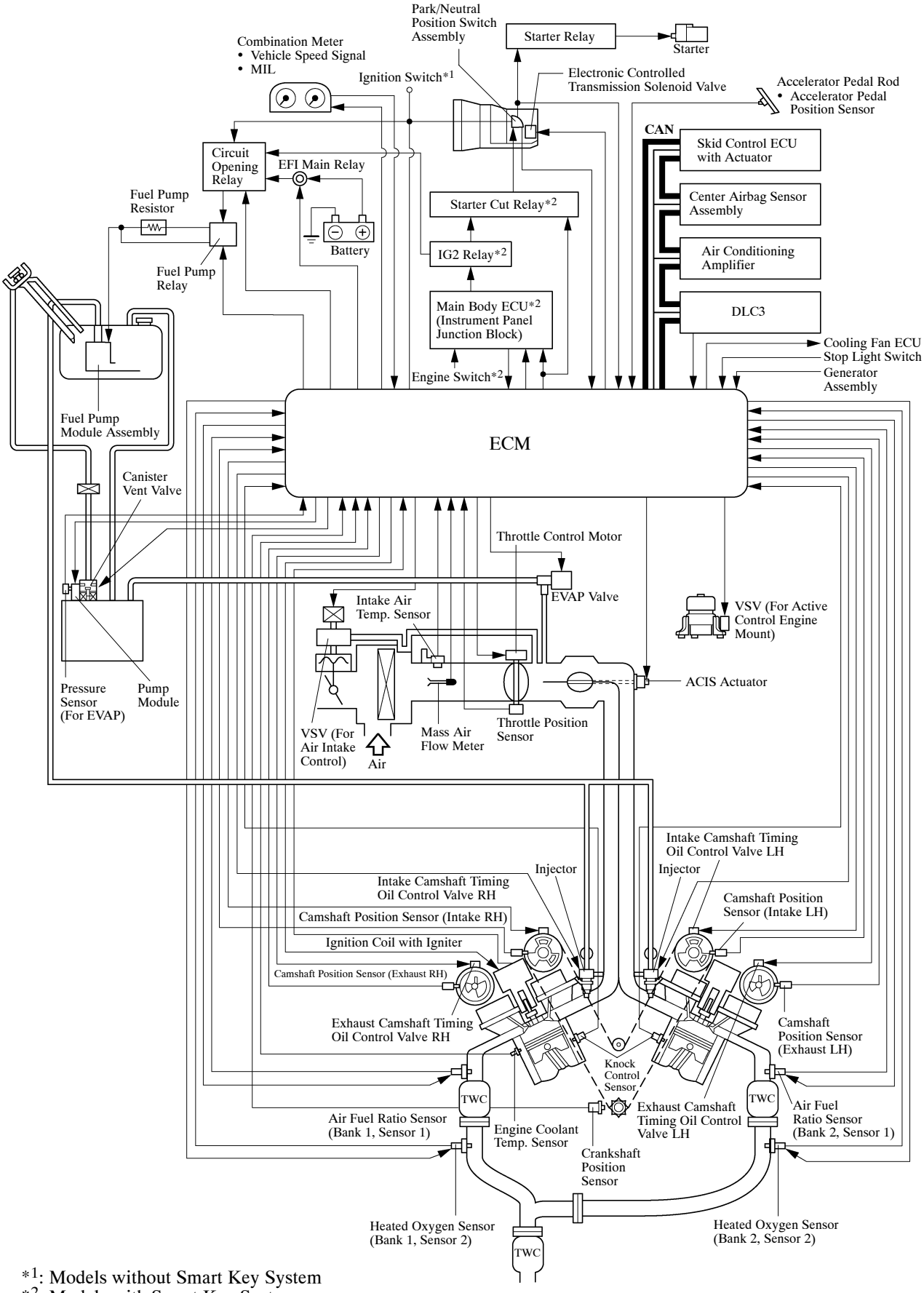
06J0EG70C

*2: Models without Smart Key System
*3: Models with Smart Key System

(Continued)


GENERATOR ASSEMBLY
ALT
BATTERY
BATT
EFI MAIN RELAY
MREL
+B
DLC3
TC
CAN
(V Bus)
SKID CONTROL ECU
WITH ACTUATOR
CENTER AIRBAG
SENSOR ASSEMBLY
AIR CONDITIONING
AMPLIFIER
ECM
EVAPORATIVE EMISSION
CONTROL
PUMP MODULE
VACUUM PUMP
CANISTER VENT VALVE
MPMP
VPMP
PRG
EVAP VALVE
ACTIVE CONTROL ENGINE MOUNT
ACM
VSV
COMBINATION METER ASSEMBLY
W
MIL
06J0EG71C

3. Engine Control System Diagram

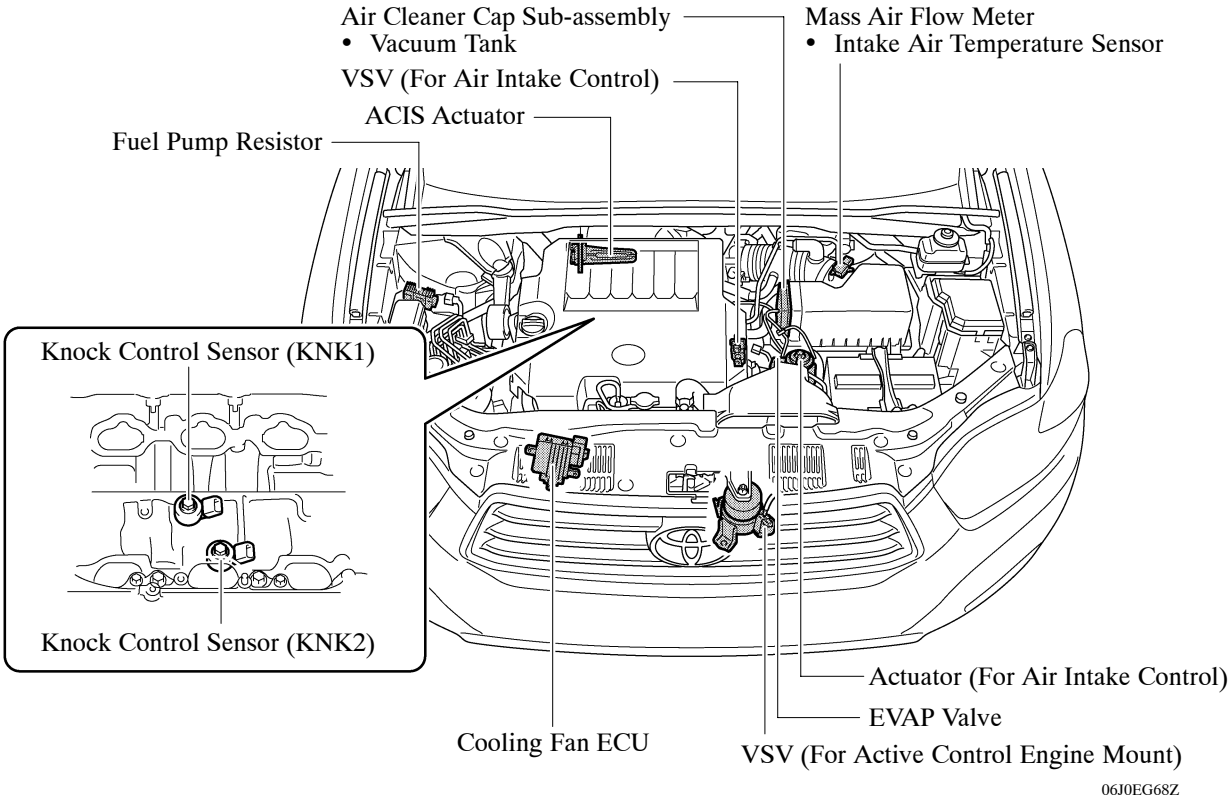


*1: Models without Smart Key System
*2: Models with Smart Key System

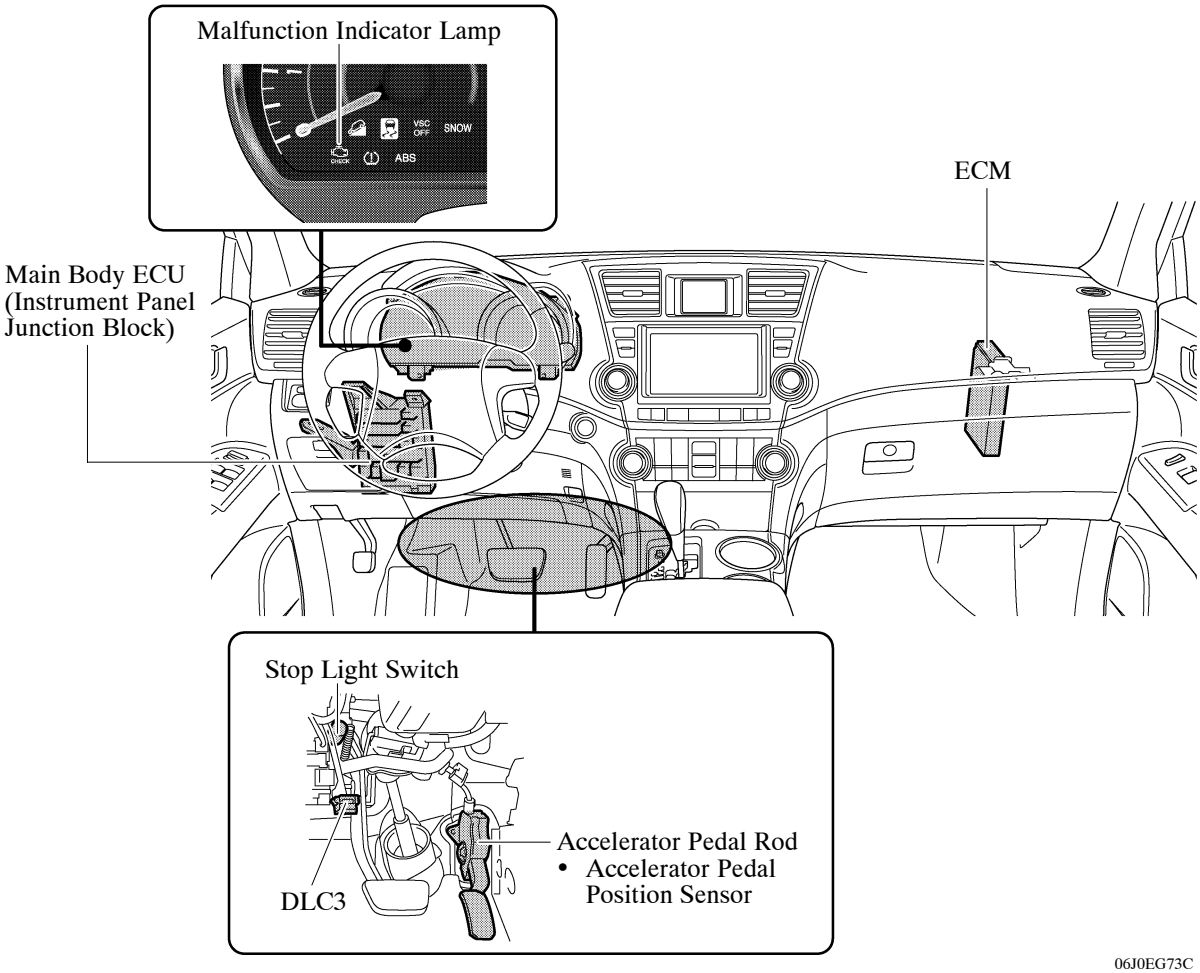
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EG

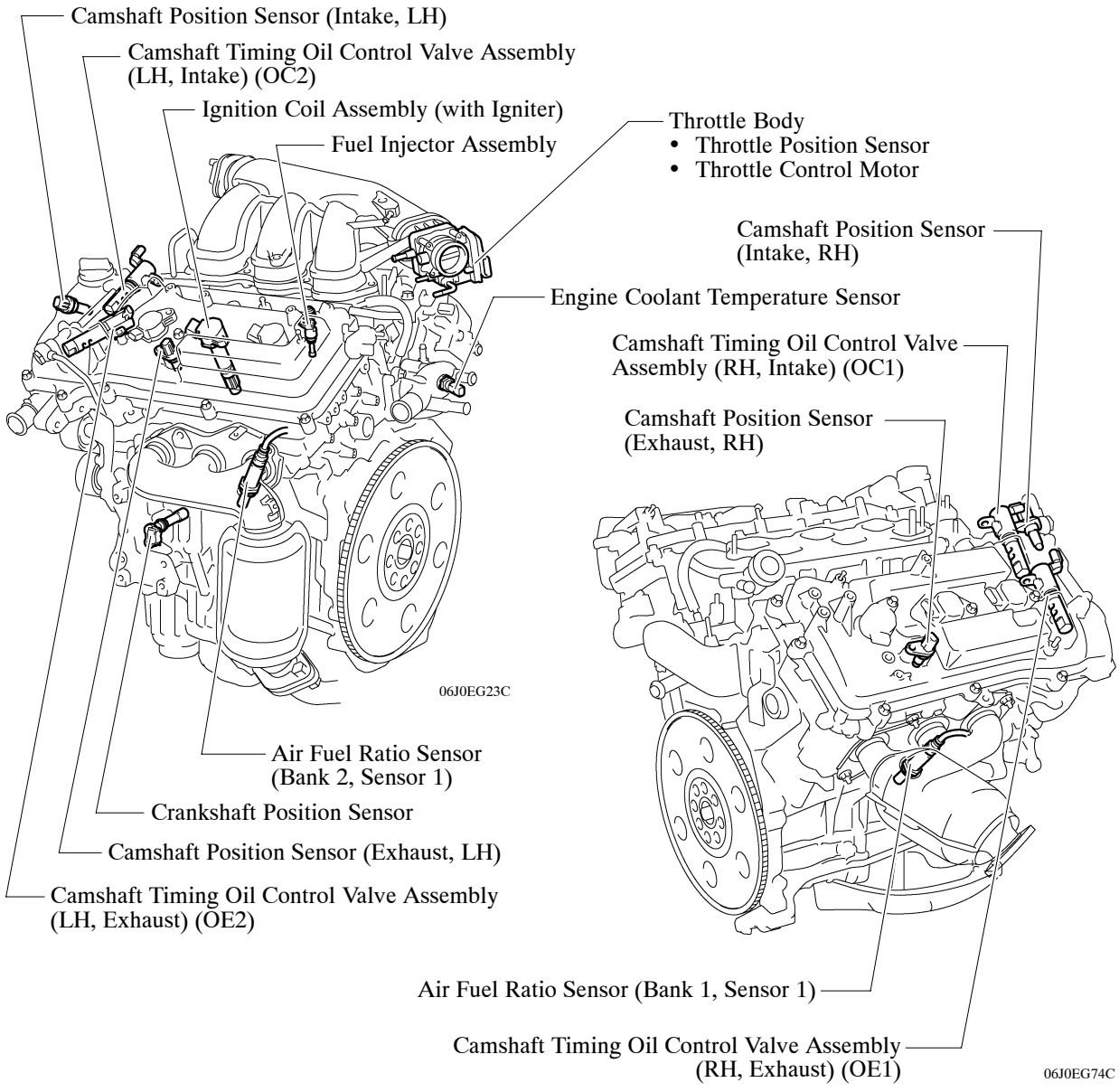
4. Layout of Main Components



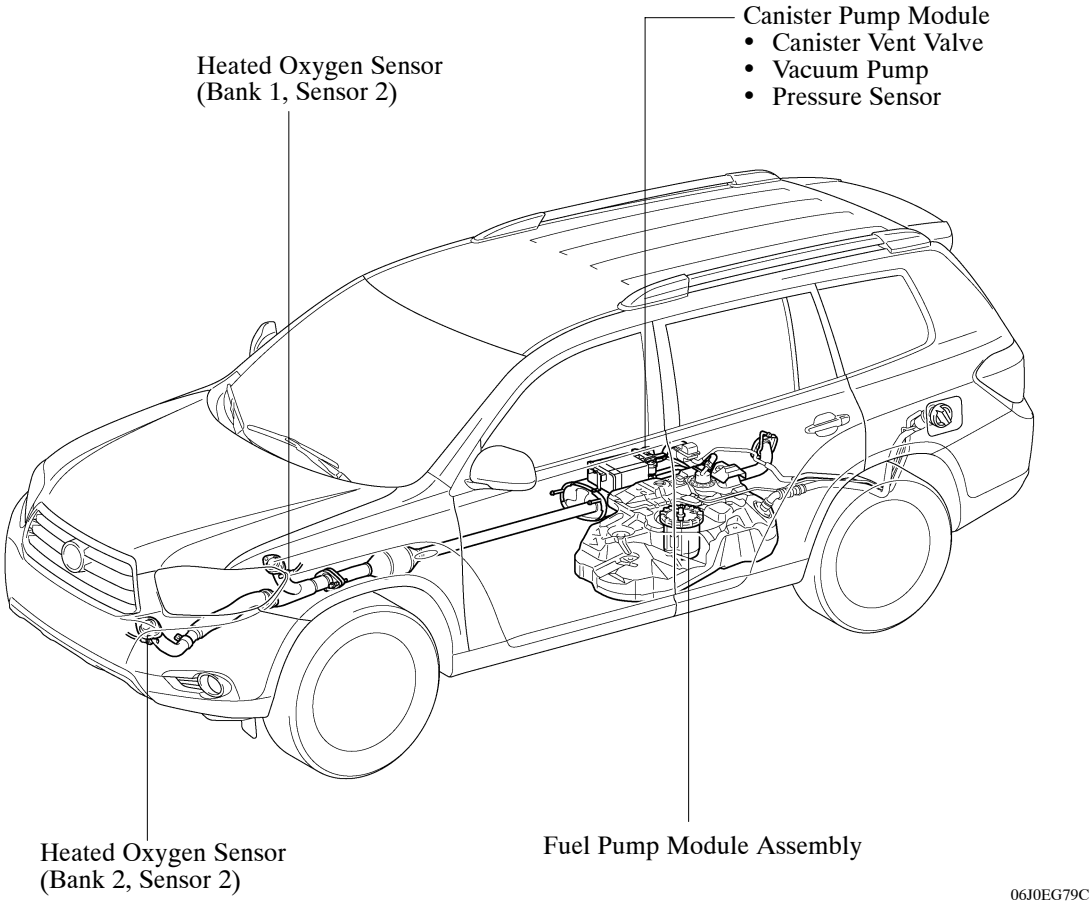
06J0EG68Z



06J0EG73C


Camshaft Position Sensor (Intake, LH)
Camshaft Timing Oil Control Valve Assembly (LH, Intake) (OC2)
Ignition Coil Assembly (with Igniter)
Fuel Injector Assembly
Throttle Body
• Throttle Position Sensor
• Throttle Control Motor
Camshaft Position Sensor (Intake, RH)
Engine Coolant Temperature Sensor
Camshaft Timing Oil Control Valve Assembly (RH, Intake) (OC1)
Camshaft Position Sensor (Exhaust, RH)
06J0EG23C
Air Fuel Ratio Sensor (Bank 2, Sensor 1)
Crankshaft Position Sensor
Camshaft Position Sensor (Exhaust, LH)
Camshaft Timing Oil Control Valve Assembly (LH, Exhaust) (OE2)
Air Fuel Ratio Sensor (Bank 1, Sensor 1)
Camshaft Timing Oil Control Valve Assembly (RH, Exhaust) (OE1)
06J0EG74C

EG


Canister Pump Module
• Canister Vent Valve
• Vacuum Pump
• Pressure Sensor
Heated Oxygen Sensor
(Bank 1, Sensor 2)
Heated Oxygen Sensor
(Bank 2, Sensor 2)
Fuel Pump Module Assembly
06J0EG79C

5. Main Components of Engine Control System

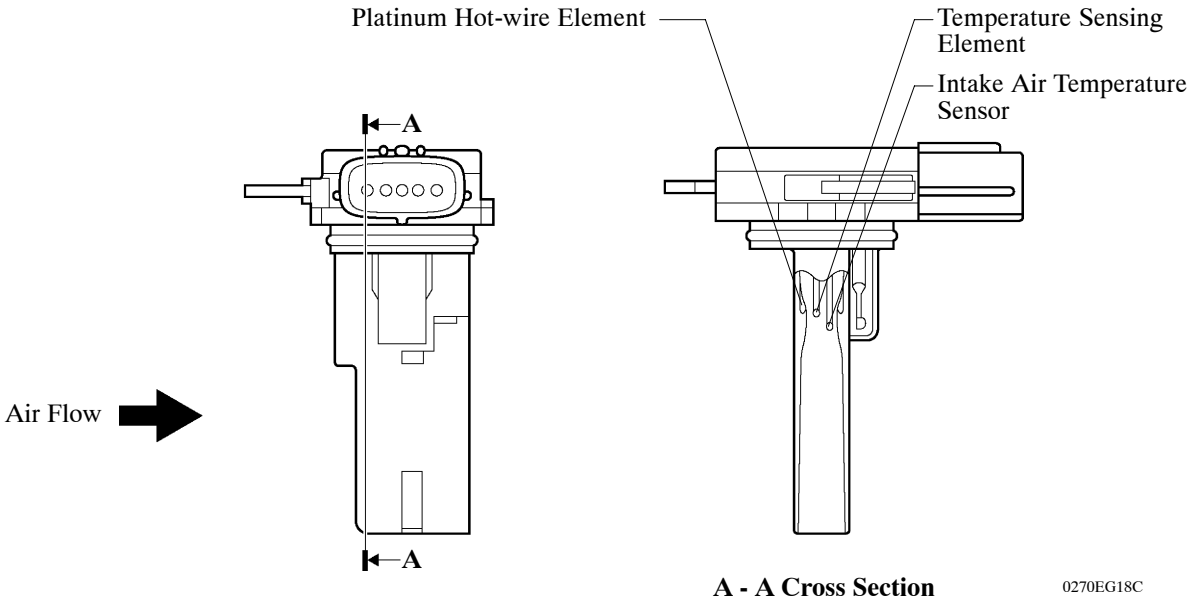
General

The main components of the engine control system are as follows:

Components	Outline	Quantity
ECM	32-bit CPU	1
Mass Air Flow Meter	Hot-wire Type	1
Crankshaft Position Sensor [Rotor Teeth]	Pick-up Coil Type [36 - 2]	1
Camshaft Position Sensor for Intake [Rotor Teeth]	MRE (Magnetic Resistance Element) Type [3]	2 (1 each bank)
Camshaft Position Sensor for Exhaust [Rotor Teeth]	MRE (Magnetic Resistance Element) Type [3]	2 (1 each bank)
Accelerator Pedal Position Sensor	Linear (Non-Contact) Type	1
Throttle Position Sensor	Linear (Non-Contact) Type	1
Knock Control Sensor 1 and 2 (KNK1 and KNK2)	Built-in Piezoelectric Type (Non-resonant Type/Flat Type)	2 (1 each bank)
Air Fuel Ratio Sensor (Bank 1, Sensor 1 and Bank 2, Sensor 1)	Heated Type (Planar Type)	2 (1 each bank)
Heated Oxygen Sensor (Bank 1, Sensor 2 and Bank 2, Sensor 2)	Heated Type (Cup Type)	2 (1 each bank)
Fuel Injector Assembly	12-hole Type	6

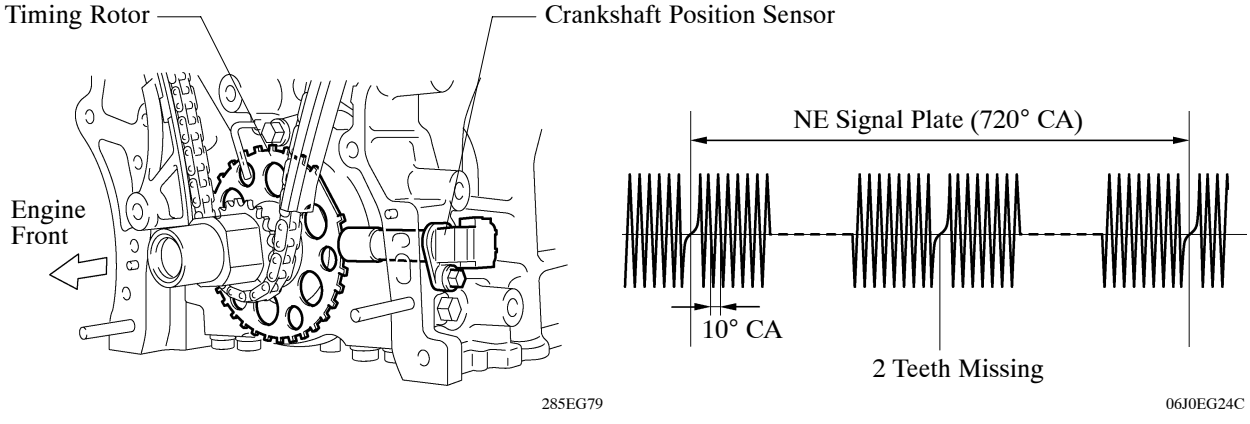
Mass Air Flow Meter

- The 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

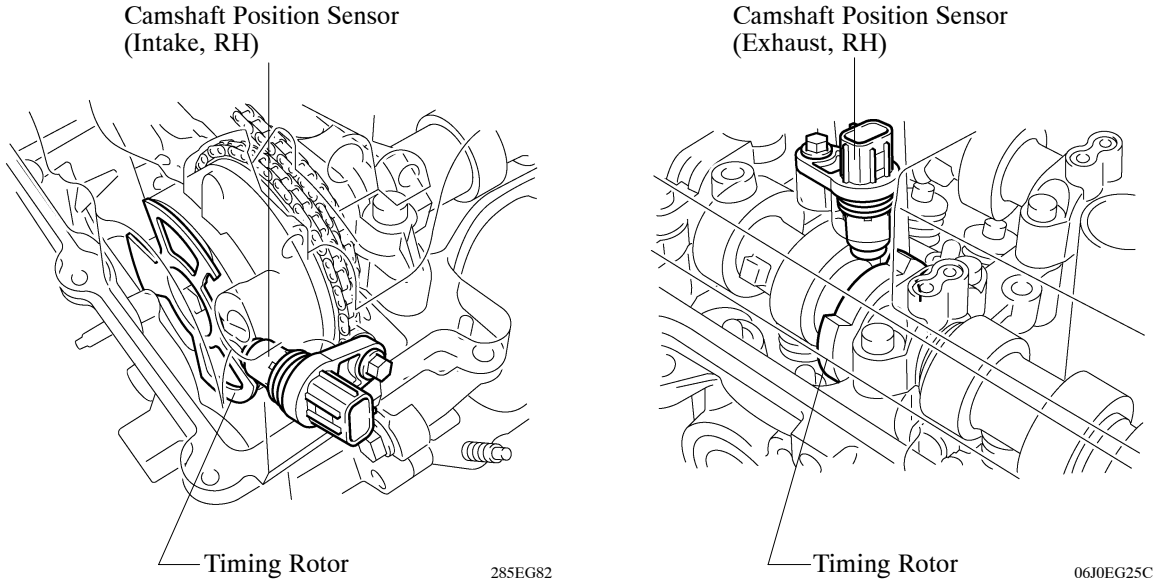
The timing rotor of the crankshaft consists of 34 teeth with 2 teeth missing. The crankshaft position sensor outputs the crankshaft rotation signals every 10°, and the change of the signal due to the missing teeth is used to determine top-dead-center.



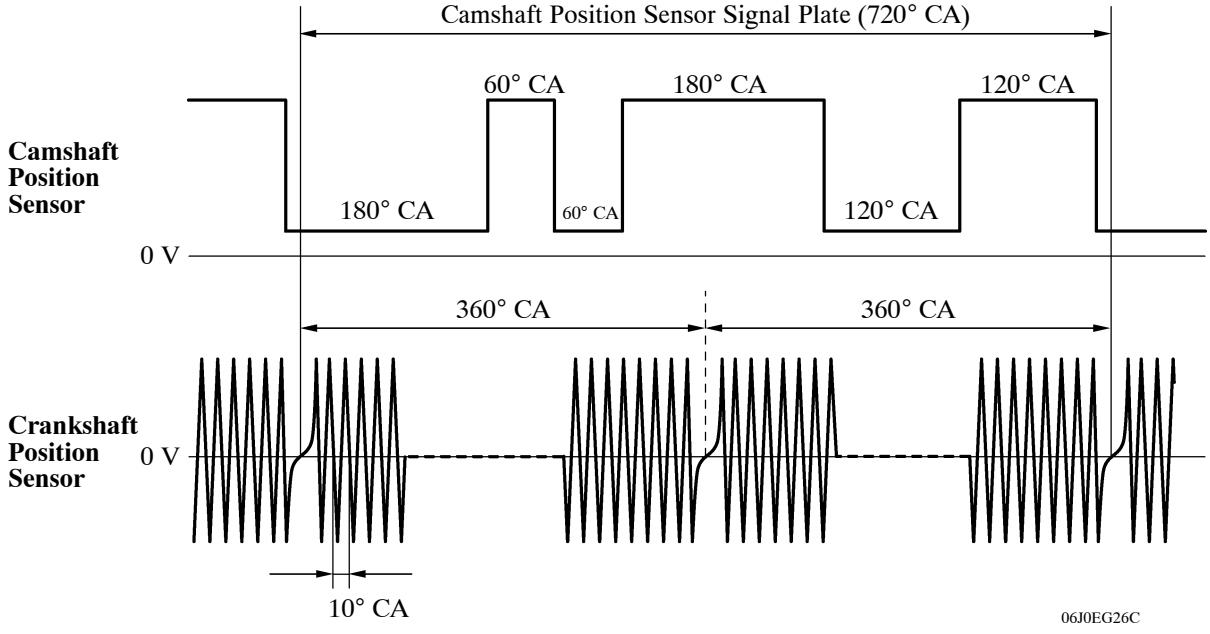
Camshaft Position Sensor

1) General

MRE (Magnetic Resistance Element) type camshaft position sensors (intake and exhaust) are used. To detect each camshaft (intake) position, a timing rotor that is secured to the camshaft (intake) in front of the camshaft timing gear assembly is used to generate 6 (3 Hi Output, 3 Lo Output) pulses for every 2 revolutions of the crankshaft. The timing rotor for each camshaft (exhaust) is part of the respective camshaft.



▶ Sensor Output Waveforms ◀

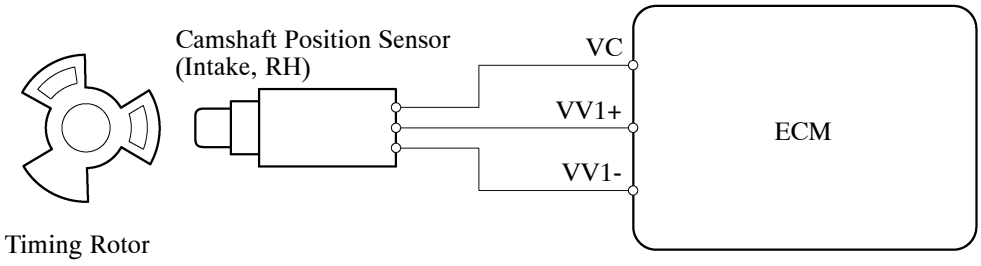


2) MRE Type Camshaft Position Sensor

- An MRE type camshaft position sensor consists of an MRE, a magnet and a sensor. The direction of the magnetic field changes due to the profile (protruding and non-protruding 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 differences between an MRE type camshaft position sensor and a pickup coil type camshaft position sensor used on a conventional model are as follows.

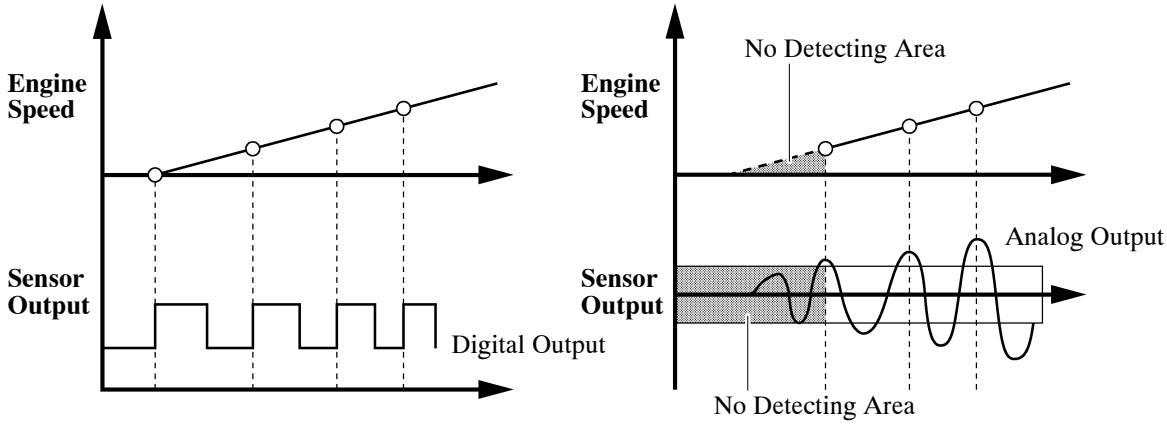
Sensor Type	MRE	Pick-up Coil
Signal Output	Constant digital output starts from low engine speeds.	Analog output changes with the engine speed.
Camshaft Position Detection	Camshaft position detection is made by comparing the NE signal with the Hi/Lo output switch timing of the camshaft position sensor which is due to the protruding/non-protruding portions of the timing rotor. Camshaft detection can also be made based on the number of the NE signals input during a Hi/Lo output.	Detection is made by comparing the NE signals with the change of waveform that is output when the protruding portion of the timing rotor passes.

▶ Wiring Diagram ◀



271EG160

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

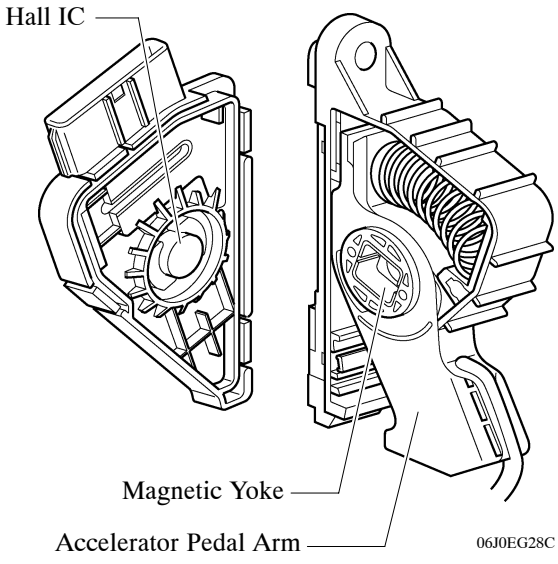


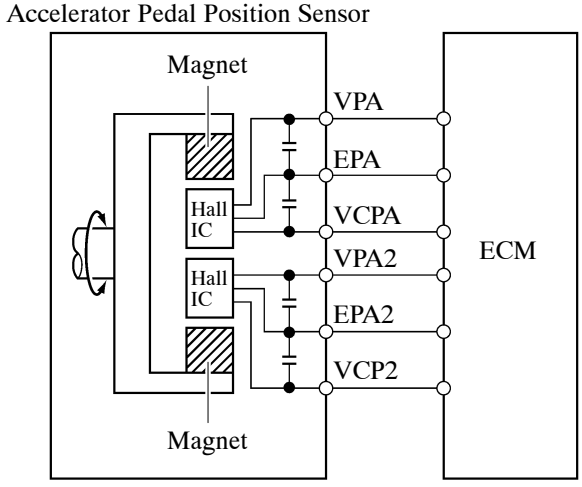
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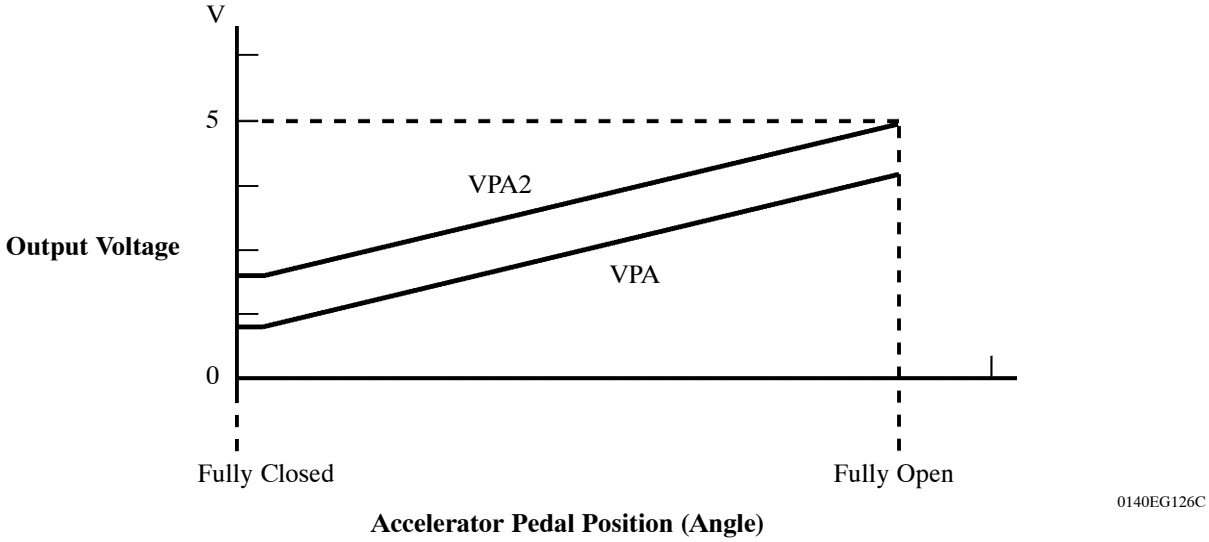
Accelerator Pedal Position Sensor

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

- A magnetic yoke is mounted at the base of the accelerator pedal arm. This yoke rotates 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.
- The Hall IC contains two circuits, one for the main signal, and one for the sub signal. It converts the accelerator pedal position (angle) into electric signals that have differing characteristics and outputs them to the ECM.







Accelerator Pedal Position (Angle)

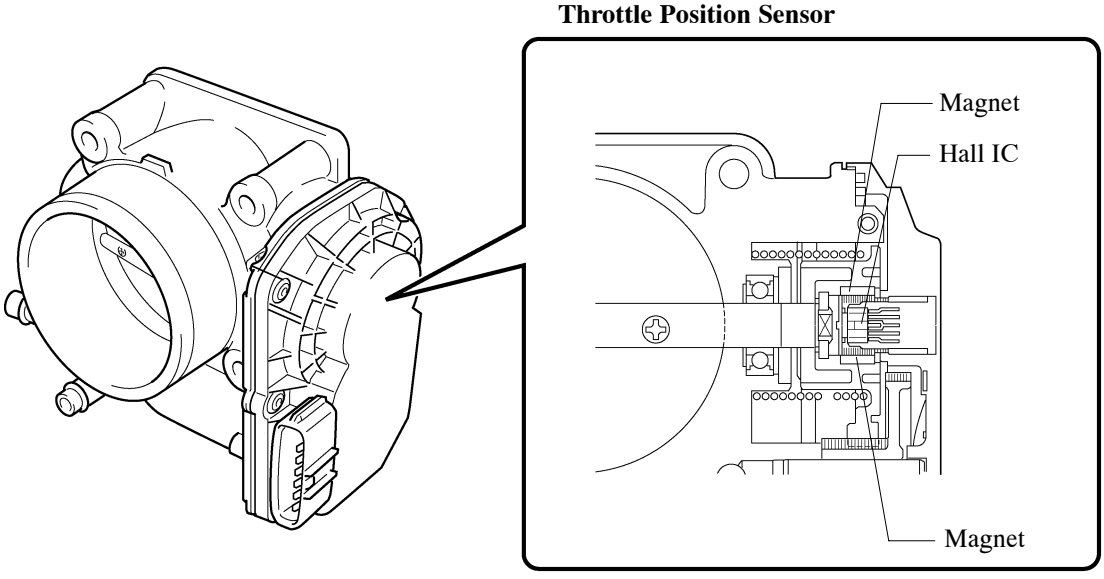
Service Tip

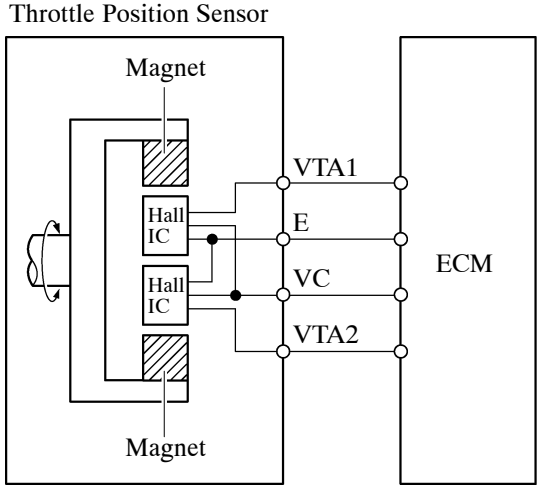
The inspection method differs from a contact type accelerator pedal position sensor because a non-contact type accelerator pedal position sensor uses a Hall IC. For details, refer to the 2008 HIGHLANDER Repair Manual (Pub. No. RM06J0U).

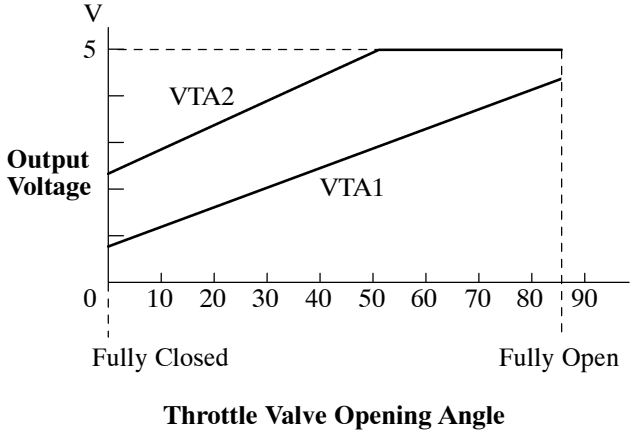
Throttle Position Sensor

This non-contact type throttle position sensor uses a Hall IC, which is mounted on the throttle body.

- 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 electric signals that have differing characteristics, and outputs them to the ECM.







Service Tip

The inspection method differs from a contact type throttle position sensor because a non-contact type throttle position sensor uses a Hall IC. For details, refer to the 2008 HIGHLANDER Repair Manual (Pub. No. RM06J0U).

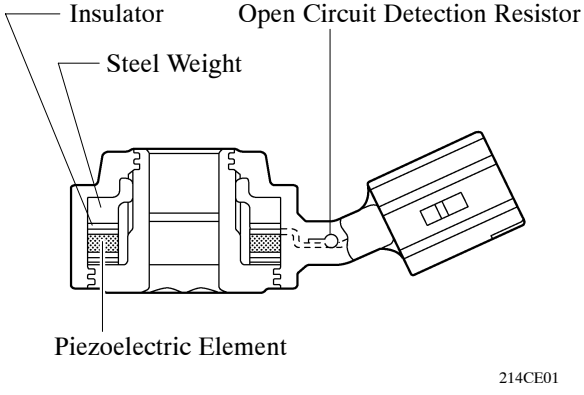
Knock Control Sensor (Flat Type)

1) General

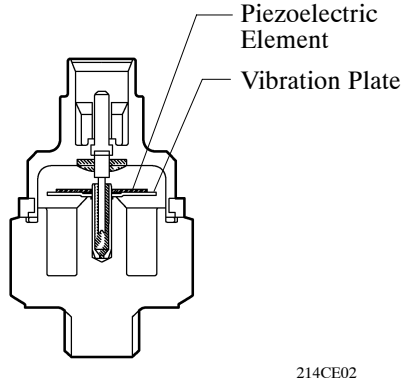
In a conventional knock control sensor (resonant type), a vibration plate is built into the sensor. This plate has the same resonance point as the knocking* frequency of the engine block. This sensor can only detect vibration in this frequency band.
A flat type knock control sensor (non-resonant type)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

- A flat type knock control sensor is installed to an engine by placing it over the stud bolt installed on the cylinder block sub-assembly. For this reason, a hole for the stud bolt exists 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.

*: The term “Knock” or “Knocking” is used in this case to describe either preignition or detonation of the air fuel mixture in the combustion chamber. This preignition or detonation refers to the air fuel mixture being ignited earlier than is advantageous.
This use of “Knock” or “Knocking” is not primarily used to refer to a loud mechanical noise that may be produced by an engine.



Flat Type Knock Control Sensor (Non-resonant Type)

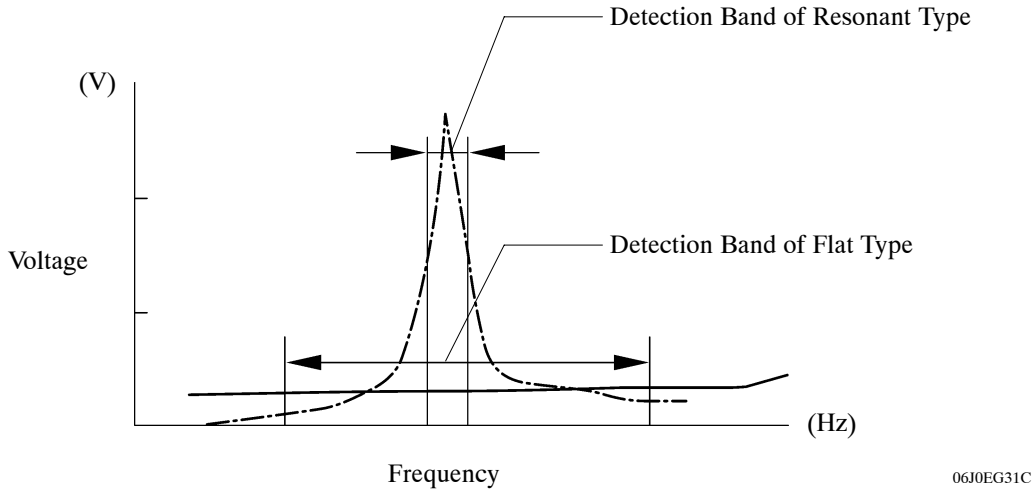


Conventional Type Knock Control Sensor (Resonant Type)

2) Resonance Characteristic

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

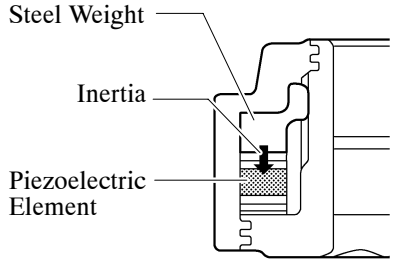
— · — : Resonance Characteristic of Conventional Type (Resonant)
——— : Resonance Characteristic of Flat Type (Non-resonant)



Characteristic of Knock Control Sensor

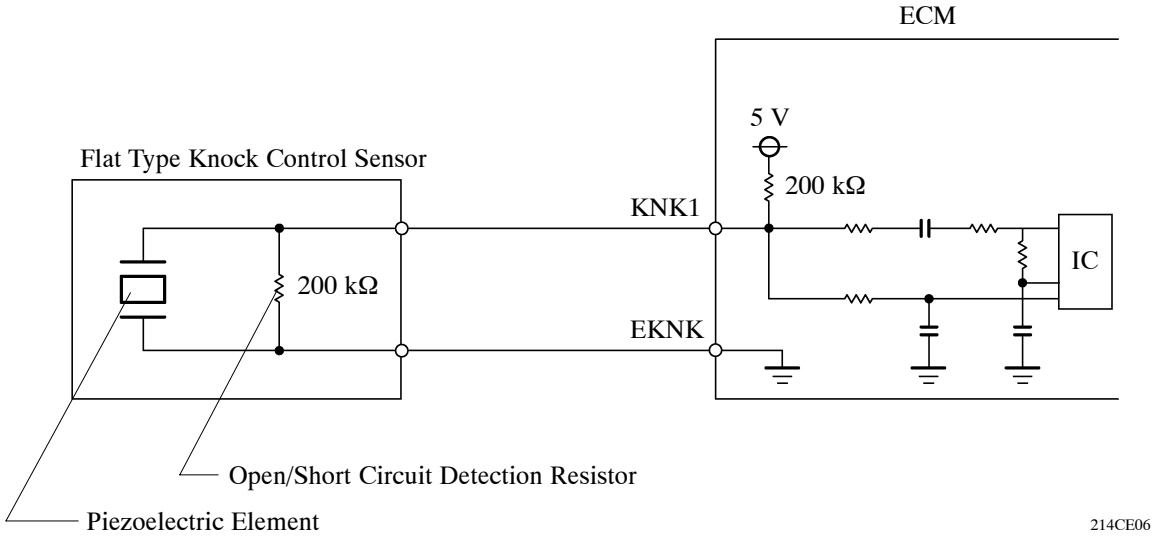
3) Operation

Vibrations caused by knocking are transmitted to the steel weight. The inertia of this weight applies pressure to the piezoelectric element. This action generates electromotive force.



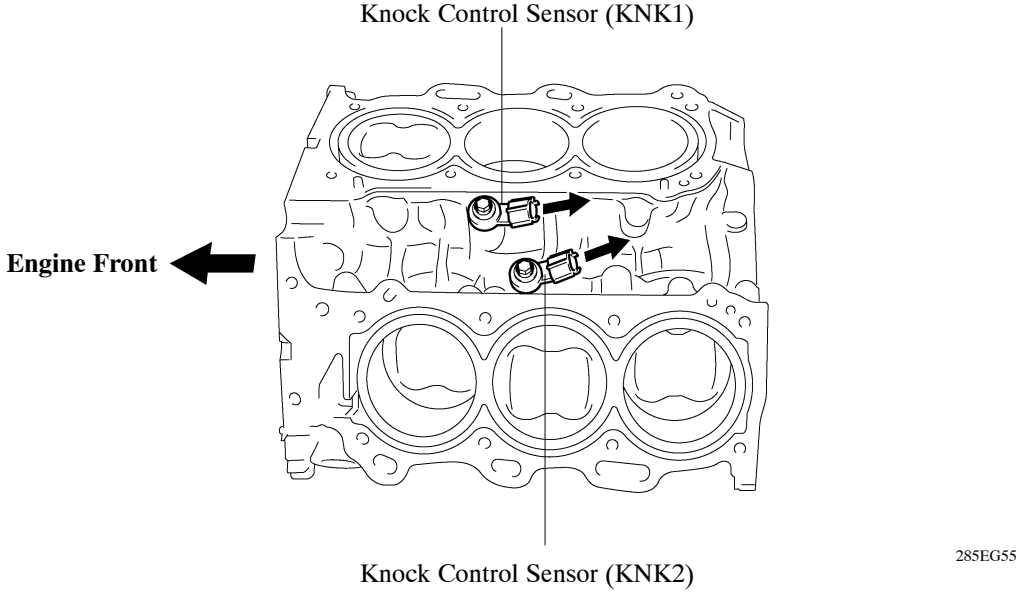
4) Open/Short Circuit Detection Resistor

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



Service Tip

These knock control sensors are mounted in the specific directions and angles as illustrated. To prevent the right and left bank connectors from being interchanged, make sure to install each sensor in its prescribed direction.

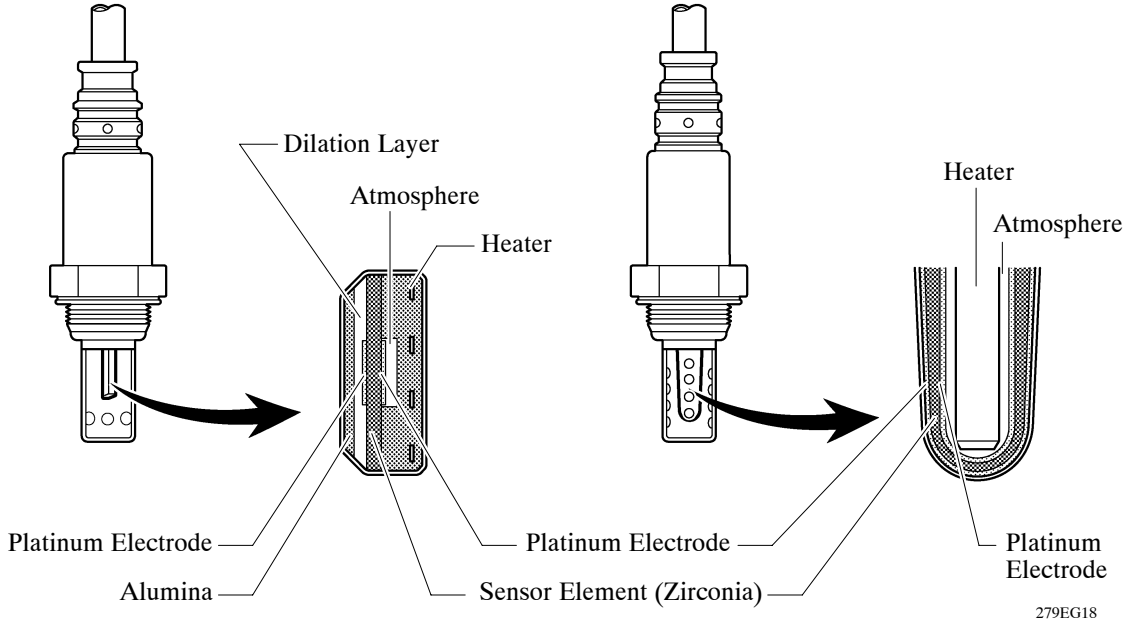


Air Fuel Ratio Sensor and Heated Oxygen Sensor

1) General

A planar type air-fuel ratio sensor and a cup type heated oxygen sensor are used. 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 used.

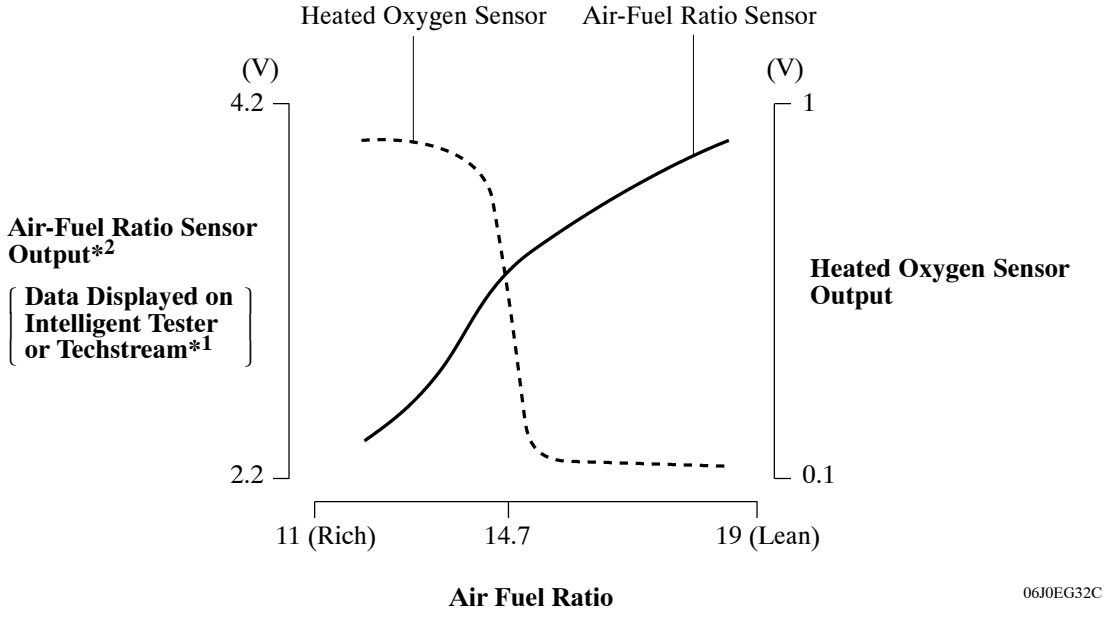
- The planar type air-fuel ratio sensor uses alumina, which excels in heat conductivity and electrical insulation, to integrate a sensor element with a heater, thus improving the warm-up performance of the sensor.
- The cup type heated oxygen sensor contains a sensor element that surrounds a heater.



Air Fuel Ratio Sensor (Planar Type) **Heated Oxygen Sensor (Cup Type)**

2) Characteristics

As illustrated below, the conventional heated oxygen sensor is characterized by a sudden change in its output voltage at the threshold of the stoichiometric air-fuel ratio (14.7:1). In contrast, the air-fuel ratio sensor data is approximately proportionate to the existing air-fuel ratio. The air-fuel ratio sensor converts the oxygen density to current and sends it to the ECM. As a result, the detection precision of the air-fuel ratio has been improved. The air-fuel ratio sensor data can be viewed using an intelligent tester or Techstream*1.

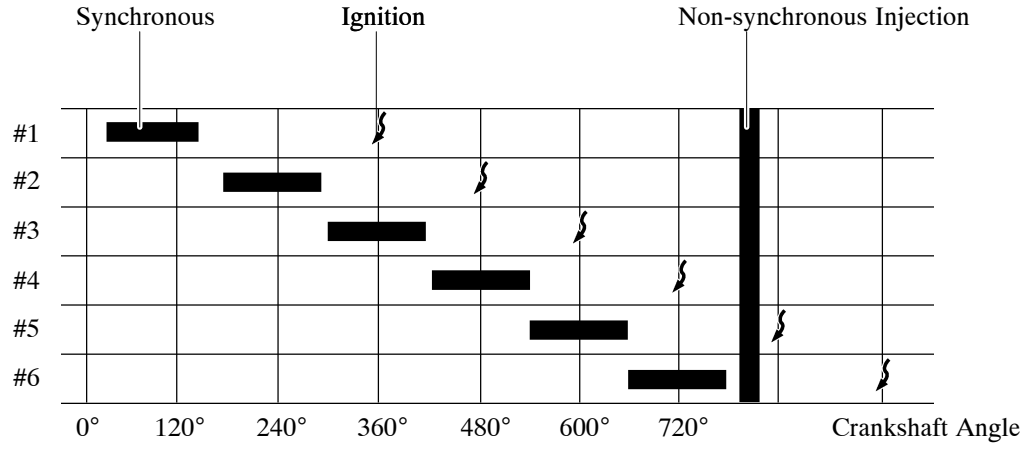


*1: Techstream is the name for the diagnostic tester in North America, but other countries will continue to use the intelligent tester.

*2: This value is calculated internally in the ECM and is not an ECM terminal voltage.

6. SFI System

- The L-type SFI (Sequential Multiport Fuel Injection) system directly detects the intake air mass using a hot-wire type mass 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.
- There are two (synchronous and non-synchronous) injections:
  a) Synchronous injection, in which injection always occurs at the same timing relative to the firing order.
  b) The non-synchronous injection in which injection is effected regardless of the crankshaft angle.
  Furthermore, to protect the engine and achieve lower fuel consumption, the system uses a fuel cutoff in which the injection of fuel may be stopped temporarily in accordance with the driving conditions.
- This system performs group injection when the engine coolant temperature is extremely low and the engine is operating at a low speed.



Independent Injection 06J0EG33C

7. ESA System

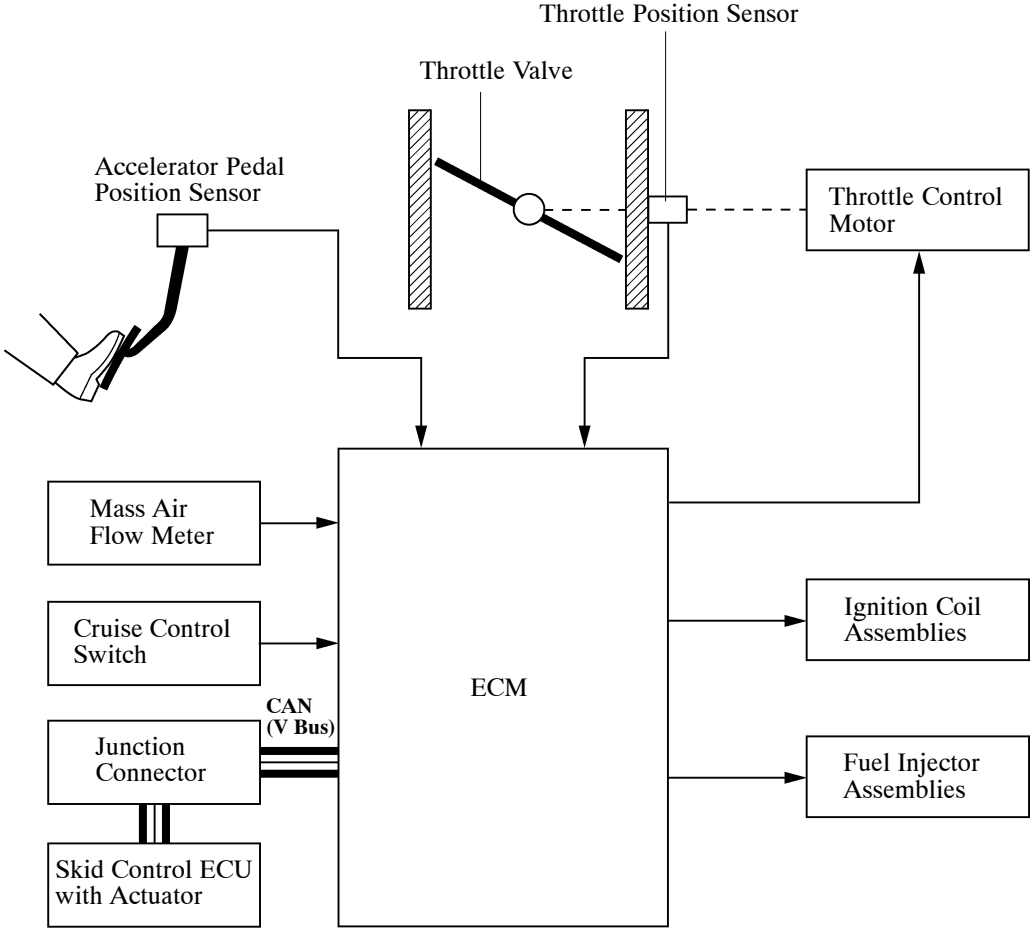
The ESA (Electronic Spark Advance) system selects the optimal ignition timing in accordance with the signals received from the sensors and sends the (IGT) ignition signal to the igniter.

8. ETCS-i

General

The ETCS-i (Electronic Throttle Control System-intelligent) uses the ECM to calculate the optimal throttle valve angle that is appropriate for the corresponding driving conditions. The ETCS-i throttle uses a throttle control motor to control the angle.

▶ System Diagram ◀



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Control

1) General

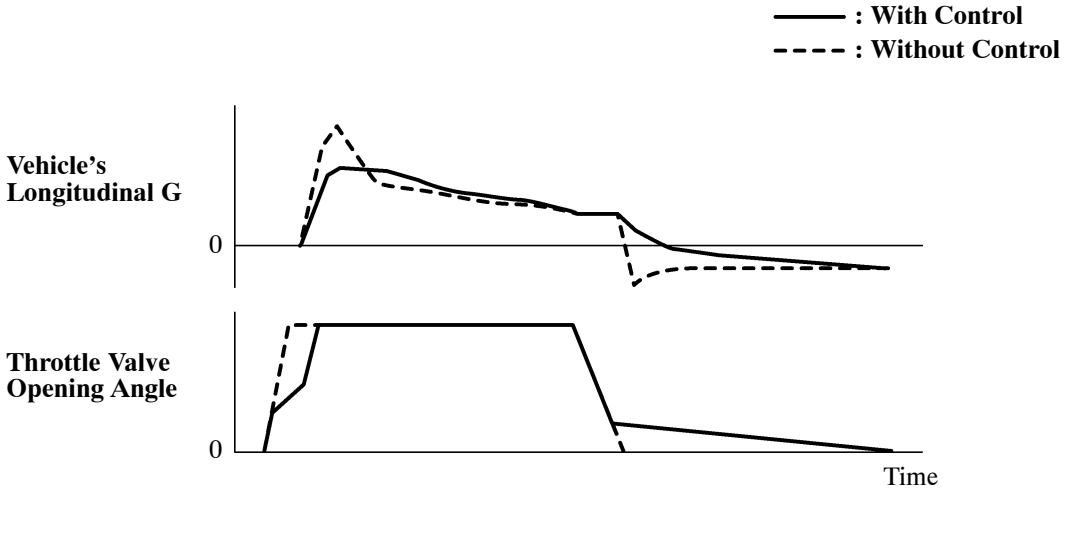
The ETCS-i consists of the following functions:

- Normal Throttle Control (Non-linear Control)
- ISC (Idle Speed Control)
- TRAC (Traction Control)
- VSC (Vehicle Stability Control)
- Cruise Control

2) Normal Throttle Control (Non-linear Control)

Controls the throttle to an optimal throttle valve angle that is appropriate for the driving condition based on information 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.

▶ Control Examples During Acceleration and Deceleration ◀



3) Idle Speed Control

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

4) TRAC Throttle Control

As part of the TRAC system, the throttle valve is closed by a demand signal from the Skid Control ECU if an excessive amount of slippage occurs at a drive wheel, thus facilitating excellent vehicle stability and driving force.

5) VSC Coordination Control

In order to bring the effectiveness of the VSC system control into full play, the throttle valve angle is controlled by effecting a coordination control with the Skid Control ECU.

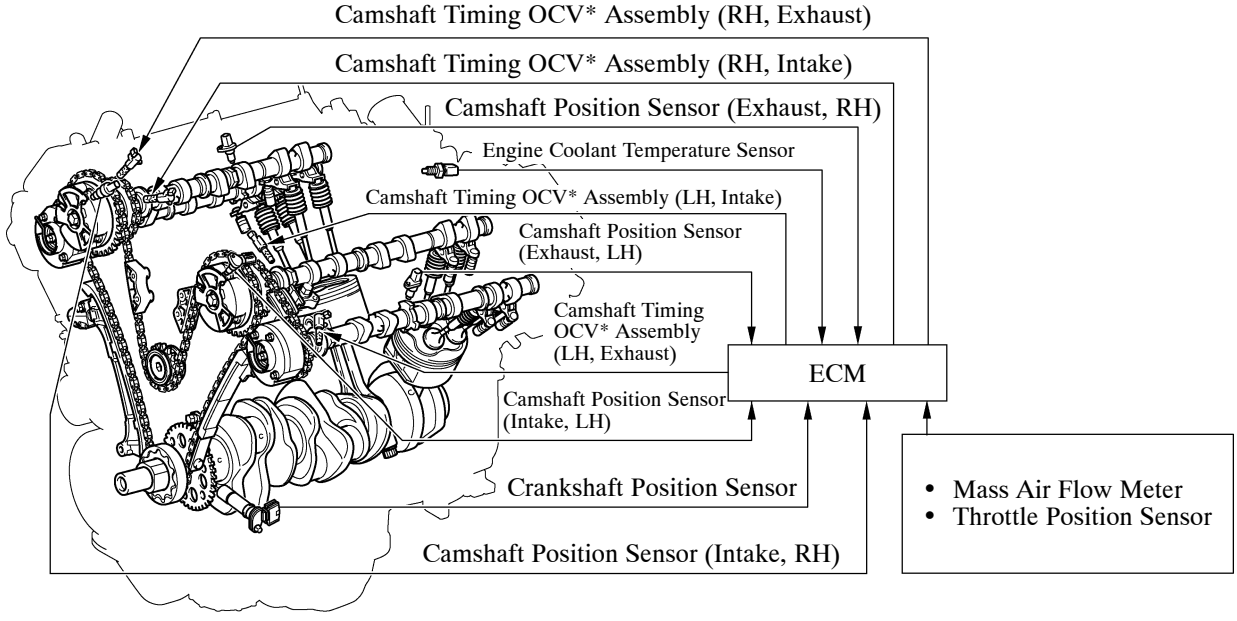
6) Cruise Control

An ECM directly actuates the throttle valve to control engine power for cruise control.

9. Dual VVT-i System

General

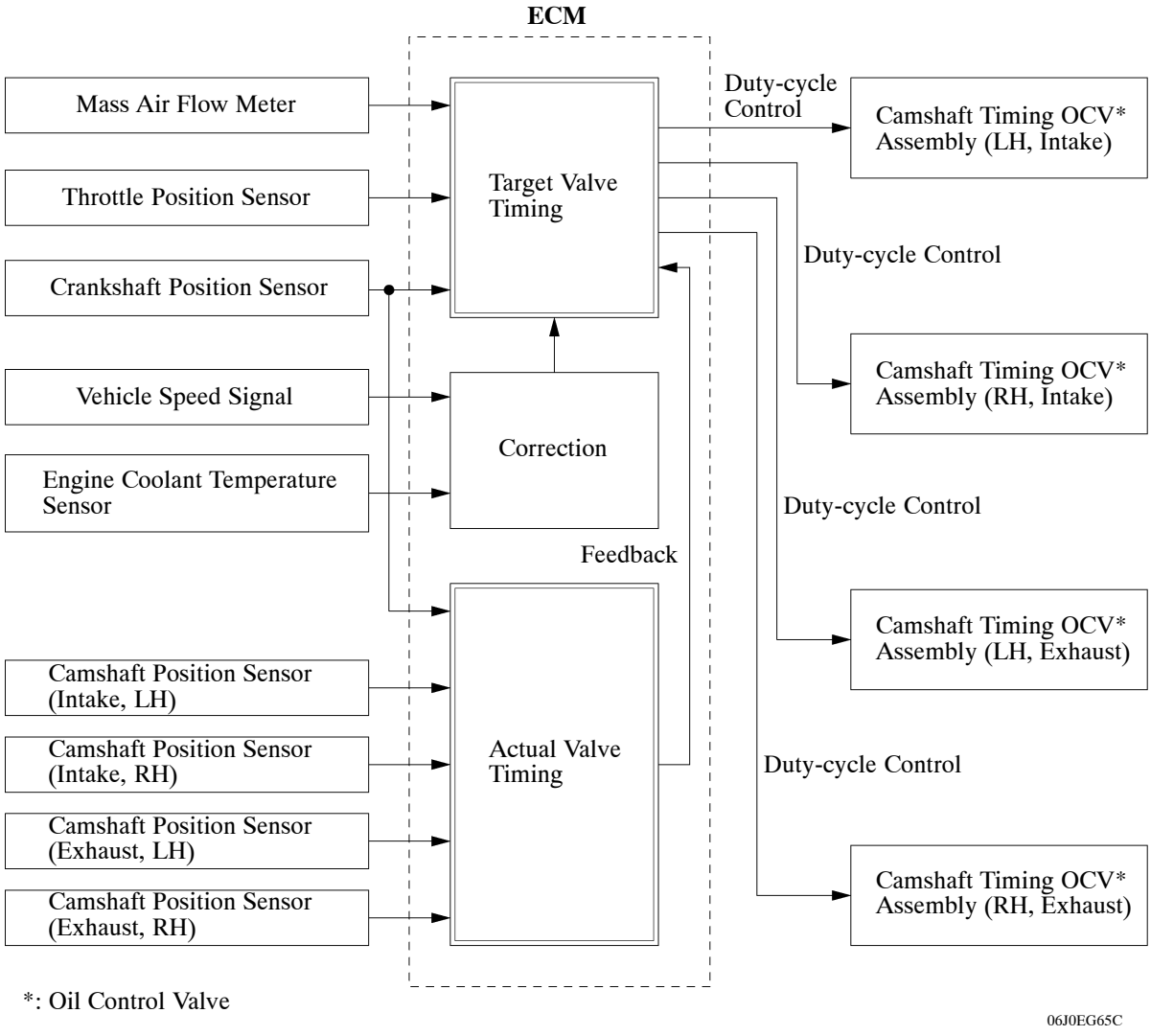
The Dual VVT-i (Variable Valve Timing-intelligent) system is designed to control the camshafts (intake) and camshafts (exhaust) within a range of 40° and 35° respectively (of Crankshaft Angle) to provide valve timing that is optimally suited to the engine condition. This improves torque in all the speed ranges as well as increasing fuel economy, and reducing exhaust emissions.



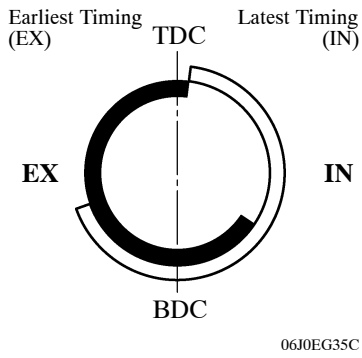
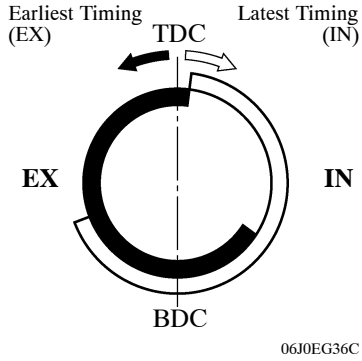
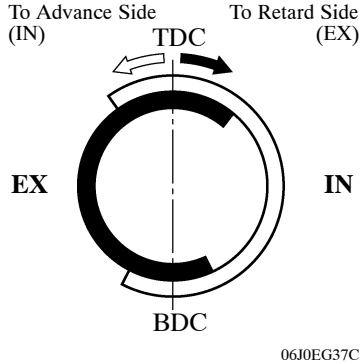
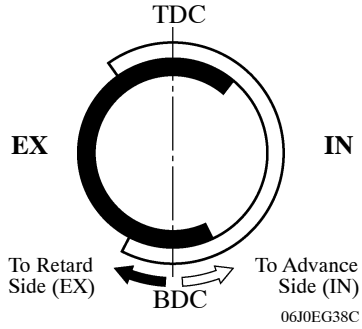
*: Oil Control Valve

EG

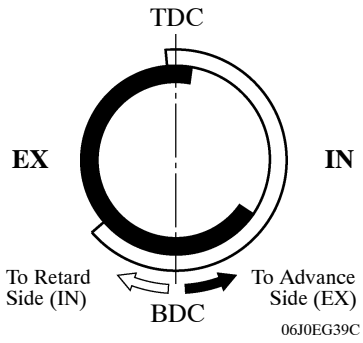
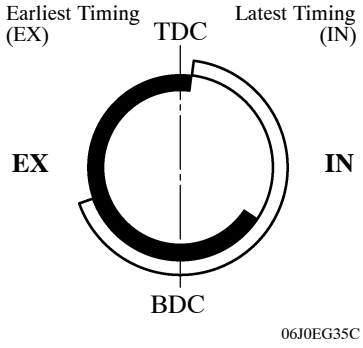
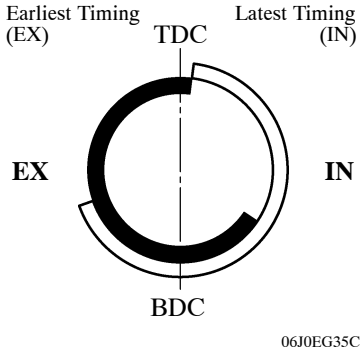
- Based on engine speed, intake air volume, throttle position and engine coolant temperature, the ECM calculates optimal valve timing for all driving conditions. The ECM also controls the camshaft timing oil control valve assemblies. In addition, the ECM uses signals from the camshaft position sensors and the crankshaft position sensor to detect the actual valve timing, thus providing feedback control to achieve the target valve timing.



Effectiveness of the Dual VVT-i System

Operation State	Objective		Effect
During Idling		Eliminating overlap reduces blow back to the intake side.	• Stabilized idling rpm • Better fuel economy
At Light Load		Eliminating overlap reduces blow back to the intake side.	Engine stability is ensured
At Medium Load		Increasing overlap increases internal EGR, reducing pumping losses.	• Better fuel economy • Improved emission control
In Low to Medium Speed Range with Heavy Load		Advancing the intake valve closing timing improves volumetric efficiency.	Improved torque in low to medium speed range

(Continued)

Operation State	Objective		Effect
In High Speed Range with Heavy Load		Retarding the intake valve closing timing improves volumetric efficiency.	Improved output
At Low Temperatures		Eliminating overlap to reduce blow back to the intake side stabilizes the idling speed at fast idle.	• Stabilized fast idle rpm • Better fuel economy
• Upon Starting • Stopping the Engine		Eliminating overlap minimize blow back to the intake side.	Improved startability

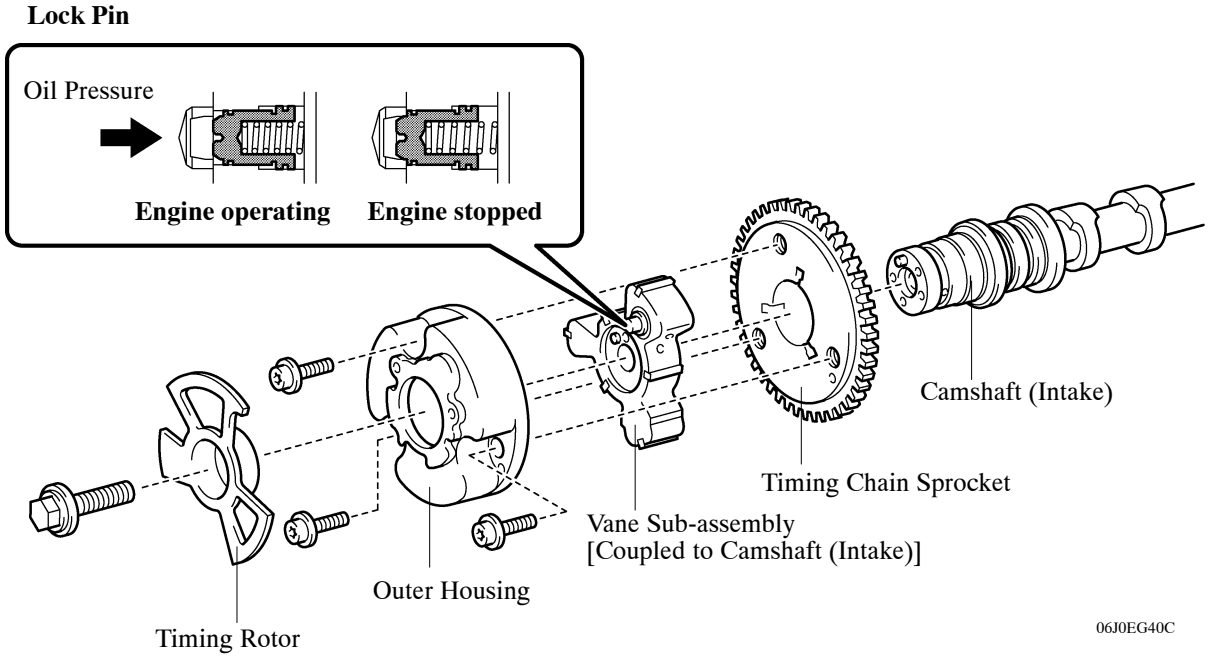
Construction

1) Camshaft Timing Gear Assembly

The camshaft timing gear assembly consists of an outer housing that is driven by the timing chain sprocket, and a vane subassembly that is coupled to each camshaft.

- The camshaft timing gear assembly uses 3 vanes.
- When the engine stops, the camshaft timing gear assembly is locked at the most retarded angle by its lock pin. This ensures excellent engine startability.
- The oil pressure sent from the advance or retard side passages of the camshafts (intake) causes rotation of the vane sub-assembly relative to the timing chain sprocket, to vary the valve timing continuously.

▶ Camshaft Timing Gear Assembly ◀

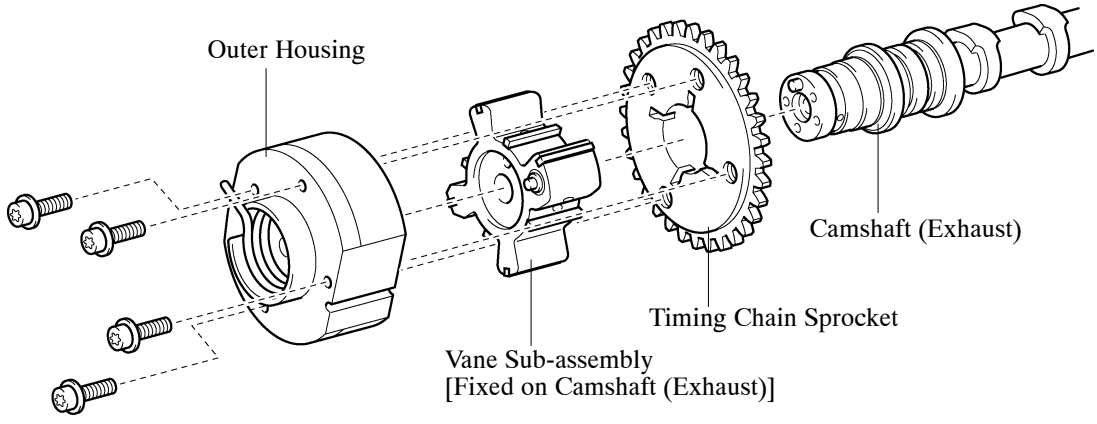


2) Camshaft Timing Exhaust Gear Assembly

The camshaft timing exhaust gear assembly consists of an outer housing that is driven by the timing chain sprocket, and a vane subassembly that is coupled to each camshaft.

- The camshaft timing exhaust gear assembly uses 4 vanes.
- When the engine stops, the camshaft timing exhaust gear assembly is locked at the most advanced angle. This ensures excellent engine startability.
- The oil pressure sent from the advance or retard side passages of the camshafts (exhaust) causes rotation of the vane sub-assembly relative to the timing chain sprocket, to vary the valve timing continuously.
- An advance assist spring is provided on the camshaft timing exhaust gear assembly. This helps to apply torque in the advanced angle direction so that the vane lock pin securely engages with the housing when the engine stops.

▶ Camshaft Timing Exhaust Gear Assembly ◀

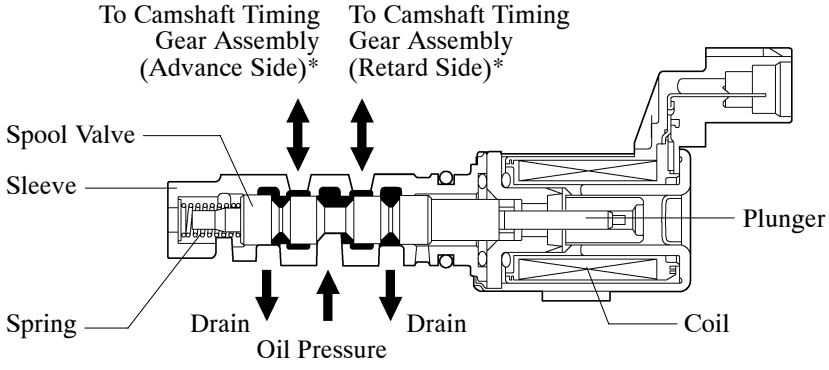


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3) Camshaft Timing Oil Control Valve Assembly

This camshaft timing oil control valve assembly controls the spool valve using duty-cycle control from the ECM. This allows hydraulic pressure to be applied to the camshaft timing gear assembly or camshaft timing exhaust gear assembly advance or retard side. When the engine is stopped, the camshaft timing oil control valve assembly (intake) will move to the retard position, and the camshaft timing oil control valve assembly (exhaust) will move to the advance position.

▶ Camshaft Timing Oil Control Valve Assembly (Intake) ◀



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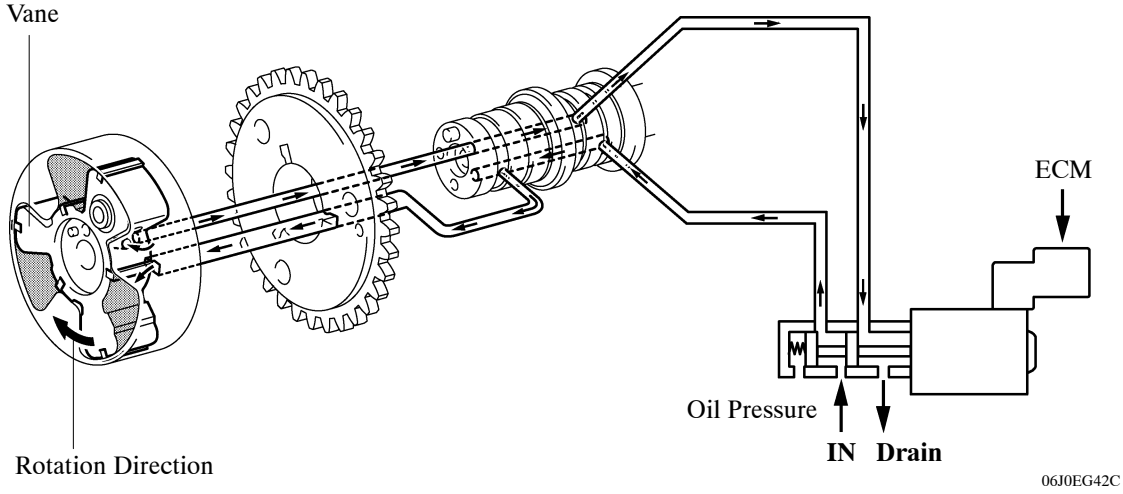
*: On the camshaft timing oil control valve assembly (exhaust), the advance and retard sides are reversed.

Operation

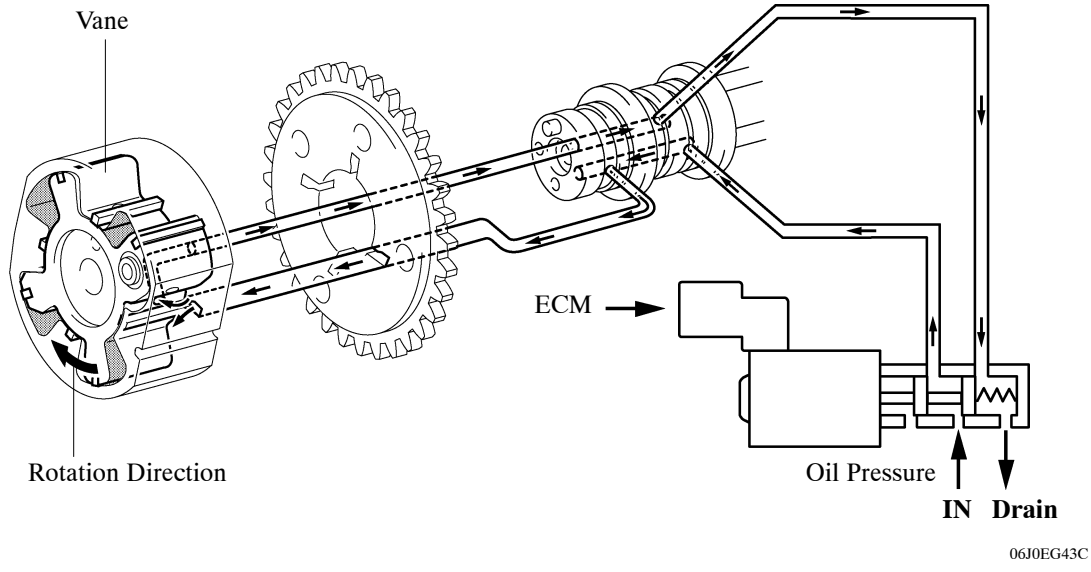
1) Advance

When the camshaft timing oil control valve assembly 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.

▶ Intake Side ◀



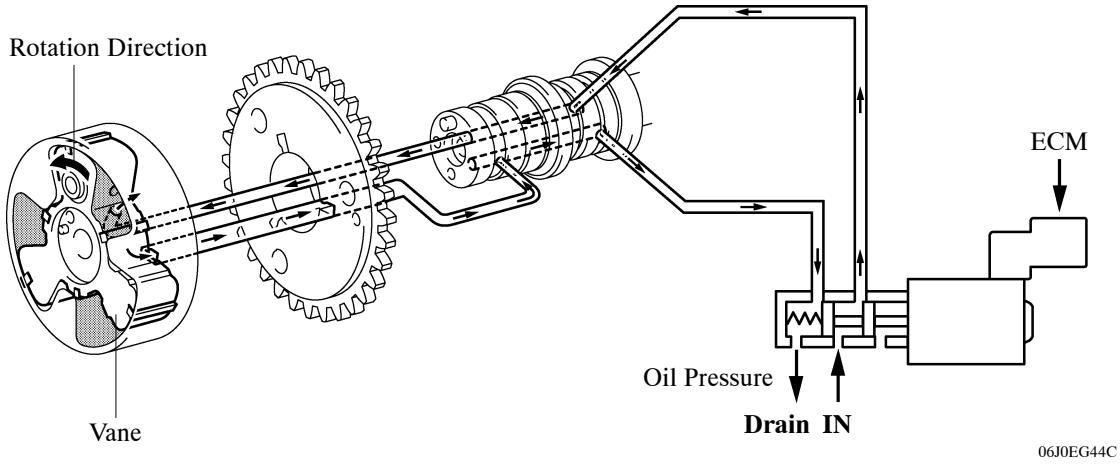
▶ Exhaust Side ◀



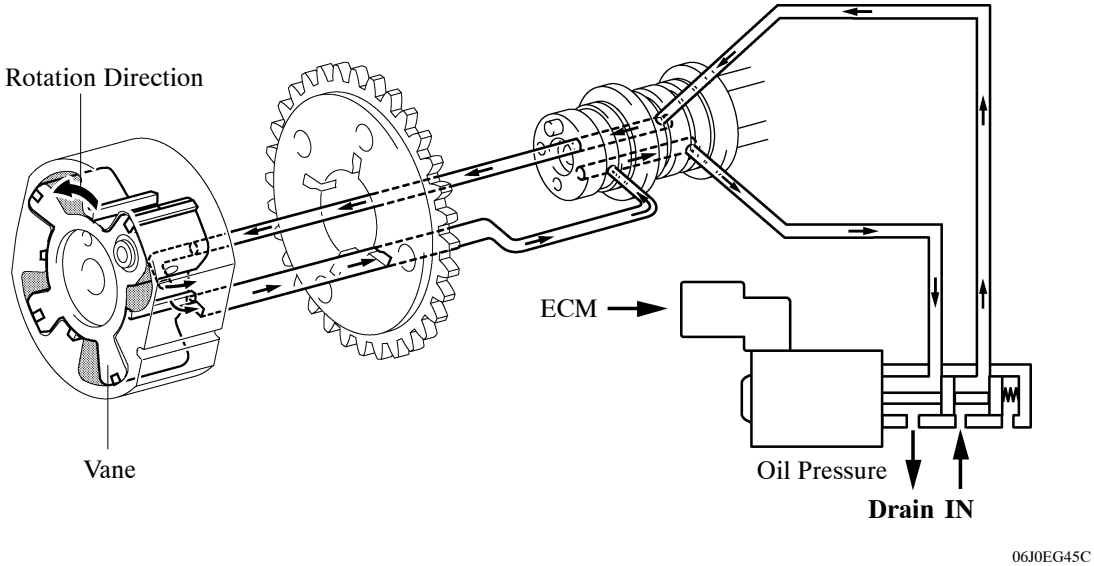
2) Retard

When the camshaft timing oil control valve assembly 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.

▶ Intake Side ◀



▶ Exhaust Side ◀



3) Hold

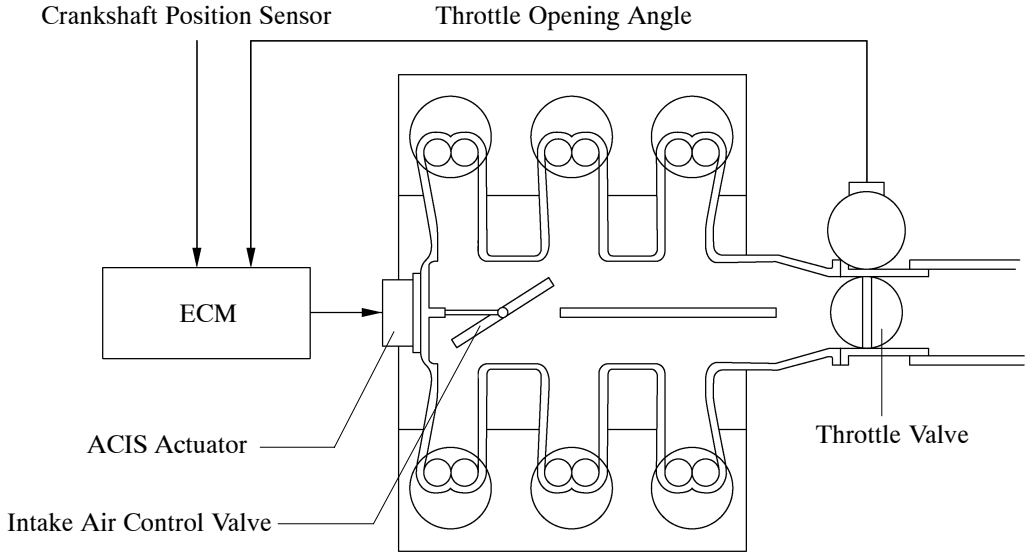
After reaching the target timing, the engine valve timing is maintained by keeping the camshaft timing oil control valve assembly in the neutral position unless the engine operating conditions change.
This maintains the engine valve timing at the desired target position by preventing the engine oil from running out of the camshaft timing oil control valve assembly.

10. ACIS

General

The ACIS (Acoustic Control Induction System) uses a bulkhead to divide the intake manifold, creating 2 stages. The intake air control valve in the bulkhead is opened or closed to vary the effective length of the intake manifold in accordance with the engine speed and throttle valve opening angle. This increases the power output in all ranges from low to high speed.

▶ System Diagram ◀

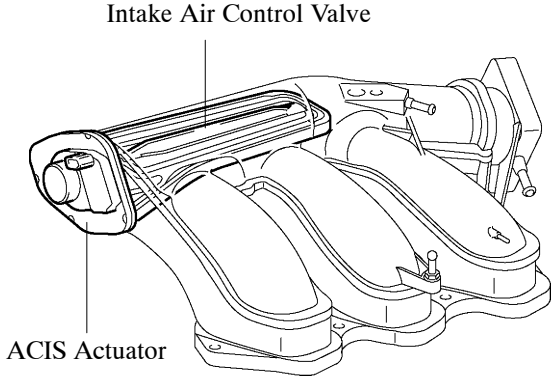


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Construction

1) Intake Air Control Valve

The intake air control valve is installed in the intake air surge tank. It opens and closes to provide two effective lengths of the intake manifold.



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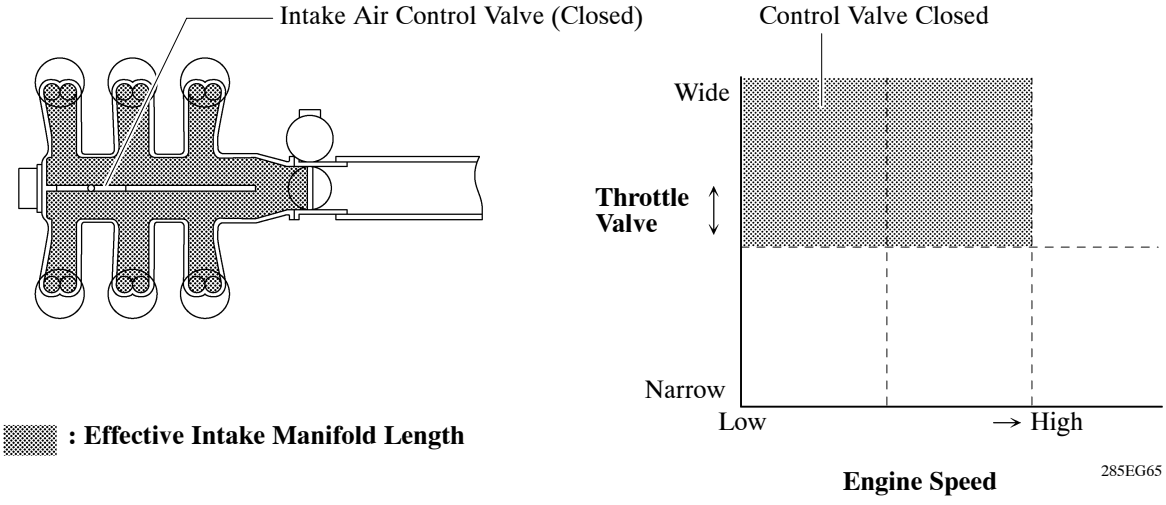
2) ACIS Actuator (Motor)

The ACIS actuator activates the intake air control valve based on signals from the ECM.

Operation

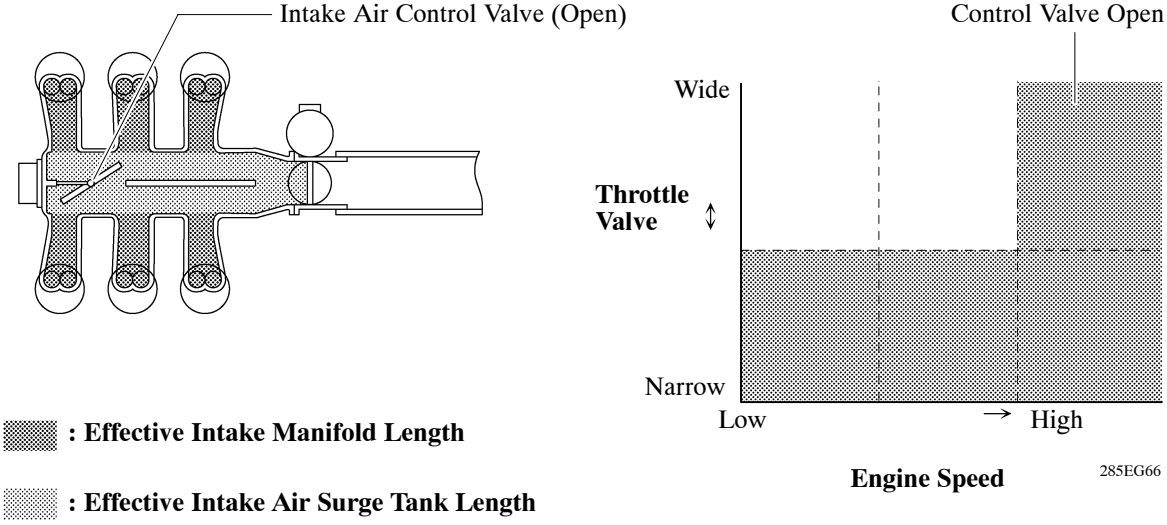
1) Intake Control Valve Closed

While the engine is running at medium speed under high load, the ECM causes the actuator to close the control valve. As a result, the effective length of the intake manifold is lengthened and the intake efficiency, in the medium speed range, is improved due to the dynamic effect (inertia) of the intake air, thereby increasing power output.



2) Intake Control Valve Open

Under any condition except when the engine is running at medium speed under high load, the ECM causes the actuator to open the control valve. When the control valve is open, the effective length of the intake air surge tank is shortened and peak intake efficiency is shifted to the low-to-high engine speed range, thus providing greater output at low-to-high engine speeds.

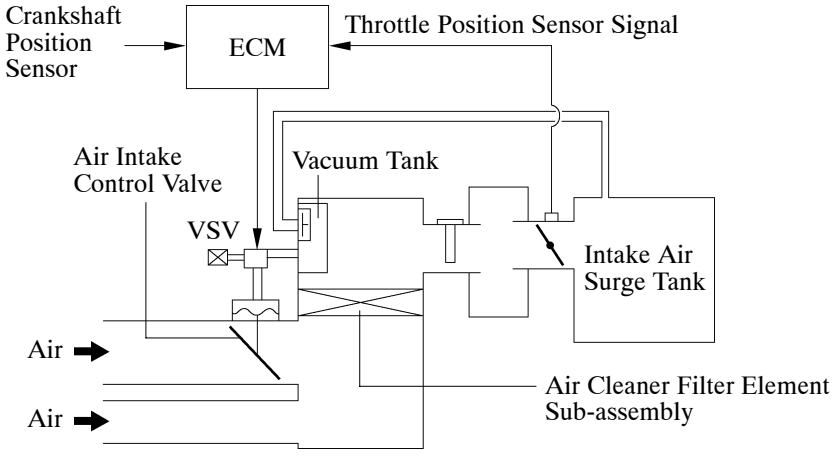


11. Air Intake Control System

General

The air intake control system switches between 2 intake air flow paths using the air intake control valve and actuator. As a result, a reduction of intake noise in the low-speed range and an increase in the power output in the high-speed range is realized.

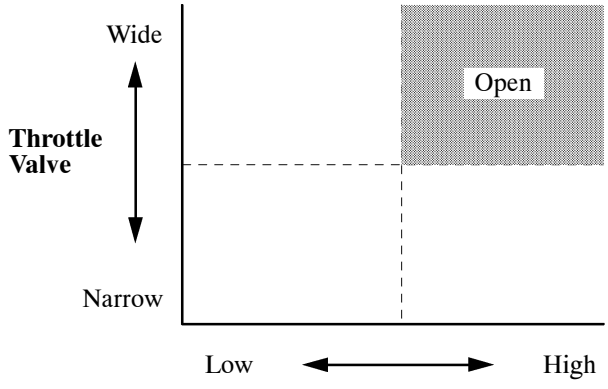
- The intake control valve position is switched by the VSV depending on engine speed and throttle valve angle signals.



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Operation

- When the engine is operating in the low- to mid-speed range, this control operates the air intake control valve to close one part of the air cleaner inlet assembly. As a result, the air enters the air filter box via the smaller port, allowing the intake air resonator sub-assembly to help to reduce the intake noise.
- When the engine is operating in the high-speed range, this control operates the air intake control valve to open both sides of the air cleaner inlet assembly. As a result, the intake area is maximized and the intake efficiency is improved.



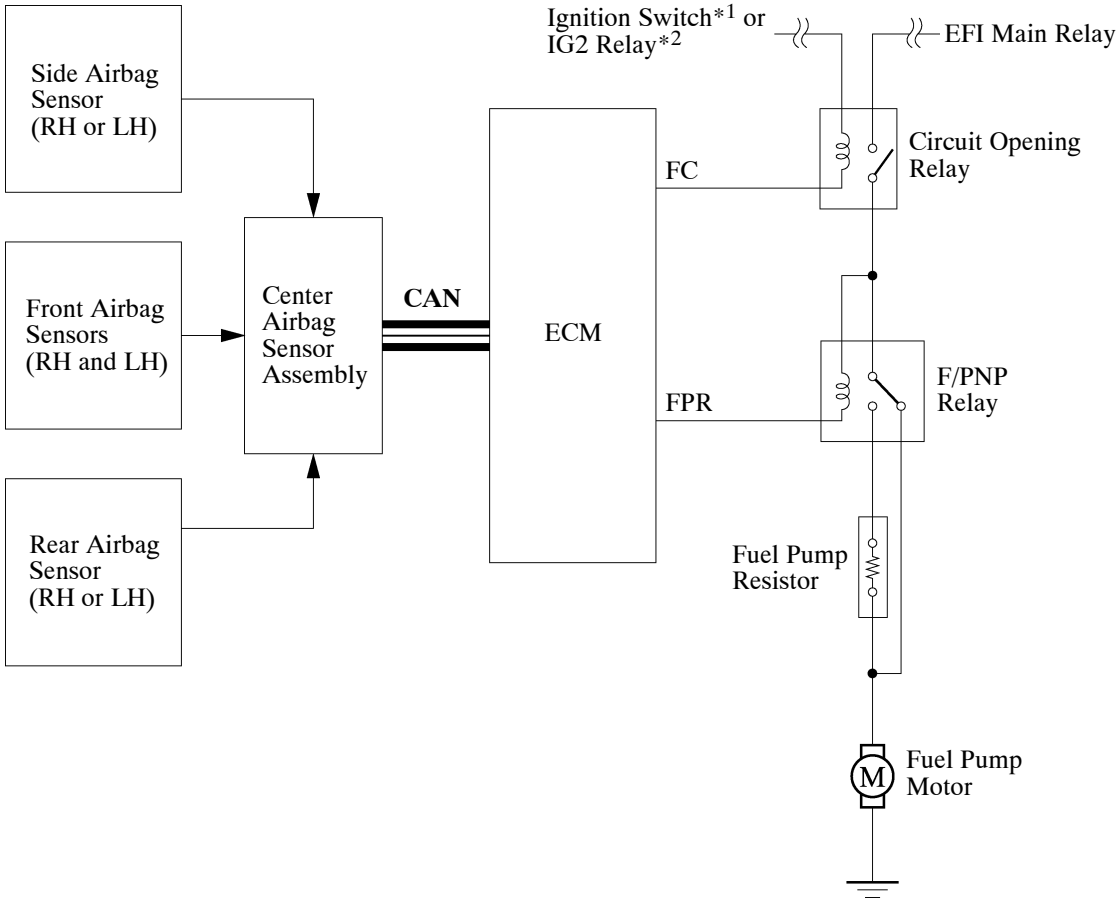
Air Intake Control Valve Condition

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12. Fuel Pump Control

The fuel pump is controlled by the ECM, using the fuel pump relay and the fuel pump resistor. The fuel pump control has a fuel cut control. A fuel cut control stops the fuel pump when any of the SRS airbags have deployed.

- When the ECM detects the airbag deployment signal from the Center Airbag Sensor Assembly, the ECM will turn the circuit opening relay off. After the fuel cut control has been activated, turning the power source from OFF to the IG-ON position cancels the fuel cut control, and the engine can be restarted.



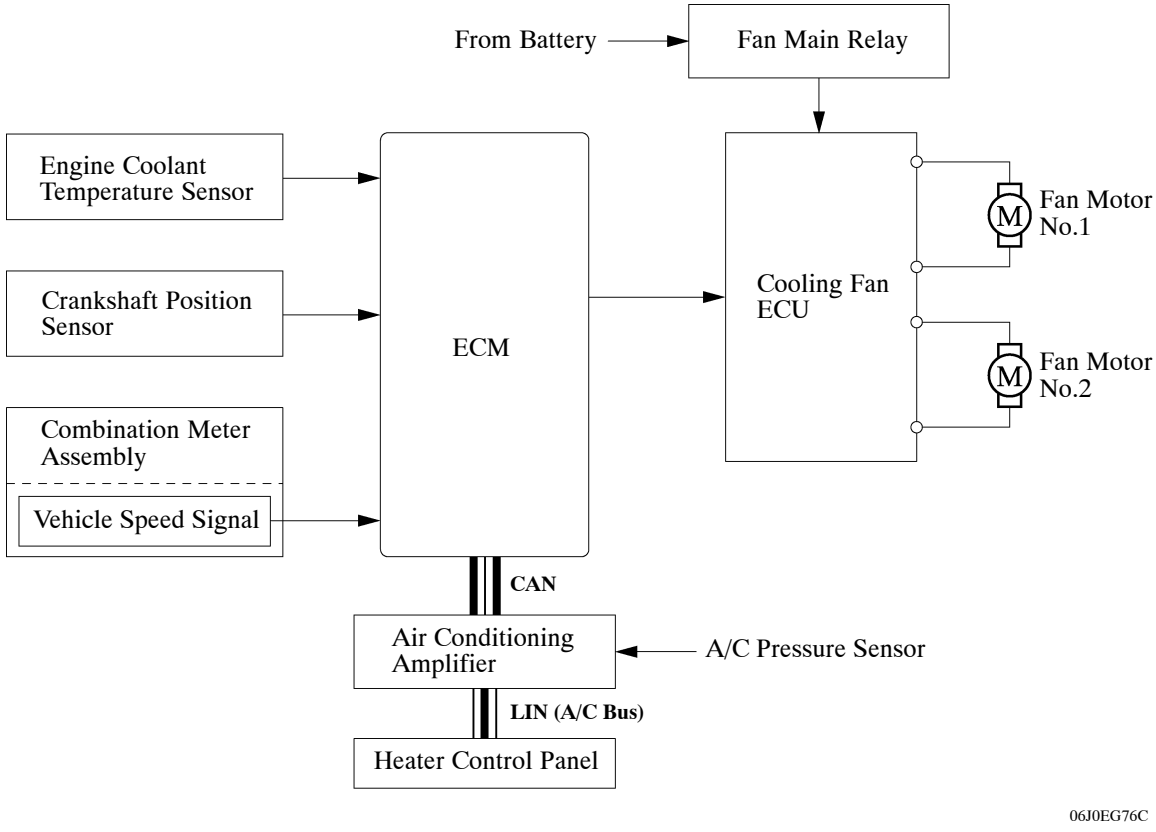
*1: Models without Smart Key System
*2: Models with Smart Key System

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13. Cooling Fan Control System

General

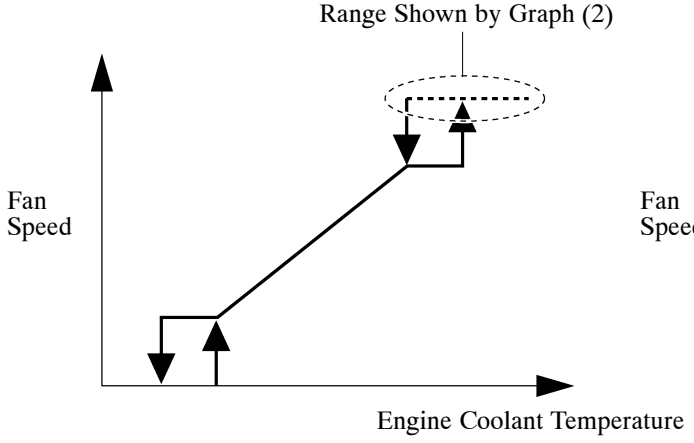
A cooling fan control system controlled to achieve an optimal fan speed in accordance with the engine coolant temperature, vehicle speed, engine speed, and air conditioning operating conditions, the ECM calculates the appropriate fan speed and sends the signals to the Cooling Fan ECU. Upon receiving the signals from the ECM, the Cooling Fan ECU actuates the fan motors.



Operation

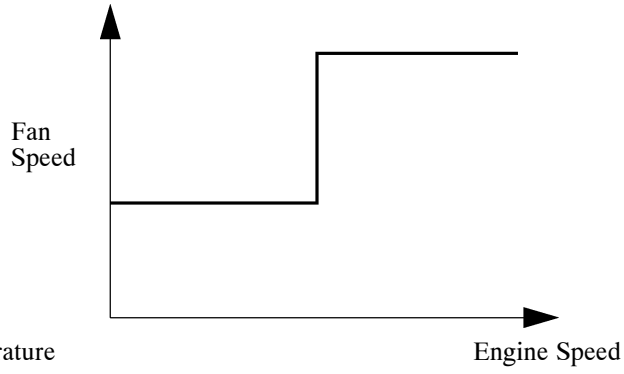
- As illustrated below, the ECM determines the required cooling fan speed by selecting the fastest fan speed from among the following:

(1) The fan speed required according to the engine coolant temperature.
(2) The fan speed required according to the engine speed (when the engine coolant temperature is high).
(3) The fan speed required based on the air conditioning refrigerant pressure.
- When the air conditioning refrigerant pressure is within the lower part of the normal operating range with the A/C switch on, the required fan speed differs according to the vehicle speed.
- When the air conditioning refrigerant pressure is higher than a specified upper limit, the required fan speed will increase based on an emergency request from the ECM.



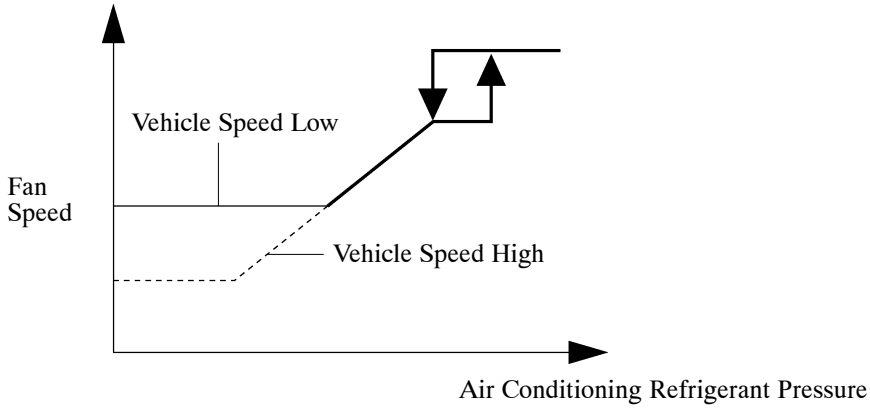
(1) Fan Speed Required according to Engine Coolant Temperature

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(2) Fan Speed When Engine Coolant Temperature is High

06J0EG49C



(3) Fan Speed Required according to Air Conditioning Refrigerant Pressure

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- If the ECM detects that the following conditions are met, the cooling fans will be operated for 3 minutes after the ignition switch is turned off, in order to cool the fuel system in consideration of the subsequent restarting of a hot engine.

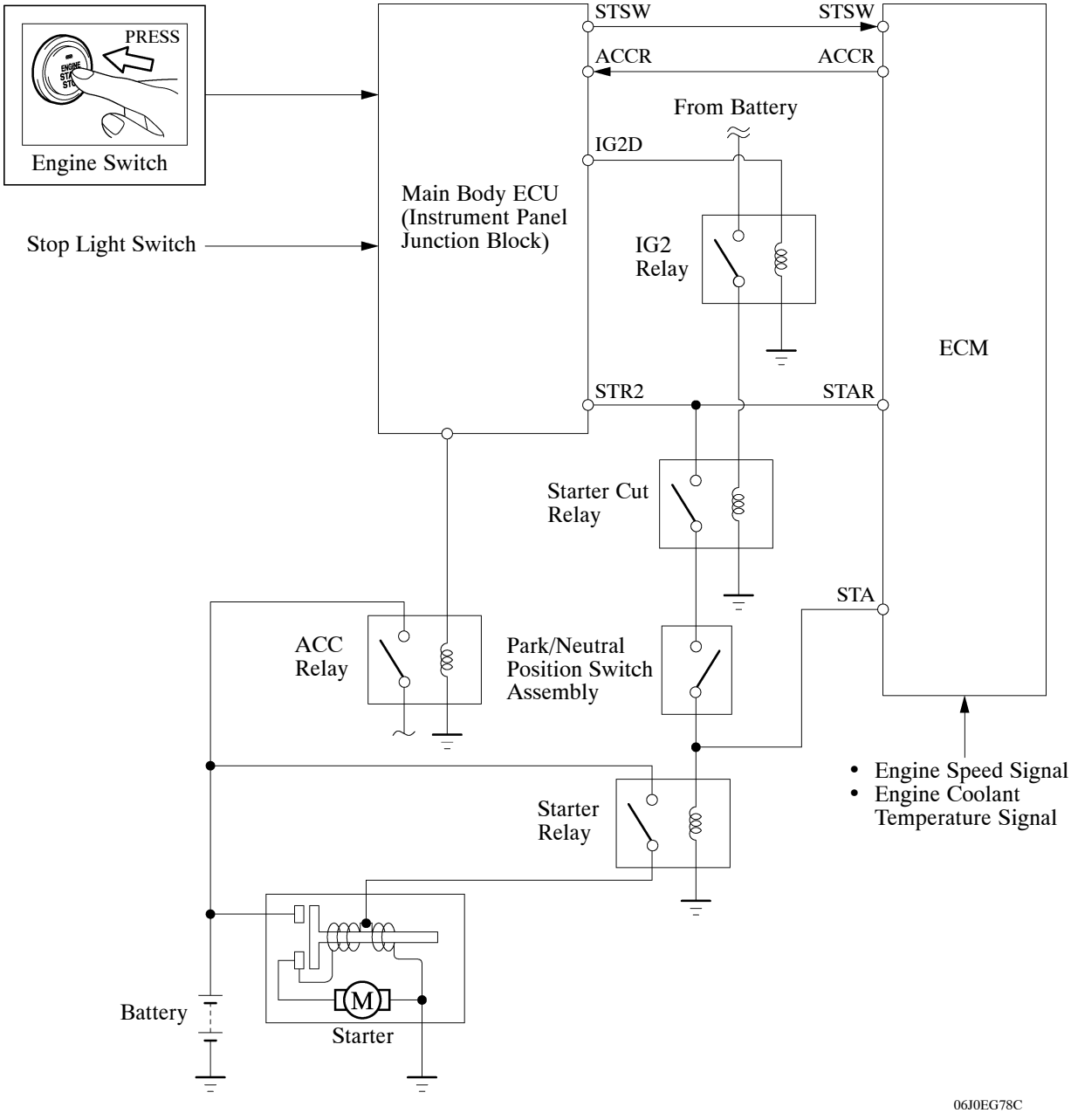
• Ambient temperature is high. • Engine coolant temperature (at the engine coolant outlet) is high. • The engine has been running at high load (detected based on the vehicle speed and intake air volume).	When all conditions are met for a total of 90 seconds or more during the period of 180 seconds immediately before the engine stops, the cooling fan is operated for 3 minutes after the ignition switch is turned off.

14. Cranking Hold Function (Only Models with Smart Key System)

General

- Once the engine switch is pressed, this function operates the starter until the engine starts, provided that the brake pedal is depressed and the shift lever is in the P or N position. This prevents application of the starter for an inadequate length of time and it also prevents the engine from being cranked after it has started.
- When the ECM detects a start signal (STSW) from the Main Body ECU (Instrument Panel Junction Block), it monitors engine speed (NE) and operates the starter until it determines that the engine has started. If the engine has already started, the ECM will not operate the starter, even if the ECM receives a start signal (STSW).

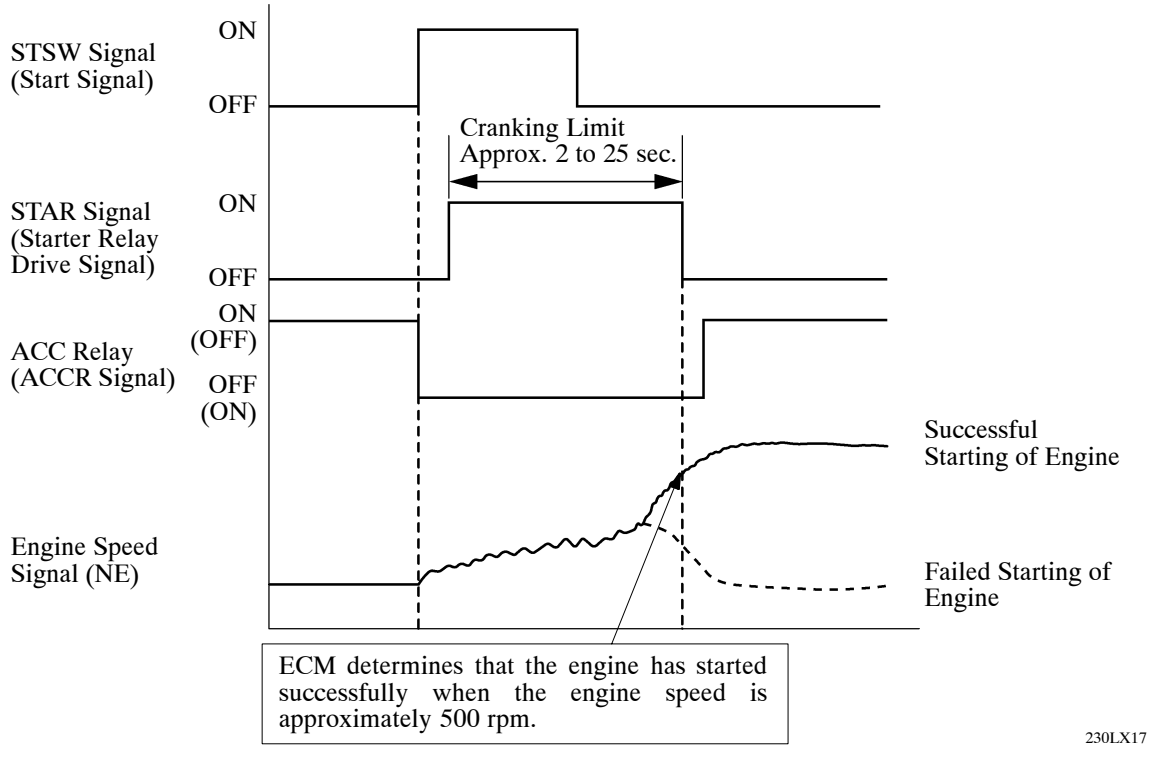
▶ System Diagram ◀



Operation

- Before starting occurs, the Main Body ECU (Instrument Panel Junction Block) sends power from its IG2D terminal to the IG2 relay, causing the IG2 relay to close. After the IG2 relay closes, it provides power to the coil of the starter cut relay, causing the contacts of the starter cut relay to close, enabling the circuit that operates the starter relay.
- When the ECM detects a start signal (STSW) from the Main Body ECU (Instrument Panel Junction Block), the ECM outputs a starter relay drive signal (STAR). The signal goes through the starter cut relay and the park/neutral position switch assembly to the starter relay. The starter relay activates the starter when it receives this signal.
- If the starter relay drive signal (STAR) cannot be output because the power supplied to the ECM is low, the Main Body ECU (Instrument Panel Junction Block) outputs the starter relay drive signal (STR2) instead to help actuate the starter.
- When the ECM detects a start signal (STSW) from the Main Body ECU (Instrument Panel Junction Block), the ECM also outputs an ACC-cut request signal (ACCR) to the Main Body ECU (Instrument Panel Junction Block).
- The ACCR signal instructs the Main Body ECU (Instrument Panel Junction Block) to turn off the ACC relay, in order to prevent accessory light flickering from occurring while cranking.
- After the engine speed rises above approximately 500 rpm, the ECM determines that the engine has started and stops the output of the STAR signal. This causes starter operation to stop and the Main Body ECU (Instrument Panel Junction Block) to turn on the ACC relay.
- If the engine does not start, the starter operates for a length of time that is based on coolant temperature. This can range from 25 seconds at lower temperatures to 2 seconds when the engine is at operating temperature.
- **This system has following safety features:**
  - While the engine is running, the starter cannot operate.
  - The starter will stop operating once the engine has started, even if the start switch remains depressed.
  - Starter operation is limited to a maximum of 30 seconds to protect the starter motor.
  - The starter will stop if the ECM cannot detect an engine speed signal (NE) while the starter is operating.

▶ Timing Chart ◀



15. Evaporative Emission Control System

General

The evaporative emission control system prevents the fuel vapor that is created in the fuel tank assembly from being released directly into the atmosphere. The charcoal canister assembly stores the fuel vapor that has been created in the fuel tank assembly.

- This system consists of an EVAP valve, charcoal canister assembly, refueling valve, pump module, and ECM.
- The ECM controls the EVAP valve in accordance with the driving conditions in order to direct the fuel vapor into the engine, where it is burned.
- In this system, the ECM checks for evaporative emission leaks and stores DTCs (Diagnostic Trouble Codes) in the event of a malfunction. An evaporative emission leak check consists of an application of vacuum to the evaporative emissions system and the ECM monitoring the system for changes in pressure in order to detect a leak.
- An ORVR (Onboard Refueling Vapor Recovery) function is provided in the refueling valve.
- The pressure sensor is included in the pump module.
- An air filter is provided on the fresh air line. This air filter is maintenance-free.
- The following 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 • Ignition Switch/Engine Switch: 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)

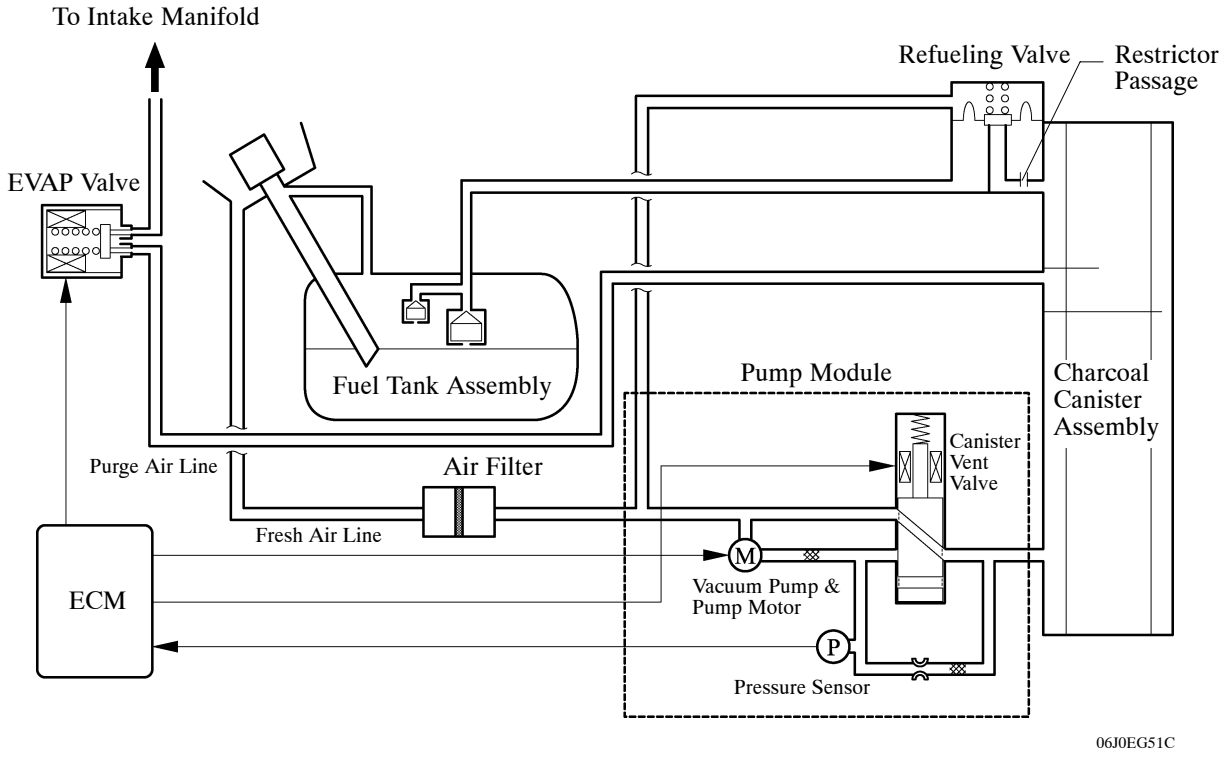
*: If engine coolant temperature does not drop below 35°C (95°F), this time should be extended to 7 hours. Even after that, if the temperature is not less than 35°C (95°F), the time should be extended to 9.5 hours.

Service Tip

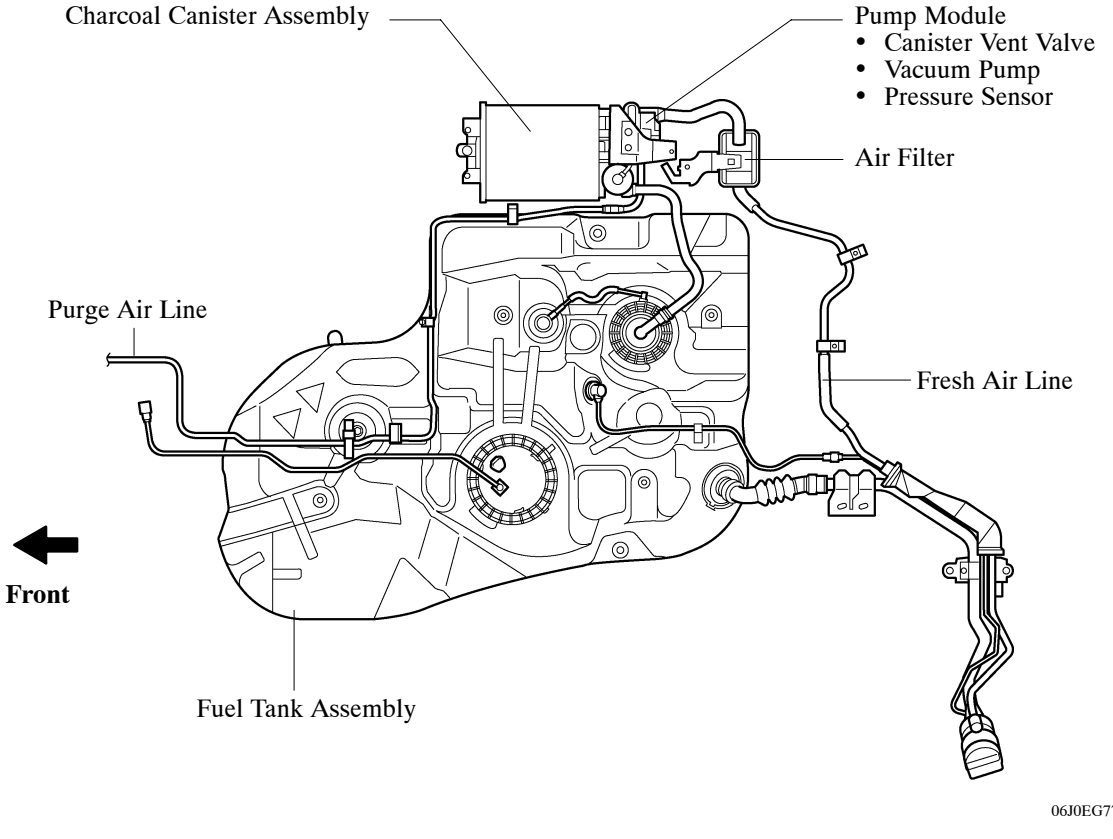
The pump module performs a fuel evaporative emission leakage check. This check is done approximately five hours after the engine is turned off. Sound may be heard coming from underneath the luggage compartment for several minutes. This does not indicate a malfunction.

- Pinpoint pressure test procedure is adopted by pressurizing the fresh air line that runs from the pump module to the air filler neck. For details, see the 2008 HIGHLANDER Repair Manual (Pub. No. RM06J0U).

System Diagram



Layout of Main Components



Function of Main Components

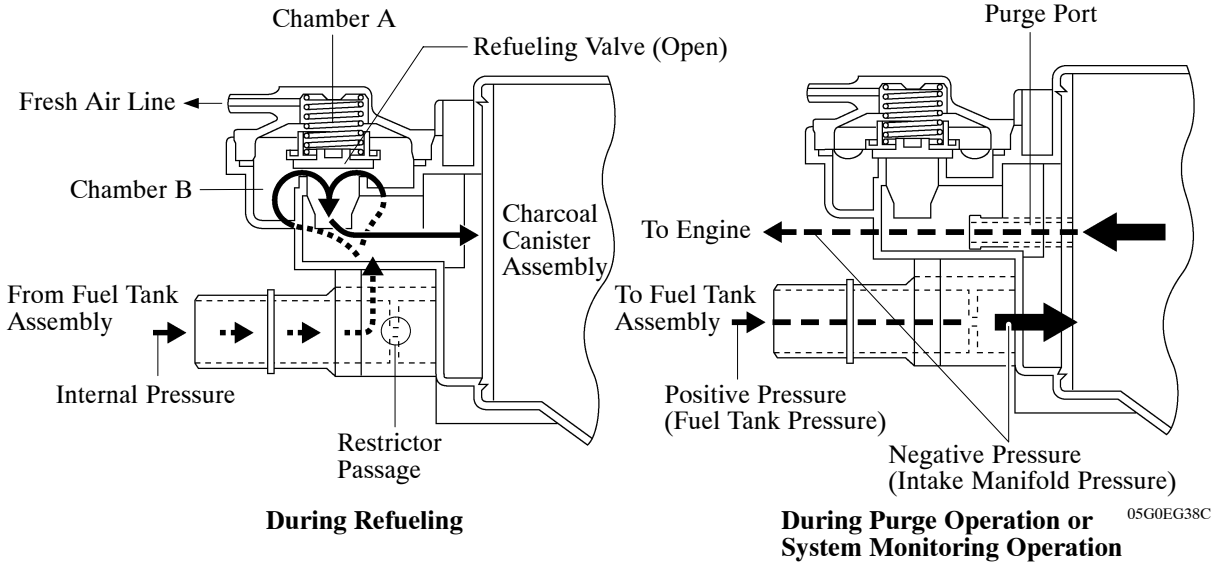
Component		Function
Charcoal Canister Assembly		Contains activated charcoal to absorb the fuel vapor that is created in the fuel tank assembly.
Refueling Valve		Controls the flow rate of the fuel vapor from the fuel tank assembly to the charcoal canister assembly when the system is purging or during refueling.
	Restrictor Passage	Prevents a large amount of vacuum during purge operation or system monitoring operation from affecting the pressure in the fuel tank assembly.
Fresh Air Line		Fresh air goes into the charcoal canister assembly and the cleaned drain air goes out into the atmosphere.
Pump Module	Canister Vent Valve	Opens and closes the fresh air line in accordance with signals from the ECM.
	Vacuum Pump & Pump Motor	Applies vacuum pressure to the evaporative emission system in accordance with signals from the ECM.
	Pressure Sensor	Detects the pressure in the evaporative emission system and sends the signals to the ECM.
EVAP Valve		Opens in accordance with the signals from the ECM when the system is purging, in order to send the fuel vapor that was absorbed by the charcoal canister assembly into the intake manifold. In system monitoring mode, this valve controls the introduction of vacuum into the fuel tank assembly.
Air Filter		Prevents dust and debris in the fresh air from entering the system.
ECM		Controls the pump module and the EVAP valve 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 stores a DTC if a malfunction is found.

Construction and Operation

1) Refueling Valve

The refueling valve consists of chamber A, chamber B, and a restrictor passage. A constant atmospheric pressure is applied to chamber A.

- During refueling, the internal pressure of the fuel tank assembly increases. This pressure causes the refueling valve to lift up, allowing the fuel vapor to enter the charcoal canister assembly.
- The restrictor passage prevents the large amount of vacuum that is created during purge operation or system monitoring operation from entering the fuel tank assembly, and limits the flow of the fuel vapor from the fuel tank assembly to the charcoal canister assembly. If a large volume of fuel vapor 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.

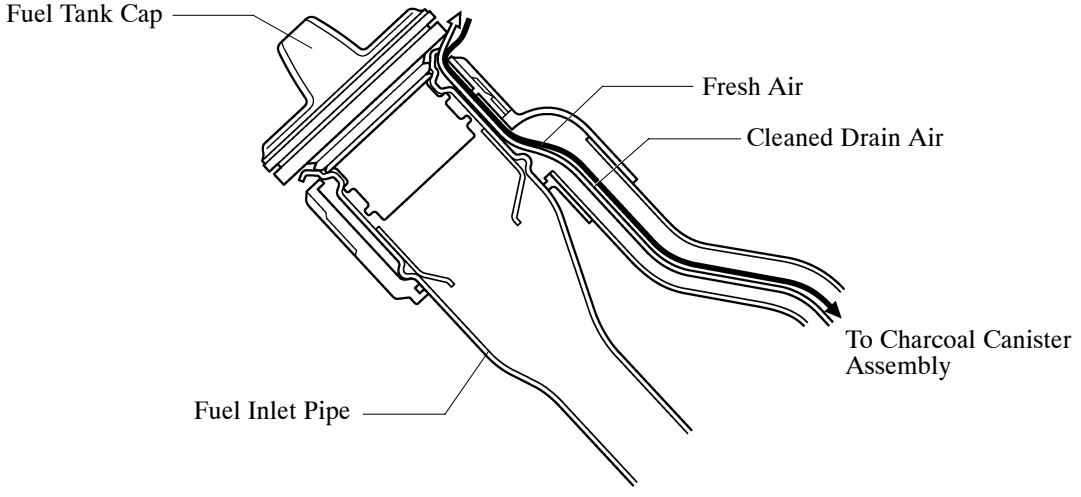


During Refueling

During Purge Operation or System Monitoring Operation

2) Fuel Inlet (Fresh Air Inlet)

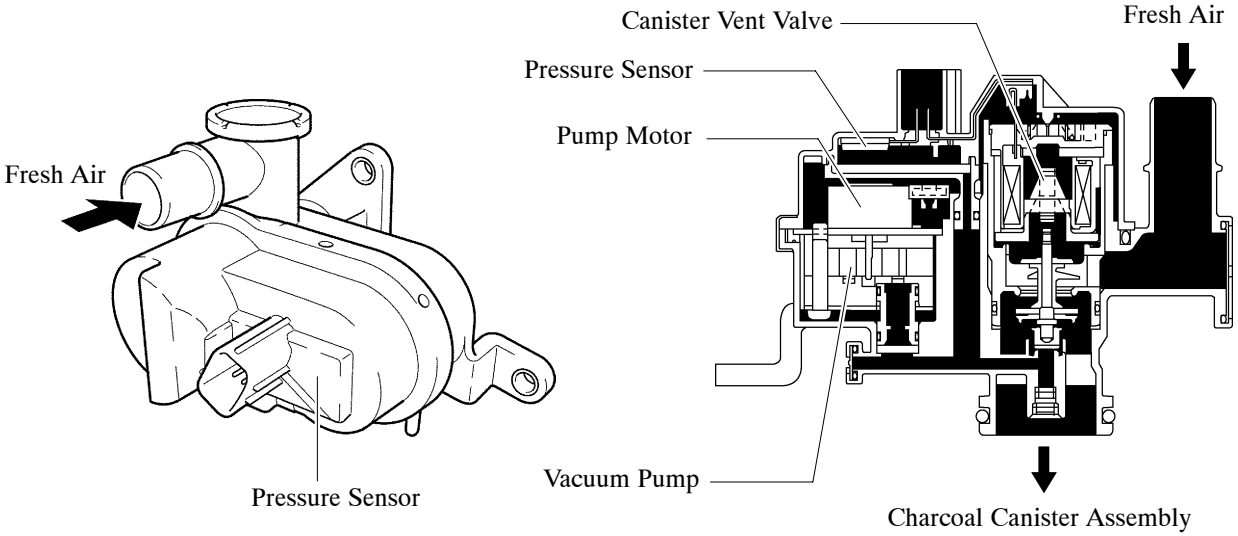
In accordance with the change of structure of the evaporative emission control system, the location of the fresh air line inlet has been moved from the air cleaner to the near the fuel inlet. The fresh air from the atmosphere and drain air cleaned by the charcoal canister assembly will go in or out of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



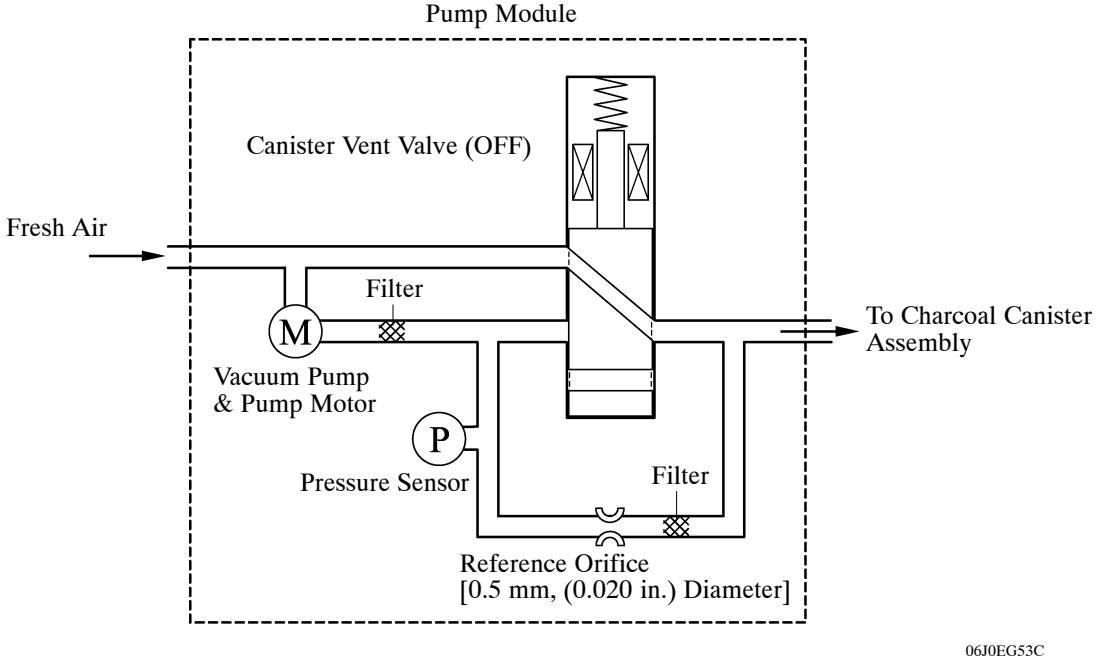
3) Pump Module

The pump module consists of the canister vent valve, pressure sensor, vacuum pump, and pump motor.

- The canister vent valve switches the passages in accordance with the signals received from the ECM.
- A DC type brushless motor is used for the pump motor.
- A vane type vacuum pump is used.



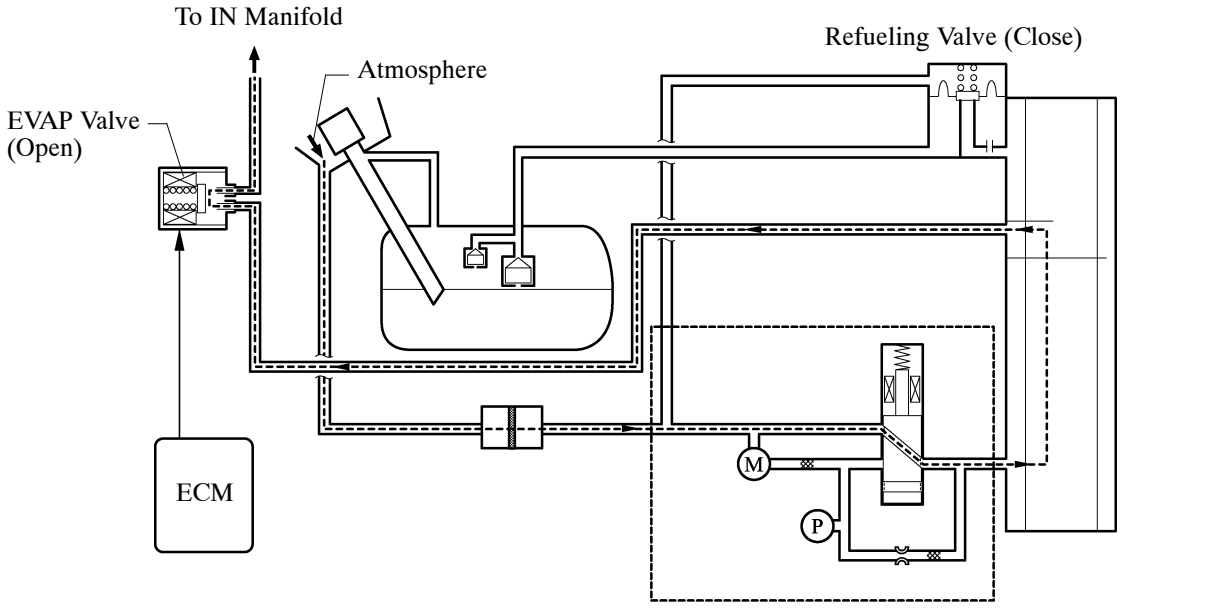
▶ Simple Diagram ◀



System Operation

1) Purge Flow Control

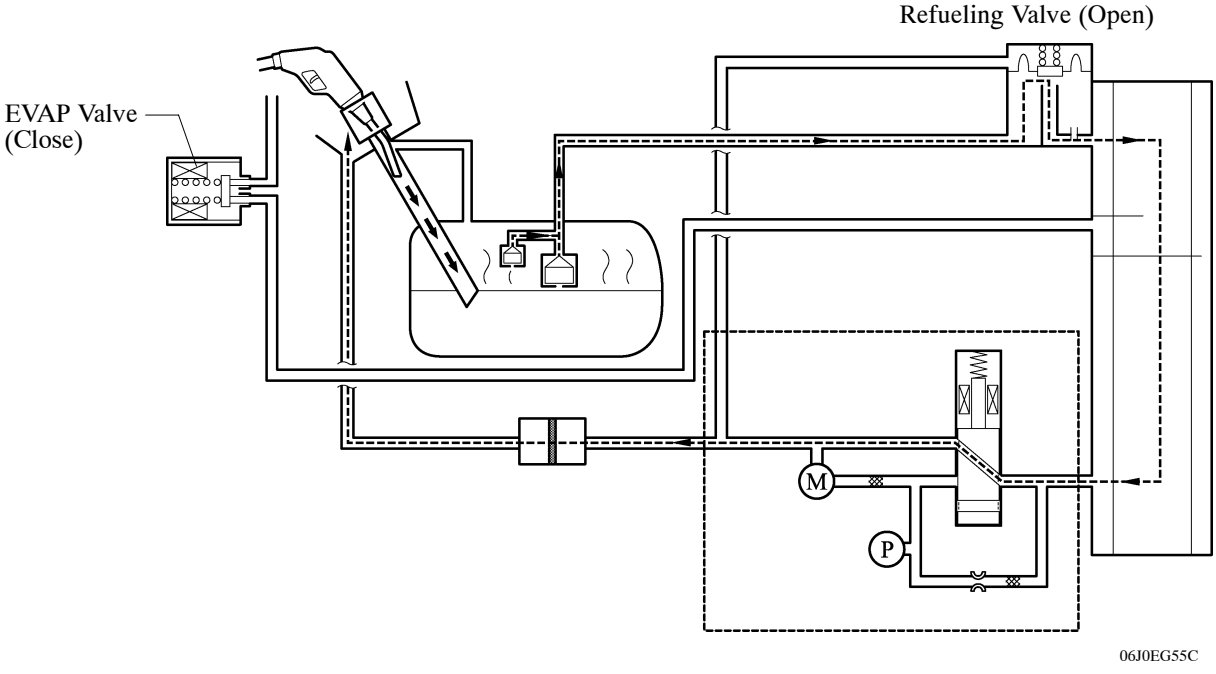
When the engine has reached predetermined parameters (closed loop, engine coolant temp. above 80°C (176°F), etc), stored fuel vapor is purged from the charcoal canister assembly whenever the EVAP valve is opened by the ECM.
The ECM will change the duty ratio cycle of the EVAP valve, thus controlling purge flow volume. Purge flow volume is determined by intake manifold pressure and the duty ratio cycle of the EVAP valve. Atmospheric pressure is allowed into the charcoal canister assembly to ensure that purge flow is constantly maintained whenever purge vacuum is applied to the charcoal canister assembly.



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2) ORVR (Onboard Refueling Vapor Recovery)

When the internal pressure of the fuel tank assembly increases during refueling, this pressure causes the diaphragm in the refueling valve to lift up. This allows the fuel vapor to enter the charcoal canister assembly. The air that has had the fuel vapor removed from it will be discharged through the fresh air line. The canister 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 pressure sensor, which will detect the sudden pressure increase in the fuel tank assembly, and the ECM will open the canister vent valve.

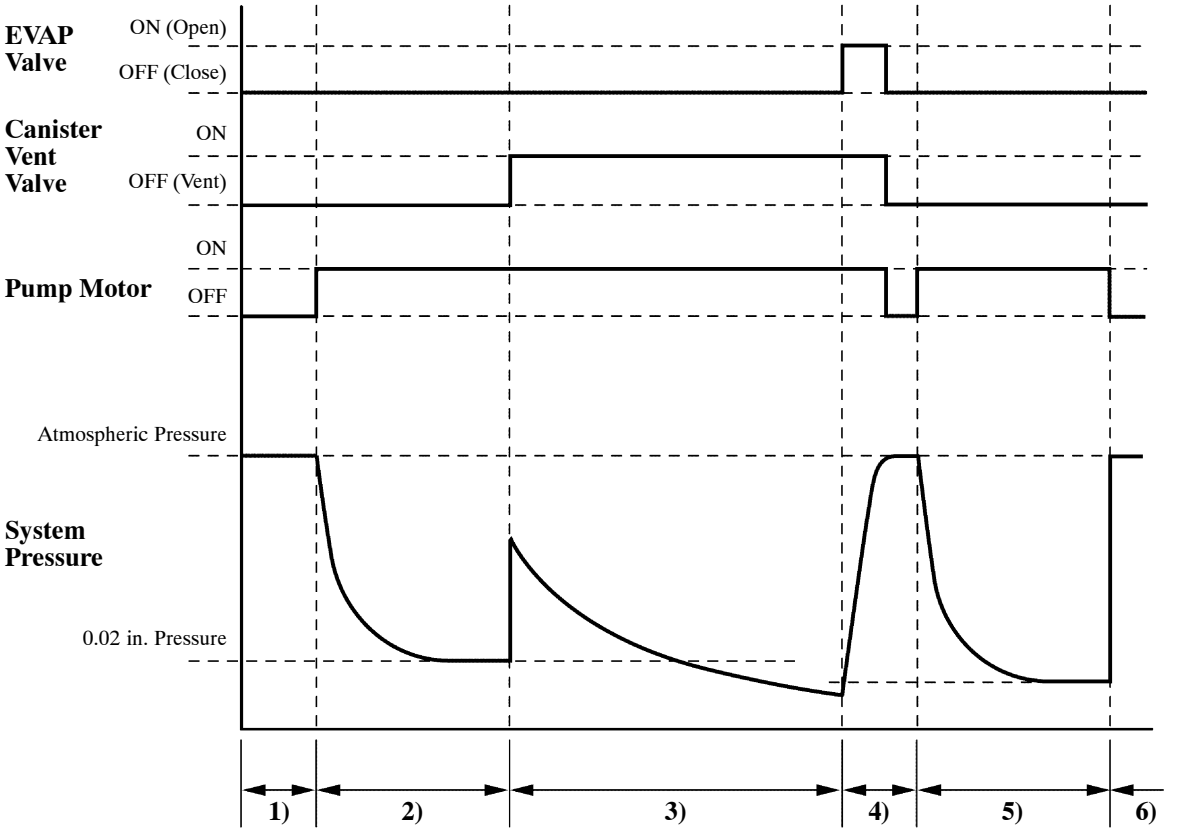


3) EVAP Leak Check

a. General

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

▶ Timing Chart ◀

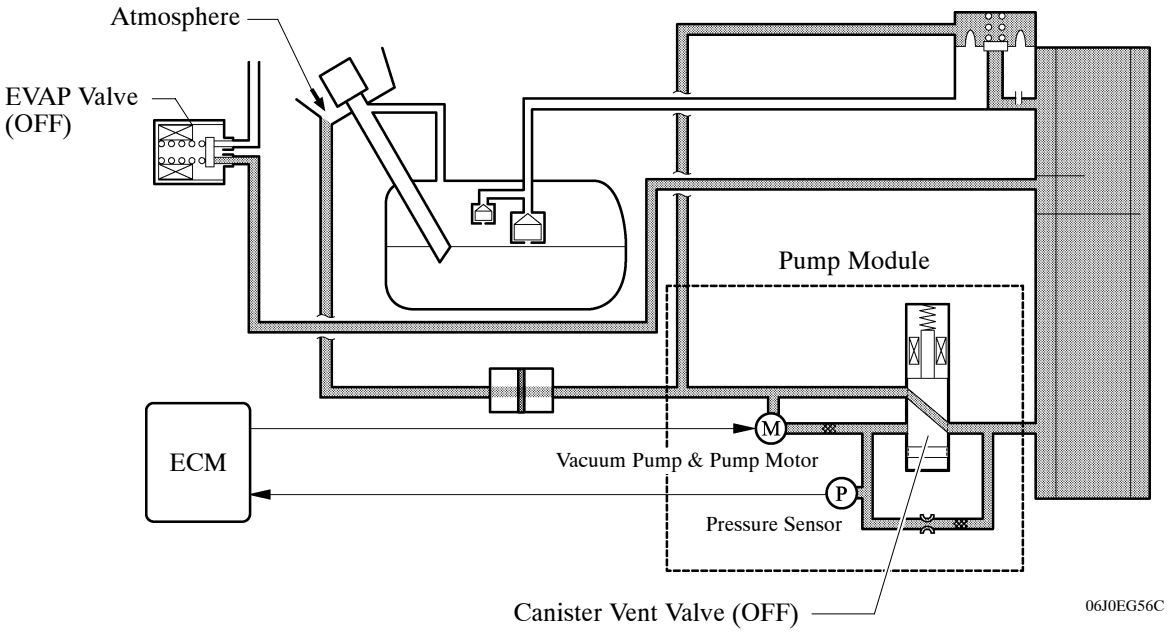


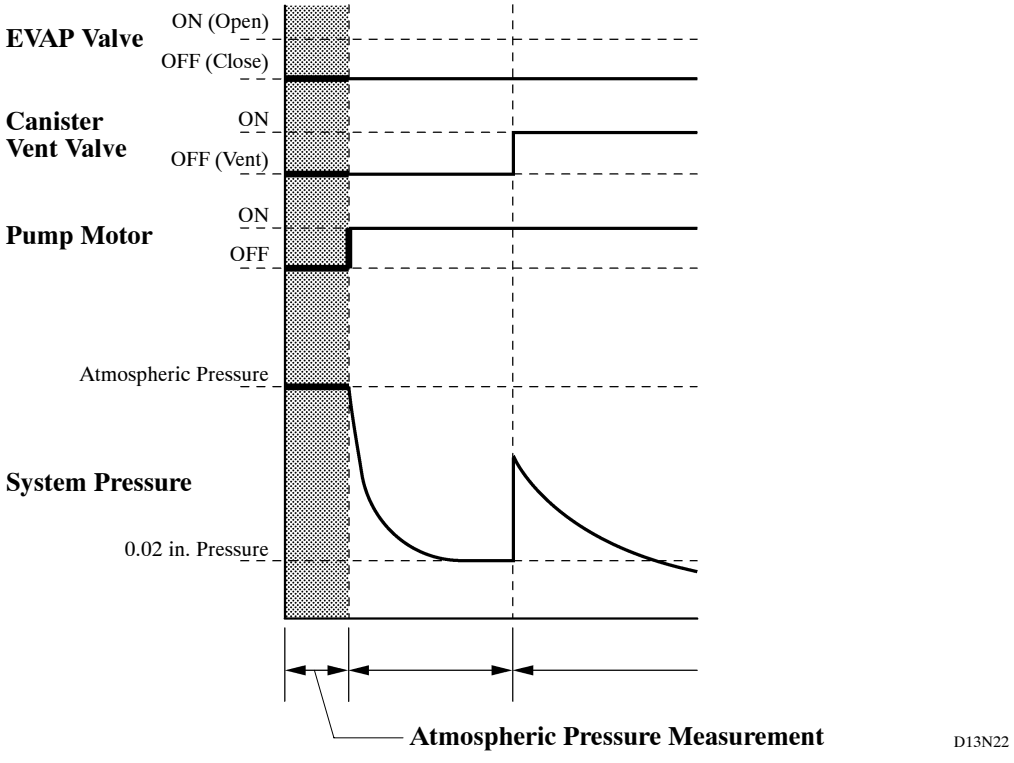
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Order	Operation	Description	Time
1)	Atmospheric Pressure Measurement	The ECM turns the canister vent valve OFF (vent) and measures EVAP system pressure to determine the atmospheric pressure.	—
2)	0.02 in. Leak Pressure Measurement	The vacuum pump creates negative pressure (vacuum), limited by 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 vacuum 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)	EVAP Valve Monitor	The ECM opens the EVAP valve 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 vacuum pump creates negative pressure (vacuum) limited by a 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 EVAP valve and the canister vent valve are turned OFF. Therefore, atmospheric pressure is introduced into the charcoal canister assembly.
2) The ECM measures the atmospheric pressure based on the signals provided by the pressure sensor.
3) If the measurement value is out of range, the ECM actuates the vacuum pump in order to monitor the changes in the pressure.

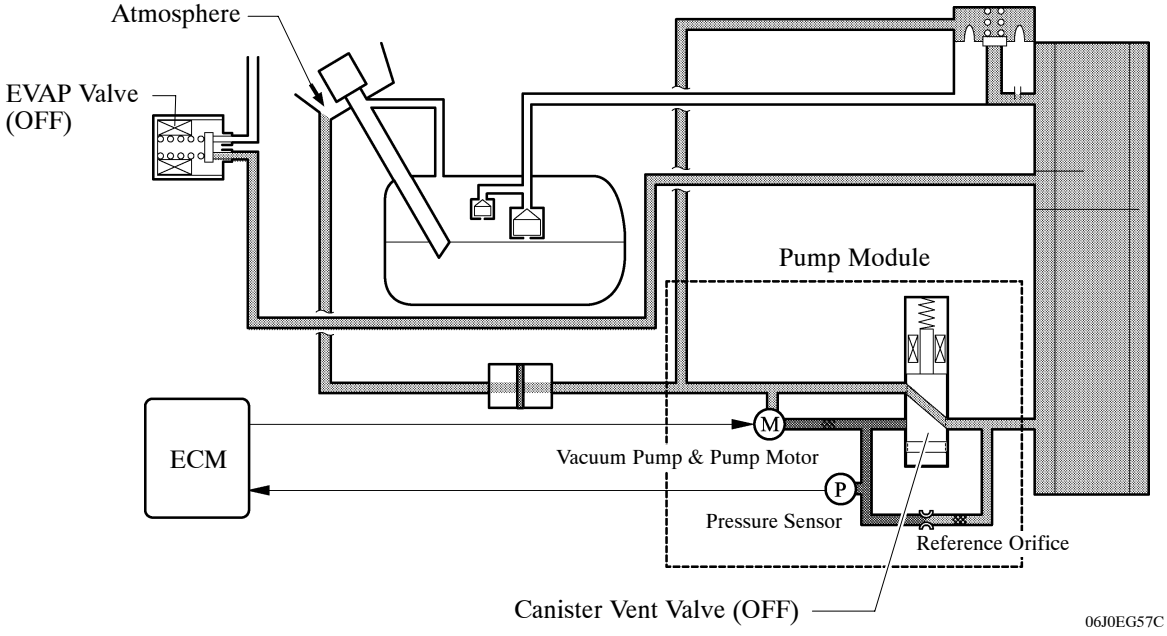




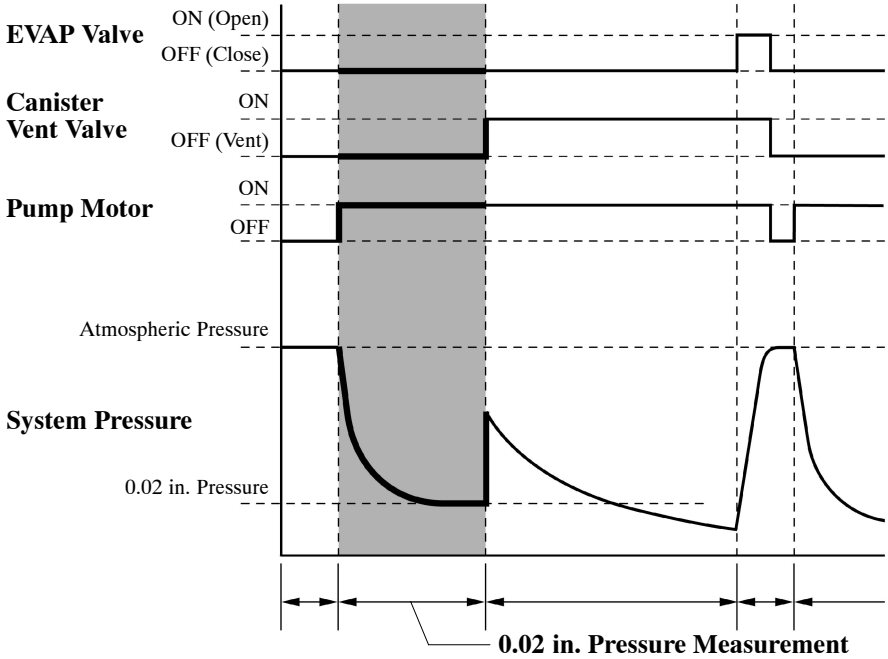
c. 0.02 in. Leak Pressure Measurement

The purpose of this measurement is to confirm vacuum pump operation, and to provide a baseline measurement value that will be used for comparison in subsequent leak test steps.

1) The canister vent valve remains off, the ECM allows atmospheric pressure into the charcoal canister assembly and actuates the vacuum pump, creating a vacuum in the piping close to the pressure sensor.
2) At this time, the pressure will not decrease below what is referred to as the 0.02 in. pressure due to the atmospheric pressure that enters the piping close to the pump and sensor through the 0.02 in. diameter reference orifice.
3) The ECM compares its standard and this pressure. If the pressure is within the acceptable range, the ECM stores this pressure as the 0.02 in. leak pressure in its memory.
4) If the pressure is below the standard, the ECM will determine that the reference orifice is clogged and store DTC (Diagnostic Trouble Code) P043E in its memory.
5) If the pressure is above the standard, the ECM will determine that a high flow rate pressure is passing through the reference orifice and store DTCs P043F, P2401 and P2402 in its memory.



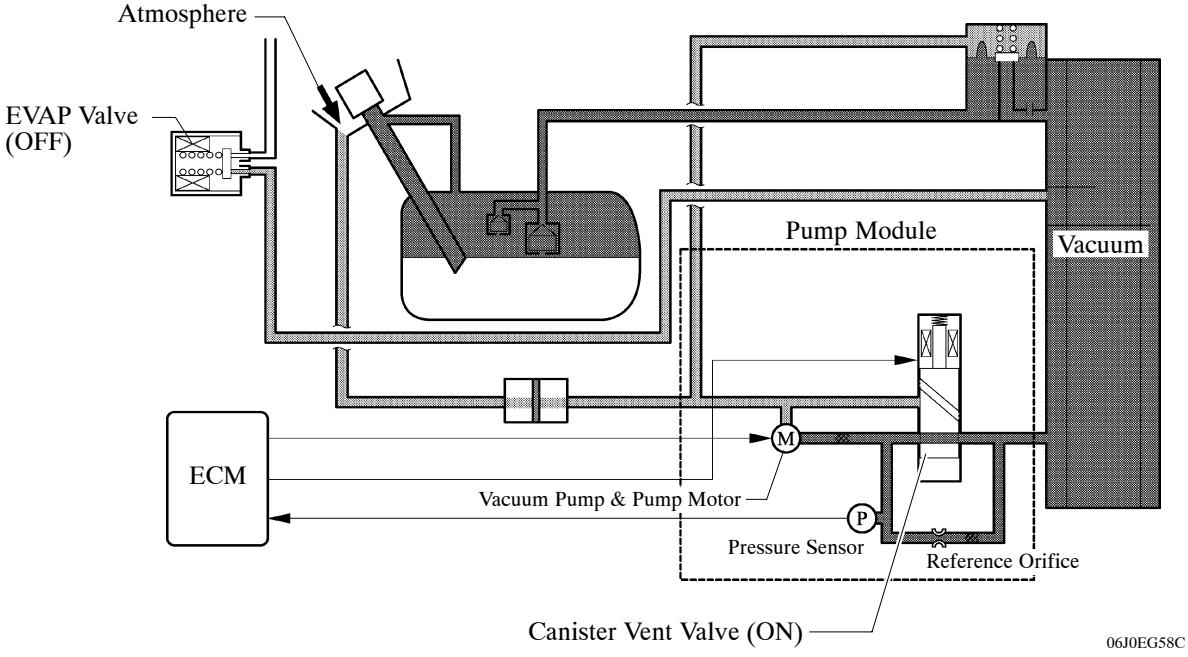
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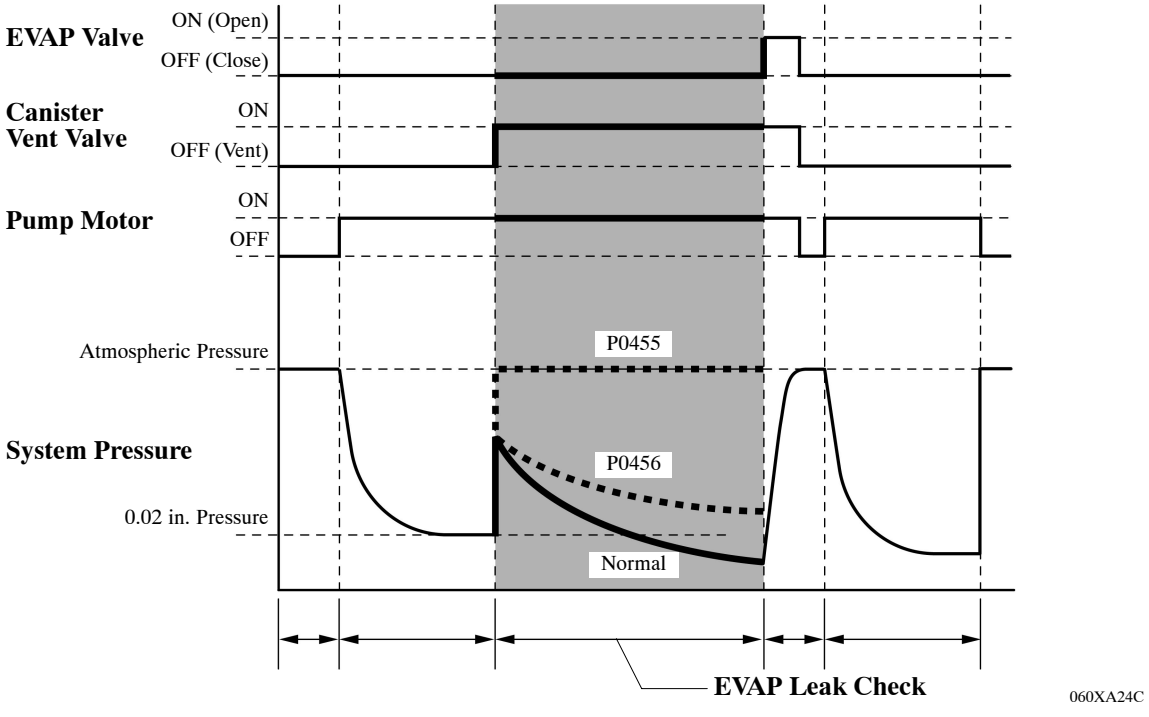


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d. EVAP Leak Check

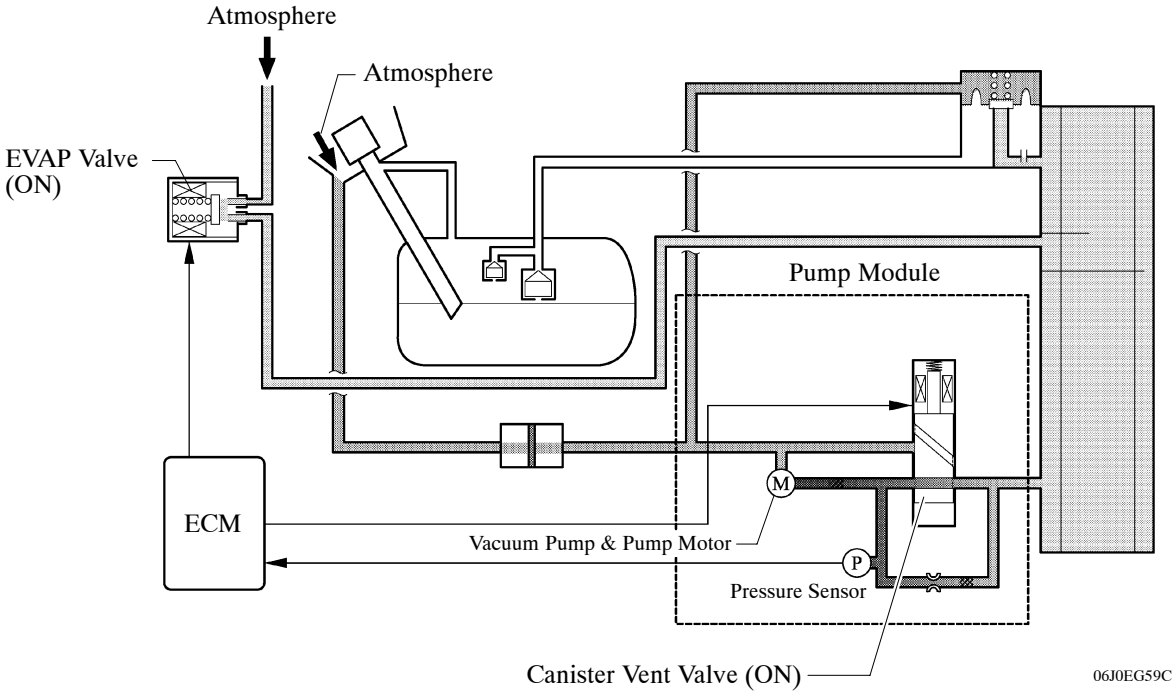
1) While actuating the vacuum pump, the ECM turns the canister vent valve on in order to introduce a vacuum into the charcoal canister assembly.
2) When the pressure in the system stabilizes, the ECM compares this pressure and the 0.02 in. pressure in order to determine if a leak is occurring.
3) If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

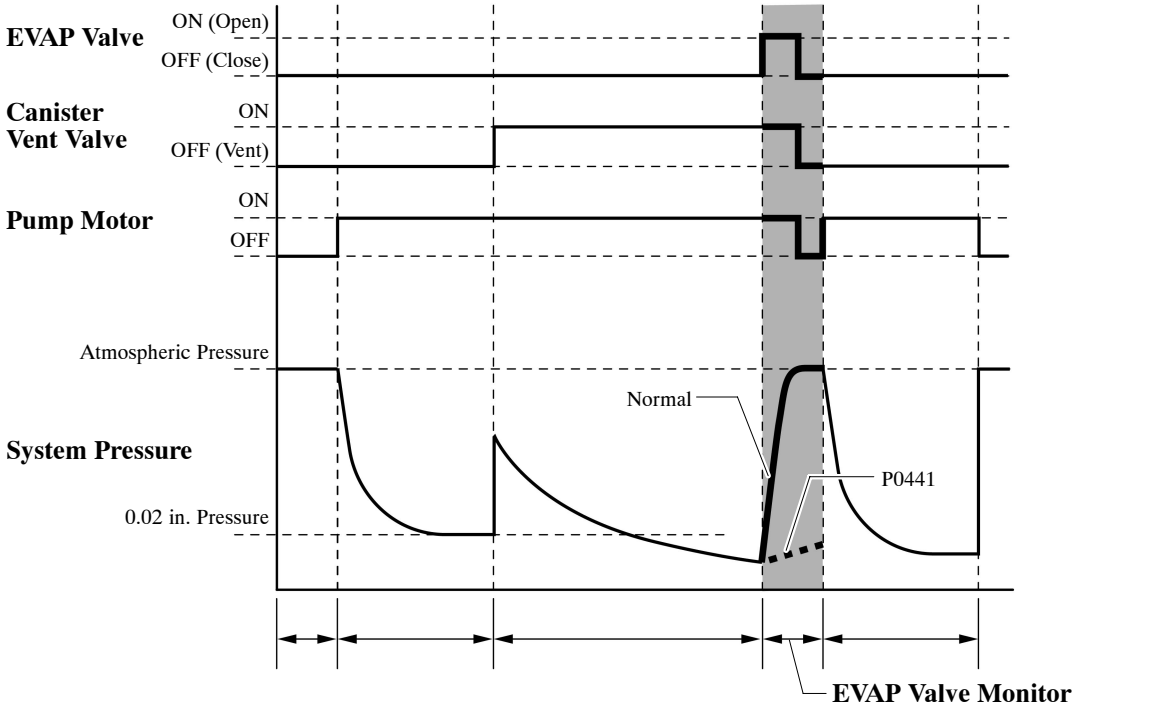




e. EVAP Valve Monitor

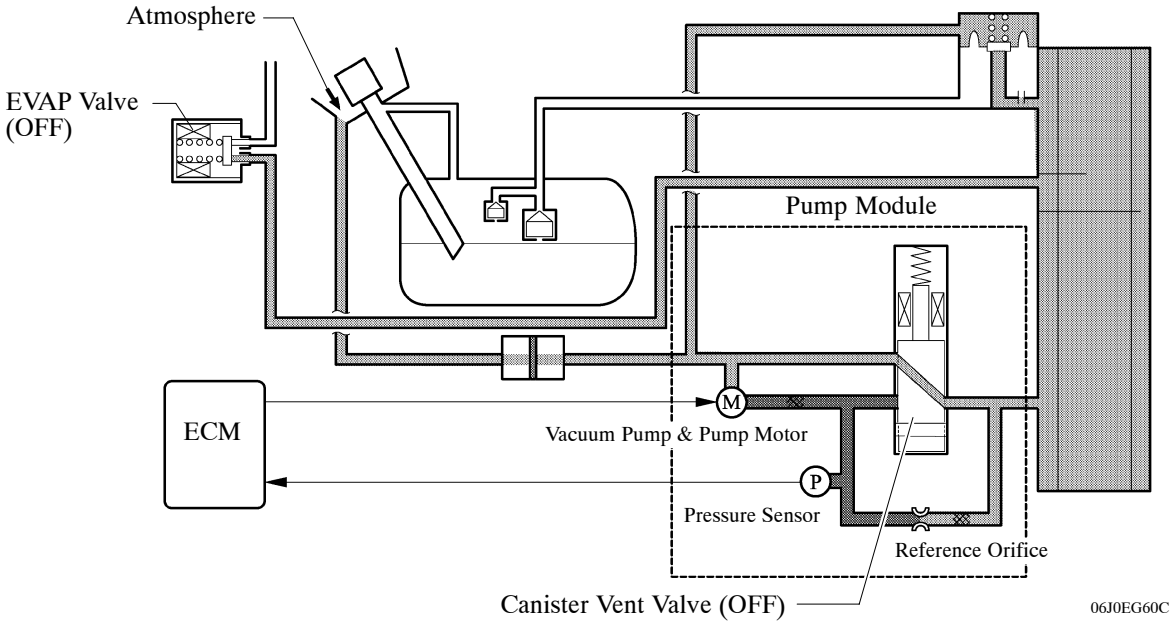
1) After completing an EVAP leak check, the ECM turns the EVAP valve on (open) with the vacuum pump actuated, and introduces the atmospheric pressure from the intake manifold to the charcoal canister assembly.
2) If the pressure change at this time is within the normal range (a pressure change occurs), the ECM determines the condition to be normal.
3) If the pressure change is out of the normal range (insufficient pressure change occurs), the ECM will stop the EVAP valve monitor and store DTC P0441 in its memory.

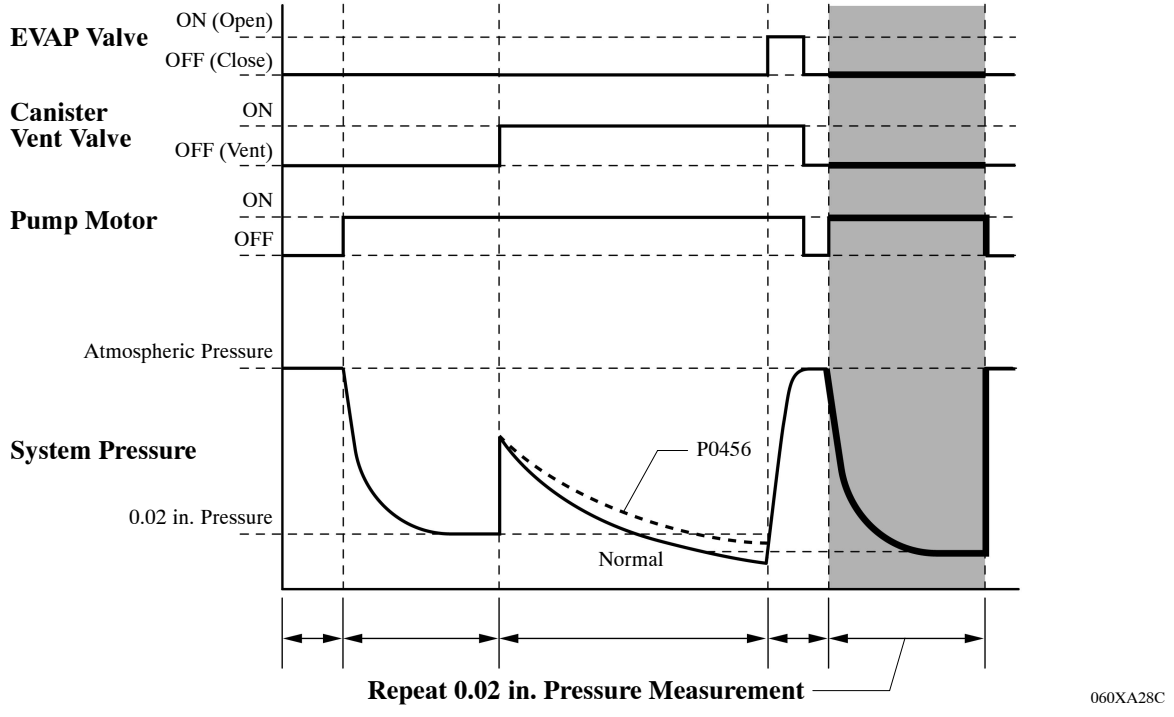




f. Repeat 0.02 in. Leak Pressure Measurement

1) While the ECM operates the vacuum pump, the EVAP valve and canister vent valve are turned 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 less than the repeat 0.02 in. leak pressure measurement, the ECM determines that there is no leakage.
4) If the pressure during the EVAP leak check is above the repeat 0.02 in. leak pressure measurement, the ECM determines that there is a small leak and stores DTC P0456 in its memory.





16. Diagnosis

- When the ECM detects a malfunction, the ECM stores the fault and information that relates to the fault. Furthermore, the ECM illuminates the MIL (Malfunction Indicator Lamp) in the combination meter assembly to inform the driver.
- The ECM will also store the DTCs (Diagnostic Trouble Codes) of the malfunctions. The DTCs can be accessed using the intelligent tester or Techstream*.
- For details, see the 2008 HIGHLANDER Repair Manual (Pub. No. RM06J0U).

Service Tip

- The ECM uses the CAN protocol for diagnostic communication. Therefore, an intelligent tester and a dedicated adapter [CAN VIM (Vehicle Interface Module)] or Techstream* are required for accessing diagnostic data. For details, see the 2008 HIGHLANDER Repair Manual (Pub. No. RM06J0U).
- To clear a DTC that is stored in the ECM, use an intelligent tester or Techstream*, disconnect the battery terminal or remove the EFI fuse for 1 minute or longer.

*: Techstream is the name for the diagnostic tester in North America, but other countries will continue to use the intelligent tester.

17. Fail-Safe

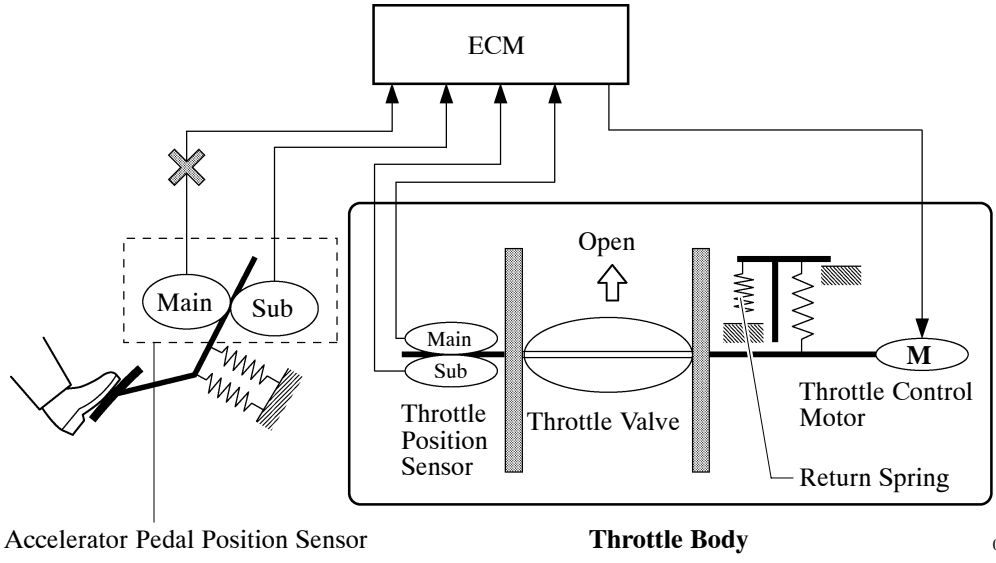
General

When the ECM detects a malfunction, the ECM stops or controls the engine according to the data already stored in the memory.
For details of the fail-safe chart, see the 2008 HIGHLANDER Repair Manual (Pub. No. RM06J0U).

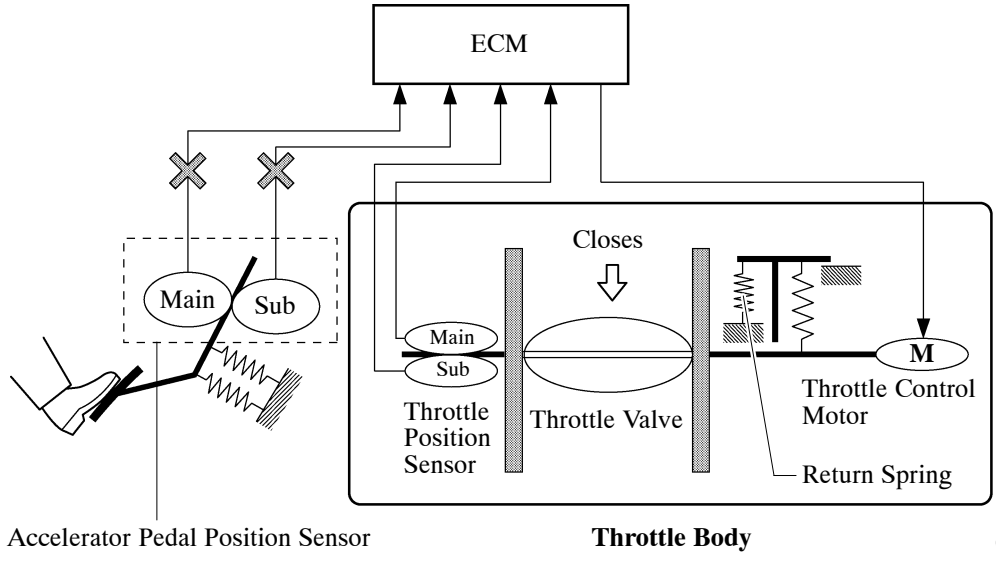
Fail-safe Operation due to Accelerator Pedal Position Sensor Malfunction

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 throttle control. At this time, the vehicle can be driven using the power generated by the engine at idle.



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.

