■ENGINE CONTROL SYSTEM

1. General

The engine control system of the 1KD-FTV engine has the following system.

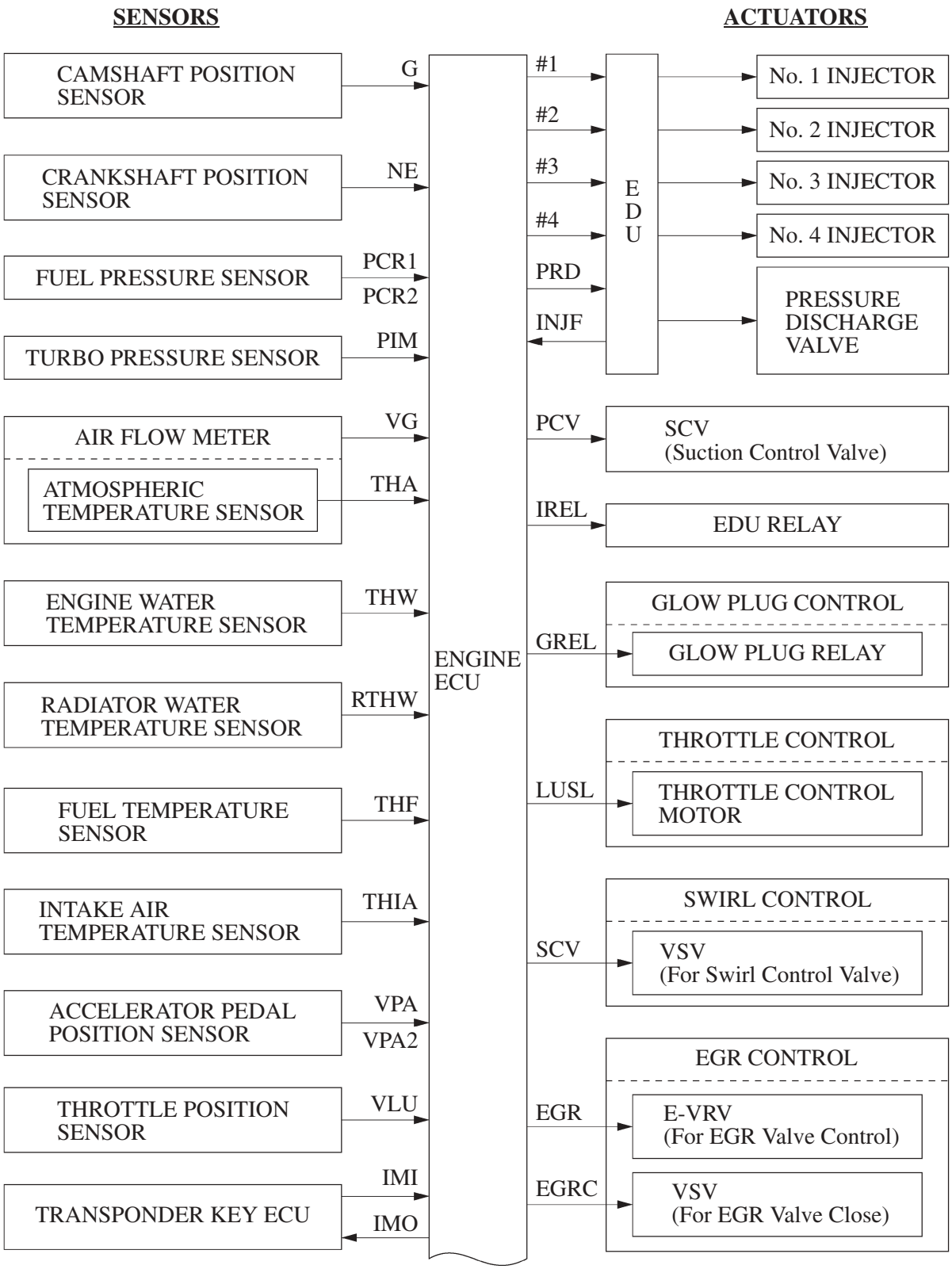
System	Outline	New Model	Previous Model
		1KD-FTV	2KD-FTV
Fuel Injection Volume Control (See page 66)	Based on the signals received from the sensors, the engine ECU determines the fuel injection volume in accordance with the engine condition.	○	○
Fuel Injection Timing Control (See page 67)	Based on the signals received from the sensors, the engine ECU determines the fuel injection timing in accordance with the engine condition.	○	○
Fuel Pressure Control (See page 68)	Based on the signals received from the sensors, the engine ECU controls fuel pressure using the SCV (Suction Control Valve) and pressure discharge valve according to the engine condition.	○	—
	Based on the signals received from the sensors, the engine ECU controls fuel pressure using the SCV according to the engine condition.	—	○
Pilot Injection Control (See page 69)	Based on the signals received from the sensors, the engine ECU determines pilot injection volume/timing, and interval (between pilot injection and main injection) in accordance with the engine condition.	○	○
During Starting Control (See page 70)	To facilitate startability, the engine ECU optimally controls the injection volume and injection timing during starting.	○	○
Idle Speed Control (See page 71)	The engine ECU determines the idle speed in accordance with the engine condition, and controls the fuel injection volume in order to maintain the target idle speed.	○	○
Glow Plug Control	Controls the length of time when the current is applied to the glow plugs, in accordance with the engine water temperature.	○	○
Throttle Control (See page 72)	Based on the signals received from the various sensors, the engine ECU determines throttle valve position in accordance with the engine condition.	○	○
	Fully closes the throttle valve in order to reduce the vibration when the engine is stopped.	○	○
Swirl Control (See page 72)	Based on the signals received from the sensors, the engine ECU controls the vacuum that is directed to the actuator via the VSV, in order to open and close the valve.	○	—
Turbocharger Control (See page 73)	Based on the signals received from the sensors, the engine ECU controls the actuator in accordance with the engine condition.	○	—

(Continued)

System	Outline	New Model	Previous Model
		1KD-FTV	2KD-FTV
EGR Control (See page 78)	Based on the signals received from the sensors, the engine ECU determines the EGR volume via EGR valve and throttle valve in accordance with the engine condition.	○	○
Cooling Fan Control (See page 79)	The engine ECU steplessly controls the cooling fan speeds in accordance with the radiator water temperature, engine speed, vehicle speed and air conditioner operating conditions. As a result, the cooling performance has been improved.	○	○
Diagnosis (See page 81)	When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section.	○	○
Fail-safe (See page 81)	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in the memory.	○	○

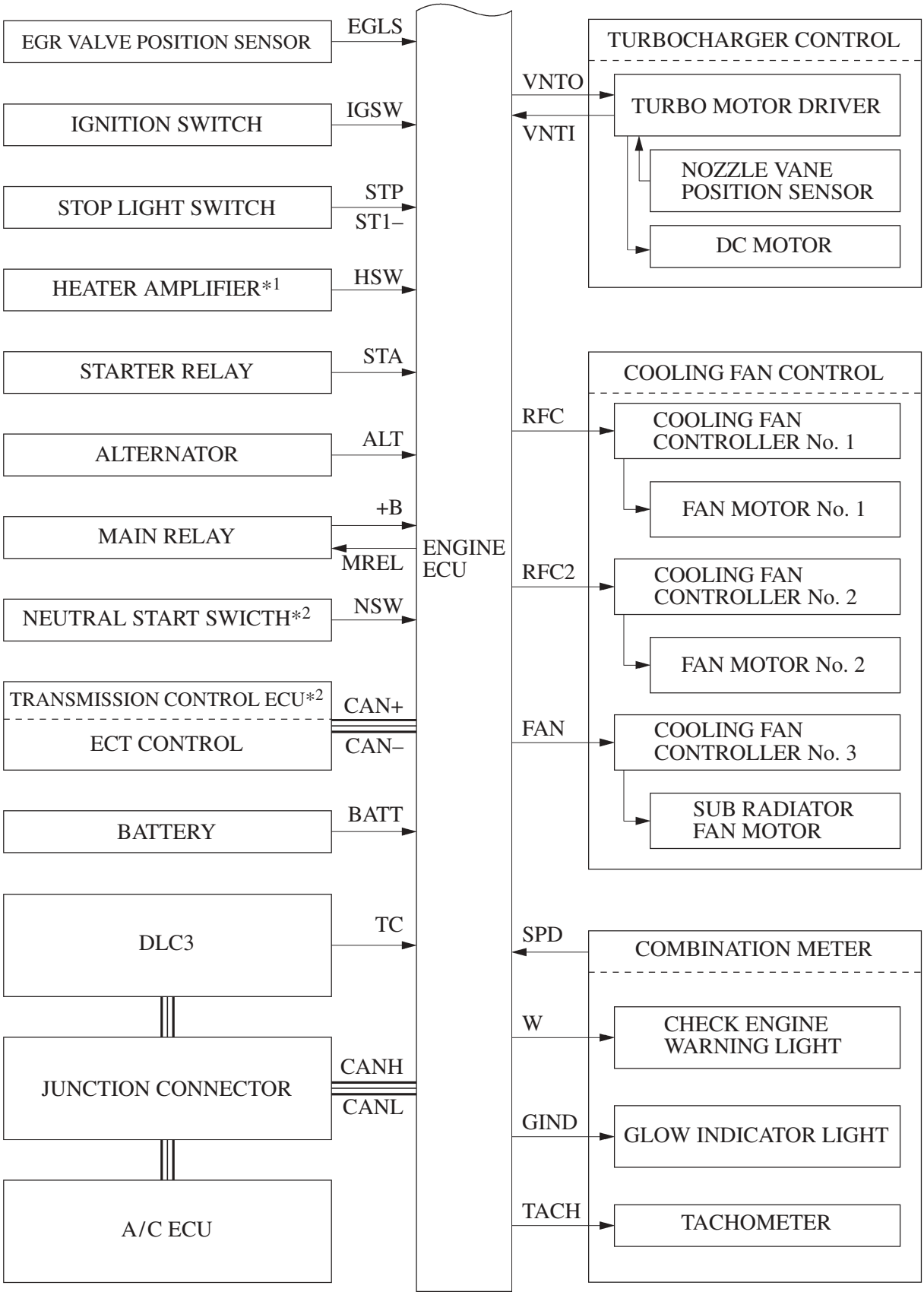
2. Construction

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



(Continued)

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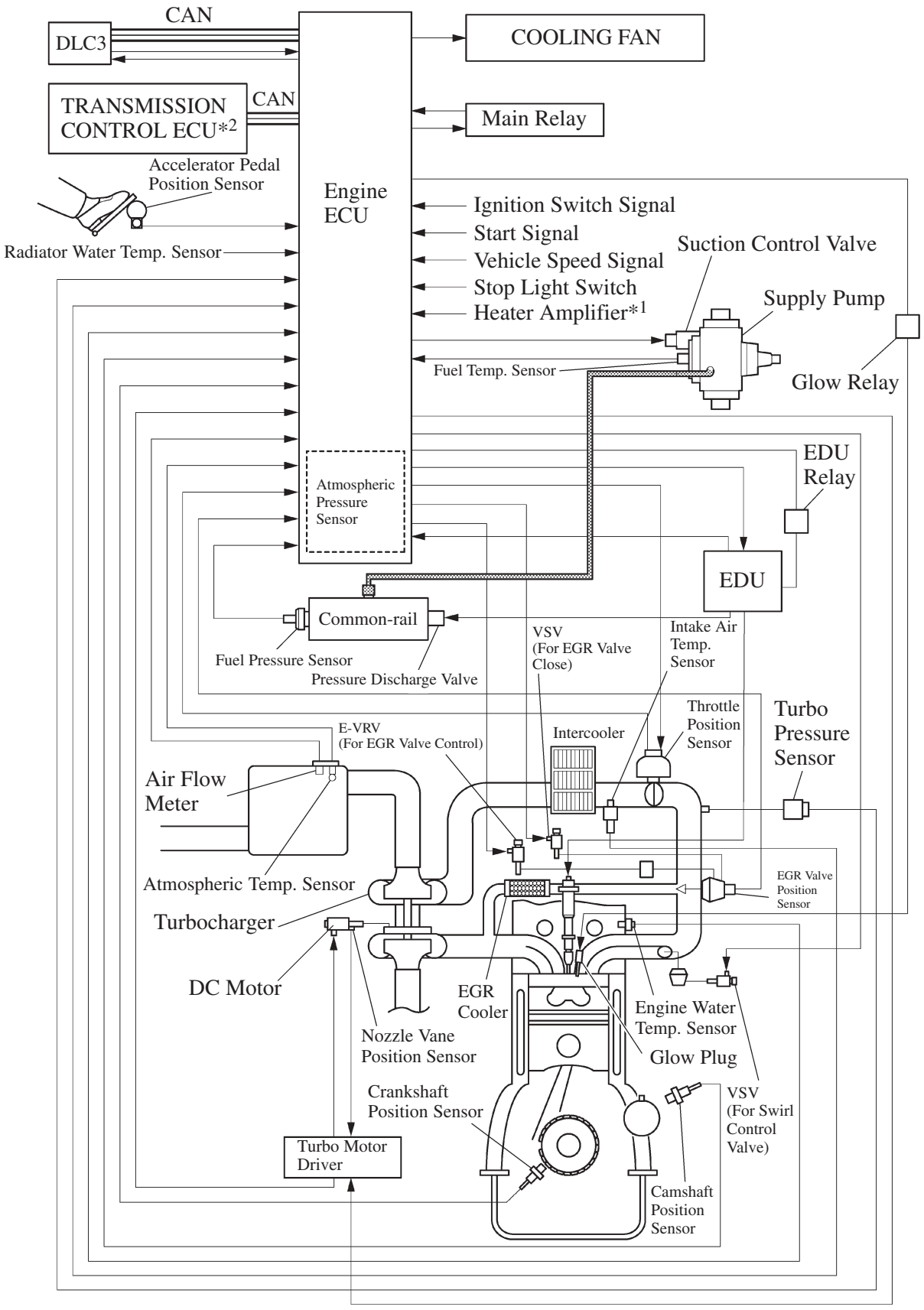


*1: Except Singapore Models

*2: Only for Models with Automatic Transmission

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3. Engine Control System Diagram

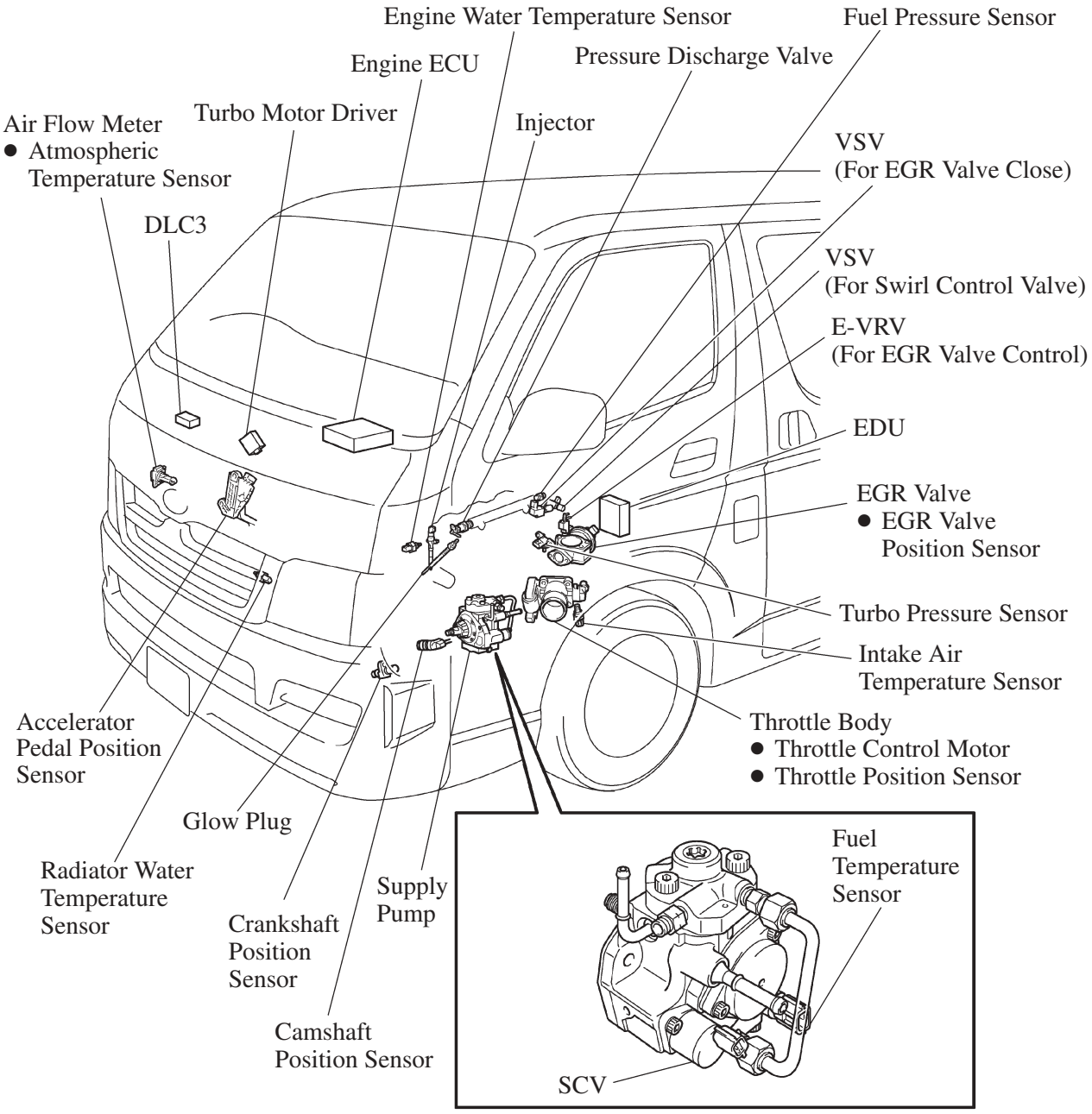


*1: Except Singapore Models

*2: Only for Models with Automatic Transmission

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4. Layout of Main Components



04ZEG027Y

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5. Main Components of Engine Control System

General

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

Components	Outline	Quantity	Function
Engine ECU	32-bit CPU	1	The engine ECU effects overall control of the engine control system to suit the operating conditions of the engine in accordance with the signals provided by the sensors.
EDU	DC/DC Converter	1	The EDU is used to drive the injector at high speeds. The EDU has realized high-speed driving under high fuel pressure conditions through the use of a DC/DC converter that provides a high voltage, quick-charging system.
Turbo Pressure Sensor	Semiconductor Silicon Chip Type	1	This sensor uses built-in semiconductors to detect the intake manifold pressure.
Atmospheric Pressure Sensor	Semiconductor Silicon Chip Type	1	This sensor, which is built into the engine ECU, uses semiconductors to detect the atmospheric pressure.
Fuel Pressure Sensor	Semiconductor Strain Gauge Type	1	This sensor uses built-in semiconductors to detect the internal pressure of the common-rail.
Crankshaft Position Sensor	Pick-up Coil Type (Rotor Teeth/36-2)	1	This sensor detects the engine speed and performs the cylinder identification.
Camshaft Position Sensor	Pick-up Coil Type (Rotor Teeth/5)	1	This sensor performs the cylinder identification.
Air Flow Meter	Hot-wire Type	1	This sensor uses a built-in hot-wire to directly detect the intake air mass and flow rate.
Atmospheric Temperature Sensor	Thermistor Type	1	● This sensor, which is provided at the air cleaner outlet, detects the atmospheric temperature by means of an internal thermistor. ● This sensor is built into the airflow meter.
Engine Water Temperature Sensor	Thermistor Type	1	This sensor detects the engine water temperature by means of an internal thermistor.
Radiator Water Temperature Sensor	Thermistor Type	1	This sensor detects the water temperature at the radiator outlet by means of an internal thermistor.
Intake Air Temperature Sensor	Thermistor Type	1	This sensor detects the intake air temperature after the intercooler.

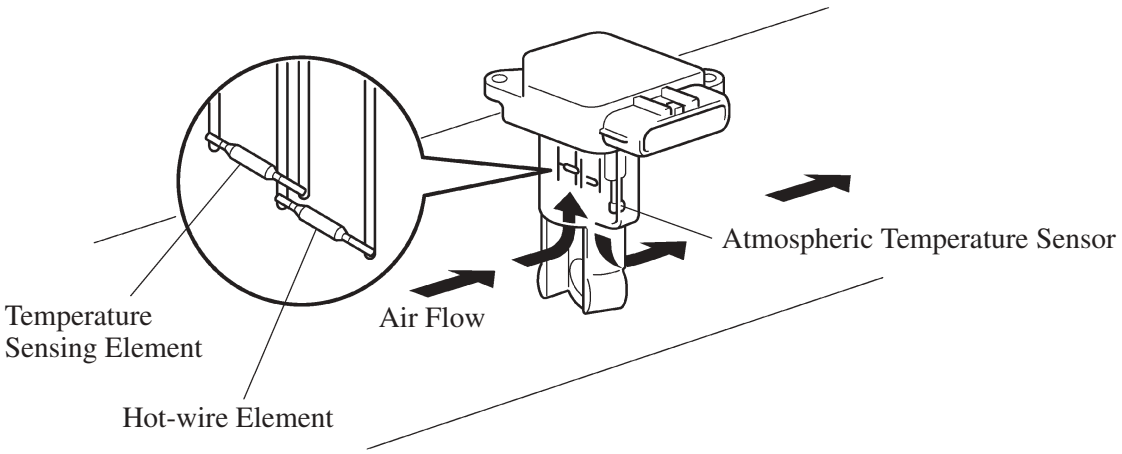
(Continued)

Components	Outline	Quantity	Function
Fuel Temperature Sensor	Thermistor Type	1	This sensor detects the fuel temperature in the supply pump by means of an internal thermistor.
Throttle Position Sensor	Non-contact Type	1	This sensor detects the throttle valve opening angle.
Accelerator Pedal Position Sensor	Contact Type	1	This sensor detects the amount of pedal effort applied to the accelerator pedal.
EGR Valve Position Sensor	Contact Type	1	This sensor detects the actual amount of the EGR valve opening.
SCV (Suction Control Valve)	Linear Solenoid Valve	1	The SCV position is controlled by the signals from the engine ECU, and a fuel volume that suits the SCV position is drawn into the pumping portion (plunger portion).
Injector	8-hole Type	4	The injector contains a solenoid valve that opens and closes to increase or decrease the pressure in the control chamber. This causes the nozzle needle to open and close the valve, which results in fuel injection.

Air Flow Meter

The air flow meter of diesel engine uses precise fuel injection volume control and EGR control to realize clean emission.

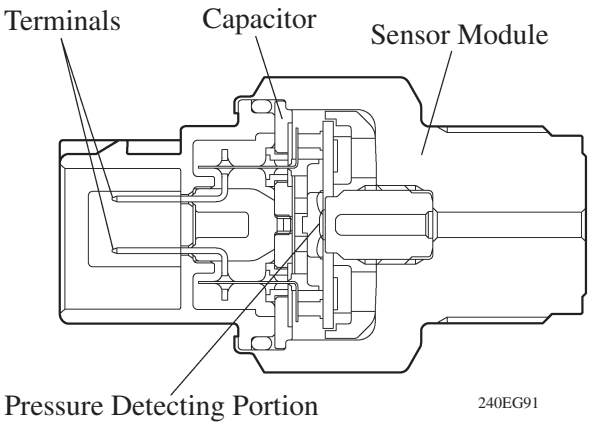
- The plug-in type air flow meter is used, and this allows a portion of the intake air to flow through the detection area. By directly measuring the mass and the flow rate of the intake air, the detection precision is ensured and the intake air resistance is reduced.
- The air flow meter has a built-in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



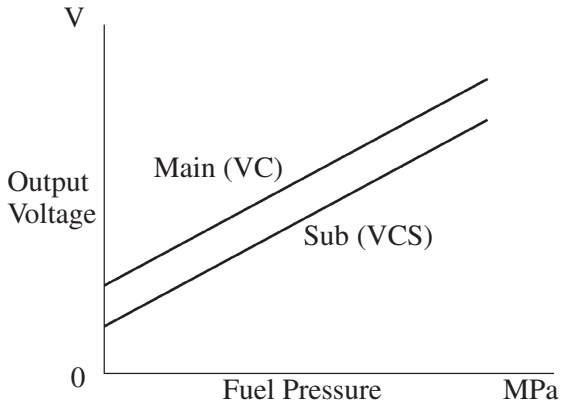
204EG54

Fuel Pressure Sensor

- The fuel pressure sensor, which is mounted on the common-rail, outputs a signal that represents the fuel pressure in the common-rail to the engine ECU in order to constantly regulate the fuel at an optimal pressure.
- The fuel pressure sensor contains two circuits (main and sub), which enable the engine ECU to constantly compare the values detected by the two circuits. As a result, highly precise values can be detected, which also enable a higher level of fail-safe control.



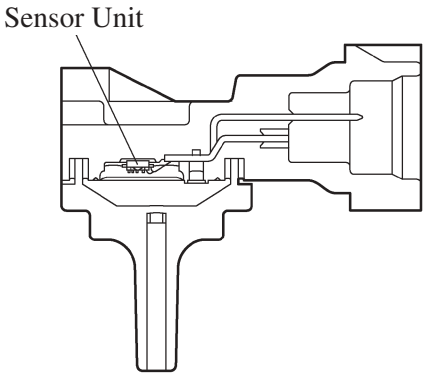
▶ Output Characteristic ◀



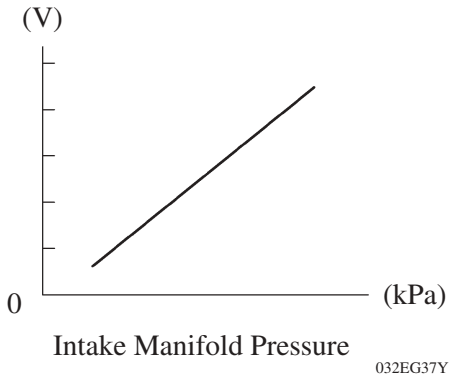
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Turbo Pressure Sensor

The turbo pressure sensor consists of a semiconductor which utilizes the characteristic of a silicon chip that changes its electrical resistance when pressure is applied to it. The sensor converts the intake air pressure into an electrical signal, and sends it to the engine ECU in an amplified form.



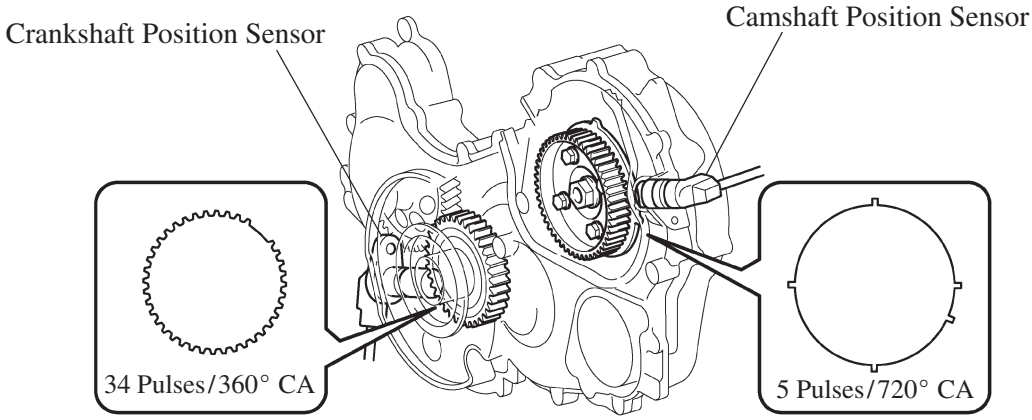
▶ Output Characteristic ◀



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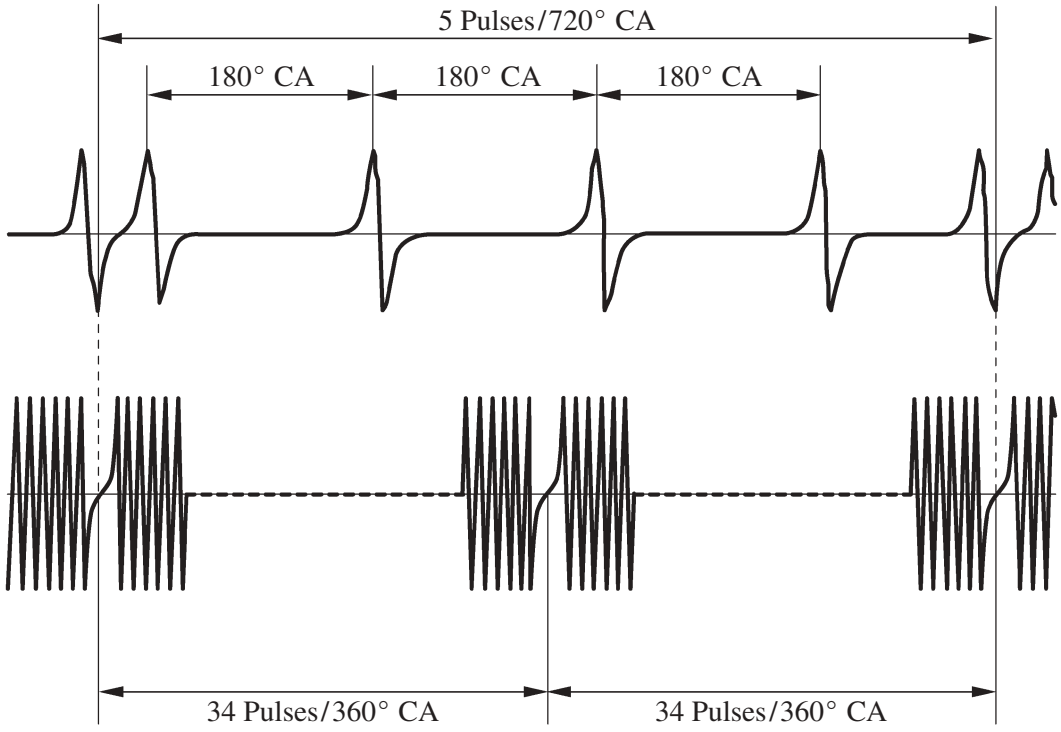
Crankshaft Position Sensor and Camshaft Position Sensor

- 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.
- To detect the camshaft position, a protrusion that is provided on the timing pulley is used to generate 5 pulses for every 2 revolutions of the crankshaft.



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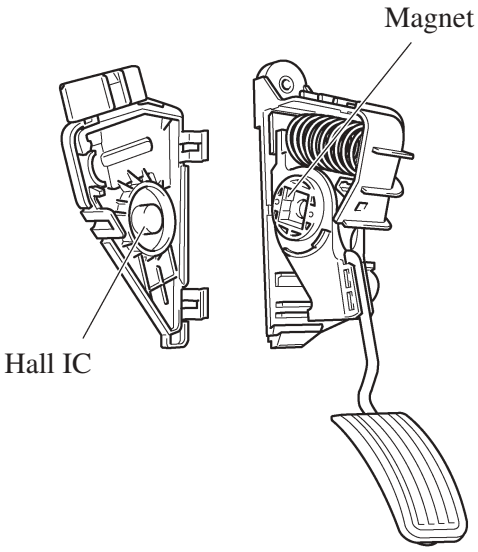
▶ Output Waveforms ◀



271EG138

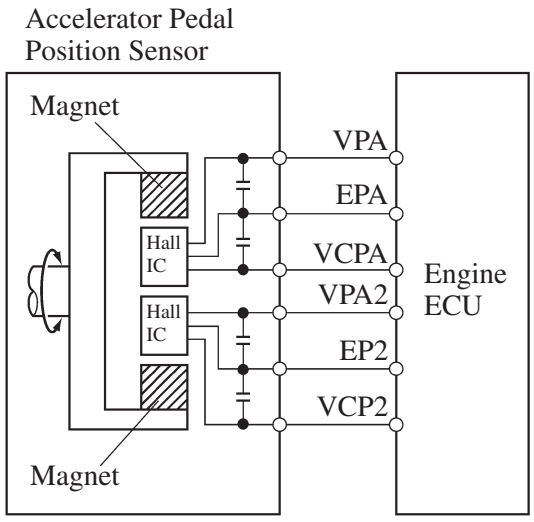
Accelerator Pedal Position Sensor

The accelerator pedal position sensor converts the acceleration pedal depressing angles into electrical signals with two differing characteristics and outputs them to the engine ECU. One is the VPA signal that linearly outputs the voltage along the entire range of the accelerator pedal depressed angle. The other is the VPA2 signal that outputs an offset voltage.



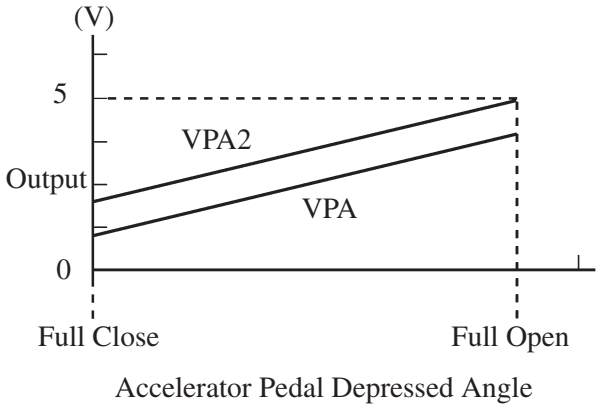
286EG12

▶ System Diagram ◀



228TU24

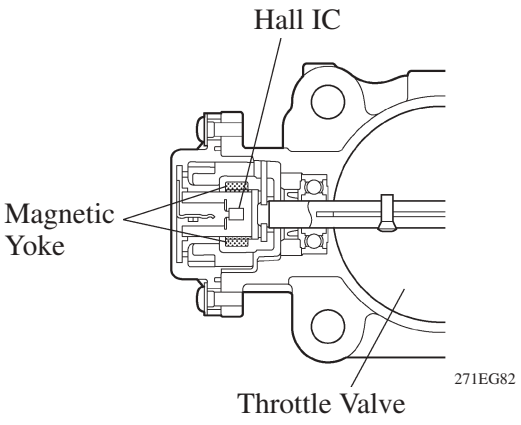
▶ Output Characteristic ◀



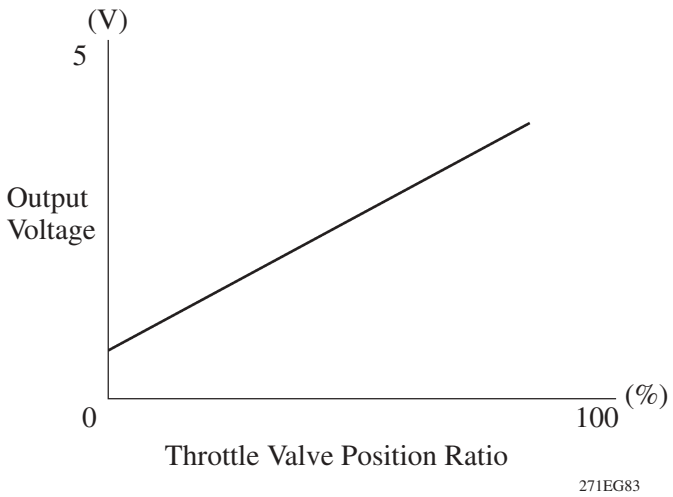
228TU25

Throttle Position Sensor

The throttle position sensor is mounted on the throttle body, to detect the opening angle of the throttle valve. The throttle position sensor converts the magnetic flux density that changes when the magnetic yoke (located on the same axis as that of the throttle valve shaft) rotates around the Hall IC into electric signals to operate the throttle control motor.



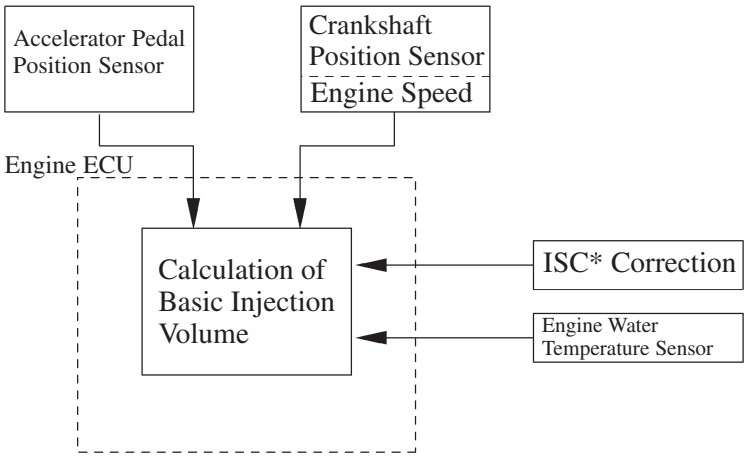
▶ Output Characteristic ◀



6. Fuel Injection Volume Control

The engine ECU calculates two types of values: the basic injection volume and the maximum injection volume. Then, the engine ECU compares the basic and maximum injection volumes, and determines a smaller calculated value to be the final injection volume.

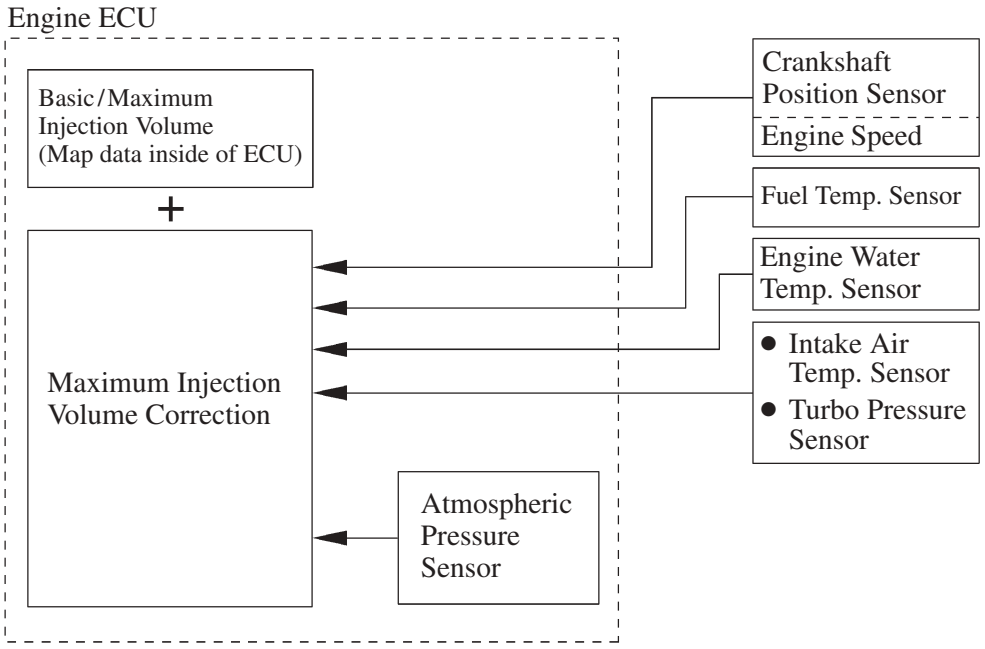
▶ Basic Injection Volume ◀



*: Idle Speed Control

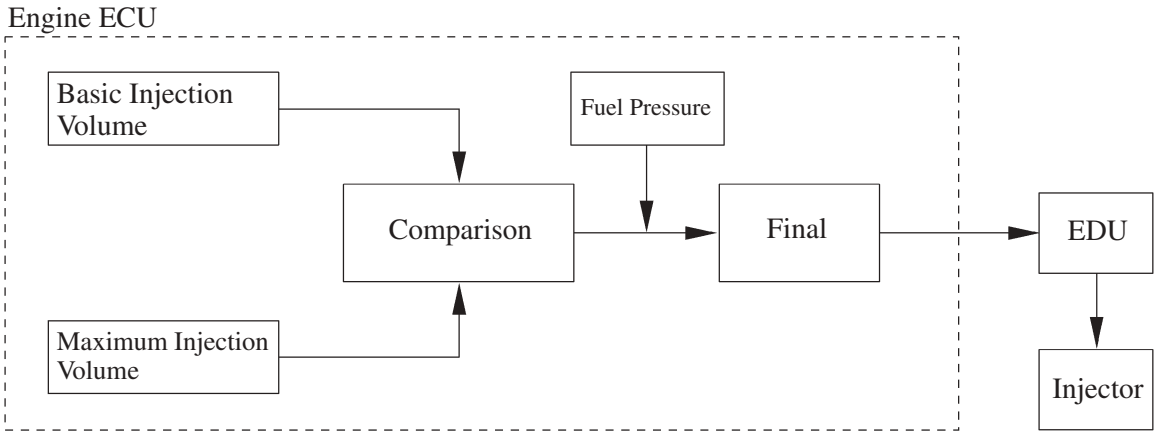
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▶ Maximum Injection Volume ◀



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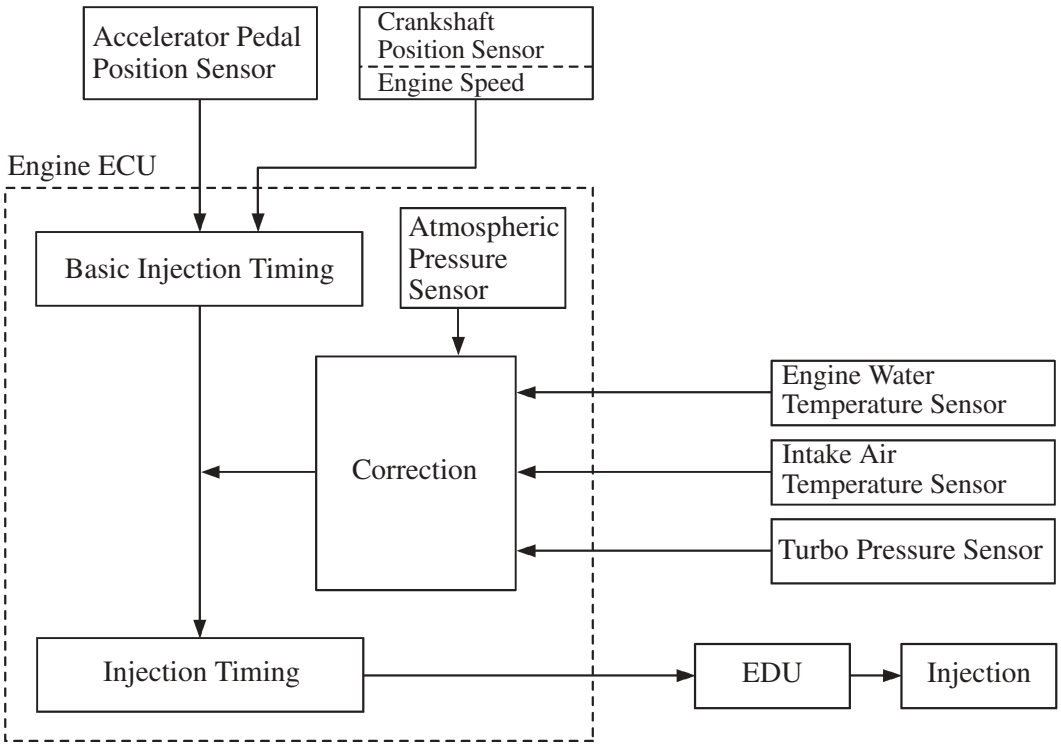
▶ Final Injection Volume Decision ◀



224EG48

7. Fuel Injection Timing Control

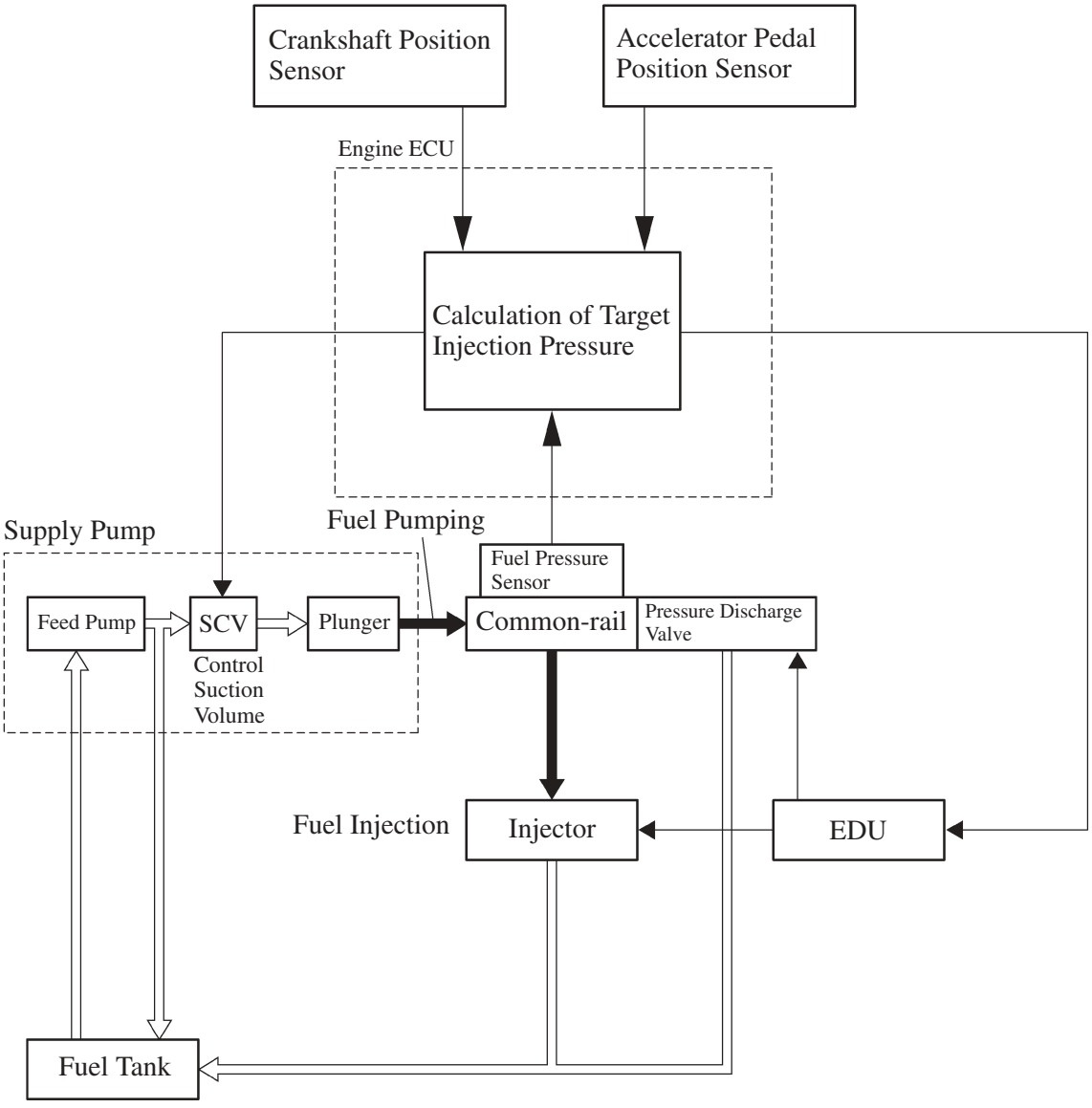
Fuel injection timing is controlled as shown below.



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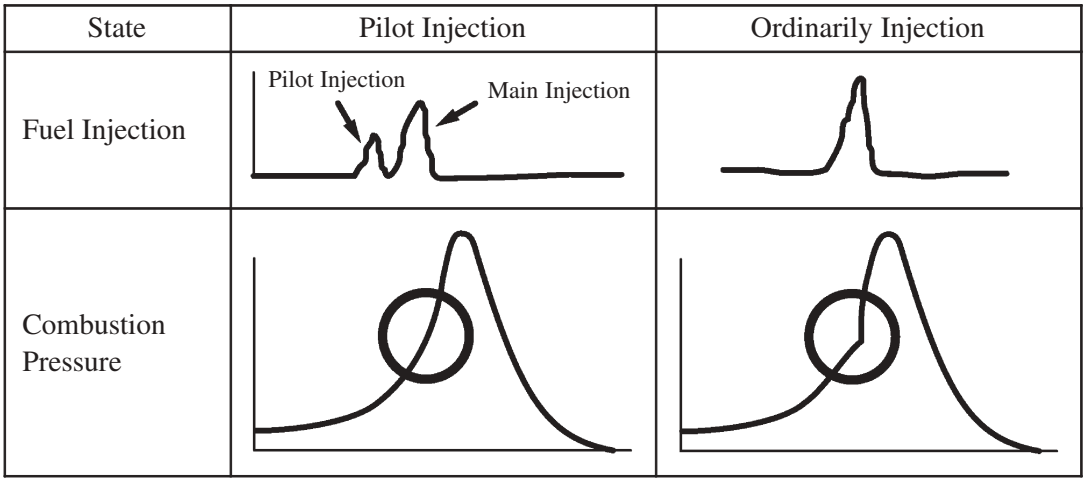
8. Fuel Pressure Control

The engine ECU calculates the target injection pressure (25 – 180 MPa) based on the engine conditions which are the signals from the accelerator pedal position sensor and the crankshaft position sensor.
To control fuel pressure, signals sent to SCV (Suction Control Valve) of the supply pump regulate the suction volume and signals sent to pressure discharge valve of the common-rail regulate the discharge volume, so that the pressure detected by the fuel pressure sensor matches the target injection pressure.



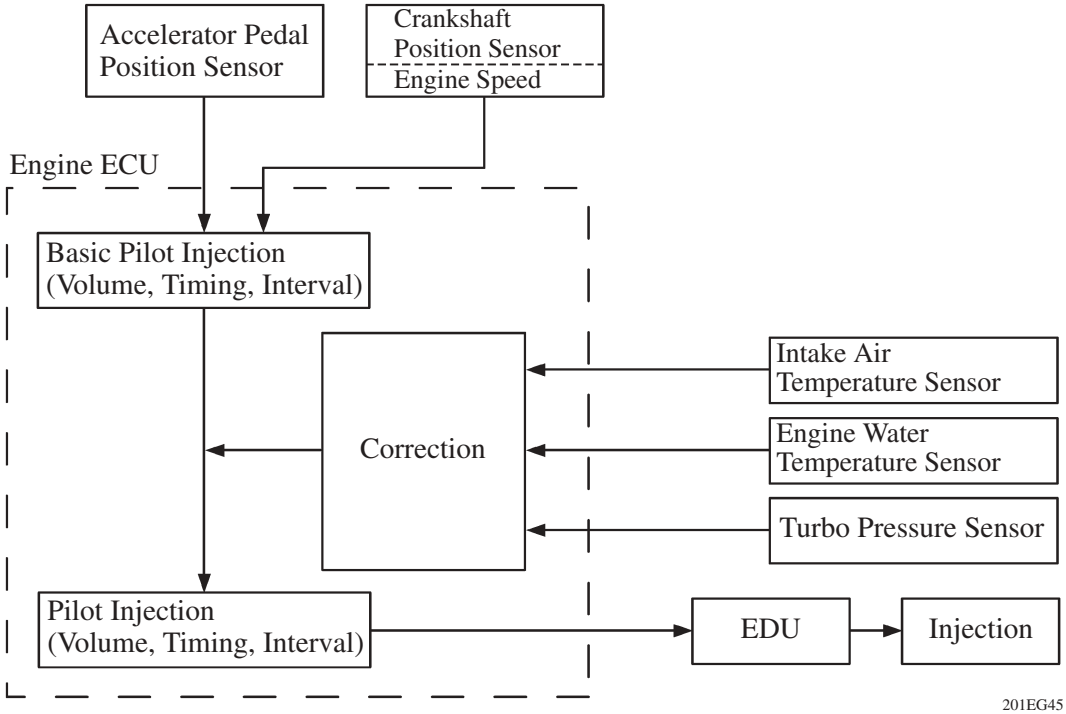
9. Pilot Injection Control

- Pilot injection is a method that provides auxiliary fuel injection before the main injection takes place. The purpose of pilot injection is to gently start the combustion of the fuel of the main injection in order to reduce combustion noise.



168EG23

- During pilot injection, the pilot injection volume, timing, and interval (between pilot injection and main injection) are controlled as shown below.



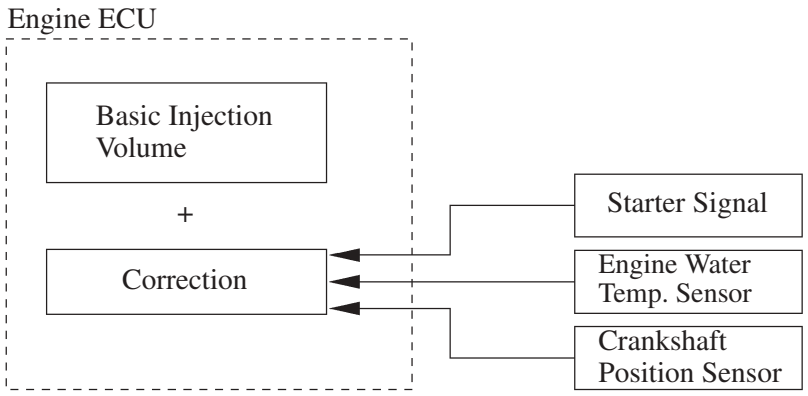
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10. During Starting Control

Injection Volume Control

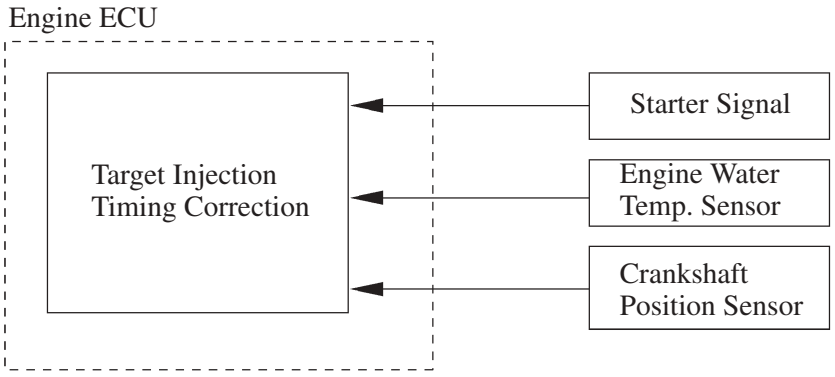
The starting injection volume is determined by adjusting the basic injection volume in accordance with the starter ON signals (ON time), engine water temperature sensor signals and engine speed signal. When the engine is cold, the engine water temperature will be lower and the injection volume will be greater.



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Injection Timing Control

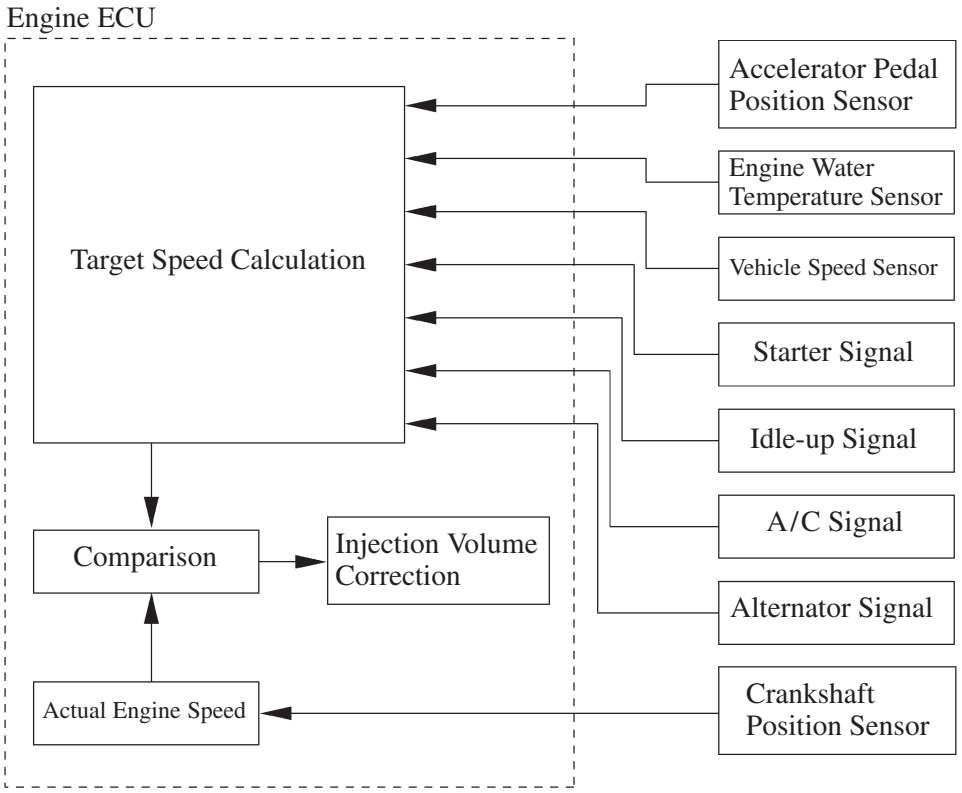
To determine the starting injection timing, the target injection timing is corrected in accordance with the starter signals, engine water temperature, and engine speed.
When the engine water temperature is low, if the engine speed is high, the injection timing is advanced.



224EG51

11. Idle Speed Control

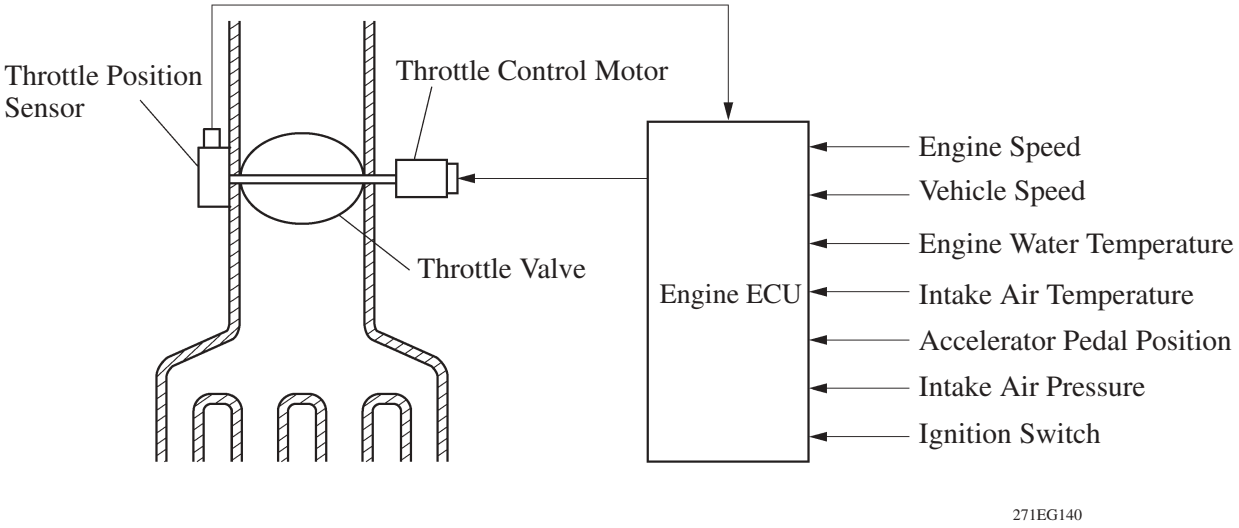
Fuel injection timing is controlled as shown below.



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12. Throttle Control

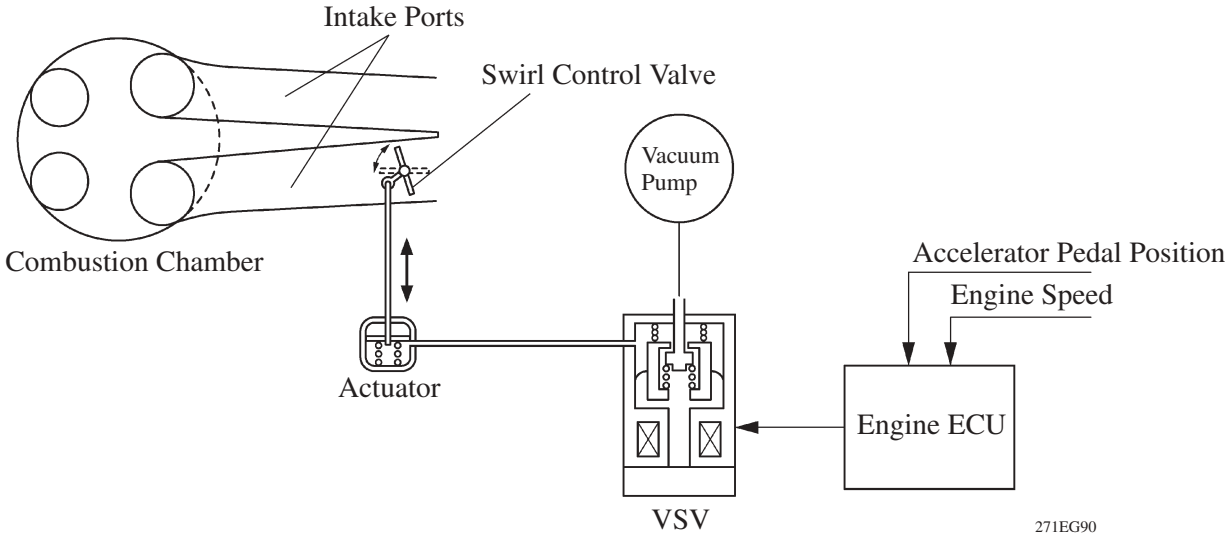
The opening of the throttle valve is controlled by the engine ECU in accordance with engine conditions. As a result, the noise that is generated during idling and deceleration, as well as the noise and vibration that are generated when the engine is stopped, have been reduced.



13. Swirl Control

The engine ECU determines the swirl control valve position (open or closed) based on the engine conditions (engine speed and accelerator pedal position). Then, it switches the vacuum that is applied to the actuator diaphragm via the VSV, in order to open and close the swirl control valve.

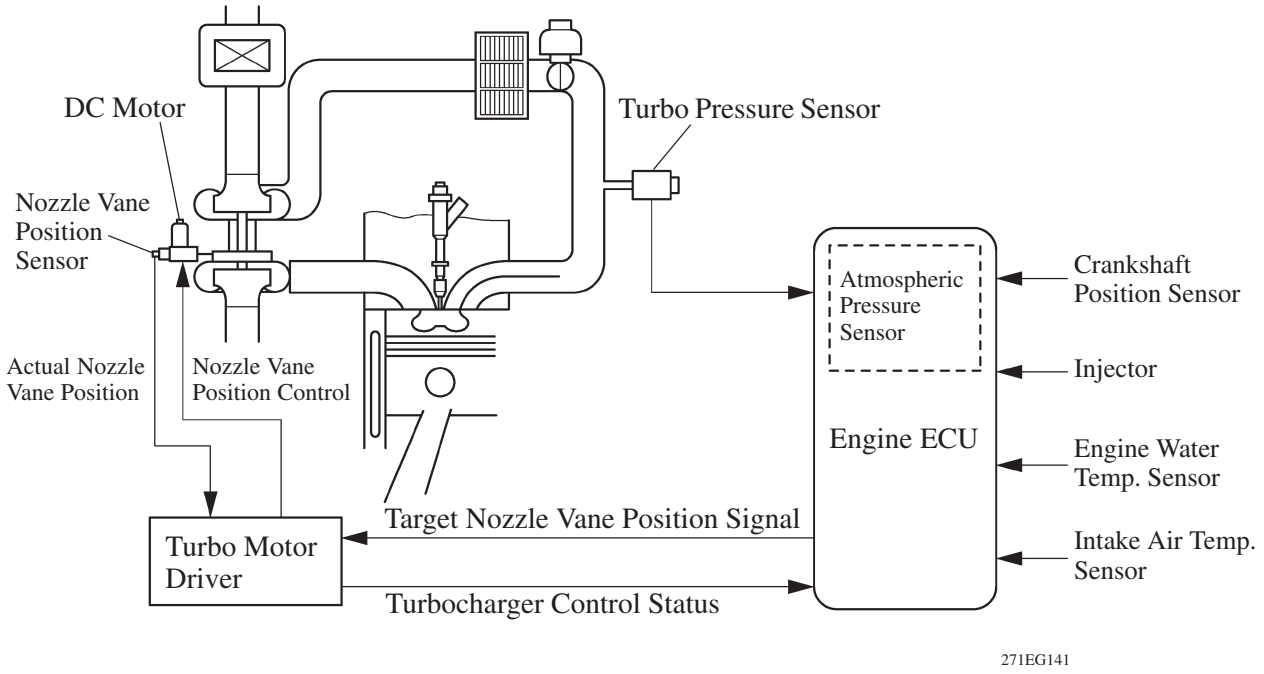
In the low engine speed range, the engine ECU closes the swirl control valve to strengthen the swirl in the combustion chamber, thus promoting the mixture of fuel and air and stabilizing combustion. When the engine speed increases to the medium or high-speed range, the engine ECU fully opens the swirl control valve. On a cold engine, the engine ECU fully closes the swirl control valve to reduce the amount of white smoke emissions.



14. Turbocharger Control

General

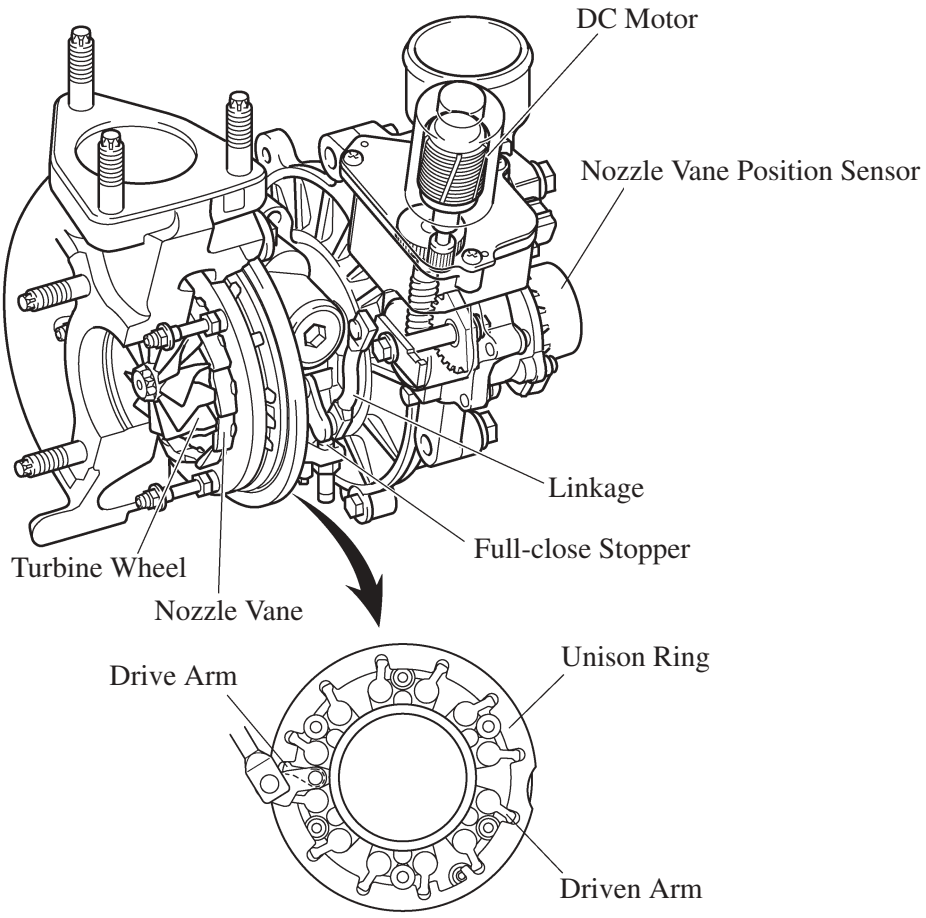
- The engine ECU controls the nozzle vane position using the turbo motor driver, in order to obtain the calculated target turbo pressure appropriate to the engine operating condition.
- The engine ECU calculates the optimal nozzle vane position in accordance with the driving conditions (engine speed, injection volume, atmospheric pressure, engine water temperature, etc.), and sends a target nozzle vane position signal to the turbo motor driver. The turbo motor driver controls the nozzle vane position in accordance with this signal and the actual nozzle vane position signal provided by the nozzle vane position sensor.



Construction

1) General

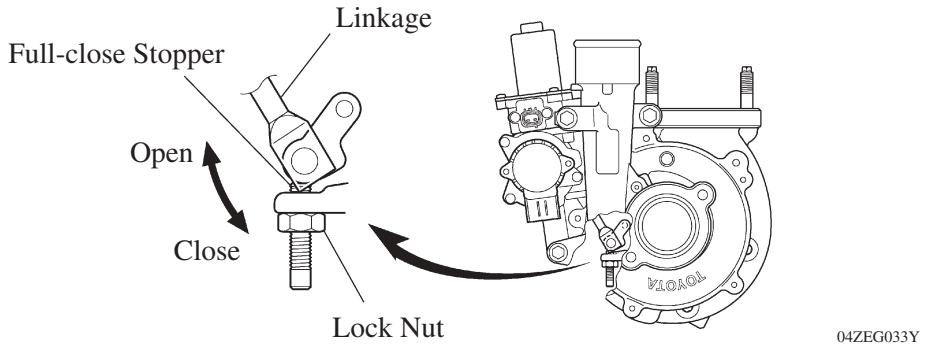
A variable nozzle vane device is provided on the turbine (exhaust) side, and consists of a DC motor, nozzle vane position sensor, linkage, full-close stopper, drive arm, unison ring, driven arms and nozzle vanes.



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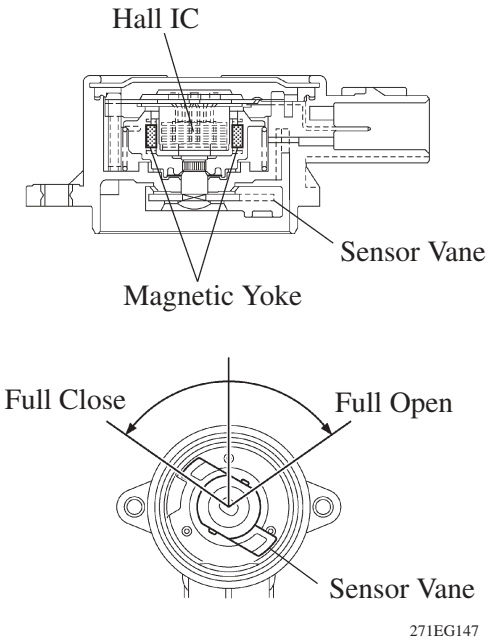
Service Tip

- To control the nozzle vane position, the turbo motor driver renders the contact position of the linkage with the full-close stopper (thus fully closing the nozzle vane) as the zero point for the nozzle vane position sensor.
- If the turbocharger has been reinstalled or replaced, turn the ignition switch from ON to OFF once, and make sure that the linkage comes in contact with the full-close stopper.
- The full-close stopper position, which is adjusted at the factory at the time of shipment, is not serviceable in the field. For this reason, if the linkage does not come in contact with the full-close stopper during an inspection, the turbocharger assembly must be replaced.
  Never attempt to loosen or tighten the lock nut of the full-close stopper because it will adversely affect the performance of the engine.
- For details, refer to the Hiace Repair Manual (Pub. No. RM04Z0E).



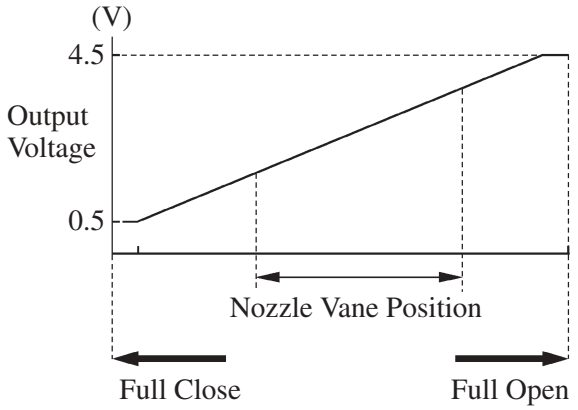
2) Nozzle Vane Position Sensor

The nozzle vane position sensor consists of a Hall IC and a magnetic yoke that rotates in unison with the movement of the linkage that actuates the nozzle vane. The nozzle vane position sensor converts the changes in the magnetic flux that are caused by the rotation of the DC motor (hence, the rotation of the magnetic yoke) into electric signals, and outputs them to the turbo motor driver. The turbo motor driver determines the actual nozzle vane position from the electric signals in order to calculate the target nozzle vane position.



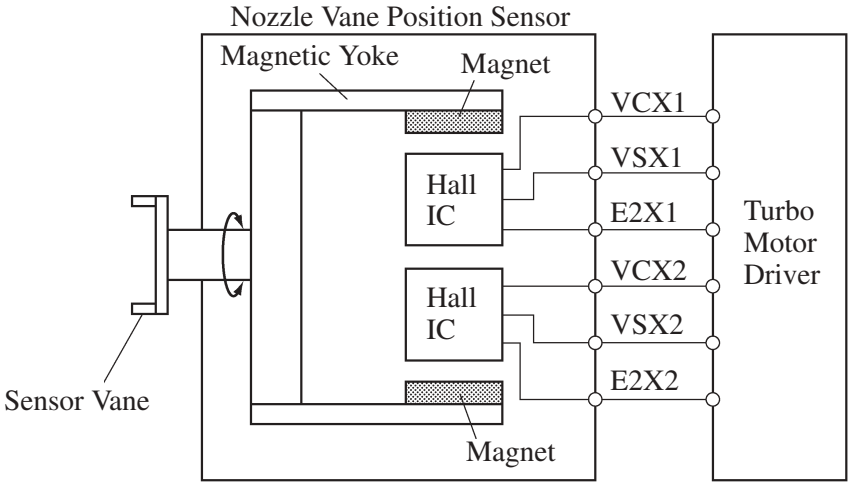
271EG147

▶ Output Characteristic ◀



271EG148

▶ System Diagram ◀



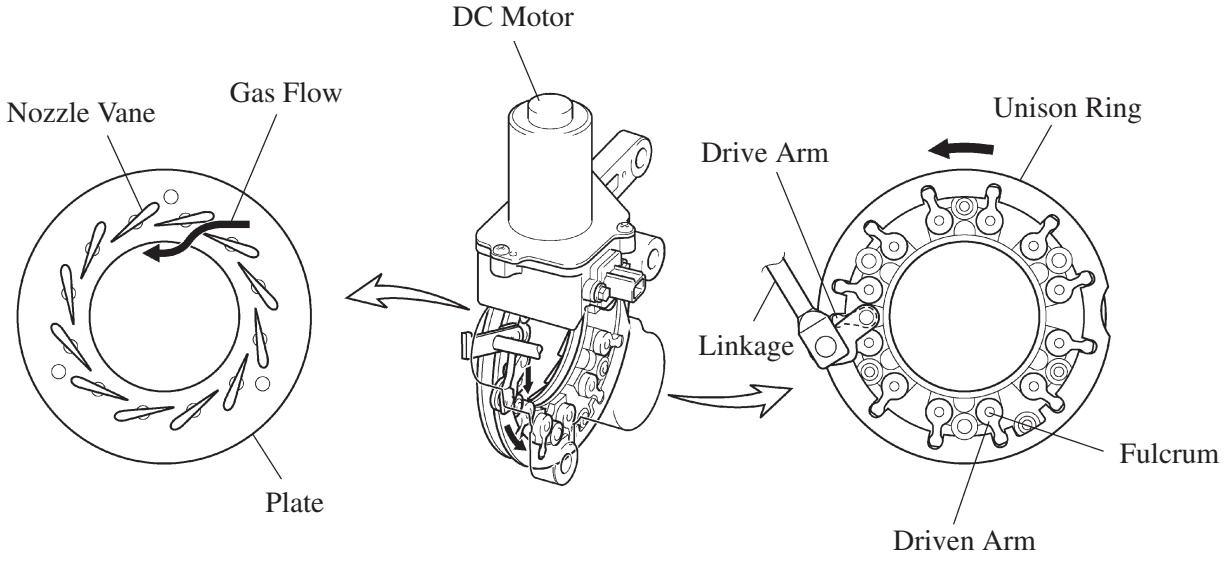
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Operation

1) At Low Speed Range

When the engine is running in a low speed range, the DC motor presses down the linkage by a signal from the turbo motor driver. The tip of the linkage rotates the unison ring counterclockwise through a drive arm.

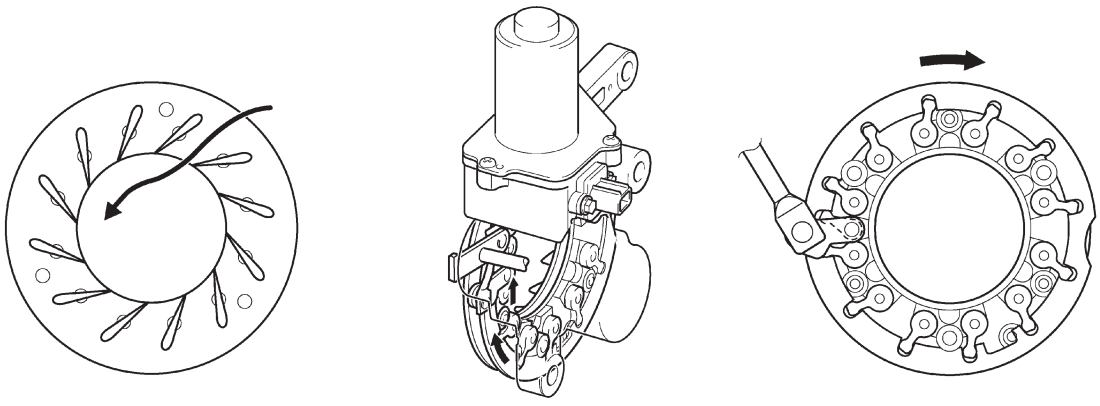
The unison ring contains a driven arm, which is placed through the cutout portion of the unison ring. This driven arm also moves in the direction of the rotation of the unison ring. The fulcrum of the driven arm is an axis that is integrated with the nozzle vane behind the plate. When the driven arm moves counterclockwise, the nozzle vane moves toward the closing direction. This results in increasing the velocity of the exhaust gas flowing to the turbine, as well as the speed of the turbine. As a result, torque is improved when the engine is running at low speeds.



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2) At Medium-to-High Speed Range

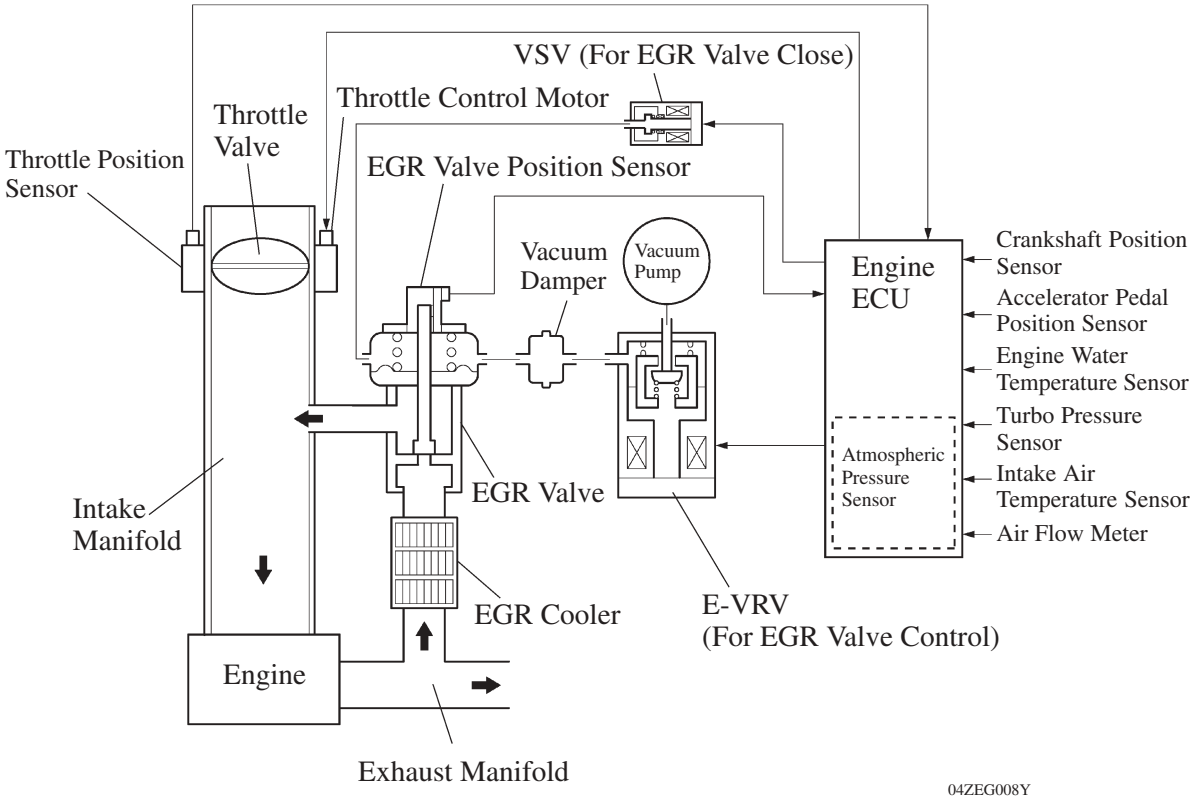
When the engine is running in a medium-to-high speed range, the DC motor pulls up the linkage by a signal from the turbo motor driver. With this, the driven arm moves clockwise and this opens the nozzle vane and holds the specified supercharging pressure. Thus, the back pressure is lowered and the output and fuel consumption are improved.



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15. EGR Control

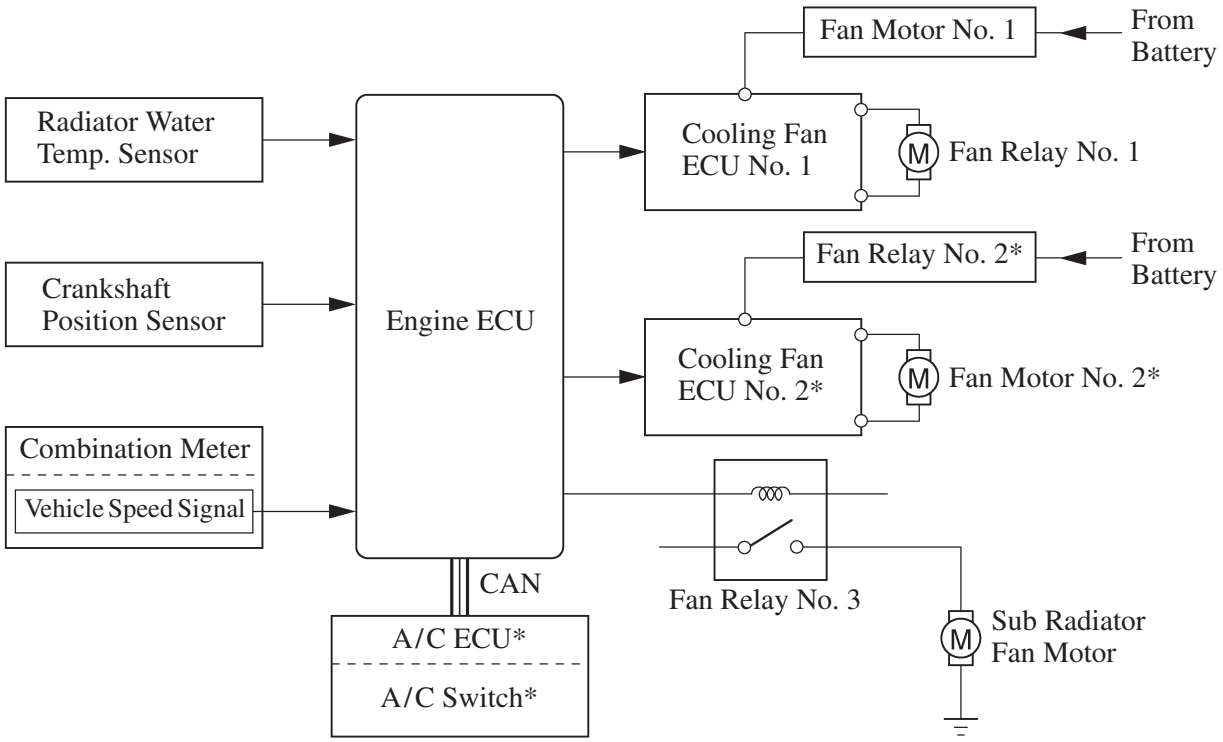
- This system is designed to reduce and control NOx formation due to a slight reduction of peak temperature in the engine combustion chamber, which is accomplished by introducing a small amount of inert gas into intake manifold.
- By sensing the engine driving conditions and actual amount of EGR valve opening, the engine ECU electrically operates the E-VRV (for EGR valve control) and VSV (for EGR valve close), which controls the magnitude of vacuum introduced into diaphragm of EGR valve and throttle valve opening angle by throttle control motor, and the amount of recirculating exhaust gas is regulated. EGR valve opening amount is controlled by modulated negative pressure.
- The VSV (for EGR valve close) is activated when the EGR control is stopped, in order to introduce the atmospheric pressure to the EGR valve diaphragm and improve EGR valve closure response to maintain drivability.
- The EGR function is stopped under the conditions given below to ensure drivability and to reduce diesel smoke.
  - While engine is cold.
  - The vehicle is under high load condition.
  - During deceleration (the EGR operation at idle).



16. Cooling Fan Control

General

- Radiator cooling fan control and sub radiator cooling fan control are used.
- The radiator water temperature sensor detects the radiator water temperature. Based on this data, the engine ECU effects radiator cooling fan control and sub radiator cooling fan control.



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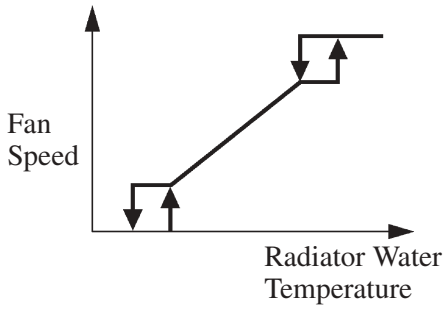
*: Only for Models with Air Conditioner

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Operation

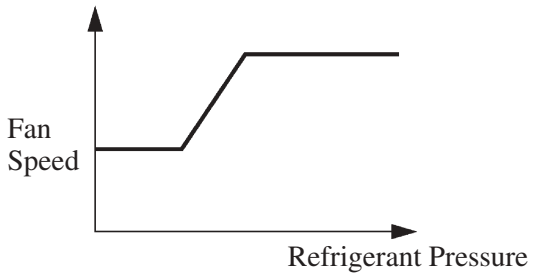
1) Radiator Cooling Fan

As illustrated below, the cooling fan ECU No. 1 determines the required fan speed by selecting the fastest fan speed from among the following:
(A) The fan speed required by the radiator water temperature, (B) the fan speed required by the air conditioner refrigerant pressure, (C) the fan speed required by the engine speed, and (D) the fan speed required by the vehicle speed.



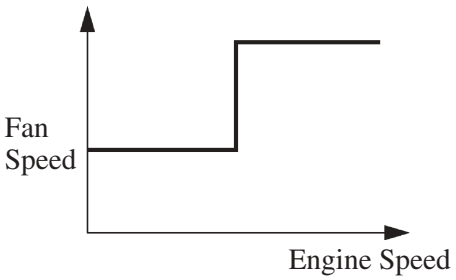
(A) Fan speed required by radiator water temperature

189EG13



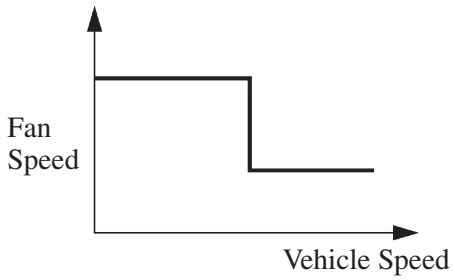
(B) Fan speed required by air conditioner refrigerant pressure

189EG14



(C) Fan speed required by engine speed

189EG15



(D) Fan speed required by vehicle speed

189EG16

2) Sub Radiator Cooling Fan

The operating temperature of the sub radiator cooling fan is as follows.

Sub Radiator Cooling Fan Operation	OFF	ON
Radiator Water Temperature °C (°F)	84 (183.2) or lower	89 (192.2) or higher

17. Diagnosis

- The diagnosis system of the 1KD-FTV engine uses the EURO-OBD (EURO On-Board 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 also stores the DTCs (Diagnostic Trouble Codes) of the malfunctions. The DTCs can be read by connecting the SST (09843-18040) to the TC and CG terminals of the DLC3, and observing the blinking of the check engine warning light (2-digit code), or by connecting the intelligent tester II to the DLC3 (5-digit code).
- By using the intelligent tester II, the ECU data can be read out. Moreover, the ACTIVE TEST can be used to drive the actuator by means of the intelligent tester II.
- The engine ECU can output freeze-frame data to the intelligent tester II. This data is stored in the engine ECU at the very moment when the engine ECU detects its last data of malfunction.
- For details, refer to the Hiace Repair Manual (Pub. No. RM04Z0E).

Service Tip

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

18. Fail-safe

When a malfunction is detected by 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 Hiace Repair Manual (Pub. No. RM04Z0E).