

■ ENGINE CONTROL SYSTEM

1. General

The engine control system of the 2AD-FHV engine has the following features. The engine ECU that controls this system is made by DENSO.

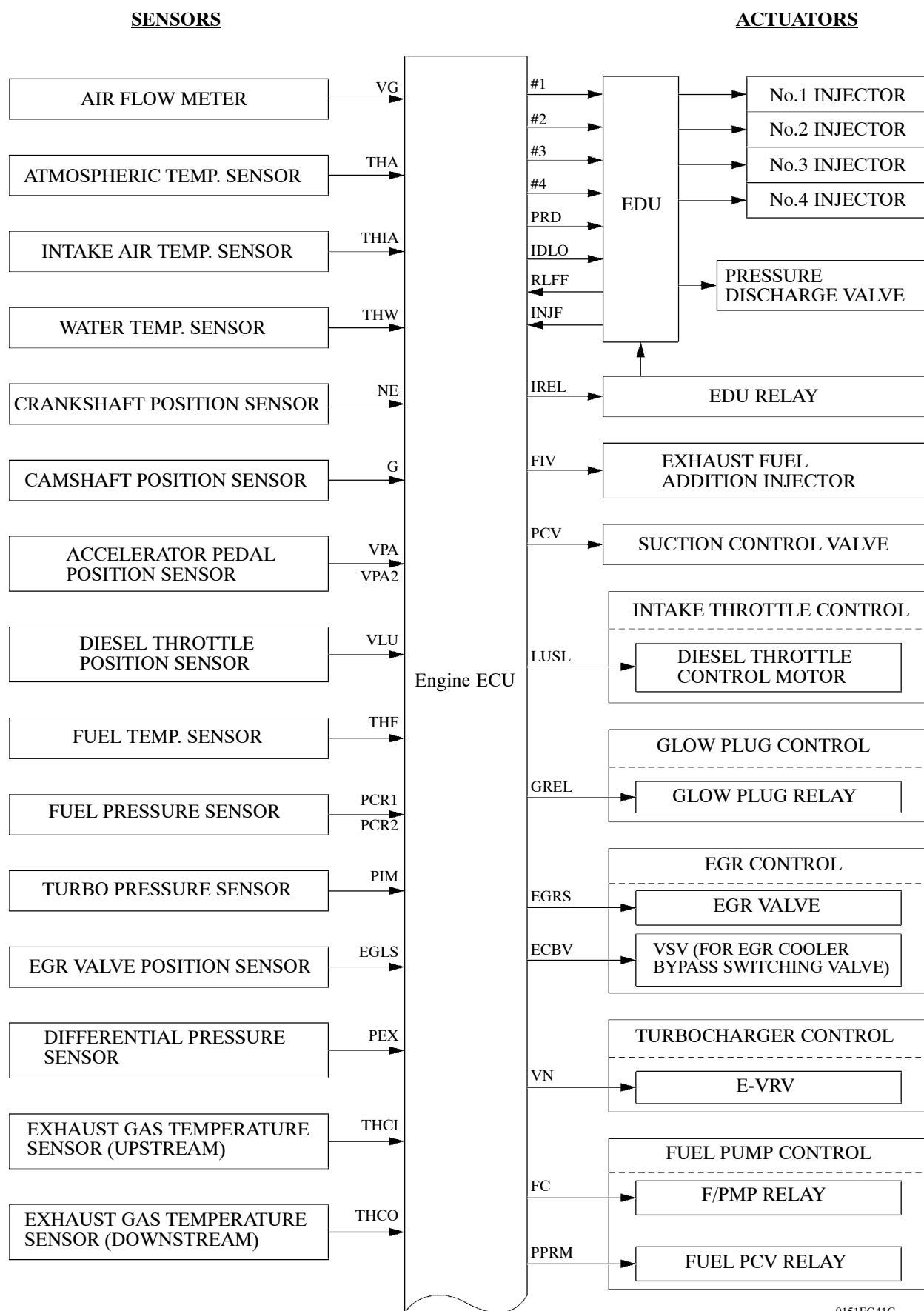
System	Outline
Fuel Injection Volume Control [See page EG-140]	Based on the signals received from the sensors, the engine ECU determines the fuel injection volume in accordance with the engine operating conditions.
Fuel Injection Timing Control [See page EG-141]	Based on the signals received from the sensors, the engine ECU determines the fuel injection timing in accordance with the engine operating conditions.
Fuel Pressure Control [See page EG-142]	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 engine operating conditions.
Pilot Injection Control [See page EG-143]	Based on the signals received from the various sensors, the engine ECU determines pilot injection volume, timing, and interval (between pilot injection and main injection) in accordance with the engine operating conditions.
Catalyst Support Control [See page EG-144]	Based on the signals received from the sensors, the engine ECU controls the exhaust fuel addition injector to purify NOx, PM and sulfur.
Idle Speed Control [See page EG-145]	The engine ECU determines the idle speed in accordance with the engine operating conditions, and controls the fuel injection volume in order to maintain the target idle speed.
Glow Plug Control	Controls the length of time that current is applied to the glow plugs, in accordance with water temperature.
EGR Control [See page EG-146]	Based on the signals received from the sensors, the engine ECU determines the EGR volume via the EGR valve position sensor, EGR cooler bypass switching valve and diesel throttle control valve in accordance with the engine operating conditions.
Turbo Pressure Control [See page EG-147]	Based on the signals received from the sensors, the engine ECU controls the actuator via the VRV in accordance with the engine operating conditions.
Intake Throttle Control	- Based on the signals received from the various sensors, the engine ECU determines the appropriate throttle position in accordance with engine operating conditions. - Fully close the diesel throttle control valve in order to reduce vibration when the engine is stopped.
Fuel Pump Control [See page EG-148]	- Based on the signals from the sensors, the engine ECU operates the fuel pump to optimally control the transfer of the fuel in the fuel tank. - Based on the operation signals from the satellite switch, the engine ECU can operate the fuel pump and fuel tank solenoid return valve to perform the auto-priming operation of the engine mounted fuel supply pump.
Air Conditioner Cut-off Control	By controlling the air conditioner compressor ON or OFF in accordance with the engine condition, drivability is maintained.
Cooling Fan Control [See page EG-76]	Cooling fan operation is controlled by signals from the Engine ECU based on the engine coolant temperature sensor signal and air conditioner operation.

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System	Outline
Starter Control (Cranking Hold Function) [See page EG-77]	Once the engine switch is pushed, this control operates the starter until the engine starts.
Air/Fuel Ratio Sensor Heater Control	Maintains the temperature of the air/fuel ratio sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in the exhaust gas.
Charging Control [See page EG-79]	The engine ECU regulates the charging voltage of the alternator in accordance with the driving conditions and the state of charge of the battery.
Oil Maintenance Management [See page EG-151]	When the engine ECU determines engine oil deterioration, the engine oil change reminder light turns on to inform the driver.
Engine Immobilizer	Prohibits fuel injection if an attempt is made to start the engine with an invalid ignition key.
Diagnosis [See page EG-153]	When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the data relating to the malfunction.
Fail-Safe [See page EG-153]	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in memory.

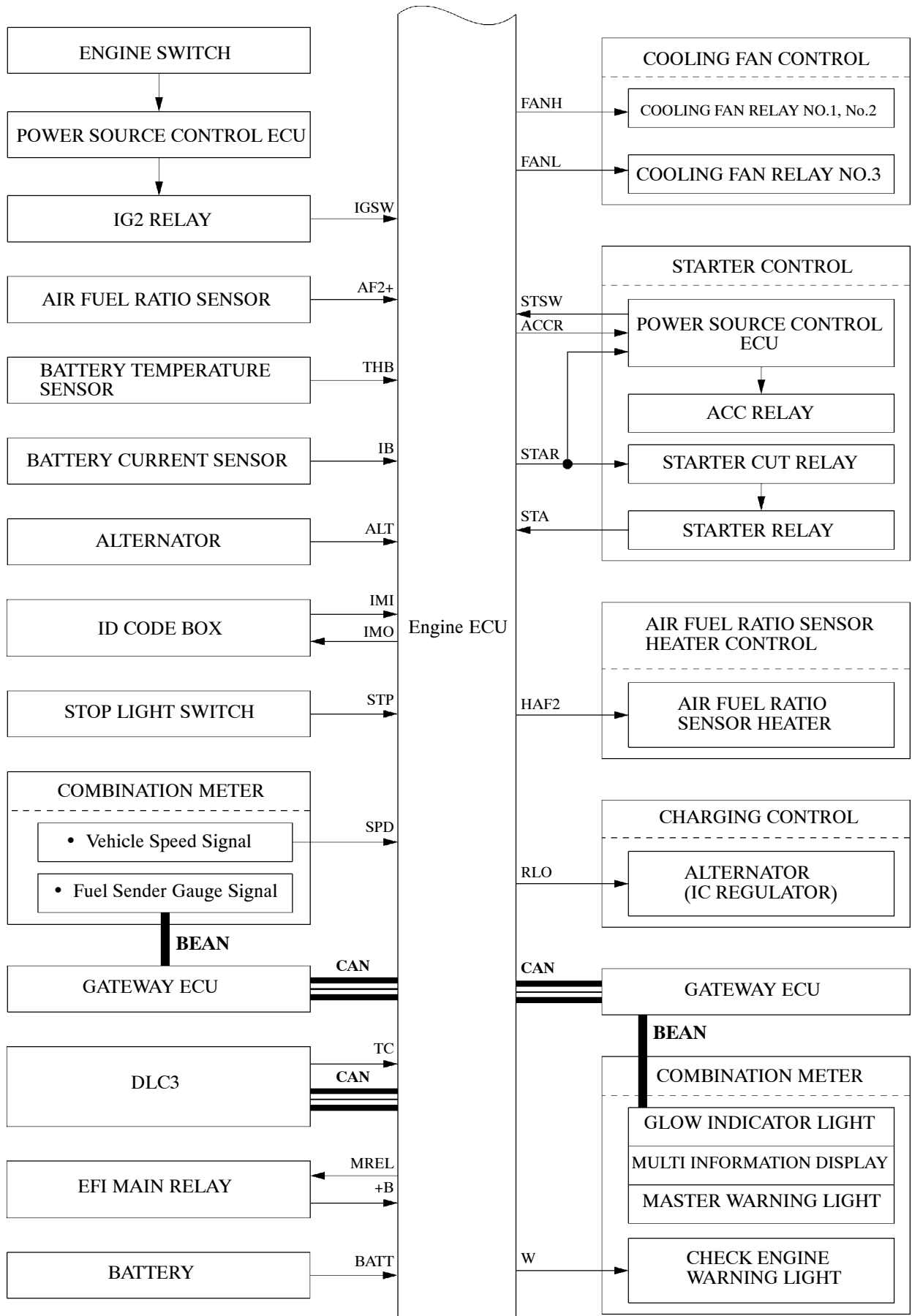
2. Construction

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

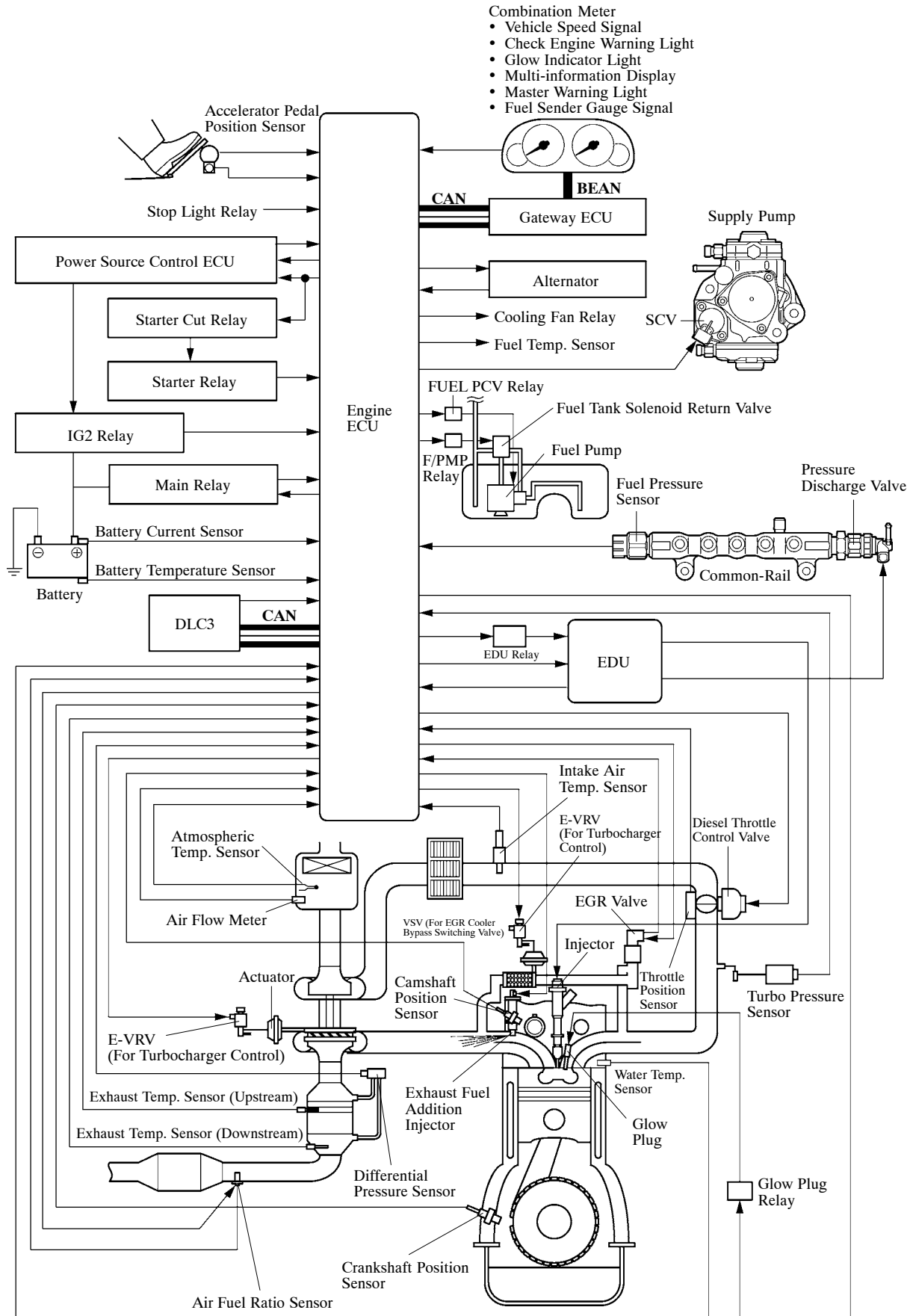


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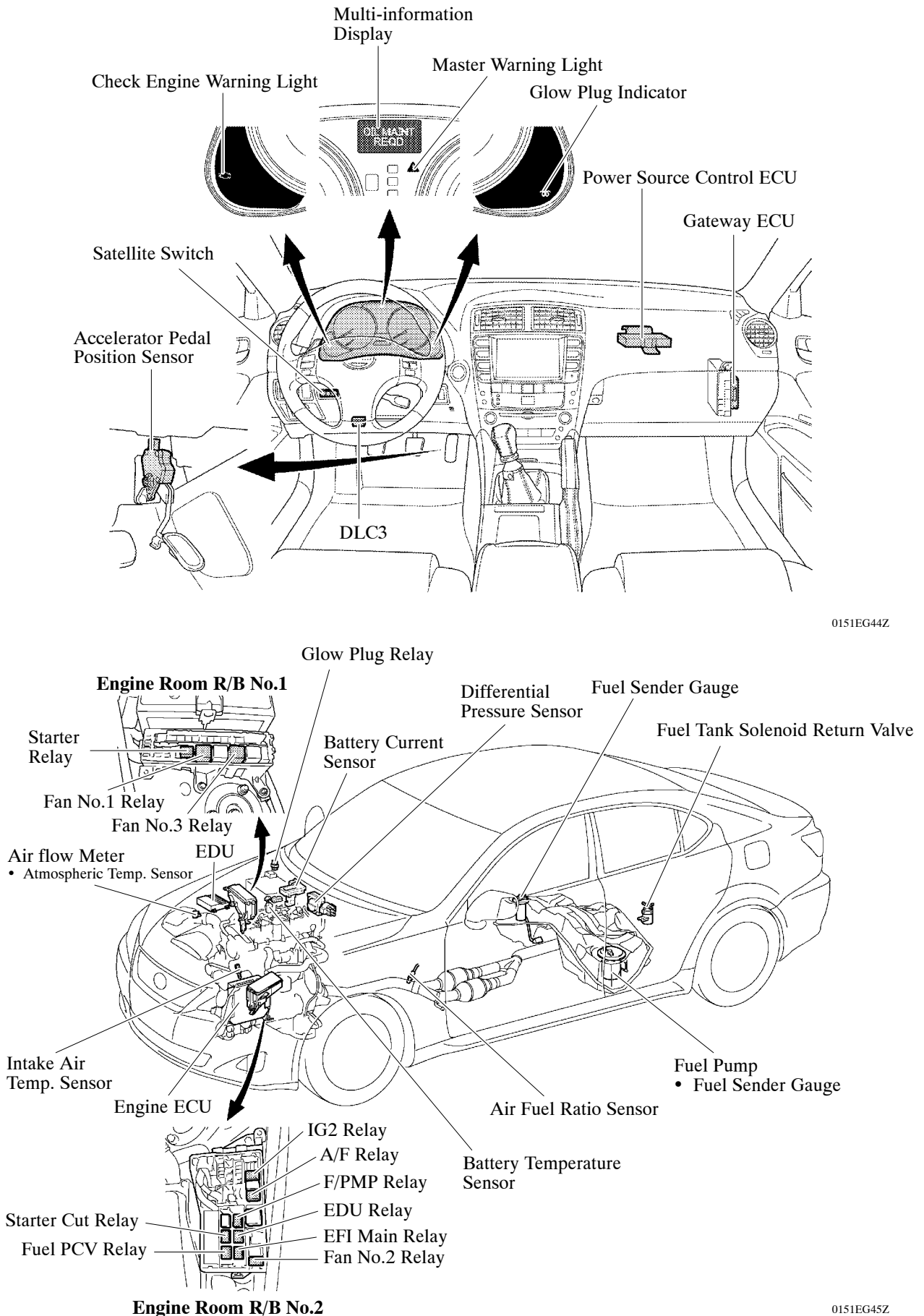
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3. Engine Control System Diagram

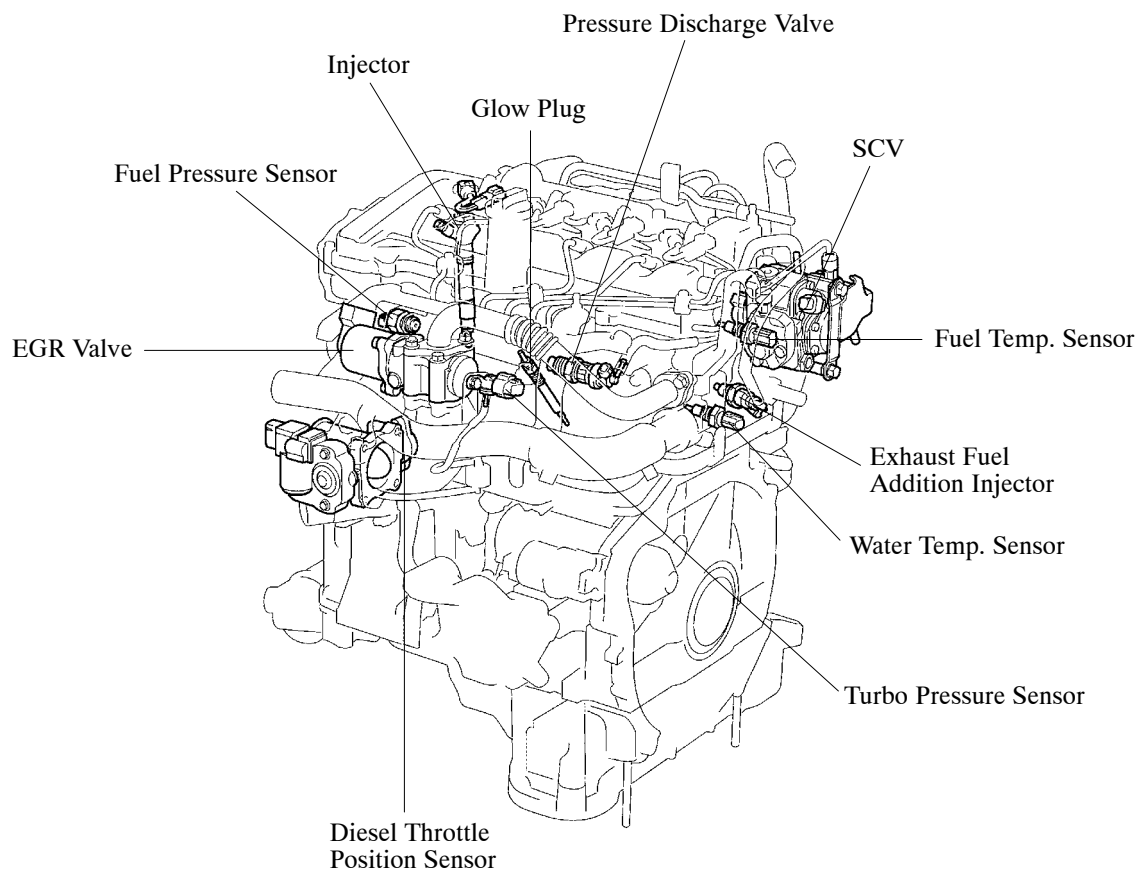


4. Layout of Main Components

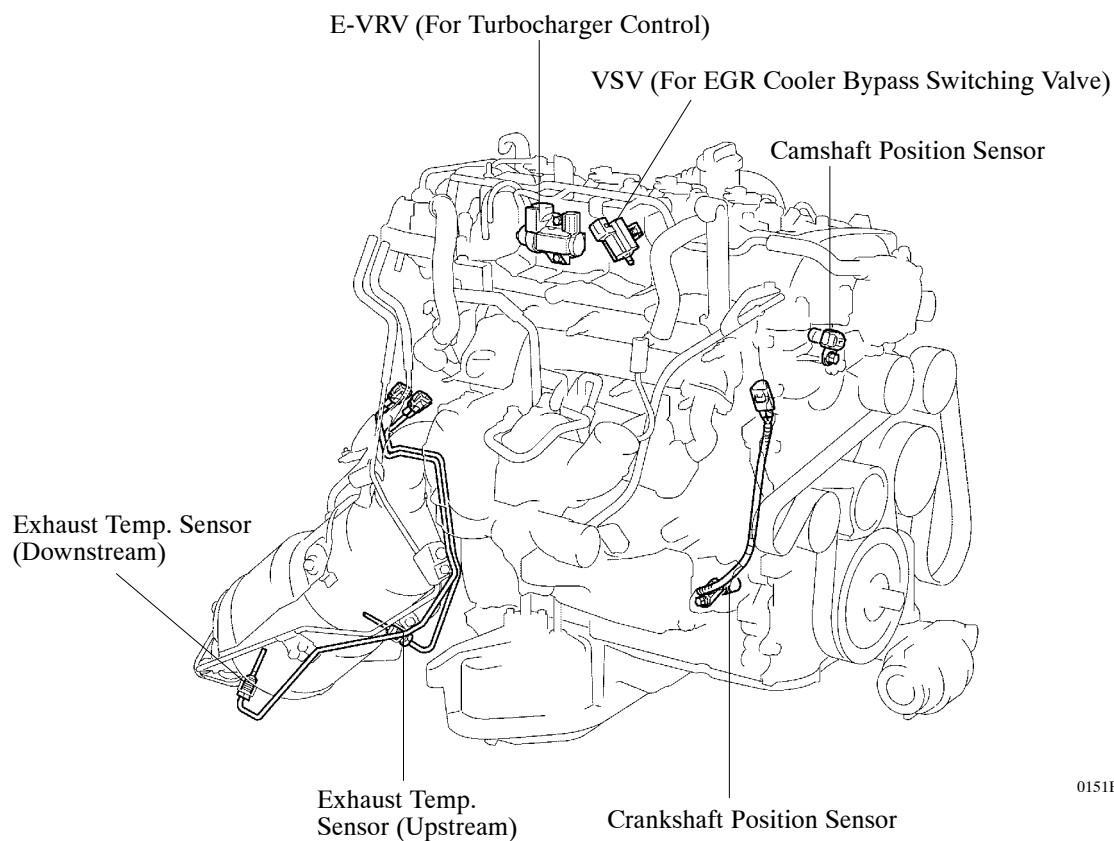


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5. Main Component of Engine Control System

General

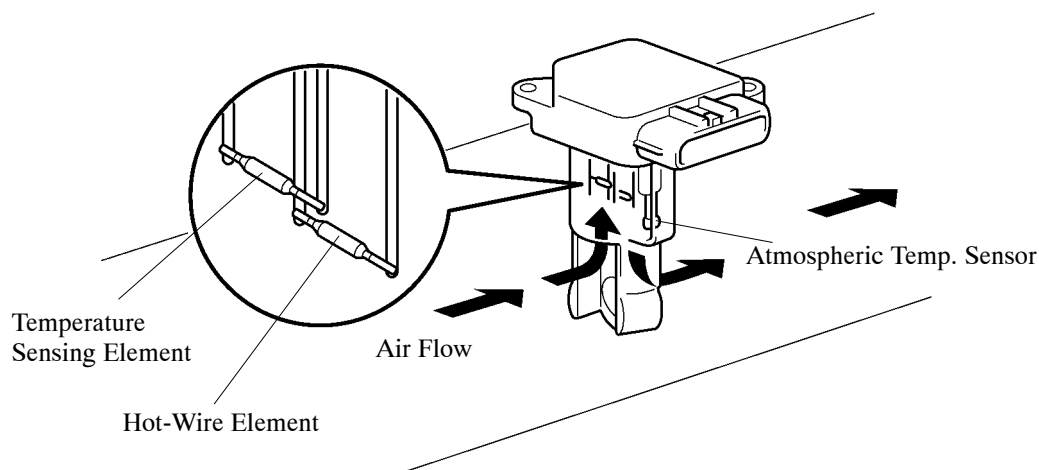
The main components of the 2AD-FHV engine control system are as follows:

Components		Outline	Quantity
Engine ECU		32-bit CPU	1
EDU		Including a built-in DC-DC converter	1
Air Flow Meter		Hot-wire Type	1
Crankshaft Position Sensor (Rotor Teeth)		Pick-up Coil Type (36 - 2)	1
Camshaft Position Sensor (Rotor Teeth)		Pick-up Coil Type (1)	1
Fuel Pressure Sensor		Semiconductor Strain Gauge Type (Two Circuits Type)	1
Accelerator Pedal Position Sensor		Linear (No-Contact) Type	1
Diesel Throttle Position Sensor		Linear (No-Contact) Type	1
Differential Pressure Sensor		Semiconductor Strain Gauge Type	1
Exhaust Gas Temperature Sensor	Upstream	Thermistor Type	2 (1 each)
	Downstream		
Air Fuel Ratio Sensor		Type with heater (Planar Type)	1

Air Flow Meter

The air flow meter of this diesel engine is used to allow precise fuel injection volume control and EGR control to realize a high level of emission control.

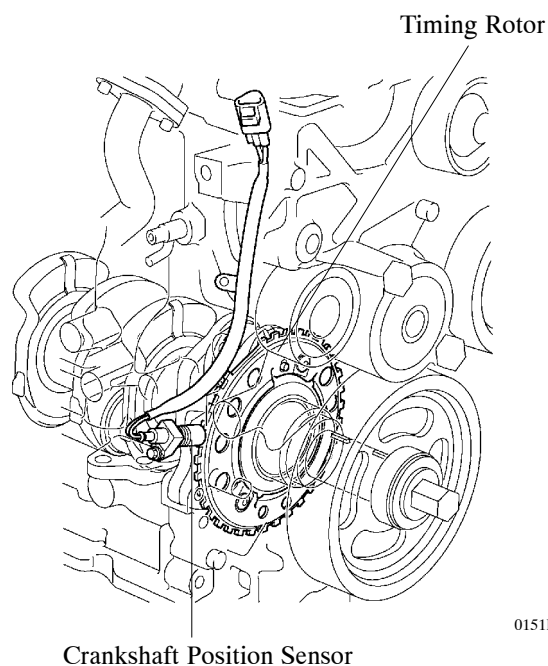
- A plug-in type air flow meter is used and it allows a portion of the intake air to flow through the detection area. By directly measuring the mass and the flow rate of the intake air, detection precision is ensured and the intake air resistance is reduced.
- The air flow meter has a built-in atmospheric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



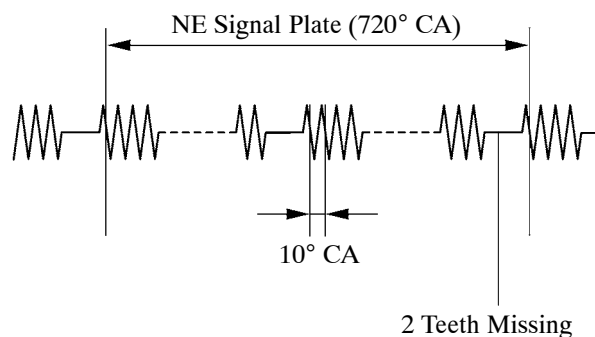
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Crankshaft Position Sensor

The timing rotor of the crankshaft consists of 34 teeth, with 2 teeth missing. The crankshaft position sensor outputs a signal every 10° of crankshaft rotation, and the missing teeth are used to determine top-dead-center.



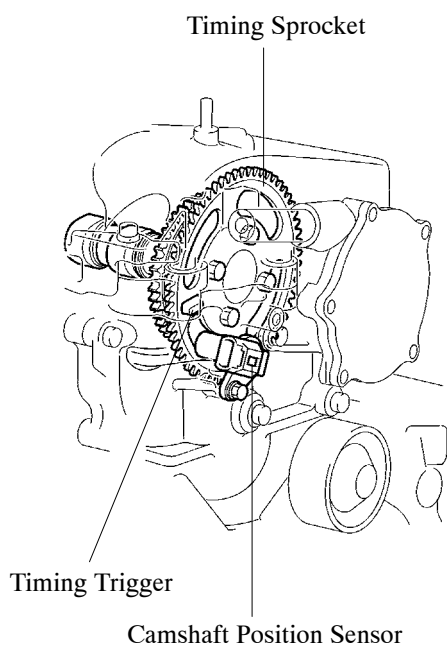
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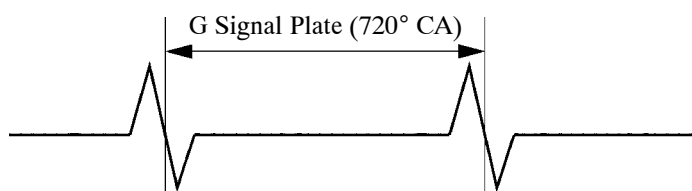
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Camshaft Position Sensor

A hall element type camshaft position sensor is used to detect the camshaft position. The sensor generates one signal for every two revolutions of the crankshaft using the timing trigger (protrusion) on the timing sprocket.



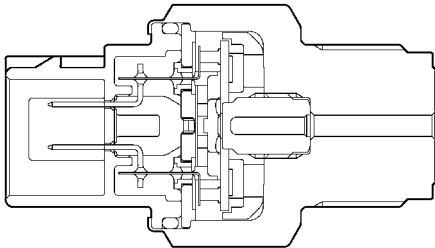
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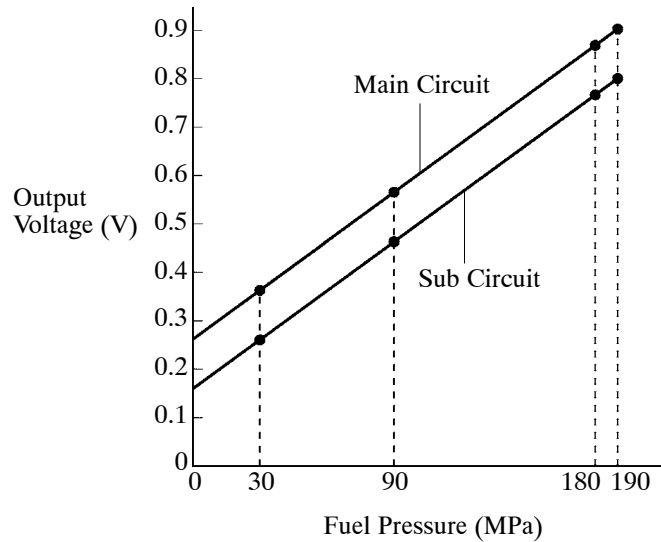
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Fuel Pressure Sensor

- The fuel pressure sensor outputs a signal to the engine ECU that represents the fuel pressure in the common-rail in order to allow the engine ECU 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 of this comparison, the engine ECU can determine that a fault exists, allowing fail-safe control to occur.



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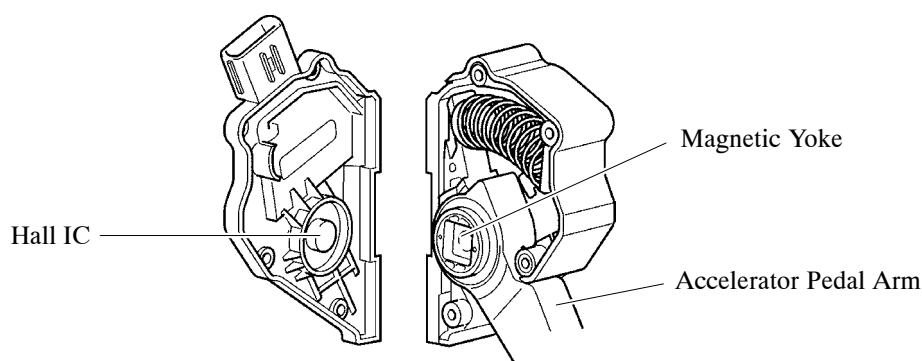


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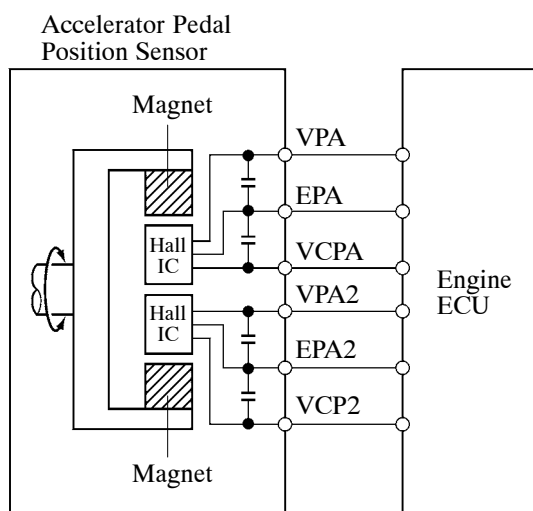
Accelerator Pedal Position Sensor

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

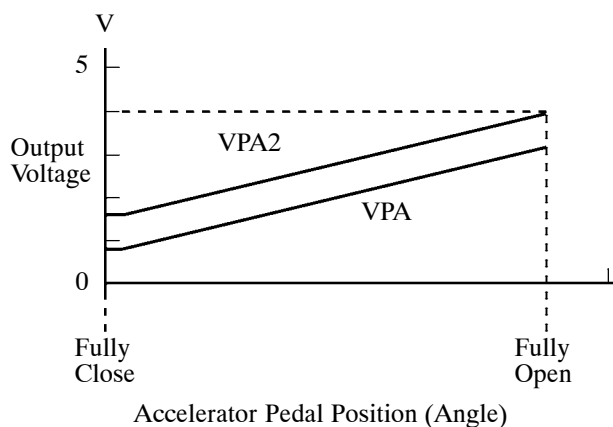
- A magnetic yoke is mounted at the base of the accelerator pedal arm. This yoke rotates around the Hall IC in accordance with the amount of effort that is applied to the accelerator pedal. The Hall IC converts the changes in the magnetic flux that occur into electrical signals, and outputs them in the form of accelerator pedal position signals to the Engine ECU.
- The Hall IC contains two circuits, one for the main signal, and one for the sub signal. It converts the accelerator pedal position (angle) into electric signals that have differing characteristics and outputs them to the Engine ECU.



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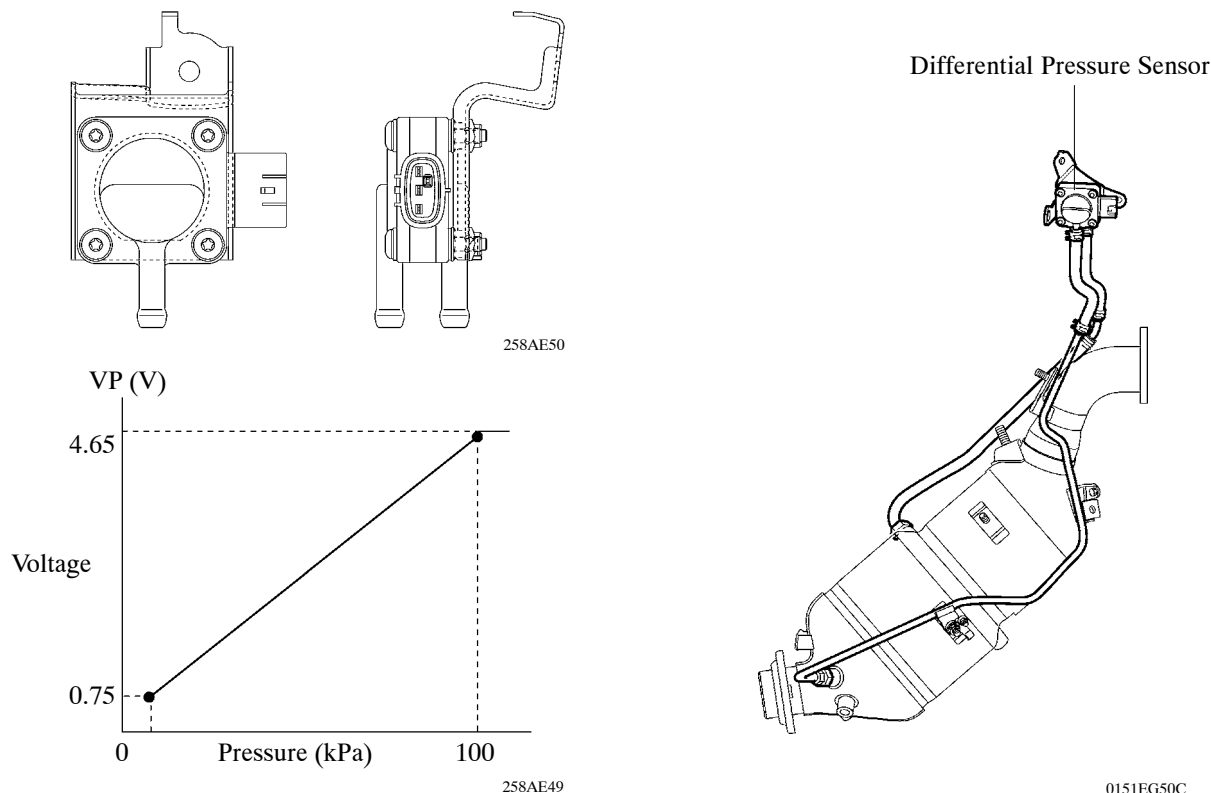
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Service Tip

The inspection method differs from a conventional accelerator pedal position sensor because this sensor uses a Hall IC. For details, refer to the LEXUS IS250/220d Repair Manual (Pub. No. RM0151E).

Differential Pressure Sensor

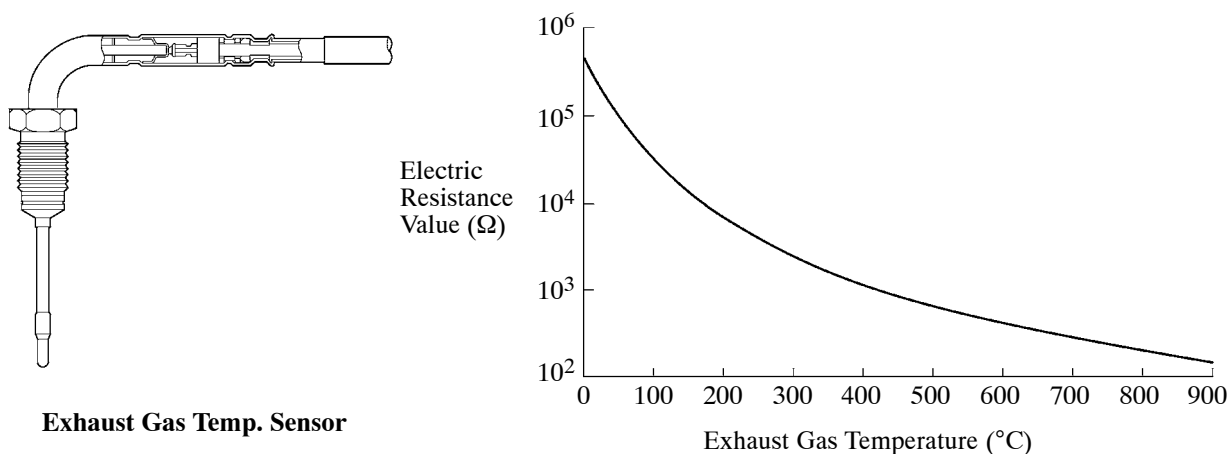
- The differential pressure sensor measures the pressure difference before and after the DPNR catalyst in order to detect clogging of the catalyst with particulate matter (PM).
- The sensor is mounted on the firewall in the engine compartment, where the effects of vibration are minimal. The DPNR catalyst and the sensor are connected with pipes and hoses.



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Exhaust Gas Temperature Sensors

The exhaust gas temperature sensors, which are a thermistor type, are installed before (upstream) and after (downstream) the DPNR catalyst, in order to detect the temperature of the catalyst.

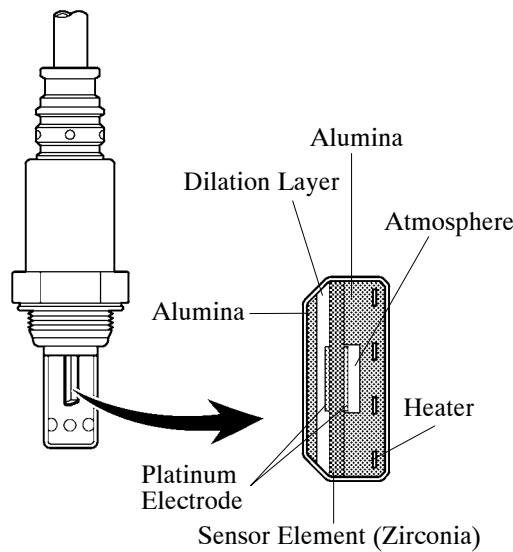


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Air Fuel Ratio Sensor

1) General

- A planar type air-fuel ratio sensor is used.
- The planar type air-fuel ratio sensor uses alumina, which excels in heat conductivity and electrical insulation, to integrate a sensor element with a heater, thus improving the warm-up performance of the sensor.
- This sensor is based on a sensor that is developed for gasoline engines. Its cover is changed for diesel engine applications in order to eliminate the influences of the sensor temperature and PM. This sensor, which is mounted after the DPNR catalyst, detects the air-fuel ratio after the exhaust gases pass through the converter.

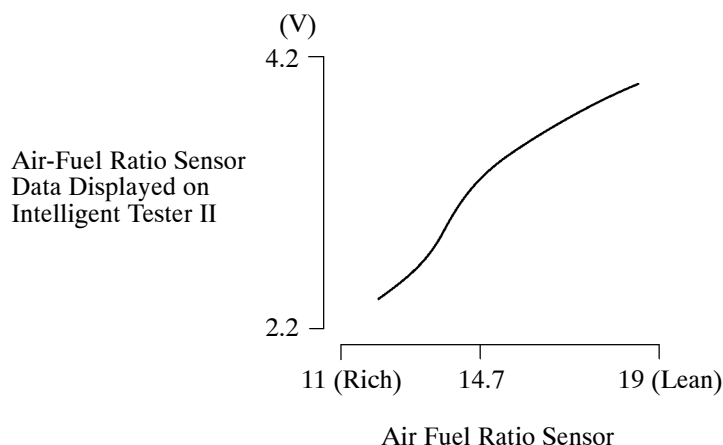


Air Fuel Ratio Sensor (Planar Type)

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2) Characteristics

The air-fuel ratio sensor data is approximately proportional to the existing air-fuel ratio. The air-fuel ratio sensor converts the oxygen density to current and sends it to the Engine ECU. As a result, the detection precision of the air-fuel ratio has been improved. The air-fuel ratio sensor data can only be read using an intelligent tester II.

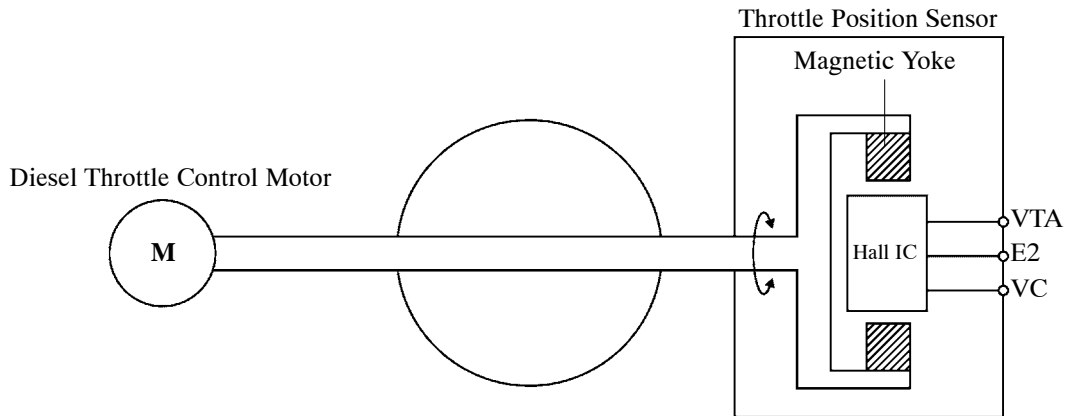


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*: This value is calculated internally in the Engine ECU and is not an Engine ECU terminal voltage.

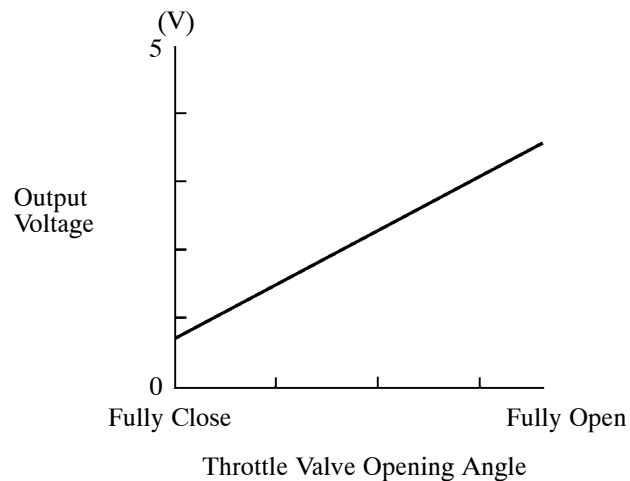
Throttle Position Sensor

The non-contact type throttle position sensor uses a Hall IC, which is integrated with the throttle body. A magnetic yoke surrounds the Hall IC. The Hall IC converts the changes that occur in the magnetic flux due to the throttle position into electrical signals and outputs them to the engine ECU. These signals are used for feedback to control the diesel throttle control motor operation.



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► Output Characteristic ◀



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Service Tip

The inspection method differs from a contact type throttle position sensor because this sensor uses a Hall IC. For details, see the LEXUS IS250/220d Repair Manual (Pub. No. RM0151E).

6. Fuel Injection Volume Control

General

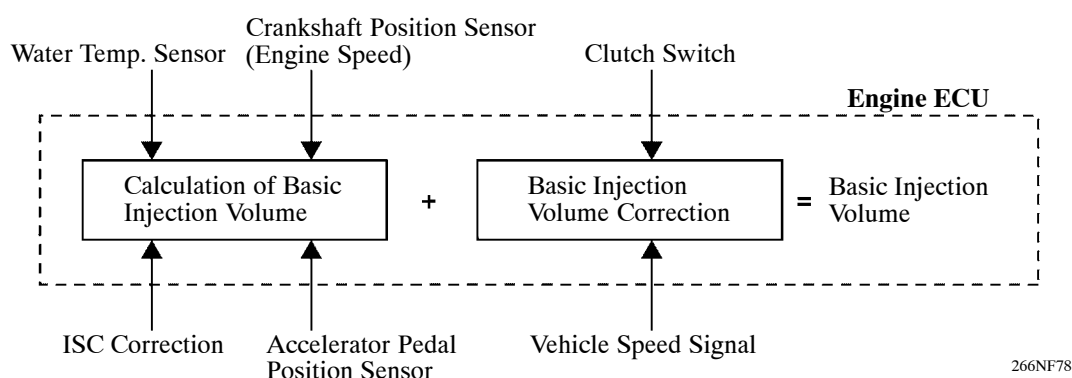
The fuel injection volume falls in to two categories:

- Final Injection Volume
- Starting Injection Volume

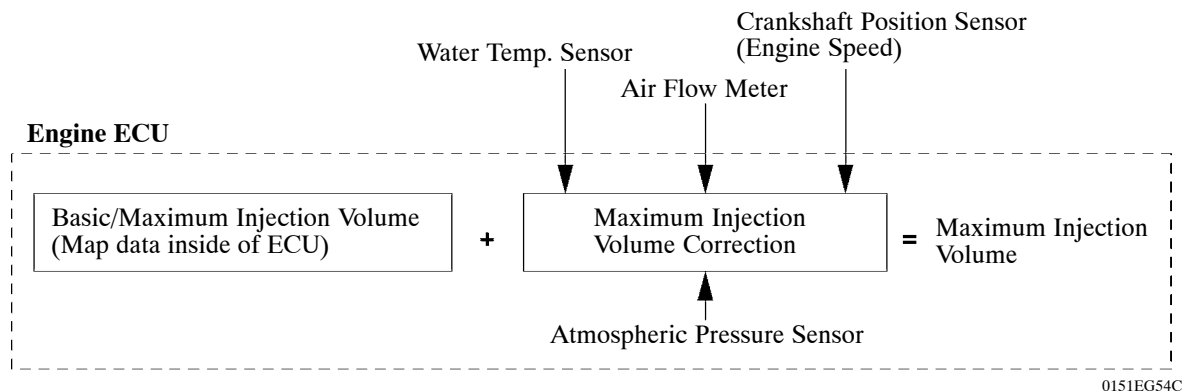
Final Injection Volume

The engine ECU compares the basic and maximum injection volumes, and determines the smaller calculated value to be the final injection volume. The ECU reduces injection volume to ensure drivability when the clutch switch is on (the clutch pedal is depressed).

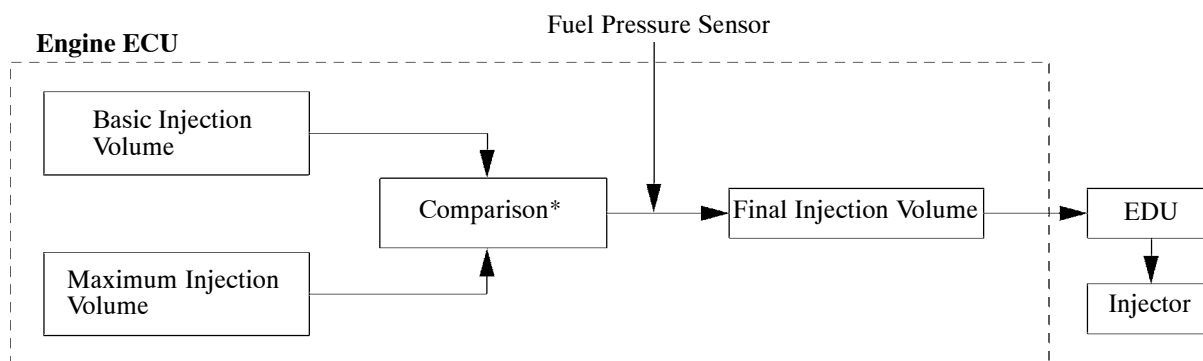
► Basic Injection Volume ◀



► Maximum Injection Volume ◀



► Final Injection Volume Decision ◀



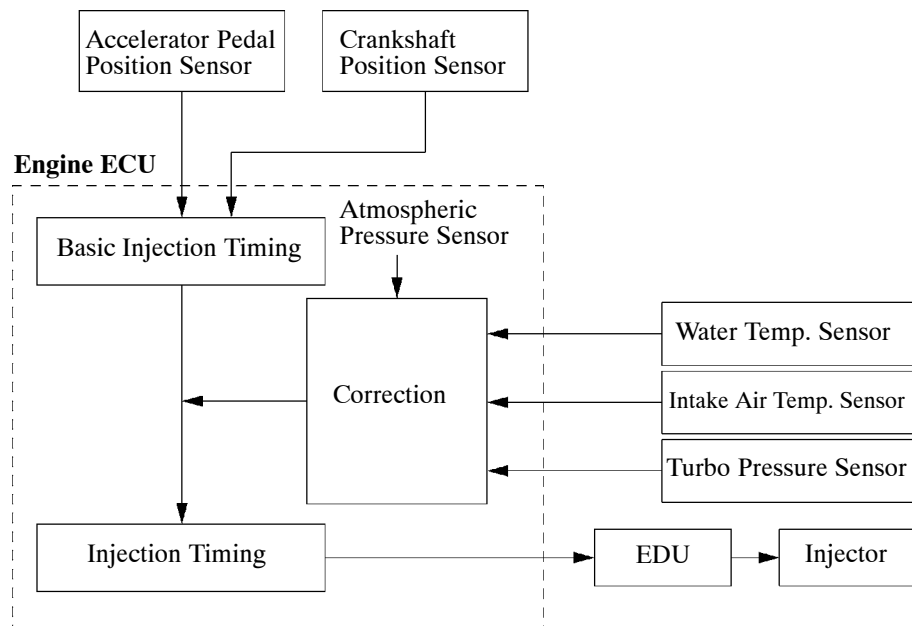
*: Selects lower injection volume

Starting Injection Volume

The starting injection volume is determined in accordance with the crankshaft position sensor signal (cranking time) and water temperature sensor signal. When the engine is cold, the water temperature will be lower and the injection volume will be greater.

7. Fuel Injection Timing Control

Fuel injection timing is controlled as shown below.

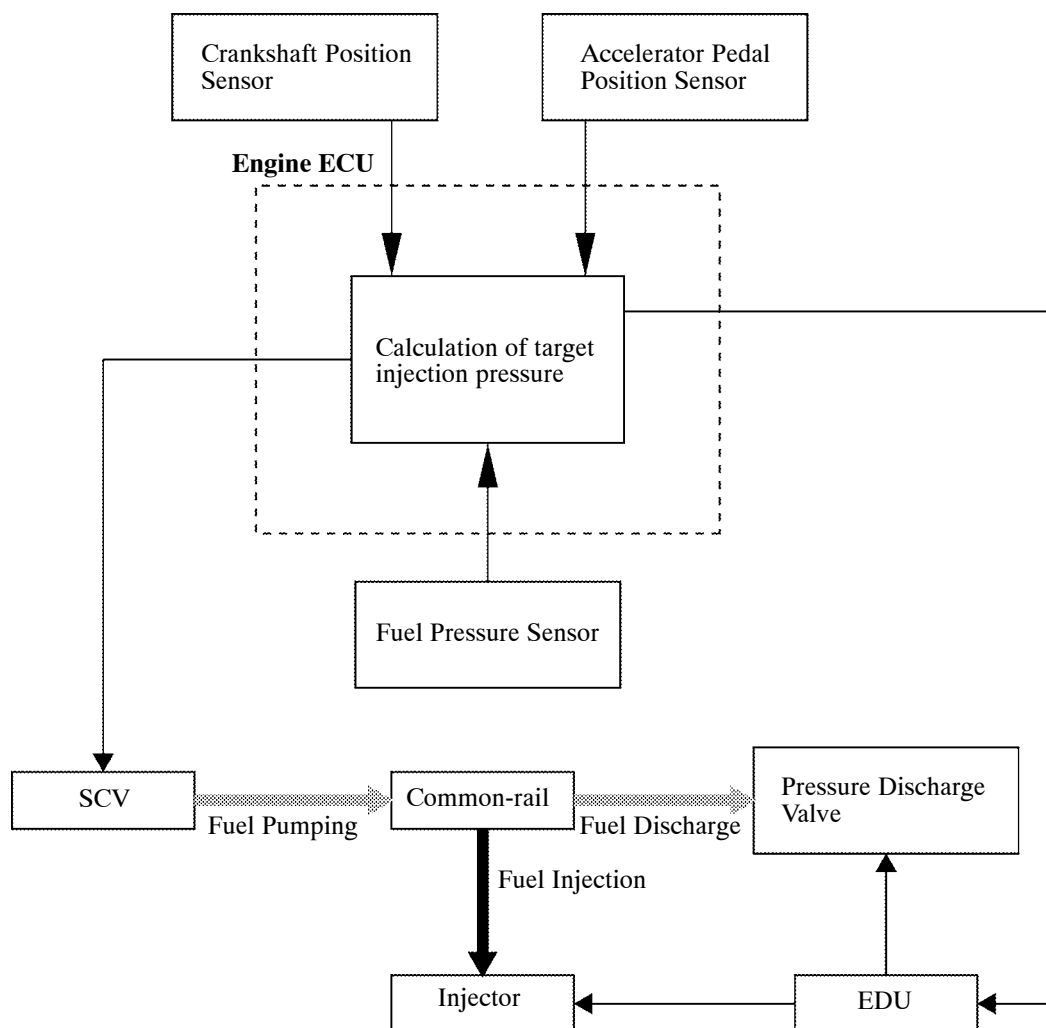


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8. Fuel Pressure Control

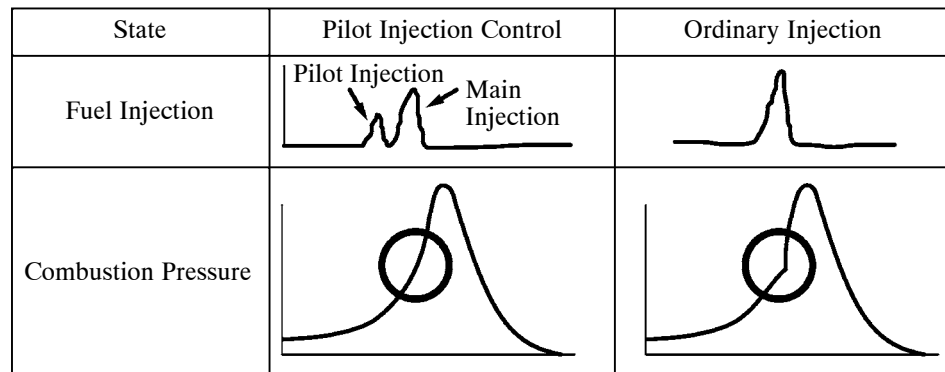
The engine ECU calculates the target injection pressure (25 - 180 MPa) based on the engine operating conditions, they include the signals from the accelerator pedal position sensor and the crankshaft position sensor.

To control fuel pressure, signals sent to the SCV (Suction Control Valve) of the supply pump regulate the pumping volume and signals sent to the pressure discharge valve of the common-rail regulate the discharge volume, to ensure that the pressure detected by the fuel pressure sensor matches the target injection pressure.



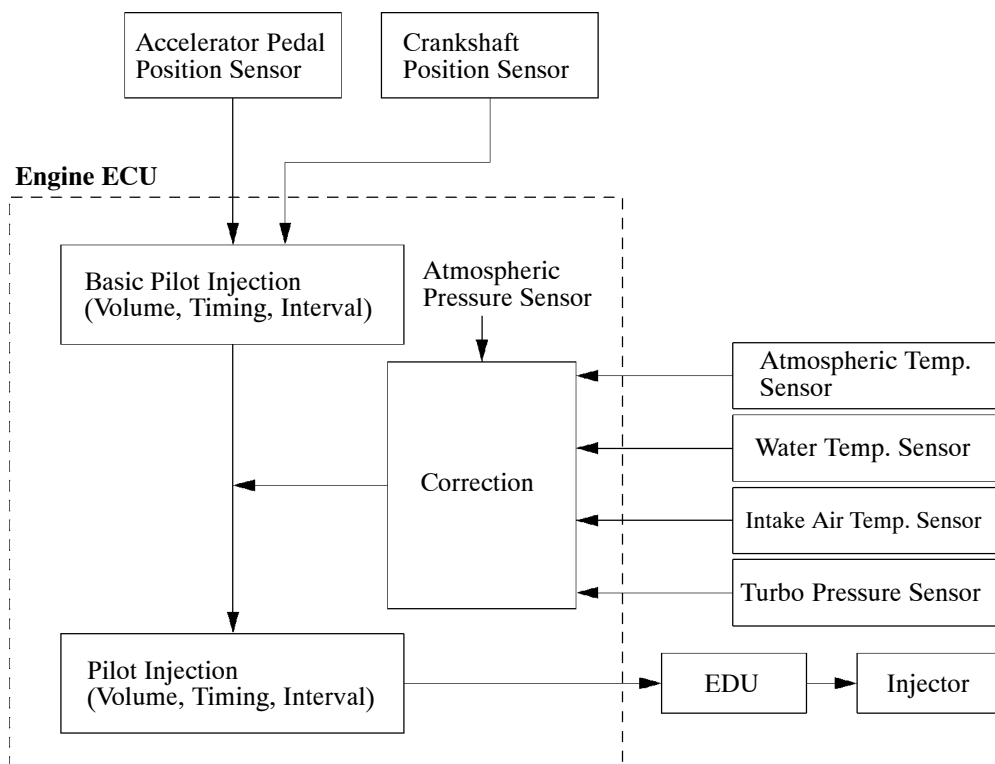
9. Pilot Injection Control

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



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



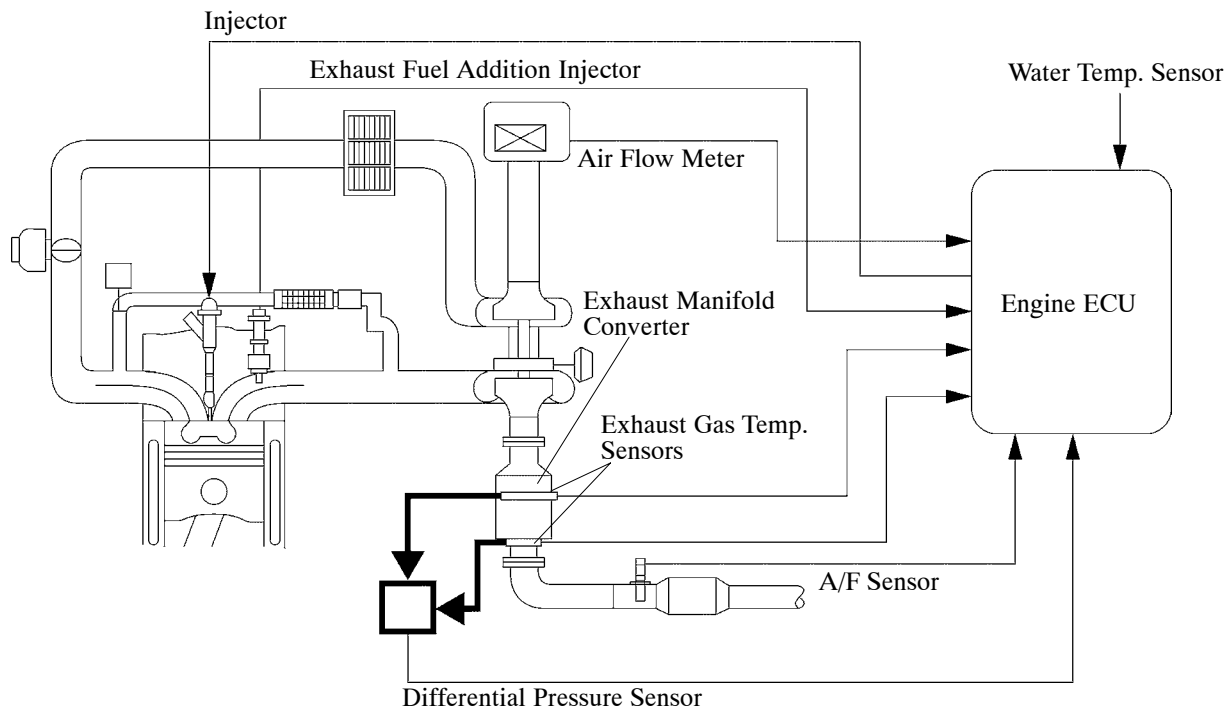
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10. Catalyst Support Control

General

The engine ECU judges exhaust manifold converter condition based on signals from the air flow meter, water temp. sensor, two exhaust gas temperature sensors, differential pressure sensor, and air fuel ratio sensor to control the injectors and exhaust fuel addition injector to cause catalyst support control.

- The catalyst support control consists of the NOx reduction control, PM (Particulate Matter = Carbon) reduction control, and sulfur poison recovery control.



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NOx Reduction Control

The engine ECU calculates the amount of NOx in the catalytic converter based on fuel injection volume, intake air volume, and exhaust gas temperature and then operates the injectors and exhaust fuel addition injector to cause NOx reduction control.

As a result of these injections, the air fuel ratio in the exhaust gas becomes rich to cause NOx to be reduced.

- Fuel efficiency momentarily drops during this control.

PM Reduction Control

If the DPNR catalytic converter temperature becomes low, catalyst performance decreases, resulting in an increase of the amount of PM stuck in the filter substrate. When the engine ECU detects clogging of the filter type catalyst substrate based on signals from the differential pressure sensor, it operates the injectors and exhaust fuel addition injector to cause PM reduction.

- As a result of these injections, the air fuel ratio in the exhaust gas becomes rich and active oxygen is generated by NOx reduction control.
- At the same time, the temperature of the filter type catalyst substrate becomes high and the PM reacts with active oxygen and changes into CO₂.
- Fuel efficiency drops during this control.

Sulfur Poison Recovery Control

The engine ECU calculates the sulfur volume in the catalyst converter based on the accumulated data of fuel injection volume and operates the injectors and exhaust fuel addition injector to cause sulfur poison recovery control.

As a result of these injectors, the air fuel ratio in the exhaust gas becomes rich to remove sulfur from the catalytic converter.

- Fuel efficiency drops during this control.

Service Tip

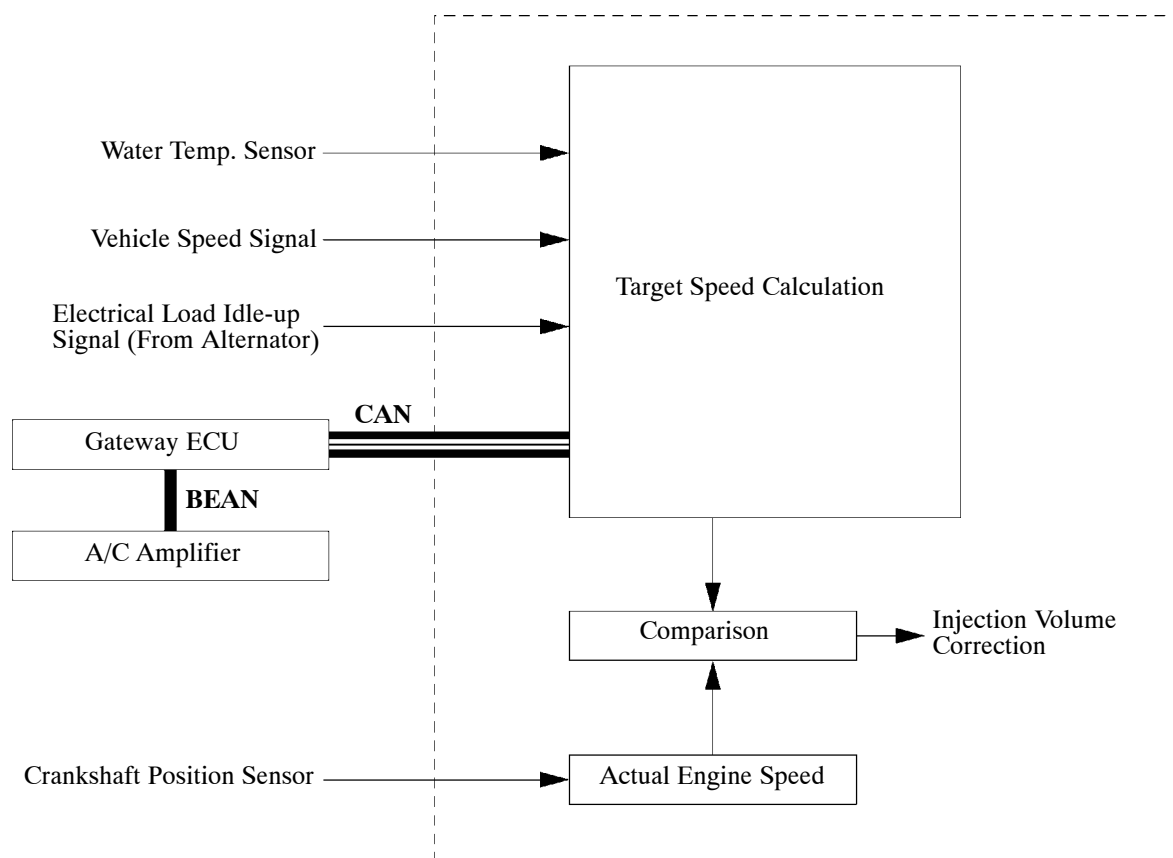
- When replacing the exhaust manifold converter with a new one, it is necessary to perform initialization of the DPNR catalyst deterioration data history in the Engine ECU using the intelligent tester II.
- When replacing the engine ECU with a new one, it is necessary to read DPNR catalyst deterioration data history from the old Engine ECU and then transfer that data history to the new Engine ECU using the intelligent tester II. When the DPNR catalyst deterioration data history is not transferred, DTC (Diagnostic Trouble Code) P1601 will be stored in the Engine ECU, and the check engine warning light will come on.
- When replacing both the exhaust manifold converter and the Engine ECU, it is necessary to perform initialization of the DPNR catalyst deterioration data history in the Engine ECU using the intelligent tester II. When DPNR catalyst deterioration history initialization is not performed, DTC (Diagnostic Trouble Code) P1601 will be stored in the Engine ECU and the check engine warning light will come on.

For details, see the LEXUS IS250/220d Repair Manual (Pub. No. RM0151E).

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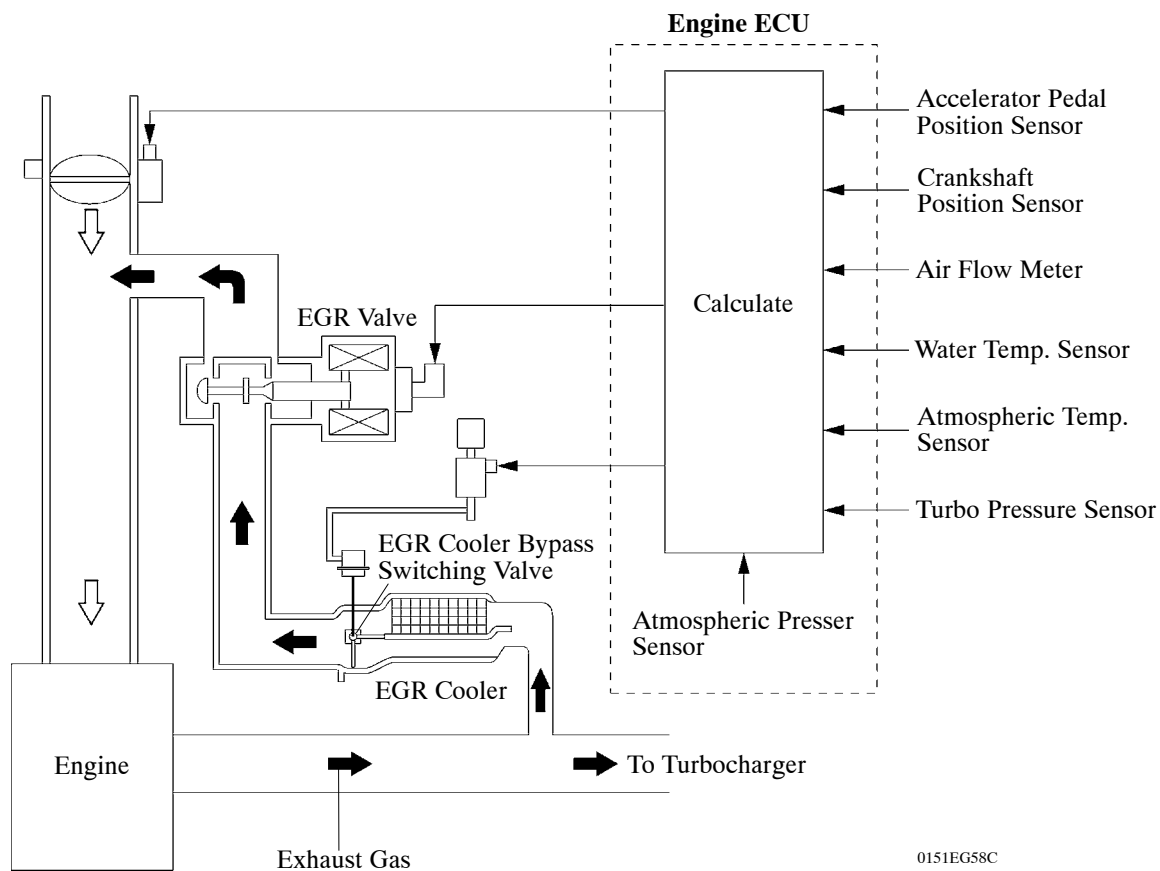
11. Idle Speed Control

In this system, the engine ECU calculates the target engine speed in accordance with the engine operating conditions, and determines the fuel injection volume, thus controlling the idle speed rpm.



12. EGR Control

By sensing the engine driving conditions, the engine ECU operates the EGR valve, diesel throttle control motor and VSV (for the EGR cooler bypass switching valve) and regulates the amount of EGR flow.

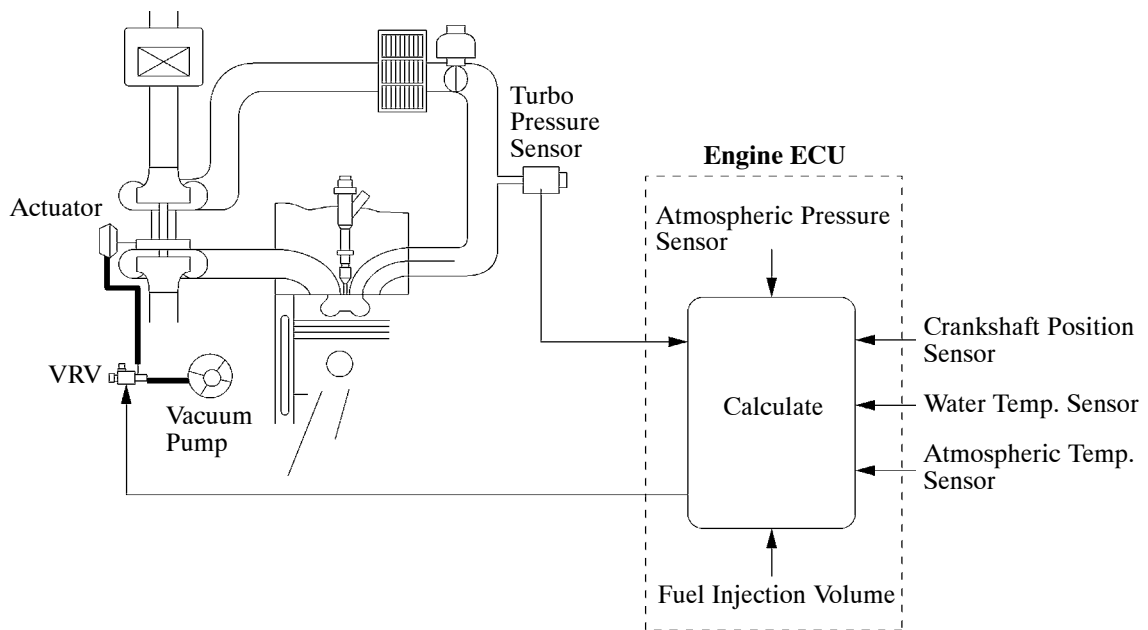


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13. Turbo Pressure Control

The engine ECU calculates the optimal turbo pressure in accordance with the driving conditions (engine speed, injection volume, atmospheric pressure, and water temperature). It controls the variable nozzle so that the turbo pressure as detected by the turbo pressure sensor matches the target turbo pressure.

- The variable nozzle vanes located in the exhaust turbine area of the turbocharger control the turbo pressure. The actuator that is directly connected to this nozzle operates it. The actuator is operated by the vacuum pressure that has been regulated by the VRV (Vacuum Regulating Valve) in accordance with the signals from the engine ECU.



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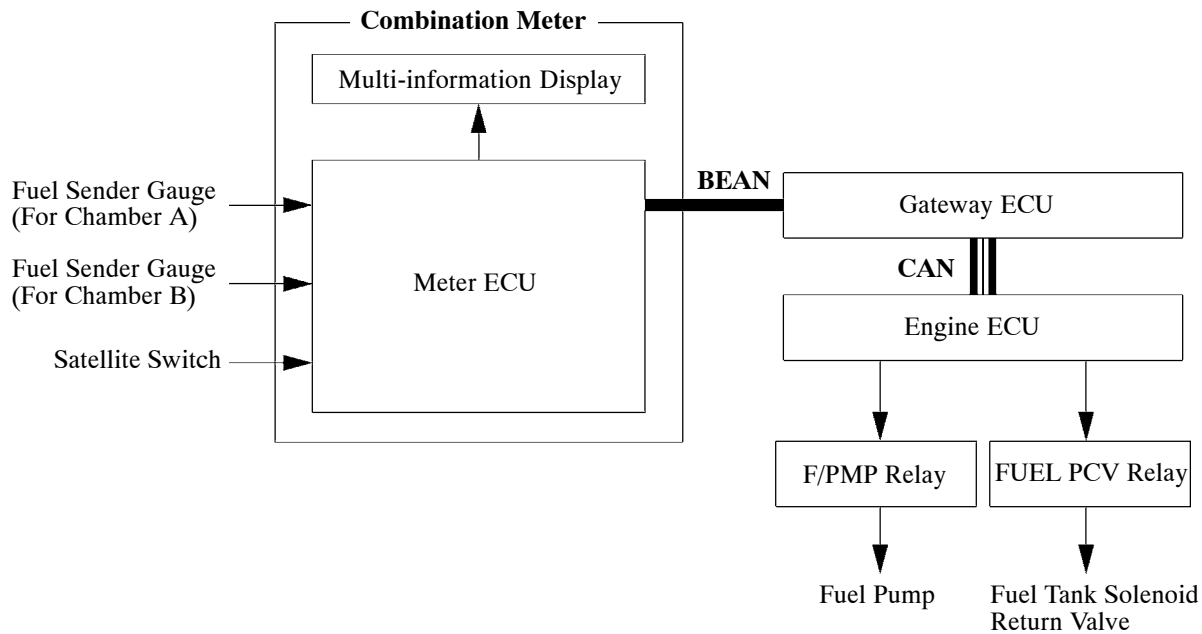
14. Fuel Pump Control

General

The fuel pump control system can transfer fuel from one side of the saddle shaped fuel tank to the other side. It is also able to perform an auto-priming operation to bleed air from the engine mounted fuel supply pump.

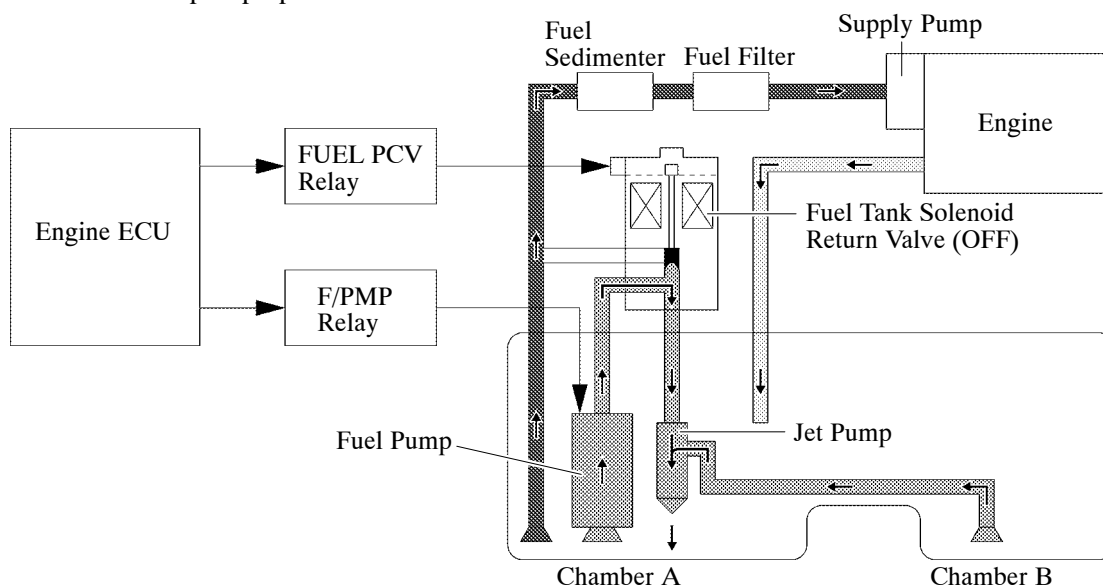
- Based on the signals from the fuel sender gauges, the engine ECU operates the fuel pump located in the fuel tank to transfer fuel within the fuel tank.
- Based on the signals from the satellite switch, the engine ECU operates the fuel pump and fuel tank solenoid return valve (fuel path switching valve) to perform the auto-priming operation.
- Control of this system requires the engine ECU, fuel pump, fuel tank solenoid return valve, two relays, satellite switch, combination meter, and two fuel sender gauges.

► System Diagram ◀



Construction and Operation

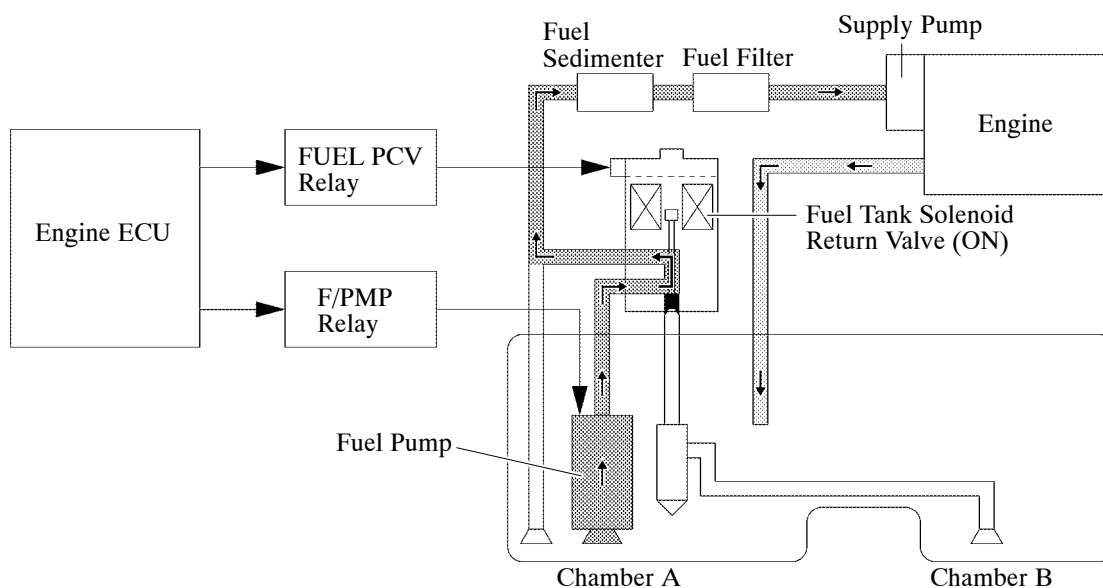
- In the saddle-shaped fuel tank, fuel remains in chambers A and B when the fuel level is low. Fuel is supplied to the engine by the supply pump from chamber A. Therefore, fuel remaining in chamber B needs to be transferred to chamber A. In this system, the engine ECU operates the fuel pump to transfer the fuel from chamber B to chamber A using the jet pump built into the fuel pump.
- The basic structure and operation of the jet pump for a vehicle equipped with the 2AD-FHV engine is the same as the jet pump of the 4GR-FSE engine. For details, see page EG-35.
- The engine ECU receives signals from each fuel level sender gauge. Using this and other information it determines the fuel level in the tank and the amount of fuel consumed. Based on fuel level and fuel consumption, the engine ECU controls the amount of fuel that is transferred from chamber B to chamber A and stops the transfer operation when the fuel level in both chambers becomes the same. This control minimizes fuel pump operation.



Fuel Transfer Operation

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- The priming operation can be performed using the satellite switch.
- Based on a signal from the satellite switch, the engine ECU turns the fuel tank solenoid return valve on and changes the route of the fuel discharged from the fuel pump in order to perform the priming operation.



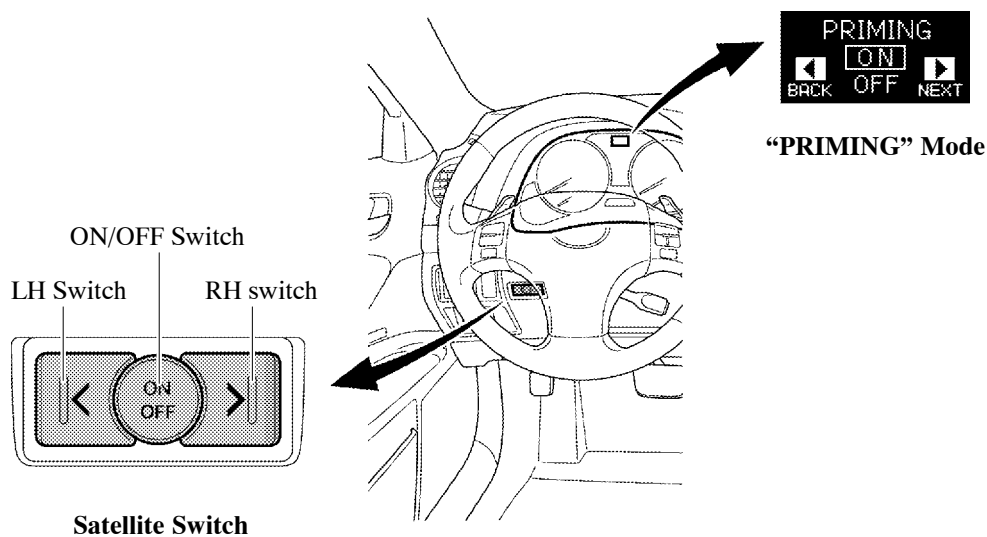
Priming Operation

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Service Tip

If the vehicle runs out of fuel and the engine dies, perform the priming operation as follows:

- 1) Refuel the vehicle.
 - 2) Power source is IG-ON.
 - 3) Press the right, left, or center of the satellite switch to activate the multi-switch mode on the multi-information display.
 - 4) Select “PRIMING” using the multi-switch mode of the satellite switch (RH or LH switch).
 - 5) To start the priming operation, press the ON/OFF switch on the satellite switch and select ON.
 - 6) Wait for 1 minute and start the engine. (The priming operation will automatically stop when the engine starts.)
- If the engine does not start after the above steps performed, wait for 10 seconds and perform steps 5 and 6 again.



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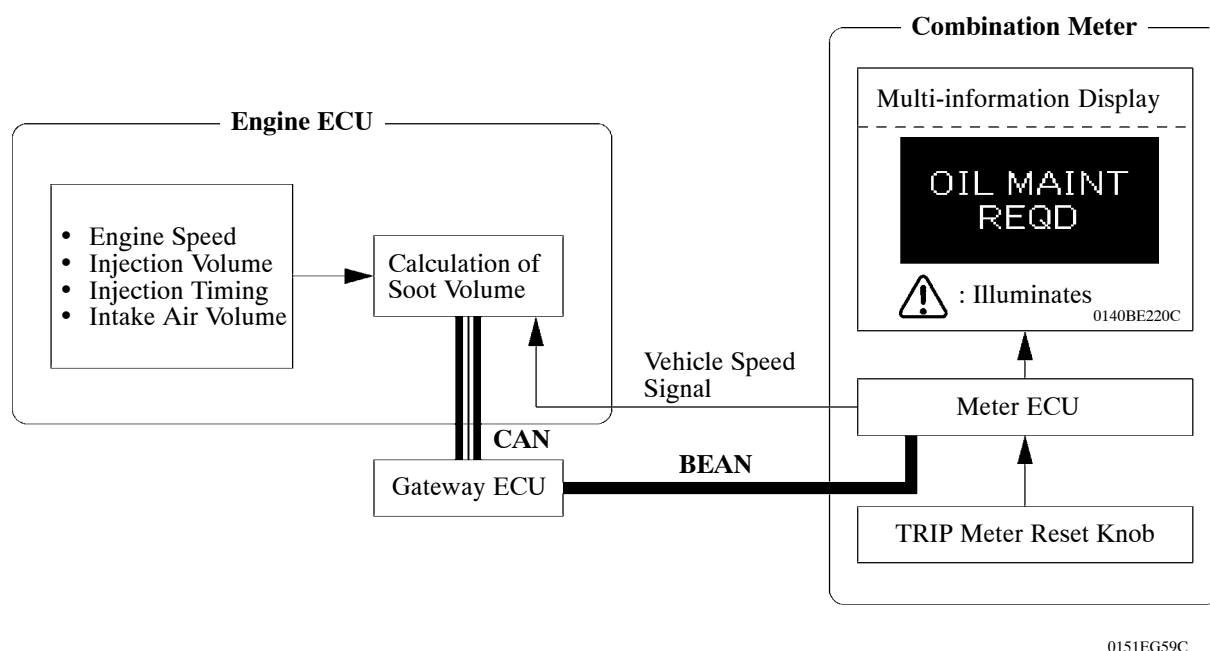
15. Oil Maintenance Management System

General

In this oil maintenance management system, the soot volume in the engine oil is calculated based on the engine operating conditions. Based on the calculated soot volume, the engine ECU displays an “OIL MAINT REQD” warning on the multi-information display to inform the driver when it is necessary to change the engine oil.

- The engine ECU calculates soot volume from the vehicle speed, engine speed, injection volume, injection timing and intake air volume in order to operate this system.

► System Diagram ◀

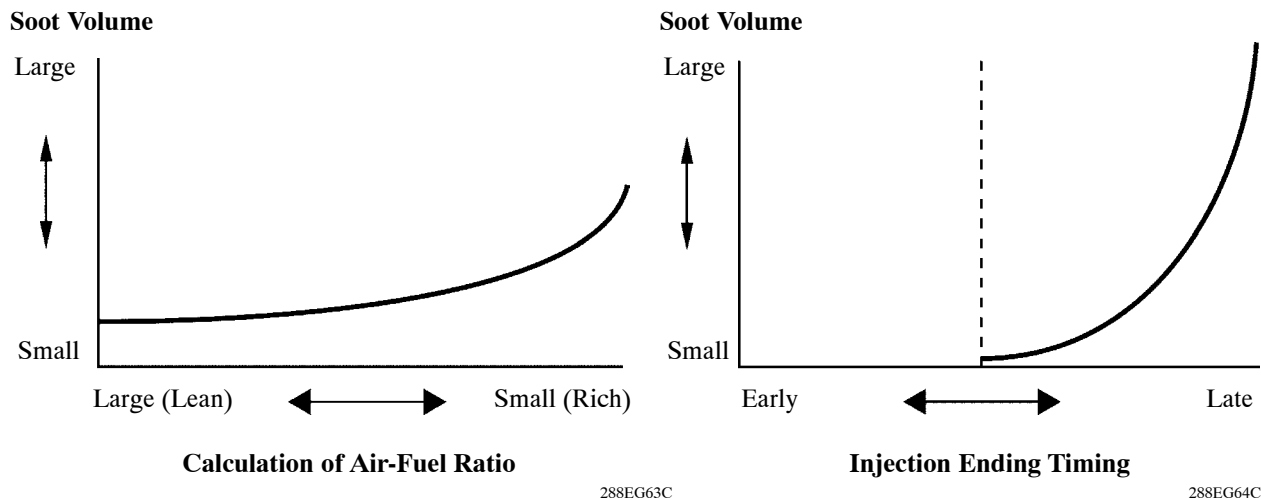


Service Tip

Since this system is controlled based on engine operating conditions, the “OIL MAINT REQD” warning may be displayed before driving 30,000 km (the maximum travel distance after oil maintenance). If the “OIL MAINT REQD” warning is displayed, immediately replace the oil and oil filter.

Soot Volume Calculation Method

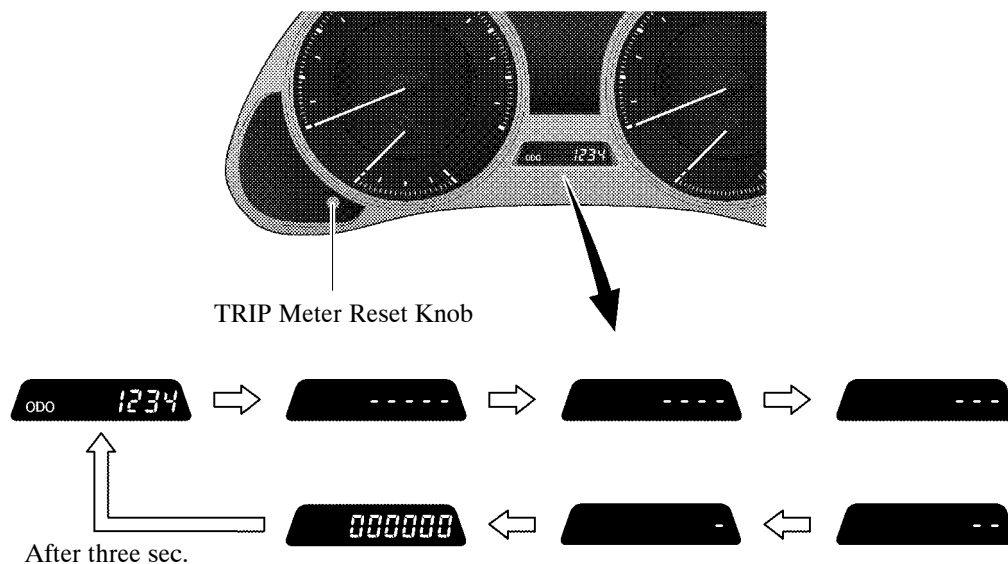
The soot volume largely depends on injection ending timing and air-fuel ratio. The engine ECU calculates soot volume from this information as shown in the graphs below.



Service Tip

The accumulated soot volume memorized in engine ECU can be reset using the following procedures.

- 1) Power source is IG-ON and make sure that the odometer is displayed on the LCD of the combination meter.
- 2) Switch the power source OFF. While pushing the "TRIP" meter reset knob, switch the power source to IG-ON.
- 3) With the power source in the IG ON mode, keep holding the "TRIP" meter reset knob (for at least five seconds) with the LCD counting down as shown below. Release the "TRIP" meter reset knob when the resetting has completed.
- 4) As the resetting completes, the LCD will display "000000" for one second. Then, the LCD will display the odometer.



16. Diagnosis

- The diagnosis system uses EURO-OBD (Europe On-Board Diagnosis) which complies with European regulations.
- When the Engine ECU detects a malfunction, the Engine ECU will record a DTC (Diagnostic Trouble Code) and memorize the data that relates to the malfunction. Furthermore, the check engine warning light in the combination meter will illuminate to inform the driver.
- The Engine ECU will also store the DTCs (Diagnostic Trouble Codes) that relate to the malfunctions. The DTCs can be accessed using the intelligent tester II.
- For details, see the LEXUS IS250/220d Repair Manual (Pub. No. RM0151E).

Service Tip

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

EG

17. Fail-Safe

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

► Fail-Safe Chart ◀

DTC No.	Fail-Safe Operation	Fail-Safe Deactivation Conditions
P0031	Limits the engine power.	“Pass” condition detected
P0032	Limits the engine power.	“Pass” condition detected
P0087	Limits the engine power.	Ignition switch OFF
P0088	Limits the engine power.	Ignition switch OFF
P0093	Limits engine power for 1 minute and then stalls engine.	Ignition switch OFF
P0095, P0097, P0098	A fixed value (180°C (356°F)) is used for the intake air (intake manifold) temperature.	“Pass” condition detected
P0100, P0102, P0103	Limits the engine power.	“Pass” condition detected
P0105, P0107, P0108	A fixed value is used for the turbo pressure sensor reading.	“Pass” condition detected
P0110, P0112, P0113	A fixed value is used for the intake air (built in mass air flow meter) temperature.	“Pass” condition detected
P0115, P0117, P0118	A fixed value is used for the engine coolant temperature sensor reading (fixed value varies depending on conditions)	“Pass” condition detected
P0120, P0122, P0123	Limits the engine power.	Ignition switch OFF
P0168	Limits the engine power.	“Pass” condition detected
P0180, P0182, P0183	A fixed value is used for the fuel temperature.	“Pass” condition detected
P0190, P0191, P0192, P0193	Limits the engine power.	Ignition switch OFF
P0200	When one injector circuit is malfunctioning, engine power is limited, when 2 or more ignition circuits are malfunctioning, engine is stopped.	Ignition switch OFF

(Continued)

DTC No.	Fail-Safe Operation	Fail-Safe Deactivation Conditions
P0234	Limits the engine power.	Ignition switch OFF
P0335	Engine is stopped.	“Pass” condition detected
P0340	Limits the engine power.	“Pass” condition detected
P0400	Limits the engine power.	Ignition switch OFF
P0405, P0406 P0488	Limits the engine power.	Ignition switch OFF
P0500	A fixed value of 0 km/h (0 mph) is used for the vehicle speed.	“Pass” condition detected
P0544, P0545 P0546	Limits the engine power.	Ignition switch OFF
P0627	Limits the engine power.	“Pass” condition detected
P1229	Limits the engine power.	Ignition switch OFF
P1251	Limits the engine power.	Ignition switch OFF
P1271	Limits the engine power.	Ignition switch OFF
P1272	Limits the engine power.	Ignition switch OFF
P1386	- Low or excess fuel addition volume: No fail-safe operation. - Low fuel addition volume: Limits the engine power (Driving at vehicle speed of up to approximately 80 km/h [50 mph] is possible). - Stuck open Limits the engine power (Driving at vehicle speed of up to approximately 10 km/h [6 mph] is possible).	Ignition switch OFF
P1425, P1427, P1428	A fixed value is used for the differential pressure sensor reading.	Ignition switch OFF
P1611	Engine is stopped.	Ignition switch OFF
P1625	Limits the engine power.	Normal condition is restored
P2002*	Limits the engine power.	Ignition switch OFF
P2031, P2032, P2033	Limits the engine power.	Ignition switch OFF
P2047	Limits the engine power.	Ignition switch OFF
P2048	Limits the engine power.	Ignition switch OFF
P2049	Limits the engine power.	Ignition switch OFF
P2120, P2121, P2122, P2123, P2125, P2127, P2128, P2138	Limits the engine power.	Ignition switch OFF
P2226, P2228, P2229	A fixed value is used for the atmospheric pressure sensor reading.	“Pass” condition detected

*: Fail-safe operation is not performed when a DTC is detected because of deterioration of the DPNR catalyst.