■ENGINE CONTROL SYSTEM

1. General

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

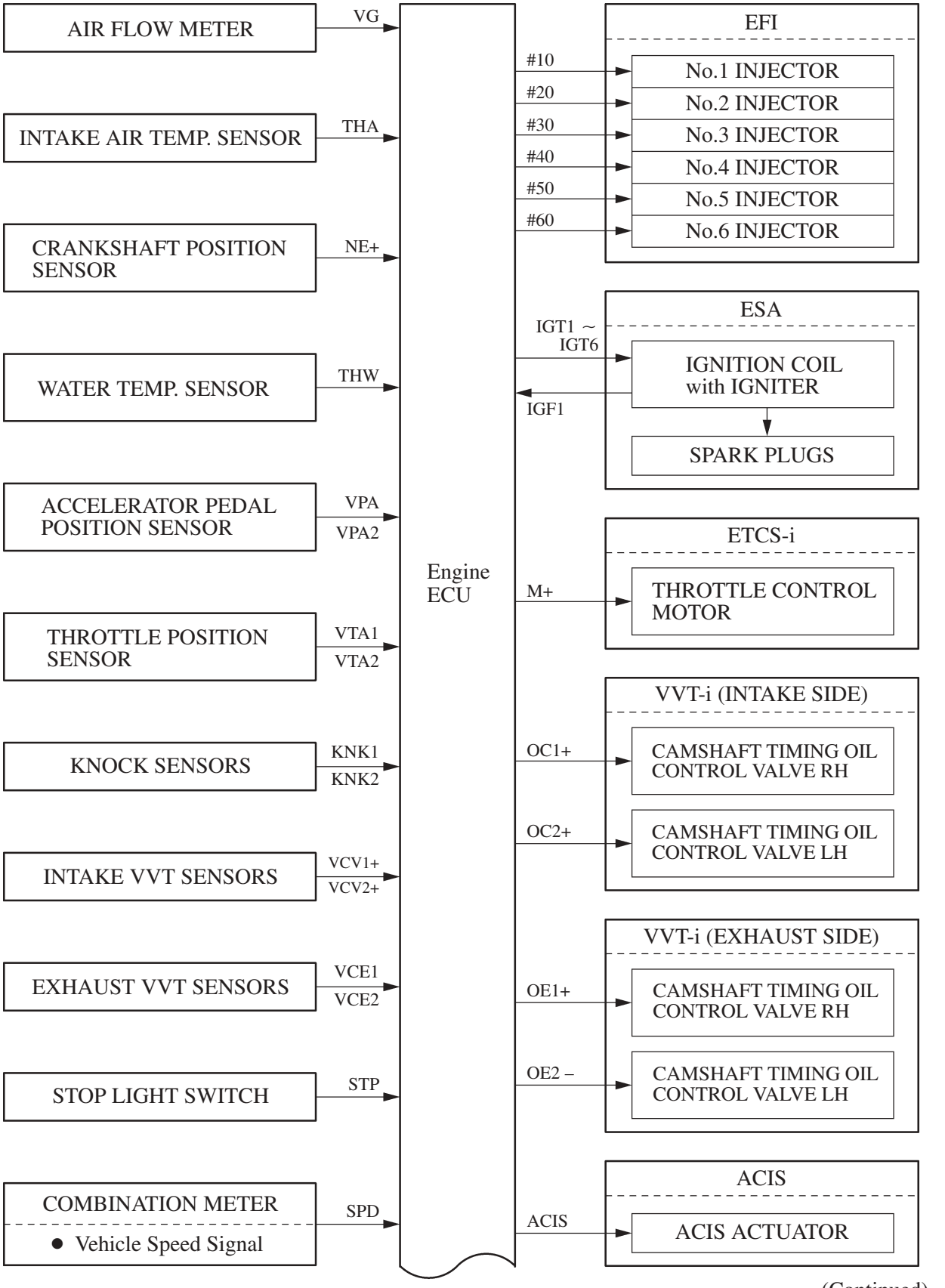
System	Outline
EFI [Electronic Fuel Injection]	● An L-type EFI system directly detects the intake air mass with a hot wire type air flow meter. ● The fuel injection system is a sequential multiport fuel injection system. ● Fuel injection takes two forms: Synchronous injection, which always takes place with the same timing in accordance with the basic injection duration and an additional correction based on the signals provided by the sensors. Non-synchronous injection, which takes place at the time an injection request based on the signals provided by the sensors is detected, regardless of the crankshaft position. ● Synchronous injection is further divided into group injection during a cold start, and independent injection after the engine is started.
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 EG-46]	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 System [Dual Variable Valve Timing-intelligent System] [See page EG-103]	Controls the intake and exhaust camshafts to an optimal valve timing in accordance with the engine condition.
ACIS [Acoustic Control Induction System] [See page EG-109]	The intake air passages are switched according to the engine speed and throttle valve opening angle to provided high performance in all speed ranges.
Air Intake Control System [See page EG-111]	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 EG-52]	● 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 of 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.
Cooling Fan Control [See page EG-112]	The Cooling Fan ECU steplessly controls the speed of the fans in accordance with the engine coolant temperature, vehicle speed, engine speed, and air conditioner operating conditions. As a result, the cooling performance is improved.
Air Fuel Ratio Sensor and Oxygen Sensor Heater Control	Maintains the temperature of the air fuel ratio sensor or oxygen sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.

(Continued)

System	Outline
Evaporative Emission Control	The engine ECU controls the purge flow of evaporative emission (HC) in the canister in accordance with engine conditions.
Active Control Engine Mount [See page EG-86]	The damping characteristic of the front engine mount is controlled variably to reduce idling vibration.
Engine Immobilizer	Prohibits fuel delivery and ignition if an attempt is made to start the engine with an invalid key.
Diagnosis [See page EG-114]	When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section.
Fail-Safe [See page EG-115]	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in the memory.

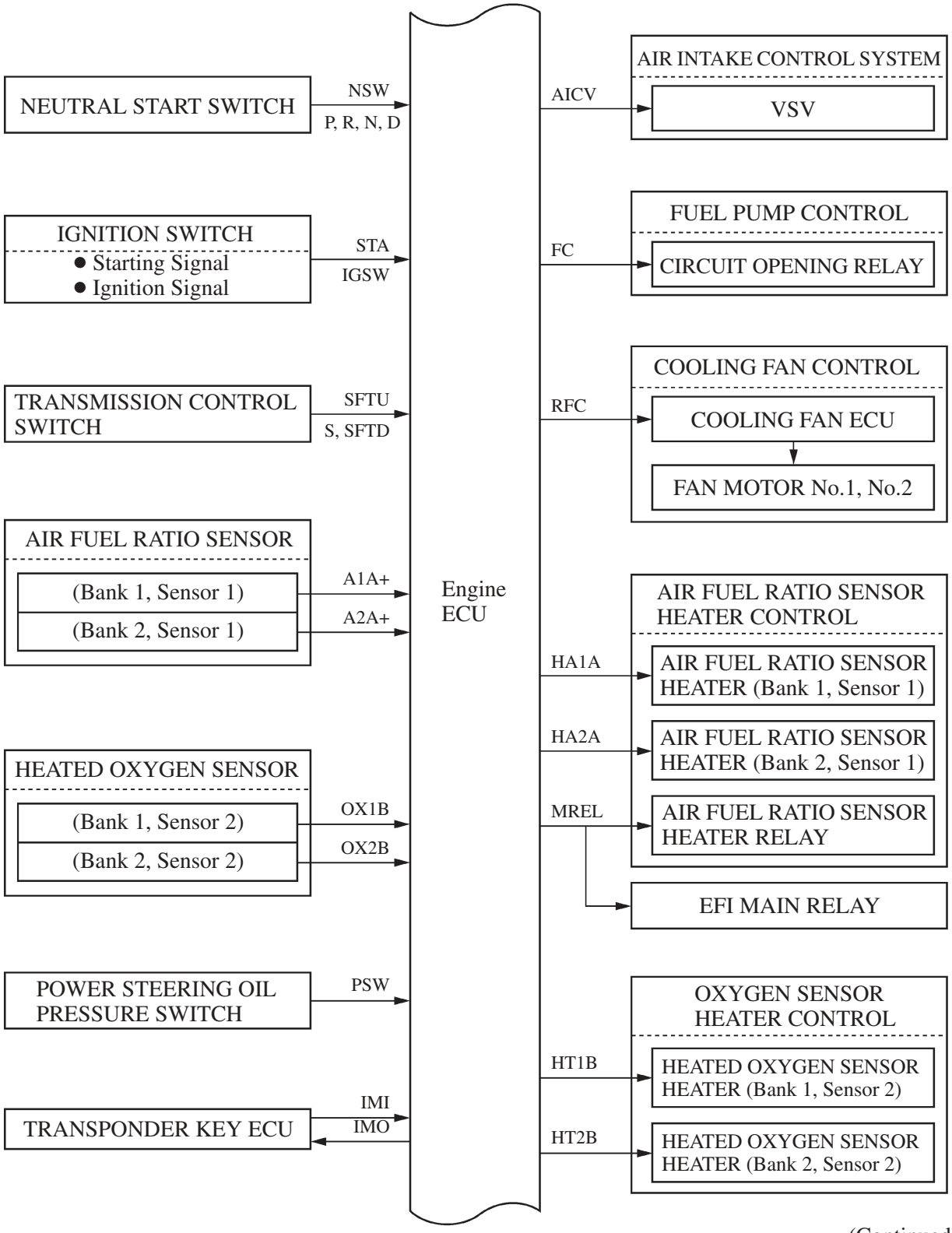
2. Construction

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



(Continued)

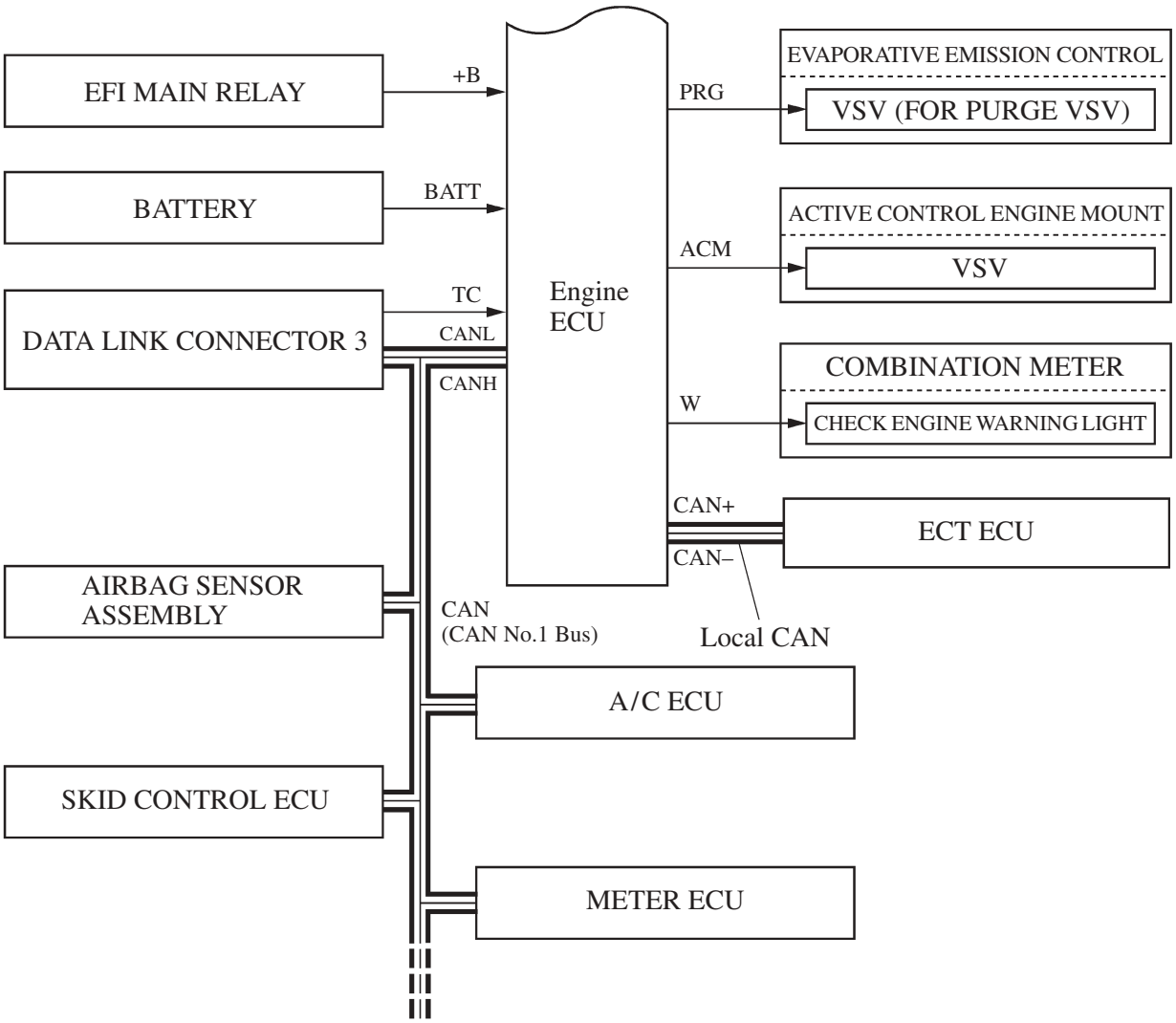
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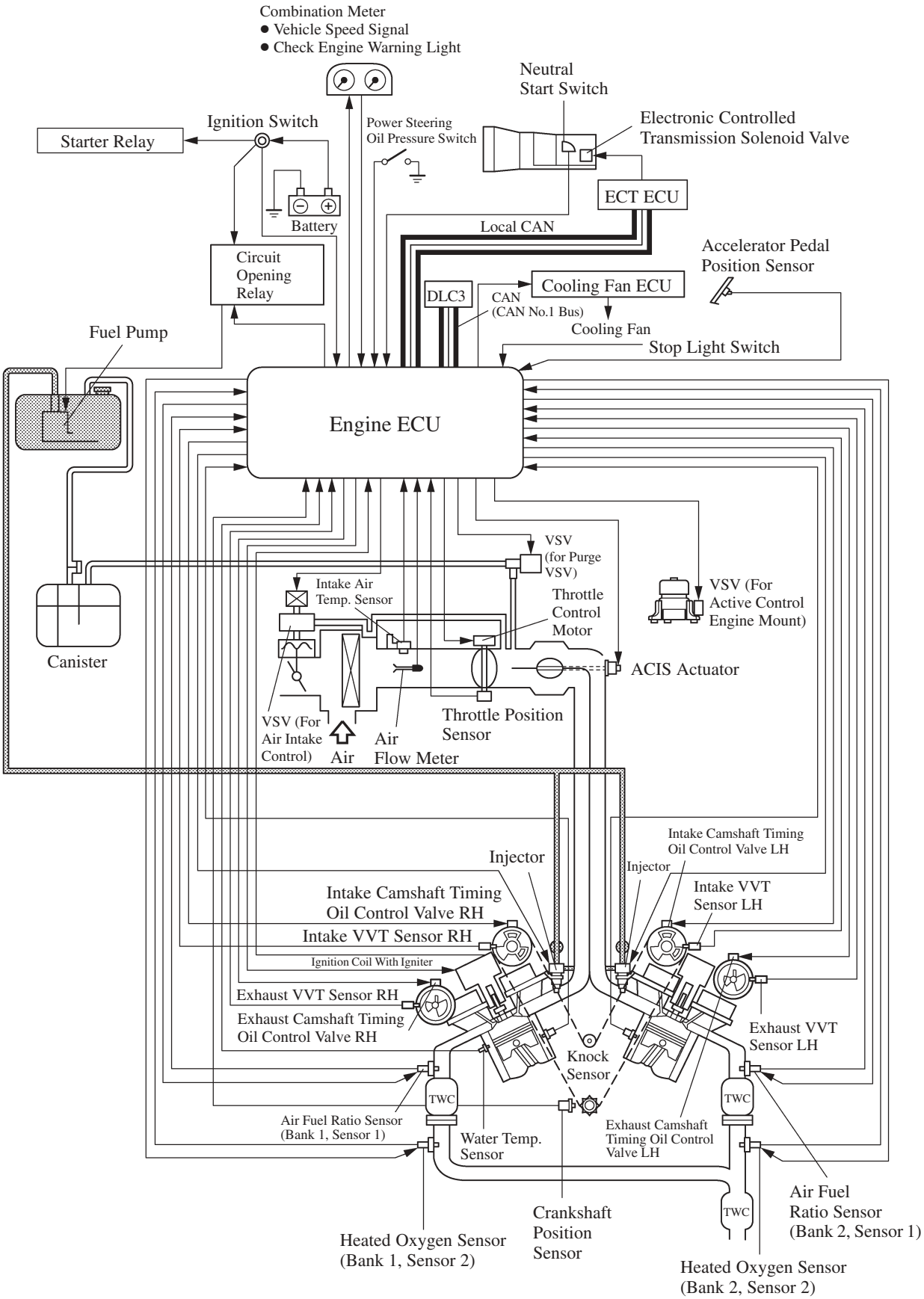
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EG


EFI MAIN RELAY
+B
BATTERY
BATT
DATA LINK CONNECTOR 3
TC
CANL
CANH
Engine ECU
PRG
EVAPORATIVE EMISSION CONTROL
VSV (FOR PURGE VSV)
ACM
ACTIVE CONTROL ENGINE MOUNT
VSV
W
COMBINATION METER
CHECK ENGINE WARNING LIGHT
CAN+
CAN–
ECT ECU
Local CAN
AIRBAG SENSOR ASSEMBLY
CAN
(CAN No.1 Bus)
A/C ECU
SKID CONTROL ECU
METER ECU
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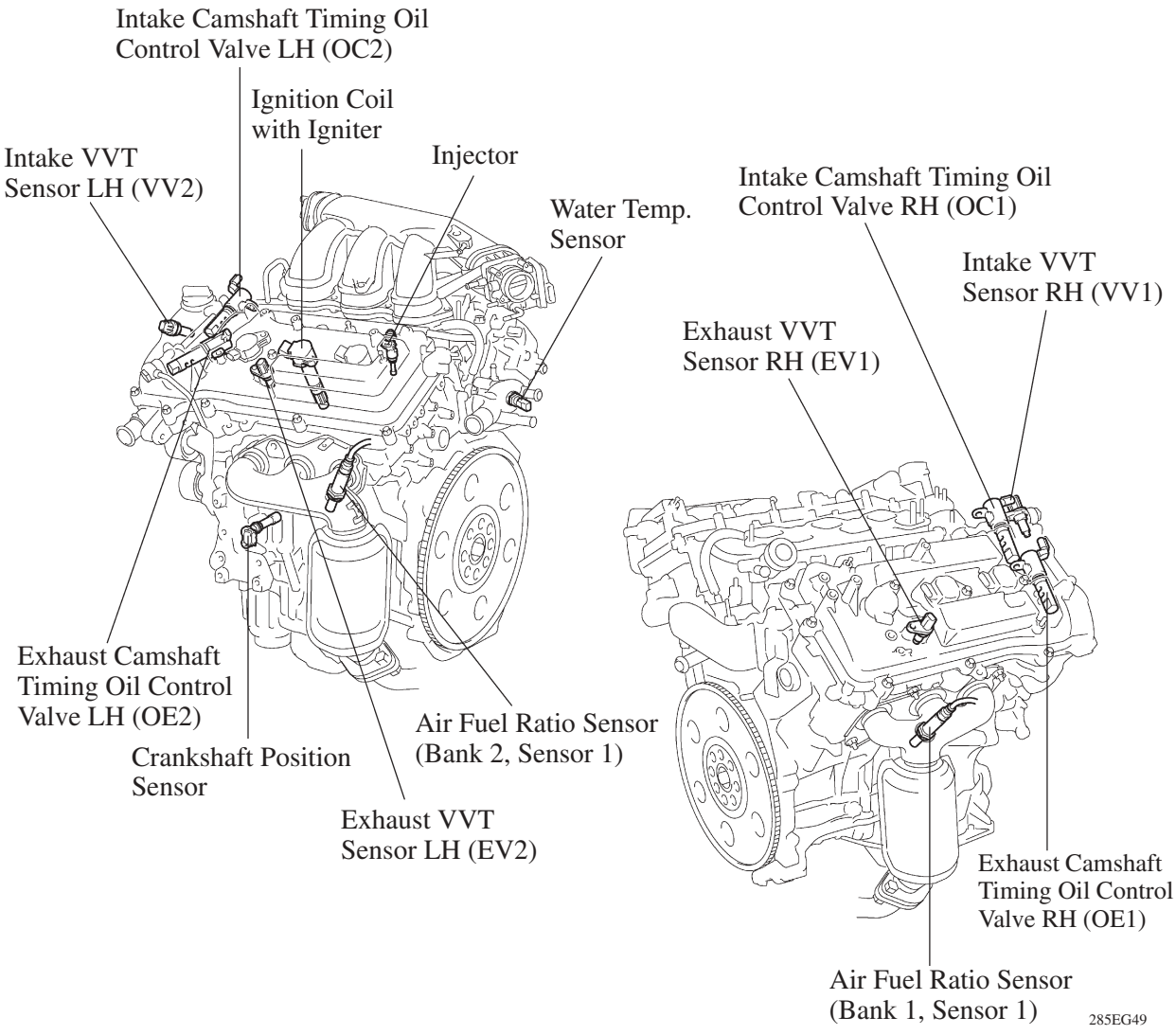
3. Engine Control System Diagram

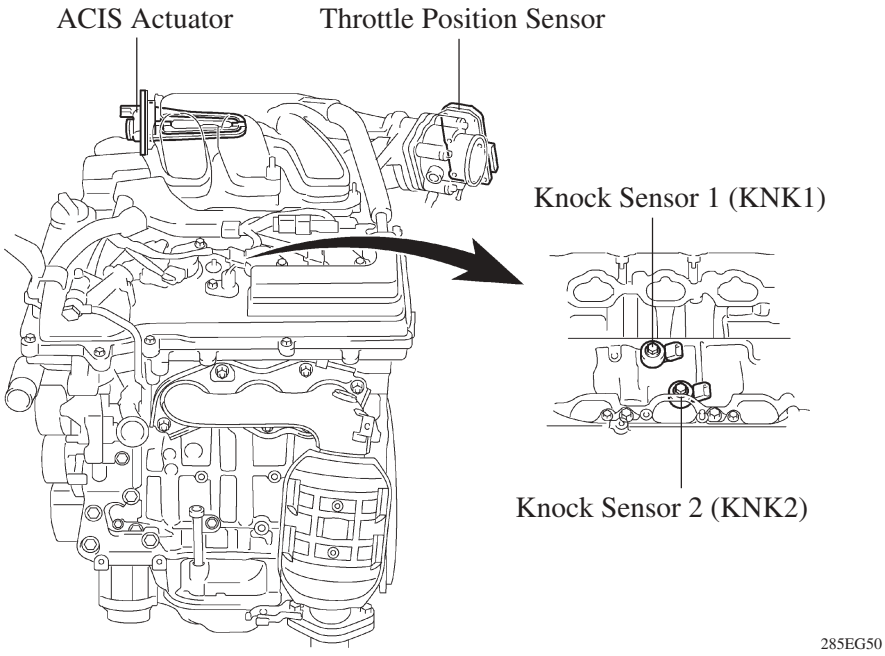


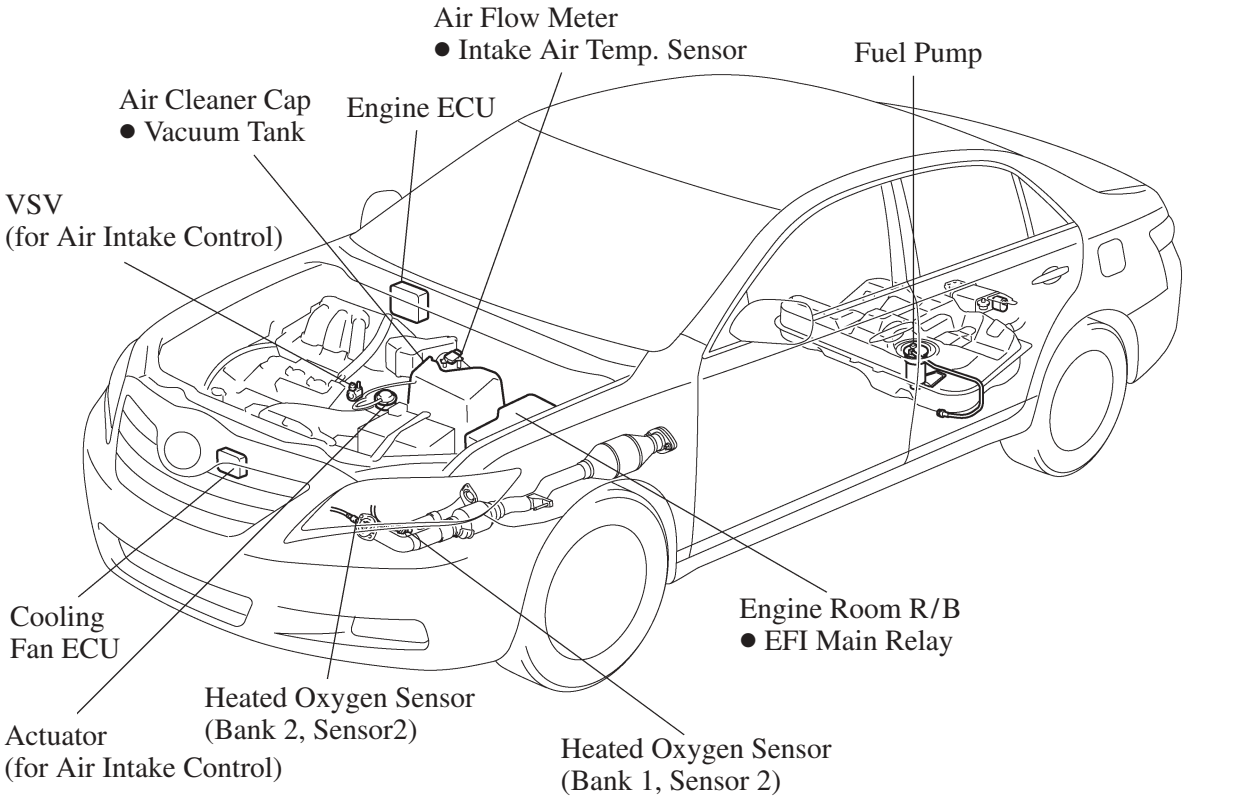
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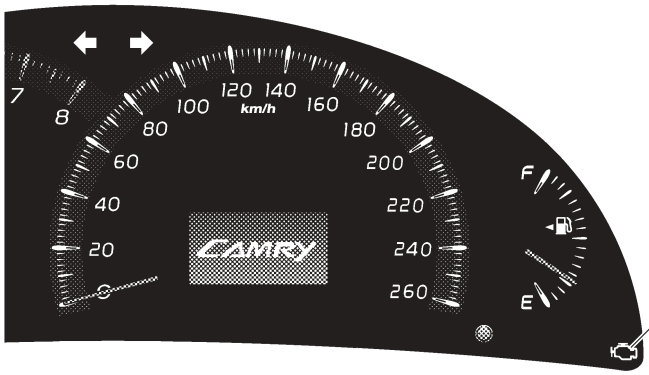
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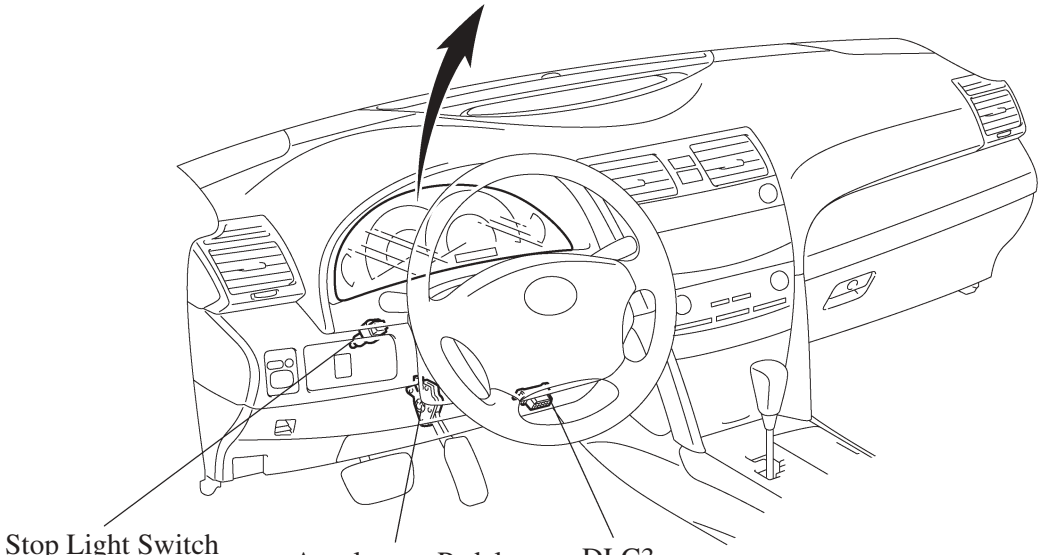
4. Layout of Main Components






Air Flow Meter
● Intake Air Temp. Sensor
Fuel Pump
Air Cleaner Cap
● Vacuum Tank
Engine ECU
VSV
(for Air Intake Control)
Cooling
Fan ECU
Engine Room R/B
● EFI Main Relay
Heated Oxygen Sensor
(Bank 2, Sensor2)
Actuator
(for Air Intake Control)
Heated Oxygen Sensor
(Bank 1, Sensor 2)


Combination Meter
● Check Engine Warning Light
CAMRY
km/h


Stop Light Switch
Accelerator Pedal
Position Sensor
DLC3

026EG11Y

EG

5. Main Component of Engine Control System

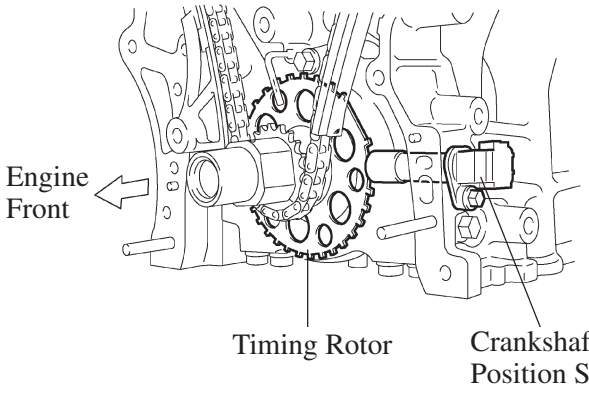
General

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

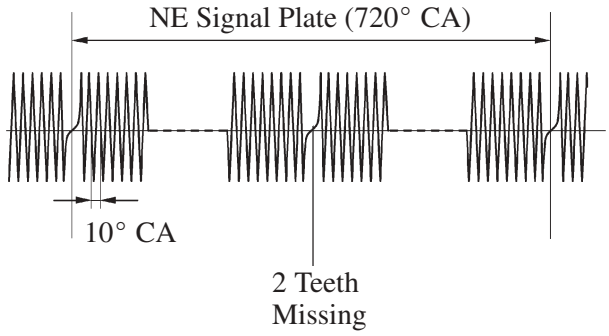
Components	Outline	Quantity	Function
Engine ECU	32-bit CPU	1	The engine ECU optimally controls the EFI ESA and ISC to suit the operating conditions of the engine in accordance with the signals provided by the sensors.
Oxygen Sensor (Bank 1, Sensor 2) (Bank 2, Sensor 2)	Cup Type with Heater	2	● This sensor detects the oxygen concentration in the exhaust emission by measuring the electromotive force which is generated in the sensor itself. ● The basic construction and operation of this sensor are the same as in the 2AZ-FE engine. For details, see page EG-44.
Air Fuel Ratio Sensor (Bank 1, Sensor 1) (Bank 2, Sensor 1)	Planar Type with Heater	2	● As with the oxygen sensor, this sensor detects the oxygen concentration in the exhaust emission. However, it detects the oxygen concentration in the exhaust emission linearly. ● The basic construction and operation of this sensor are the same as in the 2AZ-FE engine. For details, see page EG-44.
Air Flow Meter	Hot-wire Type	1	● This sensor has a built-in hot-wire to directly detect the intake air mass. ● The basic construction and operation of this meter are the same as in the 2AZ-FE engine. For details, see page EG-38.
Crankshaft Position Sensor (Rotor Teeth)	Pick-up Coil Type (36-2)	1	This sensor detects the engine speed and performs the cylinder identification.
Intake VVT Sensor LH, RH (Rotor Teeth)	MRE Type (3)	2	This sensor performs the cylinder identification.
Exhaust VVT Sensor LH, RH (Rotor Teeth)	MRE Type (3)	2	This sensor performs the cylinder identification.
Water Temperature Sensor	Thermistor Type	1	This sensor detects the engine coolant temperature by means of an internal thermistor.
Intake Air Temperature Sensor	Thermistor Type	1	This sensor detects the intake air temperature by means of an internal thermistor.
Knock Sensor 1,2	Built-in Piezoelectric Type (Flat Type)	2	This sensor detects an occurrence of the engine knocking indirectly from the vibration of the cylinder block caused by the occurrence of engine knocking.
Throttle Position Sensor	No-contact Type	1	● This sensor detects the throttle valve opening angle. ● The basic construction and operation of this sensor are the same as in the 2AZ-FE engine. For details, see page EG-41.
Accelerator Pedal Position Sensor	No-contact Type	1	● This sensor detects the amount of pedal effort applied to the accelerator pedal. ● The basic construction and operation of this sensor are the same as in the 2AZ-FE engine. For details, see page EG-40.
Injector	12-Hole Type	6	The injector is an electromagnetically-operated nozzle which injects fuel in accordance with signals from the engine ECU.

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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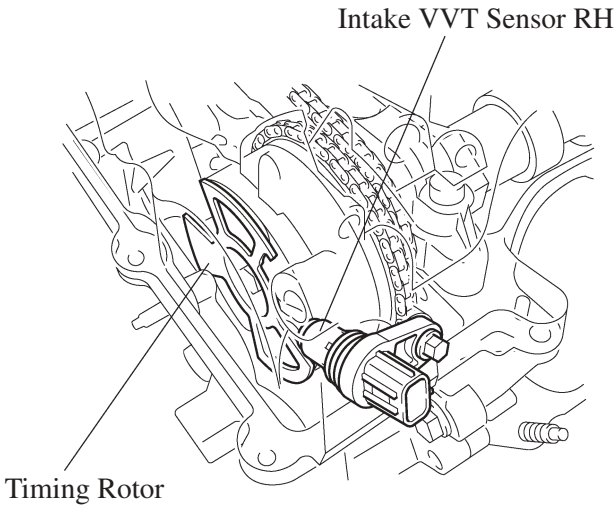


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Intake and Exhaust VVT Sensors

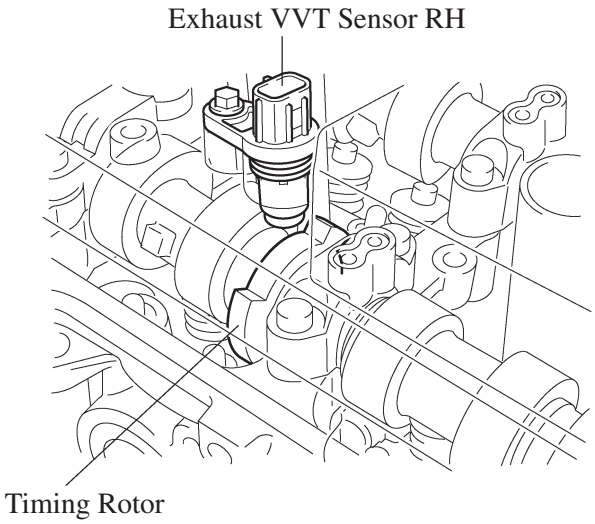
1) General

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.



Intake VVT Sensor (Right Bank)

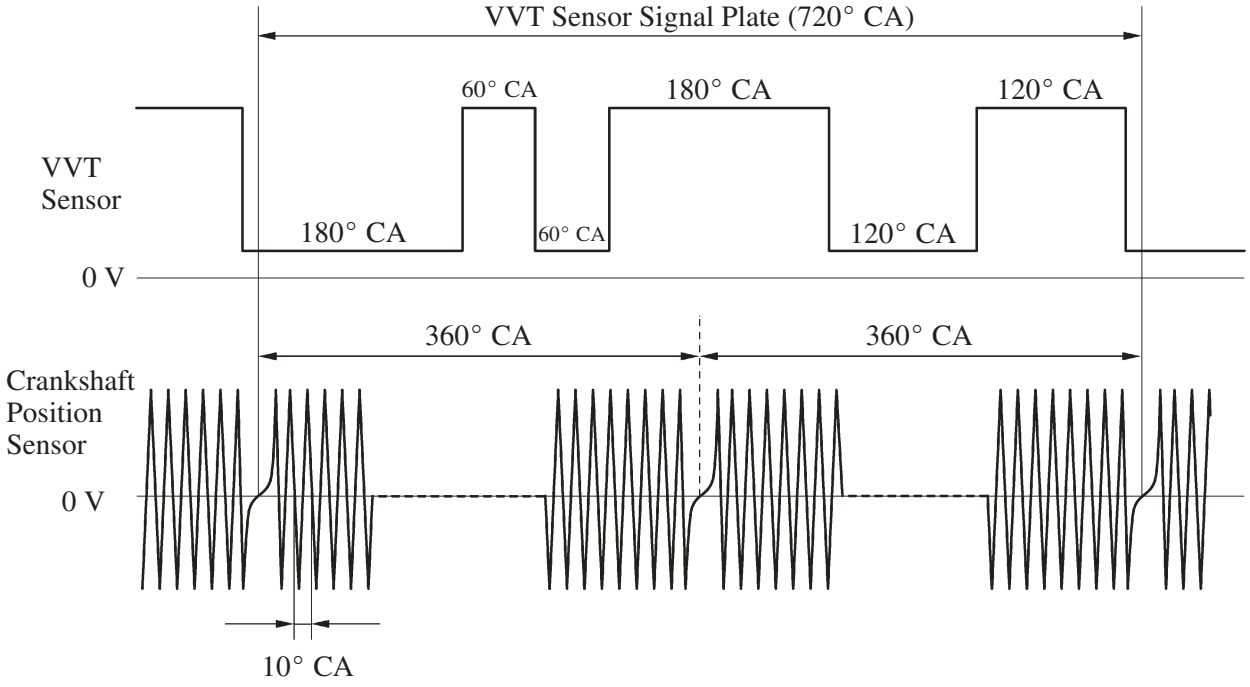
285EG82



Exhaust VVT Sensor (Right Bank)

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▶ Sensor Output Waveforms ◀

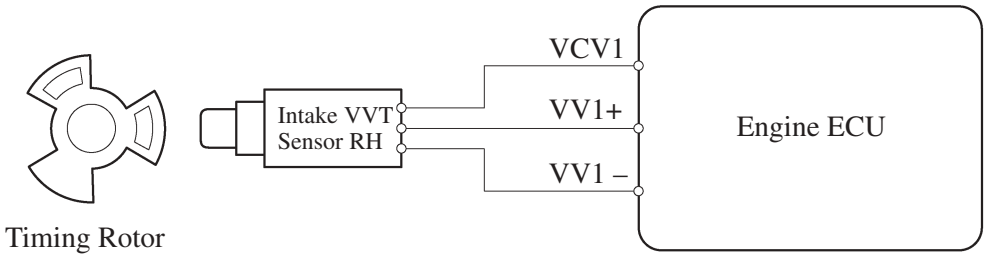


2) MRE Type VVT Sensor

- 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 pickup coil type VVT sensor used on the conventional model are as follows.

Item	Sensor Type	
	MRE	Pick-up Coil
Signal Output	Constant digital output starts from low engine speeds.	Analog output changes with the engine speed.
Camshaft Position Detection	Detection 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.

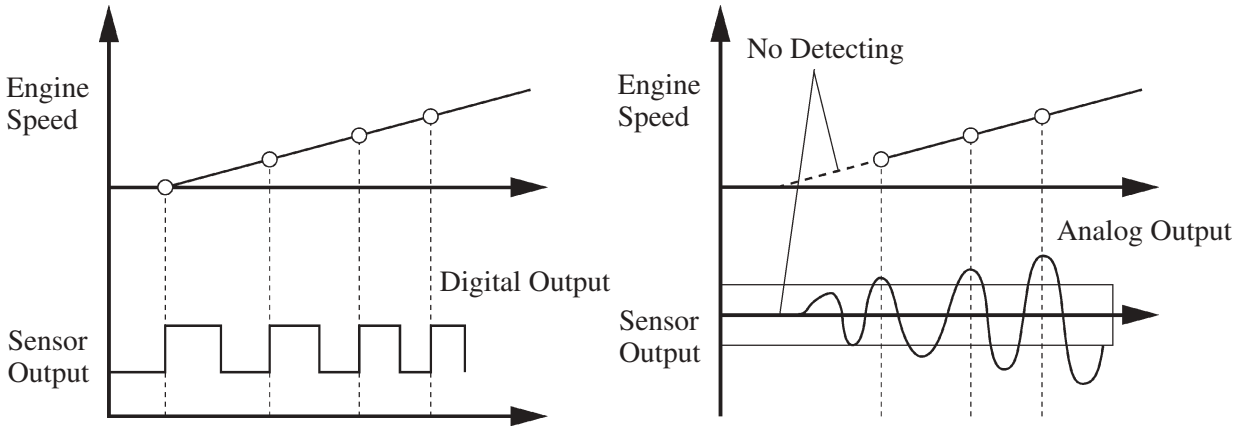
▶ Wiring Diagram ◀



Intake VVT Sensor RH

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



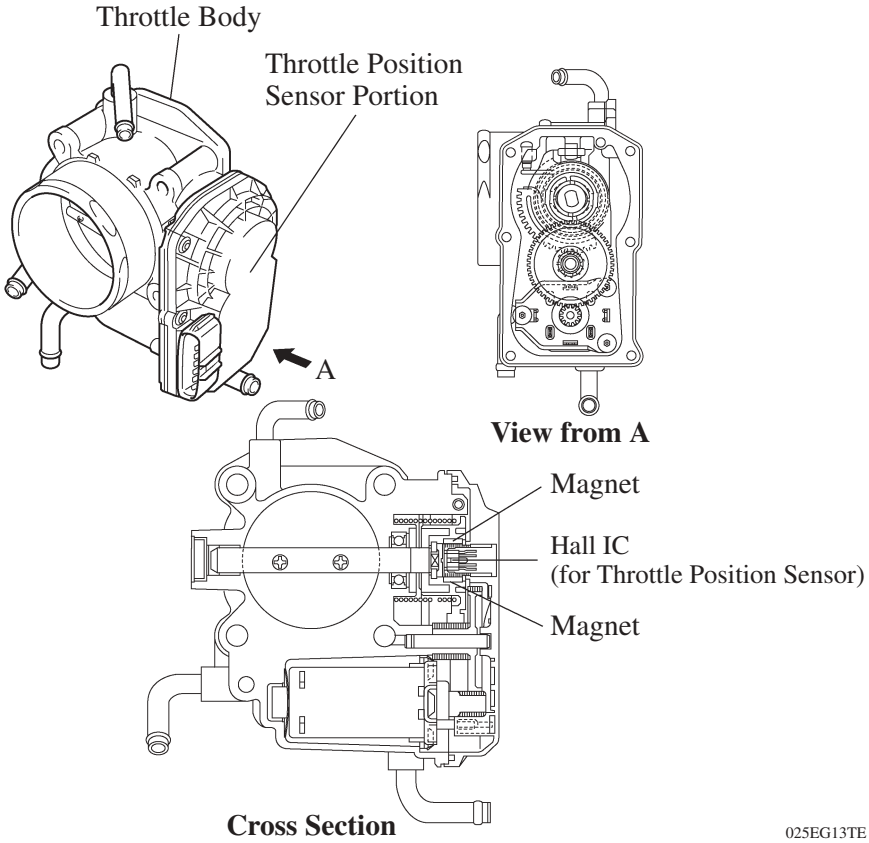
MRE Type **Pick-up Coil Type**

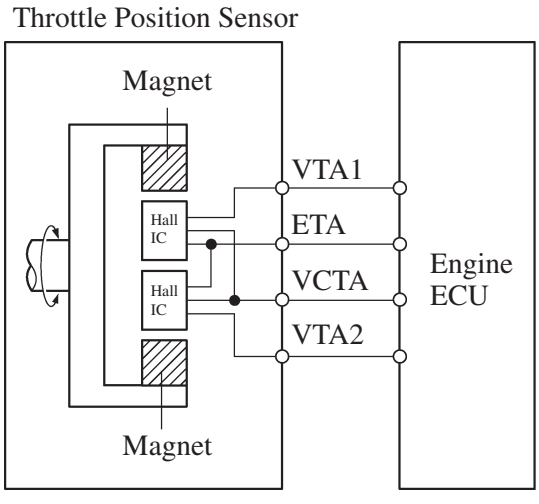
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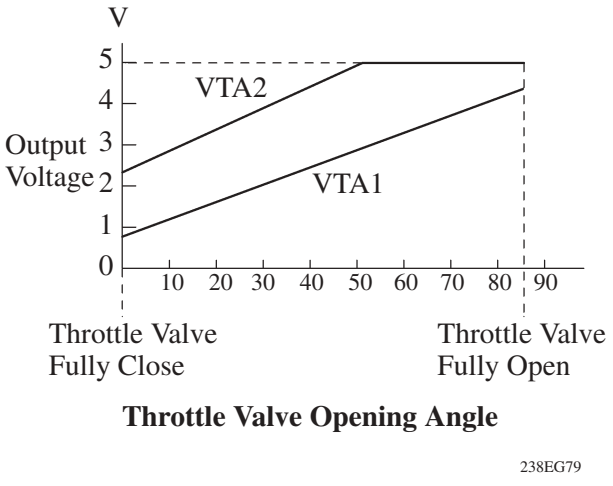
Throttle Position Sensor

The no-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.







Service Tip

The inspection method differs from the conventional throttle position sensor because this sensor uses a Hall IC. For details, refer to the Camry Repair Manual (Pub. No. RM0260E).

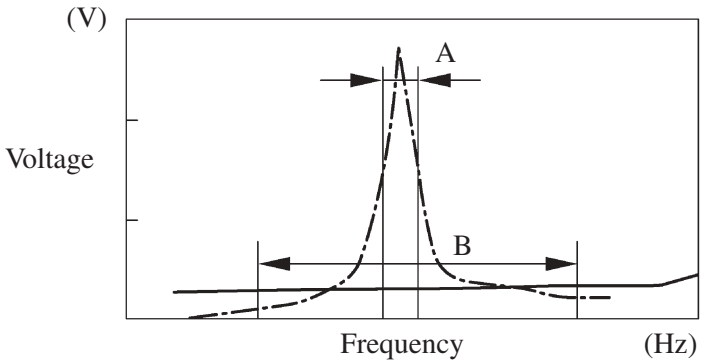
Knock Sensor (Flat Type)

1) 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 can detect the vibration in this frequency band.
On the other hand, a flat type knock sensor (non-resonant type) has the ability to detect vibration in a wider frequency band from about 6 kHz to 15 kHz, 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 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

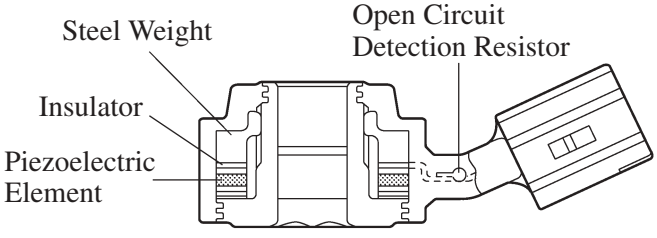


Characteristic of Knock Sensor

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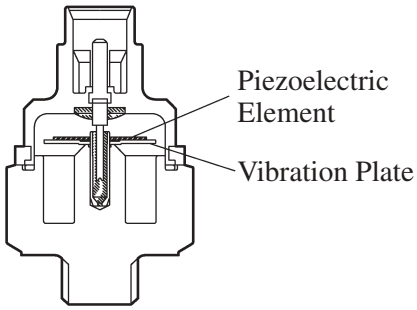
2) Construction

- 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 in 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)

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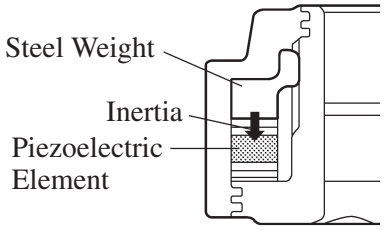


Conventional Type Knock Sensor (Resonant Type)

214CE02

3) Operation

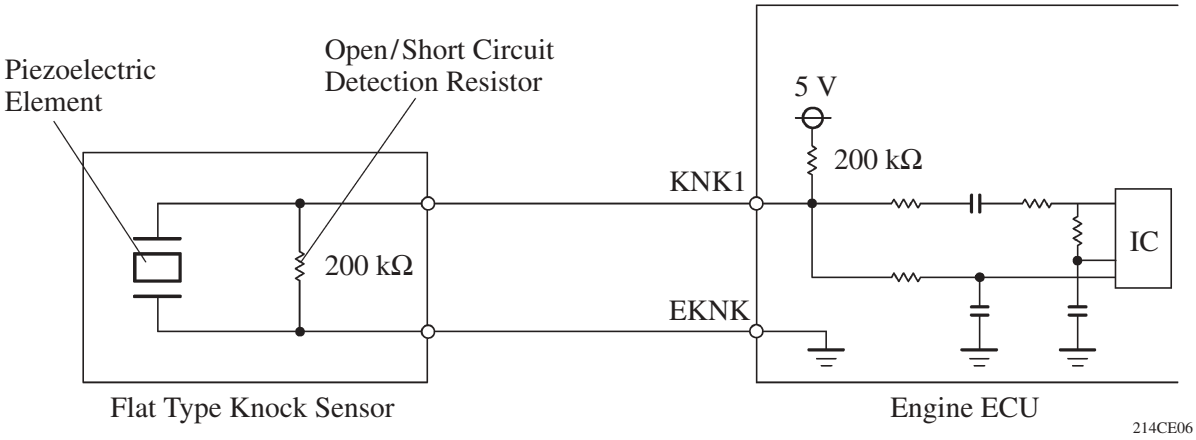
The knocking vibration is transmitted to the steel weight and its inertia applies pressure to the piezoelectric element. The action generates electromotive force.



214CE08

4) Open/Short Circuit Detection Resistor

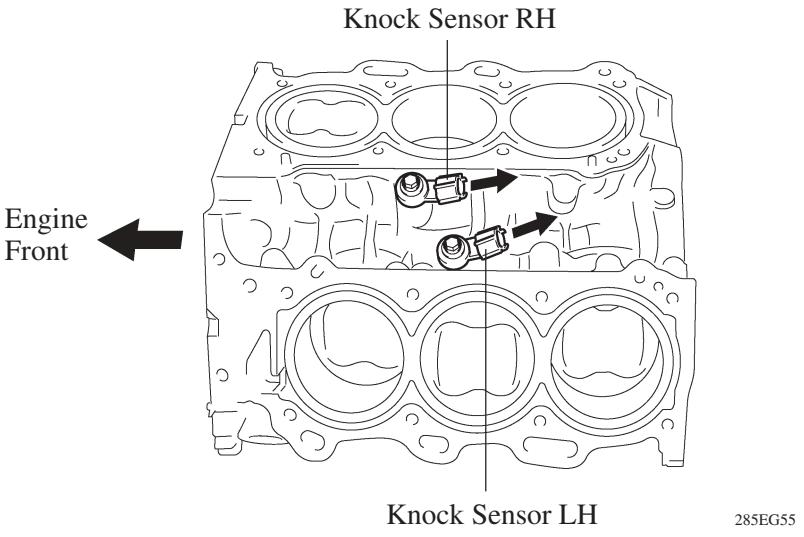
During the ignition is ON, the open/short circuit detection resistor in the knock sensor and the resistor in the engine ECU keep the voltage at the terminal KNK1 of engine constant.
An IC (Integrated Circuit) in the engine ECU is always monitoring the voltage of the terminal KNK1. If the open/short circuit 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).



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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.

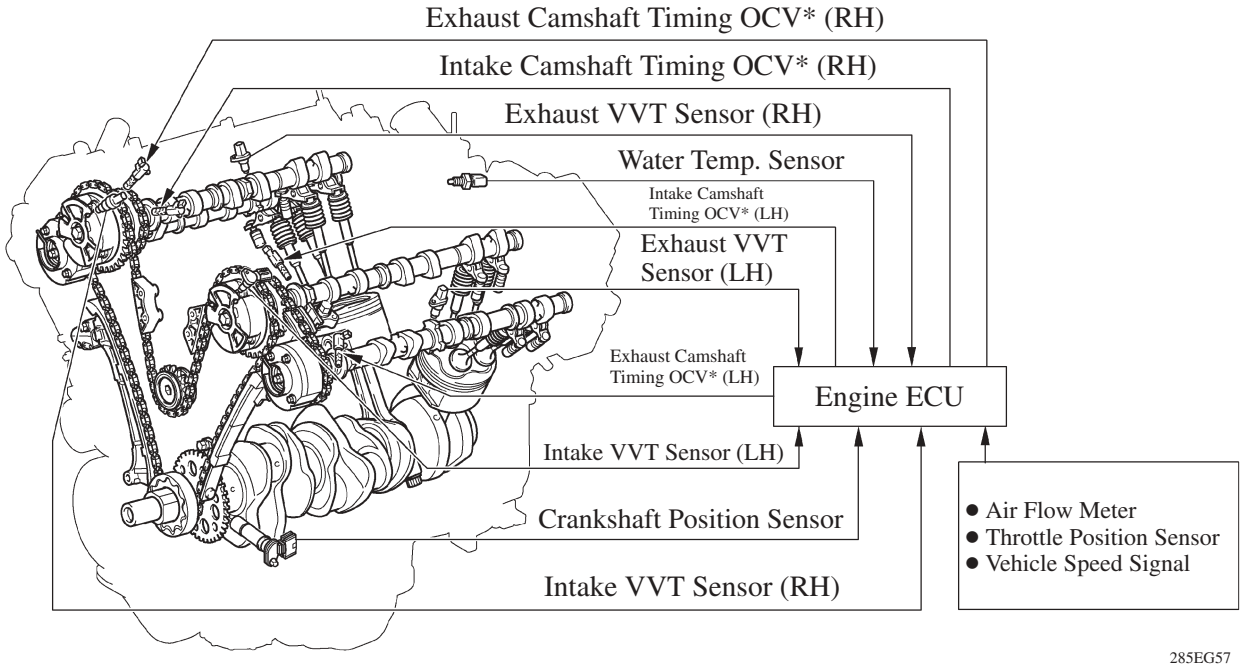


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6. Dual VVT-i (Variable Valve Timing-intelligent) System

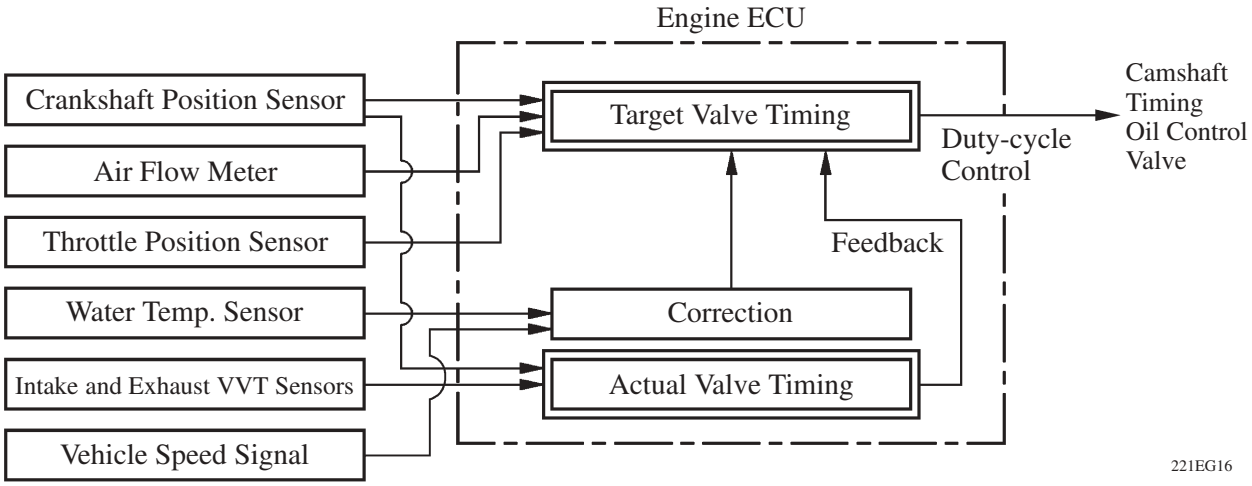
General

- 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.

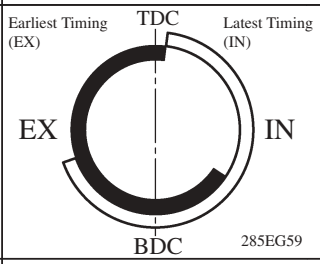
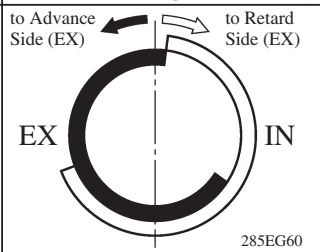
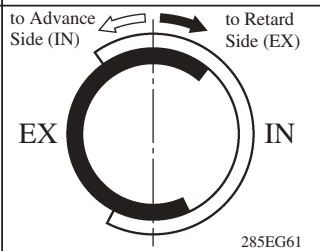
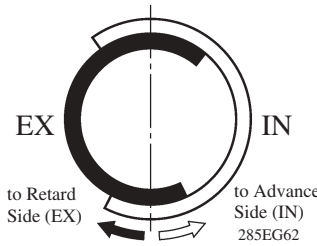
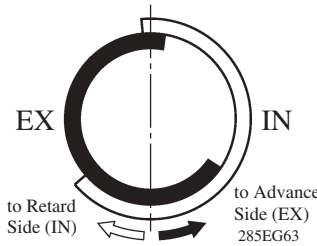
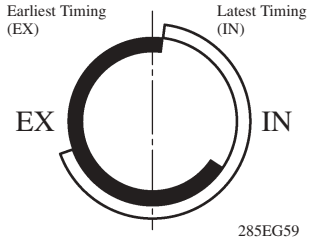
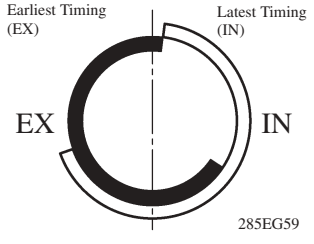


*: Oil Control Valve

- By using the engine speed, intake air volume, throttle position and engine coolant temperature, 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.



Effectiveness of the VVT-i System

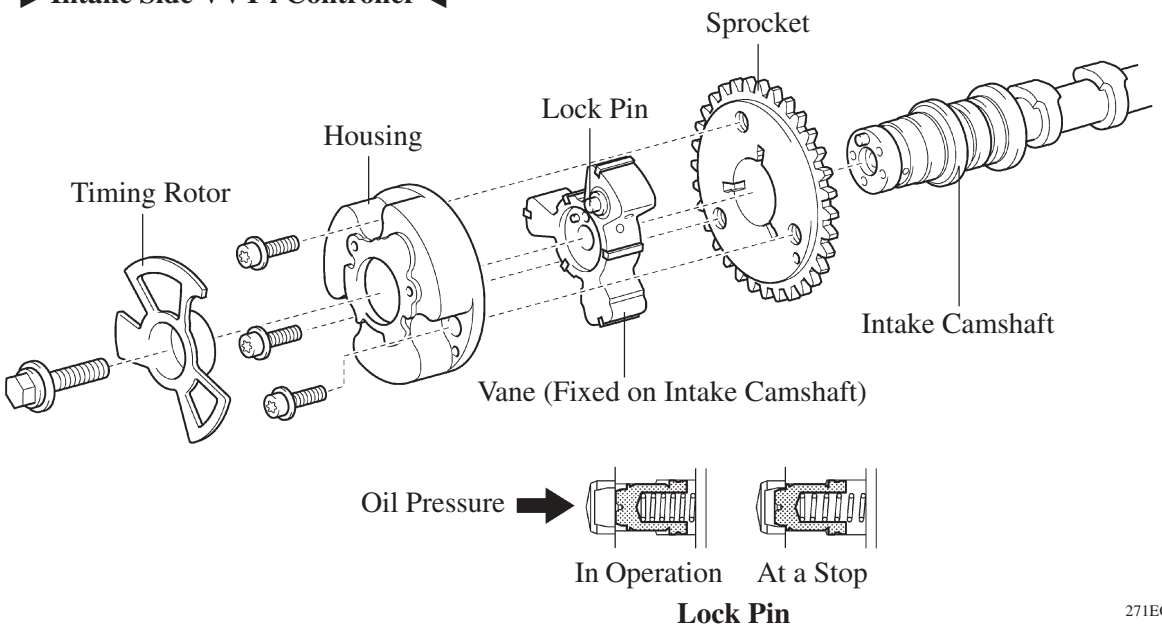
Operation State	Objective	Effect
During Idling	 Eliminating overlap to reduce blow back to the intake side.	● Stabilized idling rpm ● Better fuel economy
At Light Load	 Eliminating overlap to reduce blow back to the intake side.	Ensured engine stability
At Medium Load	 Increasing overlap increases internal 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.	● Stabilized fast idle rpm ● Better fuel economy
● Upon Starting ● Stopping the Engine	 Eliminating overlap to minimize blow back to the intake side.	Improved startability

Construction

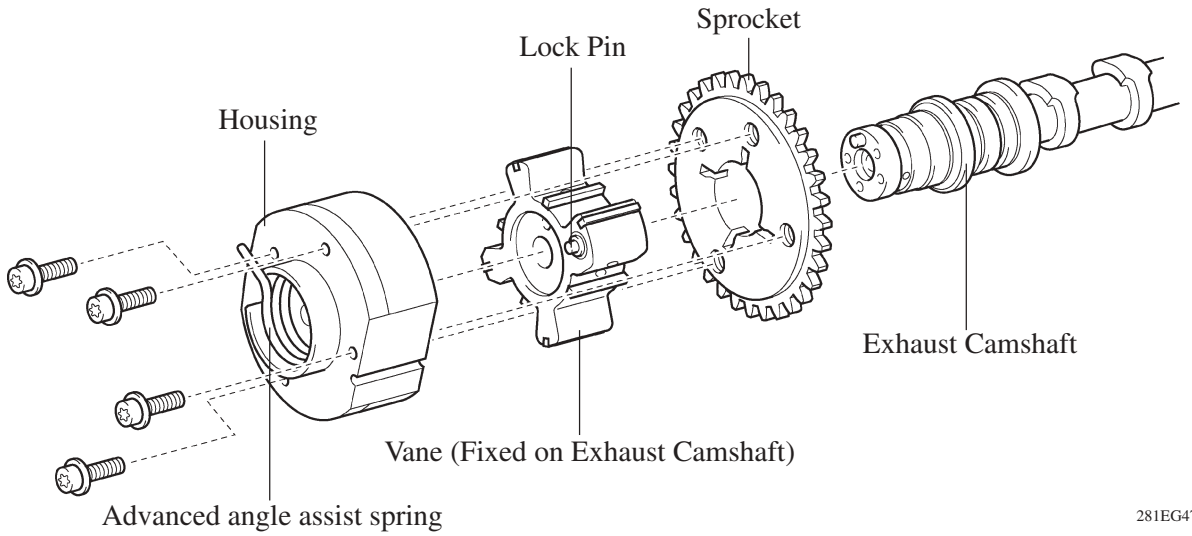
1) VVT-i Controller

- This controller consists of the housing driven from the timing chain and the vane coupled with the intake and exhaust camshafts.
- The intake side has used a VVT-i controller with 3 vanes, and the exhaust side has used one with 4 vanes.
- When the engine stops, the intake side VVT-i controller is locked on the most retarded angle side by the lock pin, and the exhaust side controller is locked on the most advanced angle side. This ensures excellent engine startability.
- The oil pressure sent from the advance or retard side path at the intake and exhaust camshaft 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 ◀



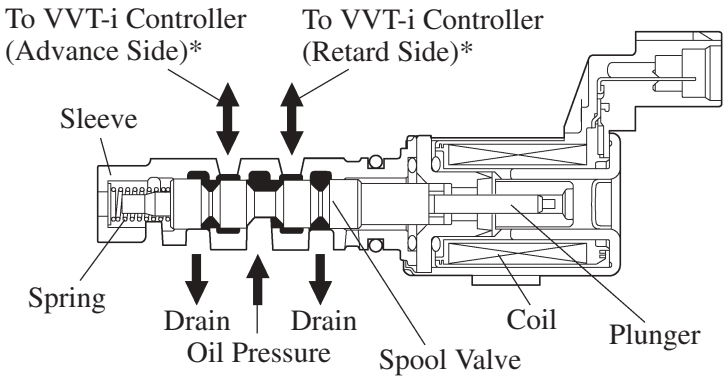
▶ Exhaust Side VVT-i Controller ◀



2) 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 advance or retard side. When the engine is stopped, the camshaft timing oil control valve is in the most retard position.

▶ Intake Camshaft Timing Oil Control Valve ◀



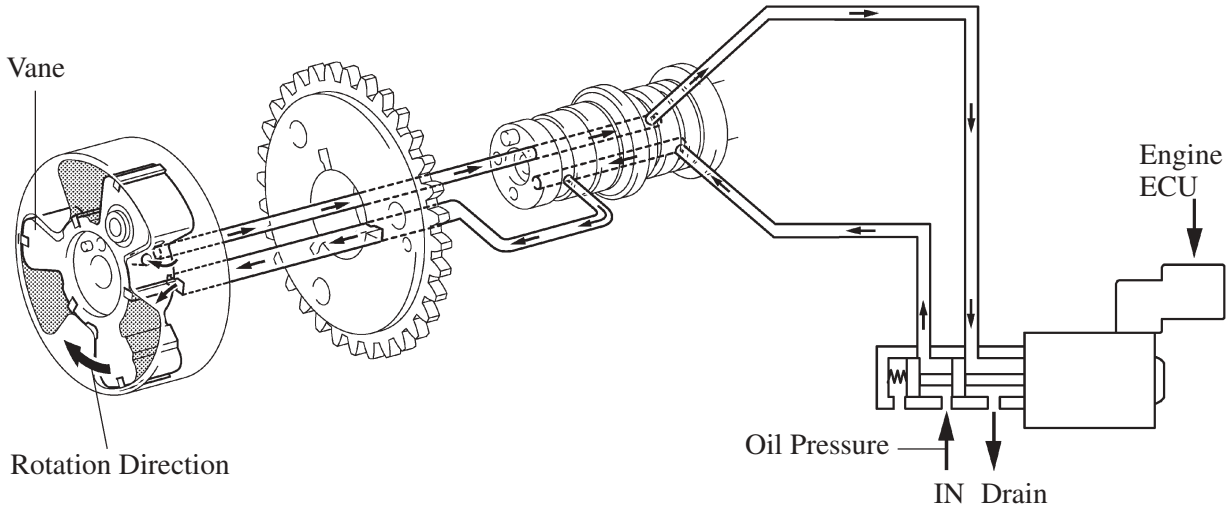
*: The advance and retard sides of the exhaust side oil control valve are reverse of the intake side.

Operation

1) Advance

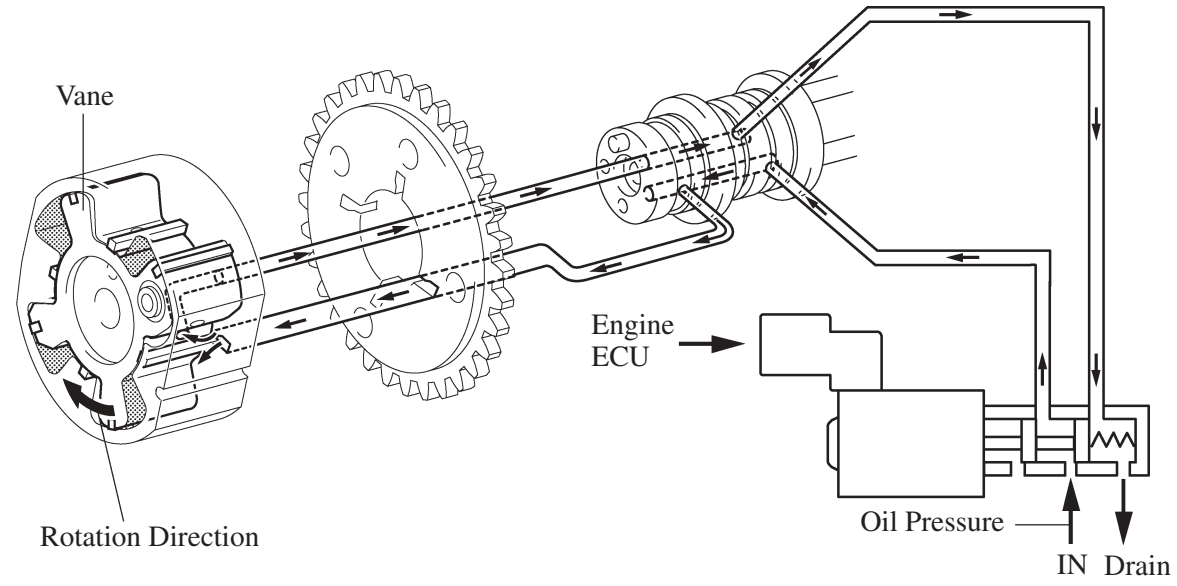
When the camshaft timing oil control valve is positioned as illustrated below by the advance signals from the engine ECU, the resultant oil pressure is applied to the timing advance side vane chamber to rotate the camshaft in the timing advance direction.

▶ Intake Side ◀



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▶ Exhaust Side ◀

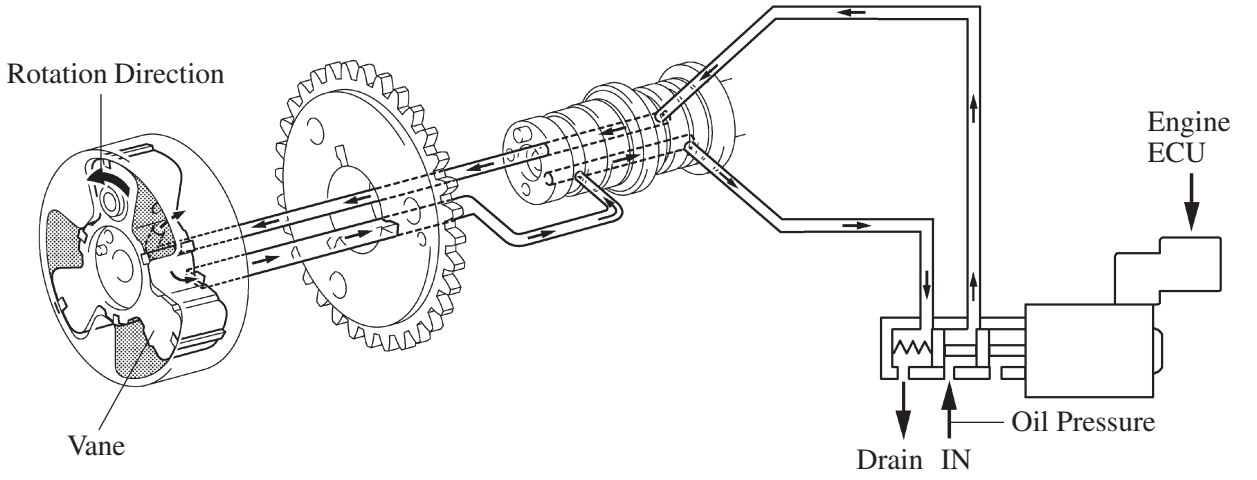


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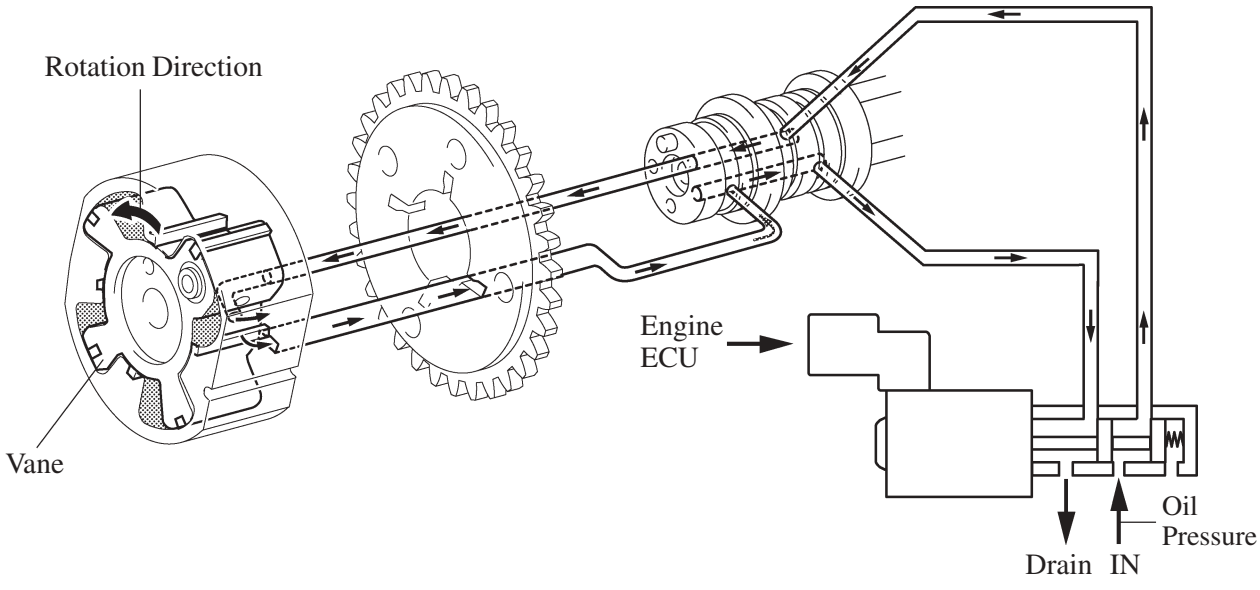
2) Retard

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 ◀



3) Hold

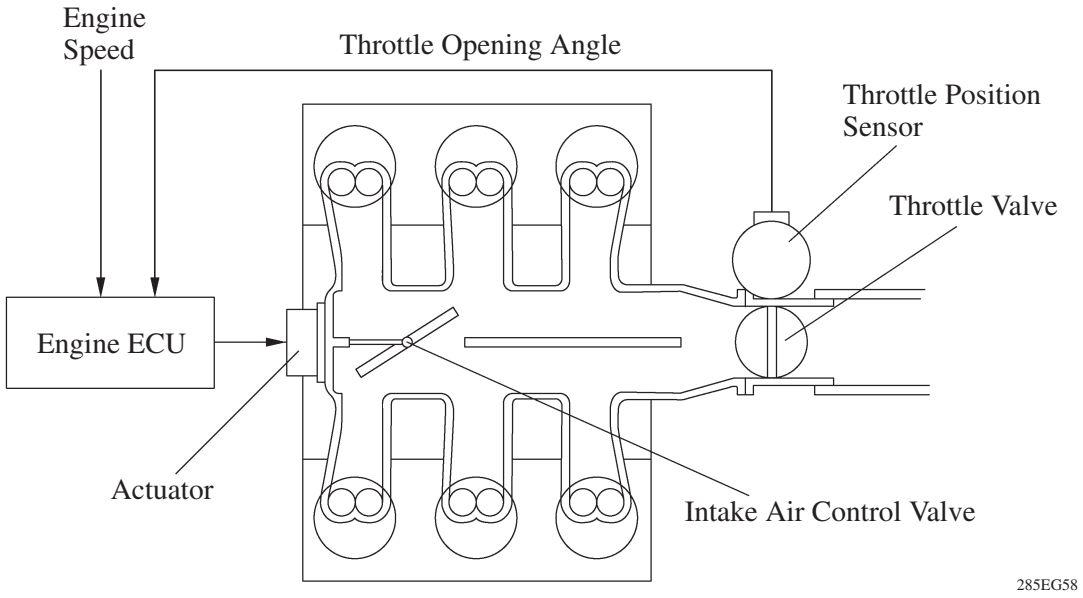
After reaching the target timing, the valve timing is held by keeping the camshaft timing oil control valve in the neutral position unless the traveling state changes.
This adjusts the valve timing at the desired target position and prevents the engine oil from running out when it is unnecessary.

7. ACIS (Acoustic Control Induction System)

General

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

▶ System Diagram ◀



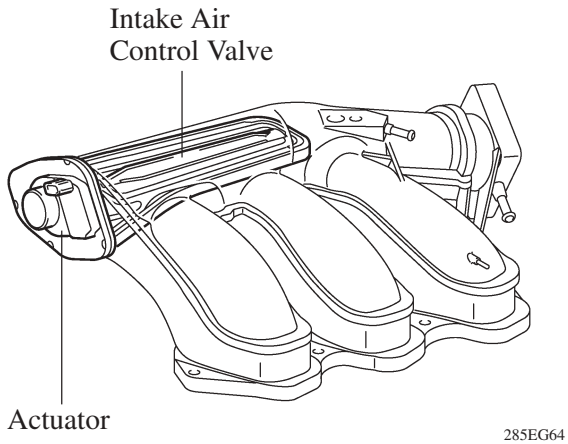
Construction

1) Intake Air Control Valve

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

2) Actuator (Motor)

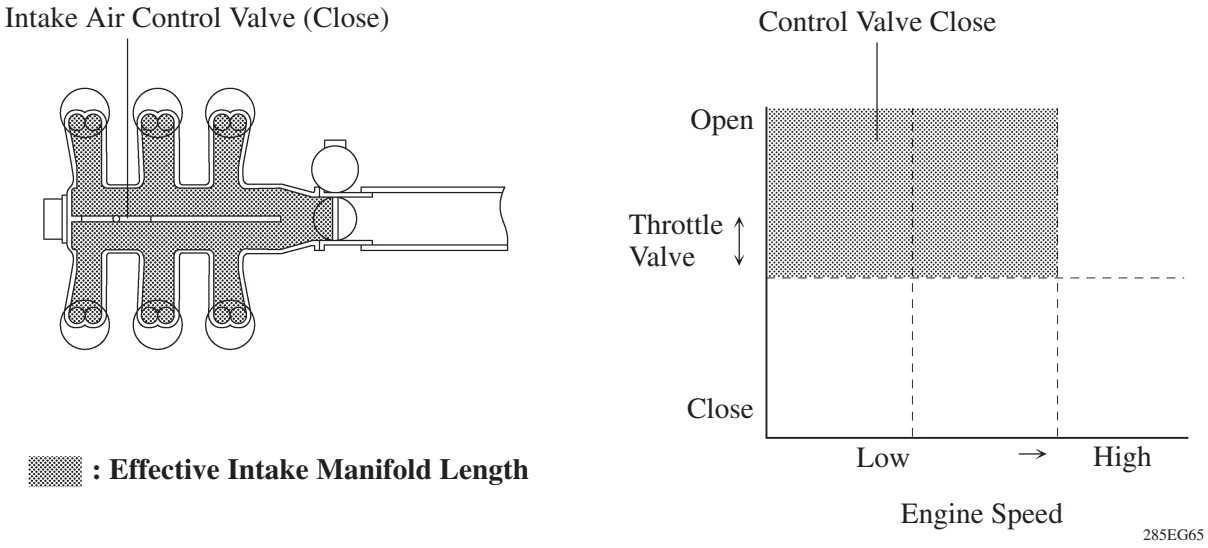
The actuator activates the intake air control valve based on signals from the engine ECU.



Operation

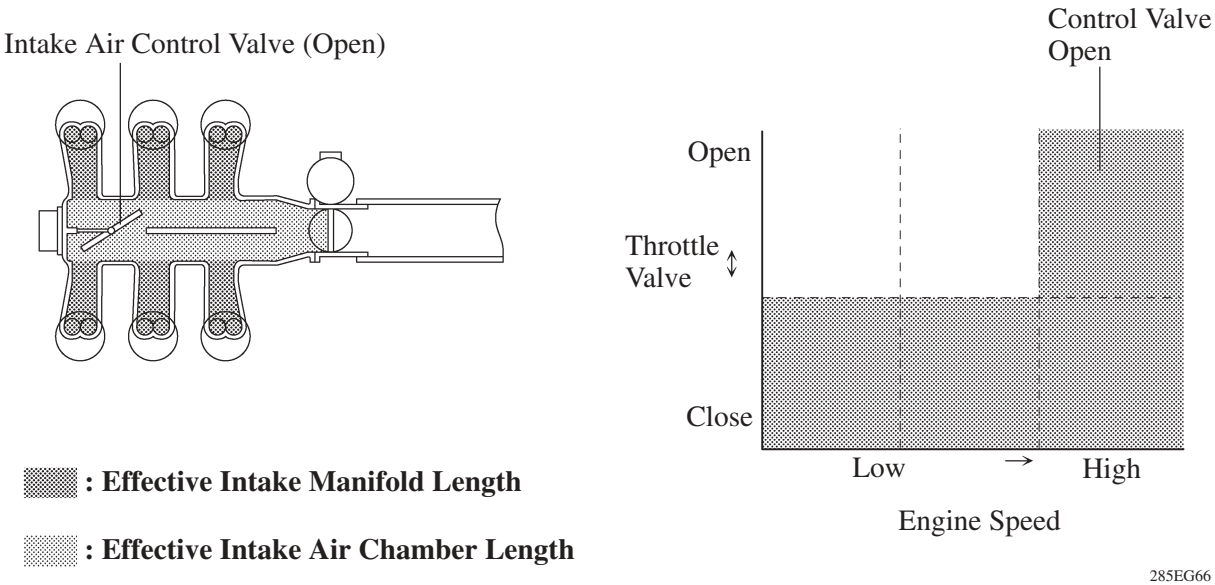
1) When the Intake Air Control Valve Closes

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



2) When the Intake Air Control Valve Open

Under any condition except when the engine is running at middle speed under high load, the engine ECU controls the actuator to open the control valve. When the 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.

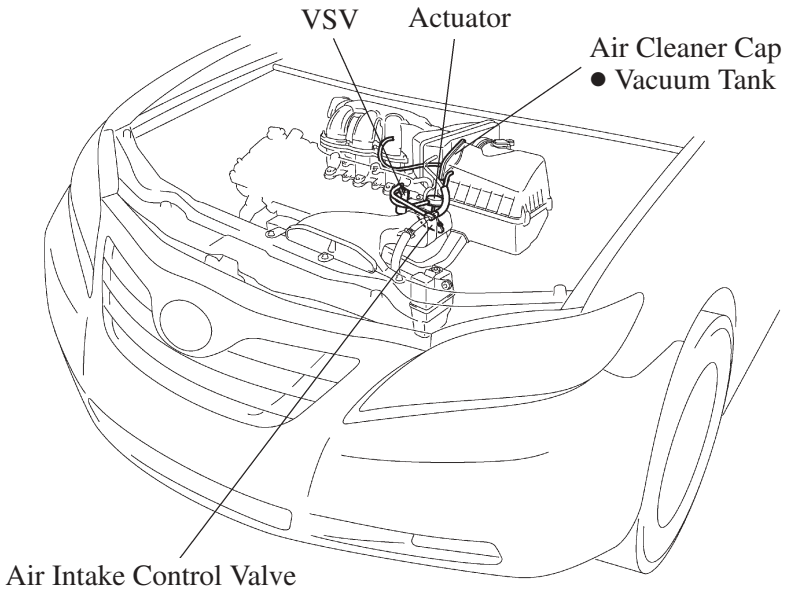


8. Air Intake Control System

General

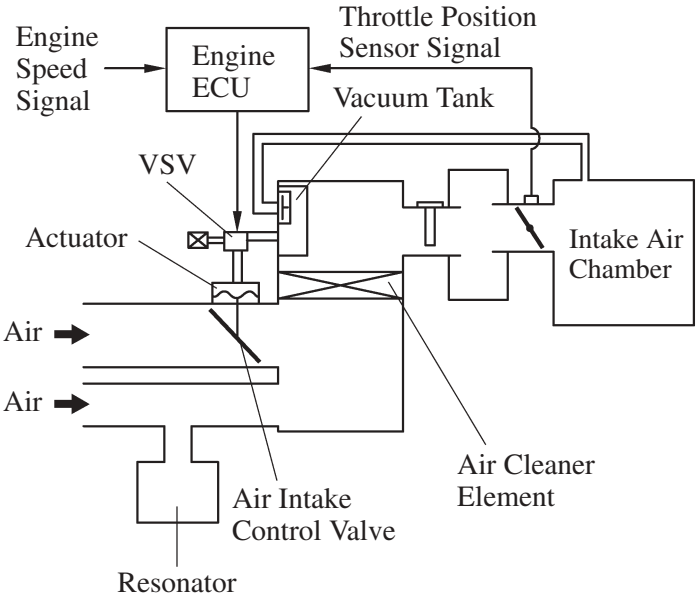
The system has a dual path design for air intake. An air intake control valve and actuator control the air flow path.
As a result, a reduction in intake noise in the low-speed range and an increase in the power output in the high-speed range is realized.

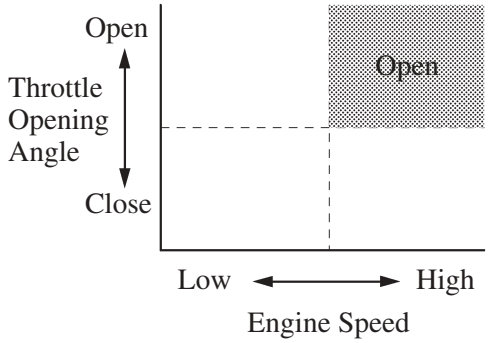
▶ Layout of Components ◀



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

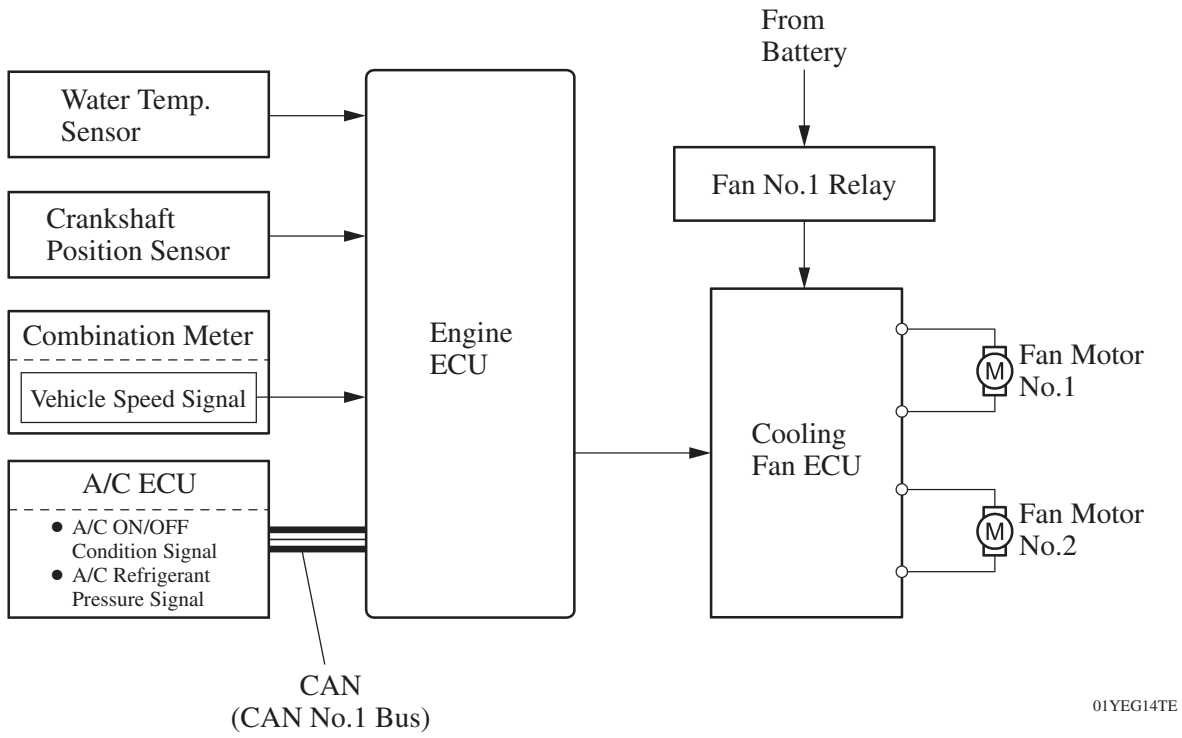
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9. Cooling Fan Control System

General

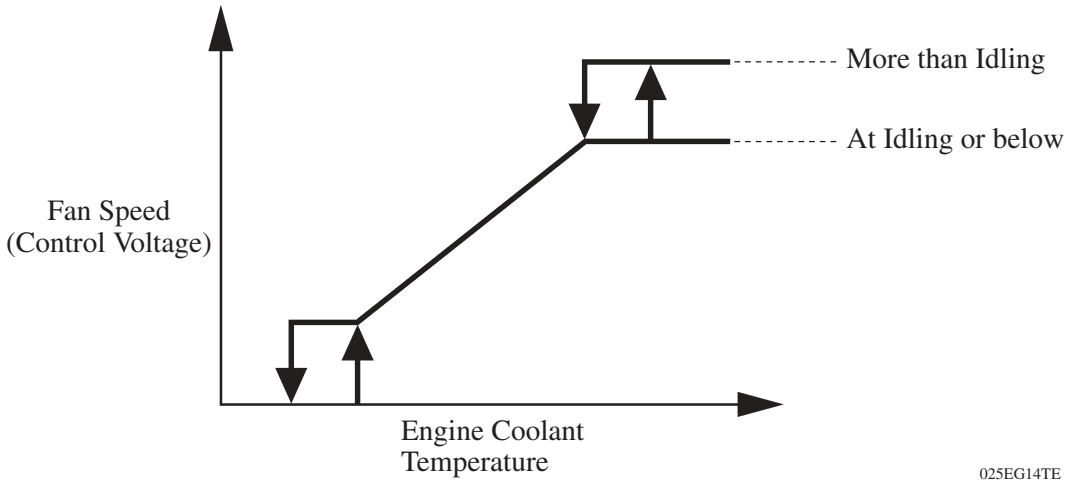
A cooling fan control system is used. To achieve an optimal fan speed in accordance with the engine coolant temperature, vehicle speed, engine speed, and air conditioner operating conditions, the engine ECU calculates the proper fan speed and sends the signals to the cooling fan ECU. Upon receiving the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

▶ Wiring Diagram ◀

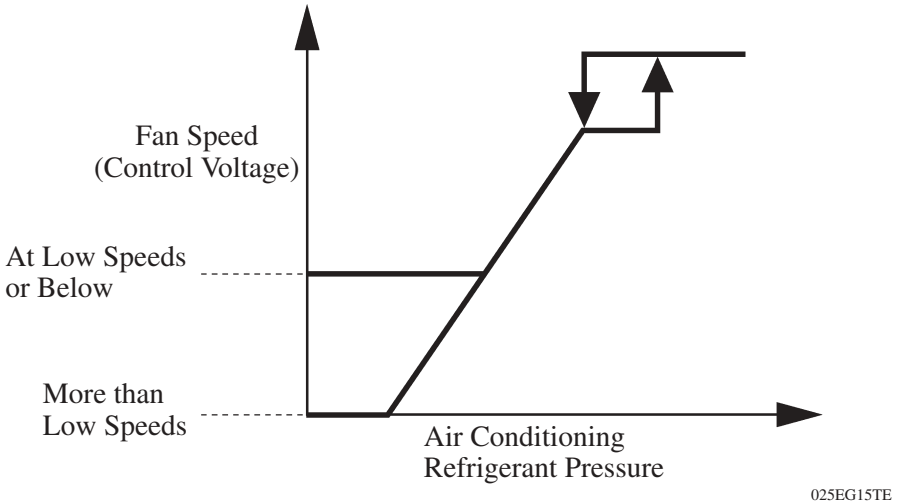


Operation

- The engine ECU controls the cooling fan speed in accordance with the value of the engine coolant temperature, as shown in the graph below. When the engine coolant temperature is higher than a specific value, the control differs depending on whether the engine speed is at idling and below or more.



- The engine ECU controls the cooling fan speed in accordance with the value of the air conditioner refrigerant pressure, as shown in the graph below. When the air conditioner refrigerant pressure is higher than a specific value, the control differs depending on whether the engine speed is at low speeds and below or more.



10. 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 DTC (Diagnostic Trouble Code) of the malfunctions. The DTC can be accessed by using the intelligent tester II.
- For details, see the Camry Repair Manual (Pub. No. RM0260E).

Service Tip

- The engine ECU of the Camry uses the CAN protocol for diagnostic communication. Therefore, an intelligent tester II is required for accessing diagnostic data. For details, see the Camry Repair Manual (Pub. No. RM0260E).
- To clear the DTC that is stored in the engine ECU, use an intelligent tester II, disconnect the battery terminal or remove the EFI No.1 fuse and ETCS fuse for 1 minute or longer.

11. Fail-Safe

When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the date already stored in the memory.

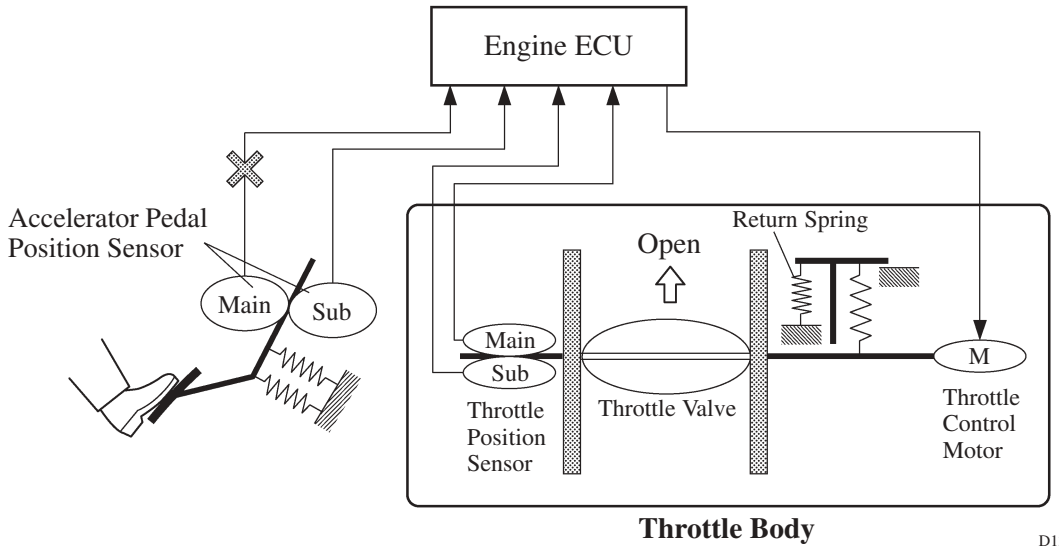
▶ Fail-Safe Chart ◀

DTC No.	Fail-Safe Operation	Fail-Safe Deactivation Conditions
P0031, P0032, P0051, P0052	Engine ECU turns off air fuel ratio sensor heater.	Ignition switch OFF.
P0037, P0038 P0057, P0058	Engine ECU turns off heated oxygen sensor heater.	Ignition switch OFF.
P0100, P0102, P0103	Ignition timing is calculated from engine speed and throttle angle.	"Pass" condition detected.
P0110, P0112, P0113	Intake air temperature is fixed at 20°C (68°F).	"Pass" condition detected.
P0115, P0117, P0118	Engine coolant temperature is fixed at 80°C (176°F).	"Pass" condition detected.
P0120, P0121, P0122, P0123, P0220, P0222, P0223, P0604, P0606, P0607, P0657, P2102, P2103, P2111, P2112, P2118, P2119, P2135	If ETCS-i (Electronic Throttle Control System-intelligent) has a malfunction, engine ECU cuts off current to throttle control motor. Throttle control valve returns to predetermined opening angle (approximately 6.5°) by force of return spring. Engine ECU then adjusts engine output by controlling fuel injection (intermittent fuel-cut) and ignition timing in accordance with accelerator pedal opening angel to enable vehicle to continue at minimal speed. If accelerator pedal is depressed firmly and slowly, vehicle can be driven slowly. If accelerator pedal is depressed quickly, vehicle may speed up and slow down erratically.	If "Pass" condition is detected and then the engine switch*1 or ignition switch*2 is turned OFF, fail-safe operation will stop and system will return to normal operating conditions.
P0327, P0328, P0332, P0333	Max. timing retardation.	Ignition switch OFF.
P0351, P0352, P0353, P0354, P0355, P0356	Fuel is cut.	"Pass" condition detected.
P2120, P2121, P2122, P2123, P2125, P2127, P2128, P2138	Accelerator pedal position sensor has two (main and sub) sensor circuits. If a malfunction occurs in either of sensor circuits, engine ECU detects abnormal signal voltage difference between two sensor circuits and switches into limp mode. In limp mode, remaining circuit is used to calculate accelerator pedal opening to allow vehicle to continue driving. If both circuits malfunction, engine ECU regards opening angle of accelerator pedal to be fully closed. In this case, throttle valve will remain closed as if engine is idling.	If "Pass" condition is detected and then the or ignition switch is turned OFF, fail-safe operation will stop and system will return to normal operating conditions.

Fail-safe of Accelerator Pedal Position Sensor

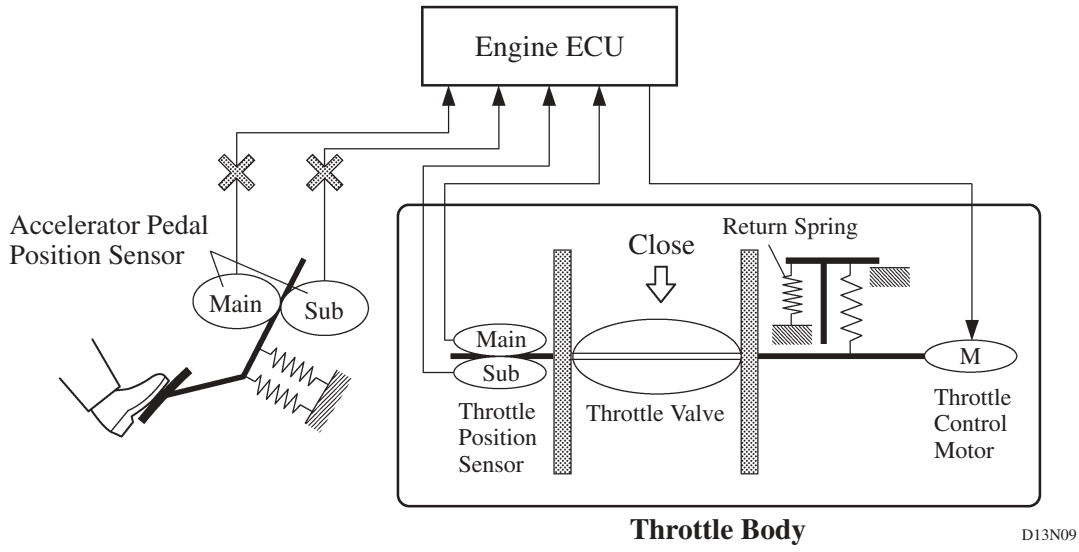
The accelerator pedal position sensor comprises two (Main, Sub) sensor circuits.

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



Throttle Body D13N08

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



Throttle Body D13N09

Fail-safe of Throttle Position Sensor

The throttle position sensor comprises two (Main, Sub) sensor circuits.

- If a malfunction occurs in either of the sensor circuits, the engine ECU detects the abnormal signal 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 limp mode while the engine output is regulated through the control of the fuel injection 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.

