13. Engine Control System

General

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

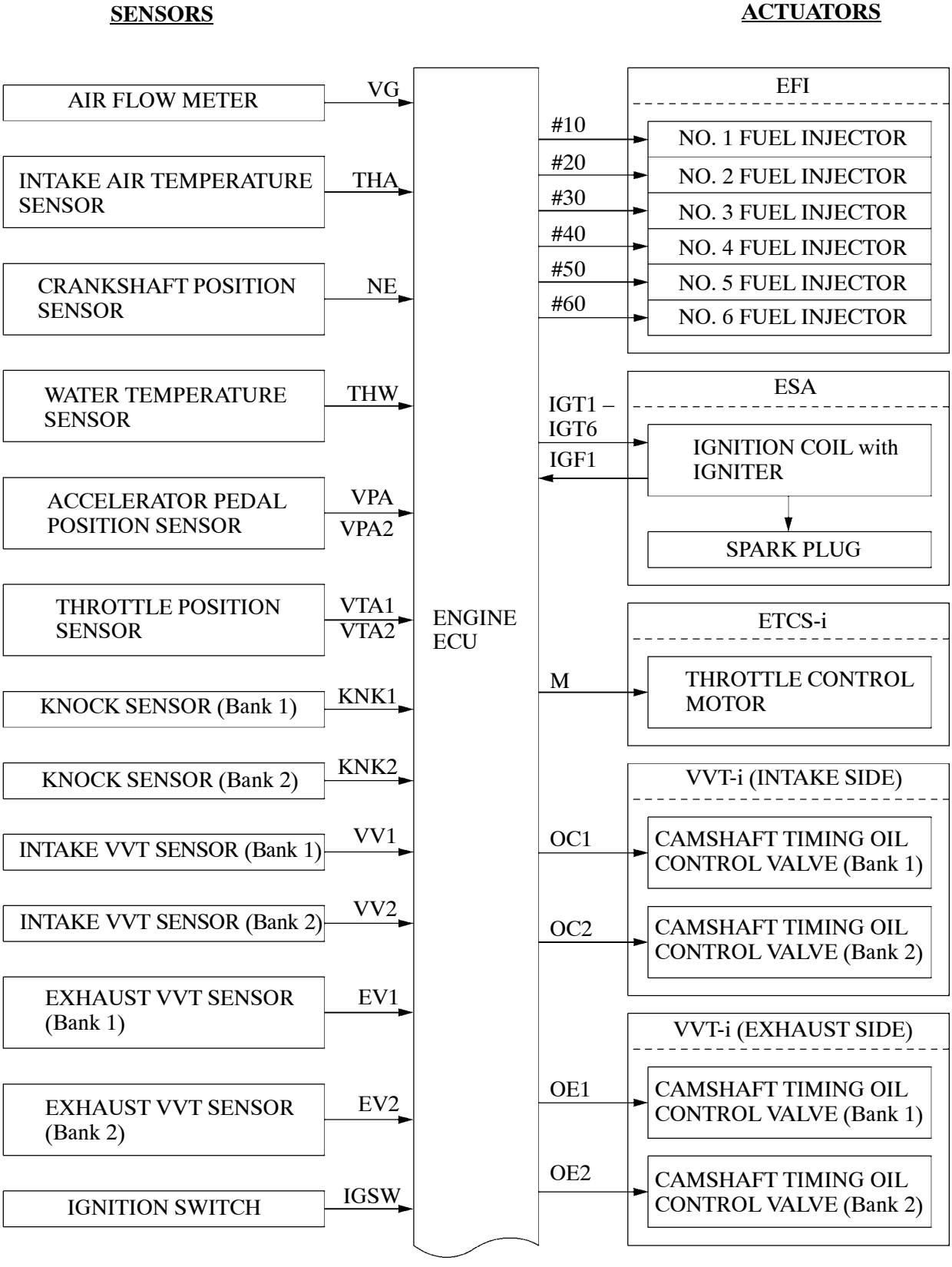
System	Outline
EFI (Electronic Fuel Injection)	An L-type EFI system detects the intake air mass with a hot-wire type air flow meter.
ESA (Electronic Spark Advance)	● Ignition timing is determined by the engine ECU based on signals from various sensors. The engine ECU corrects ignition timing in response to engine knocking. ● This system selects the optimal ignition timing in accordance with the signals received from the sensors and sends the (IGT) ignition signal to the igniter.
ETCS-i (Electronic Throttle Control System-intelligent) [See page 65]	Optimally controls the throttle valve opening in accordance with the amount of accelerator pedal effort and the condition of the engine and the vehicle.
Dual VVT-i (Variable Valve Timing-intelligent) System [See page 69]	Controls the intake and exhaust camshafts to an optimal valve timing in accordance with the engine condition.
ACIS (Acoustic Control Induction System) [See page 75]	The intake air passages are switched according to the engine speed and throttle valve opening angle to provide high performance in all speed ranges.
Air Intake Control System [See page 77]	The intake air duct is divided into two areas, and the engine ECU controls the air intake control valve and the actuator that are provided in one of the areas to reduce the amount of engine noise.
Fuel Pump Control [See page 78]	● Fuel pump operation is controlled by signals from the engine ECU. ● The fuel pump is stopped, when the SRS airbag is deployed in a frontal, side, and rear side collision.
Air Conditioner Cut-off Control	By turning the air conditioner compressor ON or OFF in accordance with the engine condition, drivability is maintained.
Evaporative Emission Control	The engine ECU controls the purge flow of evaporative emissions (HC) in the charcoal canister in accordance with engine conditions.
Cooling Fan Control [See page 79]	The cooling fan ECU steplessly controls the speed of the fans in accordance with the water temperature, vehicle speed, engine speed, and air conditioner operating conditions. As a result, the cooling performance is improved.

(Continued)

System	Outline
Charging Control [See page 81]	The engine ECU regulates the charging voltage of the alternator in accordance with the driving conditions and the charging state of the battery.
Air-fuel Ratio Sensor and Heated Oxygen Sensor Heater Control	Maintains the temperature of the air-fuel ratio sensor or heated oxygen sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.
Engine Immobilizer	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid key.
Diagnosis [See page 83]	When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section.
Fail-safe [See page 83]	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in the memory.

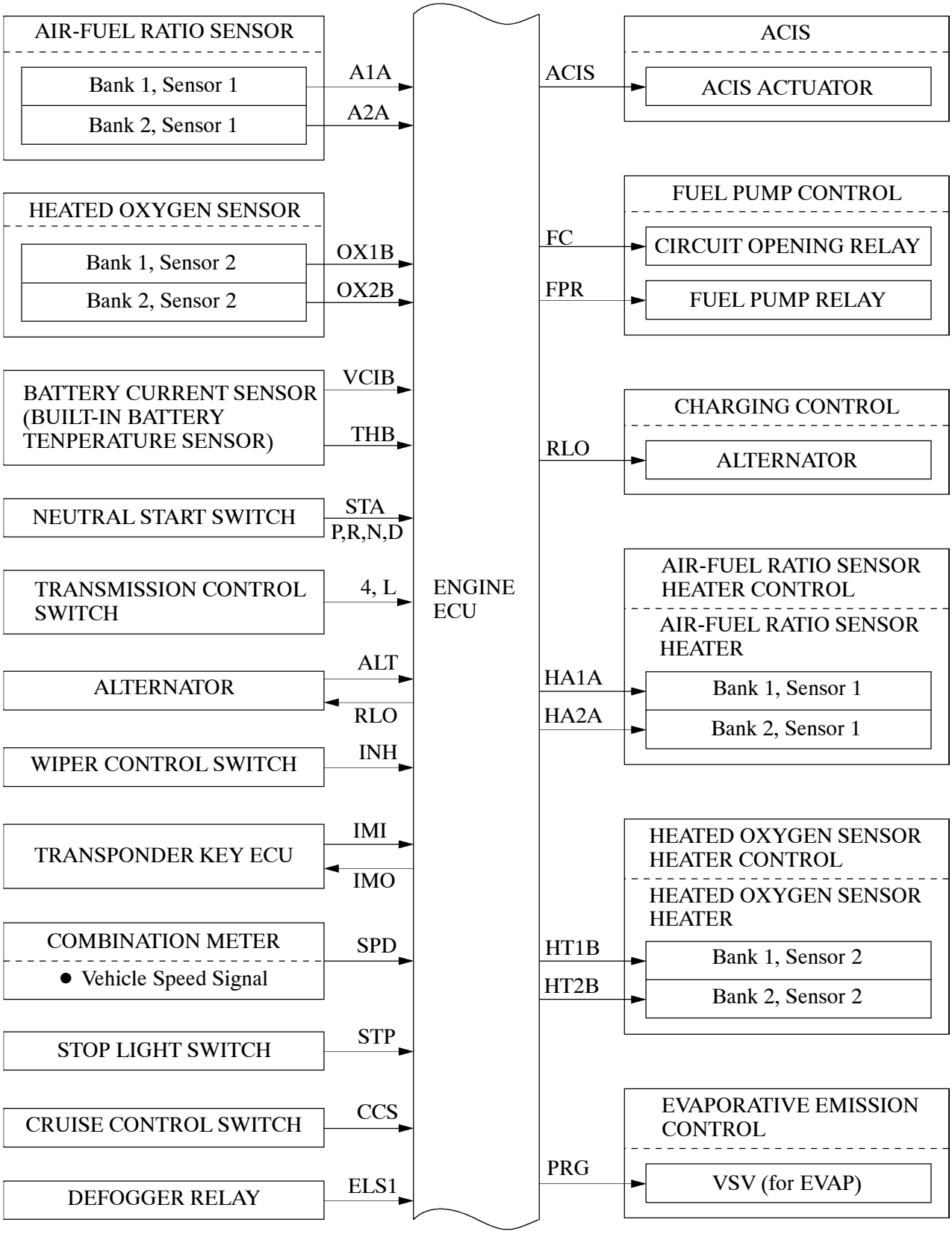
Construction

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



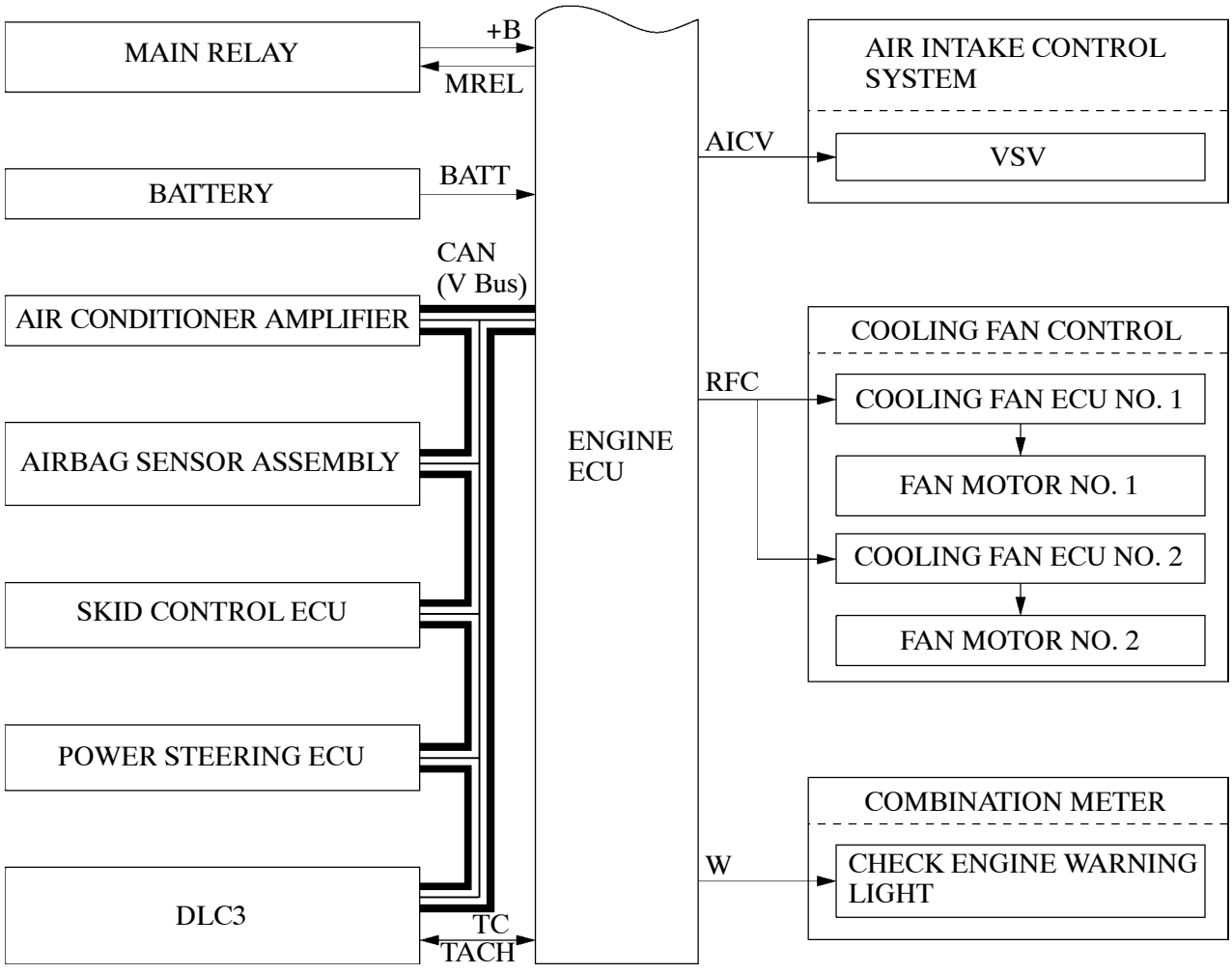
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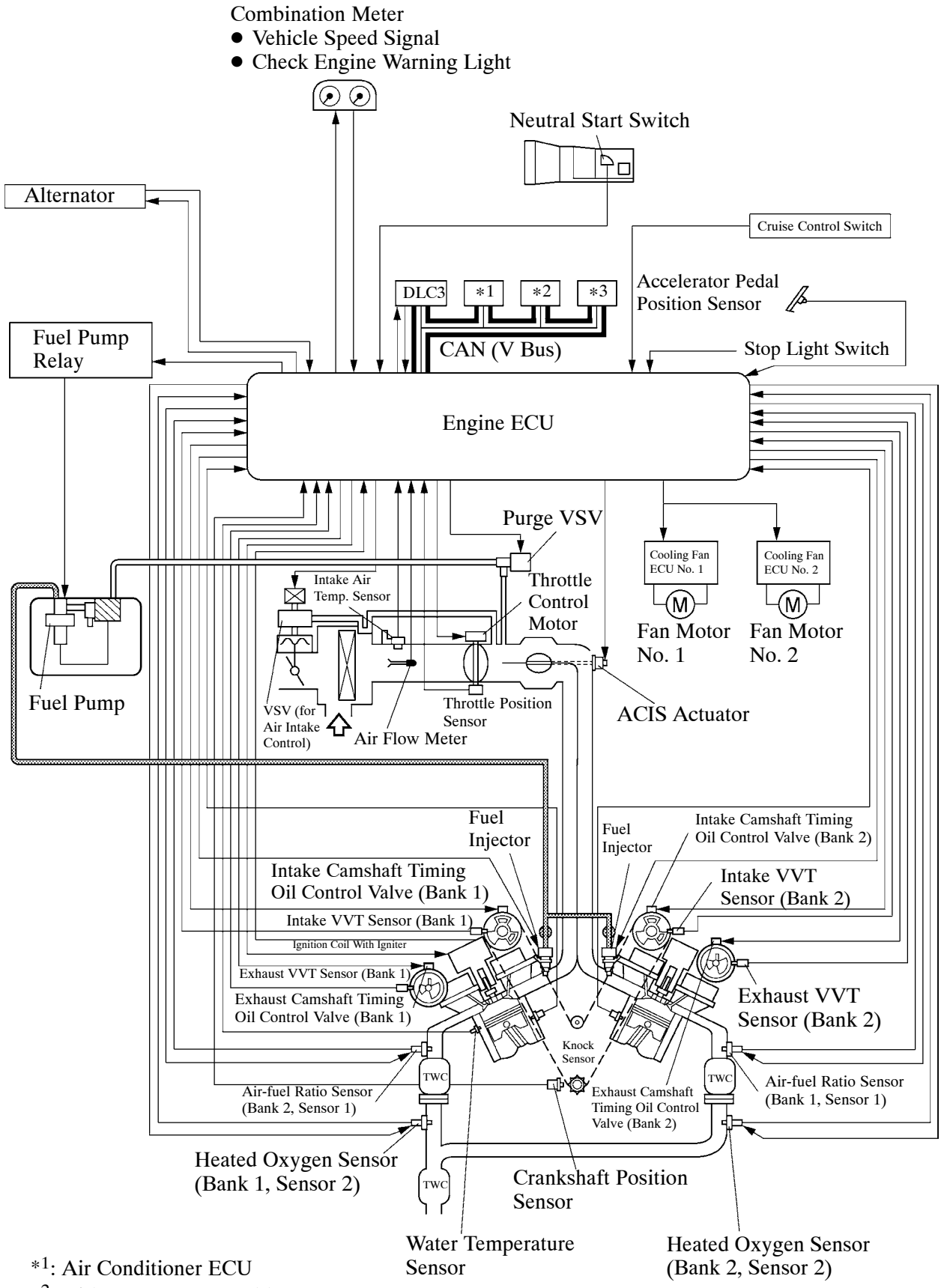
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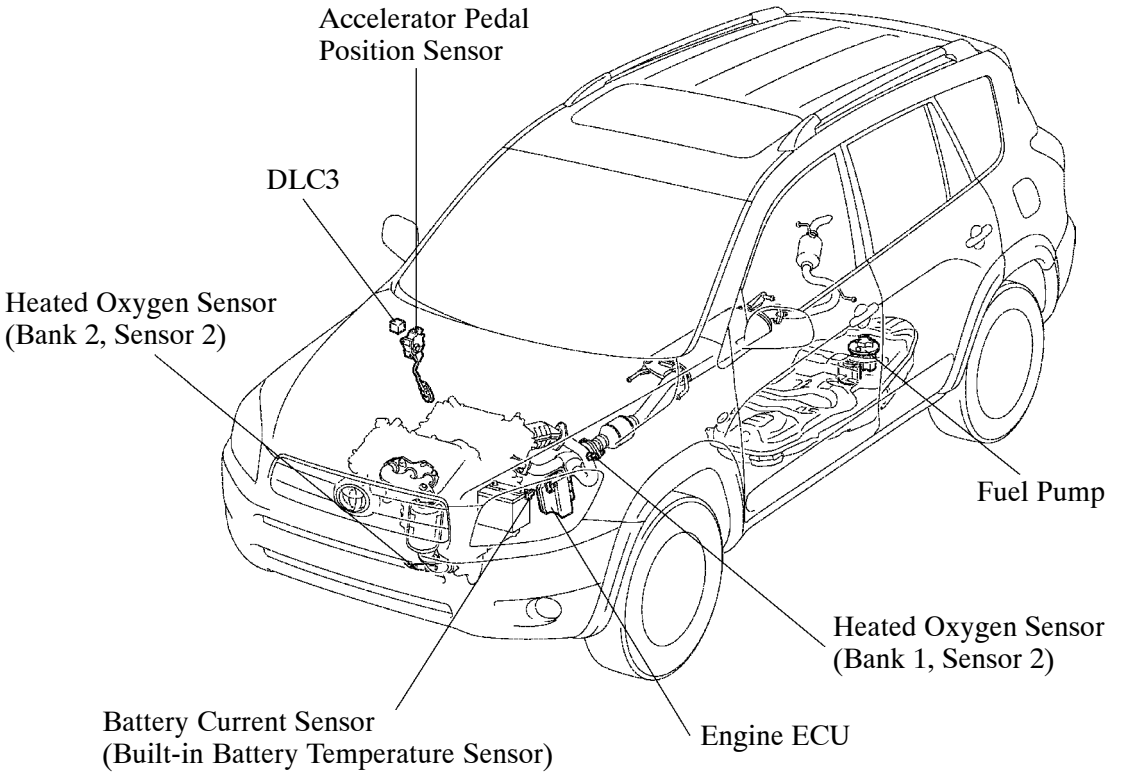

MAIN RELAY
+B
MREL
BATTERY
BATT
CAN
(V Bus)
AIR CONDITIONER AMPLIFIER
AIRBAG SENSOR ASSEMBLY
SKID CONTROL ECU
POWER STEERING ECU
DLC3
TC
TACH
ENGINE
ECU
AIR INTAKE CONTROL
SYSTEM
AICV
VSV
COOLING FAN CONTROL
RFC
COOLING FAN ECU NO. 1
FAN MOTOR NO. 1
COOLING FAN ECU NO. 2
FAN MOTOR NO. 2
COMBINATION METER
W
CHECK ENGINE WARNING
LIGHT

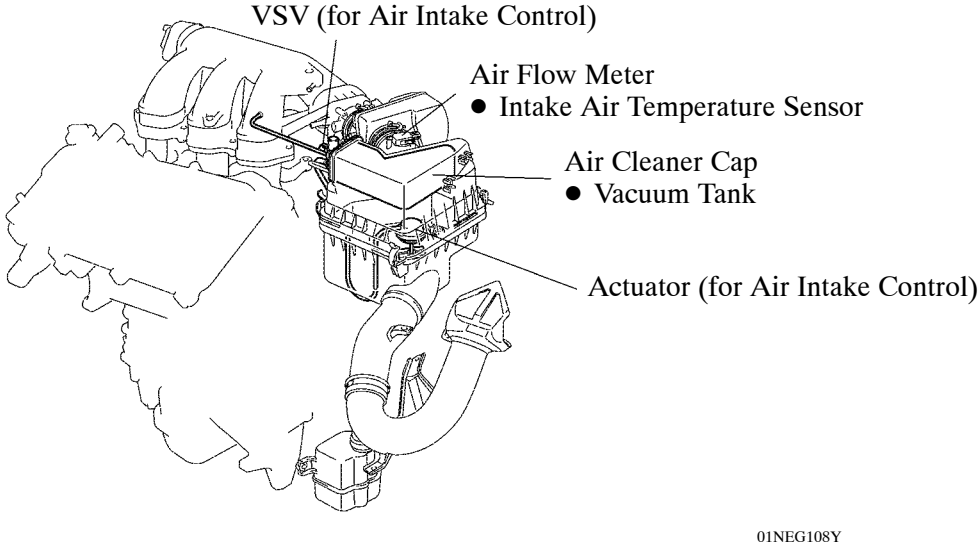
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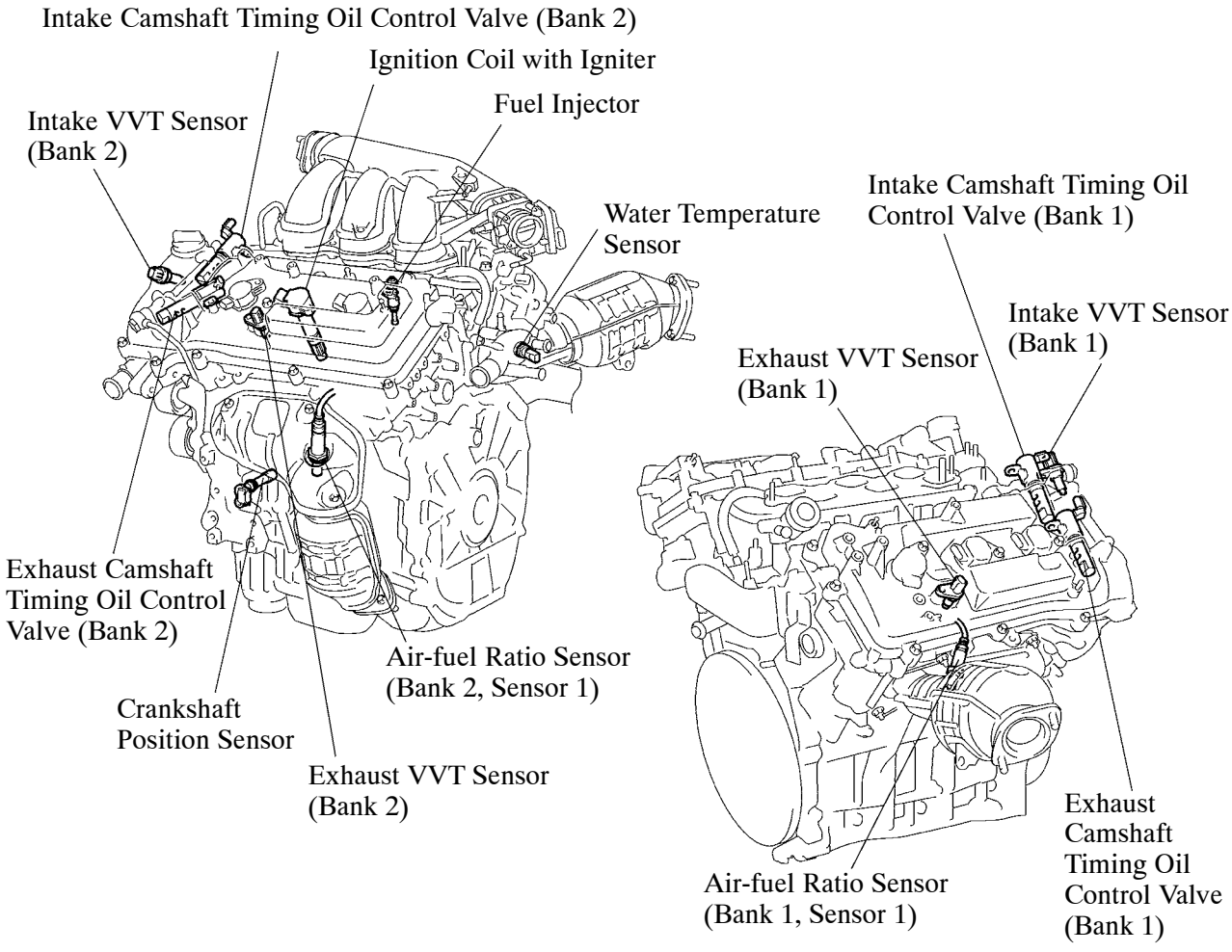
Engine Control System Diagram



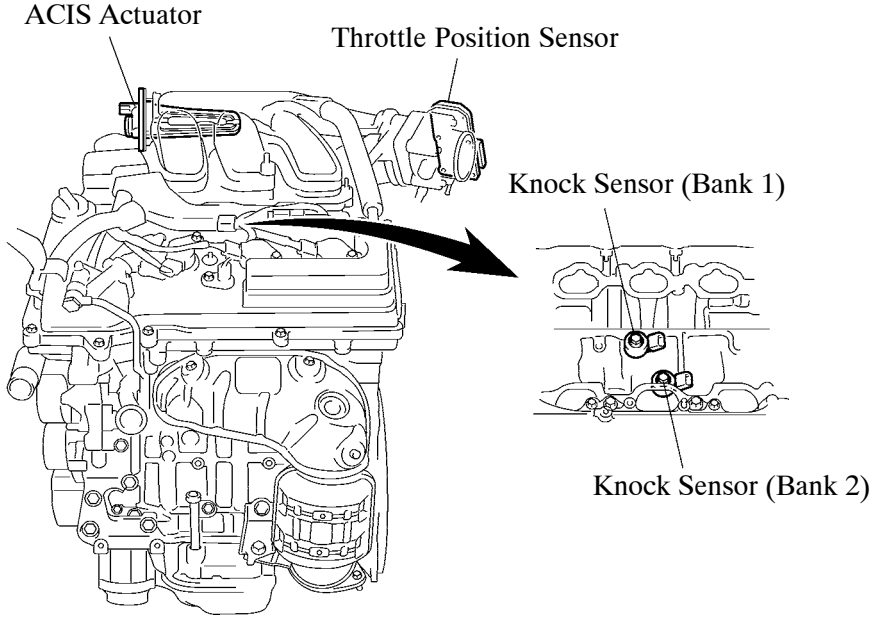
Layout of Main Components







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Main Components of Engine Control System

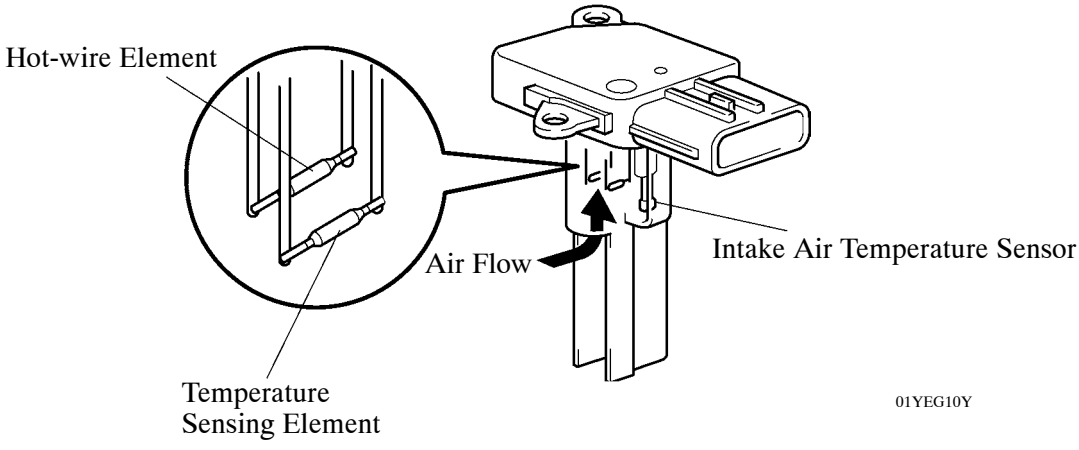
1) General

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

Component		Outline	Quantity
Engine ECU		32-bit CPU	1
Air Flow Meter		Hot-wire Type	1
Crankshaft Position Sensor (Rotor Teeth)		Pick-up Coil Type (36 – 2)	1
Intake VVT Sensor (Rotor Teeth)		MRE (Magnetic Resistance Element) Type (3)	2
Exhaust VVT Sensor (Rotor Teeth)		MRE (Magnetic Resistance Element) Type (3)	2
Accelerator Pedal Position Sensor		Non-contact Type	1
Throttle Position Sensor		Non-contact Type	1
Knock Sensor		Built-in Piezoelectric Type (Non-resonant Type/ Flat Type)	2
Air-fuel Ratio Sensor	(Bank 1, Sensor 1)	Type with Heater (Planar Type)	1 each
	(Bank 2, Sensor 1)		
Heated Oxygen Sensor	(Bank 1, Sensor 2)	Type with Heater (Cup Type)	1 each
	(Bank 2, Sensor 2)		
Fuel Injector		12-hole Type	6

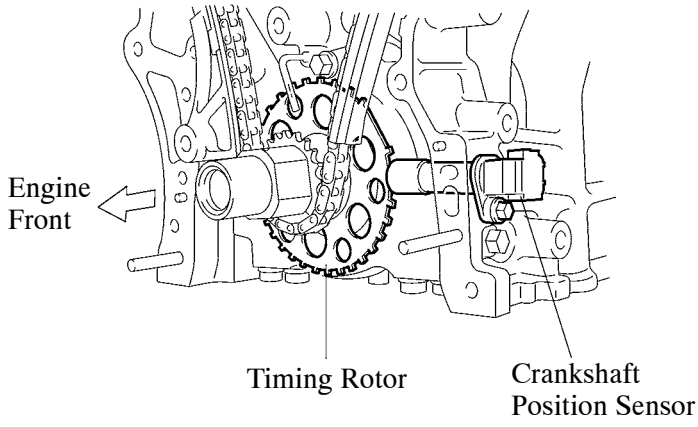
2) Air Flow Meter

- The compact and lightweight 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 high detection precision is achieved and the intake air resistance is reduced.
- This air flow meter has a built-in intake air temperature sensor.

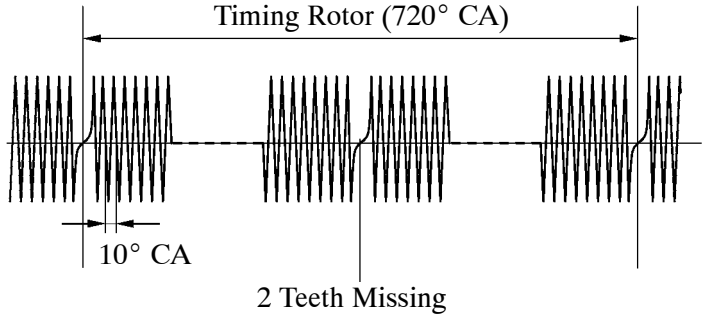


3) Crankshaft Position Sensor

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 missing teeth are used to determine the top-dead-center.



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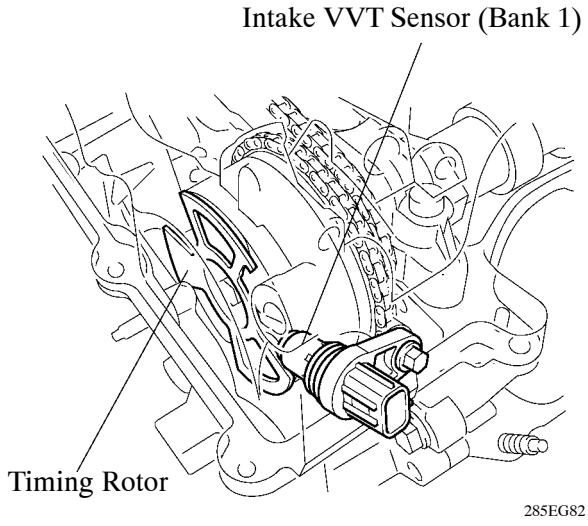


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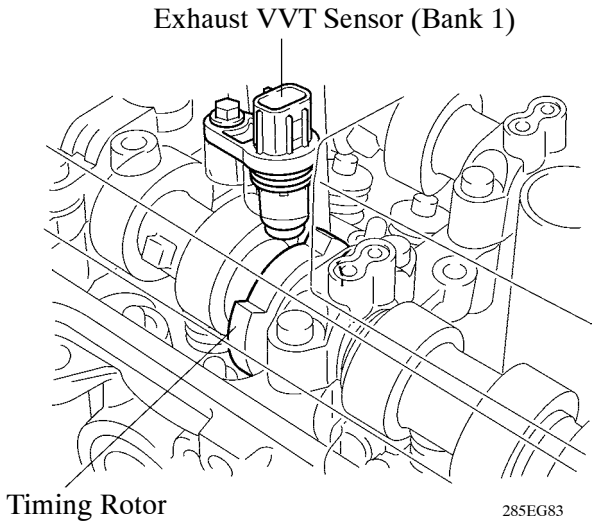
4) Intake and Exhaust VVT Sensors

a. General

The MRE (Magnetic Resistance Element) type intake and exhaust 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 6 (3 Hi Output, 3 Lo Output) pulses for every 2 revolutions of the crankshaft.

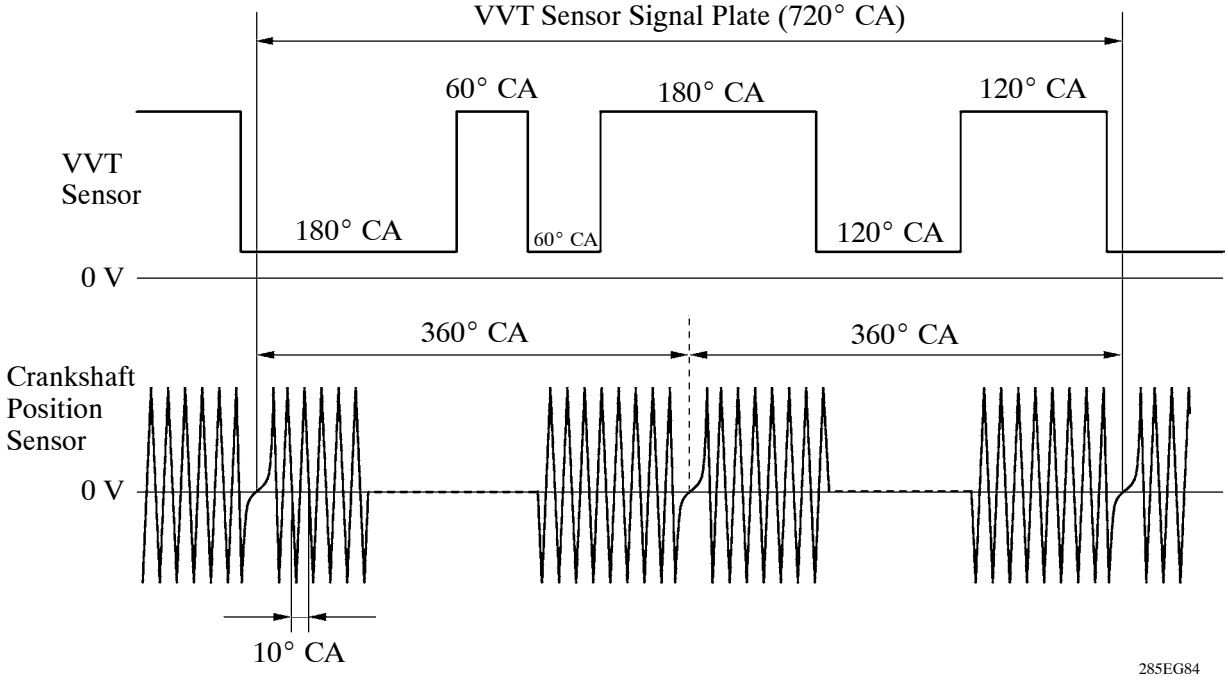


RH Bank



RH Bank

▶ Sensor Output Waveforms ◀

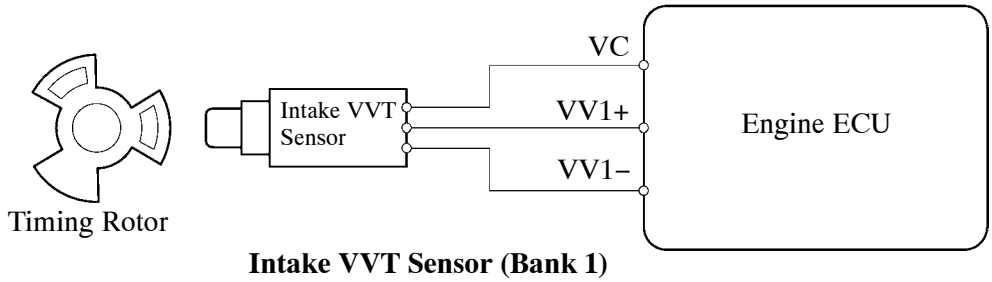


b. MRE Type VVT Sensor

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

Item	Sensor Type	
	MRE	Pick-up Coil
Signal Output	Constant digital output starts from low engine speeds.	Analog output changes with the engine speed.
Camshaft Position Detection	Detection is made by comparing the NE signals with the Hi/Lo output switch timing due to the protruded/non-protruded portions of the timing rotor, or made based on the number of the input NE signals during Hi/Lo outputs.	Detection is made by comparing the NE signals with the change of waveform that is output when the protruded portion of the timing rotor passes.

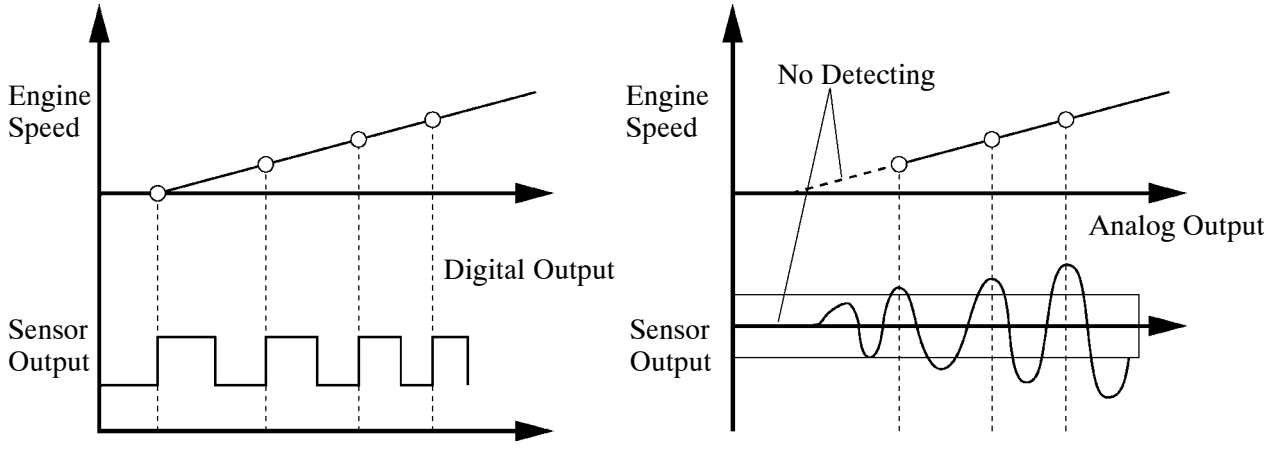
▶ Wiring Diagram ◀



Intake VVT Sensor (Bank 1)

271EG160

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



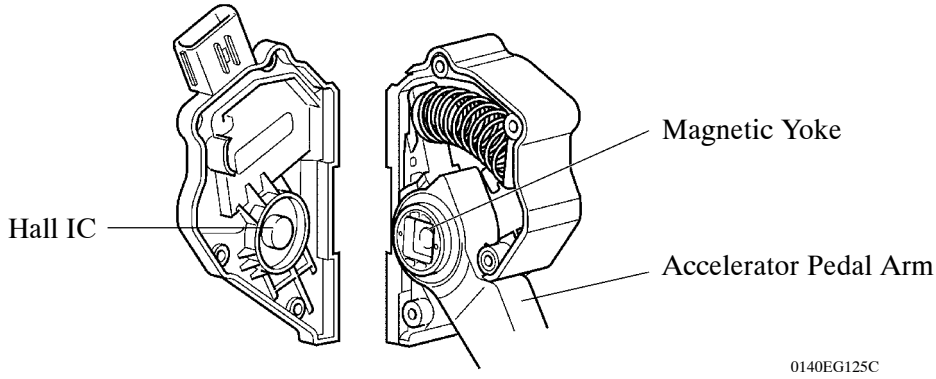
MRE Type **Pick-up Coil Type**

232CH41

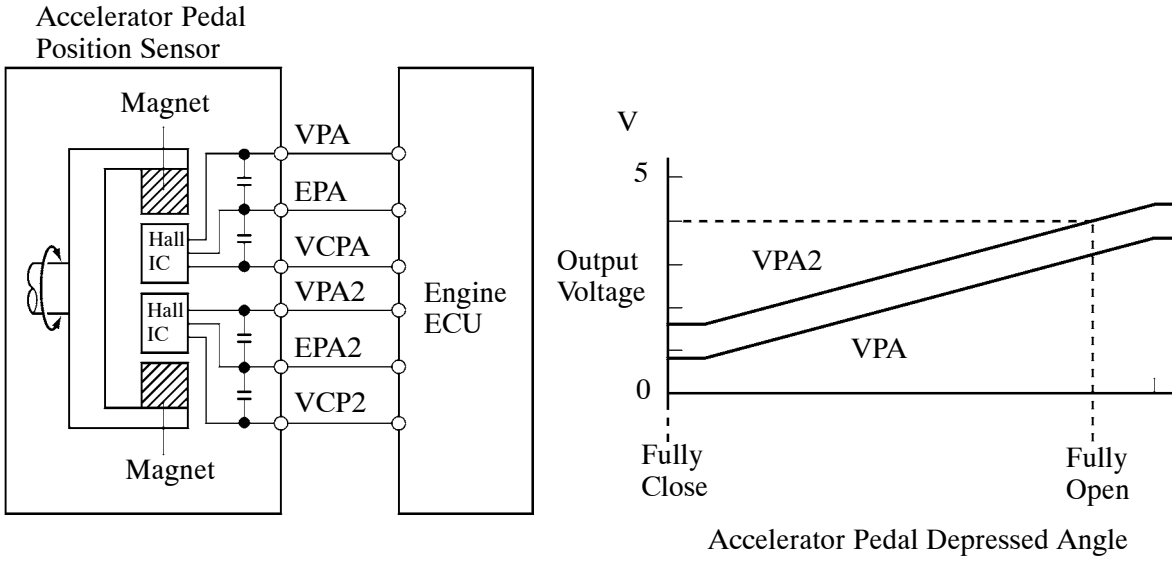
5) Accelerator Pedal Position Sensor

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

- The magnetic yoke 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 engine ECU.
- 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 engine ECU.



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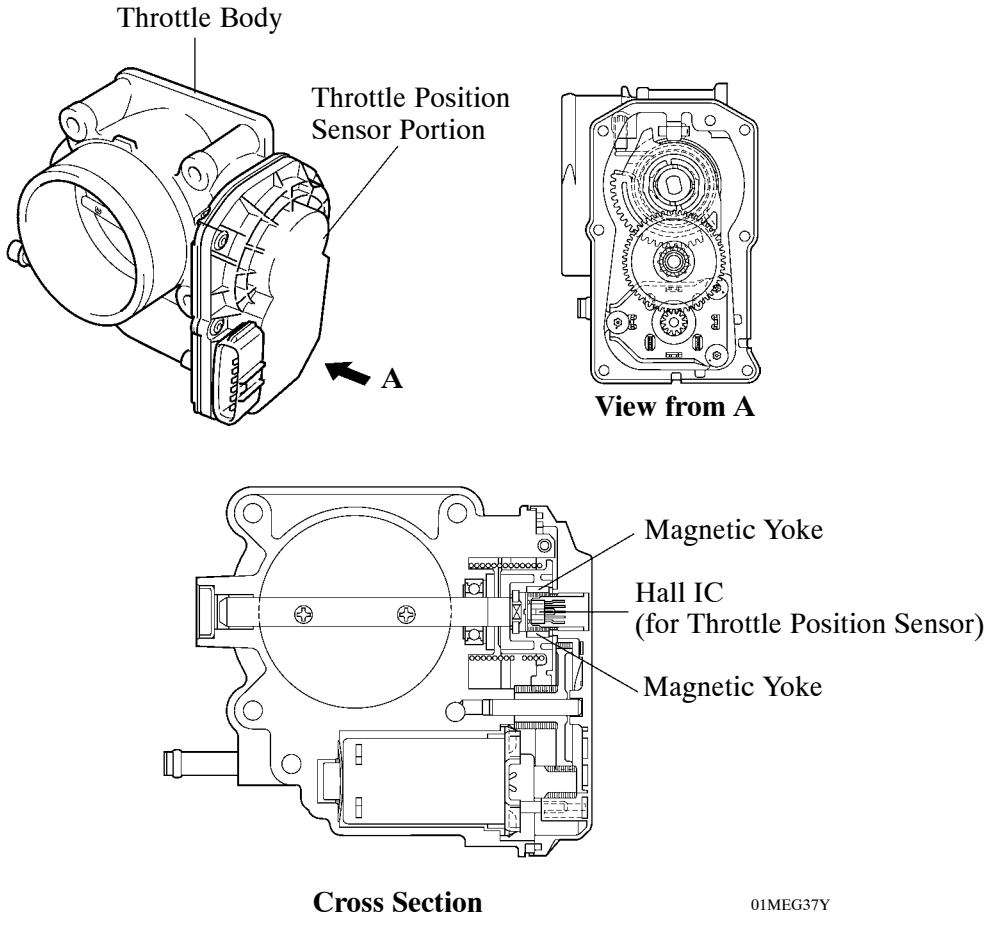
Service Tip

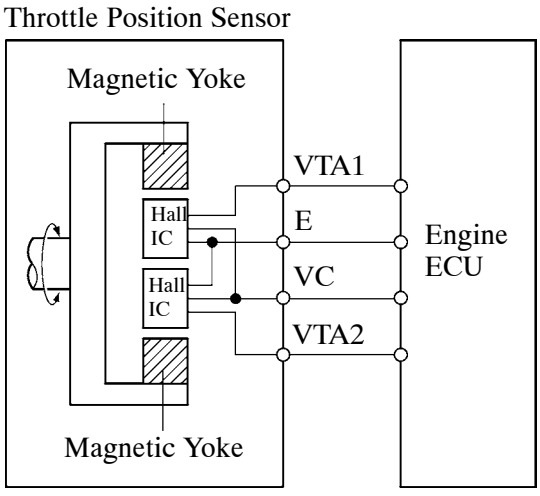
The inspection method differs from the conventional contact type accelerator pedal position sensor because this non-contact type sensor uses a Hall IC.
For details, refer to the RAV4 Repair Manual Supplement.

6) Throttle Position Sensor

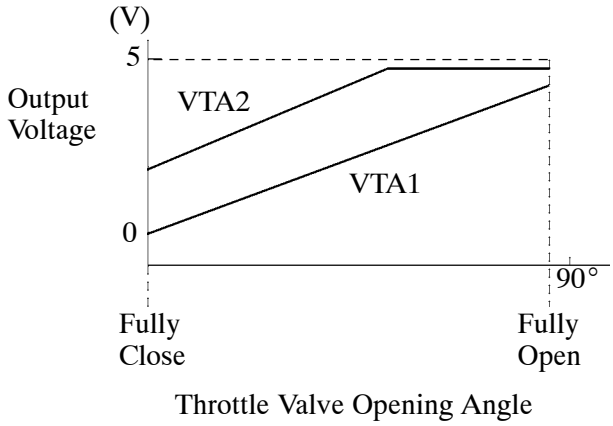
The non-contact type throttle position sensor uses a Hall IC, which is mounted on the throttle body.

- The Hall IC is surrounded by a magnetic yoke. The Hall IC converts the changes that occur in the magnetic flux at that time into electrical signals and outputs them in the form of a throttle valve effort to the engine ECU.
- The Hall IC contains circuits for the main and sub signals. It converts the throttle valve opening angles into electric signals with two differing characteristics and outputs them to the engine ECU.





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Service Tip

The inspection method differs from the conventional contact type throttle position sensor because this non-contact type sensor uses a Hall IC. For details, refer to the RAV4 Repair Manual Supplement.

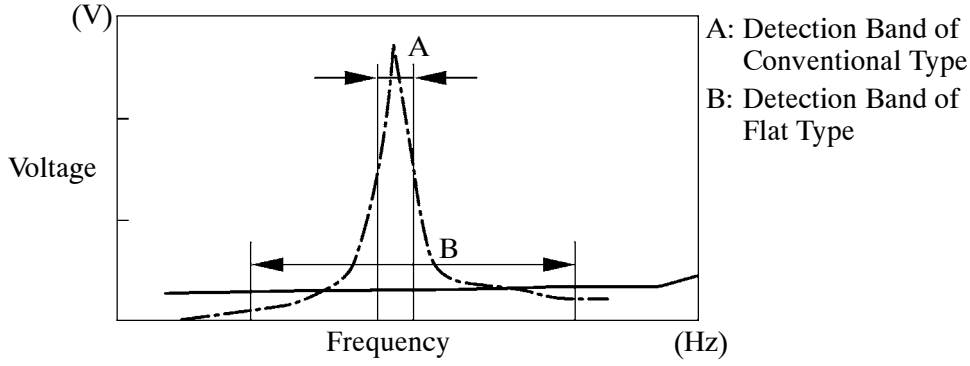
7) Knock Sensor (Flat Type)

a. General

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

- The engine knocking frequency will change a bit depending on the engine speed. The flat type knock sensor can detect the vibration even when the engine knocking frequency is changed. Thus the vibration detection ability is increased compared to the conventional type knock sensor, and a more precise ignition timing control is possible.

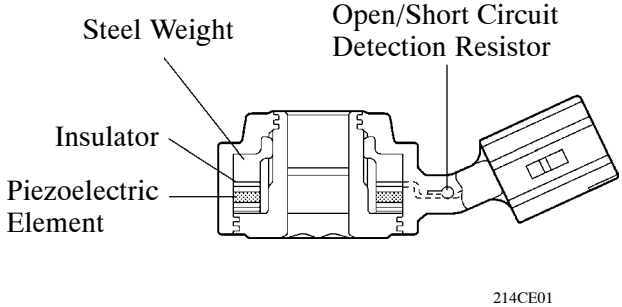
— · — : Conventional Type
——— : Flat Type



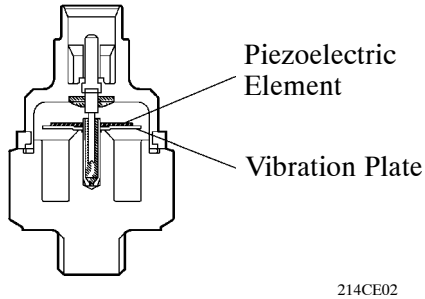
Characteristic of Knock Sensor

b. Construction

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



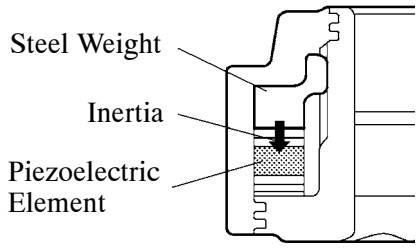
Flat Type Knock Sensor (Non-resonant Type)



Conventional Type Knock Sensor (Resonant Type)

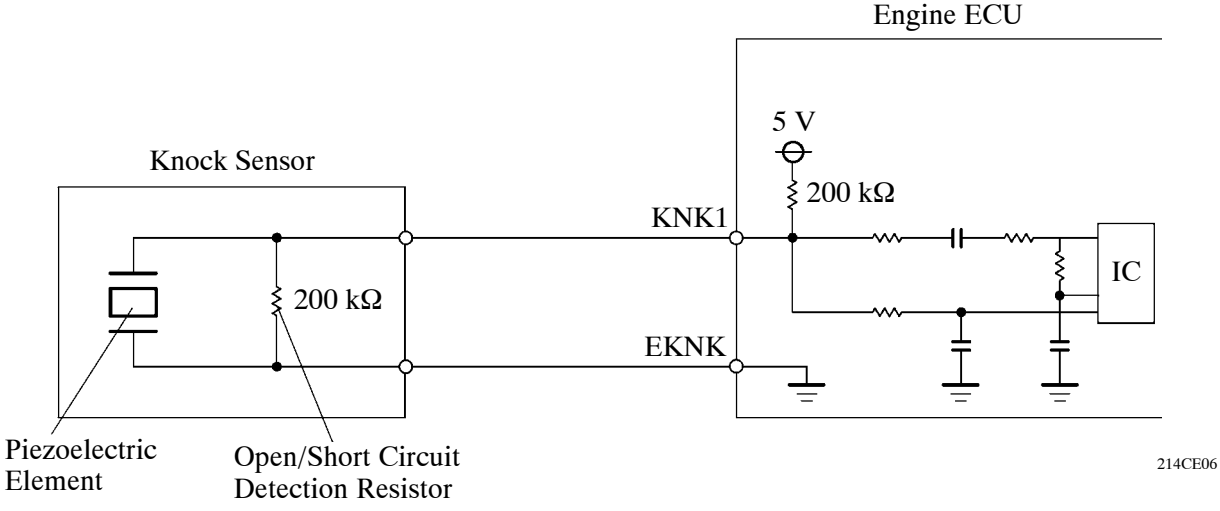
c. Operation

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



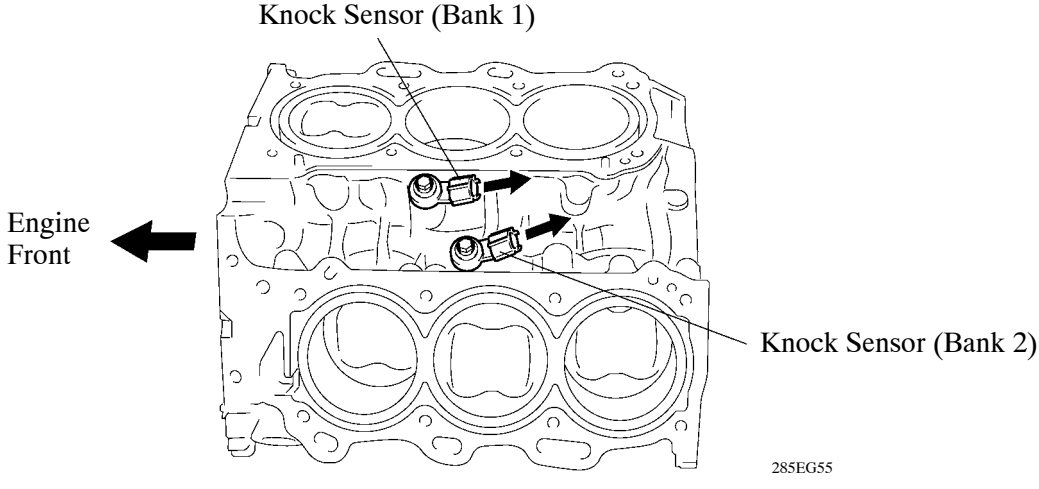
d. Open/Short Circuit Detection Resistor

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



Service Tip

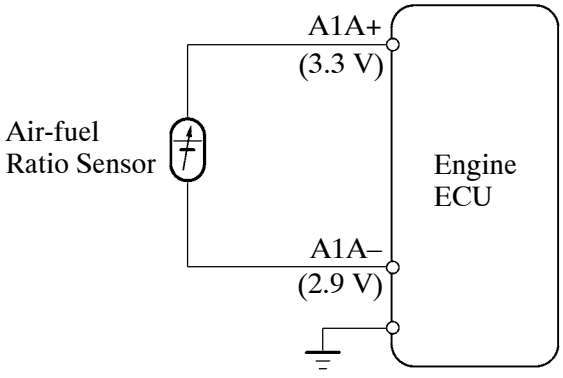
These knock sensors are mounted in the specific directions and angles as illustrated. To prevent the right and left bank connectors from being interchanged, make sure to install each sensor in its prescribed direction.



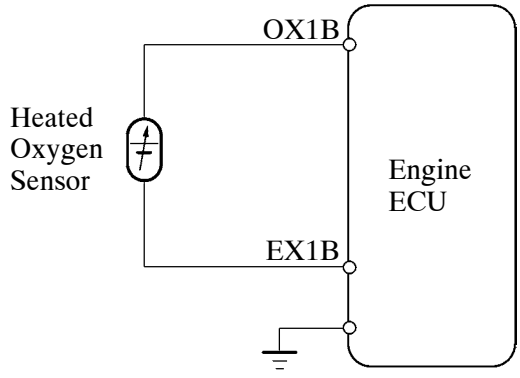
8) Air-fuel Ratio Sensor and Heated Oxygen Sensor

a. General

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

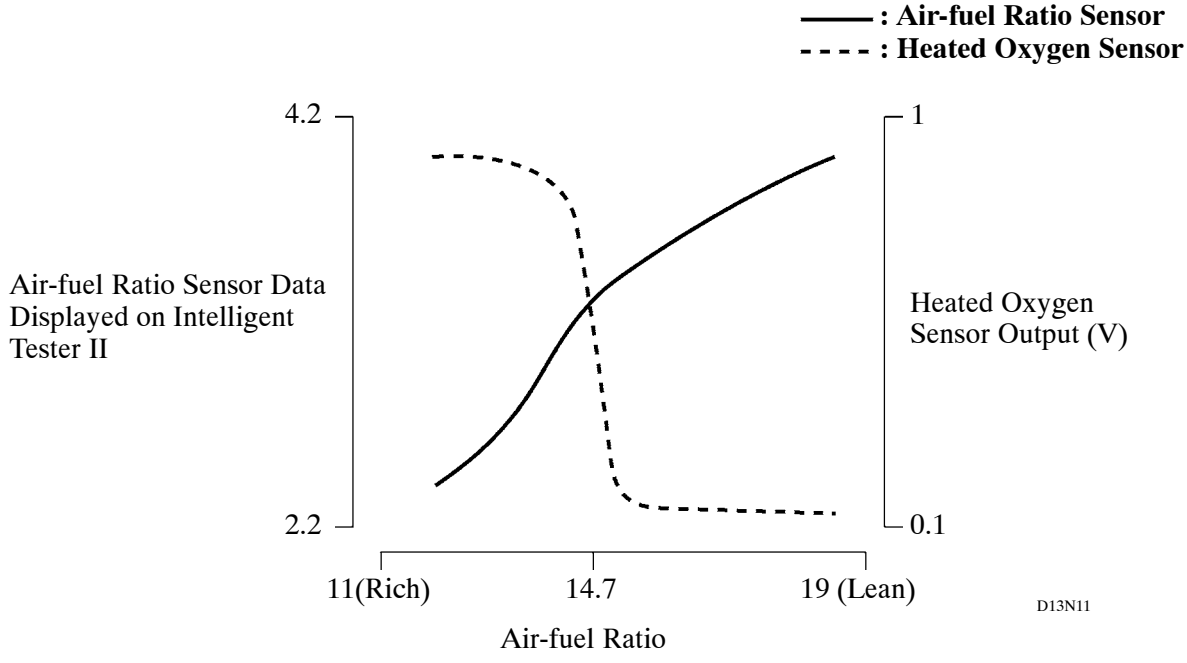


Air-fuel Ratio Sensor Circuit



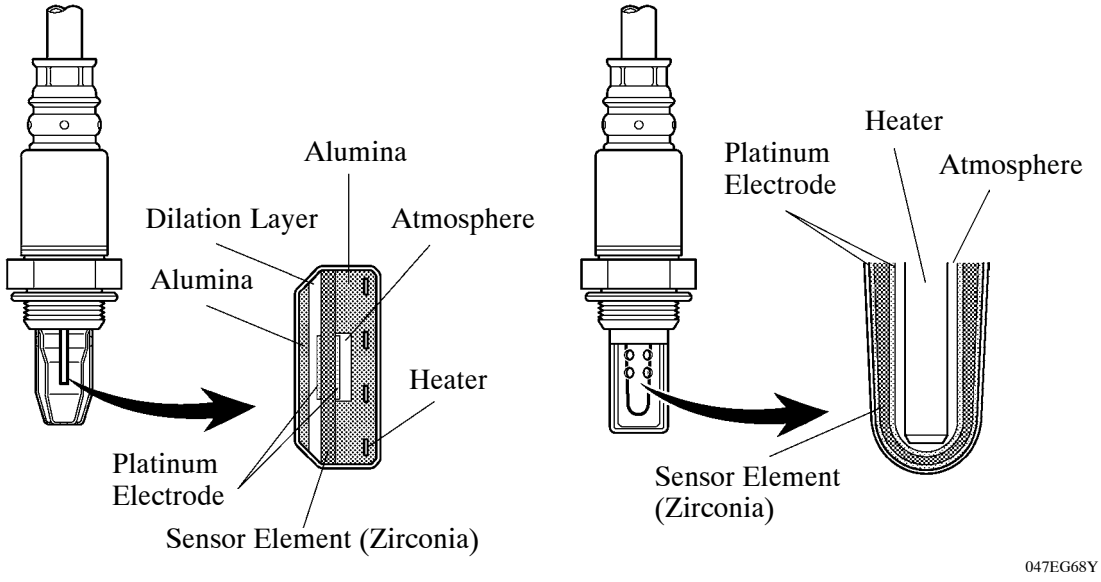
Heated Oxygen Sensor Circuit

00REG21Y



b. Construction

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



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

▶ Warm-up Specification ◀

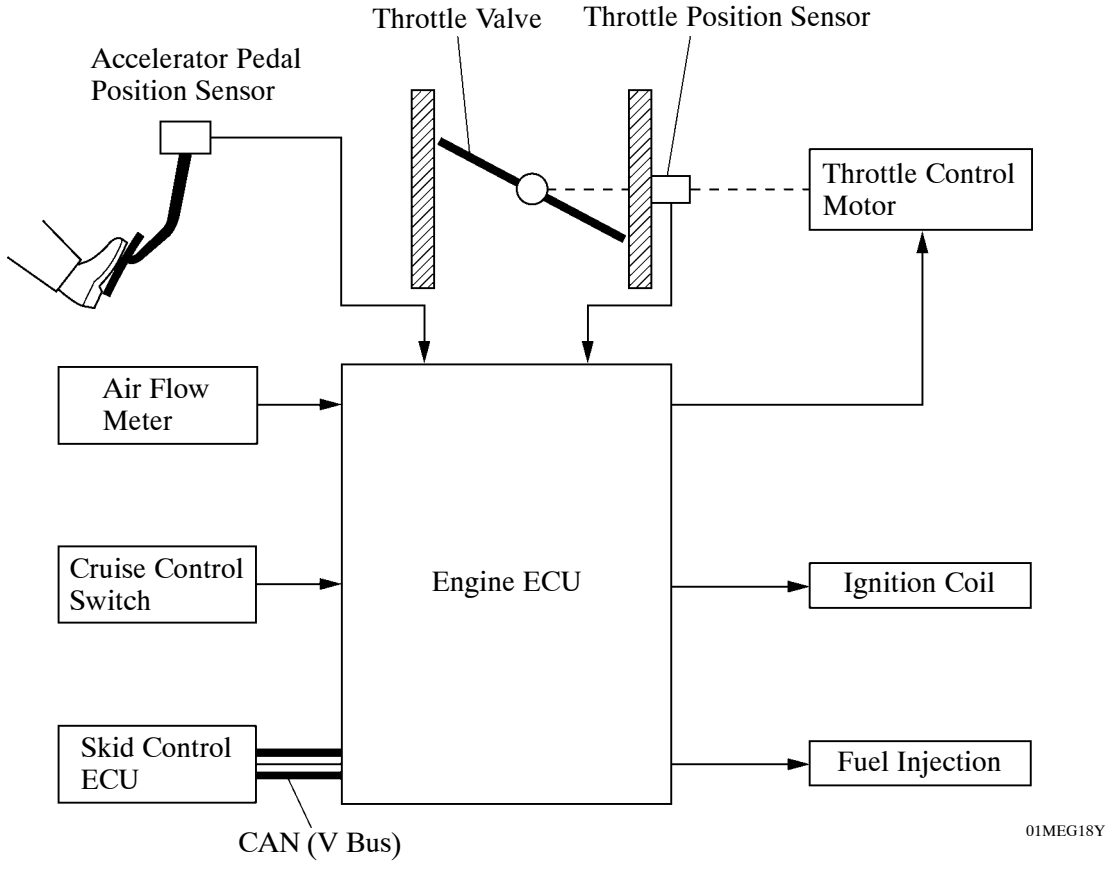
Sensor Type	Planar Type	Cup Type
Warm-up Time	Approx. 10 sec.	Approx. 30 sec.

ETCS-i (Electronic Throttle Control System-intelligent)

1) General

In the conventional throttle body, the throttle valve angle is determined invariably by the amount of the accelerator pedal effort. In contrast, ETCS-i uses the engine ECU 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.

▶ System Diagram ◀



2) Control

a. General

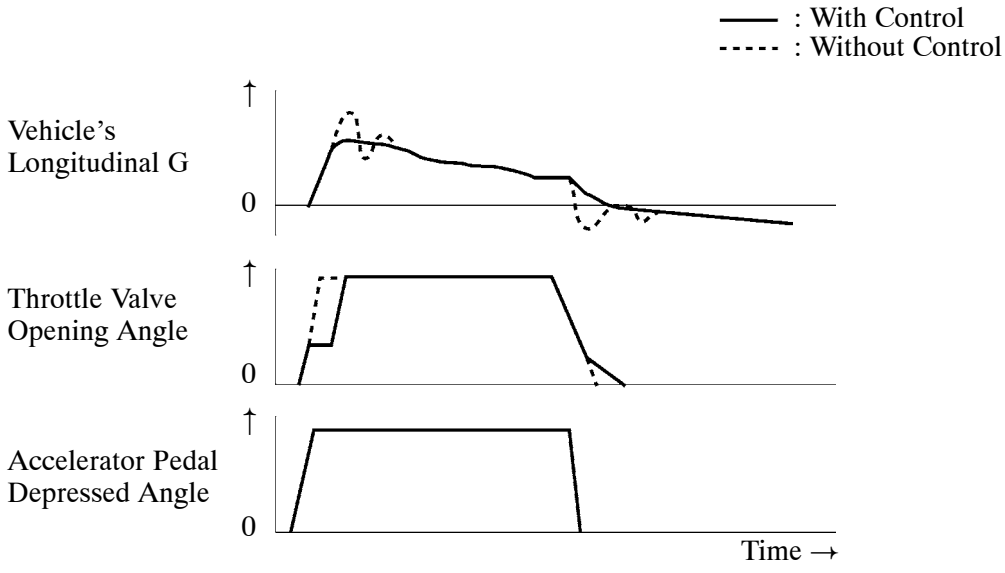
The ETCS-i consists of the following five functions:

- Normal Throttle Control (Non-linear Control)
- Idle Speed Control
- TRC Throttle Control
- VSC Coordination Control
- Cruise Control

b. Normal Throttle Control (Non-linear Control)

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

▶ Control Examples during Acceleration and Deceleration ◀



005EG13Y

c. Idle Speed Control

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

d. TRC Throttle Control

As part of the TRC system, the throttle valve is closed by a demand signal from the skid control ECU if an excessive amount of slippage is created at a driving wheel, ensuring excellent vehicle stability and driving force.

e. VSC Coordination Control

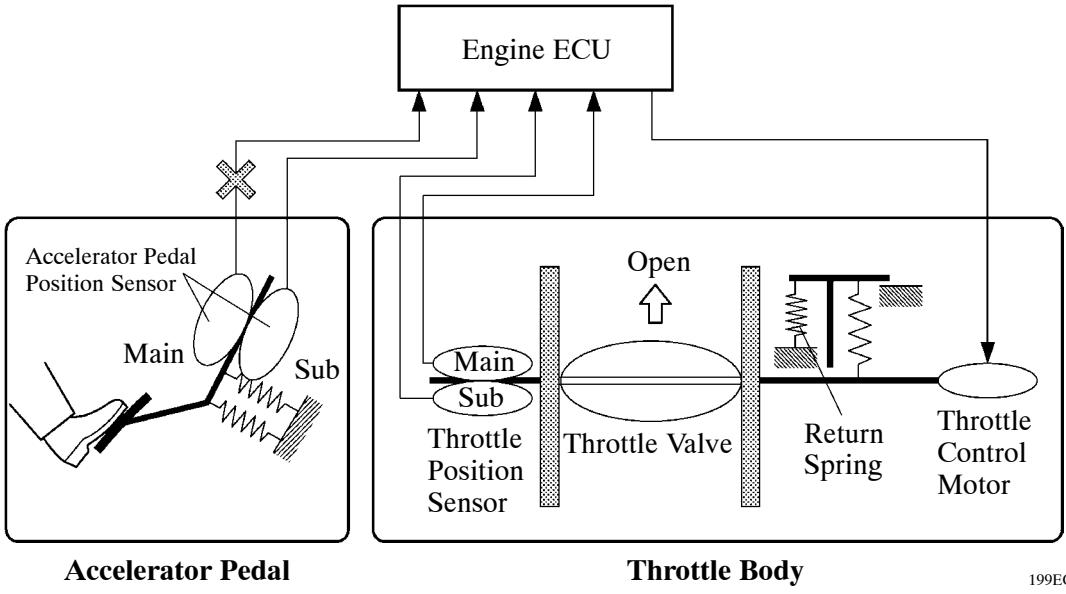
In order to bring the effectiveness of the VSC system control into full play, the throttle valve angle is controlled by effecting a coordination control with the skid control ECU.

f. Cruise Control

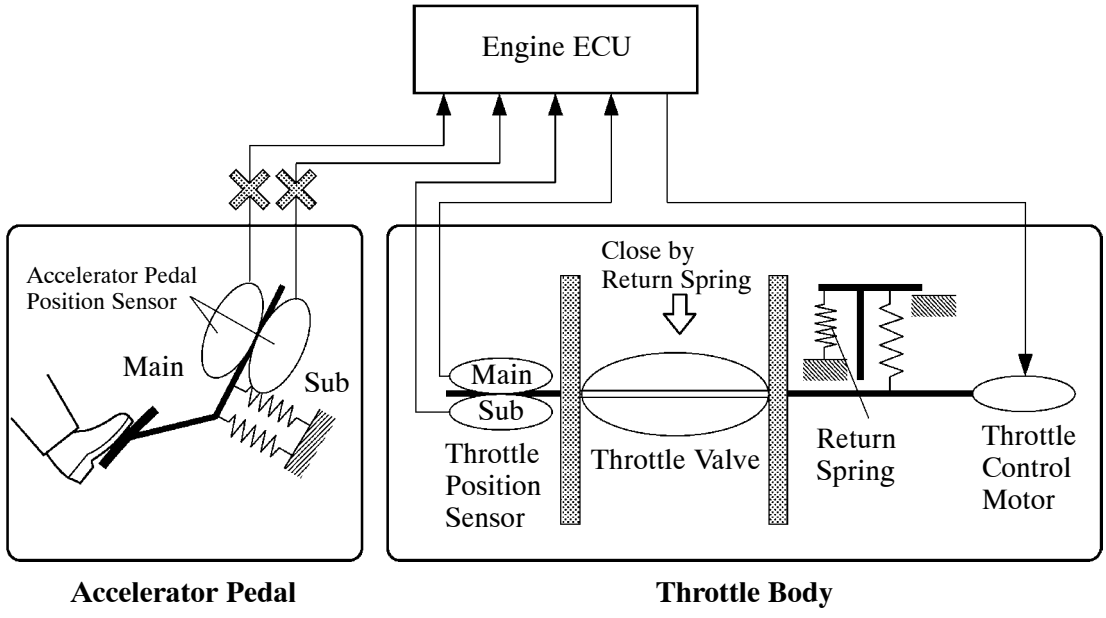
An engine ECU with an integrated cruise control ECU directly actuates the throttle valve for operation of the cruise control.

3) Fail-safe of Accelerator Pedal Position Sensor

- The accelerator pedal position sensor is comprised of two (main, sub) sensor circuits. If a malfunction occurs in either one of the sensor circuits, the engine ECU detects the abnormal signal by voltage difference between these two sensor circuits and switches to the limp mode. In the limp mode, the remaining circuit is used to calculate the accelerator pedal depressed angle, in order to operate the vehicle under the limp mode control.

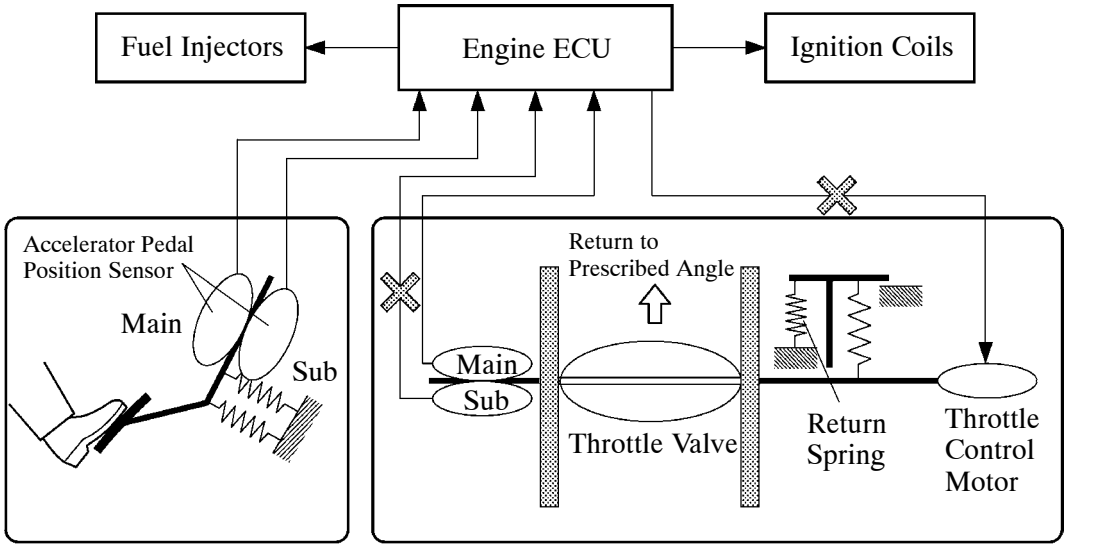


- If both circuits have a malfunction, the engine ECU detects the abnormal signal by voltage from these two sensor circuits and stops the throttle control. At this time, the vehicle can be driven within its idling range.



4) Fail-safe of Throttle Position Sensor

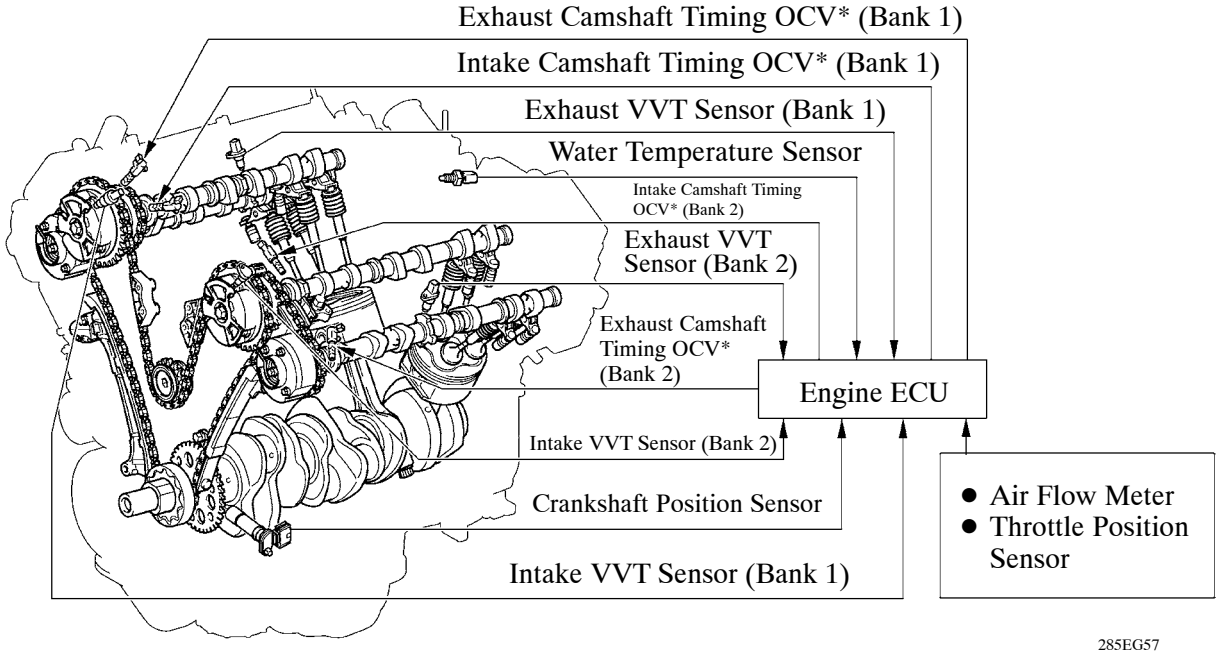
- The throttle position sensor is comprised of two (main, sub) sensor circuits. If a malfunction occurs in either one or both of the sensor circuits, the engine ECU detects the abnormal signal by voltage difference between these two sensor circuits, cuts off the current to the throttle control motor,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



Dual VVT-i (Variable Valve Timing-intelligent) System

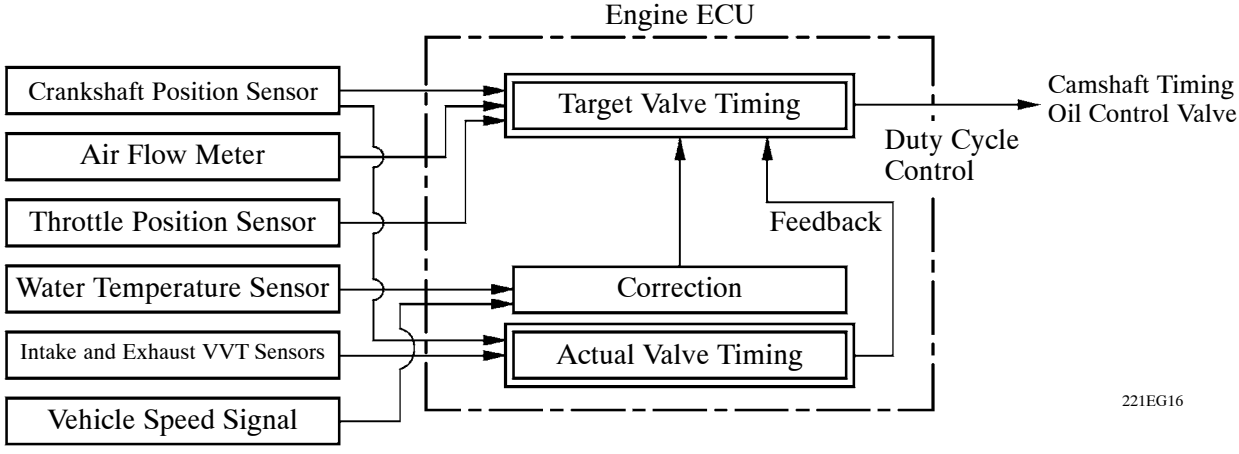
1) General

- The Dual VVT-i system is designed to control the intake and exhaust camshafts 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.

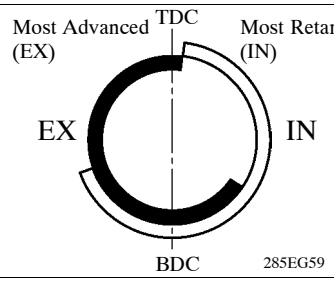
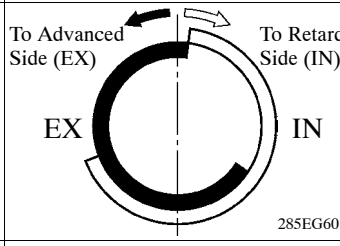
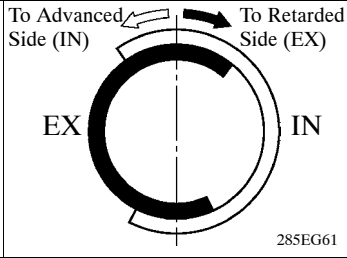
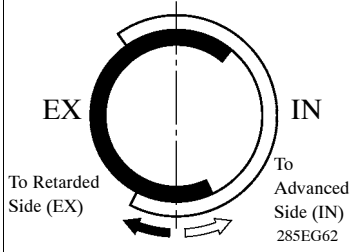
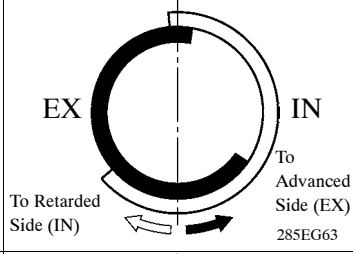
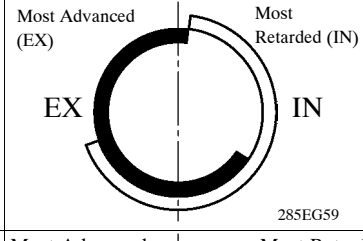
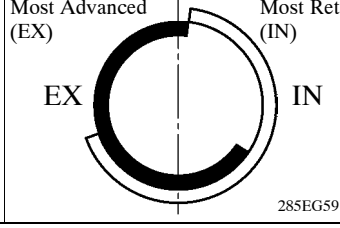


*: Oil Control Valve

- Using the engine speed signal, vehicle speed signal, and the signals from air flow meter, throttle position sensor and water temperature sensor, the engine ECU calculates optimal valve timing for each driving condition and controls the camshaft timing oil control valve. In addition, the engine ECU 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.



2) Effectiveness of the Dual VVT-i System

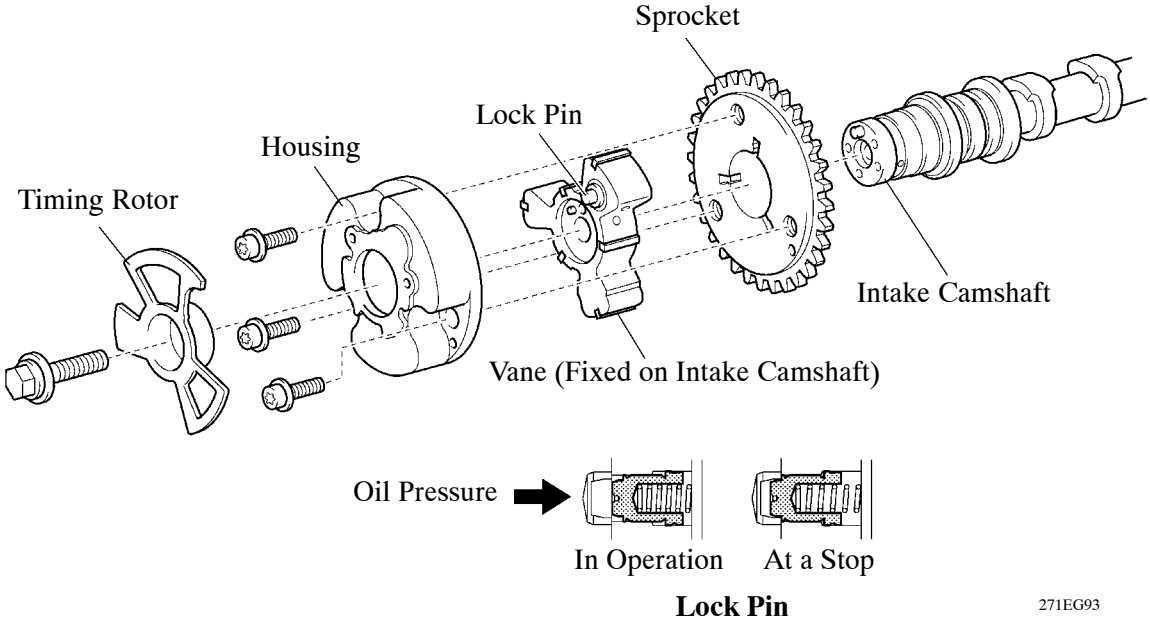
Operation State	Objective	Effect
During Idling	 Eliminating overlap to reduce blow back to the intake side.	● Stabilized idling rpm ● Better fuel economy
At Light Load	 Eliminating overlap to reduce blow back to the intake side.	Ensured engine stability
At Medium Load	 Increasing overlap increases internal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

3) Construction

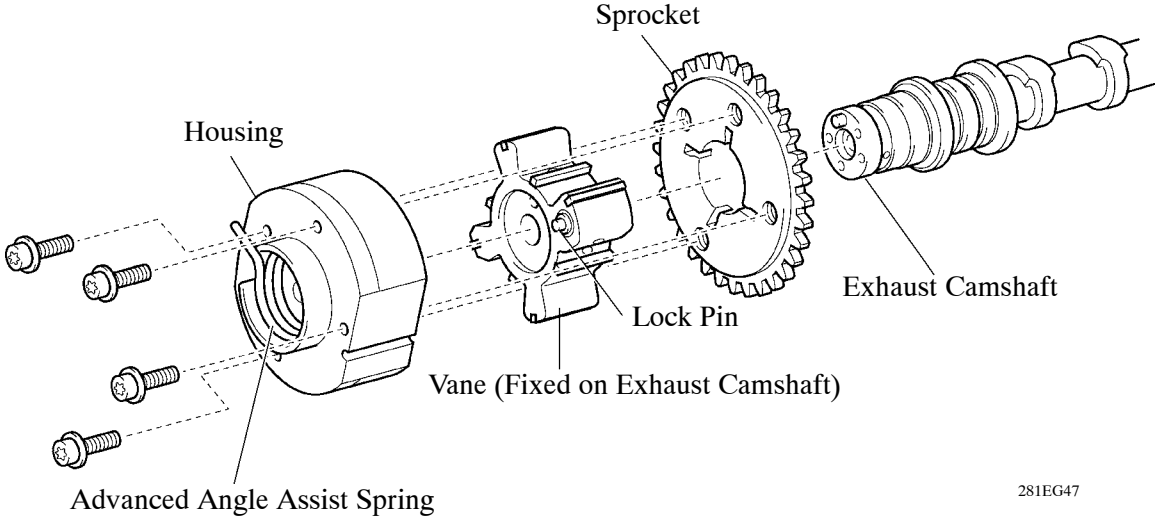
a. VVT-i Controller

- This controller consists of the housing driven by the timing chain and the vane coupled with the intake and exhaust camshafts.
- The intake side uses a VVT-i controller with 3 vanes, and the exhaust side uses one with 4 vanes.
- When the engine stops, the intake side VVT-i controller is locked on the most retarded side by the lock pin, and the exhaust side VVT-i controller is locked on the most advanced side. This ensures excellent engine startability.
- The oil pressure sent from the advance or retard side path at the intake and exhaust camshafts causes rotation in the VVT-i controller vane circumferential direction to vary the intake valve timing continuously.
- An advanced angle assist spring is provided on the exhaust side VVT-i controller. 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.

▶ Intake Side VVT-i Controller ◀



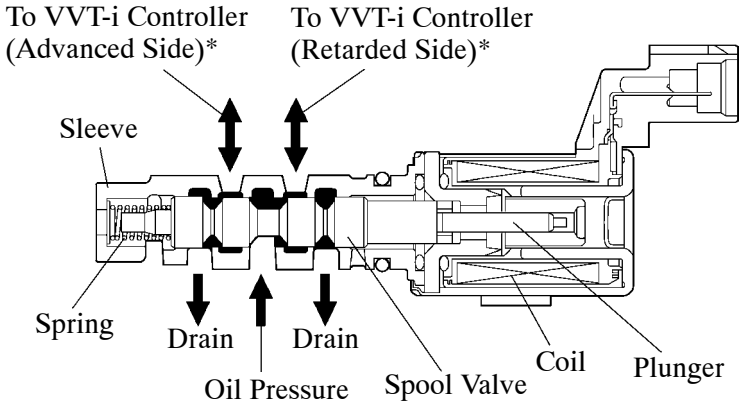
▶ Exhaust Side VVT-i Controller ◀



b. Camshaft Timing Oil Control Valve

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

▶ Intake Camshaft Timing Oil Control Valve ◀



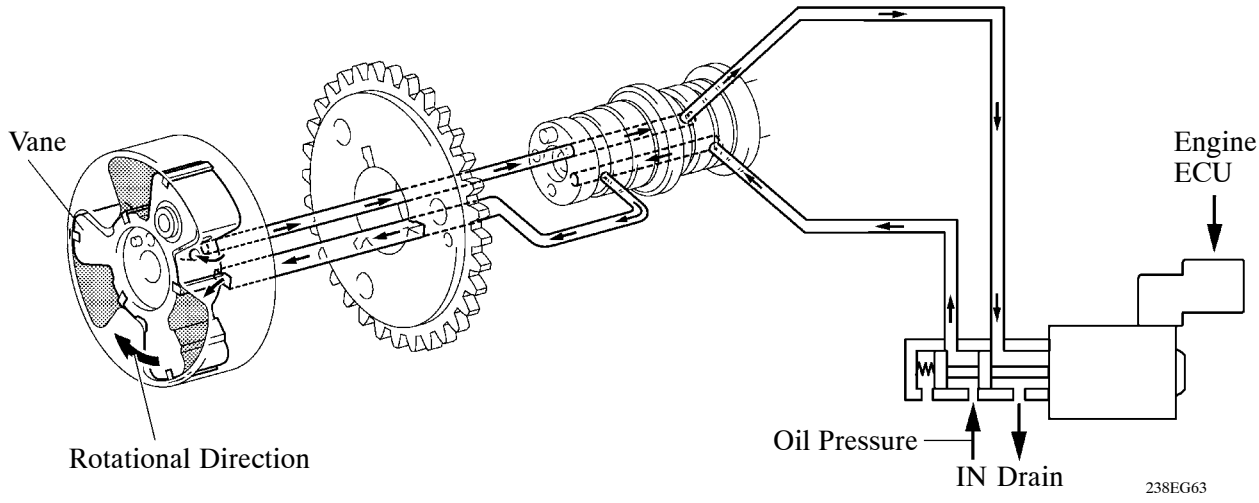
*: The advanced and retarded sides of the exhaust camshaft timing oil control valve are reverse of the intake side.

4) Operation

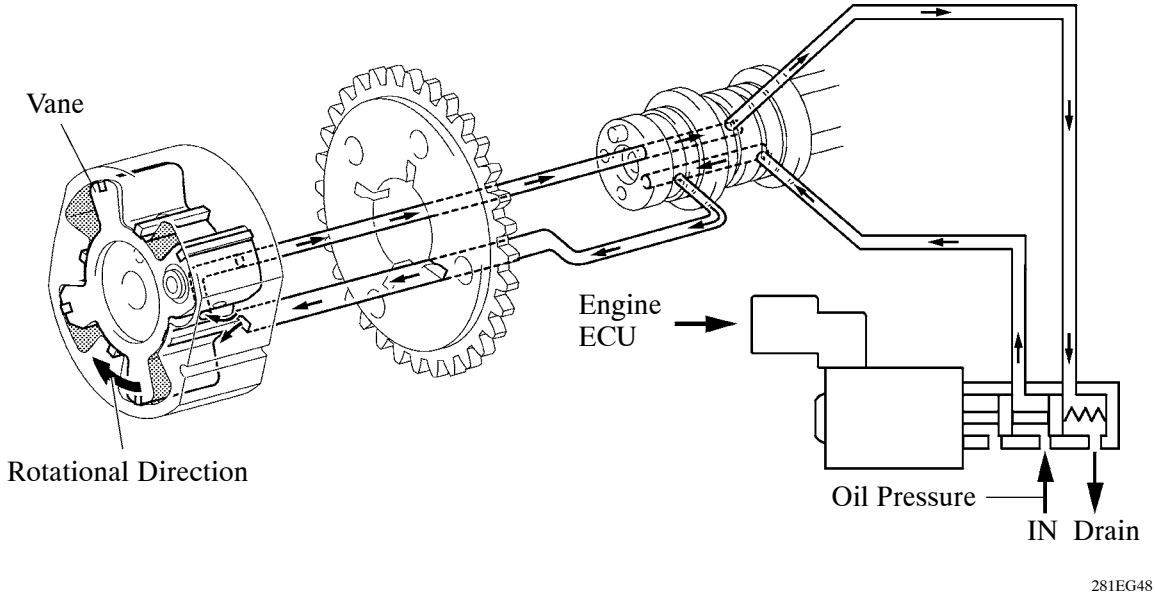
a. Advance

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

▶ Intake Side ◀



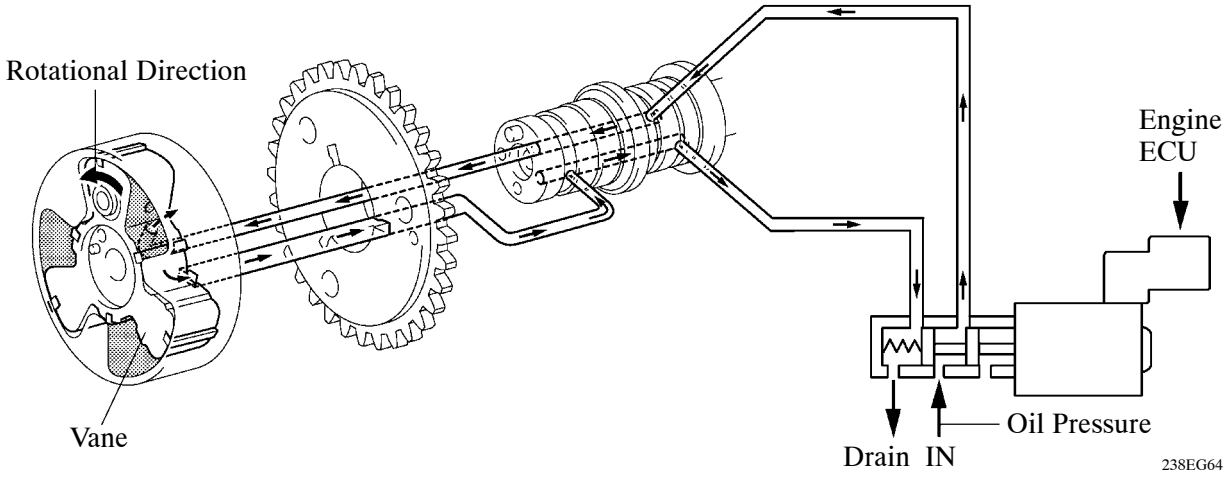
▶ Exhaust Side ◀



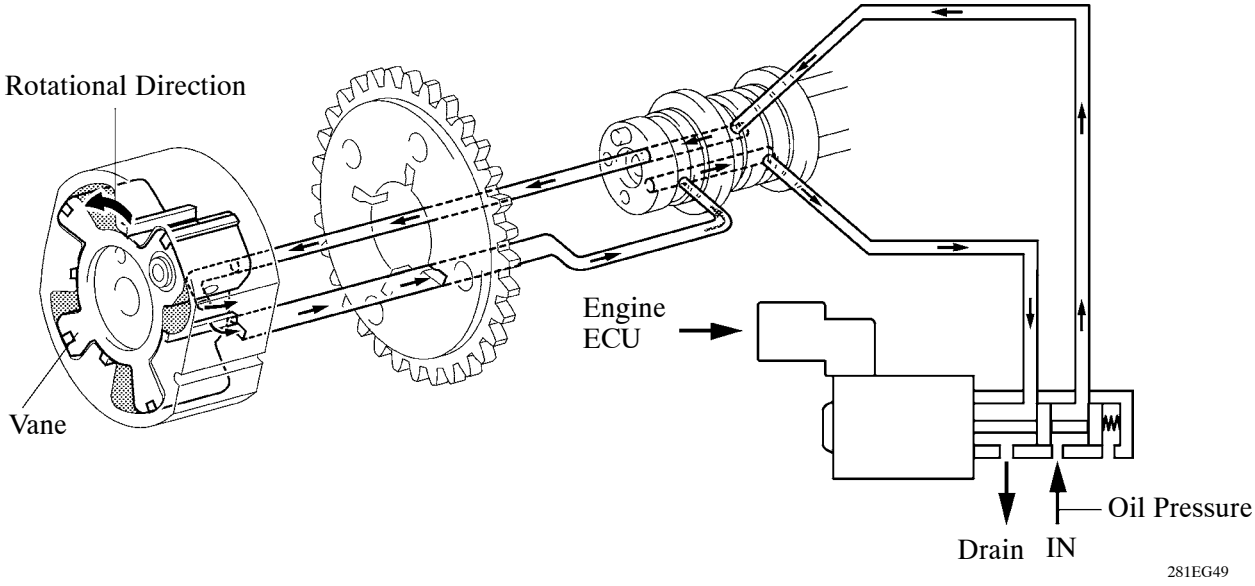
b. Retard

When the camshaft timing oil control valve is positioned as illustrated below by the retard signals from the engine ECU, 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 ◀



c. Hold

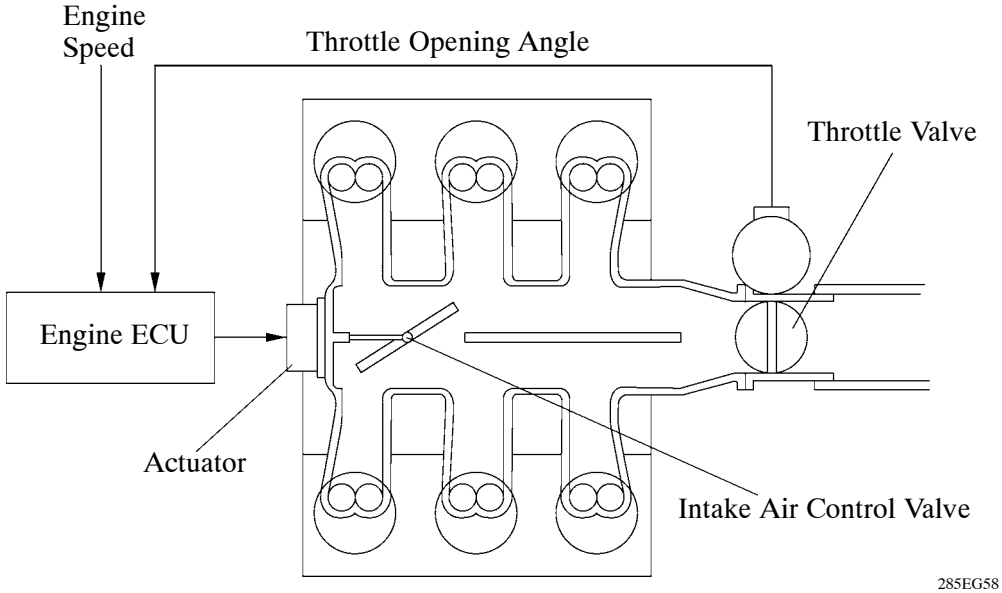
After reaching the target timing, the valve timing is held by keeping the camshaft timing oil control valve in the neutral position unless the traveling state changes.
This adjusts the valve timing at the desired target position and prevents the engine oil from running out when it is unnecessary.

ACIS (Acoustic Control Induction System)

1) General

The ACIS consists of a bulkhead to divide the intake manifold into 2 stages, and an intake air control valve in the bulkhead which opens and closes 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 ◀



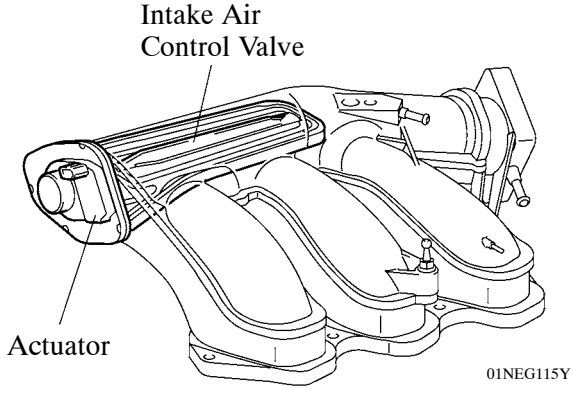
2) Construction

a. Intake Air Control Valve

The intake air control valve, which is provided in the intake air chamber, opens and closes to change the effective length of the intake manifold in 2 stages.

b. Actuator (Motor)

The actuator activates the intake air control valve based on signals from the engine ECU.

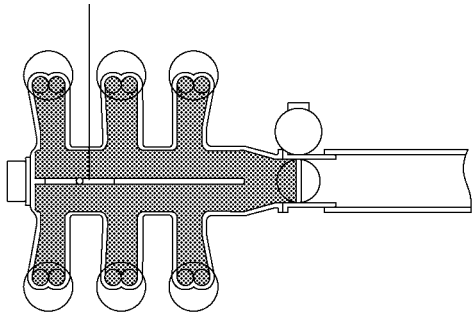


3) Operation

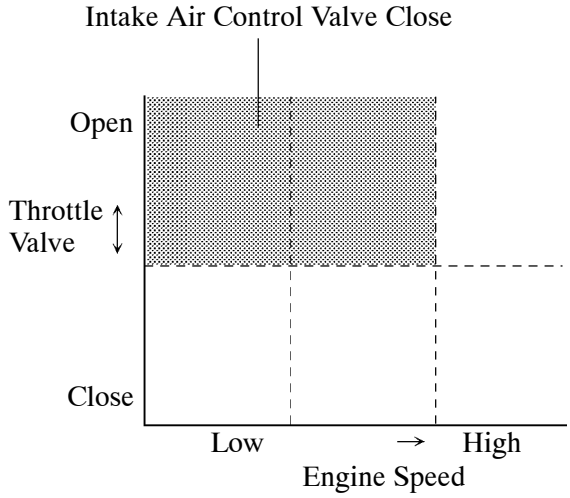
a. When Intake Air Control Valve Closes

While the engine is running at middle speed under high load, the engine ECU controls the actuator to close the intake air 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 of the intake air, thereby increasing power output.

Intake Air Control Valve (Close)



: Effective Intake Manifold Length

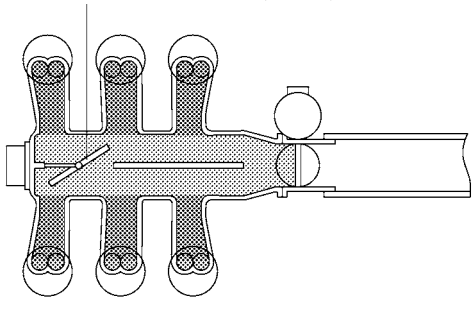


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b. When Intake Air Control Valve Opens

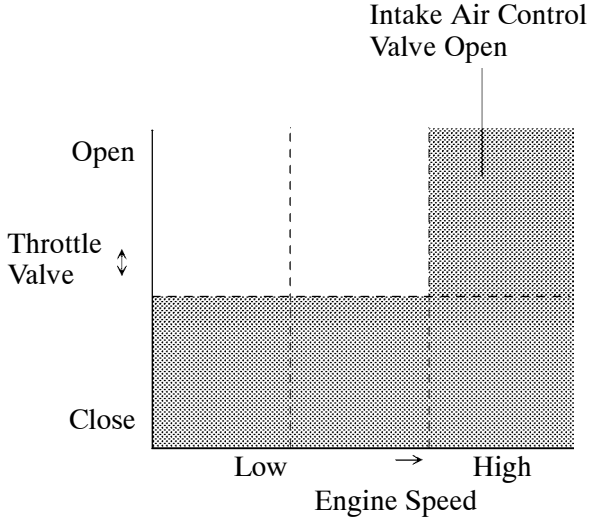
Under any condition except when the engine is running at middle speed under high load, the engine ECU controls the actuator to open the intake air control valve. When the intake air control valve is open, the effective length of the intake manifold is shortened and the peak intake efficiency is shifted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

Intake Air Control Valve (Open)



: Effective Intake Manifold Length

: Effective Intake Air Chamber Length



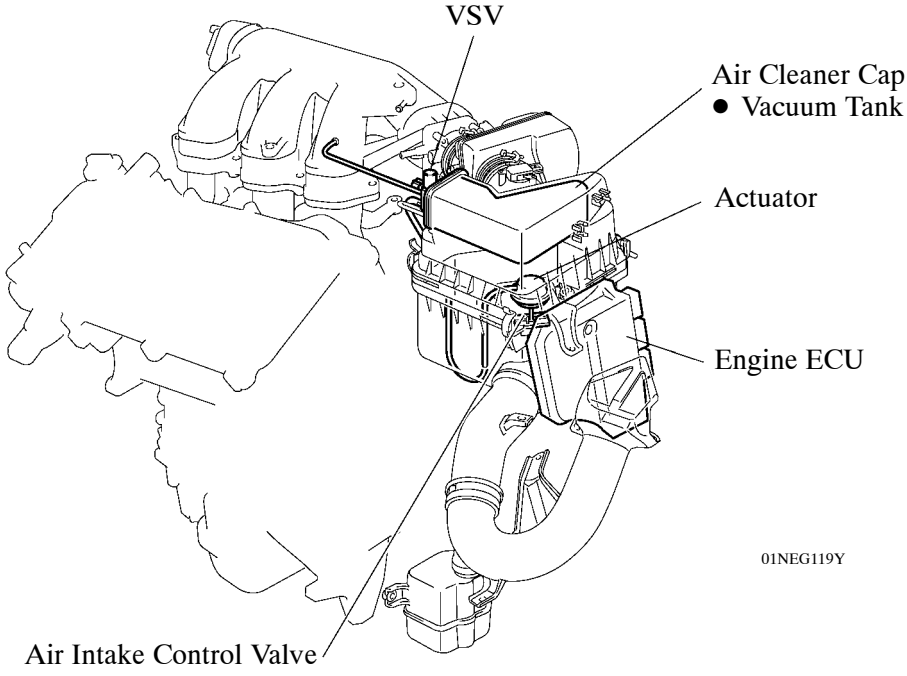
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Air Intake Control System

1) General

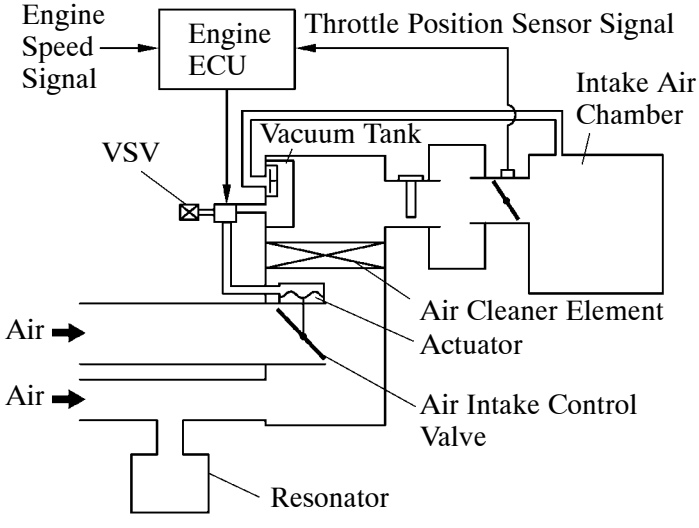
The system has a dual path design for air intake. An air intake control valve and an actuator control the air flow path.
As a result, a reduction in intake noise in the low-speed range and an increase in the power output in the high-speed range is realized.

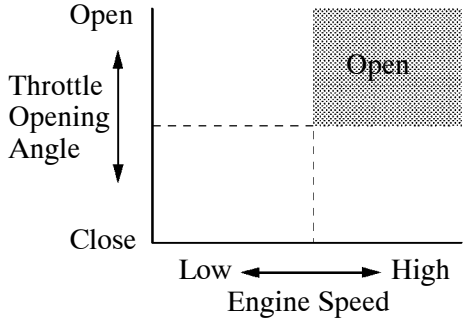
▶ Layout of Components ◀



2) Operation

- When the engine is operating in the low-to-mid speed range, this control operates the air intake control valve to close one side of the air cleaner inlet. As a result, the intake area has been minimized and the intake noise is reduced.
- 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. As a result, the intake area has been maximized and the intake efficiency is improved.



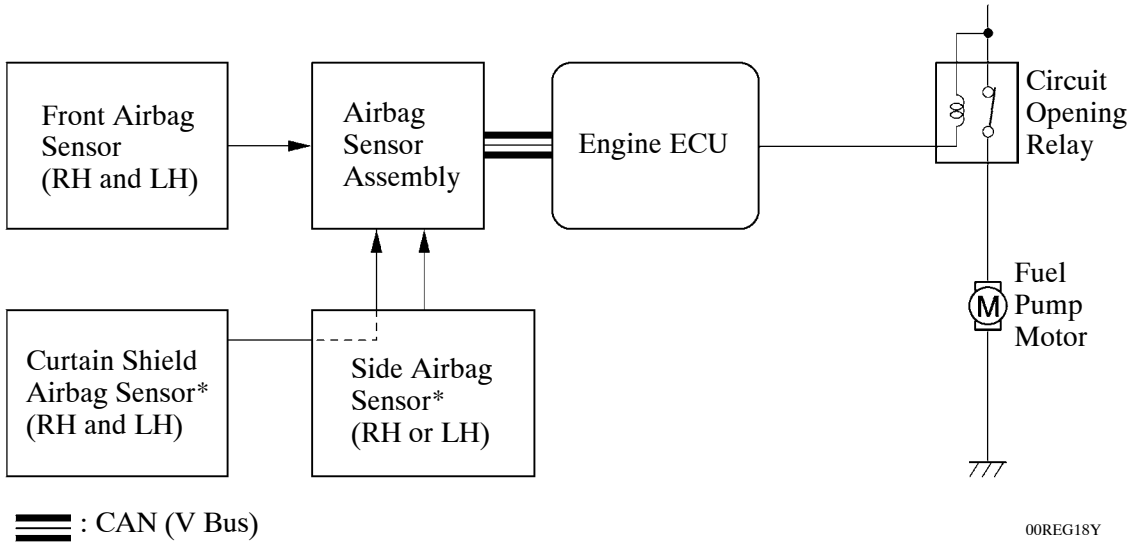


Air Intake Control Valve Condition

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Fuel Pump Control

A fuel pump control is used to stop the fuel pump when the airbag is deployed at the front collision. In this system, the airbag deployment signal from the airbag sensor assembly is detected by the engine ECU, which turns OFF the circuit opening relay.
After the fuel pump control has been activated, turning the ignition switch from OFF to ON (IG) cancels the fuel pump control, and the engine can be restarted.



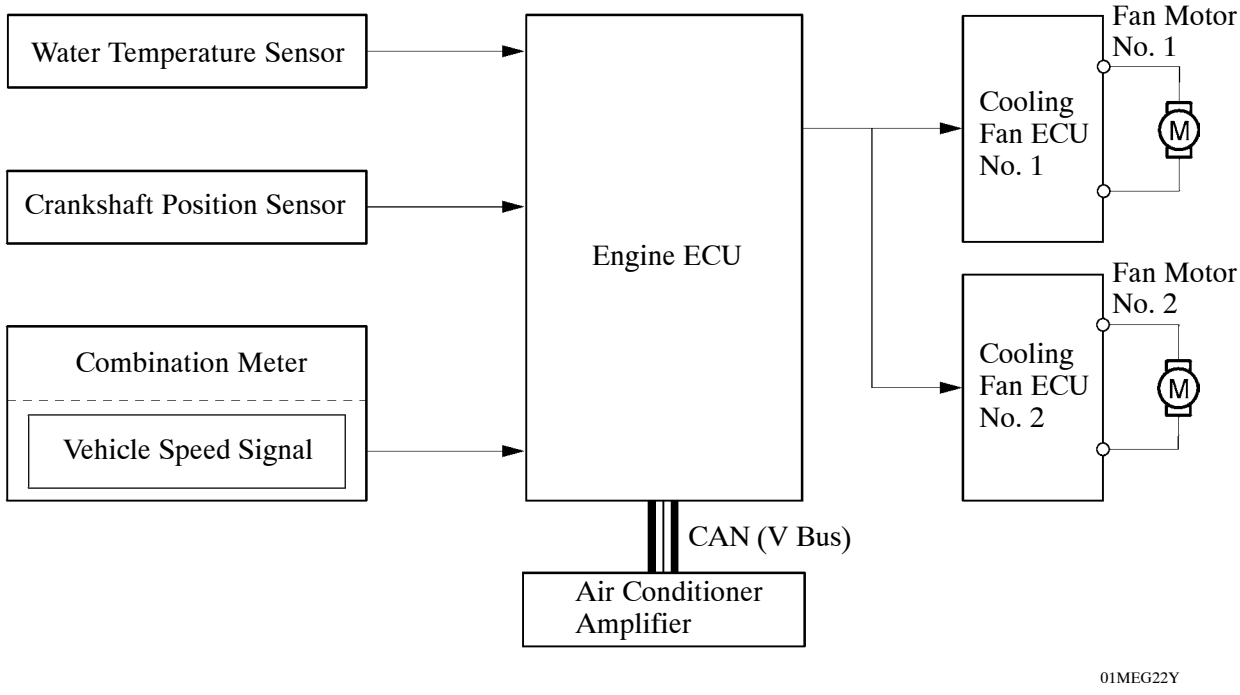
*: Models with Driver, Front Passenger, Side and Curtain Shield Airbags

Cooling Fan Control System

1) General

A cooling fan control system is used. To achieve an optimal fan speed in accordance with the water temperature, vehicle speed, engine speed, and air conditioner operating conditions, the engine ECU calculates the proper fan speed and proper fan speed control signals to the cooling fan ECU.
Upon receiving the signals from the engine ECU, the cooling fan ECU actuates the fan motors.

▶ Wiring Diagram ◀



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2) Operation

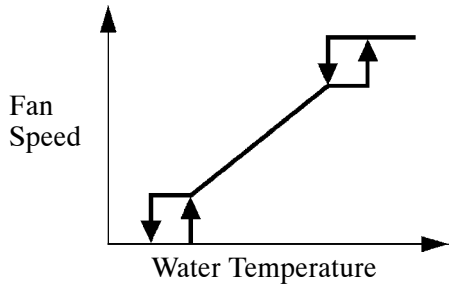
As illustrated below, the engine ECU determines the required fan speed by selecting the fastest fan speed from among the following:

(A) Fan speed required by the water temperature

(B) Fan speed required by the air conditioner refrigerant pressure

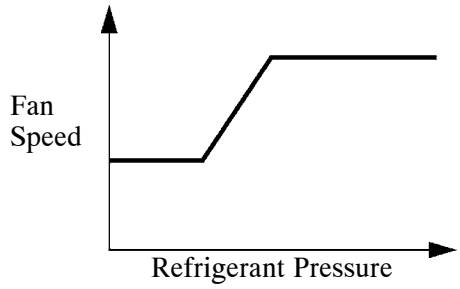
(C) Fan speed required by the engine speed

(D) Fan speed required by the vehicle speed



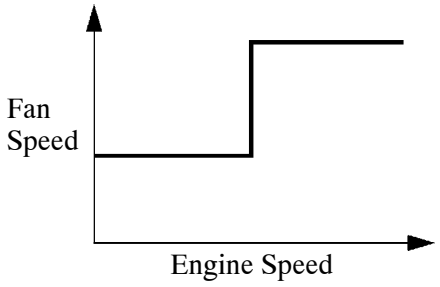
(A) Fan speed required by water temperature

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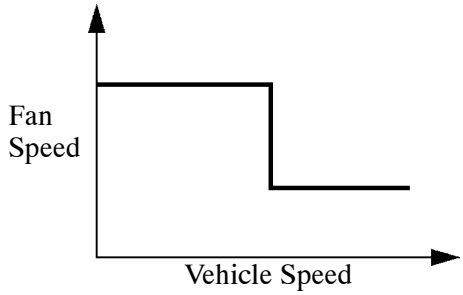
(B) Fan speed required by air conditioner refrigerant pressure

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(C) Fan speed required by engine speed

189EG15



(D) Fan speed required by vehicle speed

189EG16

Charging Control

1) General

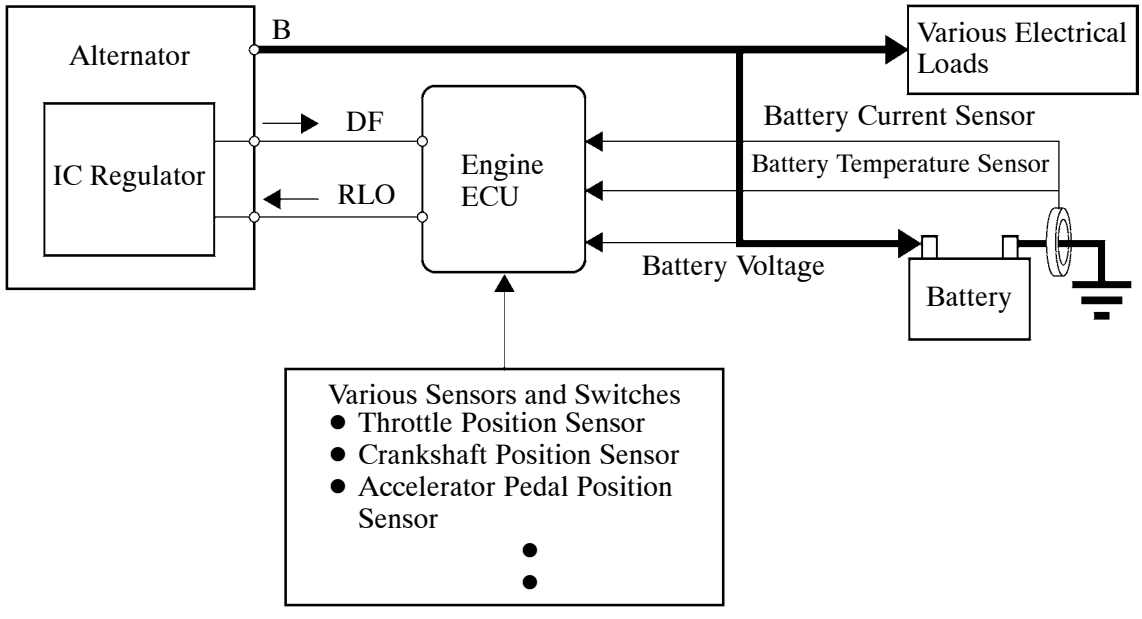
This system lowers the generated voltage when the vehicle is idling or is being driven at a constant speed, and raises the generated voltage when the vehicle is decelerating. This reduces the load on the engine as a result of the electric generation of the alternator, thus contributing to the fuel economy of the engine. During acceleration, this system regulates the generated voltage in order to place the amperage estimation value close to the target value.

- This control consists of the engine ECU, battery current sensor with a built-in battery temperature sensor, alternator, and various sensors and switches.
- The engine ECU detects driving condition based on signals from various sensors and switches, and detects charging condition based on signals from the alternator, battery current sensor and battery temperature sensor. Then the engine ECU outputs signals to the IC regulator to control the generated voltage of the alternator.

The engine ECU stops the charging control and the alternator switches to normal power generation mode under the following conditions:

- Low battery capacity
- Low or high battery temperature
- Wipers operating or blower motor operating with taillight relay ON

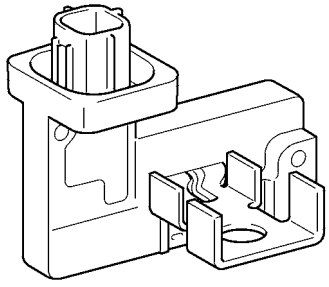
▶ System Diagram ◀



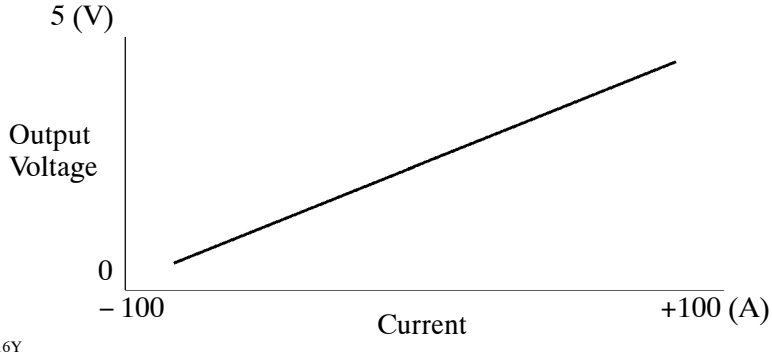
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2) Battery Current Sensor

Installed on the negative terminal of the battery, this sensor detects the amount of charging and discharging amperage of the battery and sends signal to the engine ECU. Based on this signal, the engine ECU calculates the battery capacity. A Hall IC is used for detecting the amount of charging and discharging amperage. The changes that occur in the magnetic flux density in the core as a result of the charging and amperage of the battery are converted and output as voltage.



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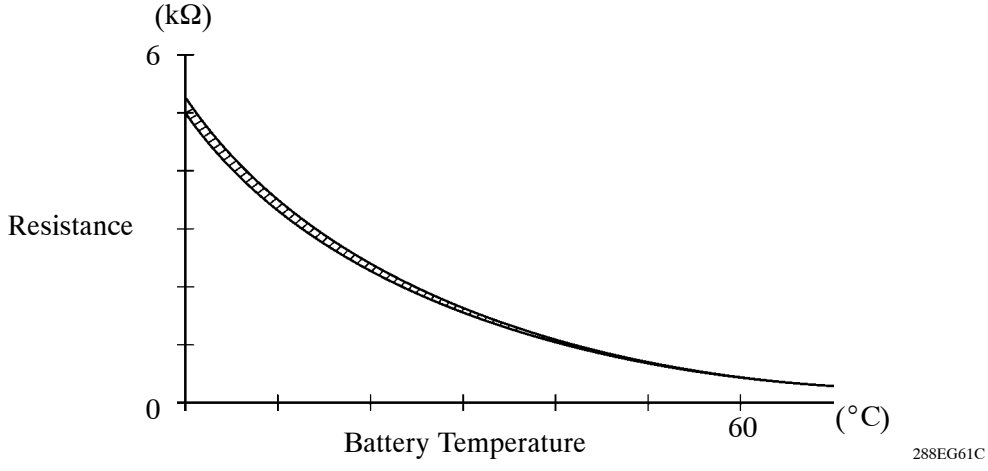


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Characteristic of Current Sensor

3) Battery Temperature Sensor

- The battery temperature sensor is built into the battery current sensor.
- The battery characteristic (battery internal resistance) of taking in current for charging varies according to battery electrolyte temperature. If the electrolyte temperature is too low or too high, the battery internal resistance will increase, resulting in early deterioration. To prevent this, the battery temperature sensor changes its resistance as shown below to detect the temperature.



288EG61C

4) Fail-safe

Due to a failure in the battery current sensor or battery temperature sensor, the engine ECU may determine the necessity of performing a fail-safe operation. Then, the engine ECU stops the charging control and the alternator switches to the normal power generation mode.
When the engine ECU detects a malfunction in a sensor, the engine ECU memorizes the DTC (Diagnostic Trouble Code). The check engine warning light does not illuminate.

▶ DTC Chart ◀

DTC No.	Detection Item	DTC No.	Detection Item
P0516	Battery Temperature Sensor Circuit Low	P1551	Battery Current Sensor Circuit Low
P0517	Battery Temperature Sensor Circuit High	P1552	Battery Current Sensor Circuit High
P0560	System Voltage	P1602	Detection of Battery
P1550	Battery Current Sensor Circuit		

Diagnosis

- When the engine ECU detects a malfunction, the engine ECU makes a diagnosis and memorizes the failed section. Furthermore, the check engine warning light in the combination meter illuminates or blinks to inform the driver.
- The engine ECU will also store the DTCs (Diagnostic Trouble Codes) of the malfunctions.
- The DTCs can be accessed by the use of the intelligent tester II.
- All the DTCs have been made to correspond to the SAE controlled codes. Some of the DTCs have been further divided into smaller detection areas than in the past, and new DTCs have been assigned to them. For details, refer to the RAV4 Repair Manual Supplement.

Service Tip

To clear the DTC that is stored in the engine ECU, use the intelligent tester II, disconnect the battery terminal or remove the EFI fuse for 1 minute or longer.

Fail-safe

When a malfunction is detected by any of the sensors, there is a possibility of an engine or another malfunction occurring if the engine ECU were to continue to control the engine control system in the normal way. To prevent such a problem, the fail-safe function of the engine ECU either relies on the data stored in memory to allow the engine control system to continue operating, or stops the engine if a hazard is anticipated. For details, refer to the RAV4 Repair Manual Supplement.