■ENGINE CONTROL SYSTEM

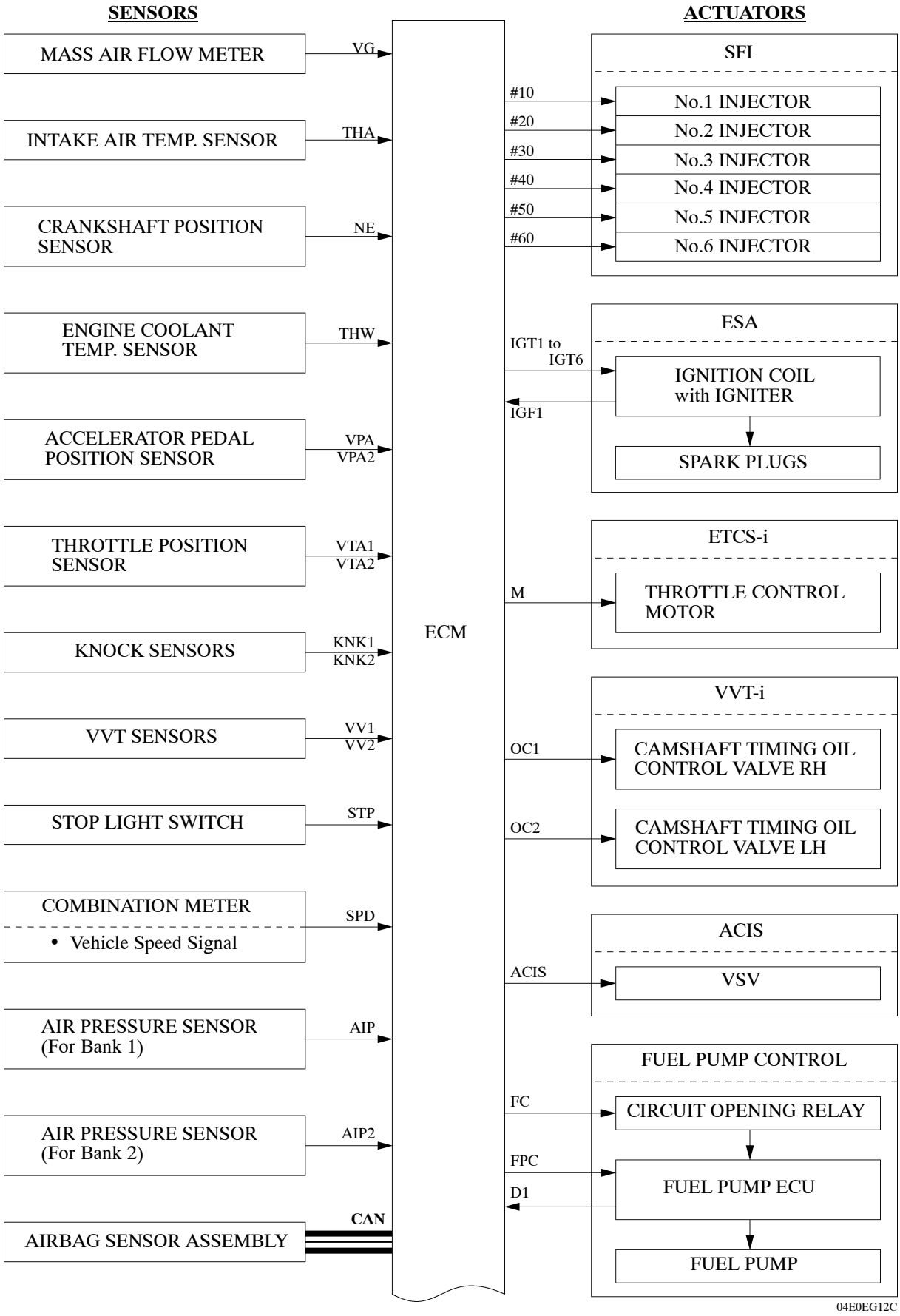
1. General

The engine control system of the 1GR-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-52]	A L-type SFI system detects the intake air volume with a hot-wire type mass air flow meter.
ESA (Electronic Spark Advance)	• This ECM determines the optimal ignition timing in accordance with the signals received from the sensors and sends (IGT) ignition signal to the igniter. • The ECM corrects ignition timing in response to engine knocking.
ETCS-i (Electronic Throttle Control System-intelligent) [See page EG-53]	Optimally controls the opening angle of the throttle valve in accordance with the accelerator pedal input and the engine and vehicle conditions.
VVT-i (Variable Valve Timing-intelligent) [See page EG-55]	Controls the intake camshafts to optimal valve timing in accordance with the engine condition.
ACIS (Acoustic Control Induction System) [See page EG-60]	The intake air passages are switched based on engine speed and throttle valve opening angle to provide high performance in all engine speed ranges.
Fuel Pump Control [See page EG-63]	• 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-65]	The ECM controls the air injection time based on the signals from the crankshaft position sensor, engine coolant temp. sensor, mass air flow meter and air pressure sensor.
Cranking Hold Function (Starter Control) [See page EG-69]	Once the ignition switch is turned to the START position, this control operates the starter until the engine starts.
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.
Evaporative Emission Control [See page EG-71]	• The ECM controls the purge flow of evaporative emission (HC) in the charcoal canister in accordance with 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 charcoal canister. The ECM can detect leaks by monitoring for changes in the fuel tank pressure.
Air Conditioning Cut-off Control	By turning the air conditioning compressor ON or OFF in accordance with the engine condition, drivability is maintained.
Diagnosis [See page EG-83]	When the ECM detects a malfunction, the ECM records the malfunction and memorizes information related to the fault.
Fail-Safe [See page EG-83]	When the ECM detects a malfunction, the ECM stops or controls the engine according to the data already stored in the memory.

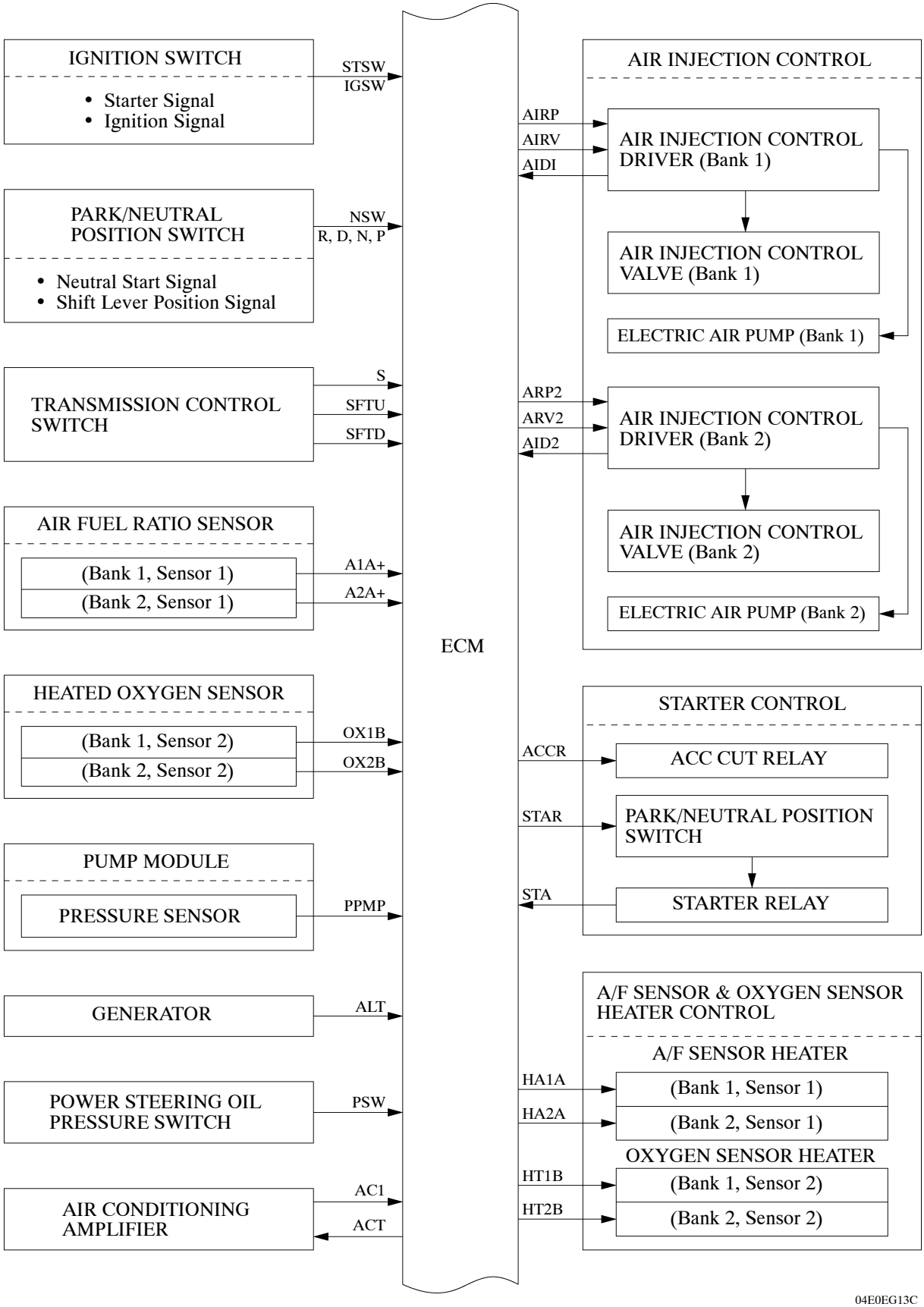
2. Construction

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



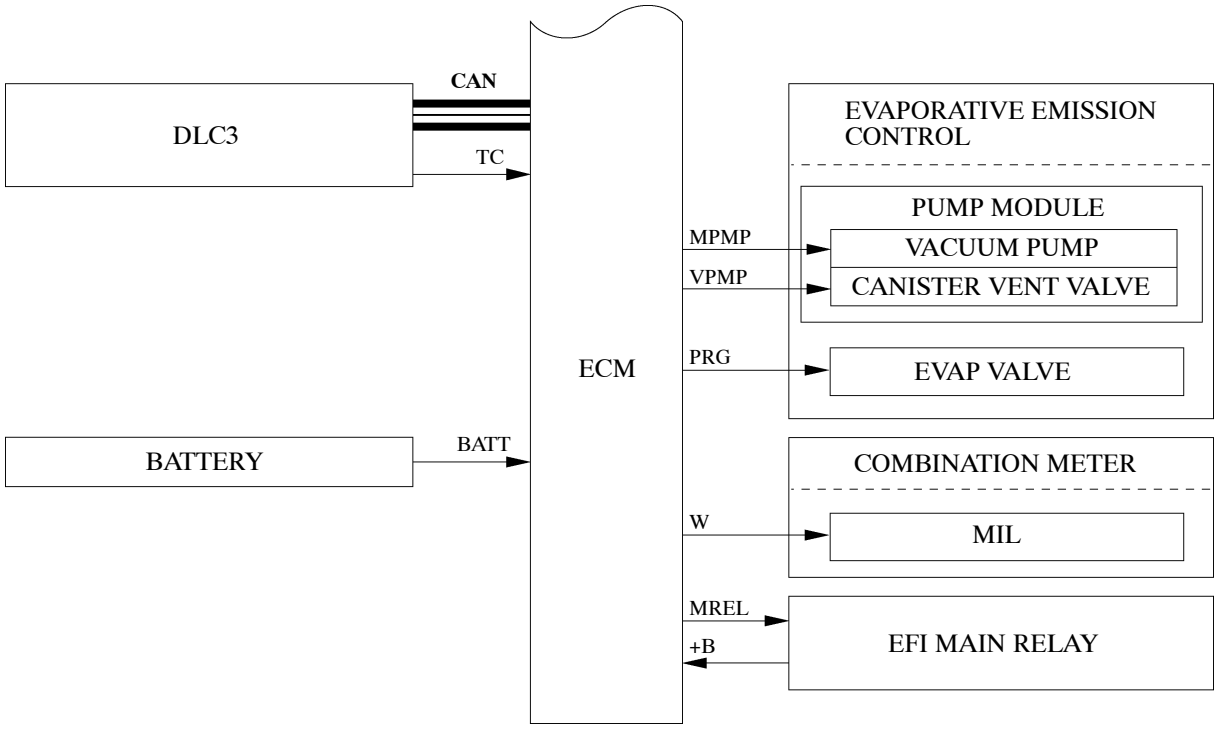
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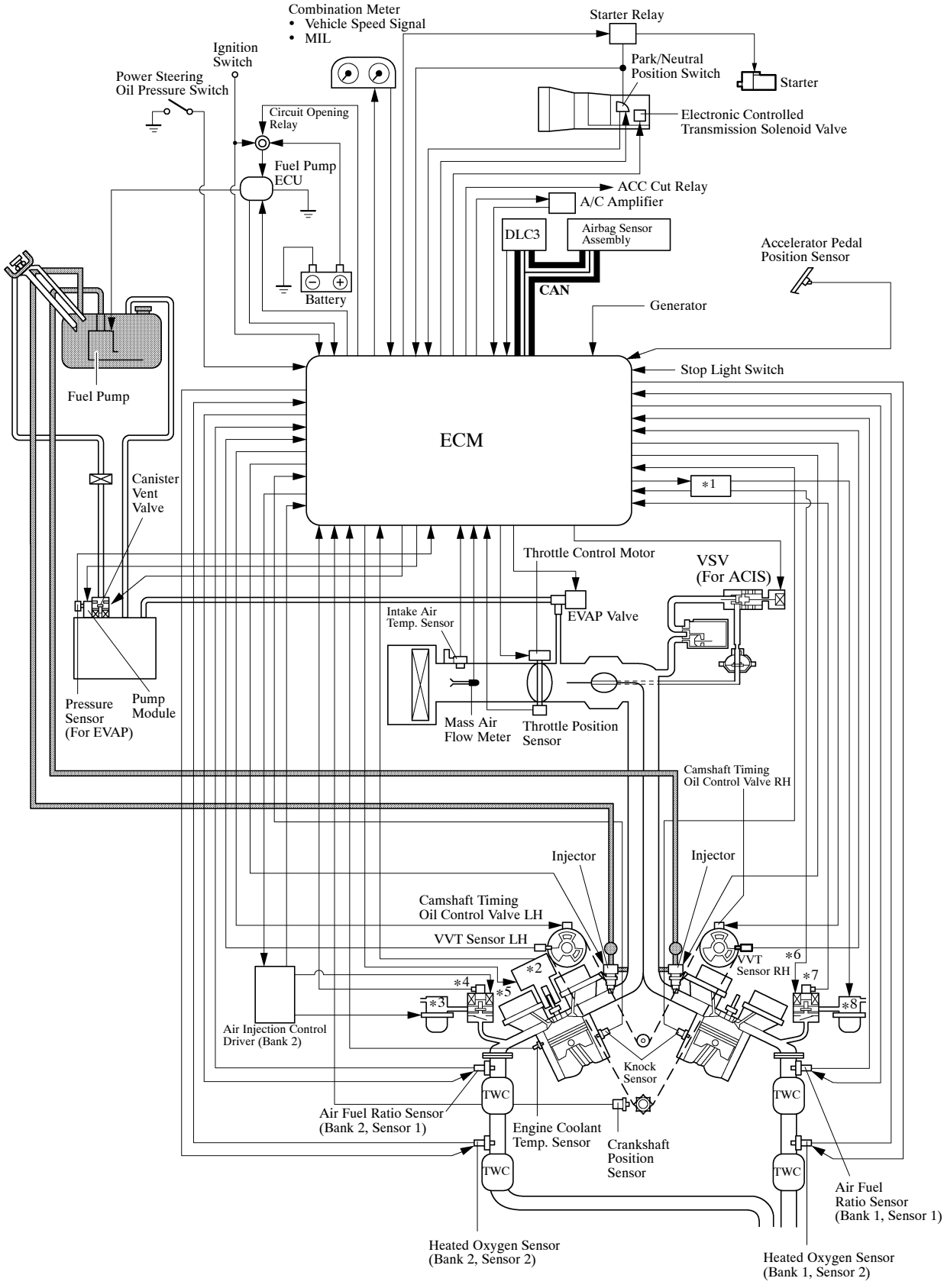
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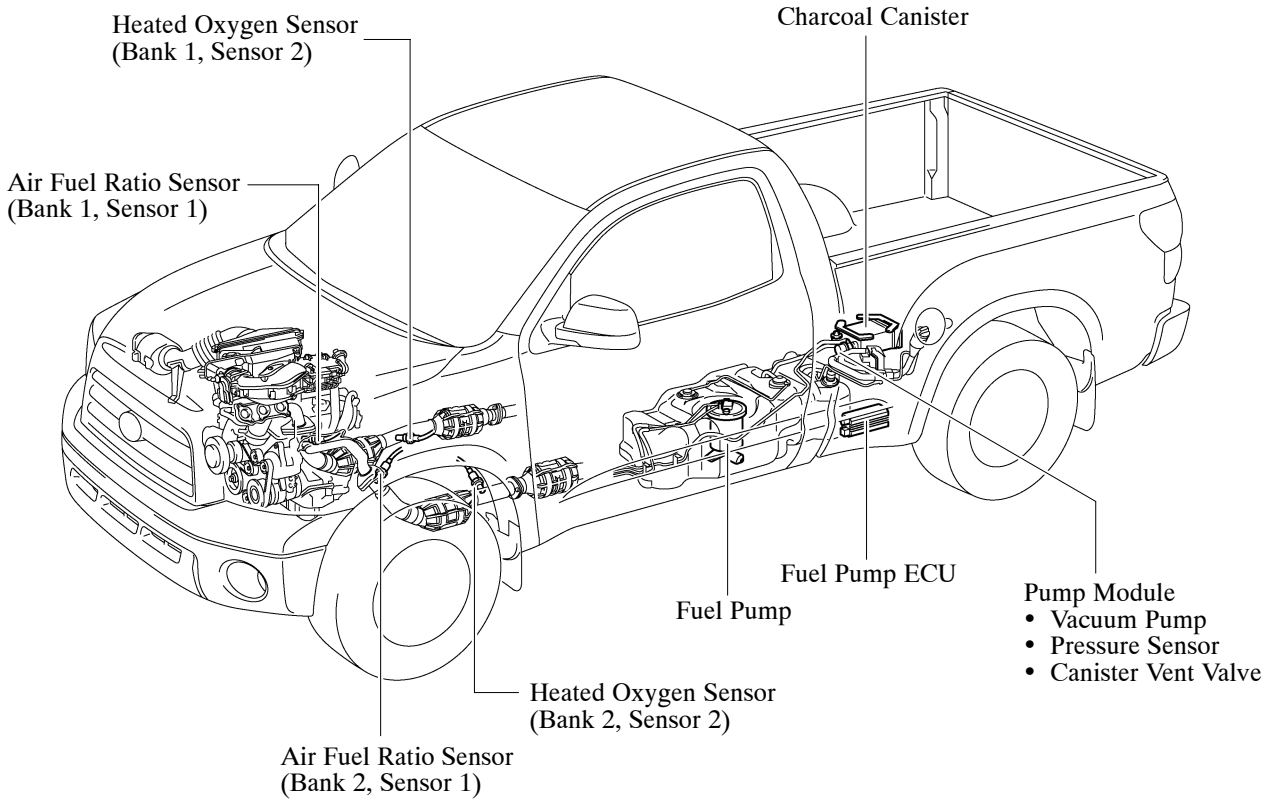
3. Engine Control System Diagram



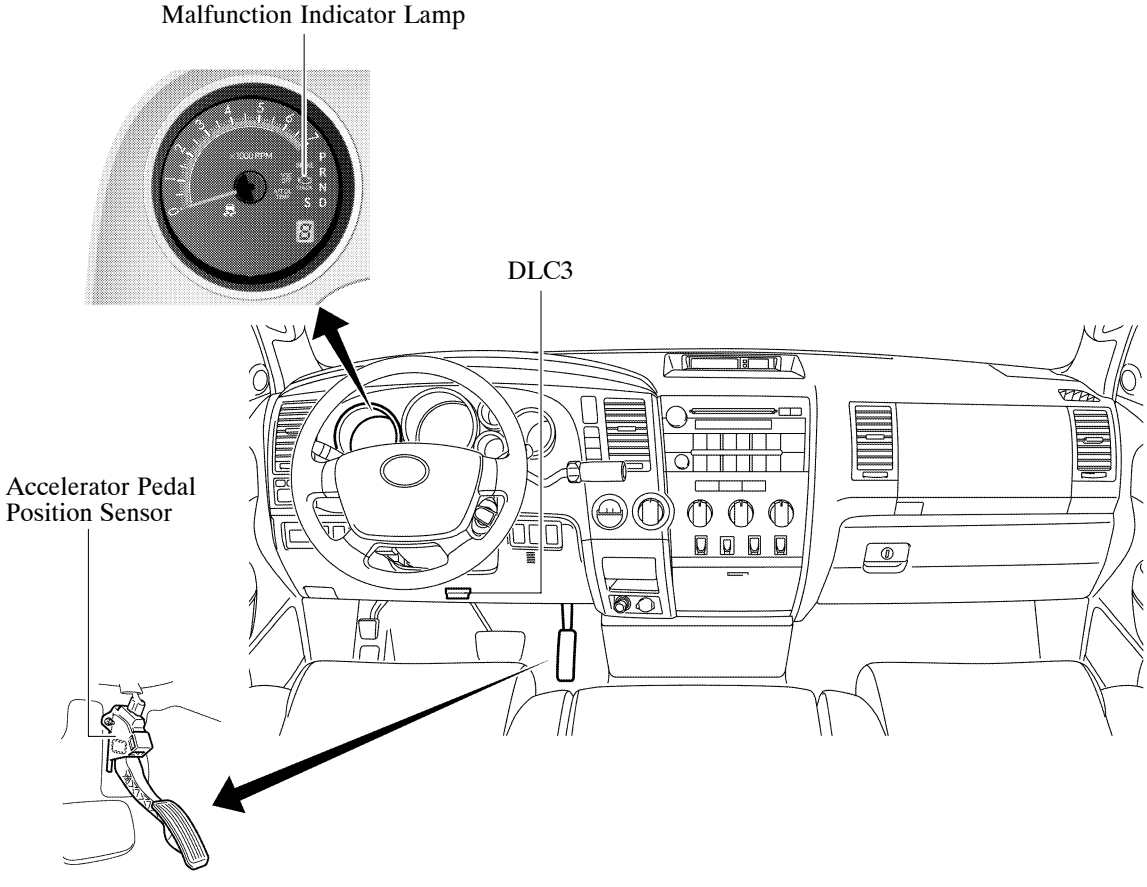
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*1: Air Injection Control Driver (Bank 1) *2: Ignition Coil with Igniter *3: Electric Air Pump (Bank 2)
*4: Air Pressure Sensor (Bank 2) *5: Air Injection Control Valve (Bank 2) *6: Air Injection Control Valve (Bank 1)
*7: Air Pressure Sensor (Bank 1) *8: Electric Air Pump (Bank 1)

4. Layout of Main Components

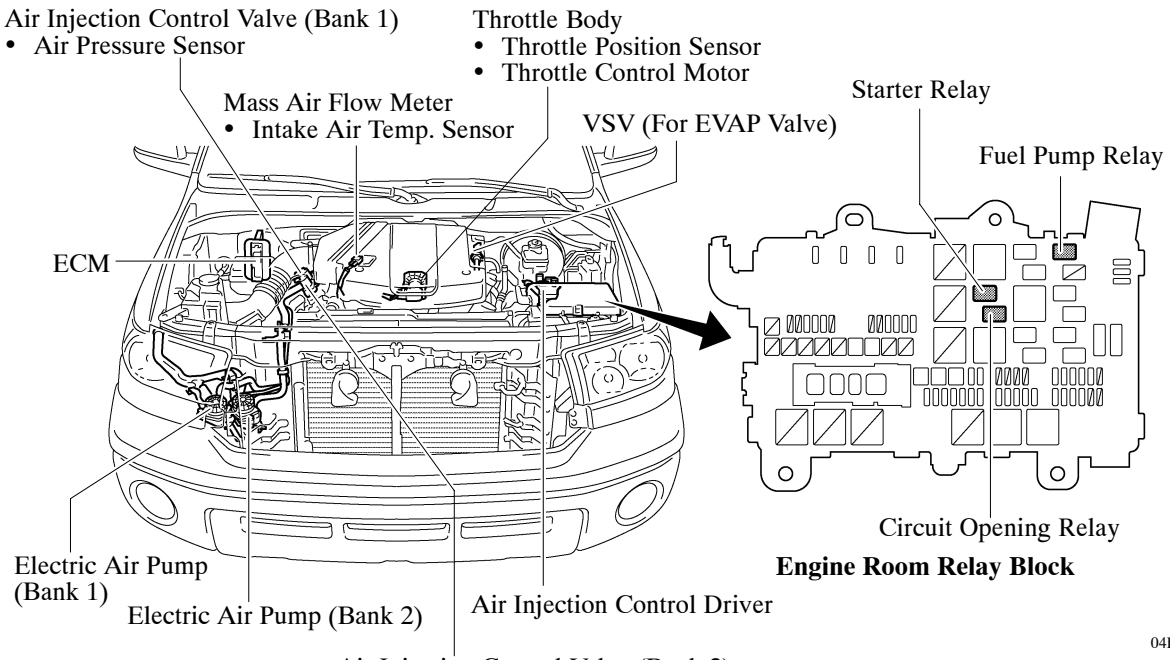


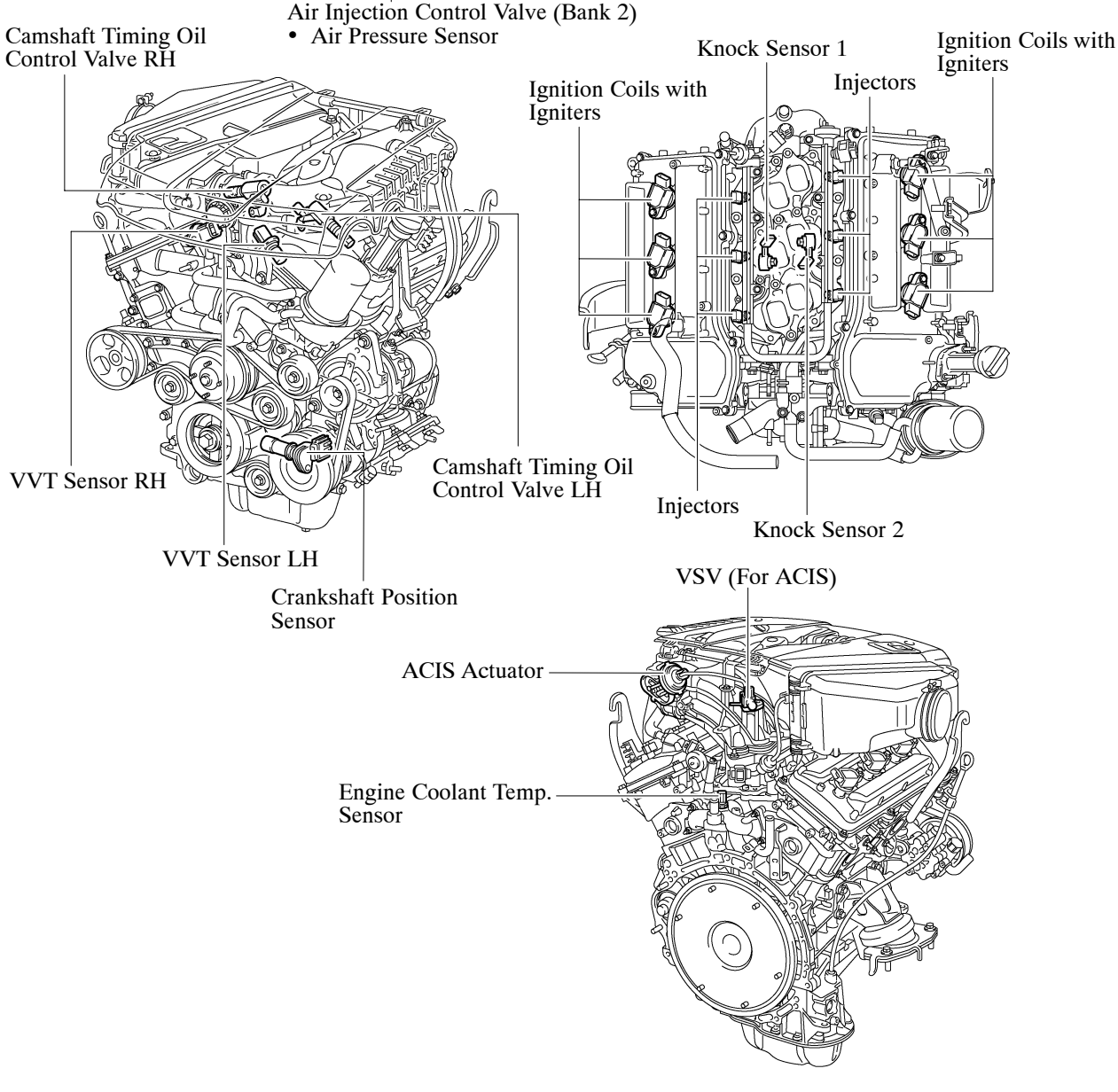
04E0EG15Z



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EG


Air Injection Control Valve (Bank 1)
• Air Pressure Sensor
Throttle Body
• Throttle Position Sensor
• Throttle Control Motor
Mass Air Flow Meter
• Intake Air Temp. Sensor
VSV (For EVAP Valve)
Starter Relay
Fuel Pump Relay
ECM
Circuit Opening Relay
Engine Room Relay Block
Electric Air Pump (Bank 1)
Electric Air Pump (Bank 2)
Air Injection Control Driver
Air Injection Control Valve (Bank 2)
• Air Pressure Sensor
04E0EG17Z


Camshaft Timing Oil Control Valve RH
Knock Sensor 1
Ignition Coils with Igniters
Injectors
Ignition Coils with Igniters
VVT Sensor RH
Camshaft Timing Oil Control Valve LH
Injectors
Knock Sensor 2
VVT Sensor LH
Crankshaft Position Sensor
VSV (For ACIS)
ACIS Actuator
Engine Coolant Temp. Sensor
04E0EG18C

5. Main Components of Engine Control System

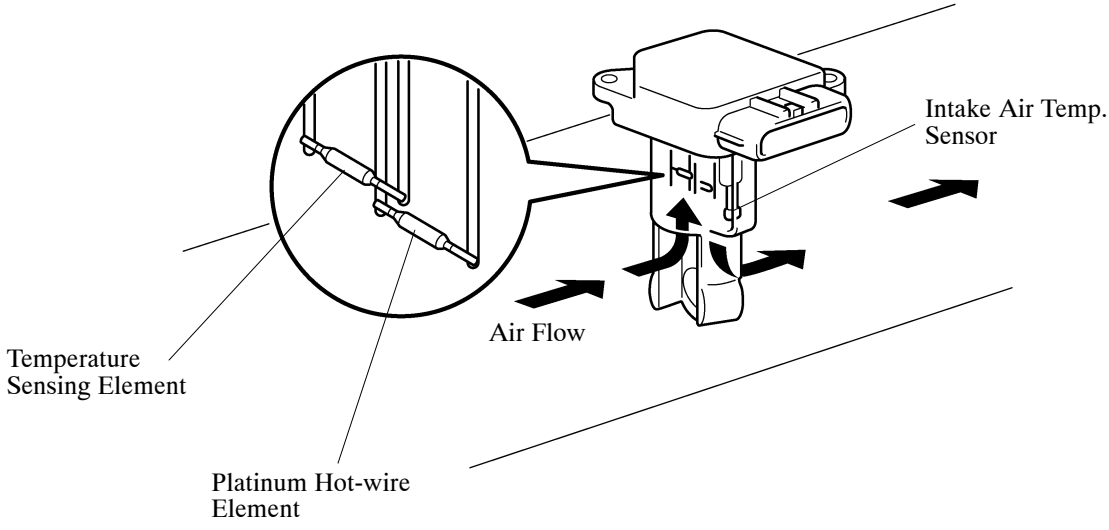
General

The main components of the 1GR-FE engine control system are as follows:

Components		Outline	Quantity
ECM (Supplier)		32-bit CPU (DENSO)	1
Mass Air Flow Meter (Built-in Intake Air Temperature Sensor)		Hot-wire Type	1
Crankshaft Position Sensor (Rotor Teeth)		Pick-up Coil Type (36 - 2)	1
VVT Sensors (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 Sensors		Built-in Piezoelectric Type (Non-resonant Type/Flat Type)	2 (1 each bank)
Air Fuel Ratio Sensors	Bank 1, Sensor 1	Heated Type (Planar Type)	2 (1 each bank)
	Bank 2, Sensor 1		
Heated Oxygen Sensors	Bank 1, Sensor 2	Heated Type (Cup Type)	2 (1 each bank)
	Bank 2, Sensor 2		
Injectors		12-hole Type	6

Mass Air Flow Meter

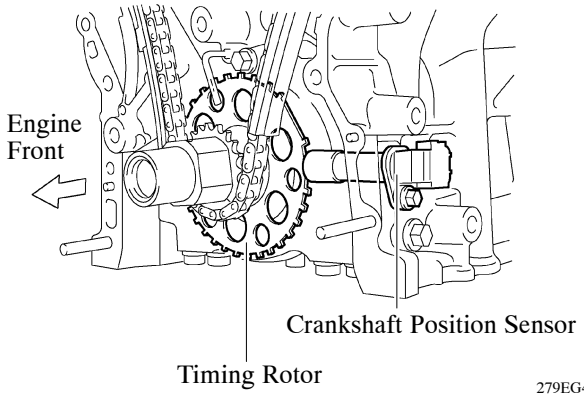
- This mass air flow meter, which is a plug-in type, allows a portion of the intake air to flow through the detection area. By directly measuring the mass and the flow rate of the intake air, the detection precision is improved and the intake air resistance is reduced.
- This mass air flow meter has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



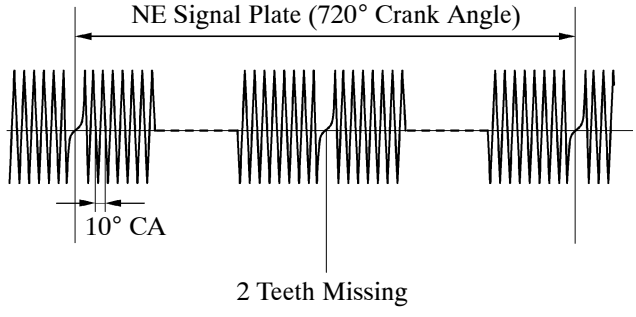
204EG54

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.



279EG49



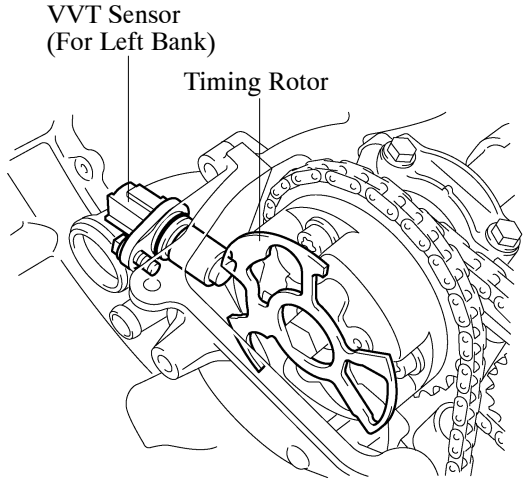
279EG50

VVT Sensor

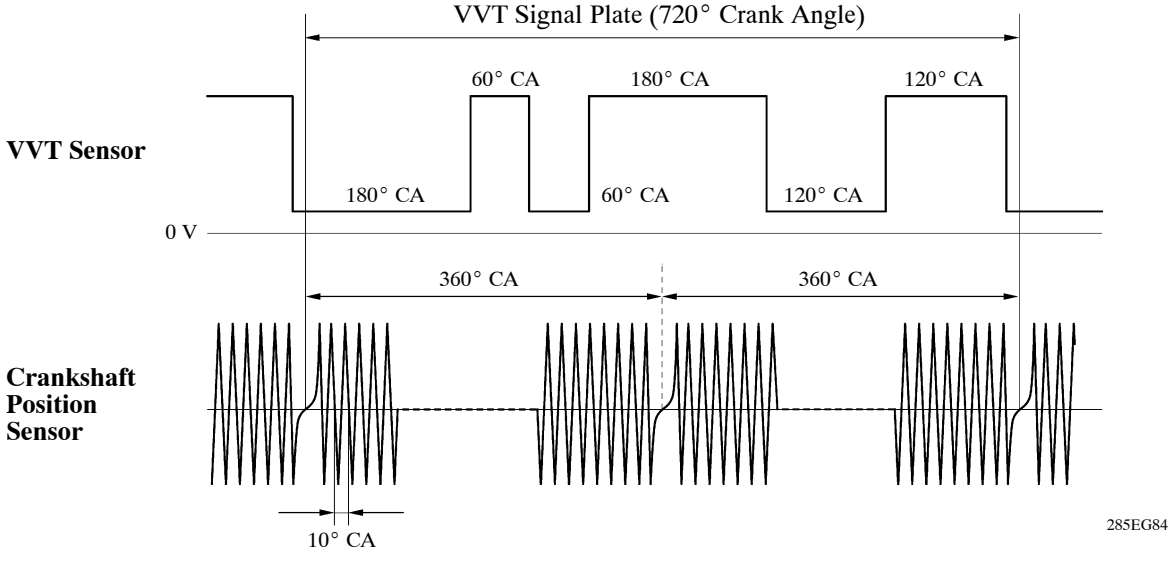
1) General

MRE (Magnetic Resistance Element) type intake VVT sensors are used. To detect the camshaft position, a timing rotor that is secured to the camshaft in front of the VVT controller is used to generate 3 (3 Hi Output, 3 Lo Output) pulses for every 2 revolutions of the crankshaft.

- An MRE type VVT 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.



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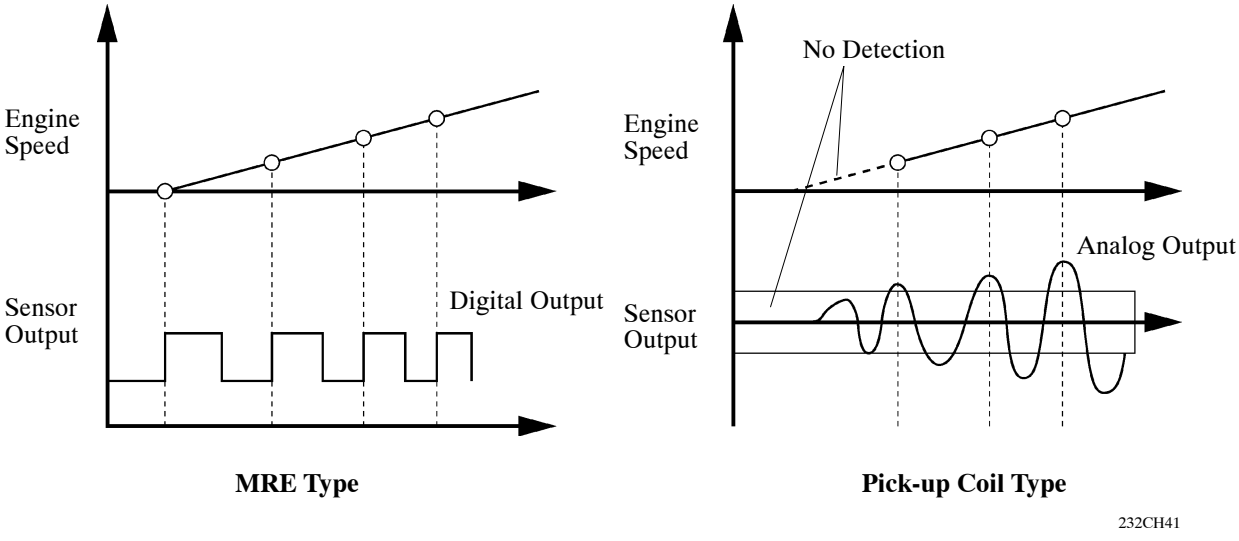
Correlation of Output Waveform between VVT Sensor and Crankshaft Position Sensor

2) MRE Type VVT Sensor

The differences between an MRE type VVT sensor and a pickup coil type VVT sensor are as follows.

Sensor Type	MRE Type Sensor	Pick-up Coil Type Sensor
Signal Output	Constant digital output starts from low engine speed.	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 VVT 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 (engine speed) signals input during a Hi/Lo output cycle.	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.

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



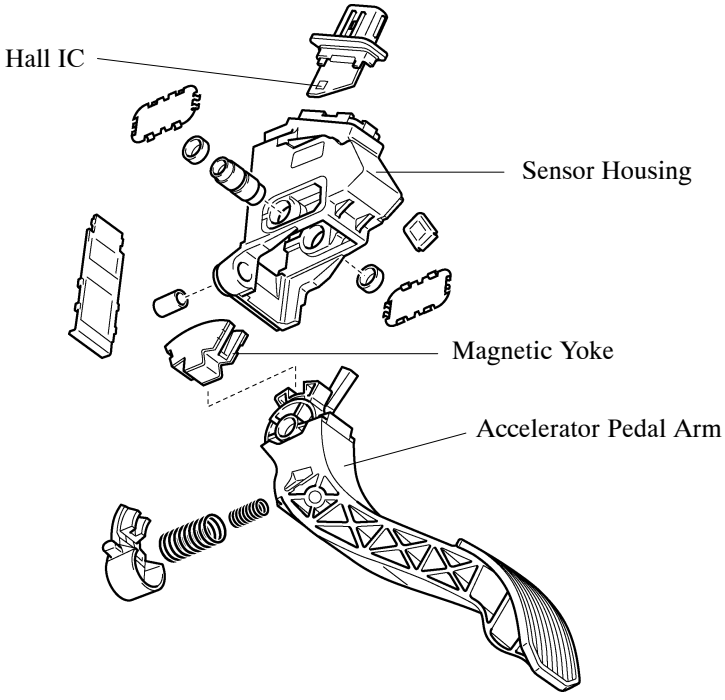
MRE Type **Pick-up Coil Type**

232CH41

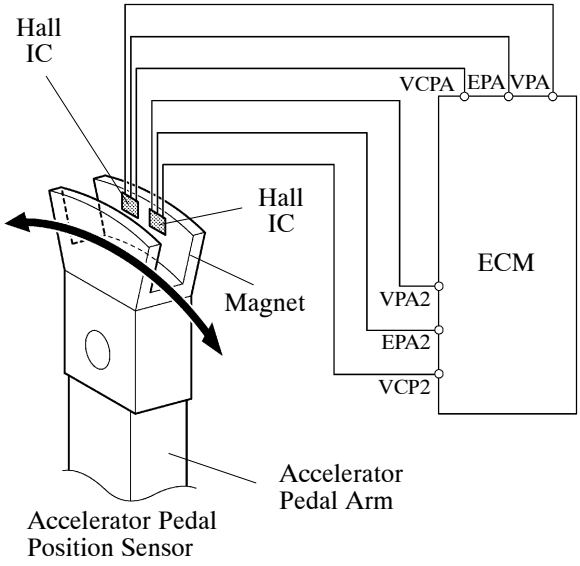
Accelerator Pedal Position Sensor

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

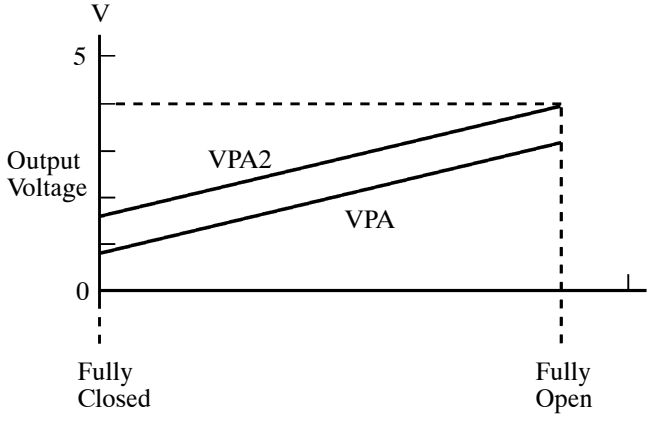
- The magnetic yoke that is mounted at the base of the accelerator pedal arm moves around the Hall IC in accordance with the amount of effort that is applied to the accelerator pedal. The Hall IC converts the changes in the magnetic flux that occur into electrical signals, and outputs them in the form 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 2 electric signals with differing characteristics and outputs them to the ECM.



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285EG72



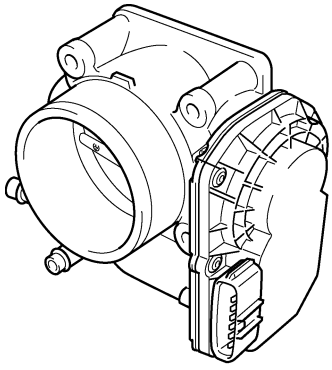
Accelerator Pedal Depression Angle

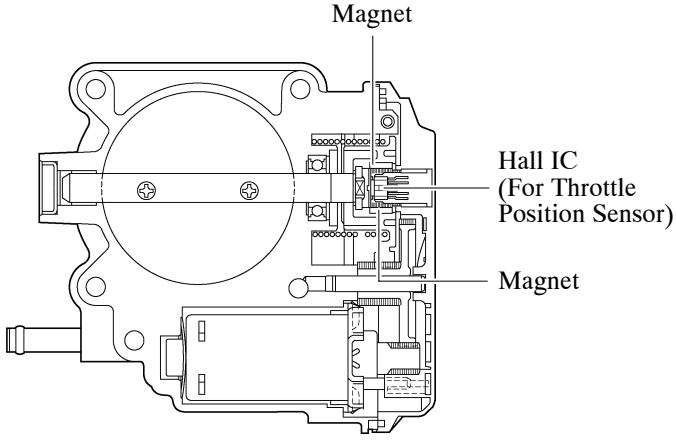
228TU25

Throttle Position Sensor

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

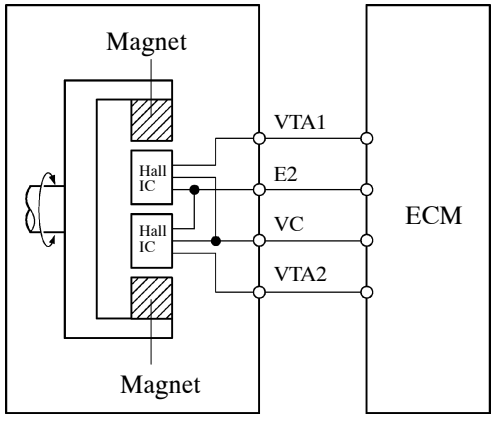
- The Hall IC is surrounded by a magnetic yoke. The Hall IC converts the changes that occur in the magnetic flux into electrical signals, and outputs them in the form of throttle valve position signals to the ECM.
- The Hall IC contains circuits for the main and sub signals. It converts the throttle valve opening angle into 2 electrical signals that have differing characteristics and outputs them to the ECM.



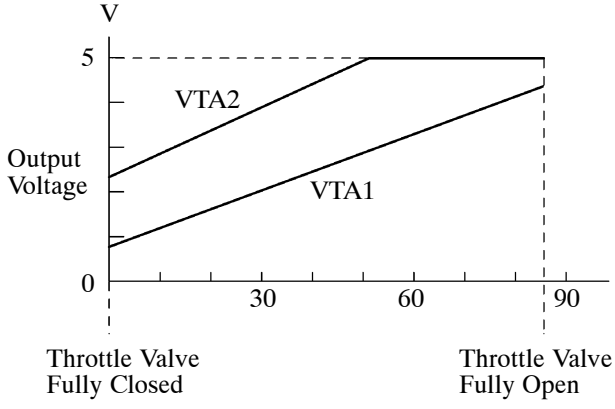


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Cross Section



230LX12



Throttle Valve Opening Angle

238EG79

Knock Sensor (Flat Type)

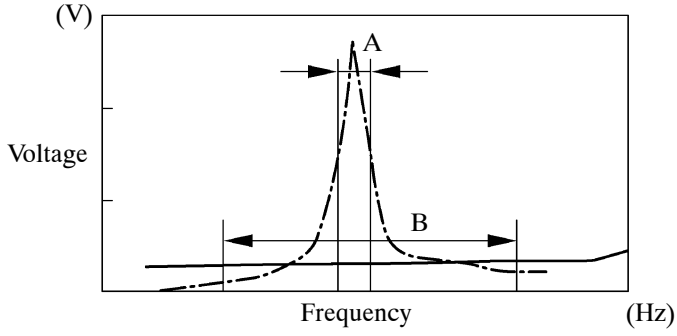
1) General

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.
The other type of knock sensor, 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.

*: 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.

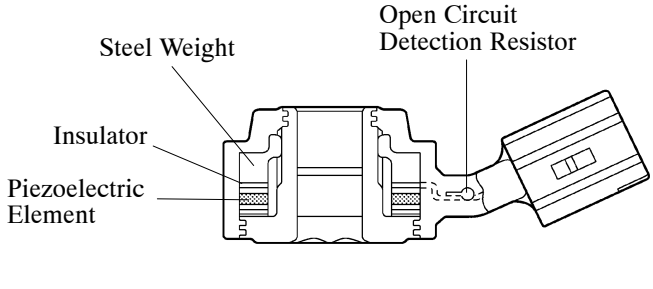
—— - —— : Resonance Characteristic of Conventional Type
———— : Resonance Characteristic of Flat Type



Characteristics of Knock Sensors 214CE04

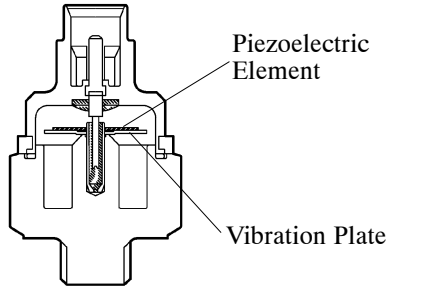
2) Construction

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



214CE01

Flat Type Knock Sensor (Non-Resonant Type)

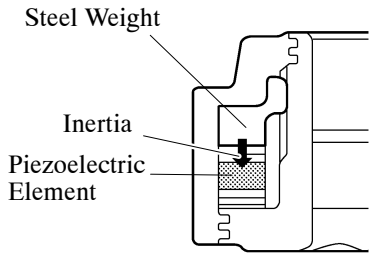


214CE02

Conventional Type Knock Sensor (Resonant Type)

3) Operation

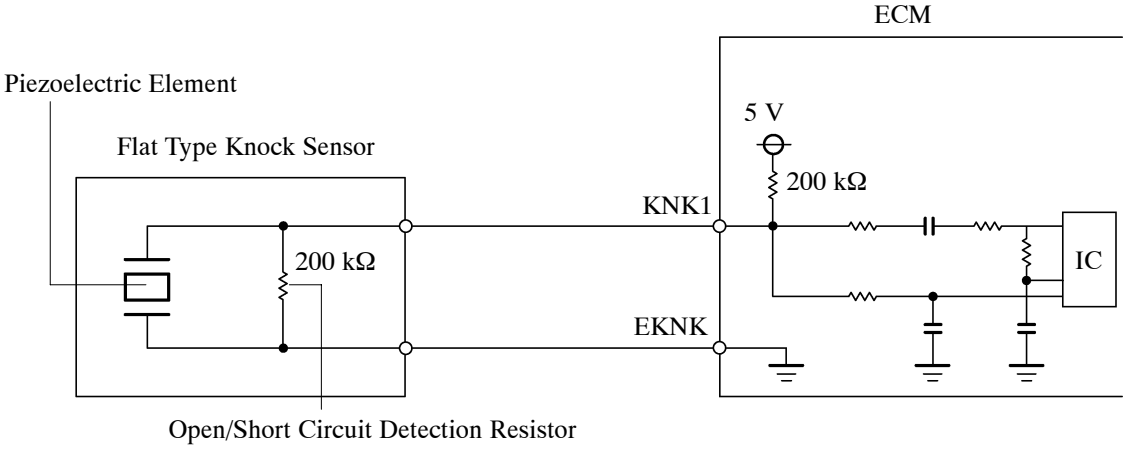
The knocking vibration is transmitted to the steel weight and its inertia applies pressure to the piezoelectric element. This action generates electromotive force (voltage).



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 allowing the ECM to detect the open/short circuit and store a DTC (Diagnostic Trouble Code).



214CE06

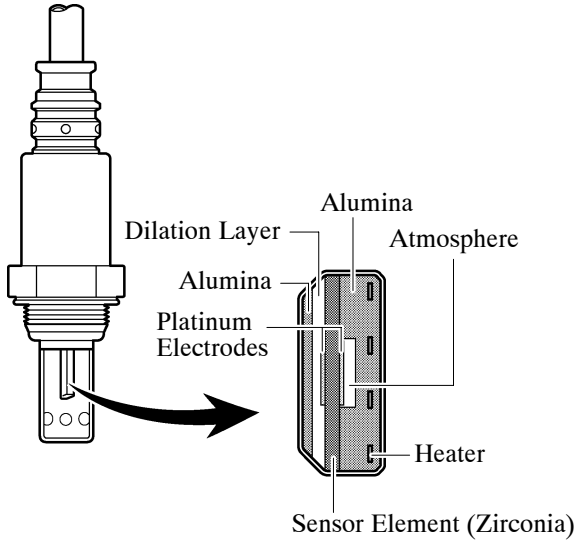
Service Tip

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 2007 TOYOTA TUNDRA Repair Manual (Pub. No. RM04E2U).

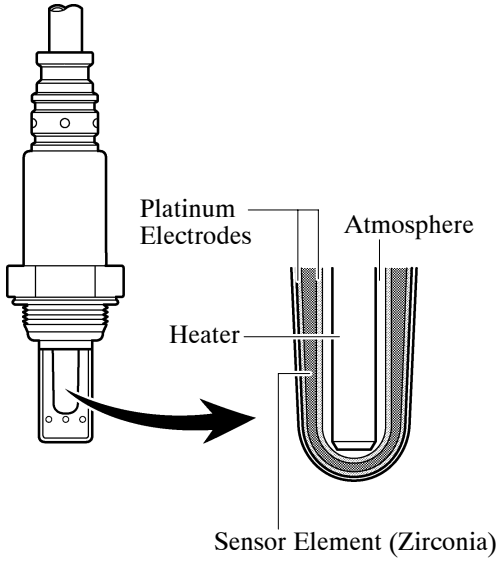
Air Fuel Ratio Sensor and Heated Oxygen Sensor

1) General

- A planar type air-fuel ratio sensor and a cup type heated oxygen sensor are used.
- The basic construction of the 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 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)

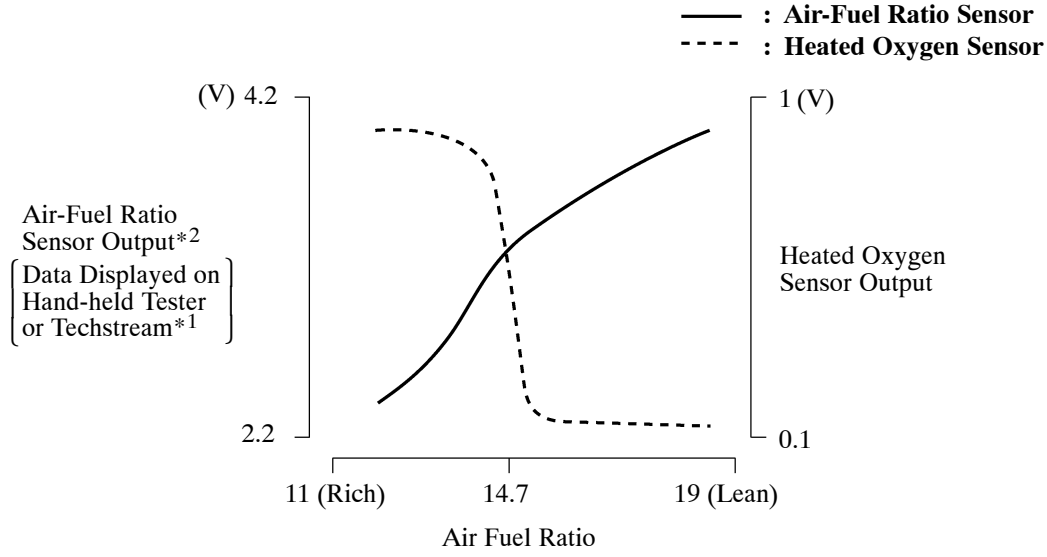


Heated Oxygen Sensor (Cup Type)

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2) Characteristics

As illustrated below, a 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 proportional 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 a hand-held tester or Techstream*1.



D13N11

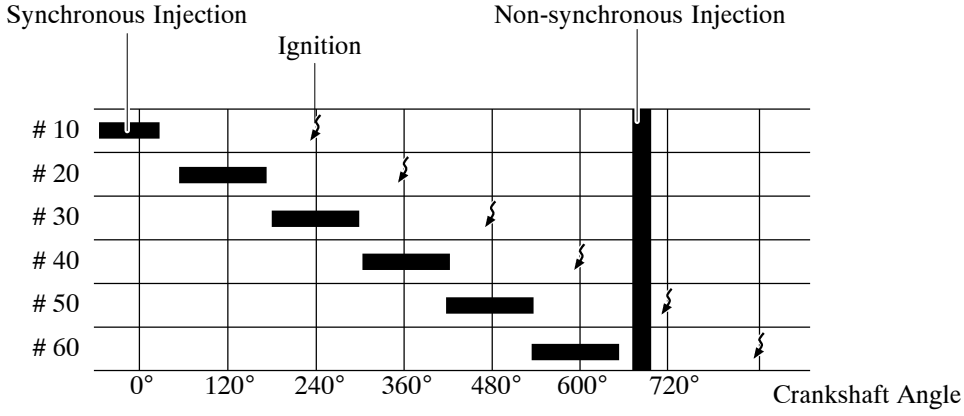
*1: Techstream is the name for the diagnostic tester in North America, but other countries will continue to use the hand-held tester.
*2: This value is calculated internally in the ECM and is not an ECM terminal voltage.

6. SFI (Sequential Multiport Fuel Injection) System

- This 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.
- 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.



Sequential Multiport Fuel Injection

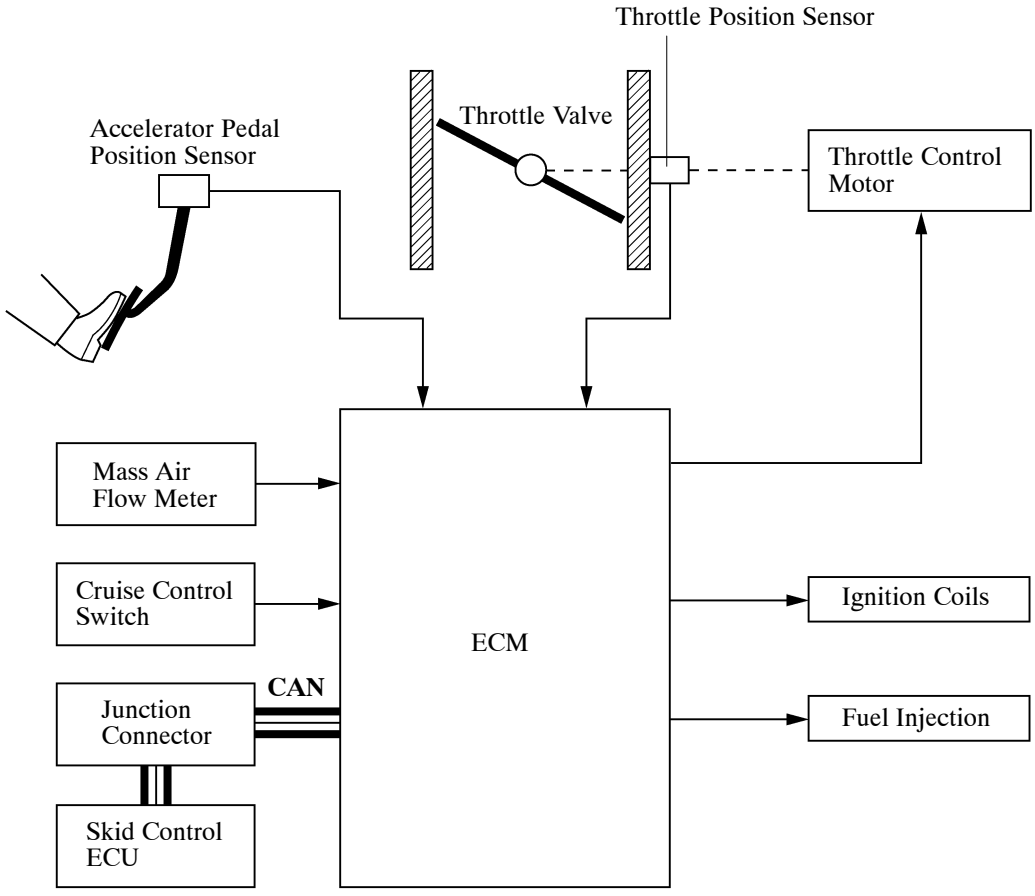
7. ETCS-i (Electronic Throttle Control System-intelligent)

General

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.
The ETCS-i consists of the following five functions:

- Normal Throttle Control (non-linear control)
- ISC (Idle Speed Control)
- TRAC (Traction Control) or AUTO LSD
- VSC (Vehicle Stability Control) Coordination Control
- Cruise Control

▶ System Diagram ◀

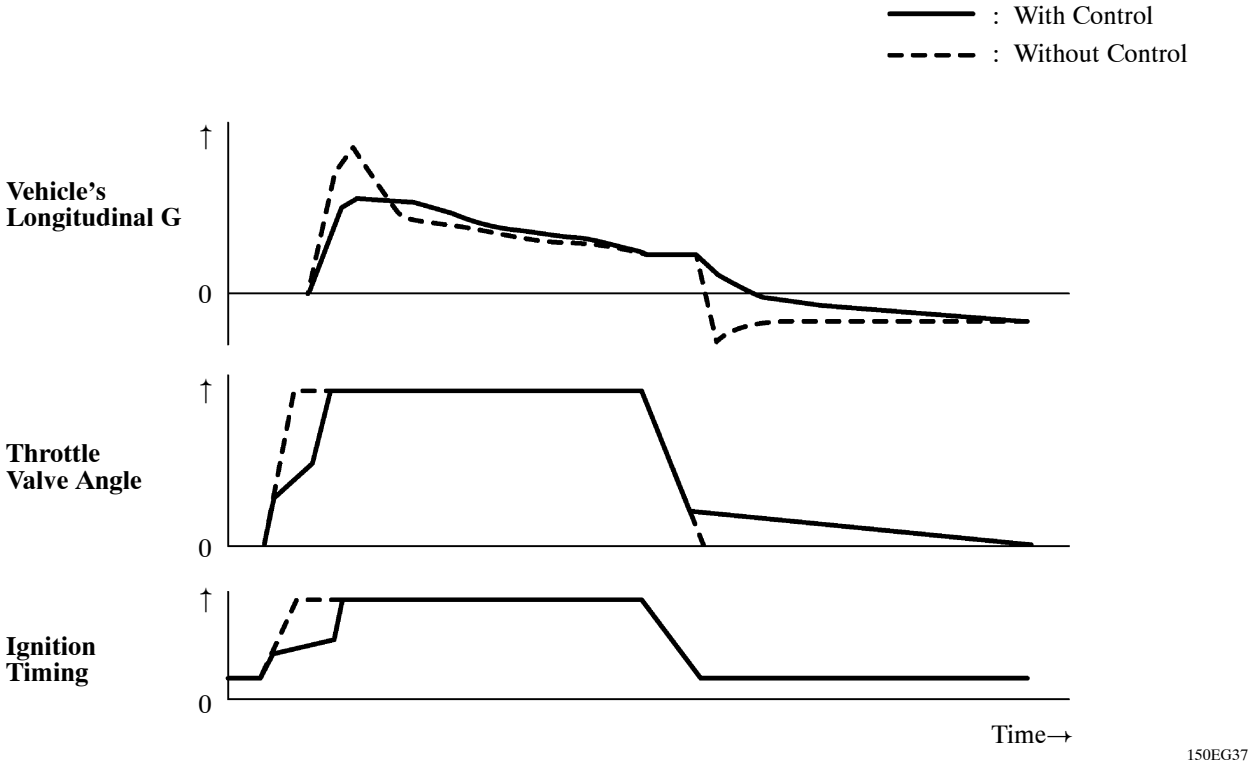


279EG19

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 ◀



Idle Speed Control

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

TRAC or AUTO LSD

As part of the TRAC or 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 facilitating vehicle stability and the application of an appropriate amount of power to the road.

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.

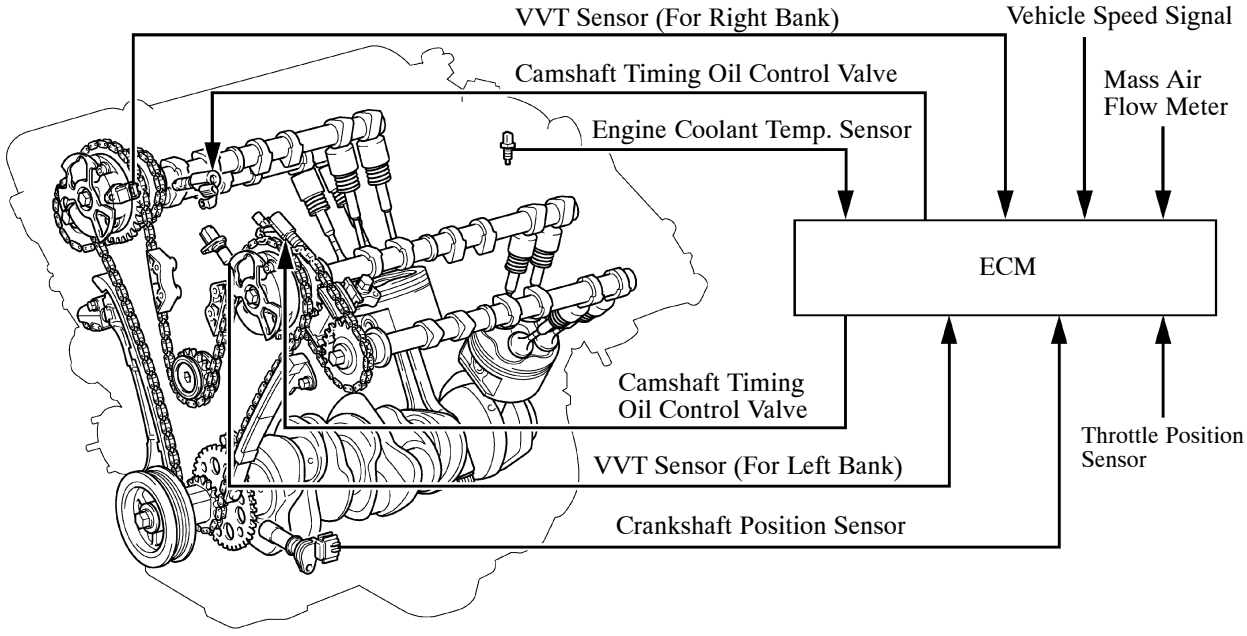
Cruise Control

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

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

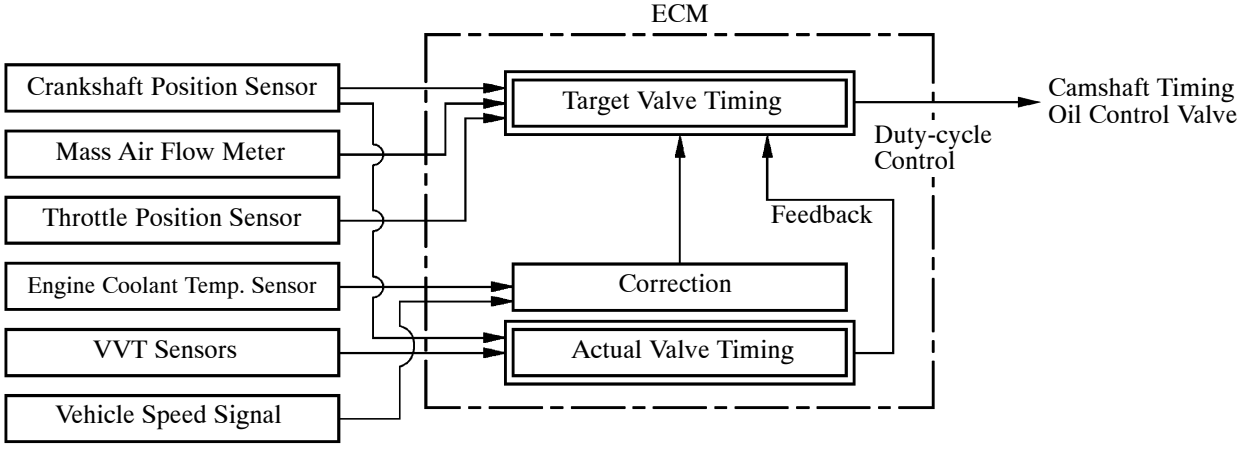
General

- The VVT-i system is designed to control the intake camshaft within a range of 50° (of Crankshaft Angle) to provide valve timing that is optimally suited to the engine operating conditions. This improves torque in all engine speed ranges as well as increasing fuel economy, and reducing exhaust emissions.



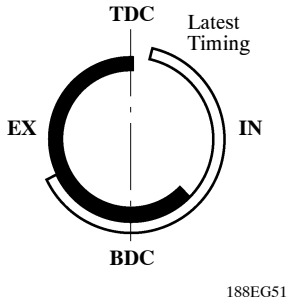
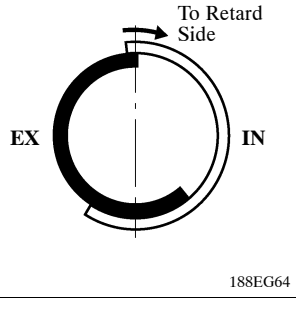
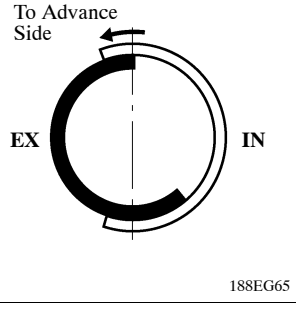
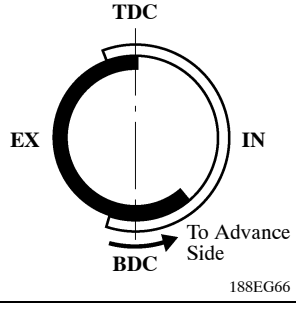
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- By using the engine speed, intake air volume, throttle position and engine coolant temperature, the ECM calculates optimal valve timing for each driving condition and controls the camshaft timing oil control valve. In addition, the ECM uses signals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

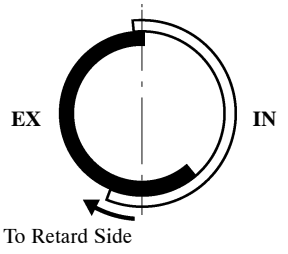
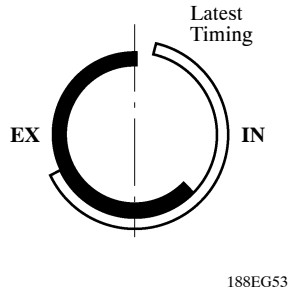
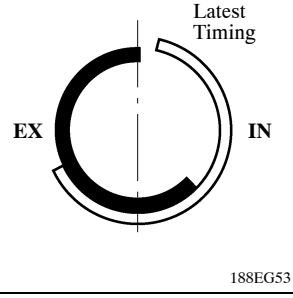


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Effectiveness of the VVT-i System

Operation State	Objective		Effect
During Idle		Eliminating overlap reduces blow back to the intake side.	• Stabilized idling rpm • Better fuel economy
At Light Load		Minimizing overlap reduces blow back to the intake side.	Ensured engine stability
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 allows for volumetric efficiency improvement.	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 allows for volumetric efficiency improvement.	Improved output
At Low Temperatures		Eliminating overlap prevents blow back to the intake side and stabilizes the idling speed at fast idle.	• Stabilized fast idling rpm • Better fuel economy
• Upon Starting • Stopping the Engine		Eliminating overlap reduces blow back to the intake side.	Improved startability

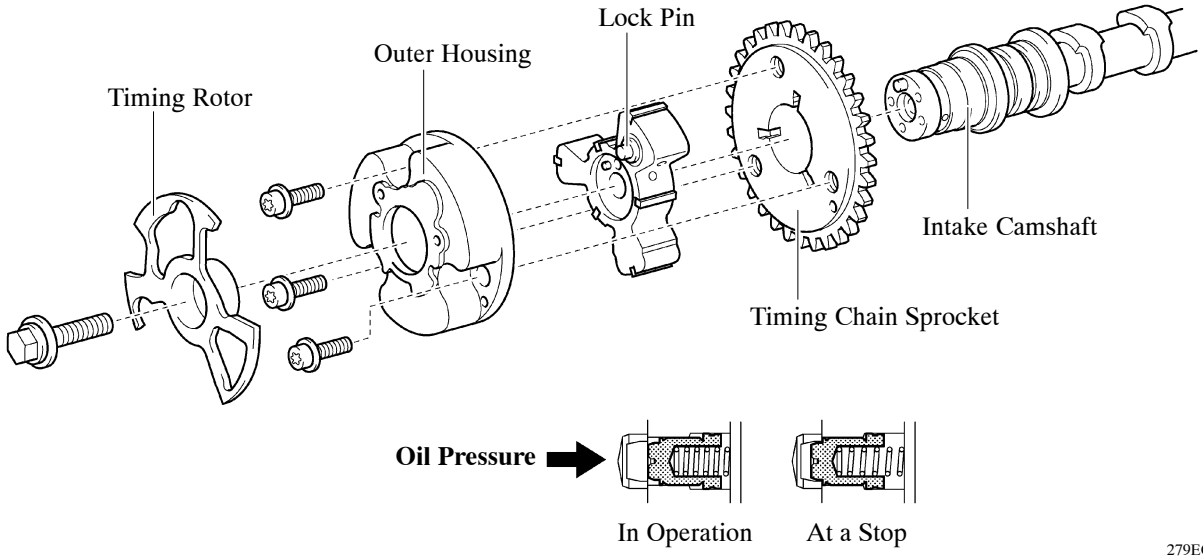
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Construction

1) VVT-i Controller

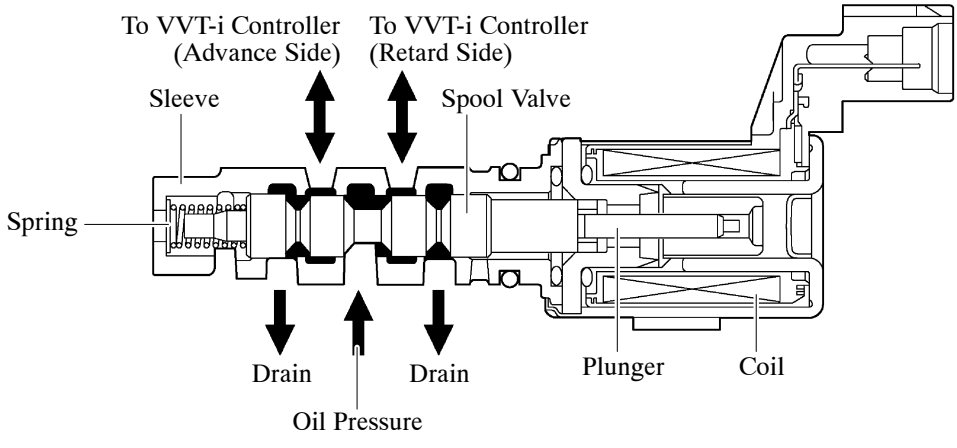
The VVT-i controller consists of an outer housing that is driven by the timing chain sprocket, and a vane subassembly that is coupled to intake camshaft.

- The oil pressure sent from the advance or retard side passage of the intake camshaft causes rotation of the VVT-i controller vane subassembly relative to the timing chain sprocket to vary the valve timing continuously (steplessly).
- When the engine stops, the VVT-i controller is locked to the most retarded angle by its lock pin. This ensures engine stability.



2) Camshaft Timing Oil Control Valve

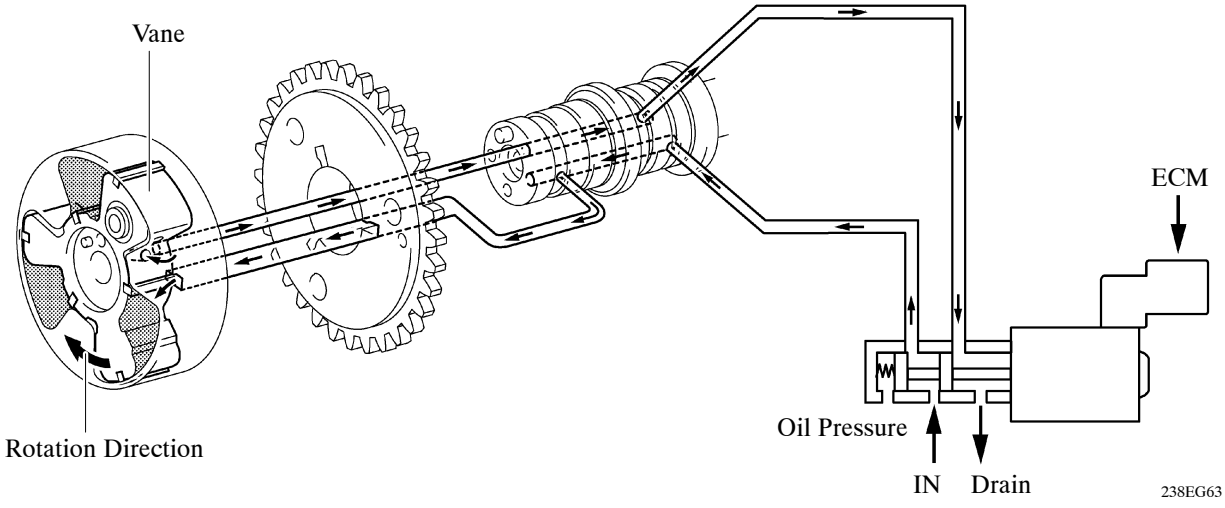
The camshaft timing oil control valve controls its spool valve using duty-cycle control from the ECM. This allows hydraulic pressure to be applied to the VVT-i controller advance or retard side. When the engine is stopped, the camshaft timing oil control valve will move to the most retarded state.



Operation

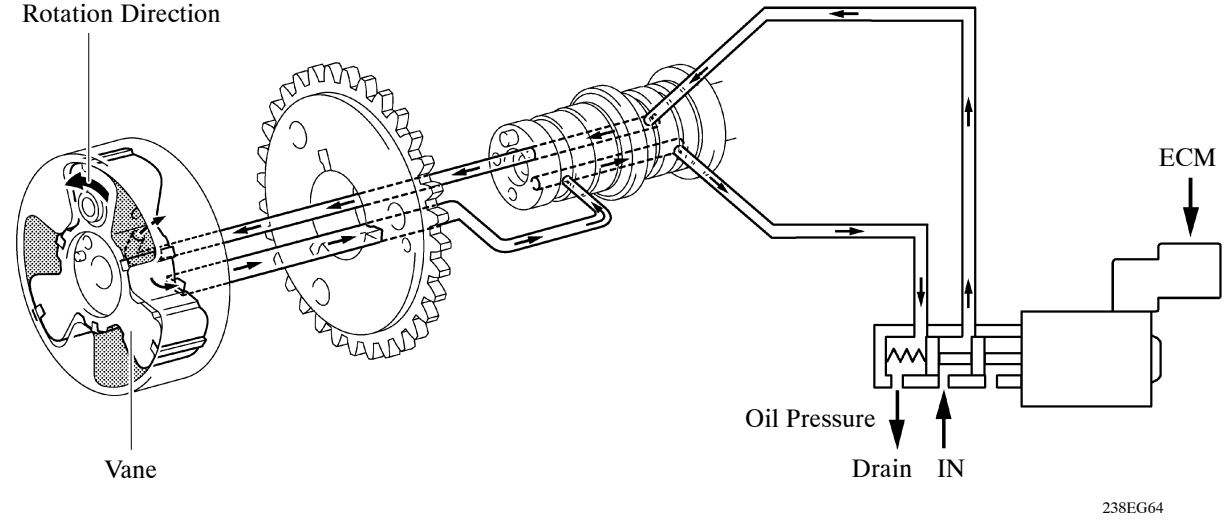
1) Advance

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

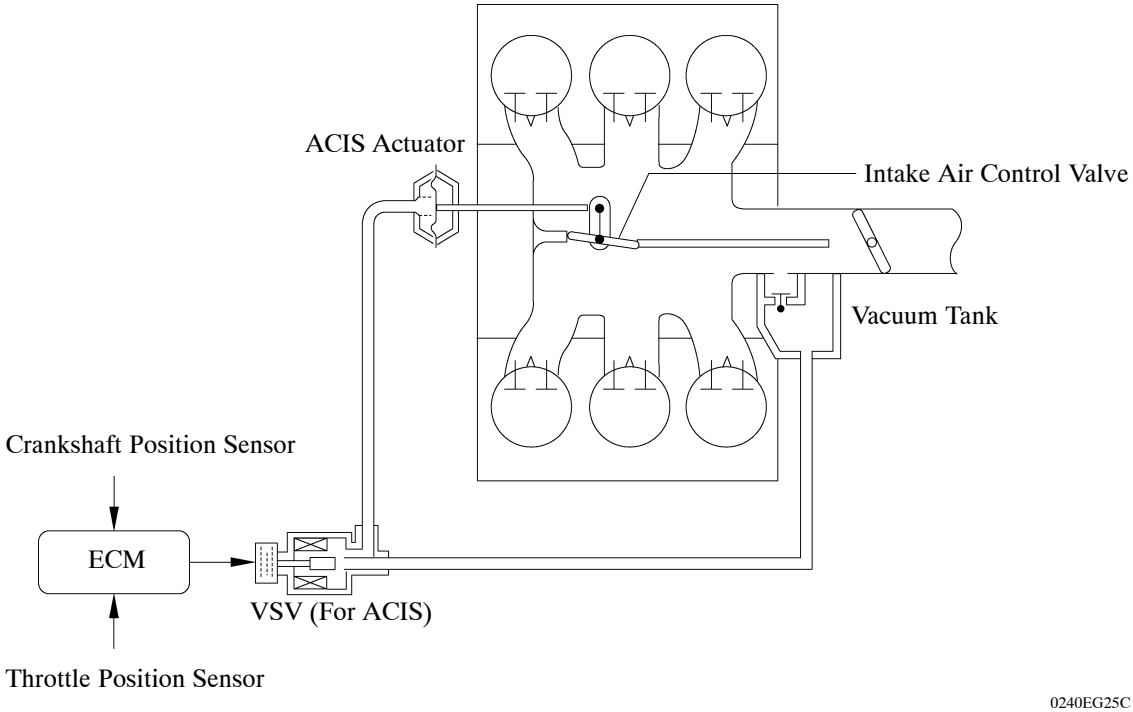
After reaching the target timing, the engine valve timing is maintained by keeping the camshaft timing oil control valve in the neutral position unless the engine operating conditions change.
This maintains the engine valve timing at the desired target position by preventing the engine oil from running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

9. 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.

▶ System Diagram ◀

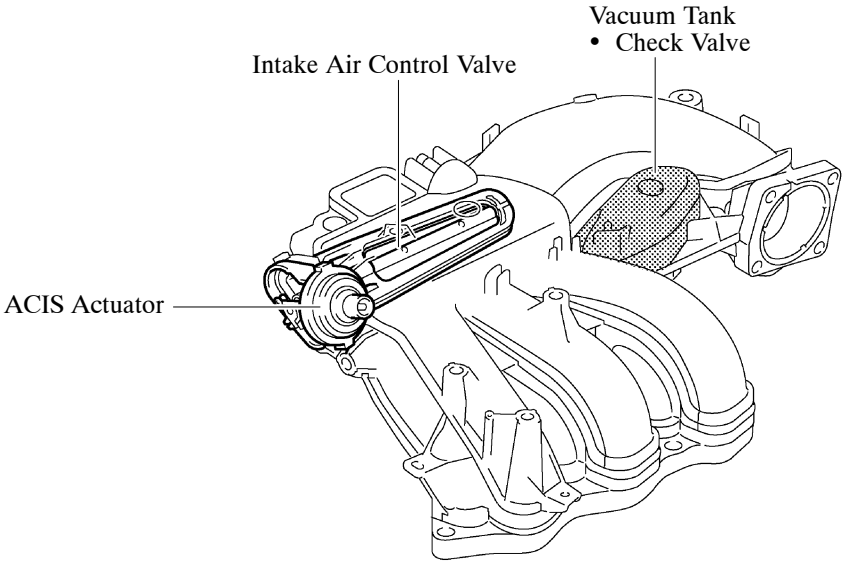


Construction

1) Intake Air Control Valve and Vacuum Tank

The intake air control valve and the vacuum tank are installed in the intake air chamber.

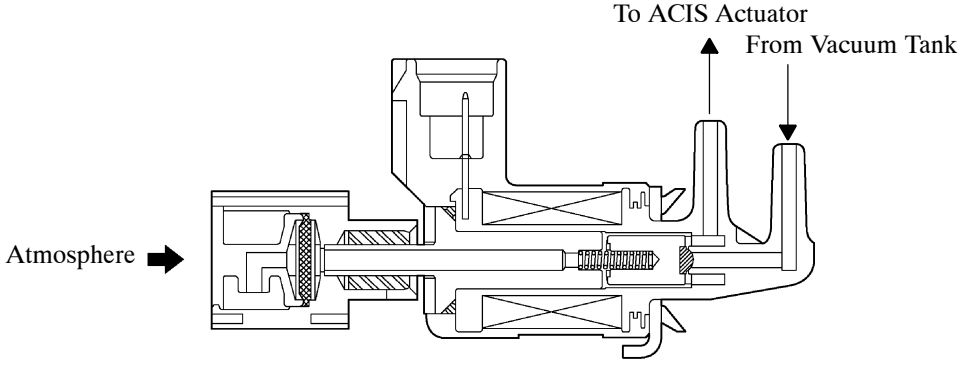
- The intake air control valve opens and closes to make two effective lengths of the intake manifold possible.
- The vacuum tank is equipped with an internal check valve. The check valve stores the vacuum that is used for application of the ACIS actuator in order to maintain the intake air control valve fully closed even during low-vacuum conditions.



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2) VSV (Vacuum Switching Valve)

Controls the vacuum that is applied to the ACIS actuator based on the ACIS signal that is output by the ECM.



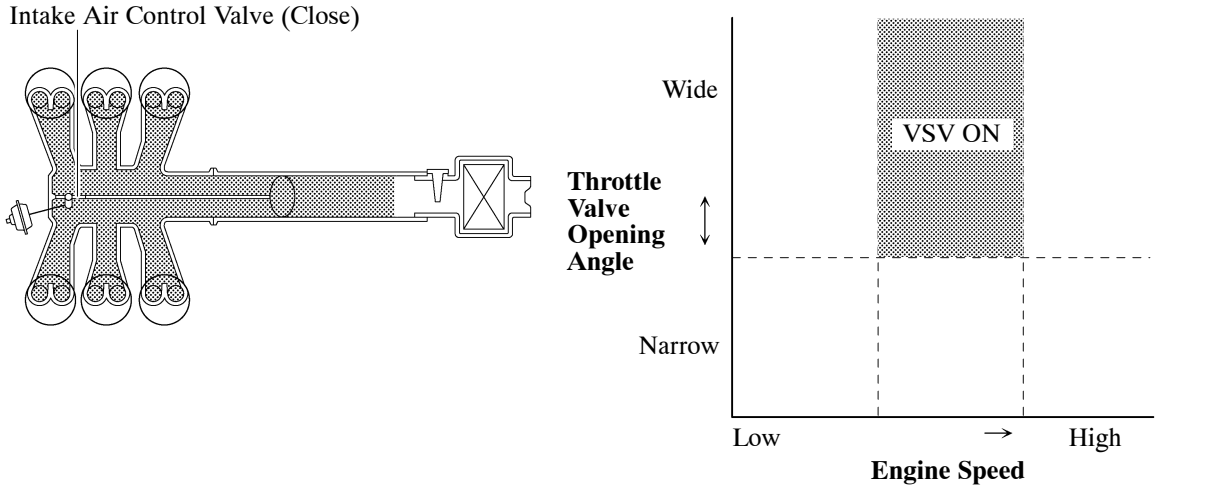
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Operation

1) Intake Air Control Valve Close (VSV ON)

The ECM activates the VSV to match the longer pulsation cycle of the intake air charge. The vacuum from the VSV acts on the diaphragm chamber of the ACIS actuator. This closes the intake air control valve. As a result, the effective length of the intake manifold is increased 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 in this engine speed range.

: Effective Intake Manifold Length



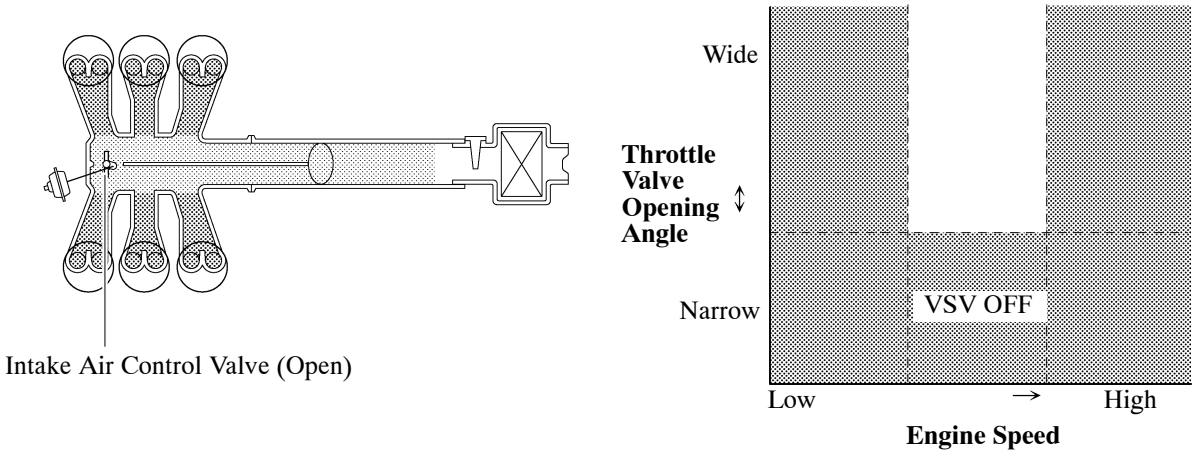
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2) Intake Air Control Valve Open (VSV OFF)

The ECM deactivates the VSV to match the shorter pulsation cycle of the intake air. Deactivating the VSV allows atmospheric air into the diaphragm chamber of the ACIS actuator opening the intake air control valve. When the intake air control valve is open, the effective length of the intake air chamber 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.

: Effective Intake Manifold Length

: Effective Intake Air Chamber Length



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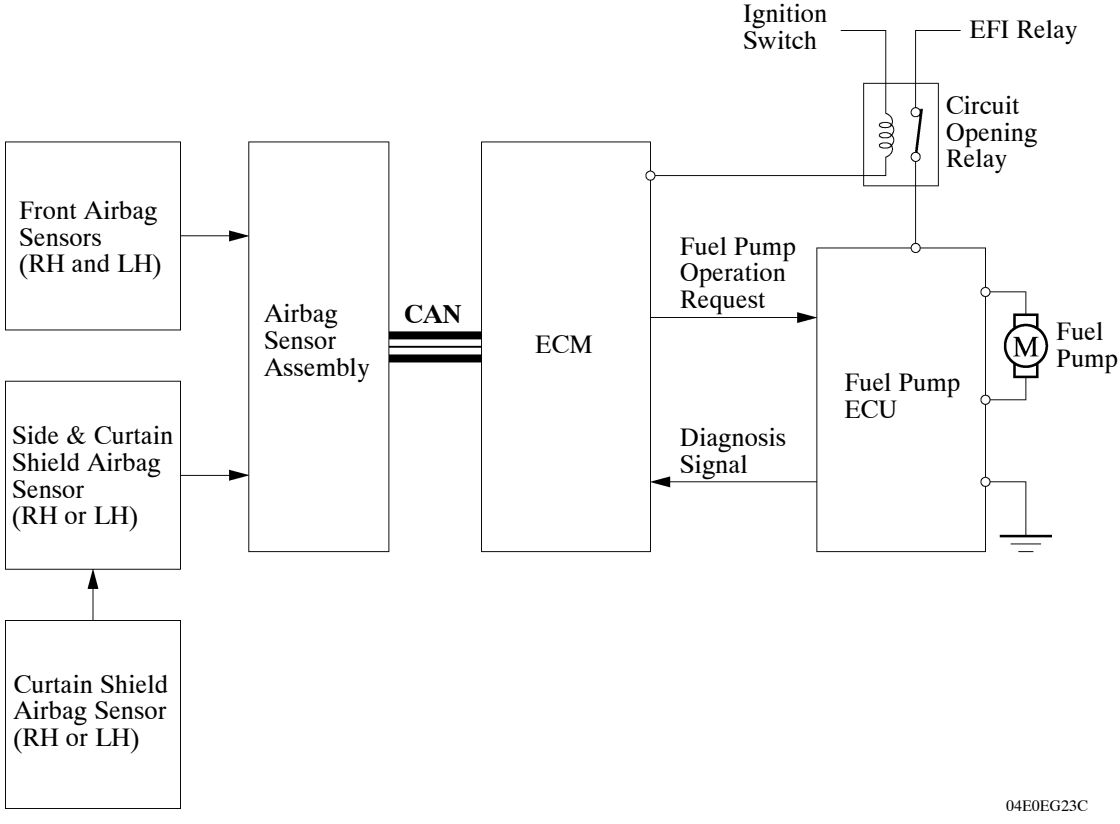
10. Fuel Pump Control

General

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

- The ECM transmits a fuel pump speed 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 deploy. In this control, if an airbag deployment signal from the 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.

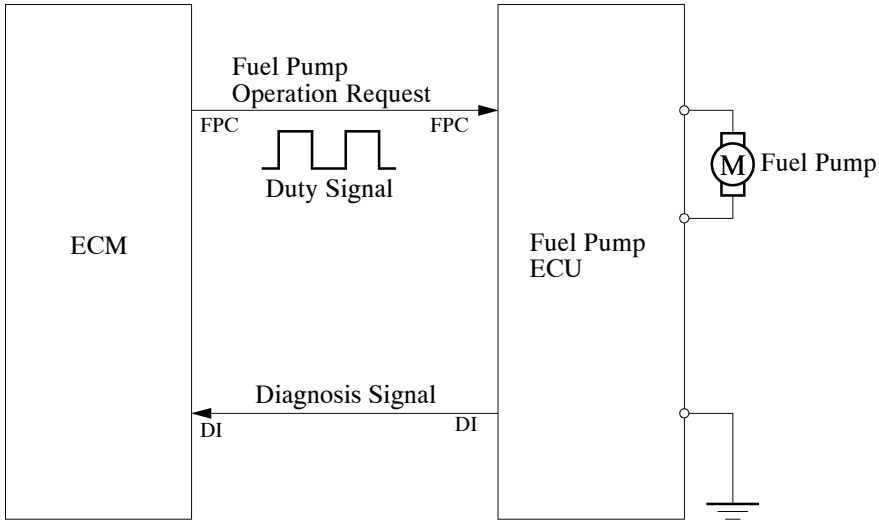
▶ System Diagram ◀



Function of Main Component

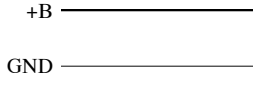
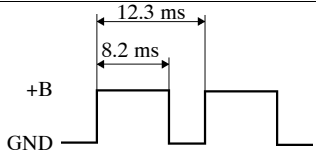
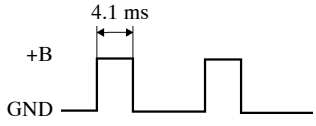
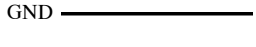
1) Fuel Pump ECU

- The Fuel Pump ECU controls fuel pump speed by receiving a duty cycle signal (FPC terminal input) from the ECM, control is performed to 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.



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▶ FPC Terminal Input ◀

FPC Input Signal (Duty Signal)	Fuel Pump Speed
 04E0EG25C	Hi
 04E0EG26C	Middle
 04E0EG27C	Low
 04E0EG28C	Stop

11. Air Injection Control System

General

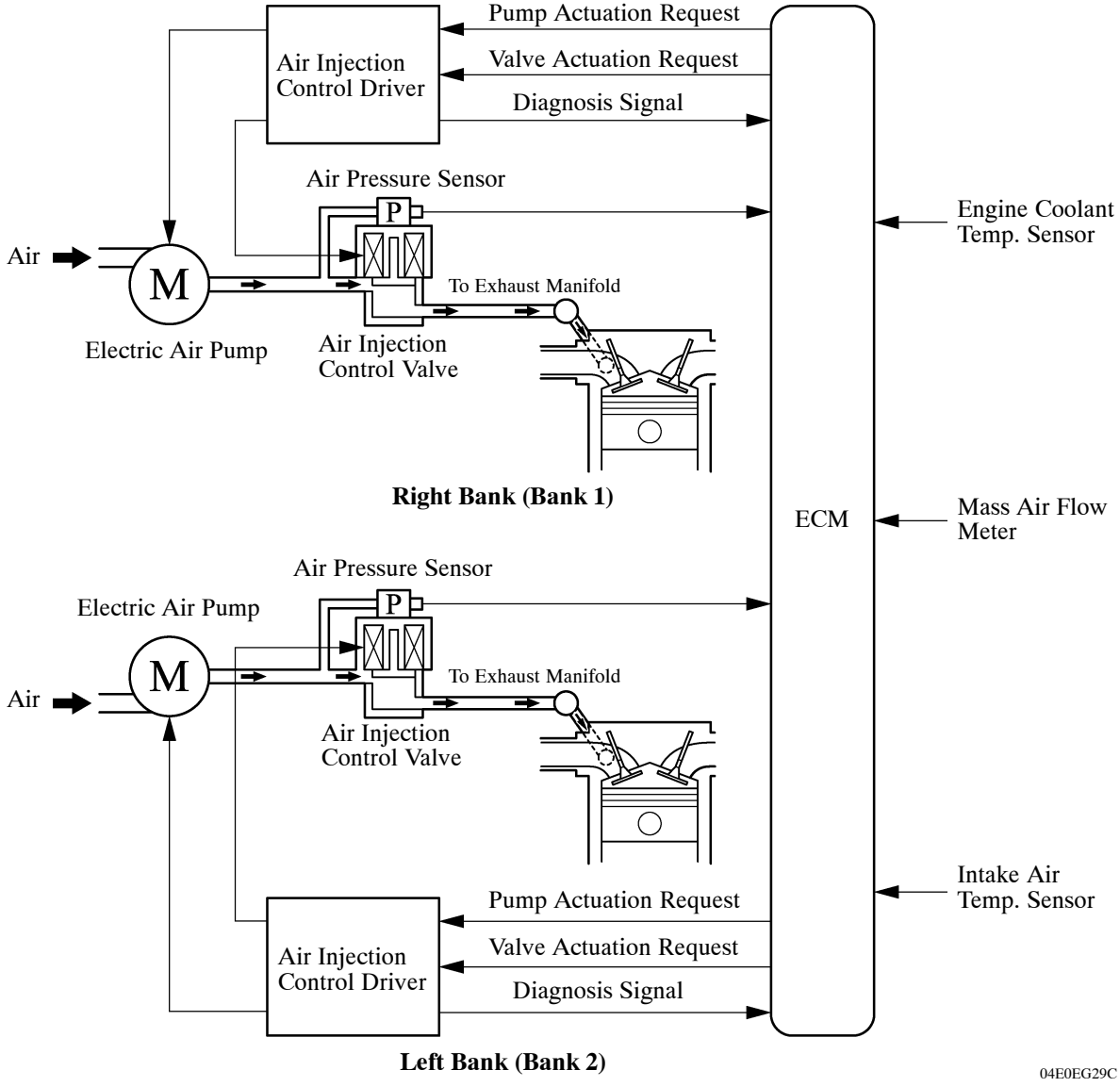
To ensure the proper warm-up performance of the TWCs (Three-Way Catalytic converter) after starting a cold engine, an air injection system is used.

- For this system, the right bank (bank 1) and left bank (bank 2) each 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 Temp.	5 to 45°C (5 to 45°C)
Intake Air Temp.	5°C (41°F) or more

▶ System Diagram ◀



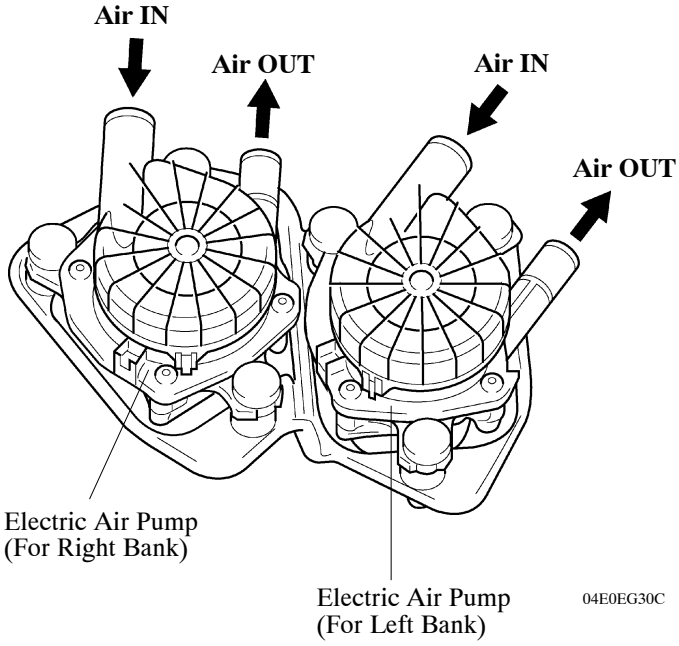
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Construction and Function of Main Components

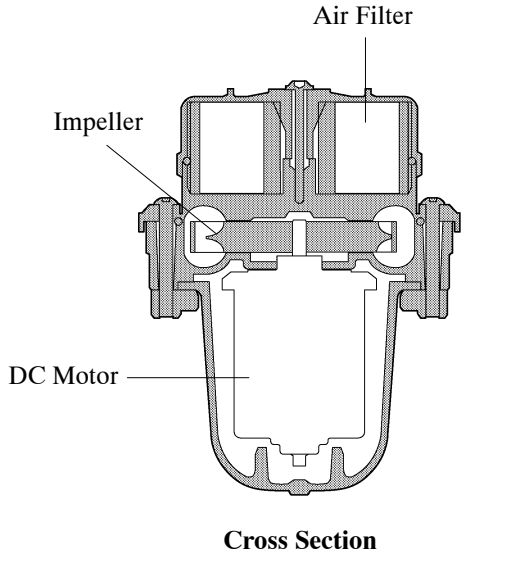
1) Electric Air Pump

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

- Each 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 pump for the right bank and left bank are basically the same.



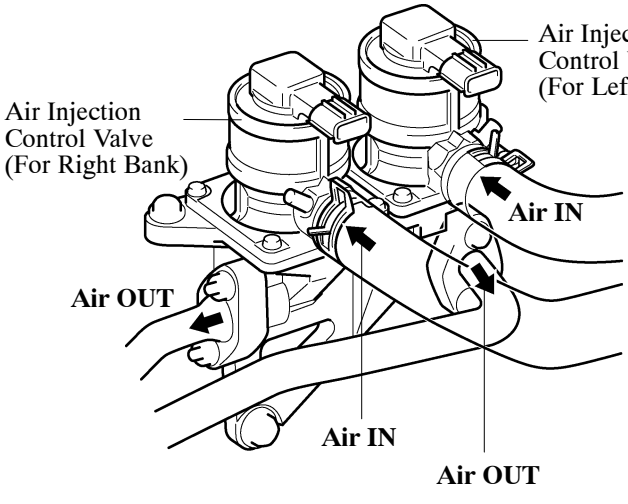
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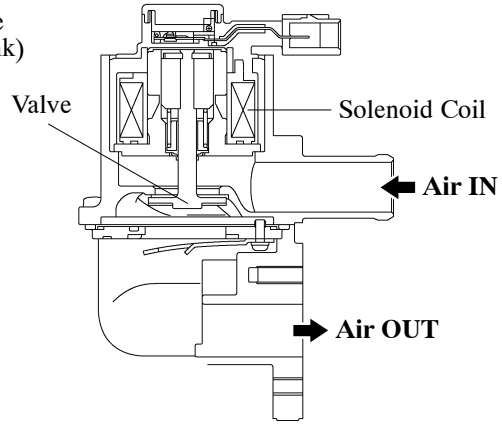


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2) Air Injection Control Valve

- 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 valve for the right bank and left bank are basically the same.

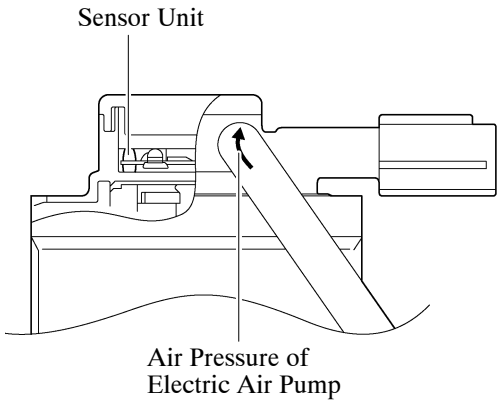




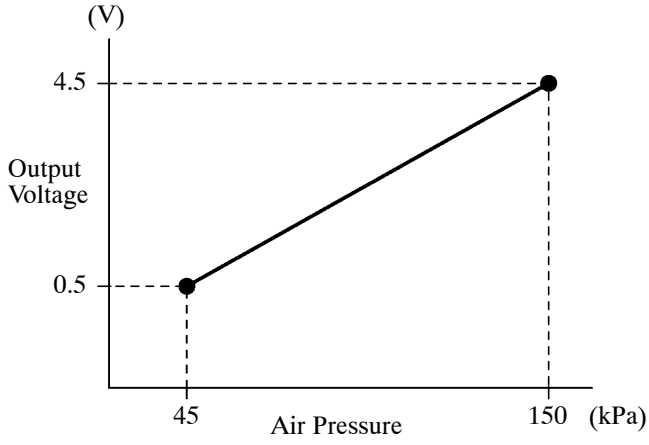
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3) Air Pressure Sensor

- 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 sensor for the right bank and left bank are basically the same.



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

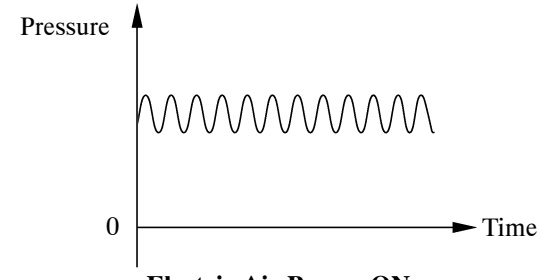
1) When the electric air pump is ON and the air injection control valve is closed, the pressure is stable.
2) When the electric air pump is ON and the air injection control valve is open, the pressure drops slightly and becomes unstable because of exhaust pulses.
3) When the electric air pump is OFF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

Example: 1



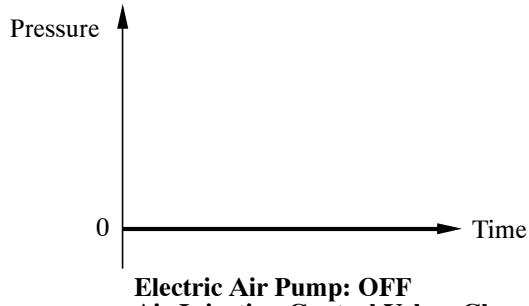
Electric Air Pump: ON
Air Injection Control Valve: Closed

Example: 2



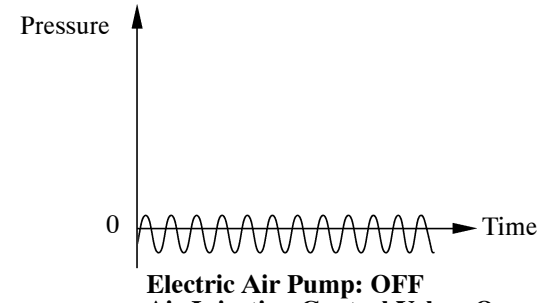
Electric Air Pump: ON
Air Injection Control Valve: Open

Example: 3



Electric Air Pump: OFF
Air Injection Control Valve: Closed

Example: 4



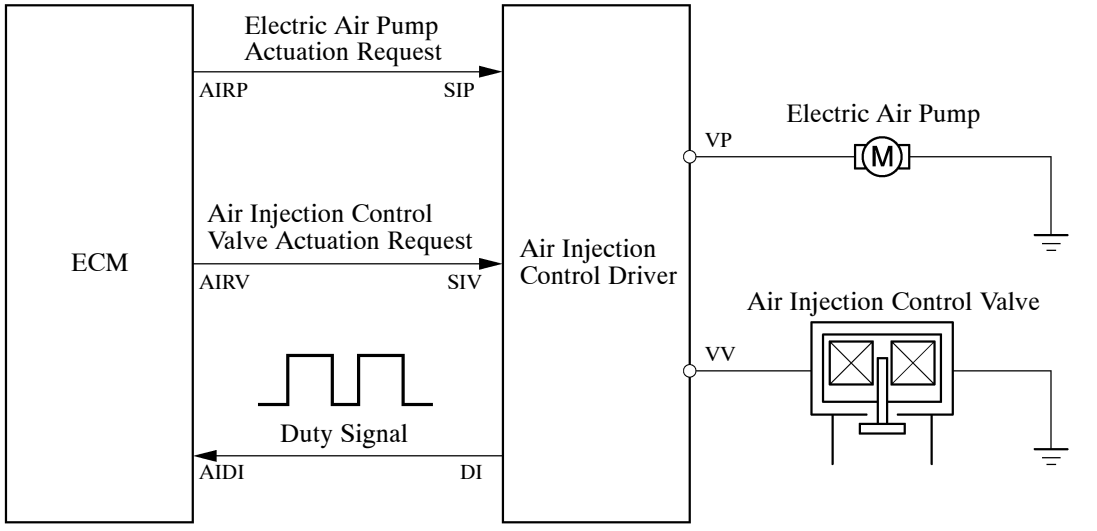
Electric Air Pump: OFF
Air Injection Control Valve: Open

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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 driver also detects failures in the input and output circuits of the air injection driver and transmits the failure status to the ECM via duty cycle signals.
- The basic functions of the air injection control driver for the right bank and left bank are the same. The following system chart shows the right bank (bank 1).



▶ DI Terminal Output ◀

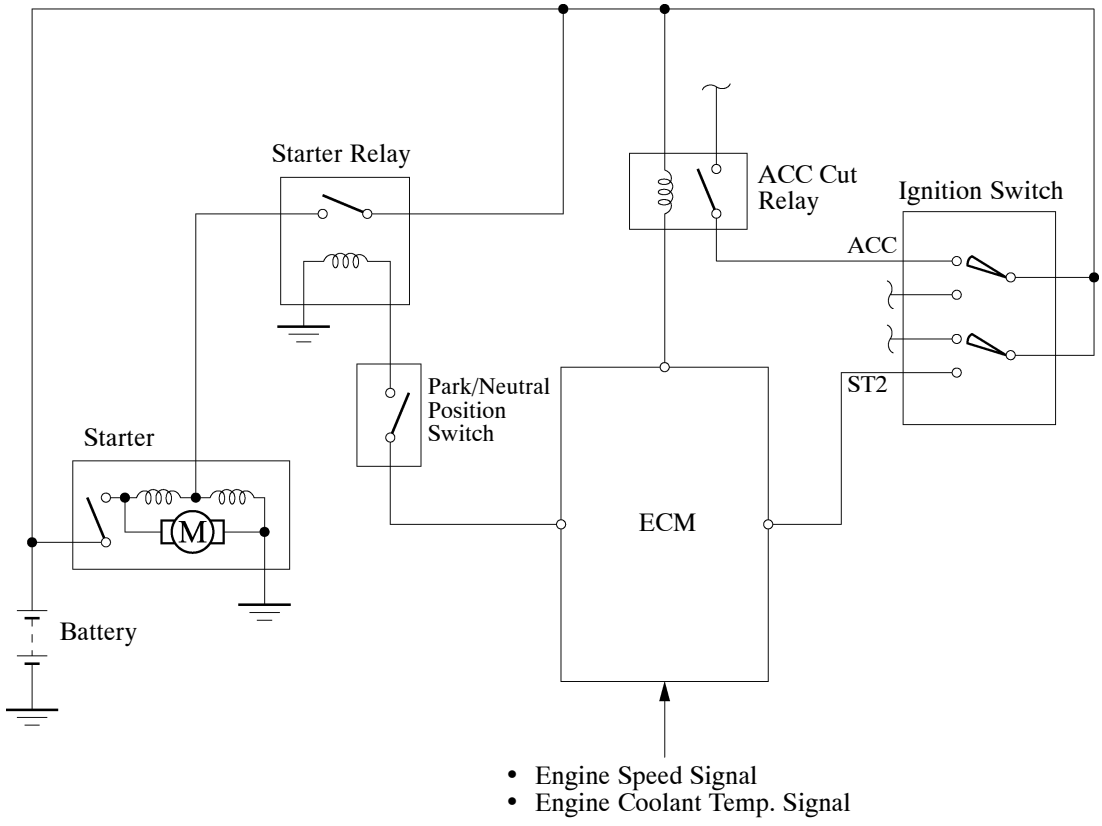
Condition	AIRP	AIRV	Output (Duty Signal)
Open circuit in line between AIDI and DI terminals.	—	—	GND 273GX28
Failure in line between ECM terminals and air injection control driver.	—	—	GND 273GX29
Output failure at air injection control driver. (Failure in electric air pump actuation circuit)	—	—	20 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	

12. Cranking Hold Function

General

- Once the ignition switch is turned to the START position, this function operates the starter until the engine starts, without having to hold the ignition switch in the START 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 from the ignition switch, 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 from the ignition switch.

▶ System Diagram ◀



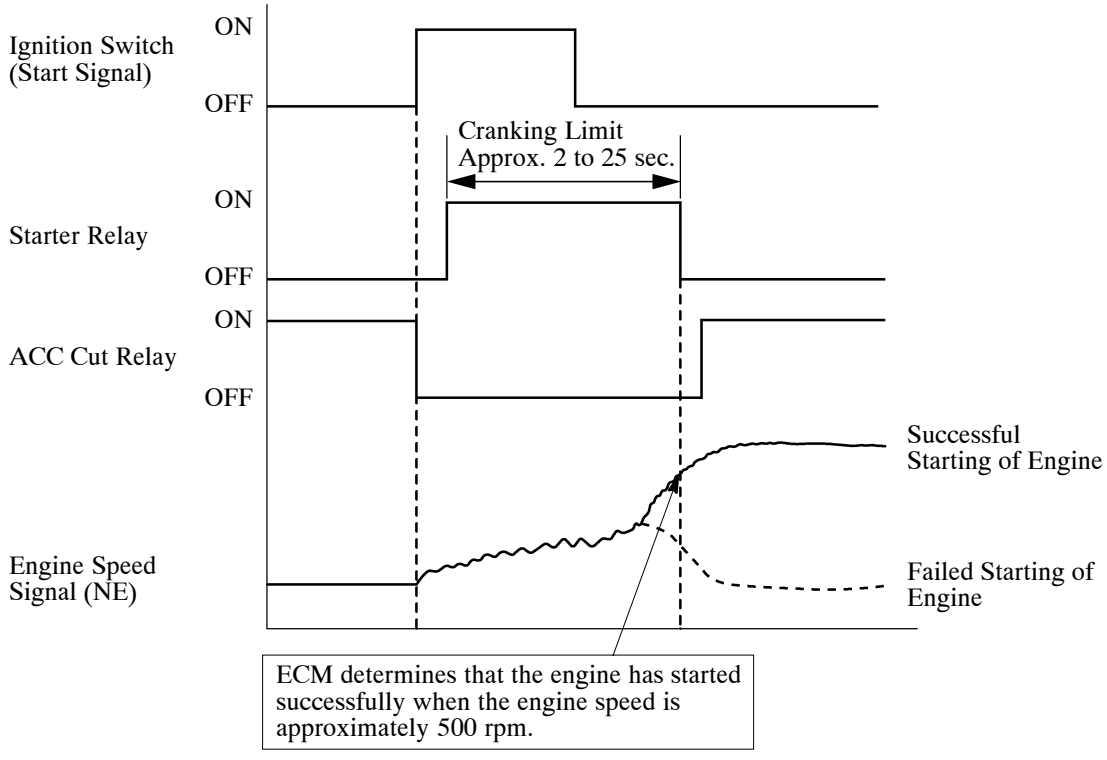
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Operation

- As indicated in the timing chart shown below, when the ECM detects a start signal from the ignition switch, the ECM outputs a starter relay drive signal (STAR) that flows through the park/neutral position switch to turn on the starter relay. As a result, the starter operates. (If the engine is already running, the ECM will not turn on the starter relay.)
- After the engine speed rises above approximately 500 rpm, the ECM determines that the engine has started and stops the output of the starter relay drive signal (STAR) to stop the operation of the starter.
- The ECM outputs an ACC cut relay drive signal (ACCR) to turn on the ACC cut relay, in order to prevent accessory light flickering from occurring while cranking.
- If the engine fails to start, the starter operates as long as its maximum continuous operation time and stops automatically. The maximum continuous operation time is approximately 2 seconds through 25 seconds depending on the engine coolant temperature. When the engine coolant temperature is extremely low, maximum cranking time is approximately 25 seconds. When the engine is warmed up sufficiently, maximum cranking time is approximately 2 seconds.
- **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 ignition switch stays in the START position.
- 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 ◀



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13. Evaporative Emission Control System

General

The evaporative emission control system prevents the fuel vapor that is created in the fuel tank from being released directly into the atmosphere.

- The charcoal canister stores the fuel vapor that has been created in the fuel tank.
- 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.
- Using 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 a vacuum to the evaporative emission system and monitoring the system for changes in pressure in order to detect a leak.
- This system consists of an EVAP valve, charcoal canister, refueling valve, pump module, and ECM.
- An ORVR (Onboard Refueling Vapor Recovery) function is provided in the refueling valve.
- The pressure sensor has been integrated with the pump module.
- An air filter has been provided on the fresh air line. This air filter is maintenance-free.
- An EVAP service port is not used.
- The following are typical conditions that 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: 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)

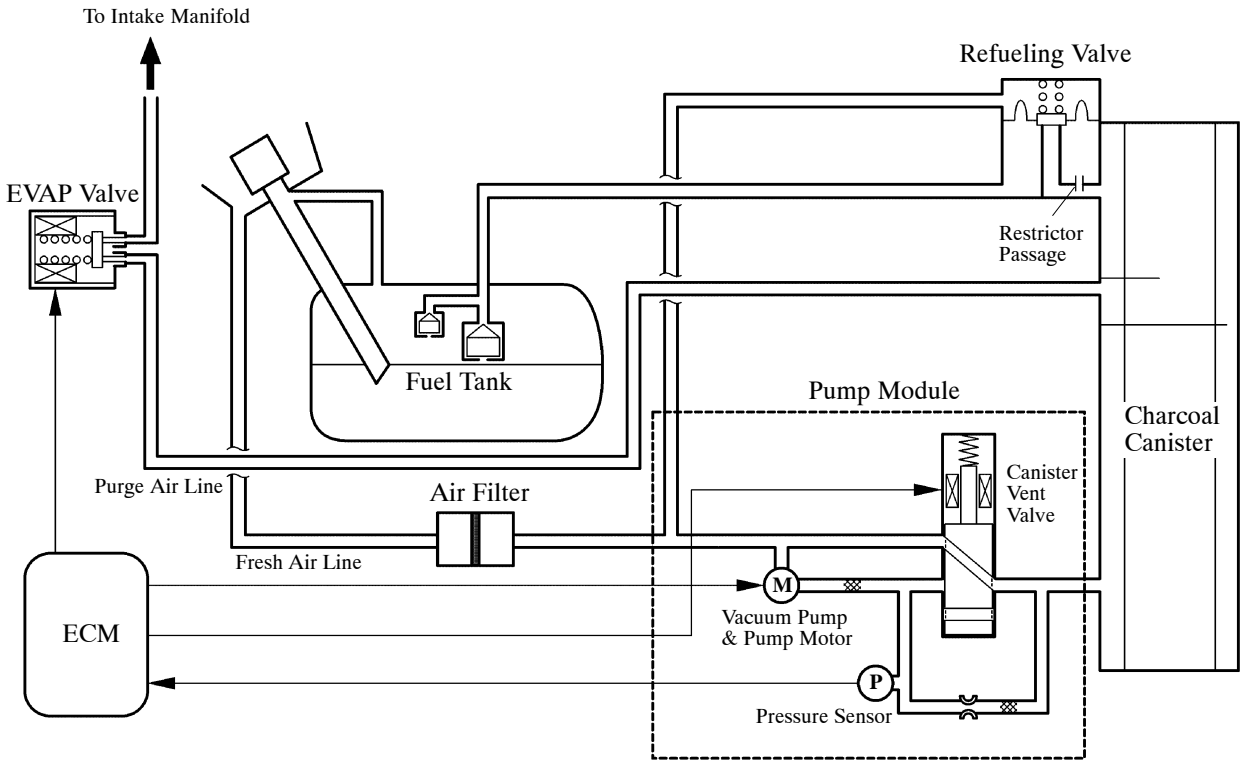
*: If engine coolant temperature does not drop below 35°C (95°F), this time is extended to 7 hours. Even after that, if the temperature is not less than 35°C (95°F), the time is extended to 9.5 hours.

Service Tip

The pump module performs a fuel evaporative emission leakage check. This check is done approximately 5 hours after the engine is turned off. Sound may be heard coming from underneath the vehicle near the fuel tank for several minutes. This does not indicate a malfunction.

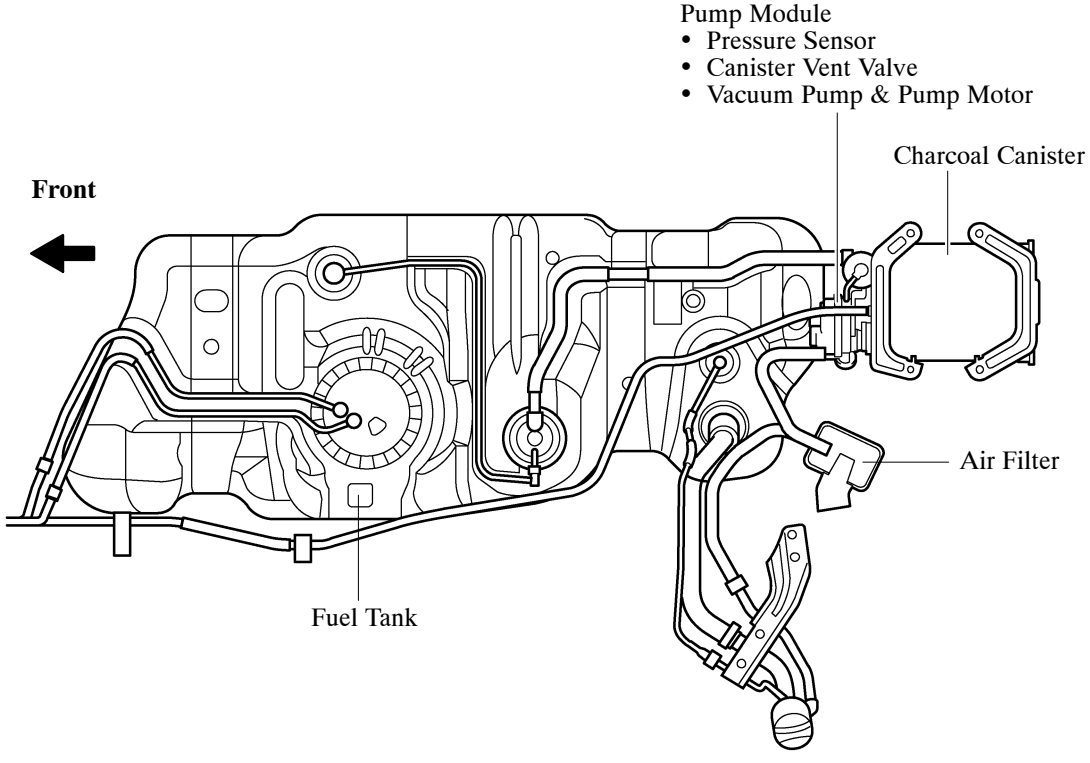
- A pinpoint pressure test procedure is adopted by pressurizing the fresh air line that runs from the pump module to the air filler neck. For details, see the 2007 TOYOTA TUNDRA Repair Manual (Pub. No. RM04E2U).

System Diagram



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Layout of Main Components



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Function of Main Components

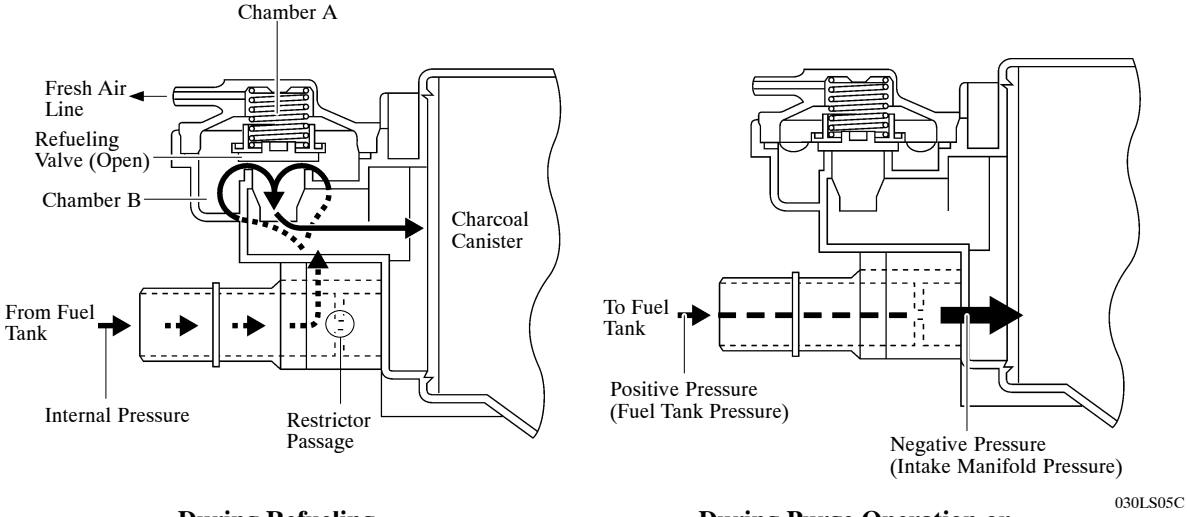
Component		Function
Charcoal Canister		Contains activated charcoal to absorb the fuel vapor that is created in the fuel tank.
Refueling Valve		Controls the flow rate of the fuel vapor from the fuel tank to the charcoal canister when the system is purging or during refueling.
	Restrictor Passage	Prevents 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 charcoal canister 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 the signals from the ECM.
	Vacuum Pump & Pump Motor	Applies vacuum to the evaporative emission system in accordance with the 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 into the intake manifold. In system monitoring mode, this valve controls the introduction of the vacuum into the fuel tank.
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 increases. This pressure causes the refueling valve to lift up, allowing the fuel vapors to enter the charcoal 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 vapor from the fuel tank to the charcoal canister. 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.

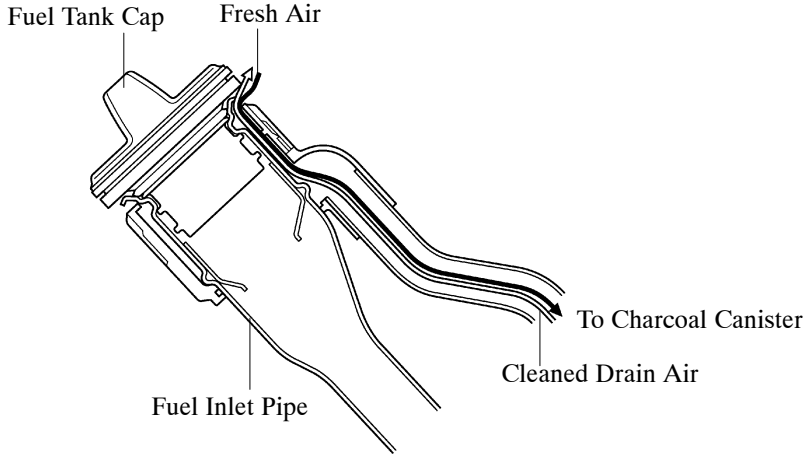


During Refueling

During Purge Operation or System Monitoring Operation

2) Fuel Inlet (Fresh Air Inlet)

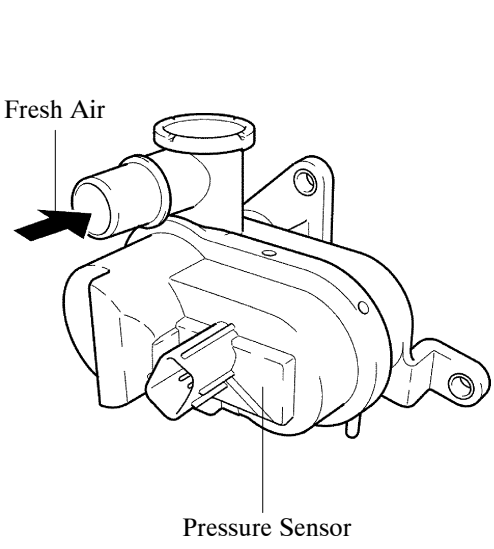
This evaporative emission control system has its fresh air line inlet located near the fuel inlet. The fresh air from the atmosphere and drain air cleaned by the charcoal canister will go in and out of the system through the passage shown below.



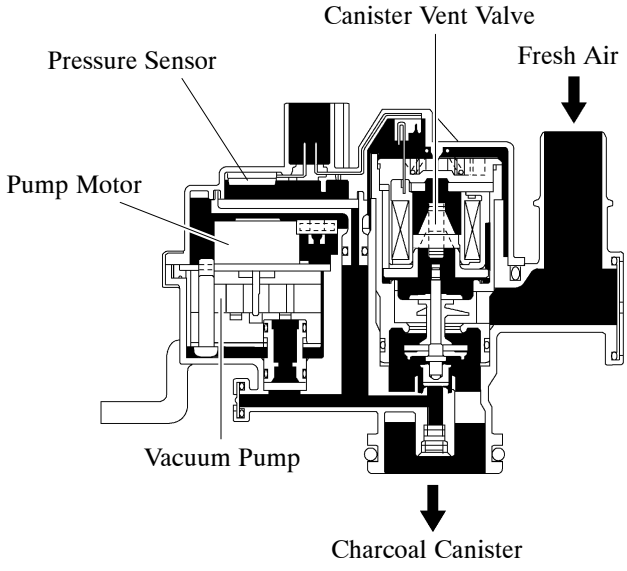
3) Pump Module

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.



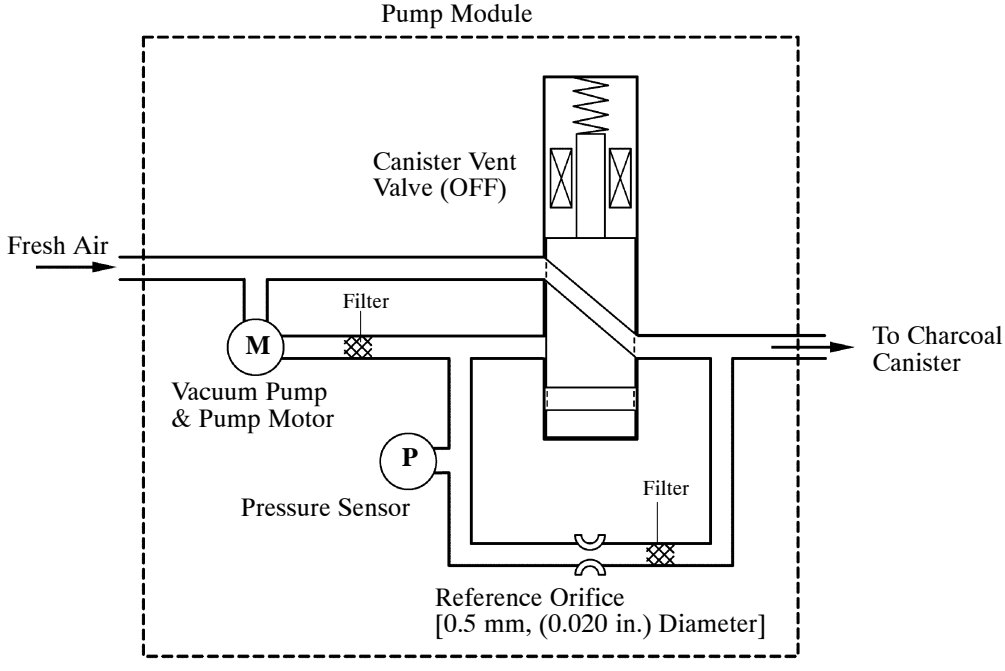
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▶ Simple Diagram ◀

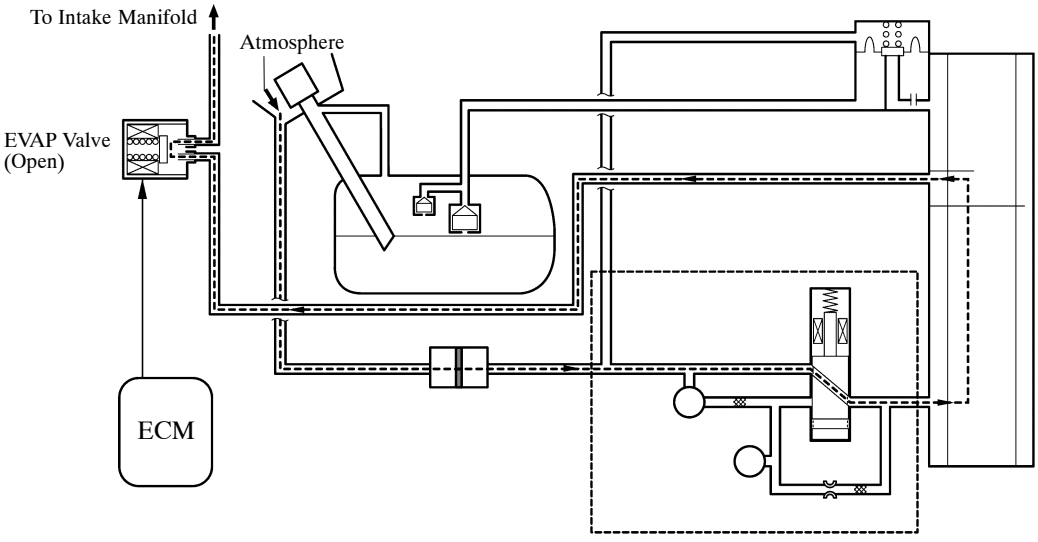


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System Operation

1) Purge Flow Control

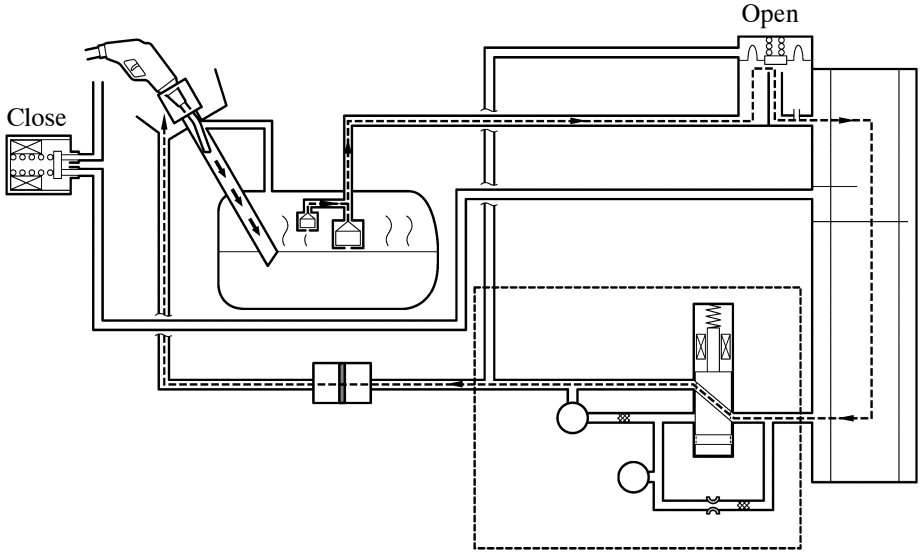
When the engine has reached a predetermined state (closed loop, engine coolant temp. above 80°C (176°F), etc.), stored fuel vapor is purged from the charcoal canister whenever the EVAP valve is opened by the ECM.
The ECM will change the duty ratio cycle of the EVAP valve, thus controlling purge flow 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 to ensure that purge flow is constantly maintained whenever purge vacuum is applied to the charcoal canister.



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2) ORVR (Onboard 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. This allows the fuel vapor to enter the charcoal canister. The air that has been cleaned through the charcoal canister is discharged outside the vehicle via the fresh air line because the canister vent valve is always open when the system is in a mode other than the monitoring mode (even when the engine is stopped). If the vehicle is refueled in system monitoring mode, the ECM will recognize the refueling by way of the pressure sensor, which detects the sudden pressure increase in the fuel tank, and will open the canister vent valve.



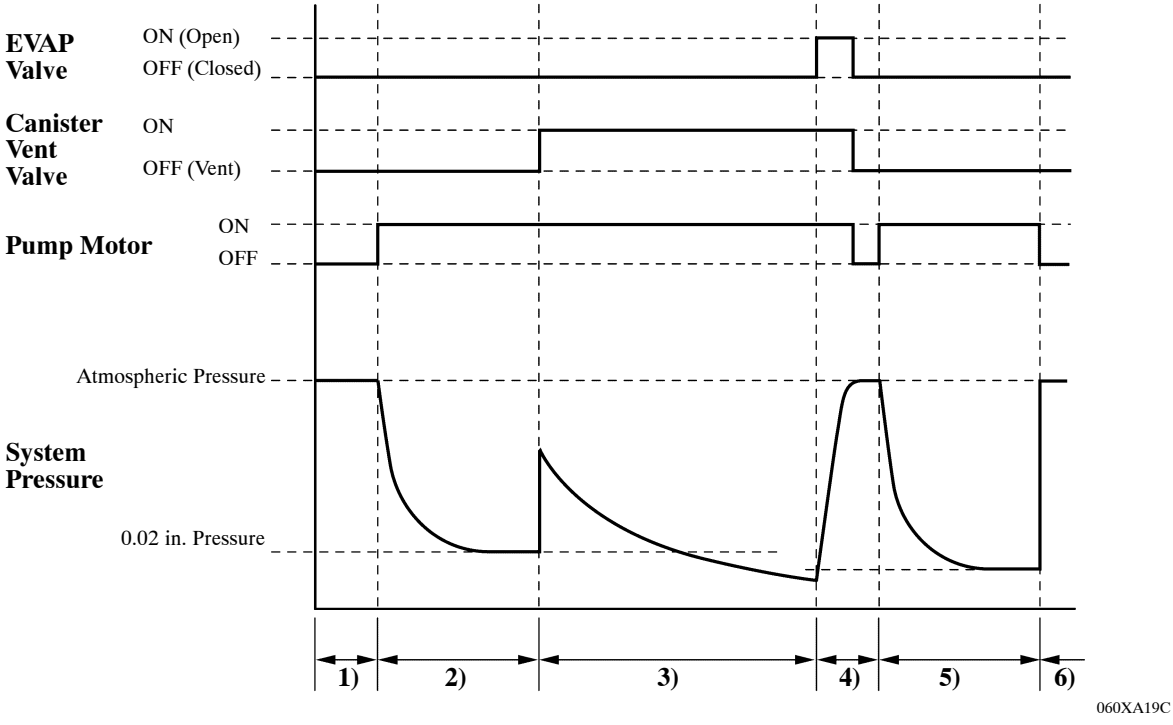
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3) EVAP Leak Check

a. General

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

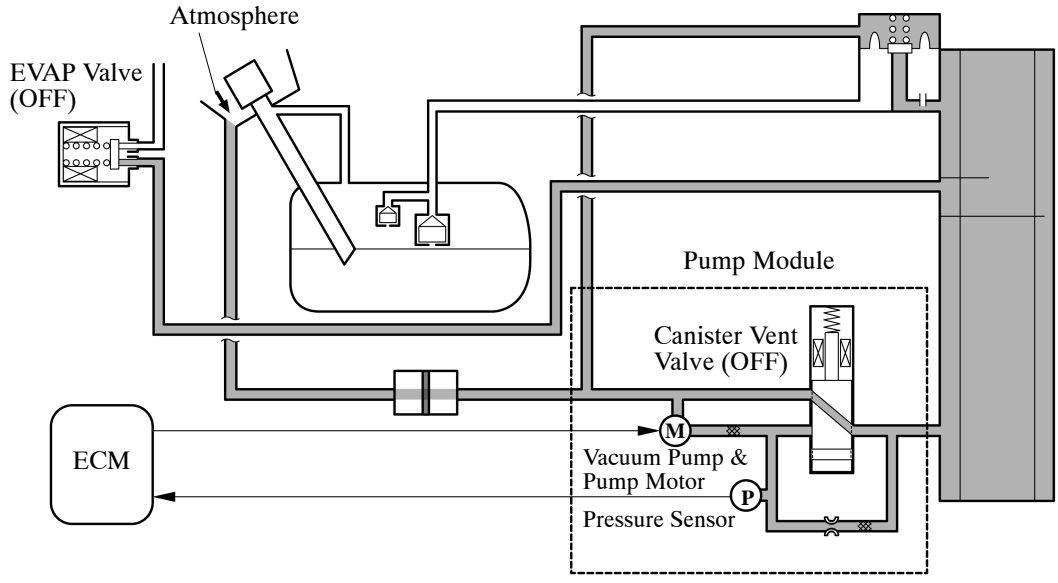
▶ Timing Chart ◀



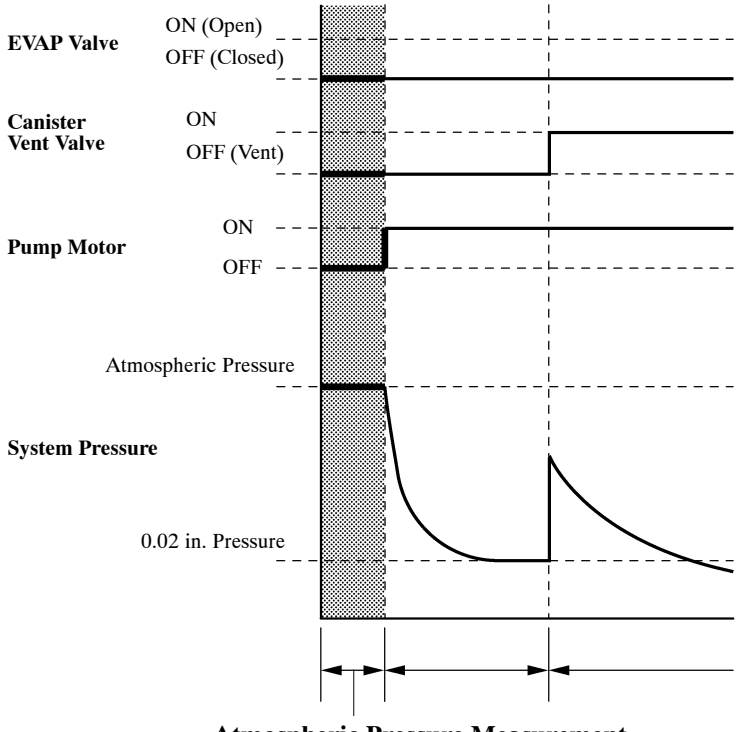
Order	Operation	Description	Time
1)	Atmospheric Pressure Measurement	The ECM turns the canister vent valve OFF (vent) and measures EVAP system pressure to determine the atmospheric pressure.	—
2)	0.02 in. Leak Pressure Measurement	The vacuum pump creates negative pressure (vacuum), which is limited by a 0.02 in. orifice. The pressure is measured, and 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 EVAP system pressure is measured. If the pressure after stabilization is greater than the 0.02 in. leak pressure, the ECM determines that the EVAP system has a leak. If EVAP pressure does not stabilize within 15 minutes, 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) that passes through the 0.02 in. orifice and pressure is measured. The ECM determines this as the 0.02 in. leak pressure.	20 sec.
6)	Final Check	The ECM measures atmospheric pressure and records the result of the monitor operation.	—

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.
2) The ECM records the atmospheric pressure measured 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.



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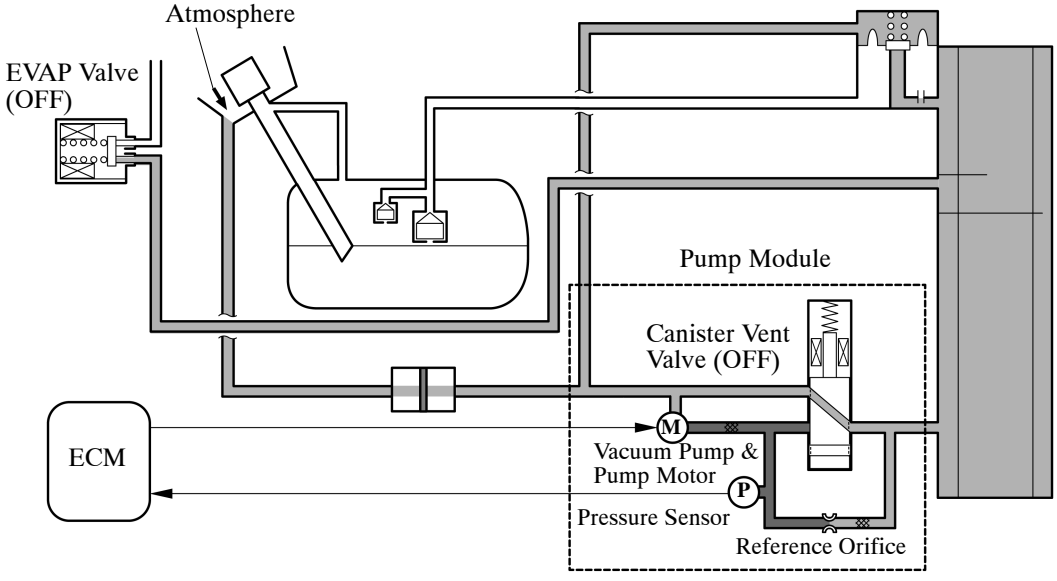
Atmospheric Pressure Measurement

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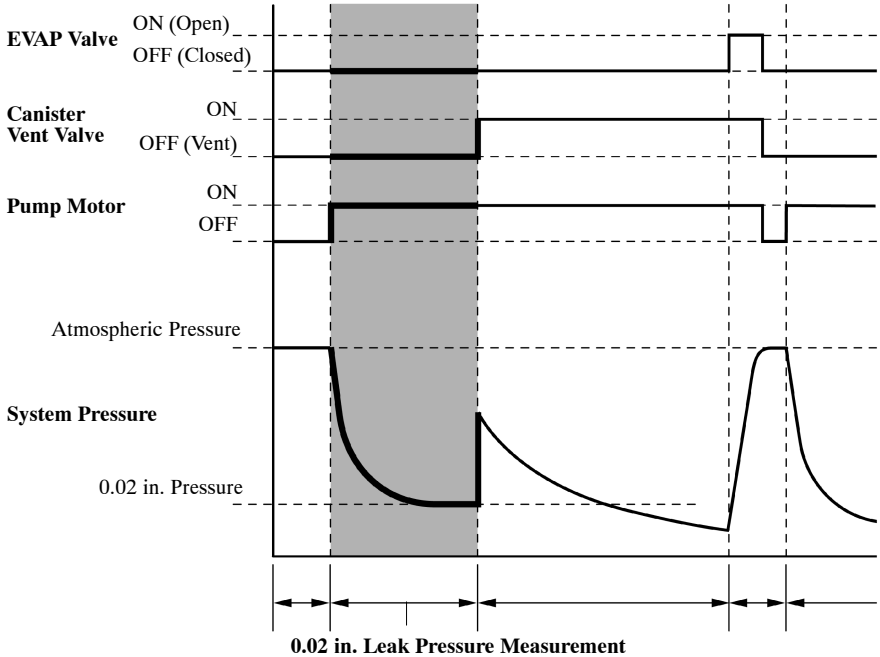
c. 0.02 in. Leak Pressure Measurement

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 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 is passing through the reference orifice and store DTCs P043F, P2401 and P2402 in its memory.



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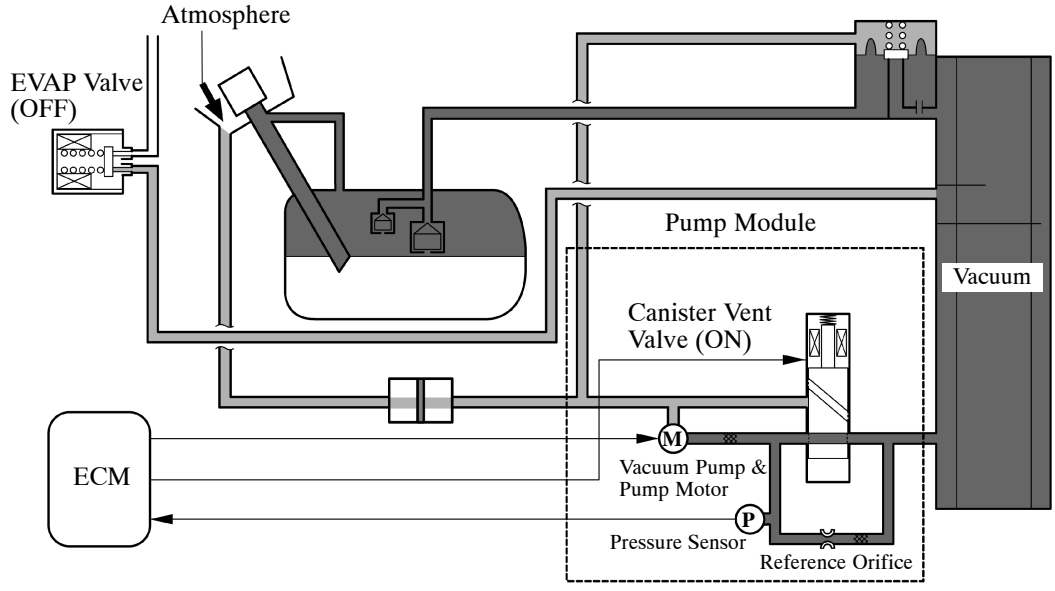


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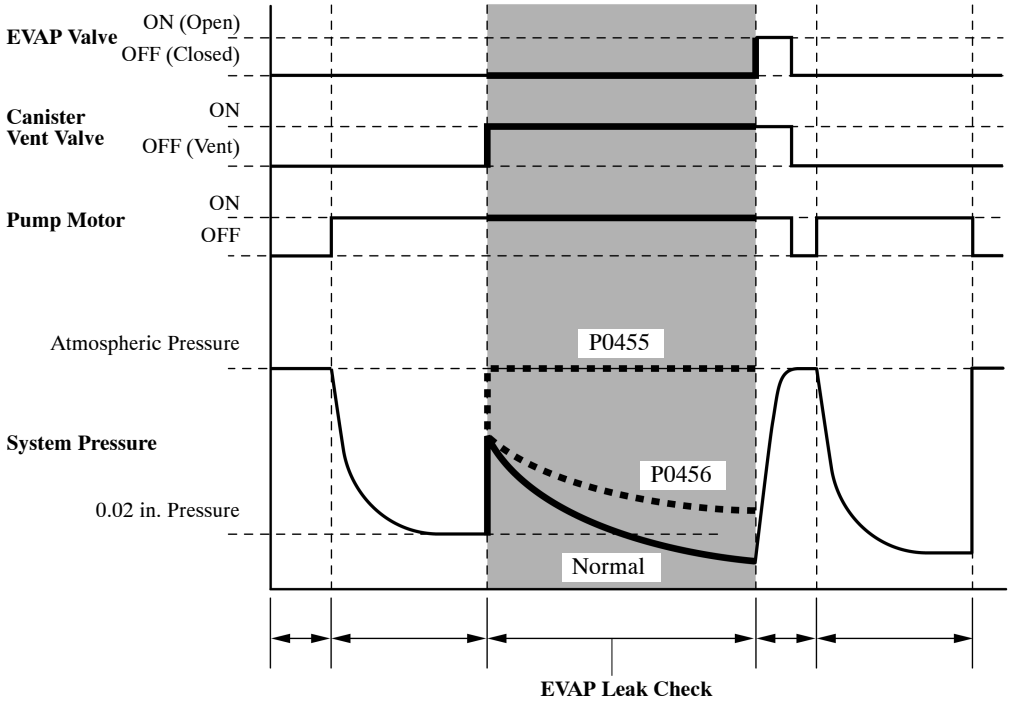
0.02 in. Leak Pressure Measurement

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.
2) When the pressure in the system stabilizes, the ECM compares this pressure and the 0.02 in. pressure in order to determine if leakage is occurring.
3) If the detected value is below the 0.02 in. pressure, the ECM determines that a leak is not occurring.
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.



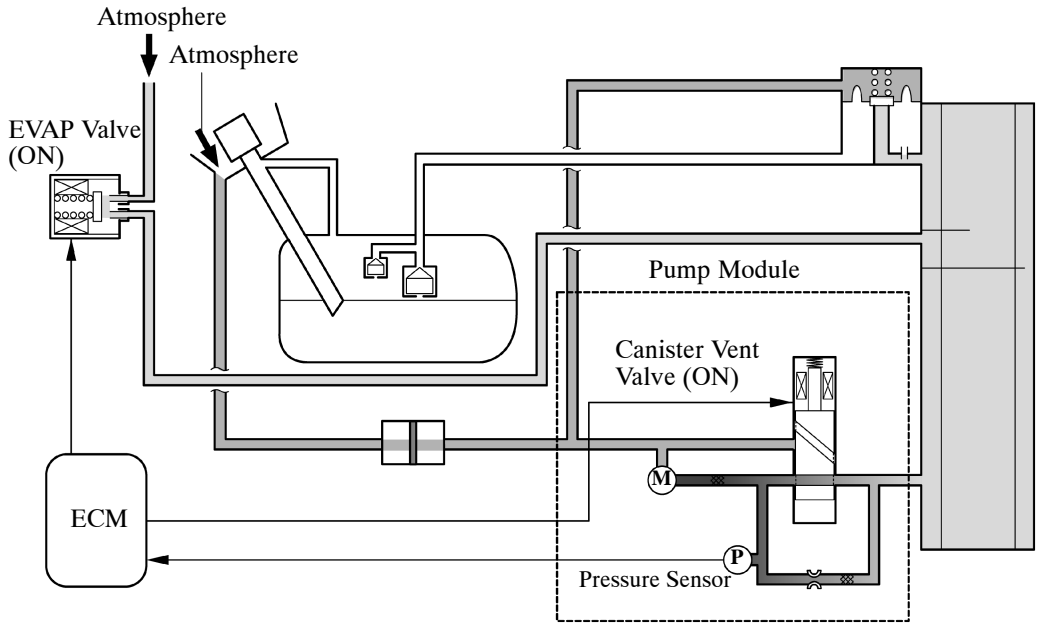
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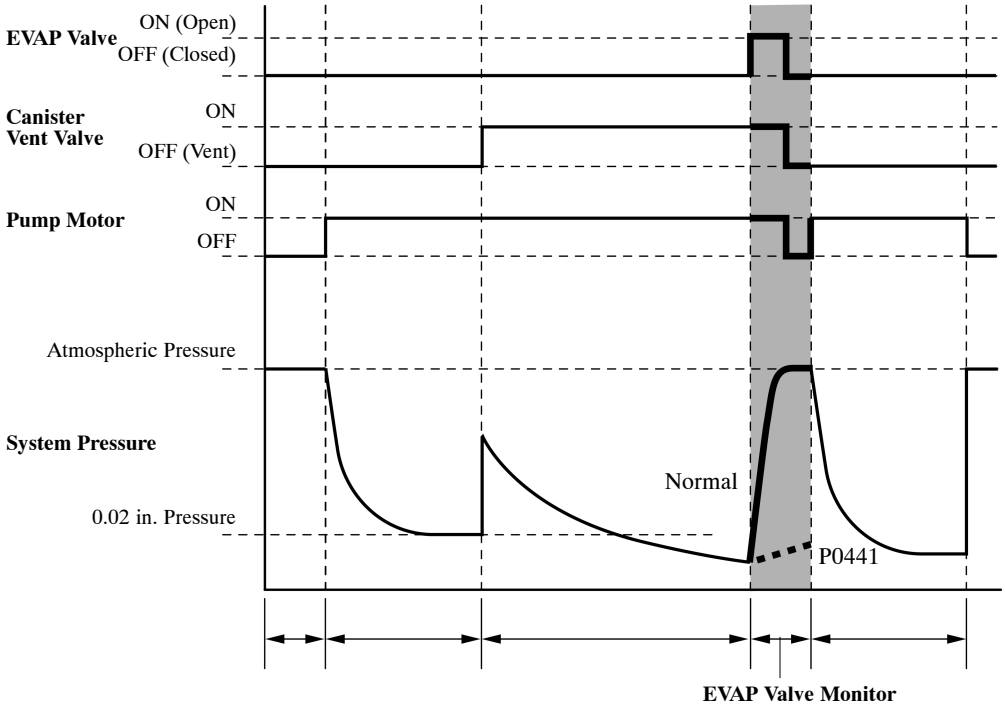
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e. EVAP Valve Monitor

1) After completing an EVAP leak check, the ECM turns the EVAP valve on with the vacuum pump still actuated, and introduces atmospheric pressure from the intake manifold to the charcoal canister.
2) If the pressure change at this time is within the normal range (a pressure change occurs), the ECM determines the condition of the EVAP valve 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.



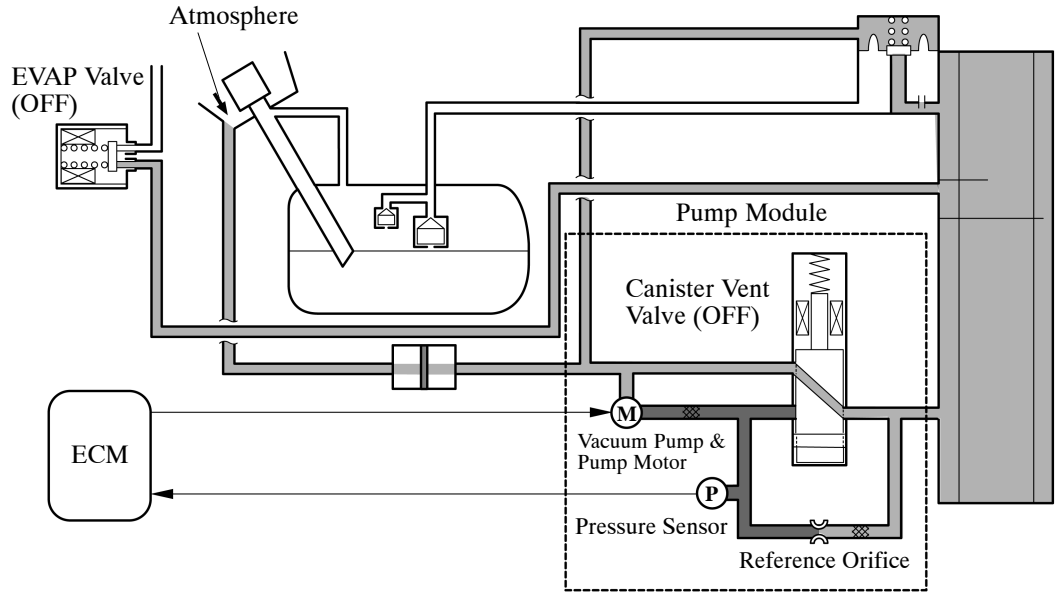
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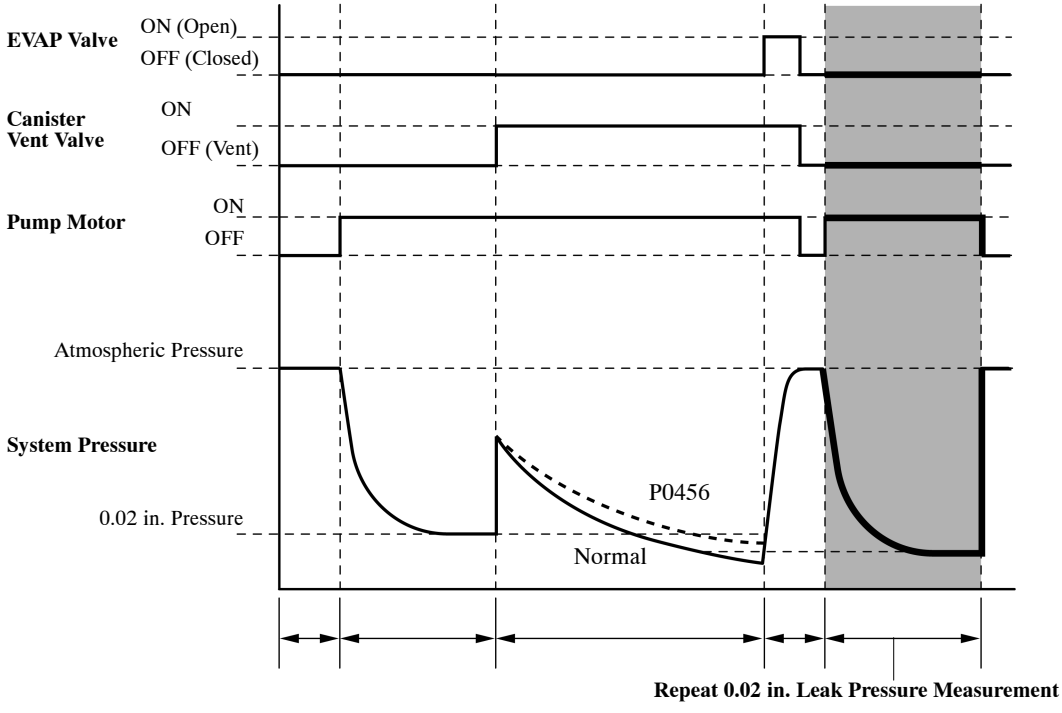
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f. Repeat 0.02 in. Leak Pressure Measurement

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 the 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.



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14. Diagnosis

- When the ECM detects a malfunction, the ECM records the fault and memorizes the information that relates to the fault. Furthermore, it illuminates or blinks the MIL (Malfunction Indicator Lamp) in the combination meter to inform the driver.
- The ECM will also store the DTCs (Diagnostic Trouble Codes) of the malfunctions. The DTCs can be accessed using the hand-held tester or Techstream*.
- For details, see the 2007 TOYOTA TUNDRA Repair Manual (Pub. No. RM04E2U).

Service Tip

- The ECM uses the CAN protocol for diagnostic communication. Therefore, a hand-held tester or Techstream* and a dedicated adapter [CAN VIM (Vehicle Interface Module)] are required for accessing diagnostic data.
- To clear a DTC that is stored in the ECM, use a hand-held tester or Techstream*, disconnect the battery terminal or remove the EFI fuse for 1 minute or longer.

For details, see the 2007 TOYOTA TUNDRA Repair Manual (Pub. No. RM04E2U).

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

15. Fail-Safe

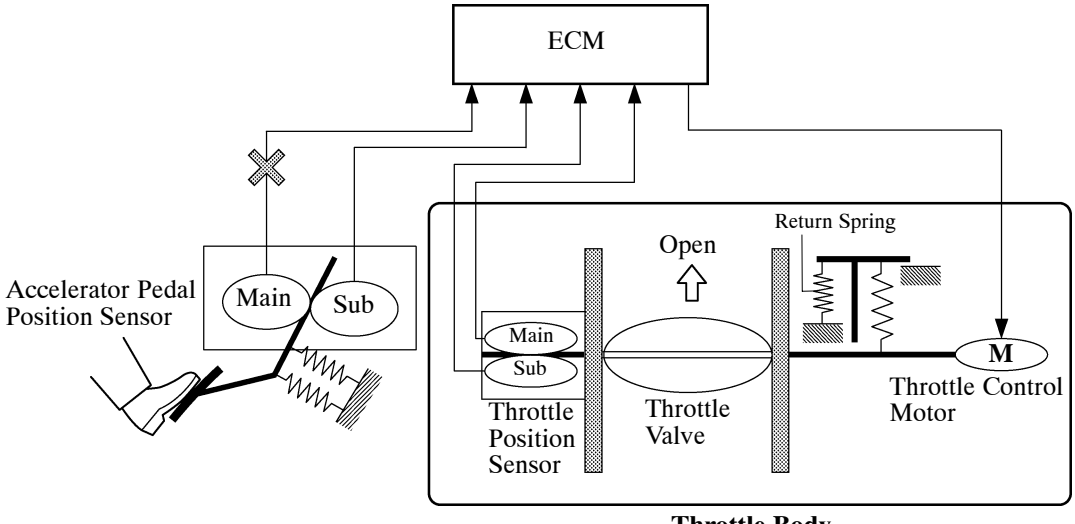
General

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 2007 TOYOTA TUNDRA Repair Manual (Pub. No. RM04E2U).

Fail-safe Operation due to Accelerator Pedal Position Sensor Malfunction

The accelerator pedal position sensor contains two (Main, Sub) sensor circuits.

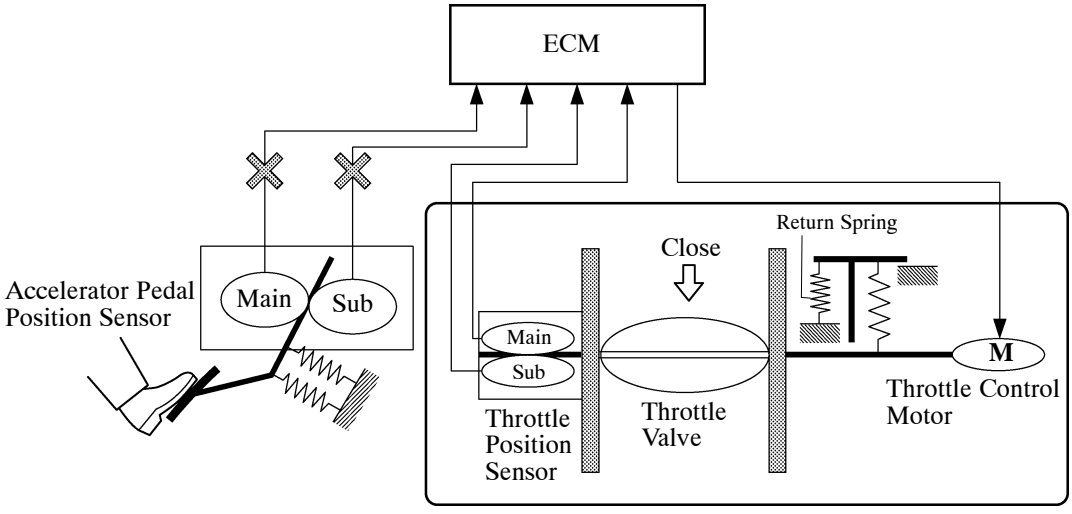
- If a malfunction occurs in either of the sensor circuits, the ECM detects the abnormal signal voltage difference between these two sensor circuits and switches into a fail-safe mode. In this fail-safe mode, the remaining circuit is used to calculate the accelerator pedal opening, in order to operate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



Throttle Body

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- 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.



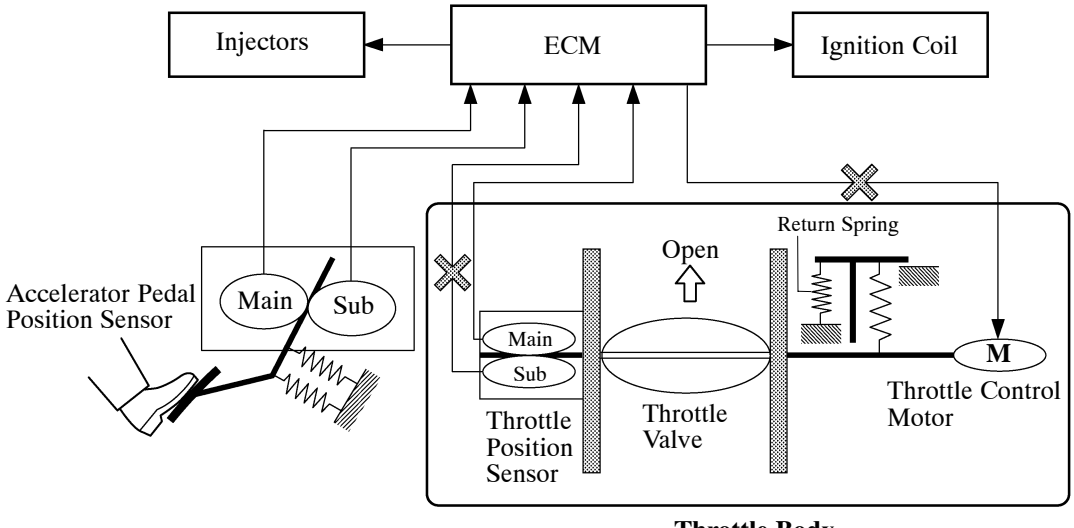
Throttle Body

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Fail-safe Operation due to Throttle Position Sensor Malfunction

The throttle position sensor contains 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 its 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.



Throttle Body

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