■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-108]	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 [Dual Variable Valve Timing-intelligent] [See page EG-110]	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-116]	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-118]	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	● 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. ● The basic system construction and operation of this control are the same as those of the control used on the 1AZ-FE and 2AZ-FE engines. For details of this control, see page EG-54.
Air Conditioner Cut-off Control	By turning the air conditioner compressor ON or OFF in accordance with the engine condition, drivability is maintained.

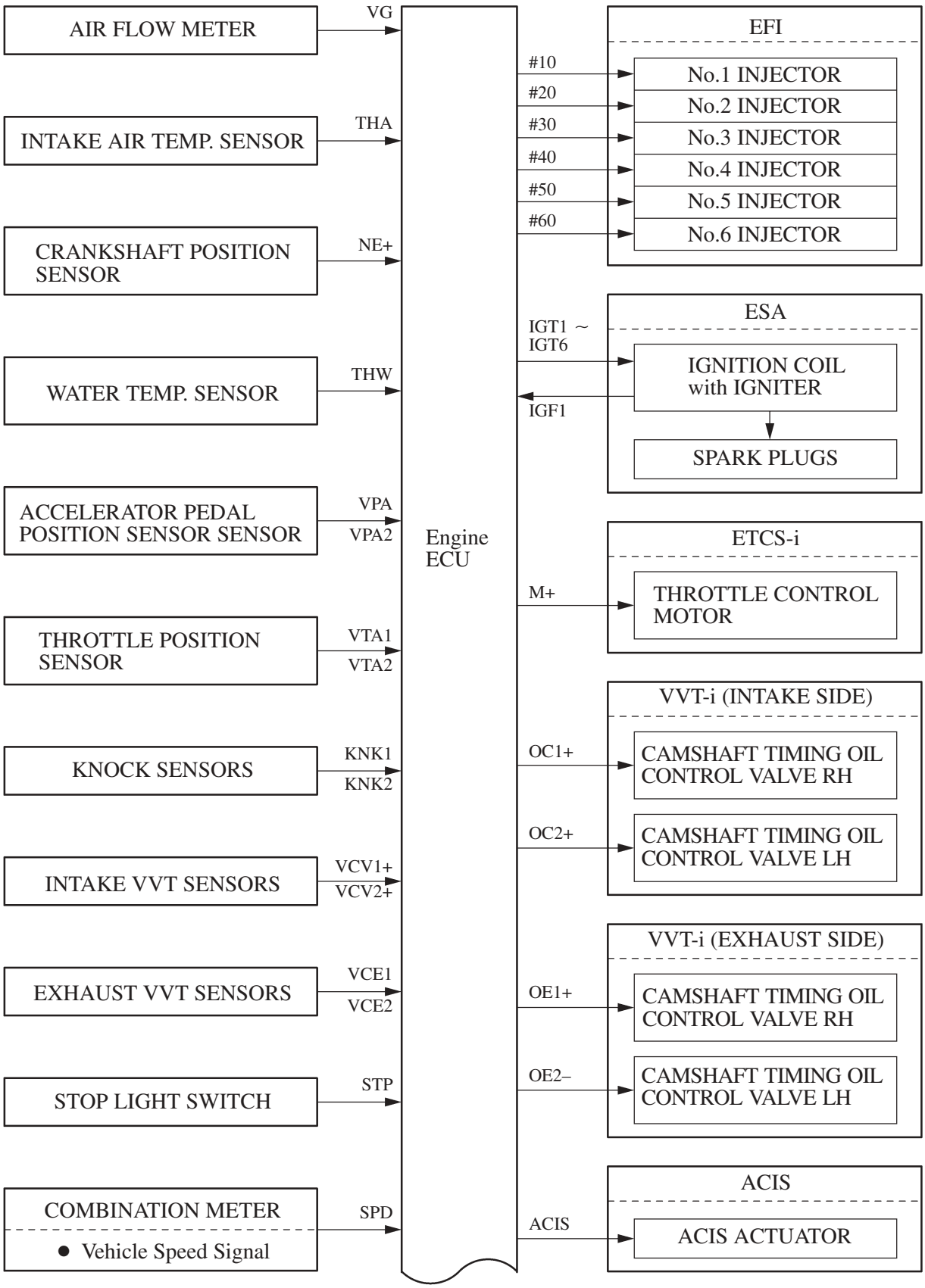
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System	Outline
Cooling Fan Control [See page EG-119]	The Cooling Fan ECU steplessly controls the speed of the fans in accordance with the engine coolant temperature, vehicle speed, engine speed, and air conditioner operating conditions. As a result, the cooling performance is improved.
Starter Control* [Cranking Hold Function]	● Once the engine switch is pushed, while the brake pedal is depressed, this control continues to operate the starter until the engine started. ● The basic system construction and operation of this control are the same as those of the control used on the 1AZ-FE and 2AZ-FE engines. For details of this control, see page EG-56.
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.
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-92]	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-121]	When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section.
Fail-Safe [See page EG-121]	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in the memory.

*: Only for models with smart entry and start system

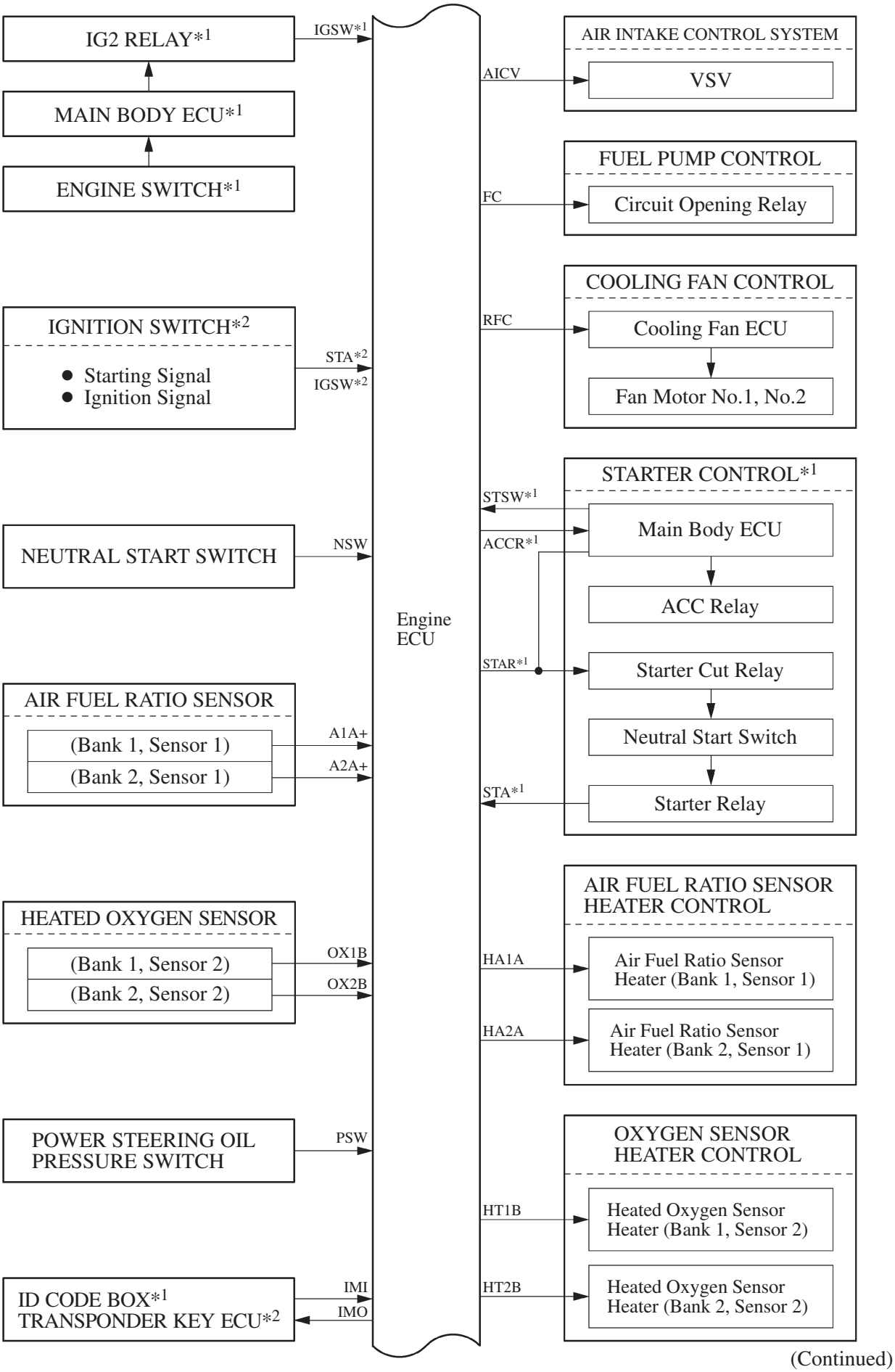
2. Construction

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



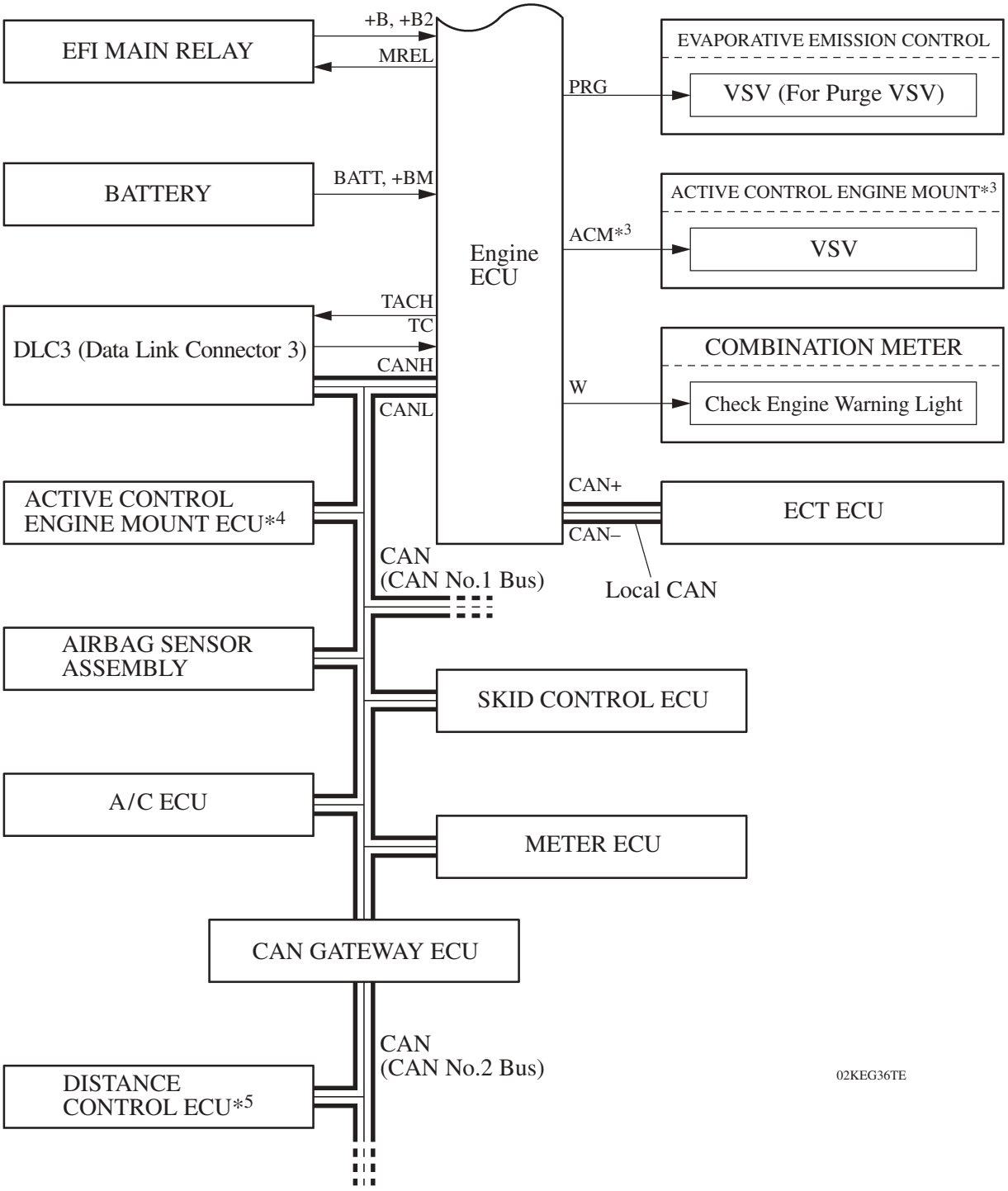
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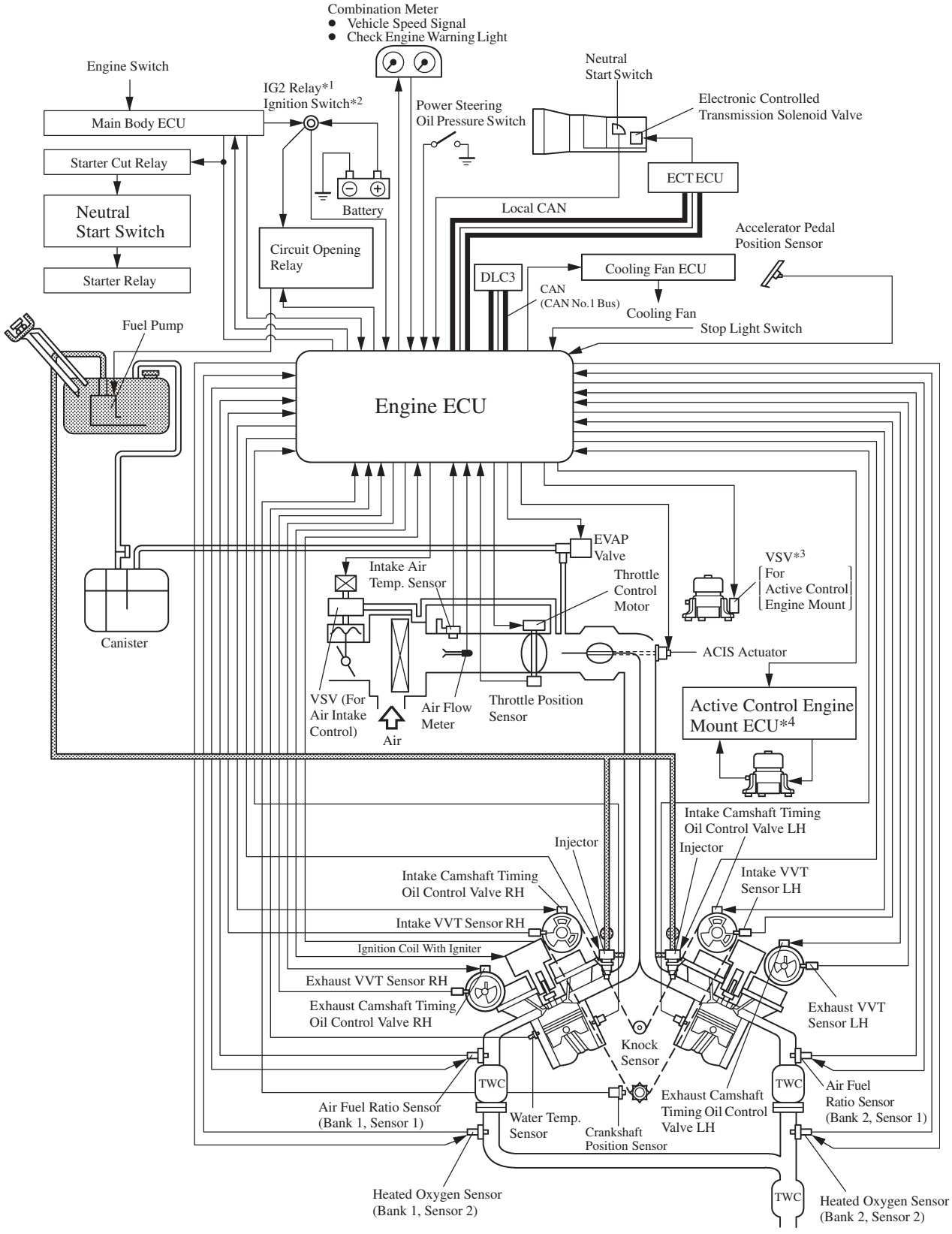
02KEG35TE



*1: Only for models with smart entry and start system
*2: Only for models without smart entry and start system
*3: Only for models without power tilt and power telescopic steering column
*4: Only for models with power tilt and power telescopic steering column
*5: Only for models with dynamic radar type cruise control system

EG

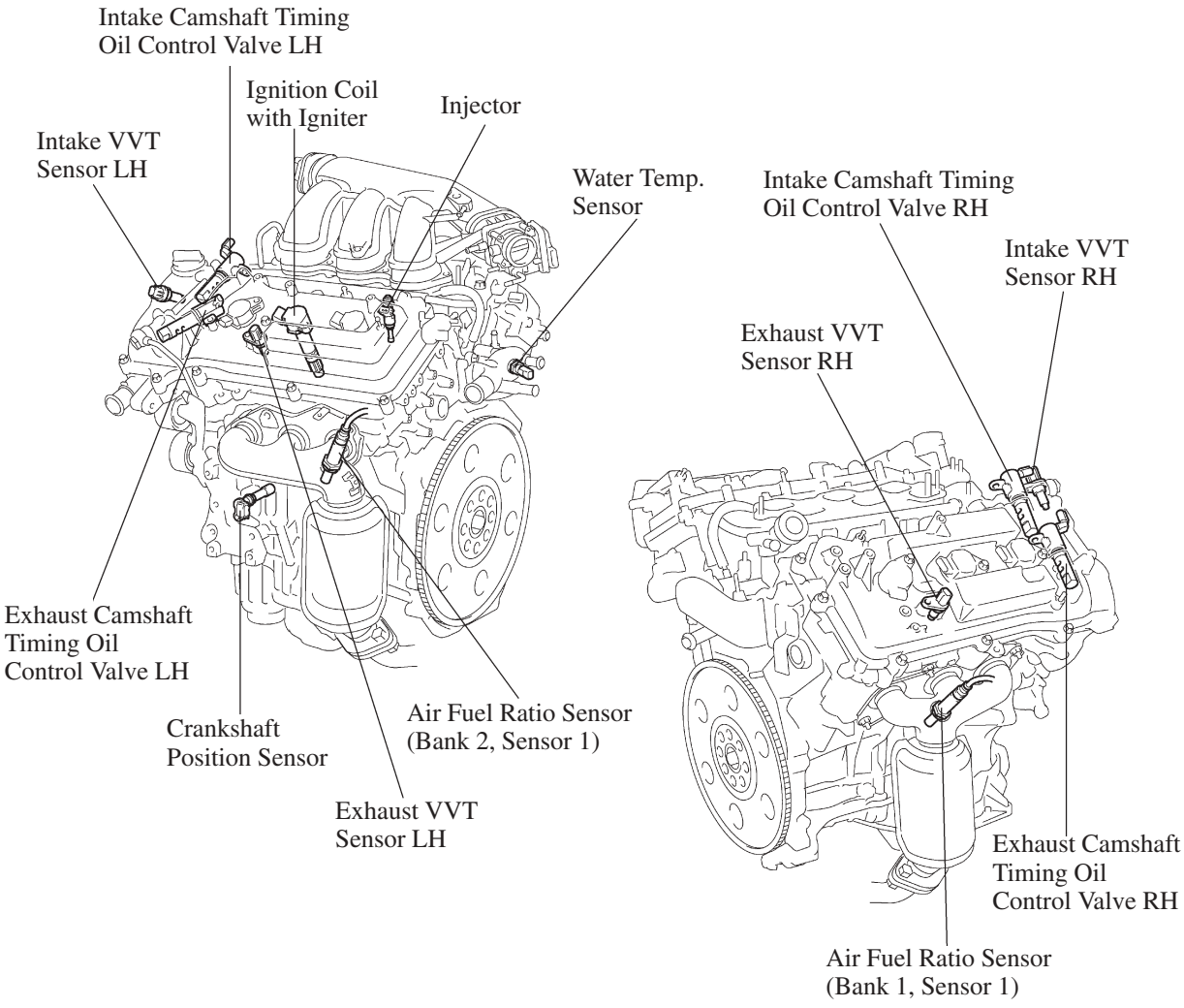
3. Engine Control System Diagram



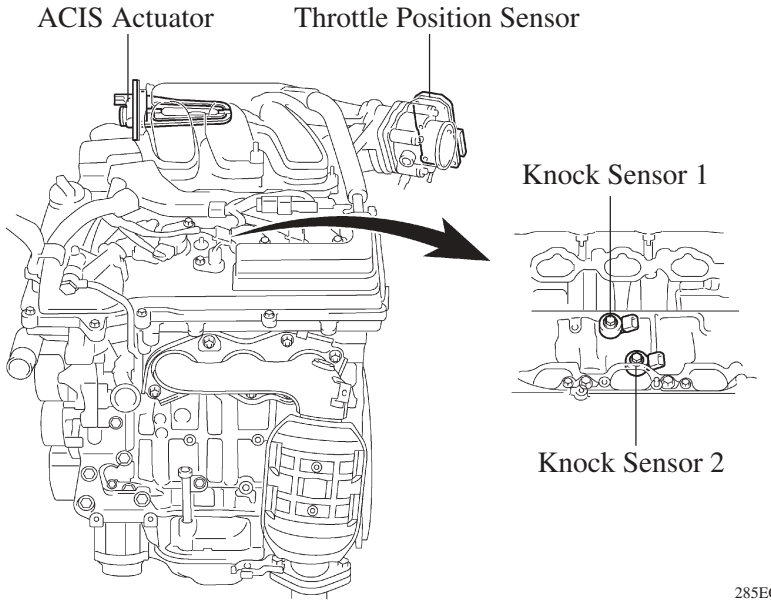
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*1: Only for models with smart entry and start system
*2: Only for models without smart entry and start system
*3: Only for models without power tilt and power telescopic steering column
*4: Only for models with power tilt and power telescopic steering column

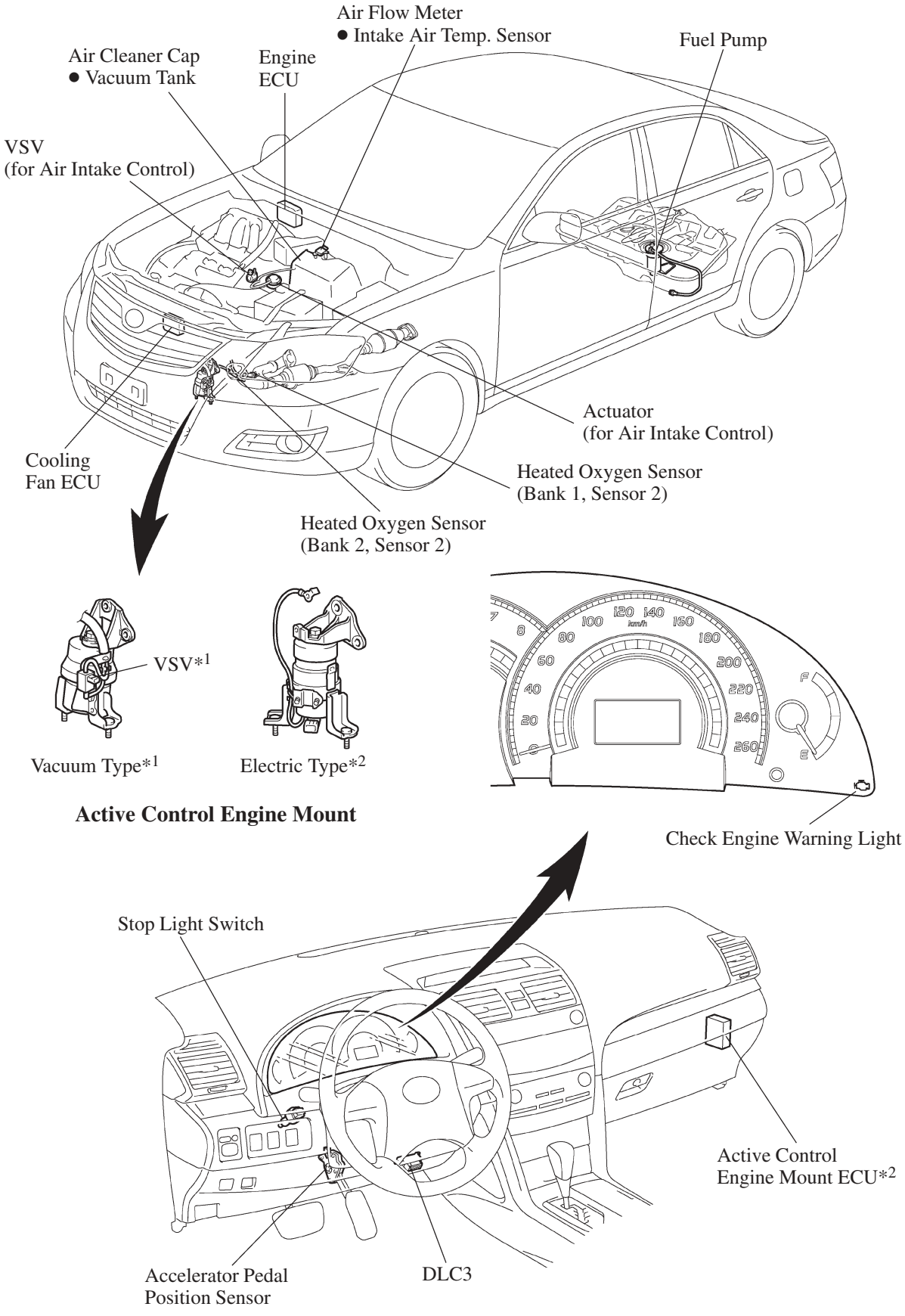
4. Layout of Main Components



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*1: Only for models without power tilt and power telescopic steering column

*2: Only for models with power tilt and power telescopic steering column

5. Main Component of Engine Control System

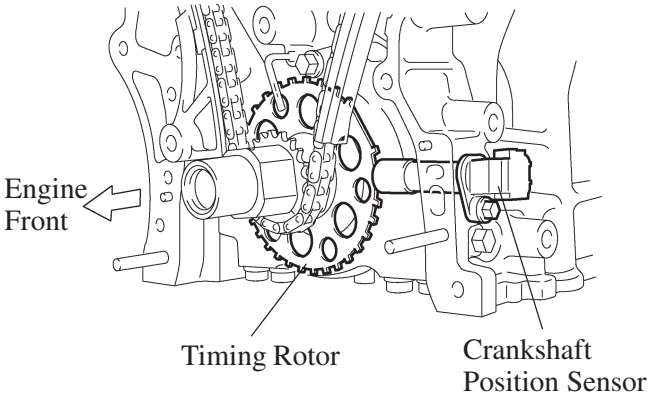
General

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

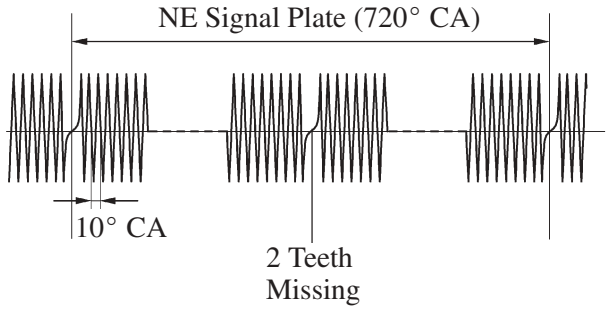
Components	Outline	Quantity	Function
Engine ECU	32-bit CPU	1	The engine ECU optimally controls the EFI ESA and ISC to suit the operating conditions of the engine in accordance with the signals provided by the sensors.
Oxygen Sensor (Bank 1, Sensor 2) (Bank 2, Sensor 2)	Cup Type with Heater	2	● This sensor 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 1AZ-FE and 2AZ-FE engines. For details, see page EG-46.
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 1AZ-FE and 2AZ-FE engines. For details, see page EG-46.
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 sensor are the same as in the 1AZ-FE and 2AZ-FE engines. For details, see page EG-40.
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 1AZ-FE and 2AZ-FE engines. For details, see page EG-43.
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 1AZ-FE and 2AZ-FE engines. For details, see page EG-42.
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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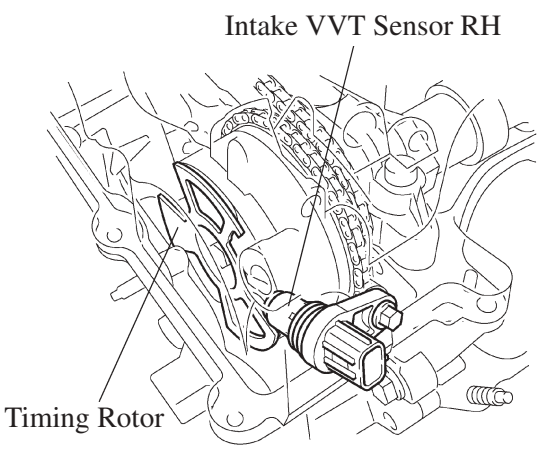


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Intake and Exhaust VVT Sensors

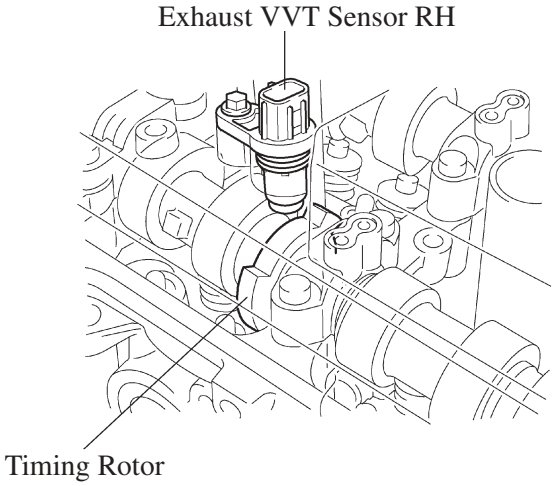
1) General

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)

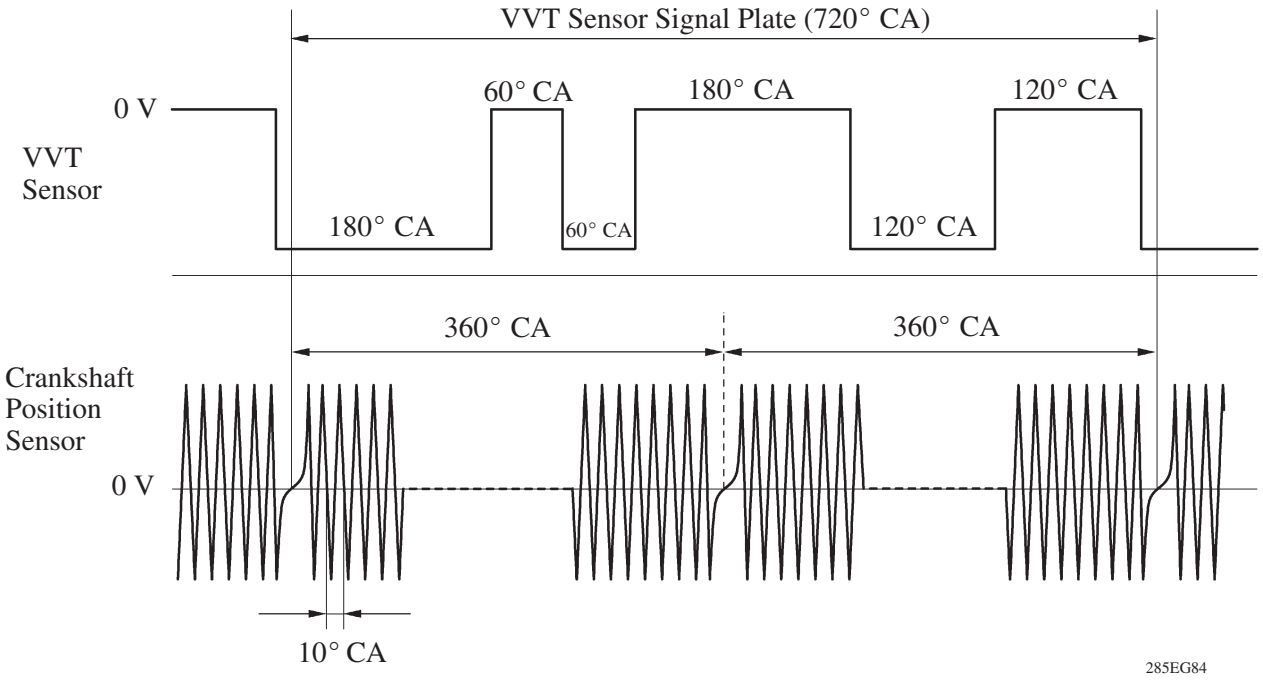
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Exhaust VVT Sensor (Right Bank)

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▶ Sensor Output Waveforms ◀

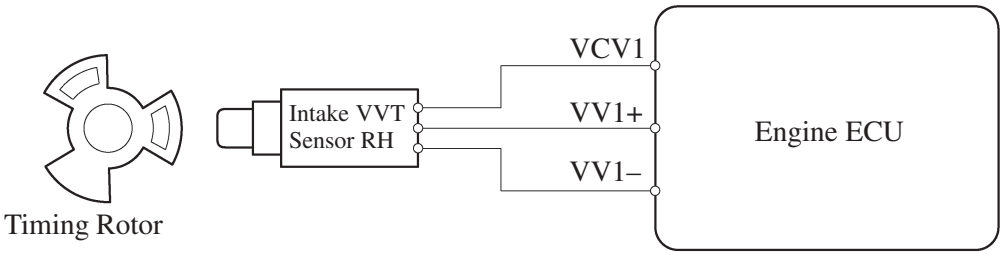


2) MRE Type VVT Sensor

- 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.

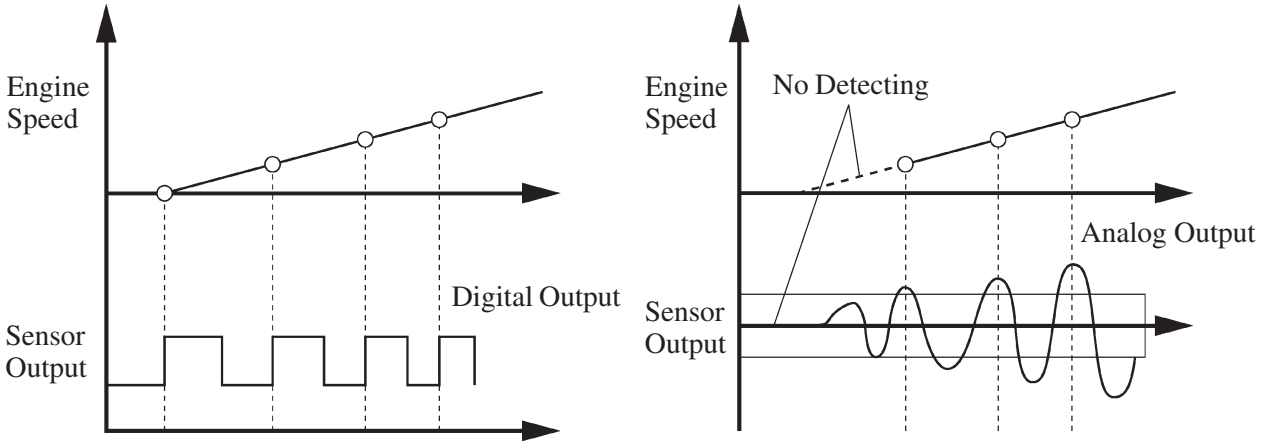
▶ Wiring Diagram ◀



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**

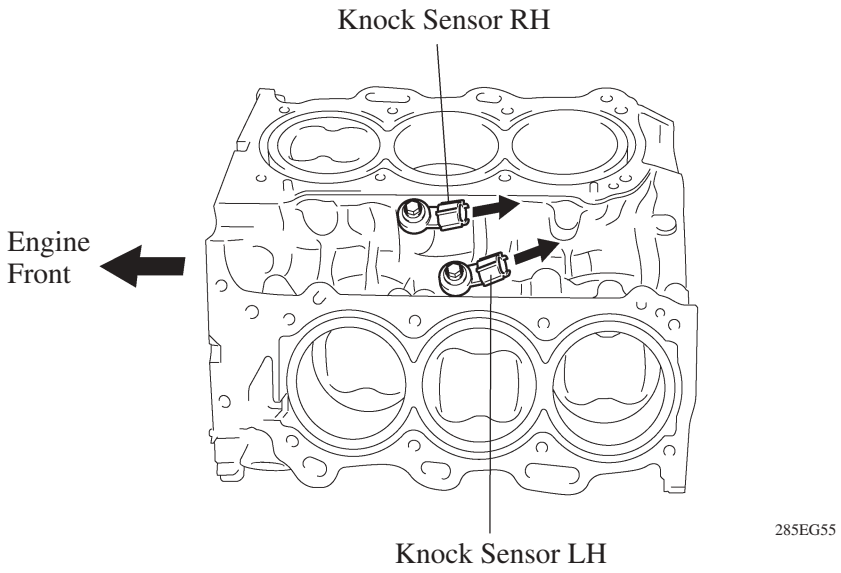
232CH41

Knock Sensor (Flat Type)

- 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.
- The basic construction and operation of this sensor are the same as in the 1AZ-FE and 2AZ-FE engines. For details, see page EG-44.

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.

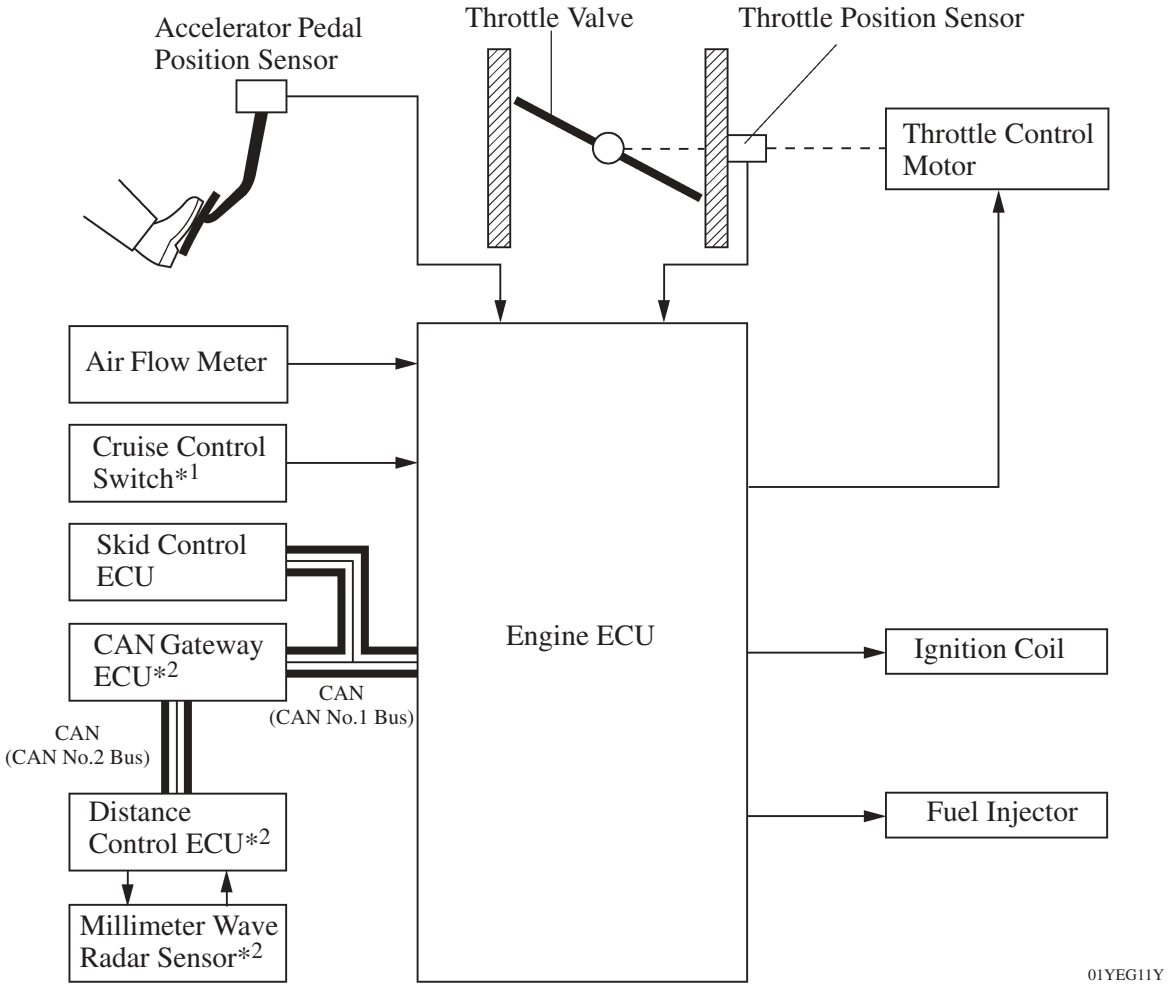


6. ETCS-i (Electronic Throttle Control System-intelligent)

General

- In the conventional throttle body, the throttle valve angle is determined invariably by the amount of the accelerator pedal effort. In contrast, ETCS-i uses the 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.
- In case of an abnormal condition, this system transfers to the limp mode. For details, see page EG-122.

▶ System Diagram ◀



*1: Only for models with cruise control system (conventional or dynamic radar type)
*2: Only for models with cruise control system (dynamic radar type)

Control

1) General

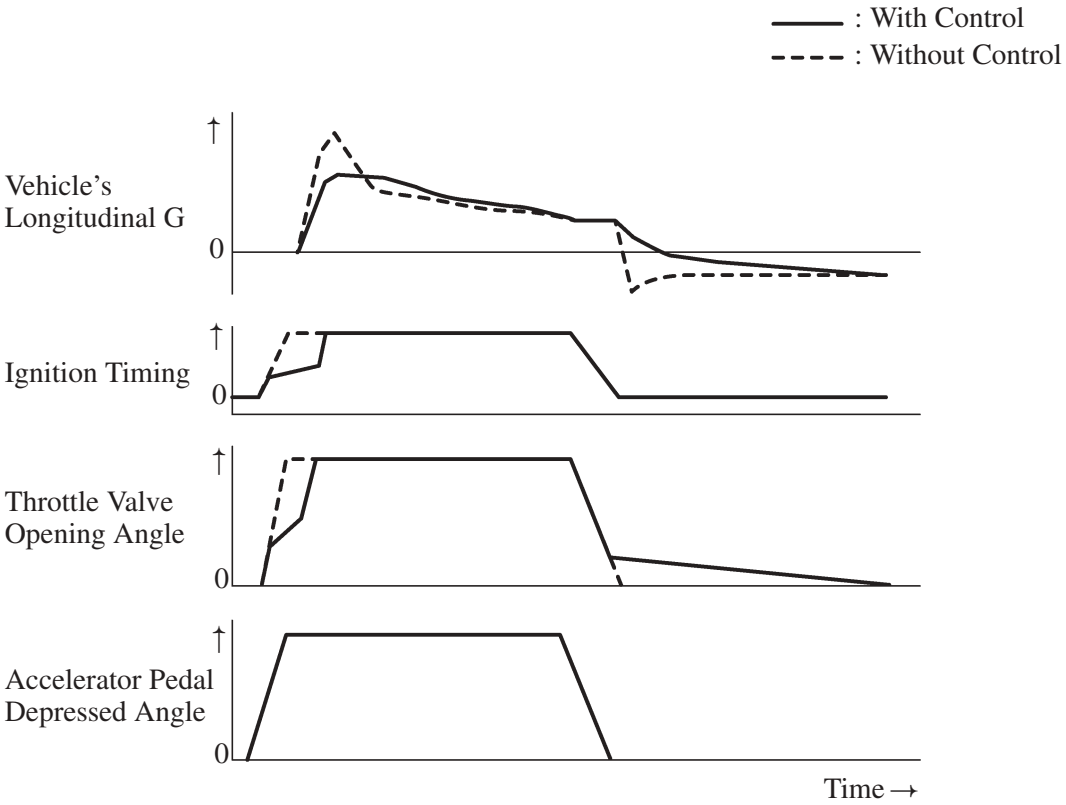
The ETCS-i consists of the following six functions:
- Normal Throttle Control (Non-linear Control)
- ISC (Idle Speed Control)
- TRC (Traction Control)
- VSC (Vehicle Stability Control)
- Cruise Control*1
- Dynamic Radar type Cruise Control*2

*1: Only for models with cruise control system (conventional or dynamic radar type)
*2: Only for models with cruise control system (dynamic radar type)

2) Normal Throttle Control (non-linear control)

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

▶ Conceptual Diagrams of Engine Control During Acceleration and Deceleration ◀



3) Idle Speed Control

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

4) 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, thus facilitating the vehicle in ensuring excellent vehicle stability and driving force.

5) VSC Coordination Control

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

6) Cruise Control

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

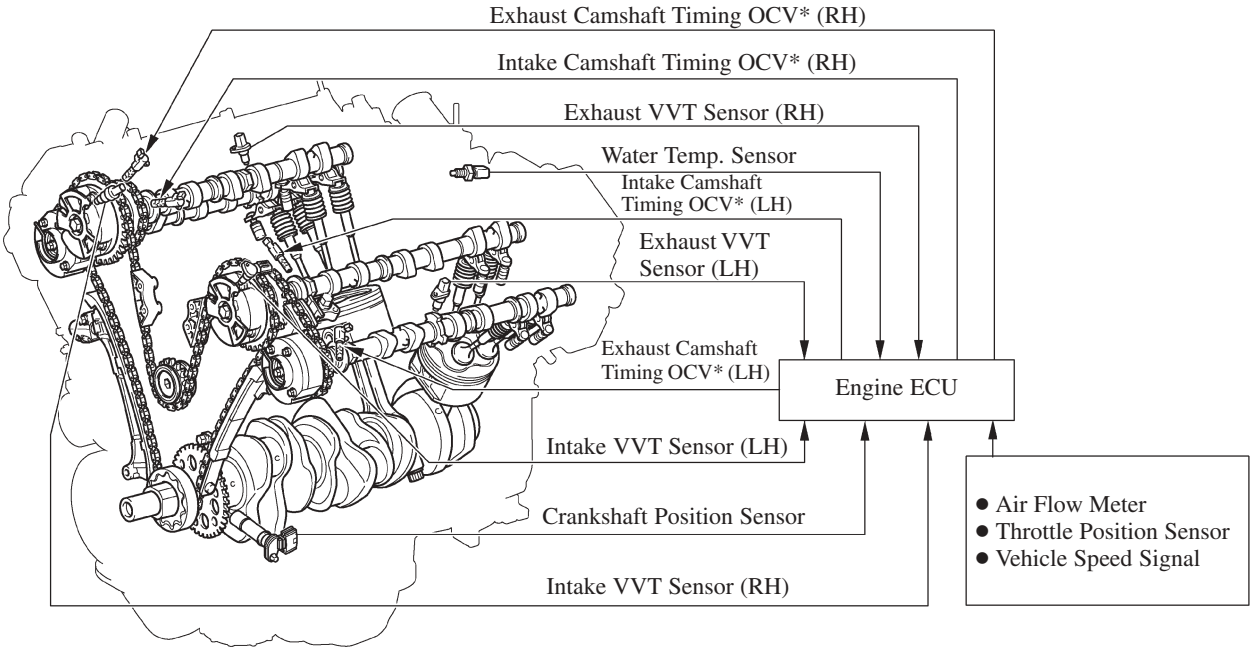
7) Dynamic Radar type Cruise Control

The dynamic radar type cruise control uses a millimeter wave radar sensor and distance control ECU to determine the distance of the vehicle driven ahead, its direction, and relative speed. Thus, the system can effect deceleration cruising control, follow up cruising control, cruising at a fixed speed control, and acceleration cruising control. To make these controls possible, the engine ECU controls the throttle valve.

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

General

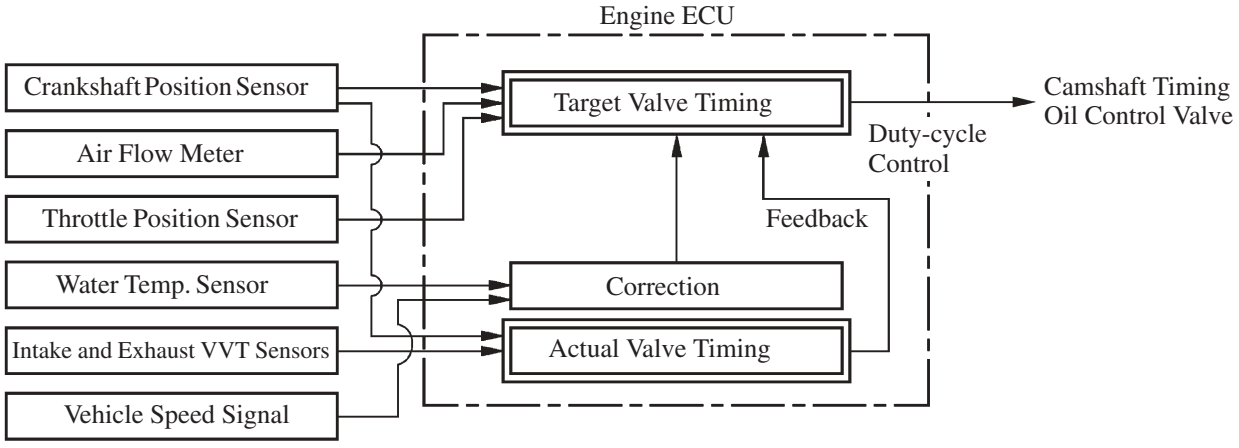
- The dual VVT-i system is designed to control the intake and exhaust camshafts within a range of 40° and 35° respectively (of Crankshaft Angle) to provide valve timing that is optimally suited to the engine condition. This improves torque in all the speed ranges as well as increasing fuel economy, and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



285EG57

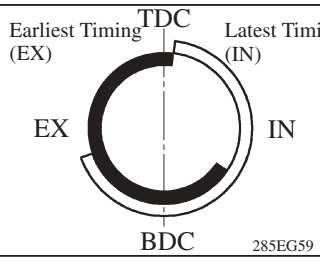
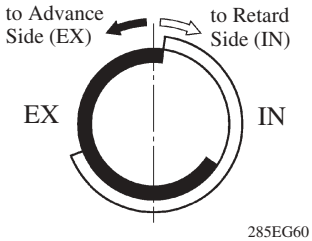
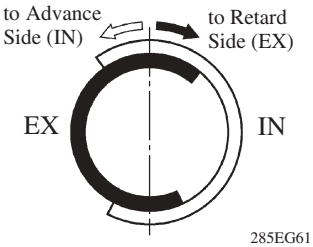
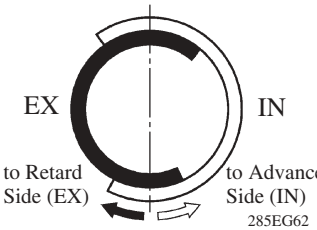
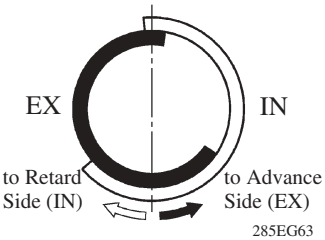
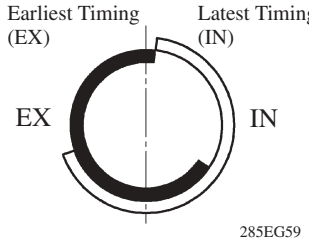
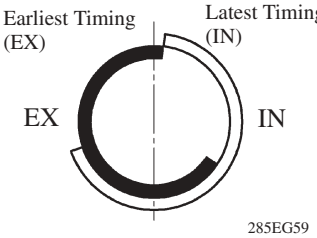
*: Oil Control Valve

- 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.



221EG16

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

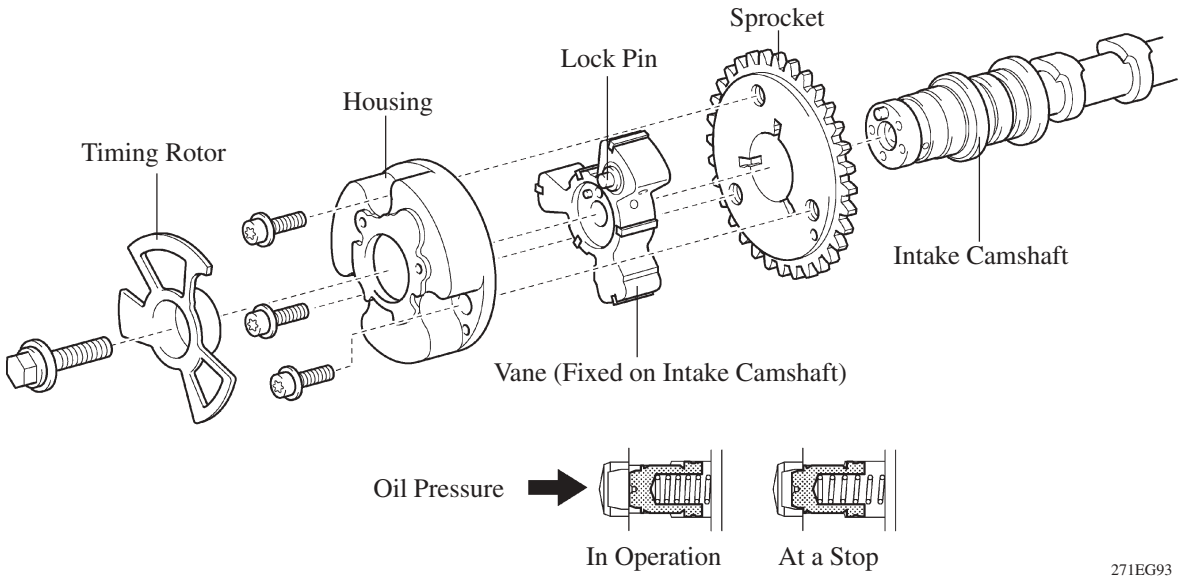
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Construction

1) VVT-i Controller

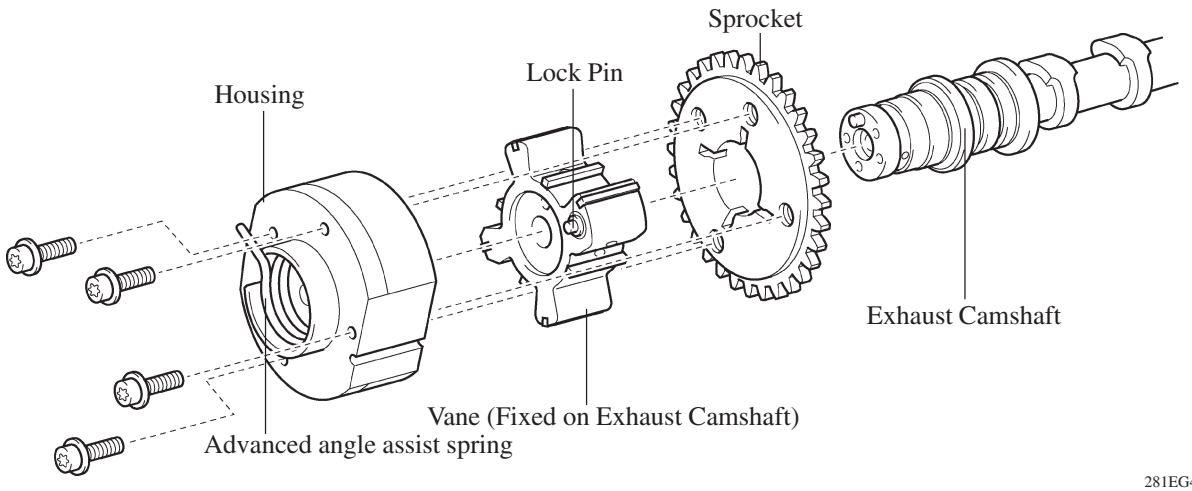
- This controller consists of the housing driven from the timing chain and the vane coupled with the intake and exhaust camshafts.
- The intake side has used a VVT-i controller with 3 vanes, and the exhaust side has used one with 4 vanes.
- When the engine stops, the intake side VVT-i controller is locked 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 ◀



Lock Pin

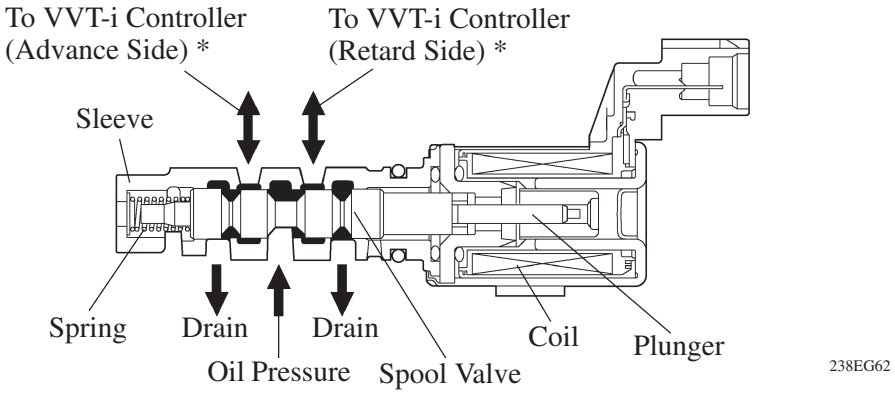
▶ Exhaust Side VVT-i Controller ◀



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 ◀



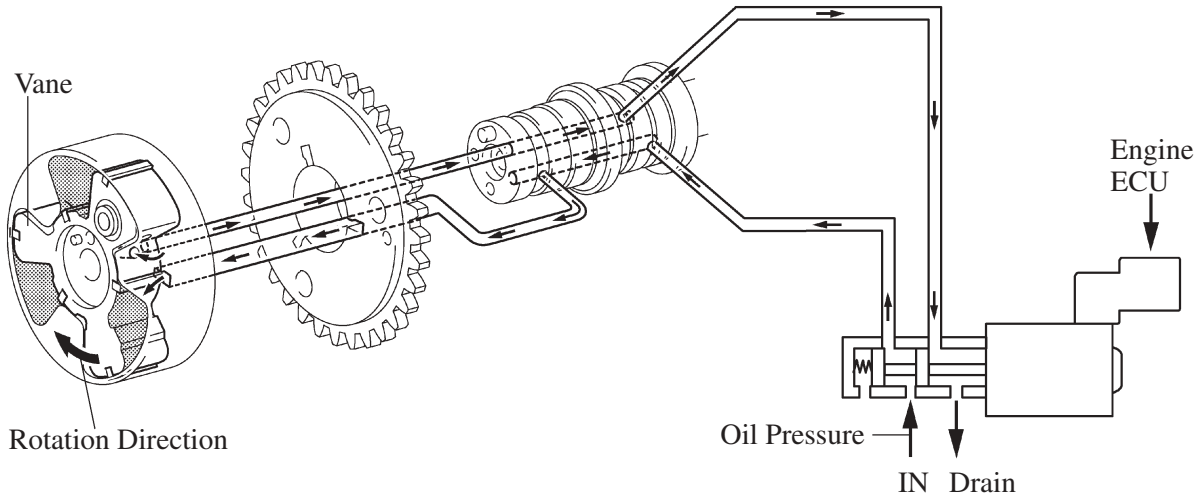
*: The advance and retard sides of the exhaust side oil control valve are reverse of the intake side.

Operation

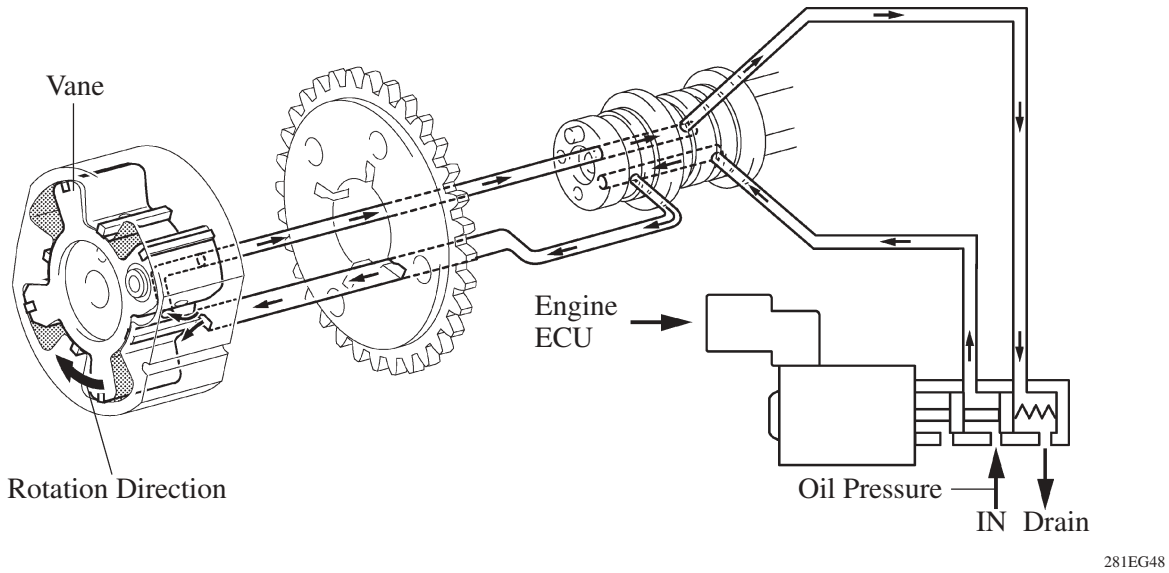
1) Advance

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 ◀



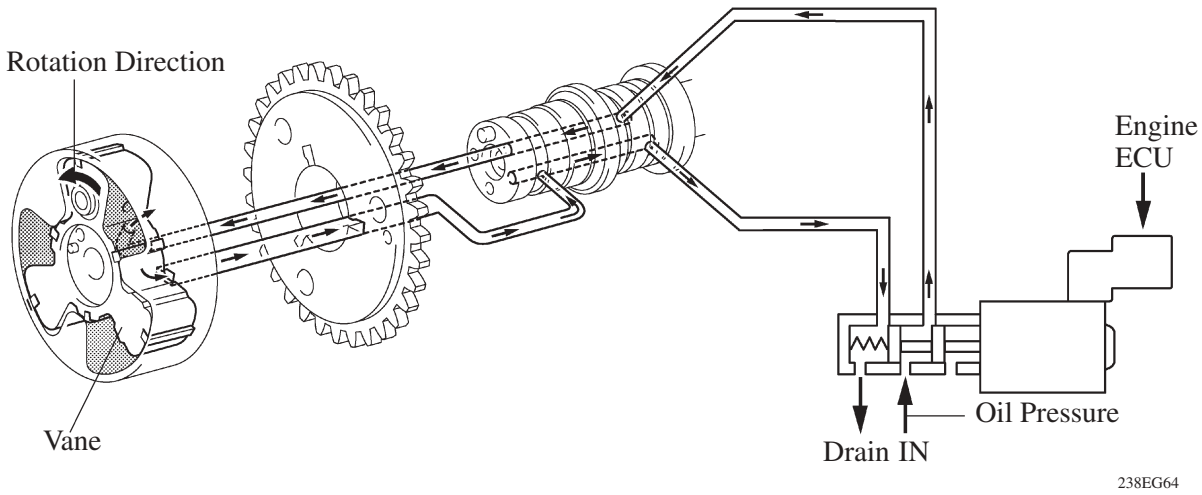
▶ Exhaust Side ◀



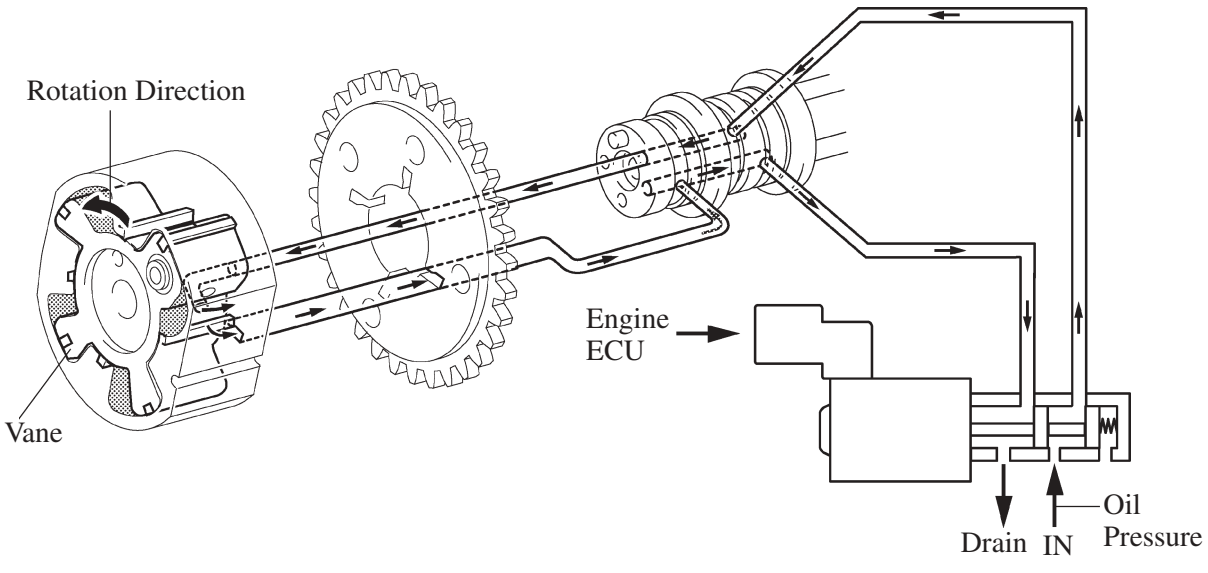
2) Retard

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

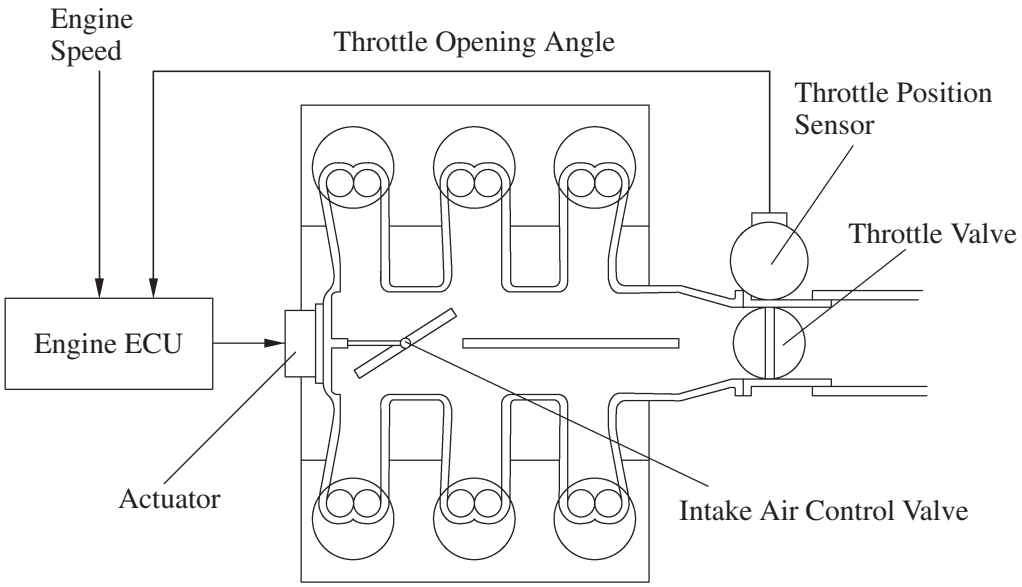
After reaching the target timing, the valve timing is held by keeping the camshaft timing oil control valve in the neutral position unless the traveling state changes.
This adjusts the valve timing at the desired target position and prevents the engine oil from running out when it is unnecessary.

8. 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 ◀



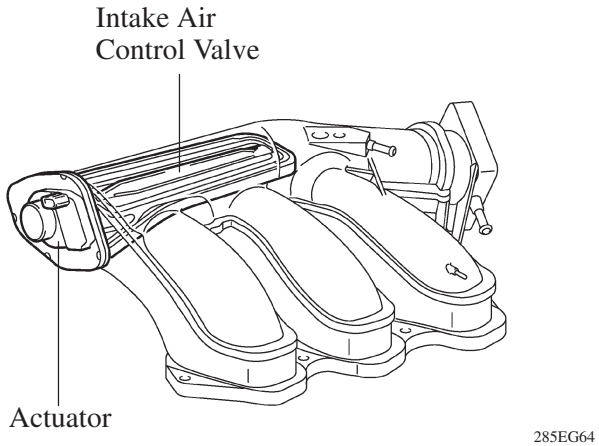
Construction

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)

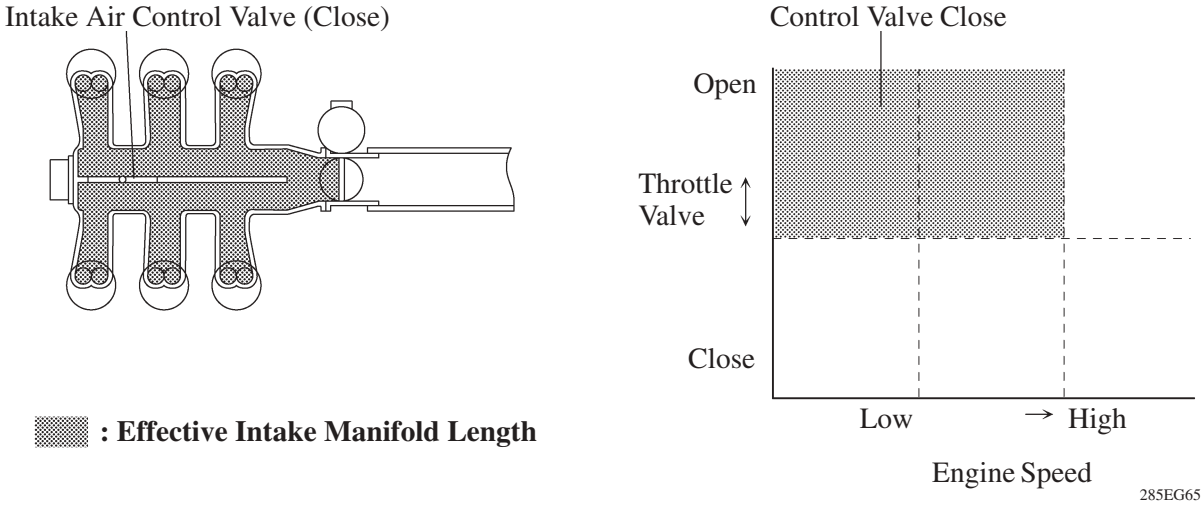
The actuator activates the intake air control valve based on signals from the engine ECU.



Operation

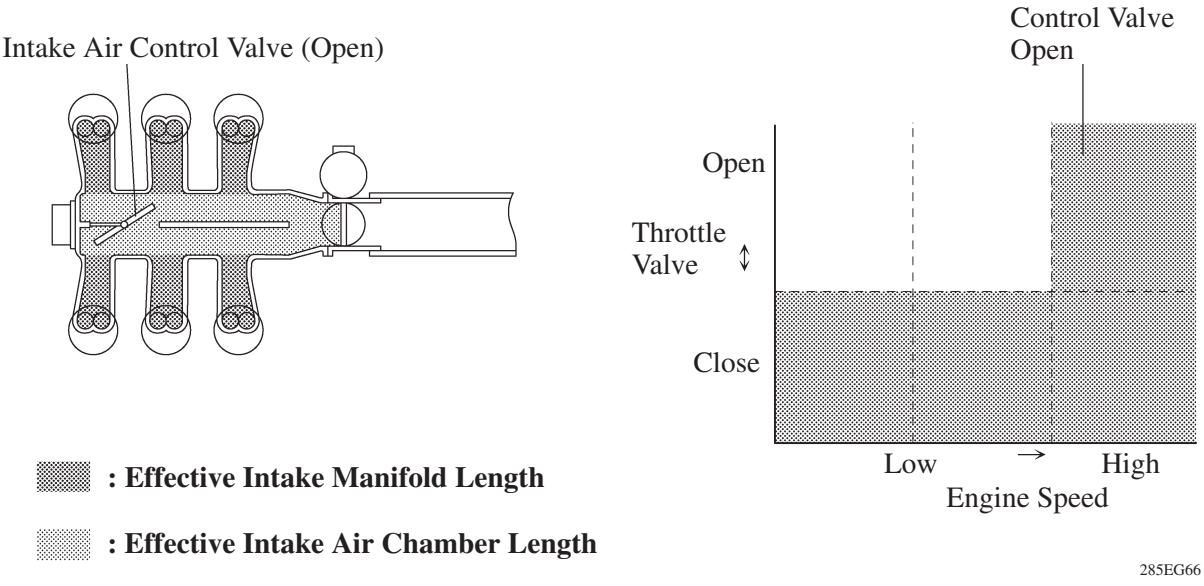
1) When the Intake Air Control Valve Closes

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.

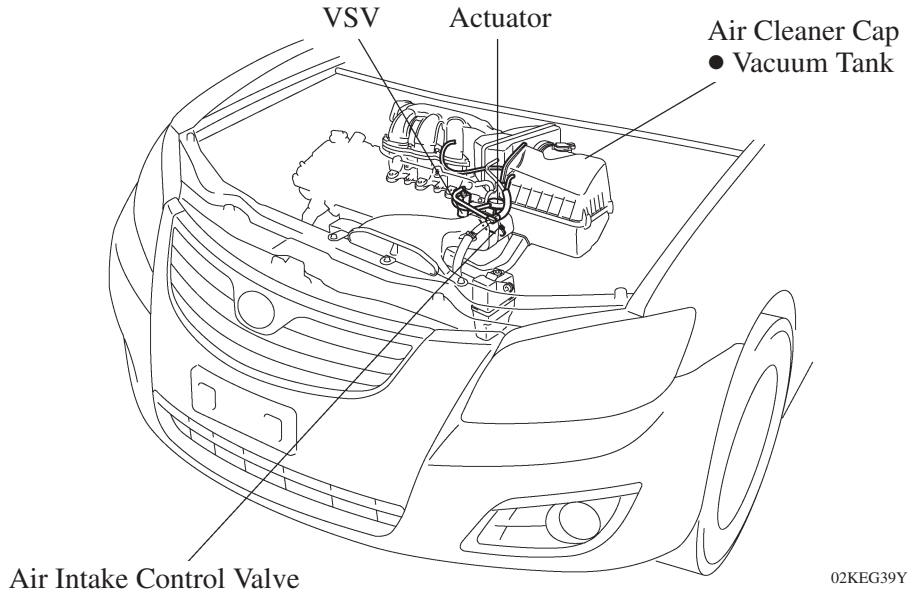


9. Air Intake Control System

General

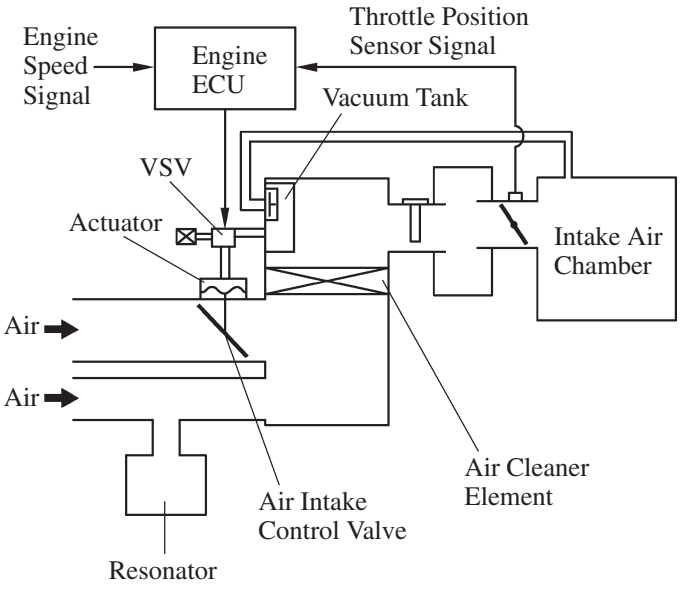
The system has a dual path design for air intake. An air intake control valve and actuator control the air flow path.
As a result, a reduction in intake noise in the low-speed range and an increase in the power output in the high-speed range is realized.

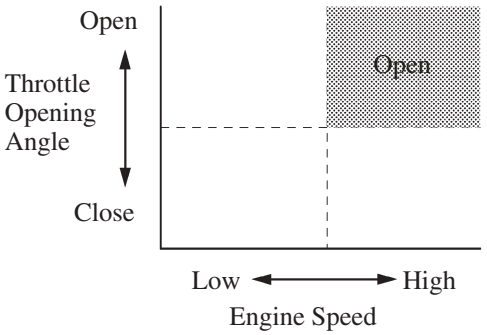
▶ Layout of Components ◀



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

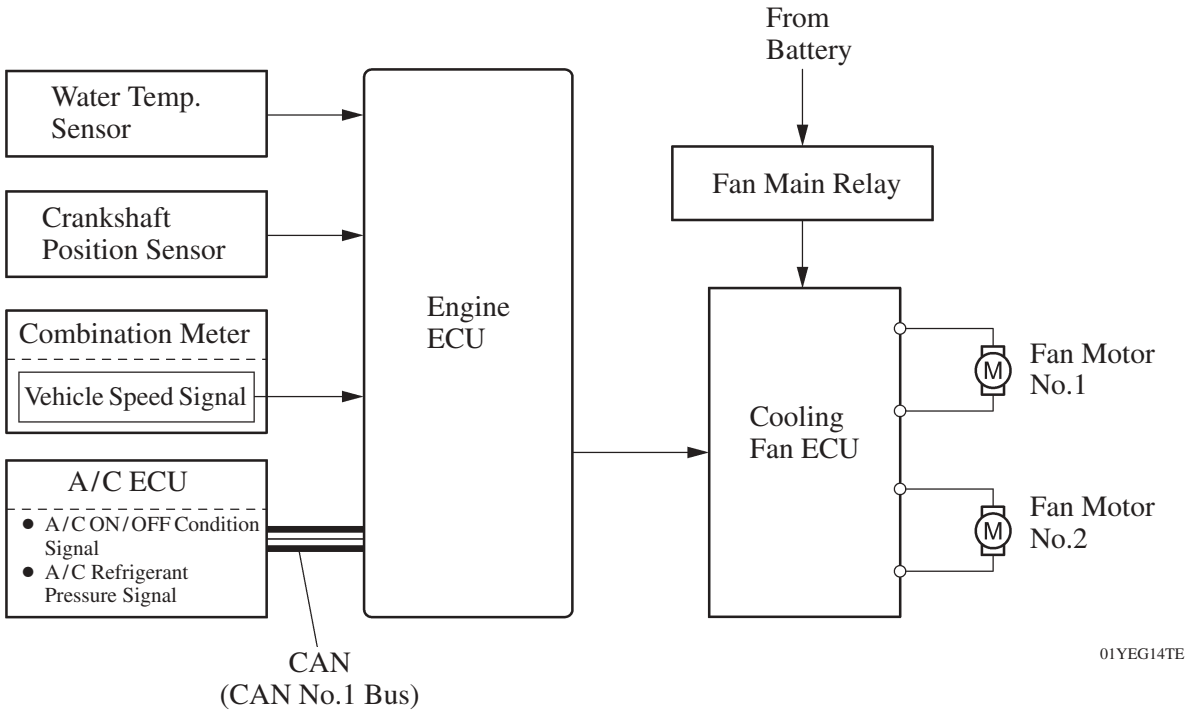
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10. Cooling Fan Control System

General

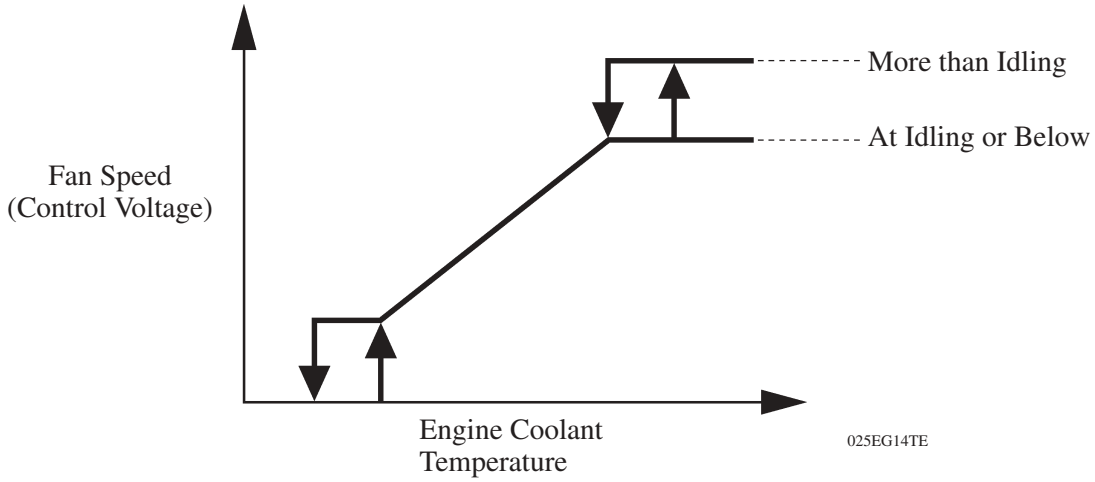
A cooling fan control system is used. To achieve an optimal fan speed in accordance with the engine coolant temperature, vehicle speed, engine speed, and air conditioner operating conditions, the engine ECU calculates the proper fan speed and sends the signals to the cooling fan ECU. Upon receiving the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

▶ Wiring Diagram ◀

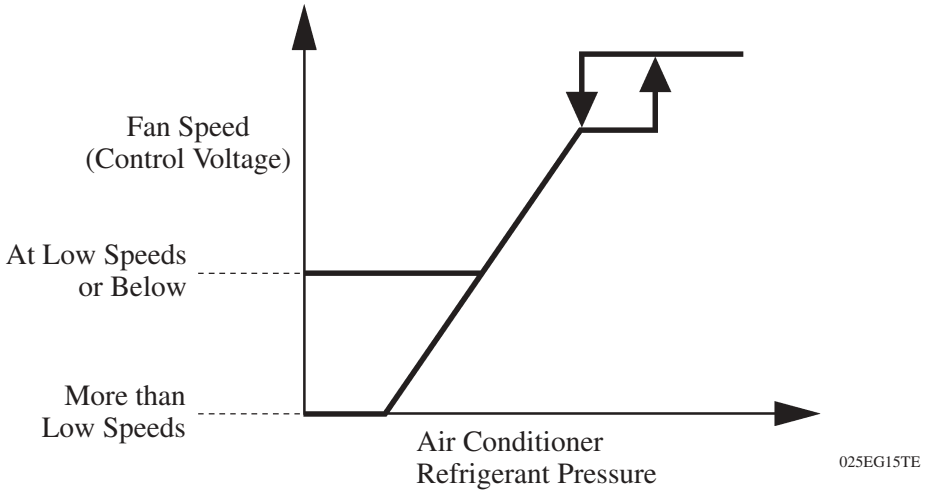


Operation

- 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.



11. 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.

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.
- 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.

12. Fail-Safe

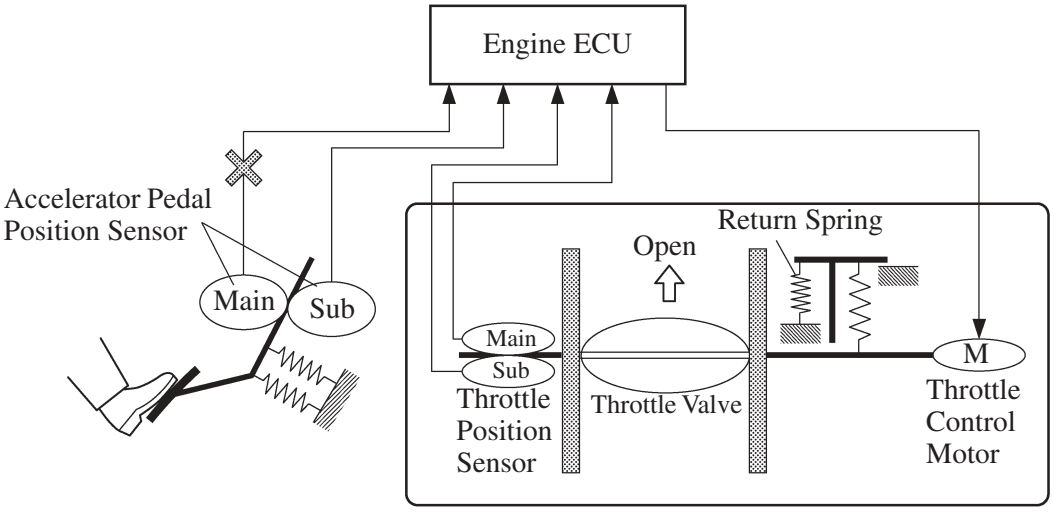
General

When a malfunction is detected at any of the sensors, there is a possibility of an engine or other malfunction occurring if the 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 Camry Repair Manual.

Fail-safe of Accelerator Pedal Position Sensor

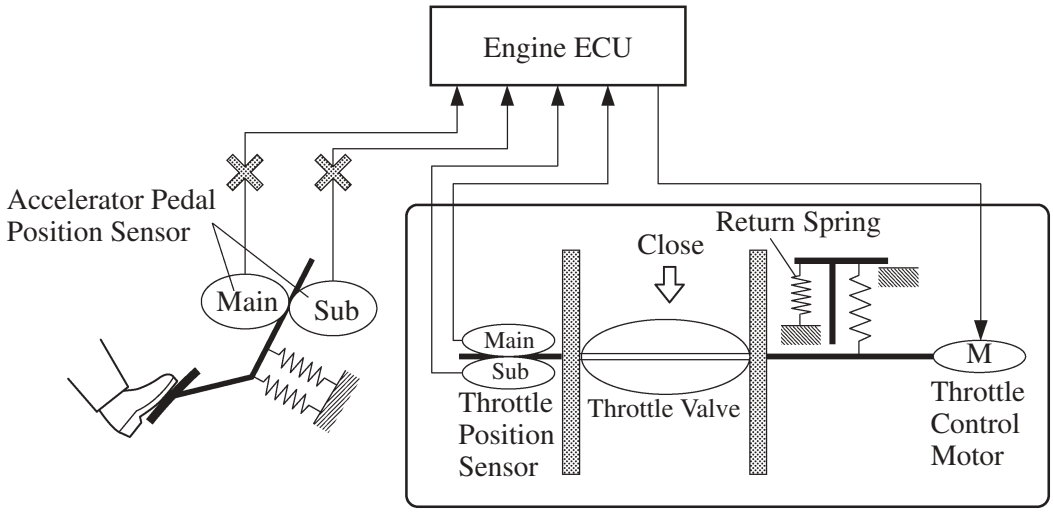
The accelerator pedal position sensor comprises two (Main, Sub) sensor circuits.

- 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.

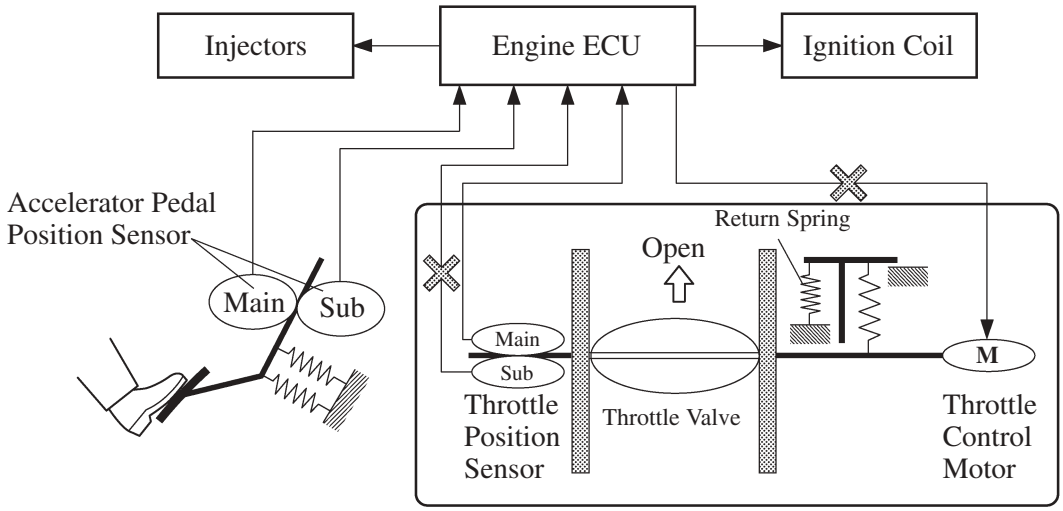


Throttle Body D13N09

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.



Throttle Body

D13N10