■ENGINE CONTROL SYSTEM

1. General

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

System	Outline
Fuel Injection Volume Control (See page EG-192)	Based on the signals received from the sensors, the ECM determines the fuel injection volume in accordance with the engine condition.
Fuel Injection Timing Control (See page EG-193)	Based on the signals received from the sensors, the ECM determines the fuel injection timing in accordance with the engine condition.
During Starting Control (See page EG-194)	To facilitate startability, the ECM optimally controls the injection volume and injection timing during starting.
Idle Speed Control (See page EG-195)	The ECM determines the idle speed in accordance with the engine condition, and controls the fuel injection volume in order to maintain the target idle speed.
Fuel Pressure Control (See page EG-196)	Based on the signals received from the sensors, the ECM controls fuel pressure using the SCV (Suction Control Valve) according to the engine condition.
Pilot Injection Control (See page EG-199)	Based on the signals received from the sensors, the ECM determines pilot injection volume/timing, and interval (between pilot injection and main injection) in accordance with the engine condition.
Glow Plug Control	Controls the length of time when the current is applied to the glow plugs, in accordance with the engine coolant temperature.
Throttle Control (See page EG-200)	• Based on the signals received from the various sensors, the ECM determines throttle valve position in accordance with the engine condition. • Fully close the throttle valve in order to reduce the vibration when the engine is stopped.
Turbocharger Control (See page EG-201)	Based on the signals received from the sensors, the ECM controls the actuator via the turbo motor driver in accordance with the engine conditions.
Fuel Pump Control*1 (See page EG-205)	Based on the signals from the sensors, the ECM operates the fuel pump to optimally control the transfer of the fuel from the fuel sub tank to the fuel tank.
EGR Control*2 (See page EG-206)	Based on the signals received from the sensors, the ECM determines the EGR volume via EGR valve and throttle valve in accordance with the engine condition.
Engine Mounting Control (See page EG-207)	When the engine speed and the vehicle speed are low, this control utilizes vacuum to soften the engine mounting characteristics in order to restrain the engine vibration.
Oil Maintenance Management*3 (See page EG-210)	When the ECM determines engine oil deterioration, the engine oil change reminder light turns on to inform the driver.

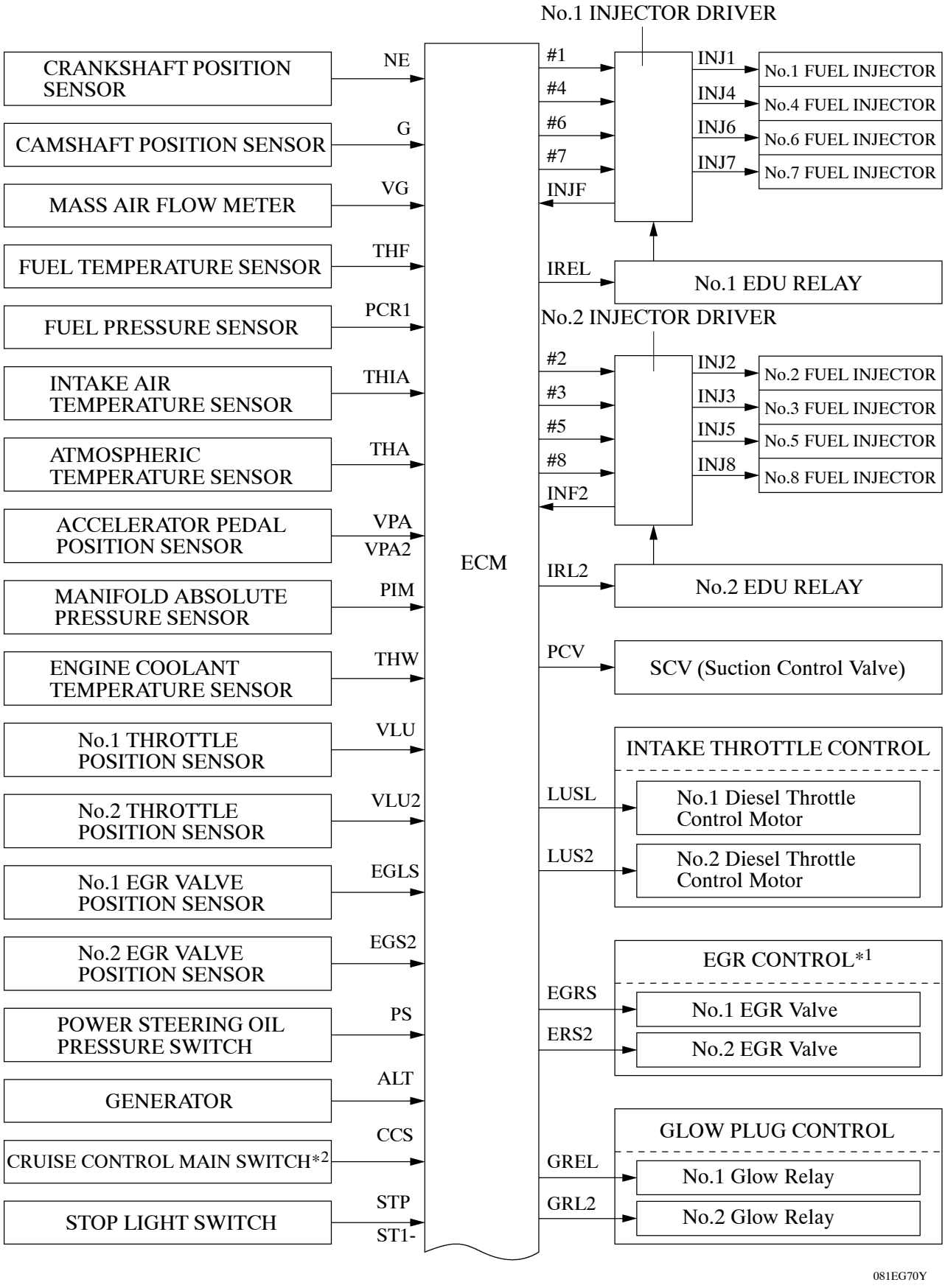
(Continued)

System	Outline
Starter Control (Cranking Hold Function)	• Once the engine switch is pushed, this control continues to operate the starter until the engine is started. • The basic construction and operation of the starter control are the same as in the 1GR-FE engine. For details, see page EG-70.
Air Conditioner Cut-off Control	By controlling the air conditioner compressor ON or OFF in accordance with the engine condition, drivability is maintained.
Engine Immobilizer	Prohibits fuel injection if an attempt is made to start the engine with an invalid key.
Diagnosis [See page EG-212]	When the ECM detects a malfunction, the ECM records the malfunction and memorizes information related to the fault.
Fail-safe [See page EG-212]	When the ECM detects a malfunction, the ECM stops or controls the engine according to the data already stored in the memory.

*1: Only on models with dual fuel tank
*2: Only on models complying with emission regulations (EURO II, EURO III, EURO IV)
*3: Only on European models complying with EURO IV

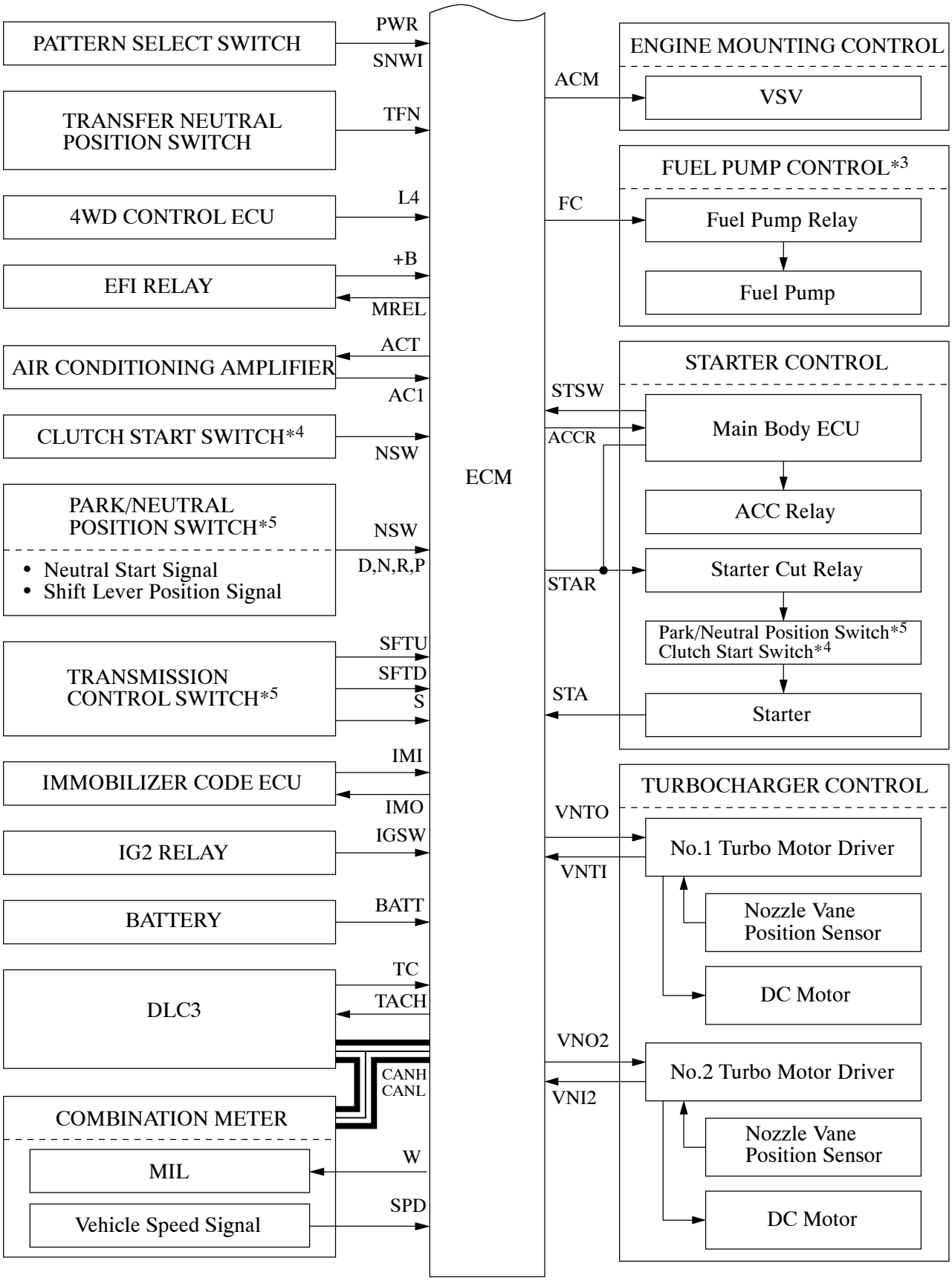
2. Construction

The configuration of the engine control system in the 1VD-FTV engine is as shown in the following chart.



081EG70Y

(Continued)

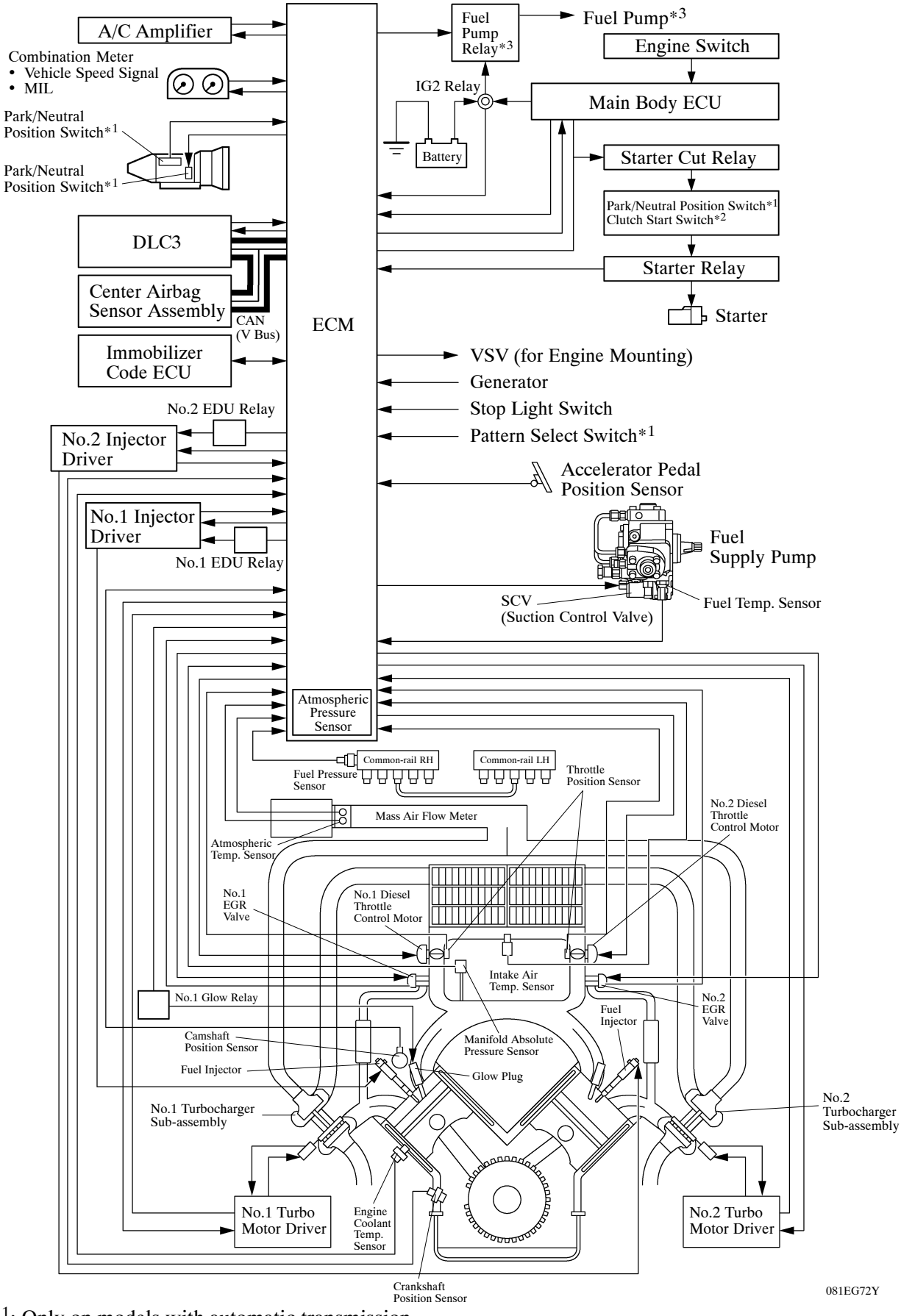


081EG71Y

*1: Only on models complying with the emission regulations
*2: Only on models with cruise control system
*3: Only on models with dual fuel tank
*4: Only on models with manual transmission
*5: Only on models with automatic transmission

EG

3. Engine Control System Diagram

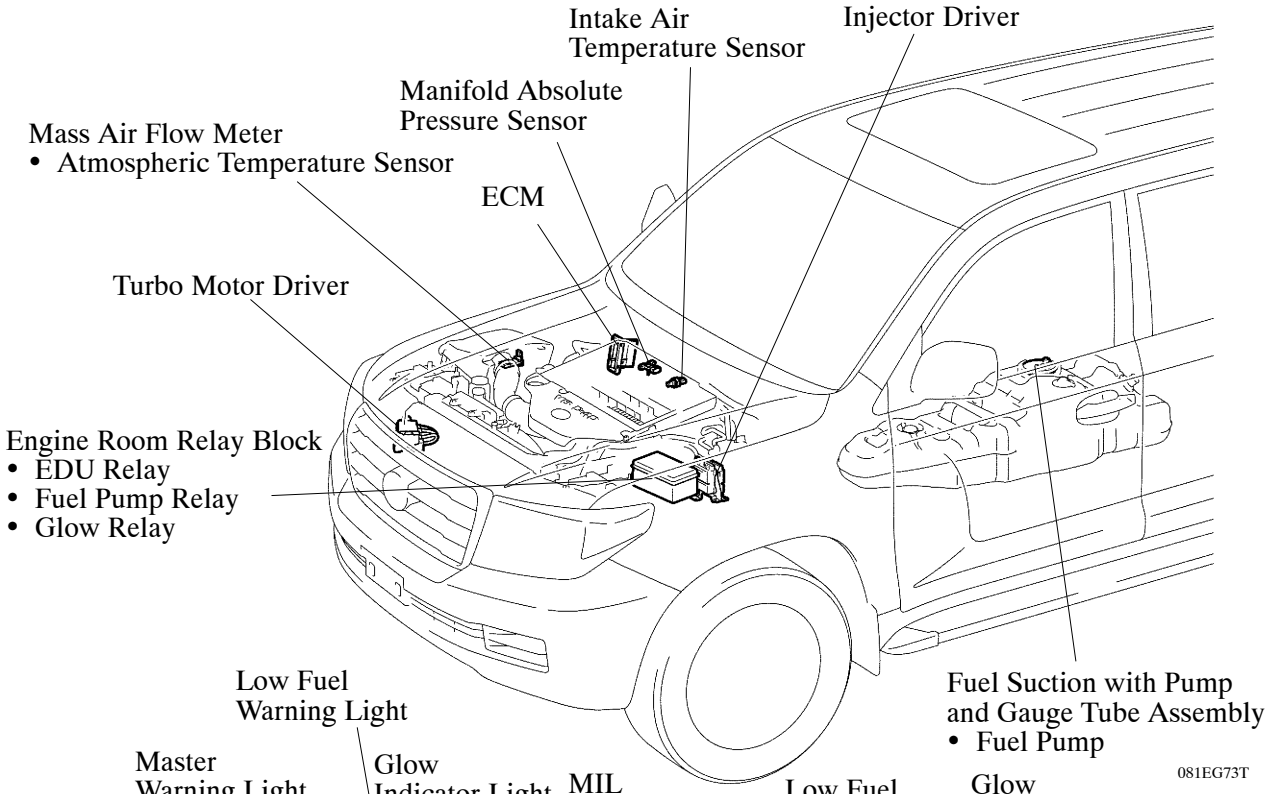


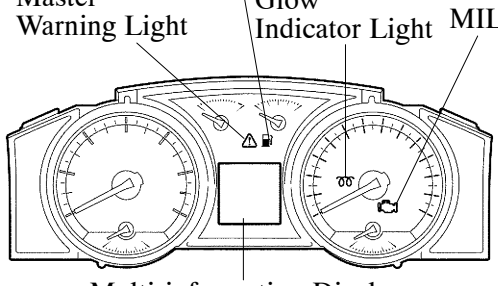
*1: Only on models with automatic transmission

*2: Only on models with manual transmission

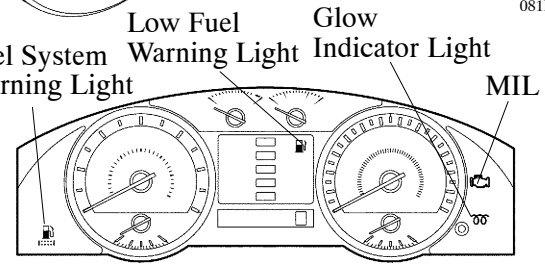
*3: Only on models with dual fuel tank

4. Layout of Main Components

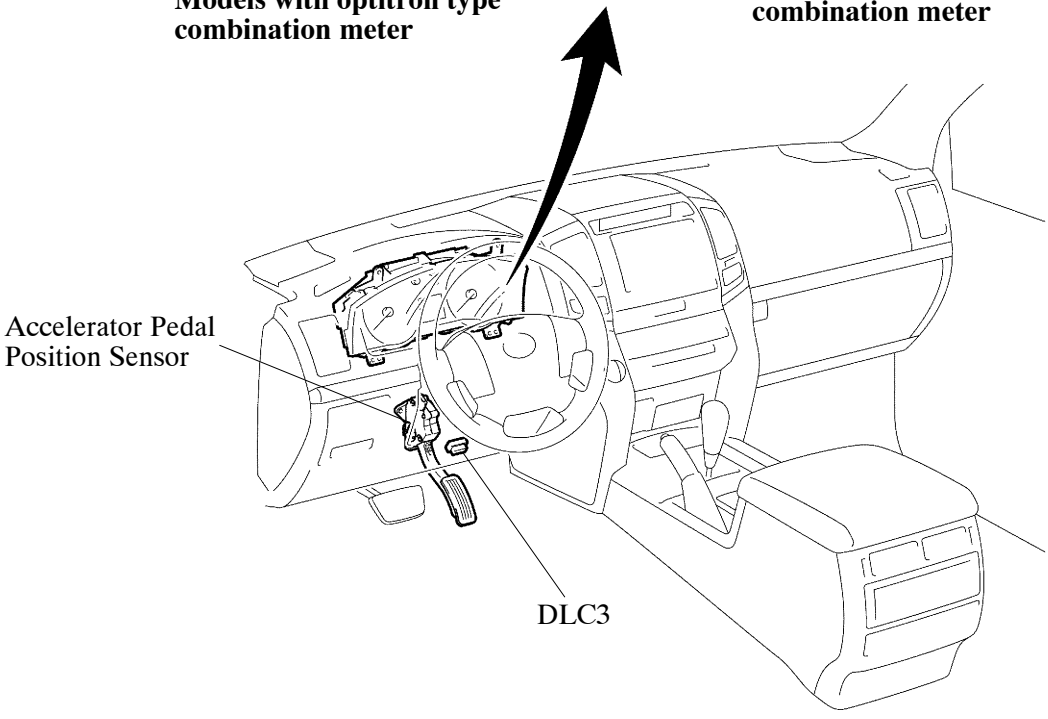




Models with optitron type combination meter



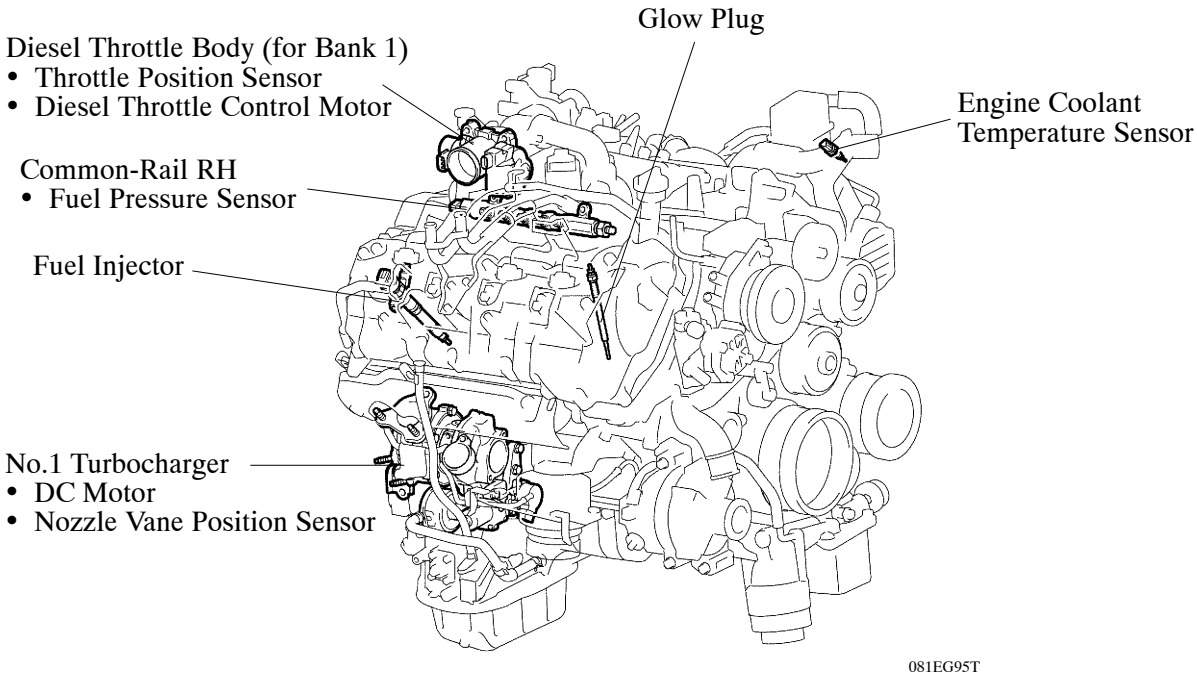
Models with analog type combination meter

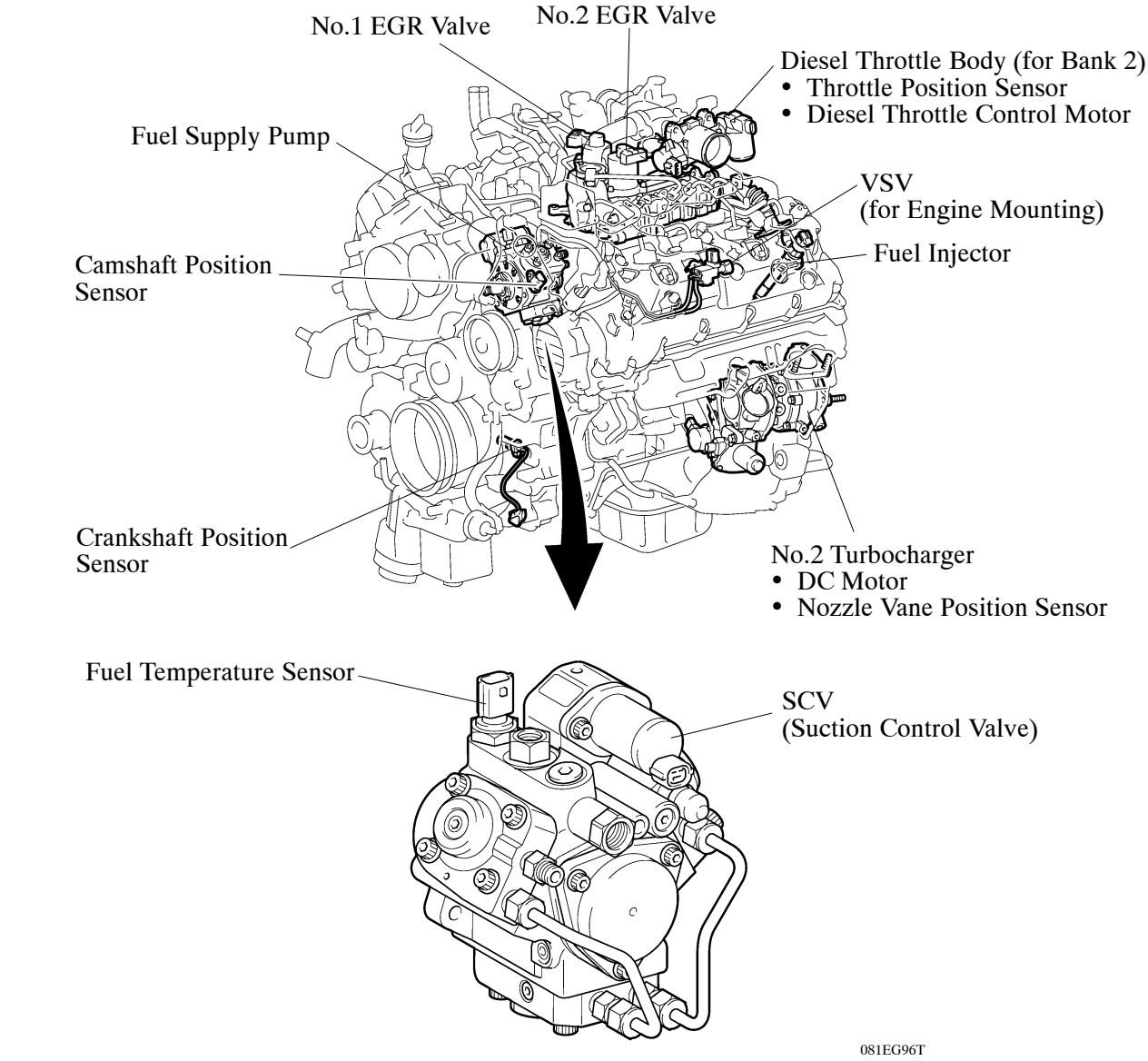


LHD Models with Dual Fuel Tank

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EG


Glow Plug
Diesel Throttle Body (for Bank 1)
• Throttle Position Sensor
• Diesel Throttle Control Motor
Engine Coolant Temperature Sensor
Common-Rail RH
• Fuel Pressure Sensor
Fuel Injector
No.1 Turbocharger
• DC Motor
• Nozzle Vane Position Sensor
081EG95T


No.1 EGR Valve
No.2 EGR Valve
Diesel Throttle Body (for Bank 2)
• Throttle Position Sensor
• Diesel Throttle Control Motor
Fuel Supply Pump
VSV
(for Engine Mounting)
Camshaft Position Sensor
Fuel Injector
Crankshaft Position Sensor
No.2 Turbocharger
• DC Motor
• Nozzle Vane Position Sensor
Fuel Temperature Sensor
SCV
(Suction Control Valve)
081EG96T

5. Main Components of Engine Control System

General

The main components of the 1VD-FTV engine control system are as follows:

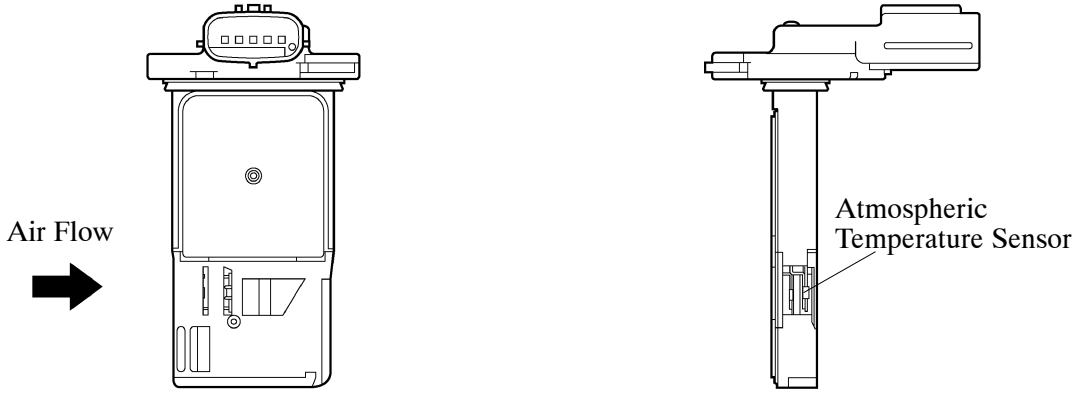
Components	Outline	Quantity	Function
ECM	32-bit CPU (DENSO)	1	The ECM effects overall control of the engine control system to suit the operating conditions of the engine in accordance with the signals provided by the sensors.
Injector Driver	DC/DC Converter	2	The injector driver is used to drive the fuel injector at high speeds. The injector driver 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.
Mass Air Flow Meter [See page EG-188]	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 detects the atmospheric temperature by means of an internal thermistor.
Fuel Pressure Sensor [See page EG-189]	Semiconductor Strain Gauge Type	1	This sensor uses built-in semiconductors to detect the internal pressure of the common-rail.
Manifold Absolute Pressure Sensor [See page EG-189]	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 ECM, uses semiconductors to detect the atmospheric pressure.
Crankshaft Position Sensor [See page EG-190]	Pick-up Coil Type (Rotor Teeth /36-2)	1	This sensor detects the engine speed and performs the cylinder identification.
Camshaft Position Sensor [See page EG-190]	Pick-up Coil Type (Rotor Teeth /1)	1	This sensor performs the cylinder identification.
Throttle Position Sensor [See page EG-191]	Non-contact Type	2	This sensor detects the throttle valve opening angle.
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 1GR-FE engine. For details, see page EG-54.
Engine Coolant 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 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.
SCV (Suction Control Valve)	Linear Solenoid Valve	1	The SCV position is controlled by the signals from the ECM, and a fuel volume that suits the SCV position is drawn into the pumping portion (plunger portion).
Fuel Injector [See page EG-165]	9-hole Type	8	The fuel 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.

Mass Air Flow Meter

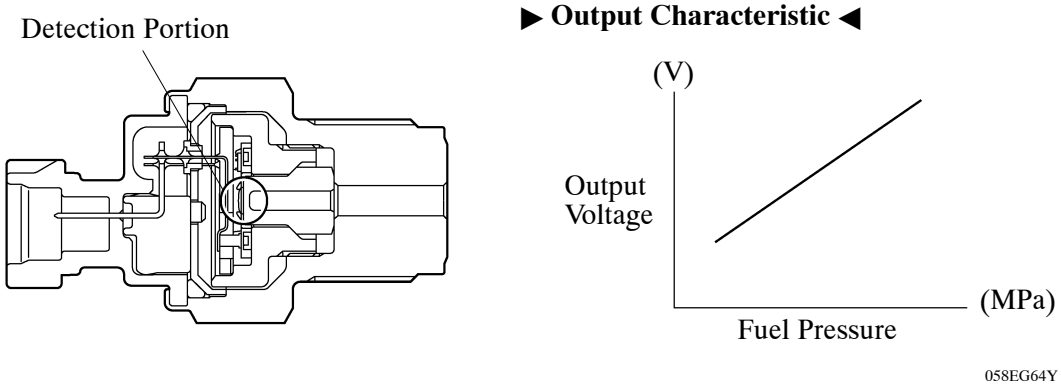
- The mass air flow meter of diesel engine uses precise fuel injection volume control and EGR control to realize clean emission.
- This mass air flow meter, which is a slot-in type, allows a portion of the intake air to flow through the detection area. By directly measuring the mass and the flow rate of the intake air, the detection precision is improved and the intake air resistance is reduced.
- The mass air flow meter has a built-in atmospheric temperature sensor.



273GX15

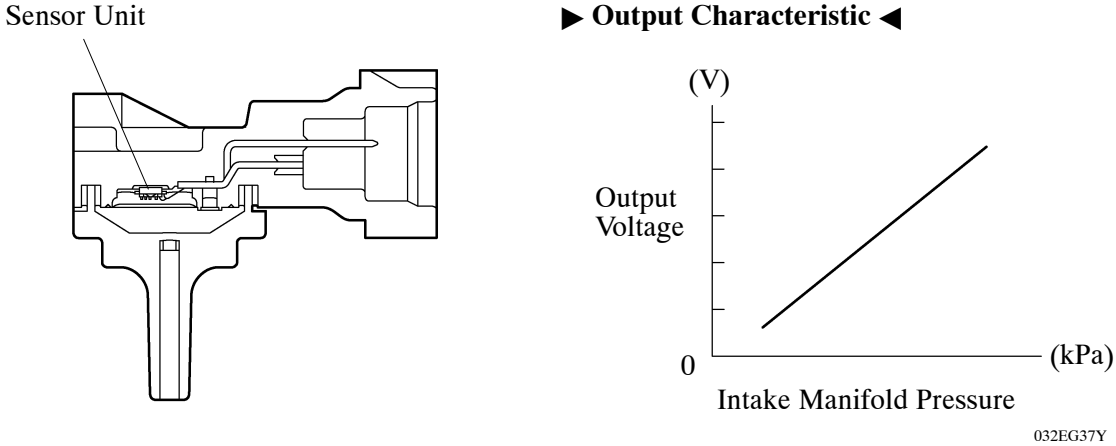
Fuel Pressure Sensor

The fuel 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. This sensor is mounted on the common-rail, outputs a signal that represents the fuel pressure in the common-rail to the ECM, in order to constantly regulate the fuel at an optimal pressure.



Manifold Absolute Pressure Sensor

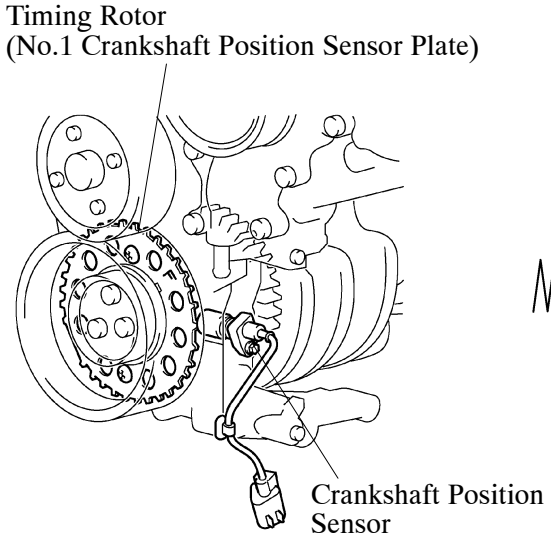
The manifold absolute pressure sensor consists of a semiconductor which utilizes the characteristic of a silicon chip that changes its electrical resistance when pressure is applied to it. The sensor converts the intake air pressure into an electrical signal, and sends it to the ECM in an amplified form.



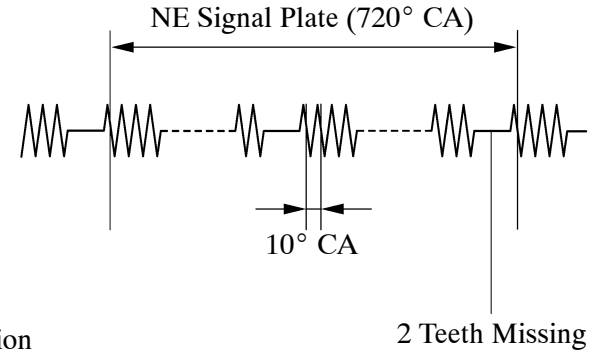
EG

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.



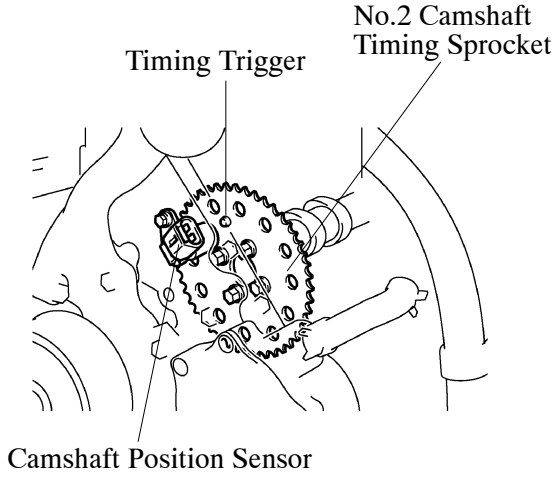
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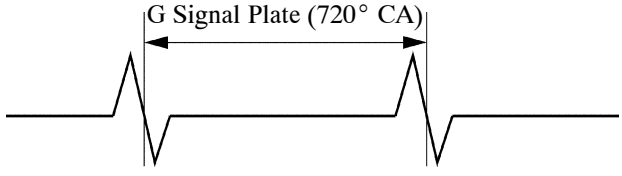
240EG90

Camshaft Position Sensor

The camshaft position sensor generates one signal in every two revolutions of the crankshaft by using the timing trigger of the No.2 camshaft timing sprocket.



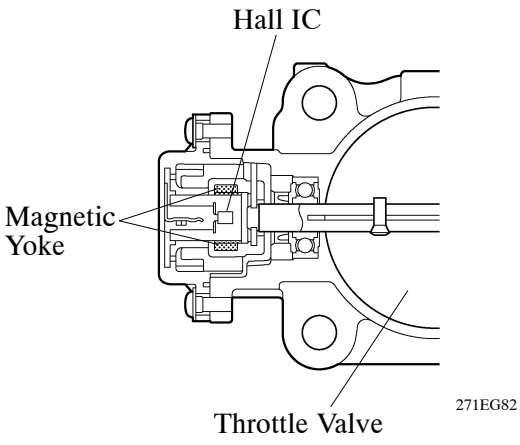
058EG57Y



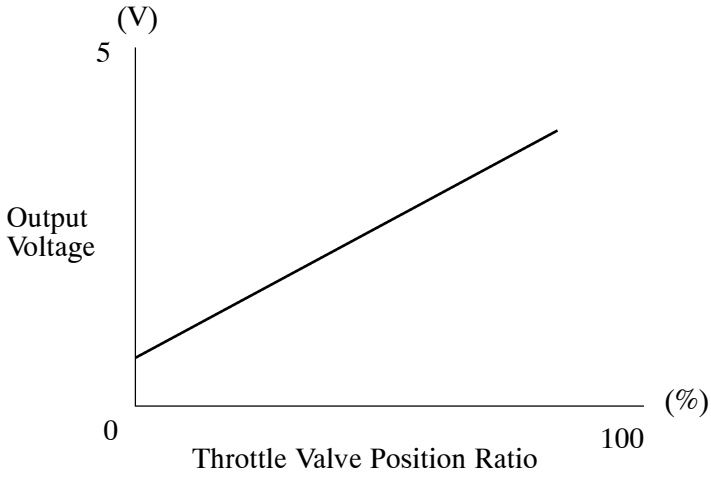
288EG95C

Throttle Position Sensor

The throttle position sensor is mounted on the diesel 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 diesel throttle control motor.



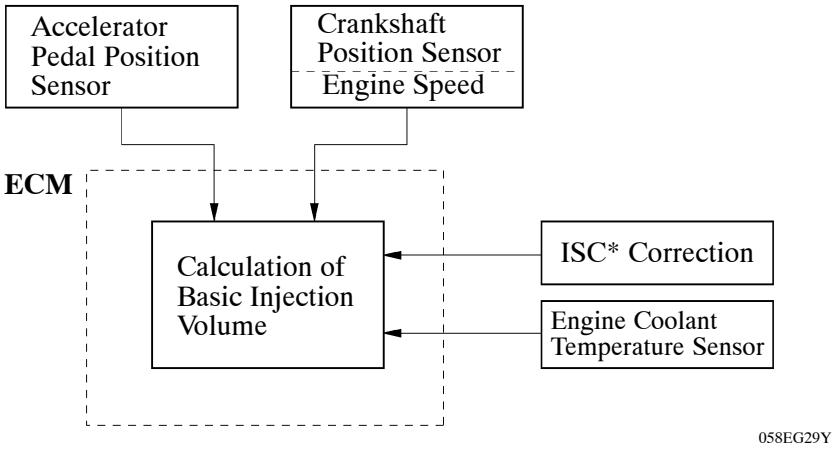
▶ Output Characteristic ◀



6. Fuel Injection Volume Control

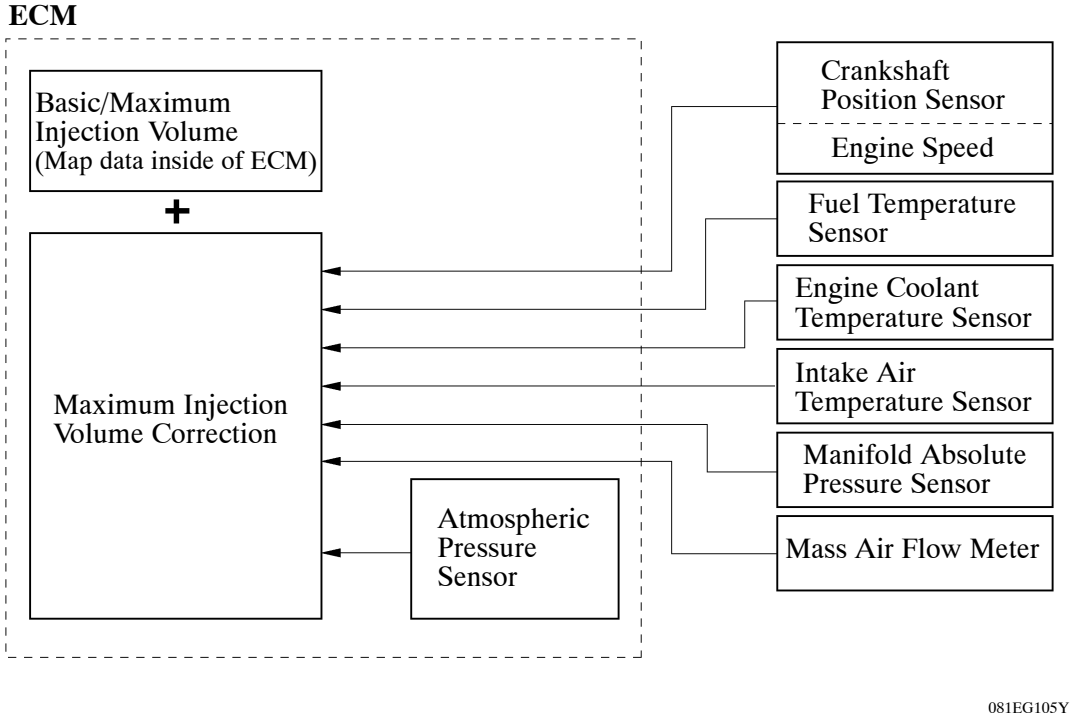
The ECM calculates two types of values: the basic injection volume and the maximum injection volume. Then, the ECM compares the basic and maximum injection volumes, and determines a smaller calculated value to be the final injection volume.

▶ Basic Injection Volume ◀

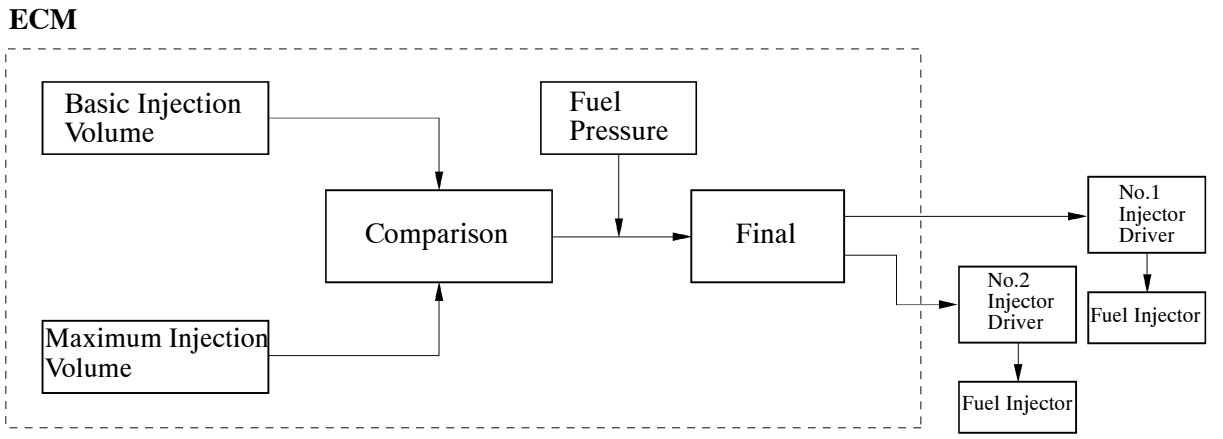


*: Idle Speed Control

▶ Maximum Injection Volume ◀



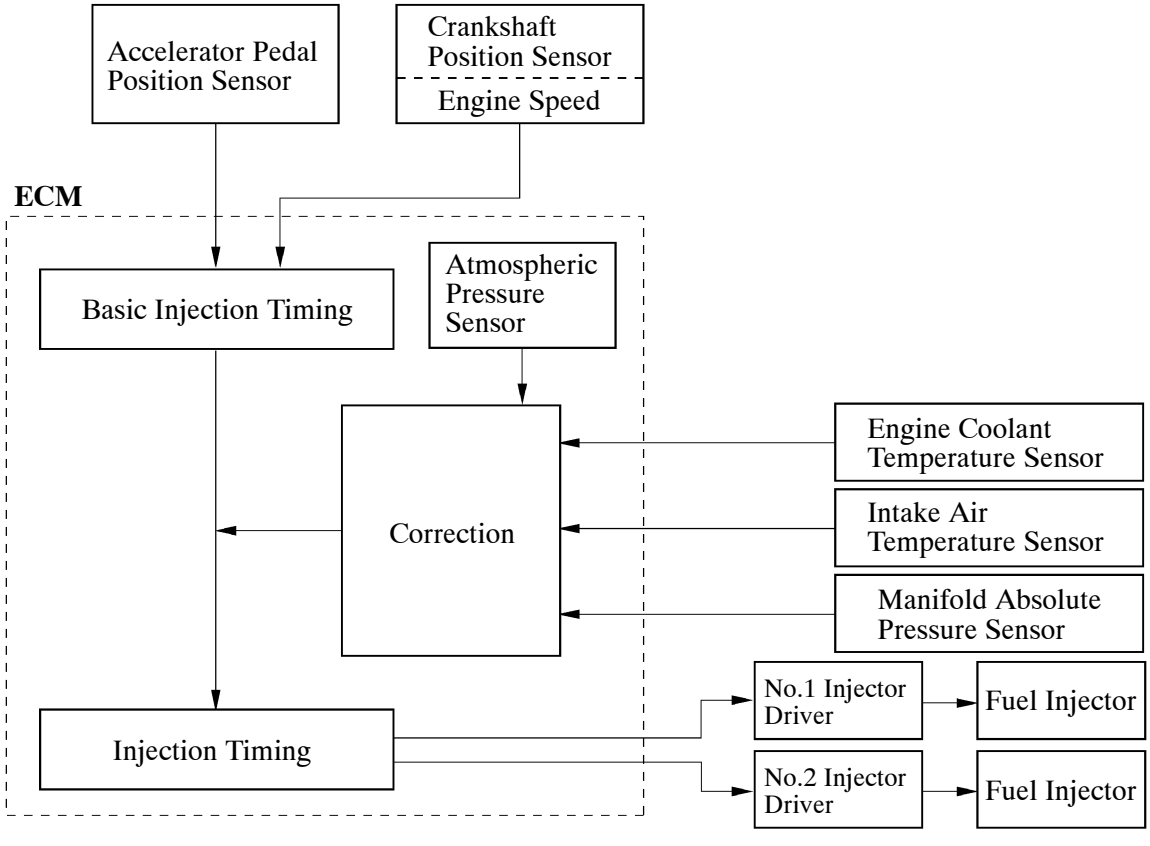
▶ Final Injection Volume Decision ◀



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7. Fuel Injection Timing Control

Fuel injection timing is controlled as shown below.



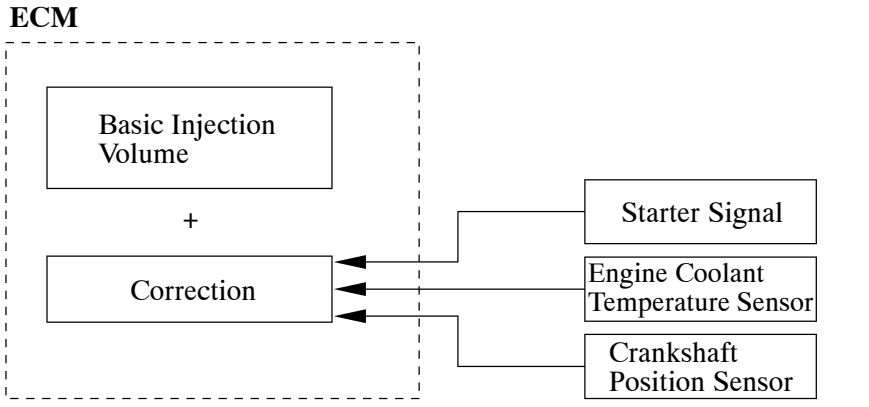
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8. During Starting Control

Injection Volume Control

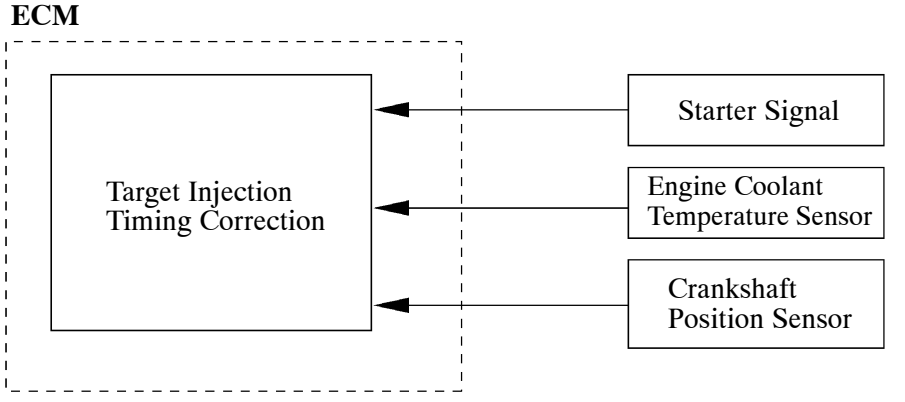
The starting injection volume is determined by adjusting the basic injection volume in accordance with the starter ON signals (ON time), engine coolant temperature sensor signals and engine speed signal. When the engine is cold, the engine coolant temperature will be lower and the injection volume will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



224EG50

Injection Timing Control

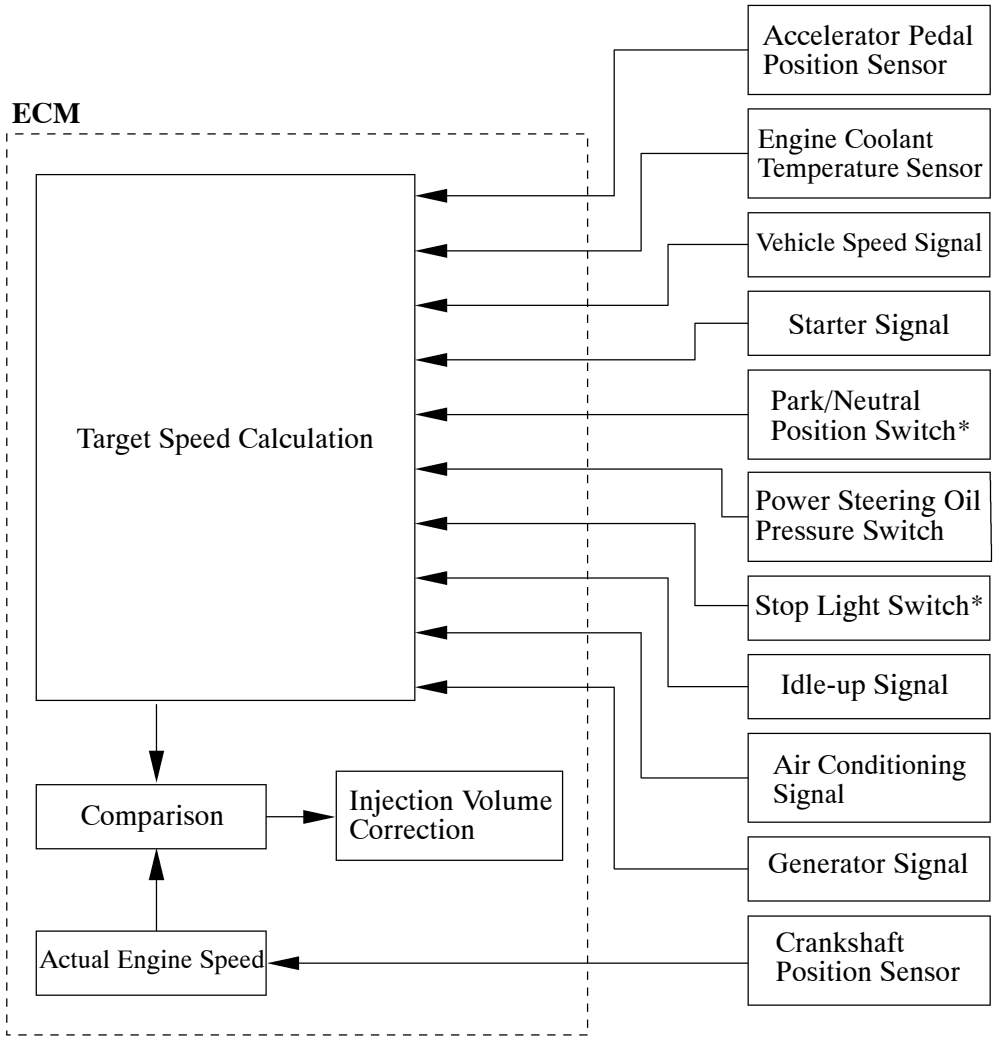
To determine the starting injection timing, the target injection timing is corrected in accordance with the starter signals, engine coolant temperature, and engine speed. When the engine coolant temperature is low, if the engine speed is high, the injection timing is advanced.



224EG51

9. Idle Speed Control

Fuel injection volume is controlled as shown below.



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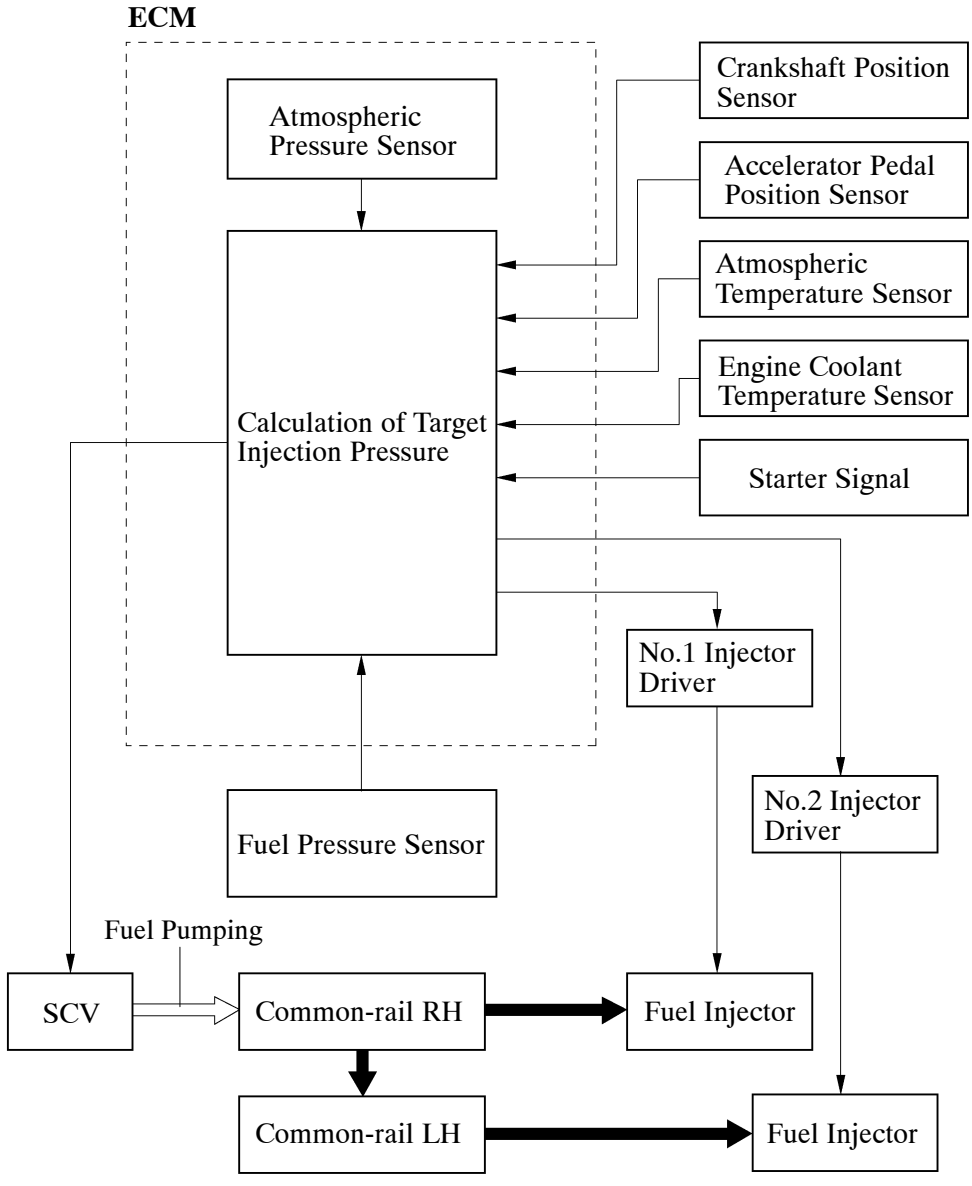
*: Models with Automatic Transmission

10. Fuel Pressure Control

General

The ECM calculates the target injection pressure (25 - 175 MPa*1, 25-129MPa*2) based on the engine conditions, that 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 fuel supply pump regulate the pumping volume, so that the pressure detected by the fuel pressure sensor matches the target injection pressure.

*1: Models complying with EURO IV
*2: Models not complying with EURO IV



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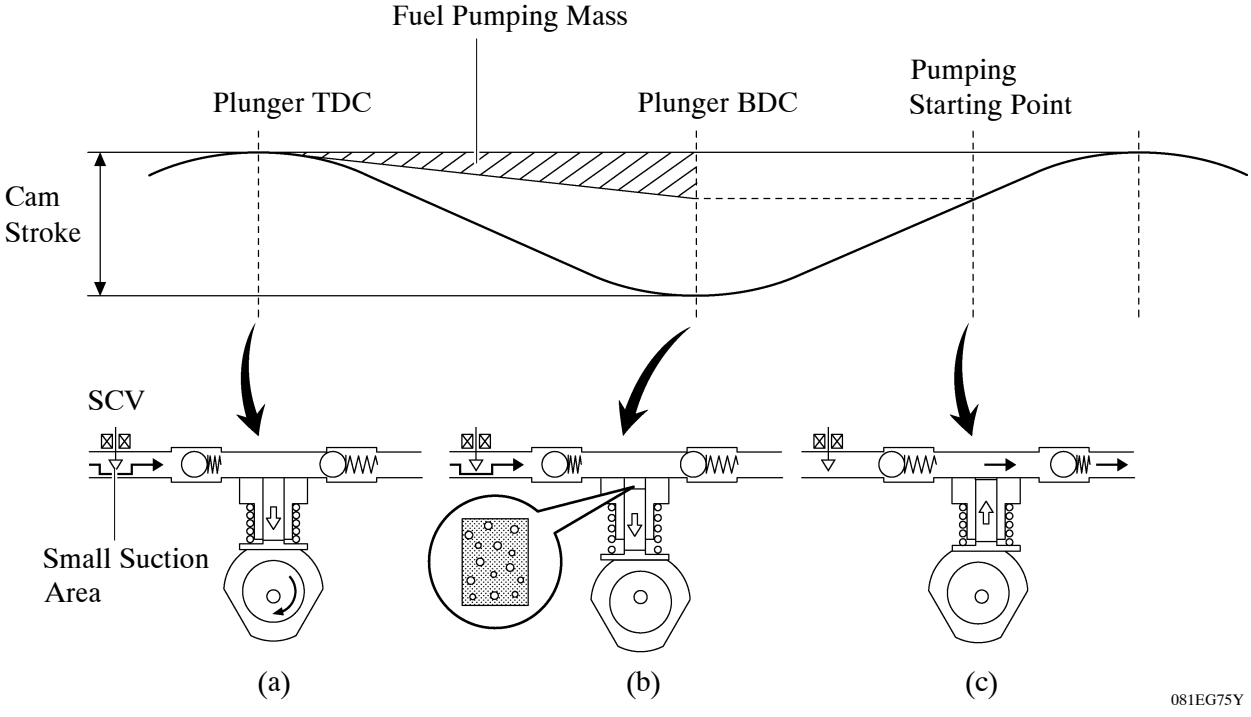
System Operation

1) General

The ECM controls the opening of the SCV (Suction Control Valve) in order to regulate the volume of fuel that is pumped by the fuel supply pump to the common-rail. Consequently, the fuel pressure in the common-rail is controlled to the target injection pressure.

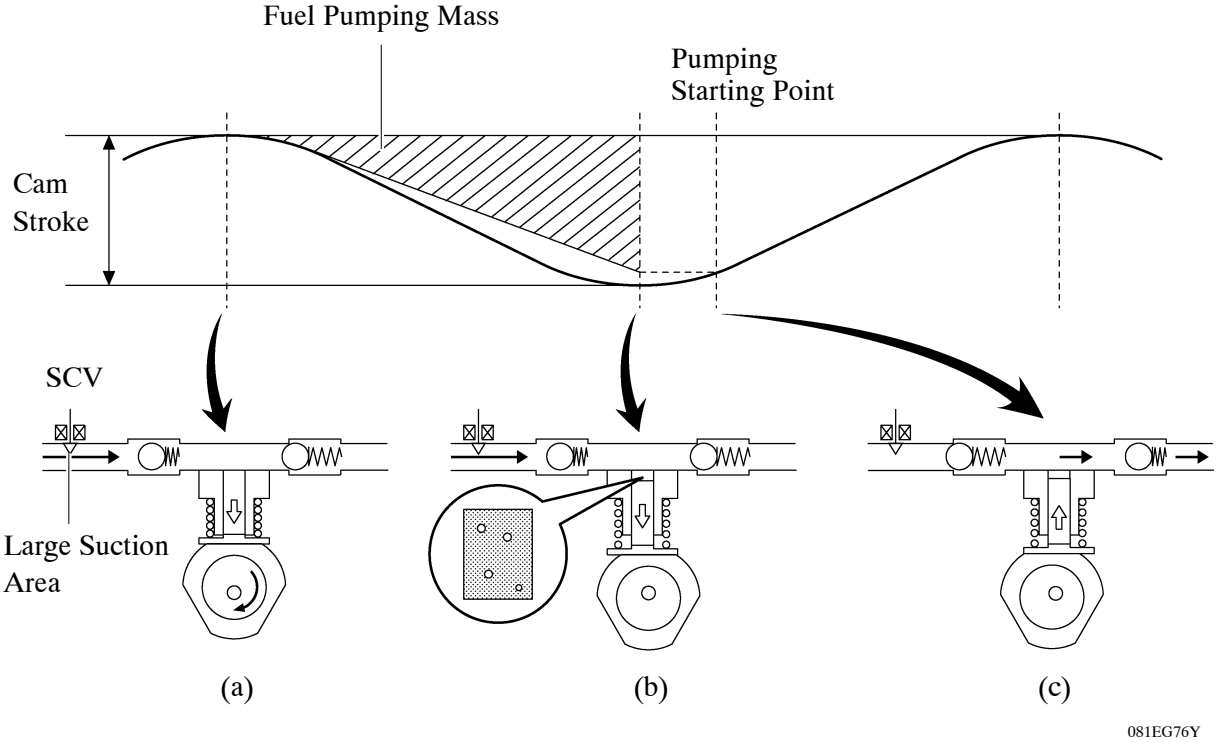
2) SCV Opening Small

(a) When the opening of the SCV is small, the fuel suction area is kept small, which decrease the transferable fuel quantity.
(b) The plunger strokes fully, however, the suction volume becomes small due to the small suction area. Therefore, the difference of the volume between the geometry volume and the suction volume is in vacuum condition.
(c) Pumping will start at the time when the fuel pressure has become higher than the common-rail pressure.



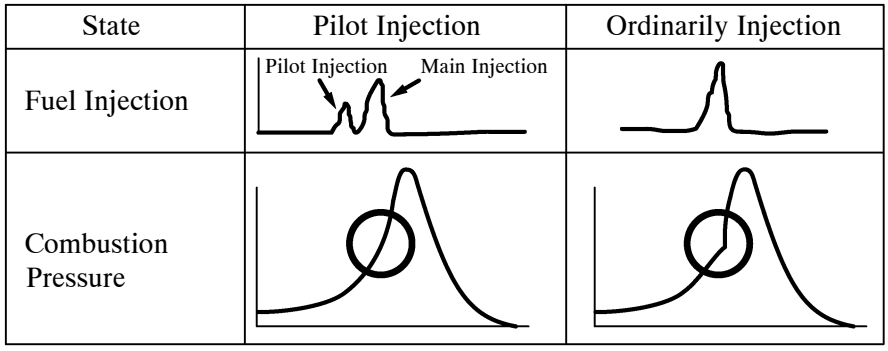
3) SCV Opening Large

(a) When the opening of the SCV is large, the fuel suction area is kept large, which increase the transferable fuel quantity.
(b) If the plunger strokes fully, the suction volume will increase because the suction area is large.
(c) Pumping will start at the time when the fuel pressure has become higher than the common-rail pressure.

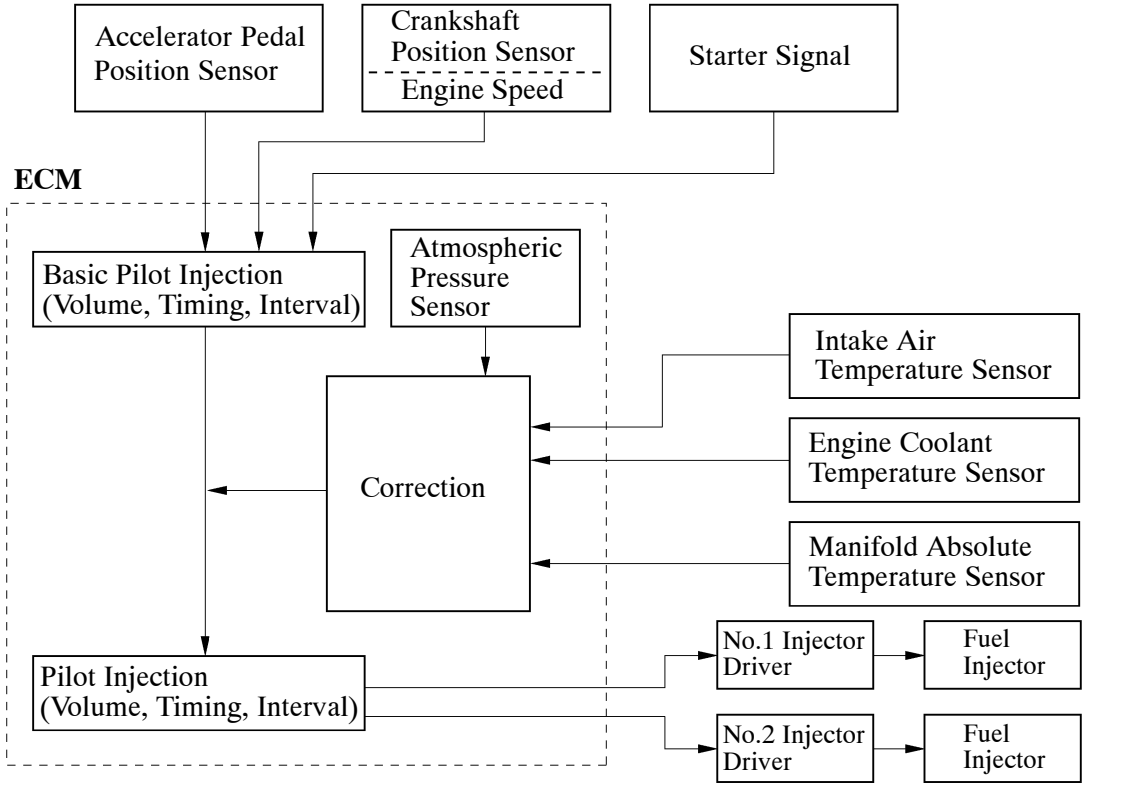


11. Pilot Injection Control

- 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.



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

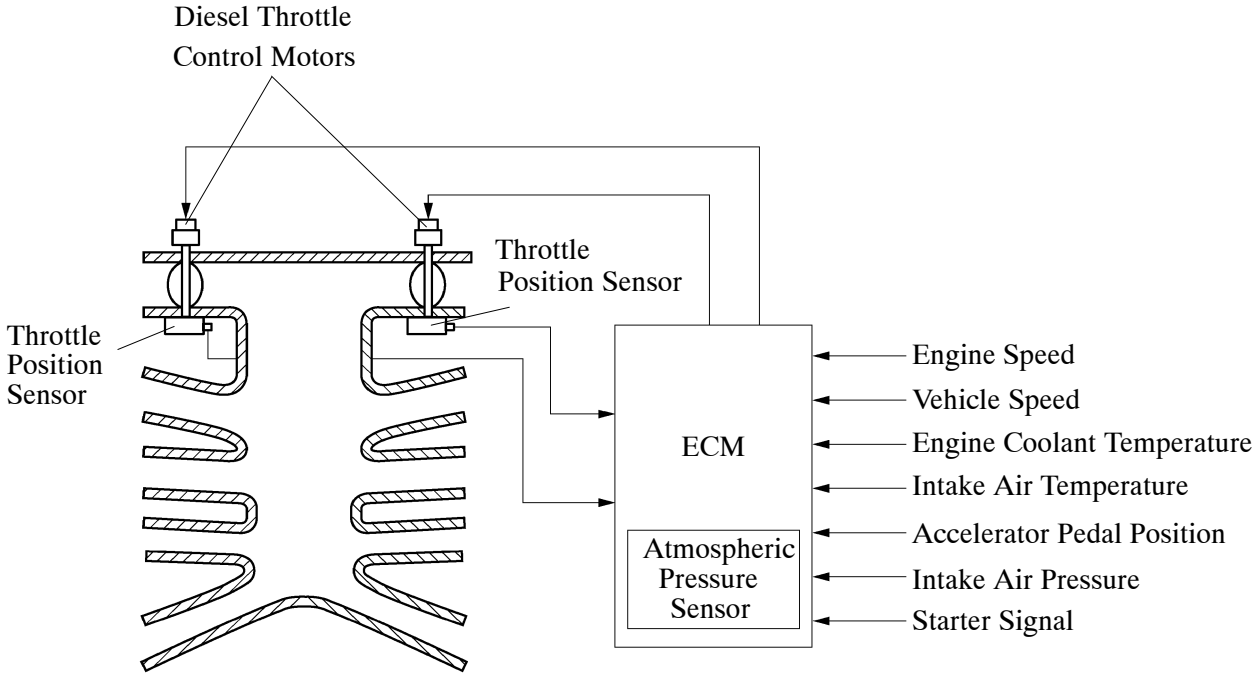


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12. Throttle Control

The opening of the throttle valve is controlled by the ECM 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.

▶ System Diagram ◀

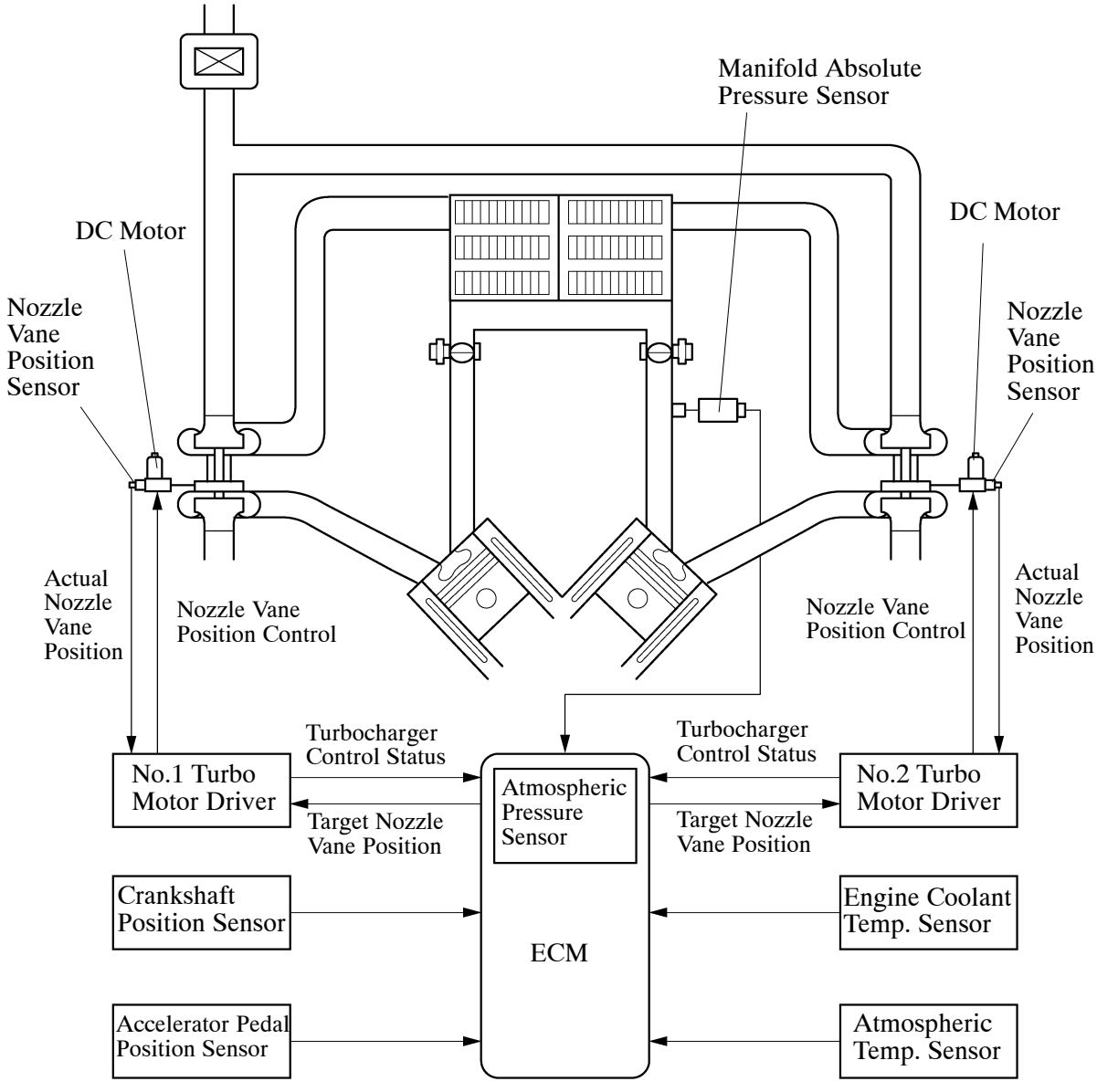


13. Turbo Charger Control

General

- The ECM controls nozzle vane positions in the turbochargers on each bank via the turbo motor drivers in order to obtain the calculated target turbo pressure appropriate to the engine operation conditions.
- The ECM calculates the optimal nozzle vane position in accordance with the driving conditions (such as engine speed, injection volume, atmospheric pressure and engine coolant temperature), and sends a target nozzle vane position signal to each 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.

▶ System Diagram ◀

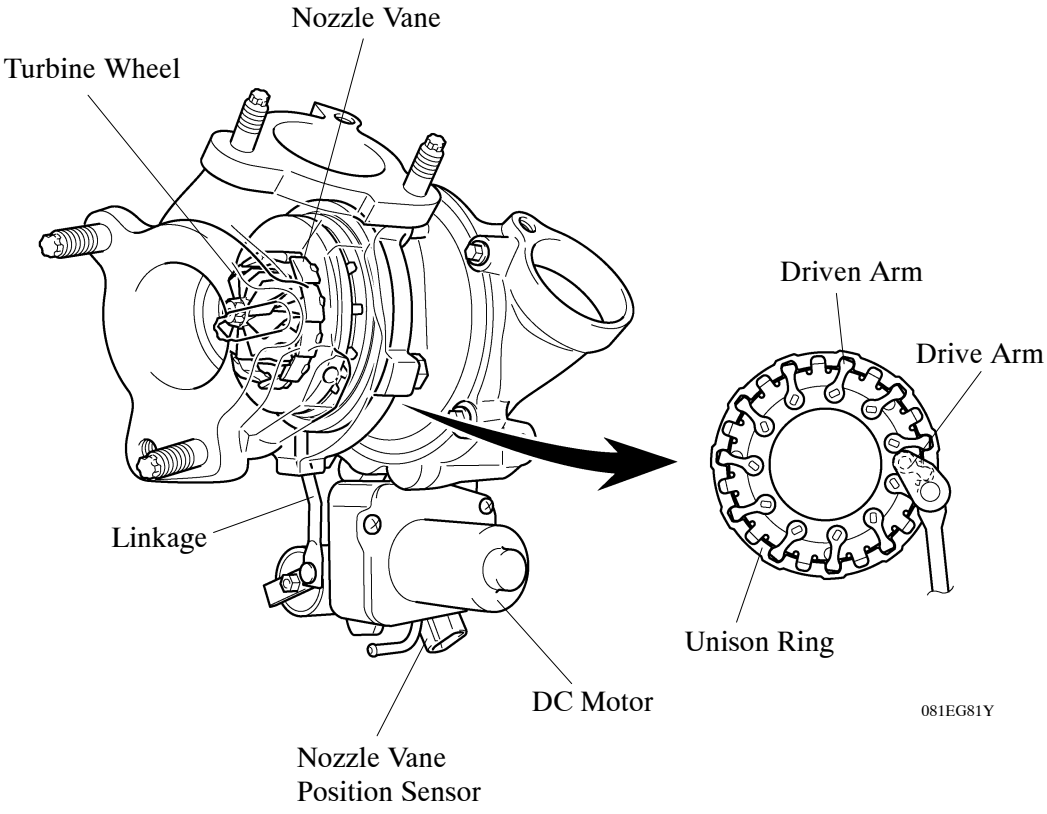


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Construction

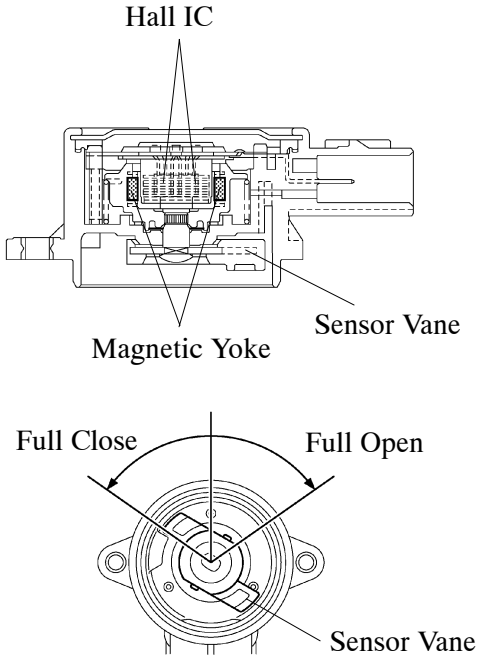
1) General

Variable nozzle vane device is established on the turbine wheel (exhaust) side, and consisted of a DC motor, nozzle vane position sensor, linkage, drive arm, unison ring, driven arms and nozzle vanes.

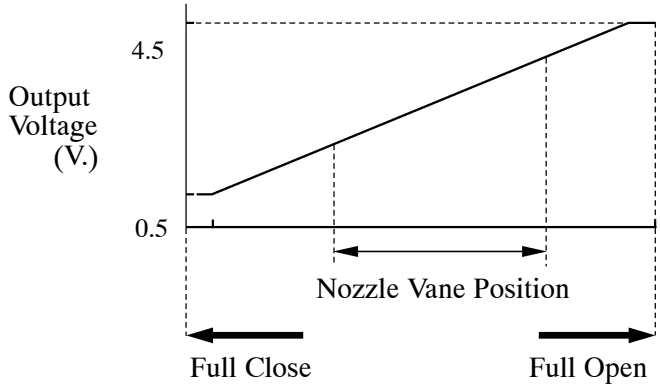


2) Nozzle Vane Position Sensor

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.

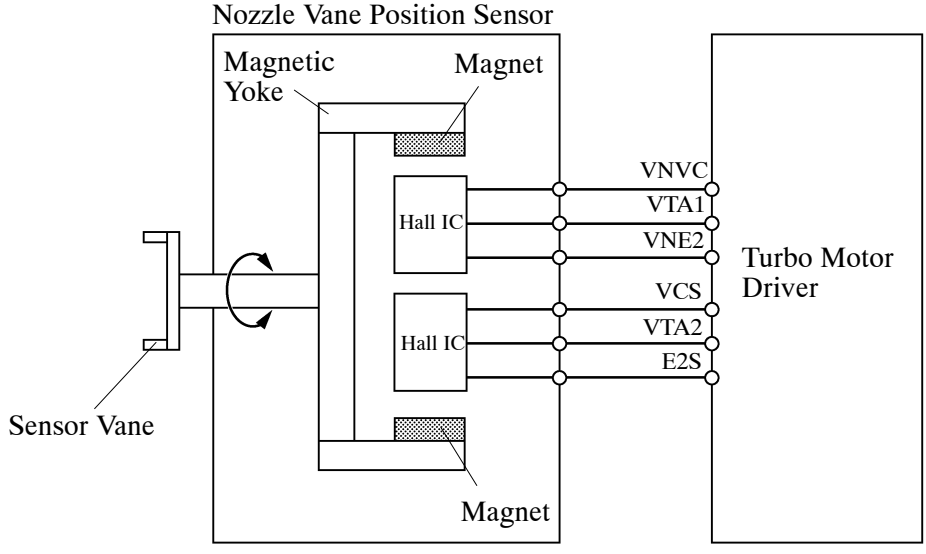


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271EG148

▶ System Diagram ◀

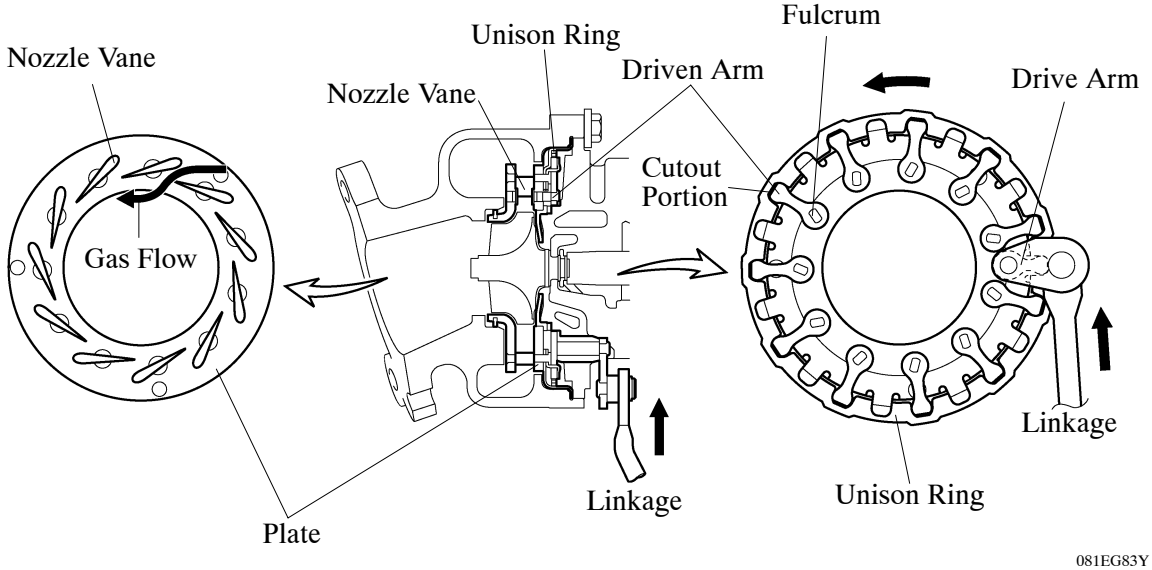


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Operation

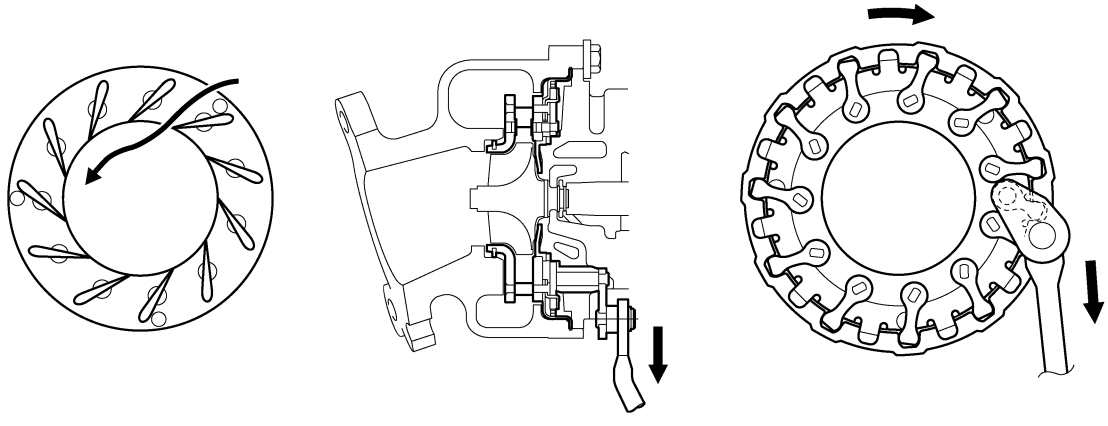
1) At Engine Low Speed Range

When the engine is running in a low speed range, the DC motor pulls up 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.



2) At Engine Medium-to-High Speed Range

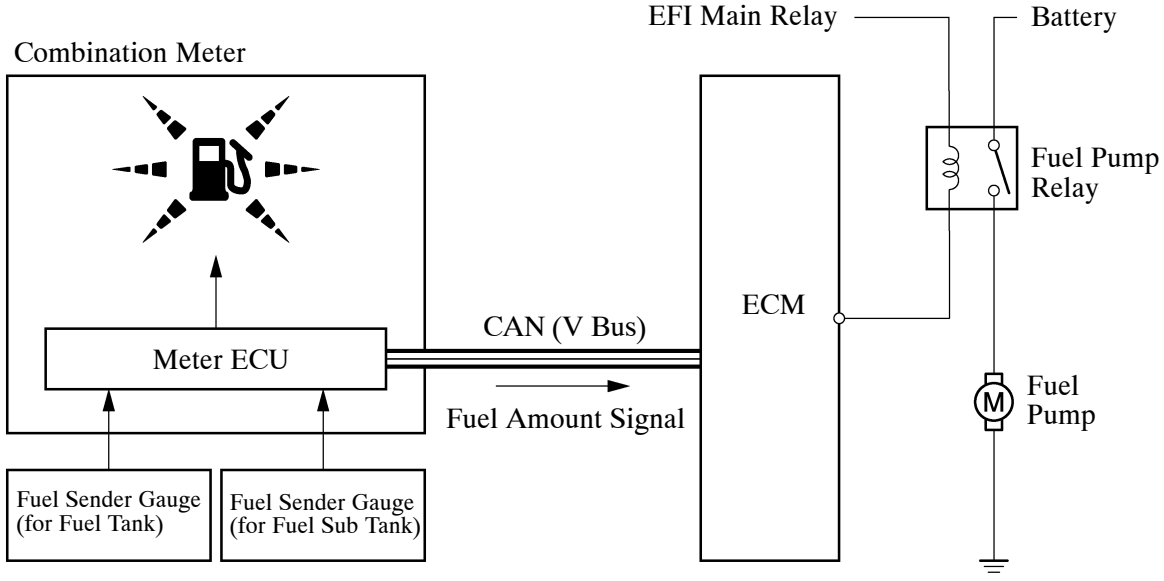
When the engine is running in a medium-to-high speed range, the DC motor presses down the linkage by a signal from the turbo motor driver. With this, the driven arm moves clockwise and this opens the nozzle vane and holds the specified supercharging pressure. Thus, lowering the back pressure and improving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



14. Fuel Pump Control

- The ECM operates the fuel pump in accordance with signals from the meter ECU, which indicate the fuel amount in the fuel tanks (calculated by signals from fuel sender gauges in each fuel tank), to transfer fuel from the sub fuel tank to the main fuel tank using the jet pump for fuel transfer.
- The meter ECU determines if the fuel pump control system is malfunctioning based on the fuel amount in the main fuel tank and sub fuel tank. When the meter ECU detects that the fuel amount in the main fuel tank is small (20.7 liters [21.9 US qts, 18.2 Imp. qts] or less) and the amount in the sub fuel tank is large (7.8 liters [8.2 US qts, 6.9 Imp. qts] or more), it determines that fuel has not been transferred from the sub fuel tank to the main fuel tank. The meter ECU then blinks the low fuel warning light in the combination meter to inform the driver of the fuel pump control system malfunction. In addition, the master warning light comes on, the buzzer sounds and the warning message (Check Fuel System) is displayed on the multi-information display on models with optitron display type combination meter.

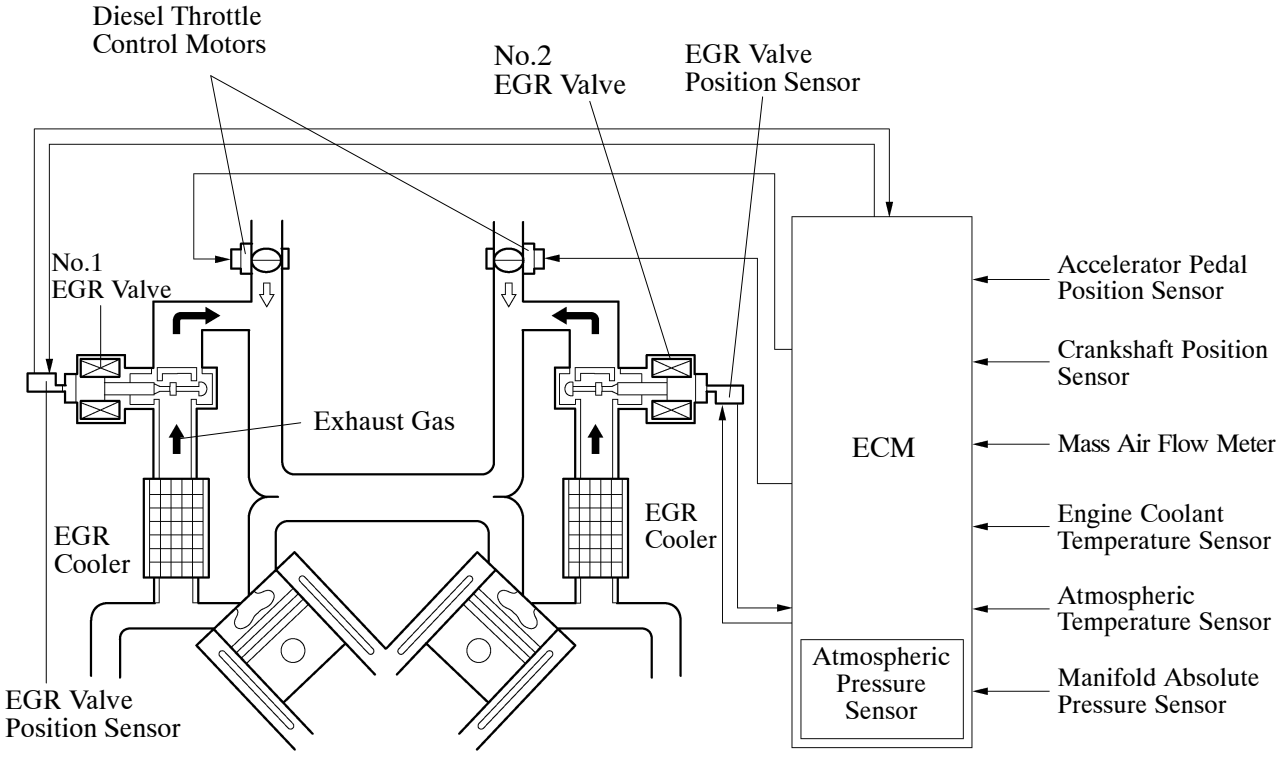
▶ System Diagram ◀



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 the EGR valve opening, the ECM operates the EGR valve and diesel throttle control motor, and regulates the amount of exhaust gas.

▶ System Diagram ◀

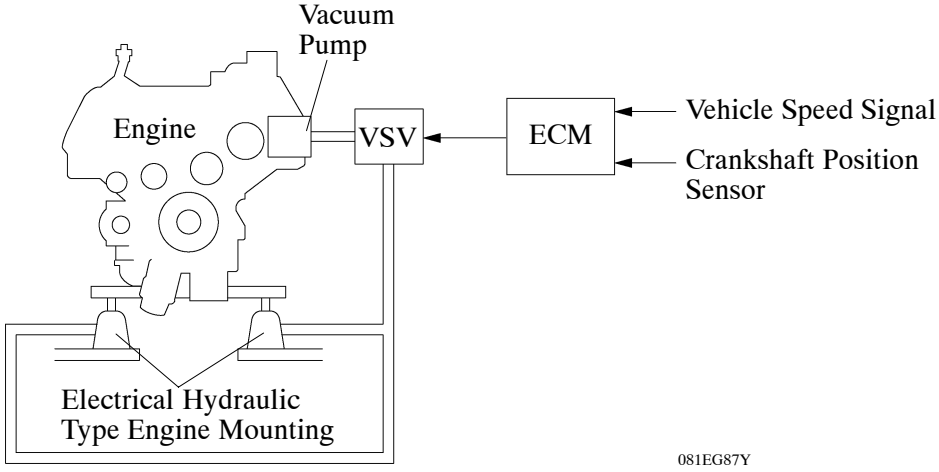


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16. Engine Mounting Control

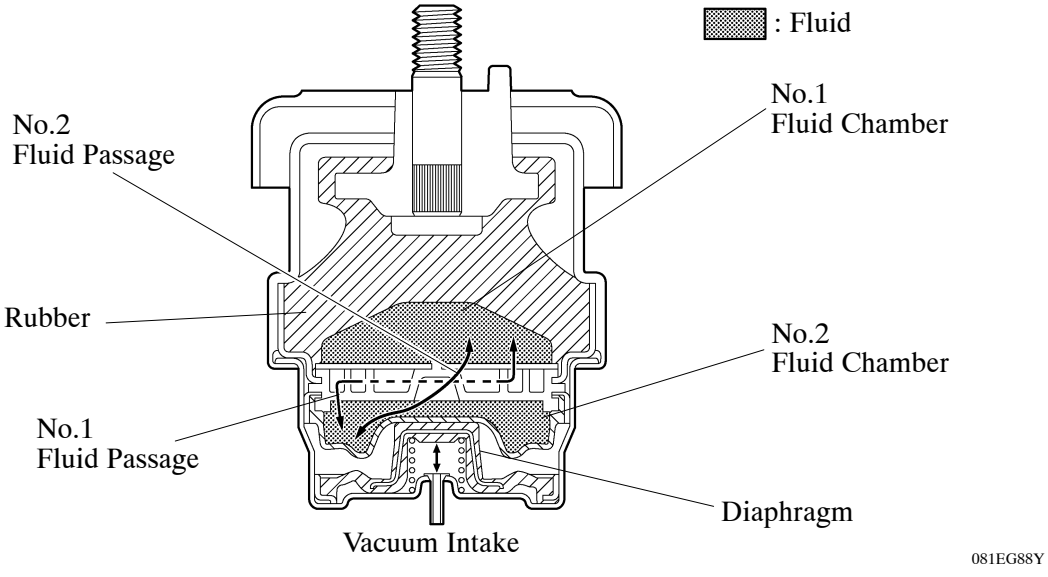
General

When the engine speed and the vehicle speed are low, this engine mounting utilizes the vacuum from the vacuum pump to move the diaphragm inside the mount, which switches the passage for the fluid sealed in the fluid chambers. By softening the damping characteristics of the mounting in this manner, the mounting restrains the engine vibration.



Construction

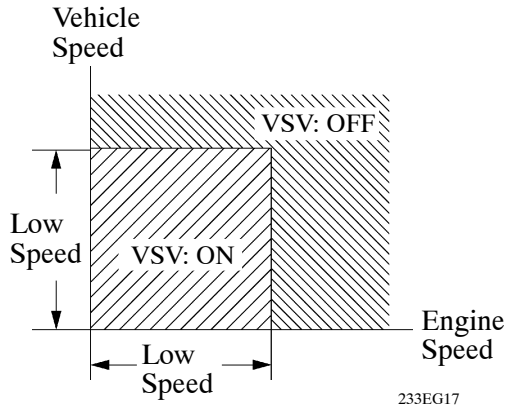
- This engine mounting consists primarily of the rubber portion, No.1 fluid chamber, No.2 fluid chamber, and diaphragm. Fluid is sealed in the No.1 and No.2 fluid chambers.
- This engine mounting obtains a vacuum from the vacuum pump via the VSV. It utilizes the vacuum to pull the diaphragm down in order to open or close the passages that connect the No.1 and No.2 fluid chambers.
- The No.1 and No.2 fluid chambers use two fluid passages: the No.1 fluid passage that is always connected regardless of whether the diaphragm is open or closed; and the No.2 fluid passage that is connected only when the diaphragm is open. The fluid flows back and forth between the No.1 and No.2 fluid chambers through these two passages in order to restrain the vibration.



Operation

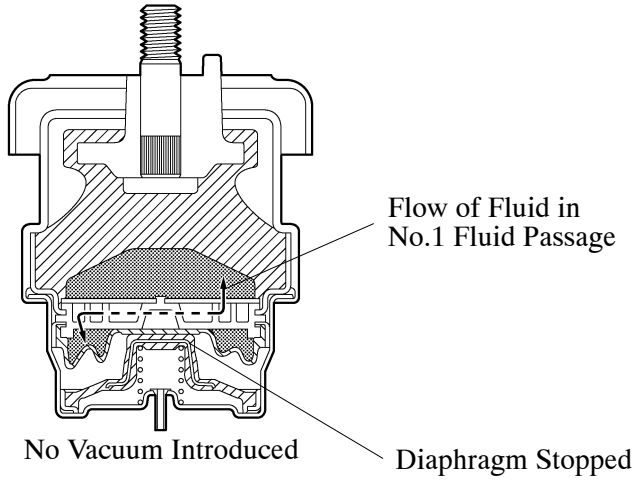
1) General

- When the ECM determines that the engine speed and the vehicle speed are low, it controls the introduction of vacuum from the vacuum pump to the engine mounting by turning the VSV ON or OFF.
- A hysteresis is provided for both the engine speed and the vehicle speed at the point in which the VSV switches from ON to OFF.
- While the engine is cranking, the VSV is OFF.



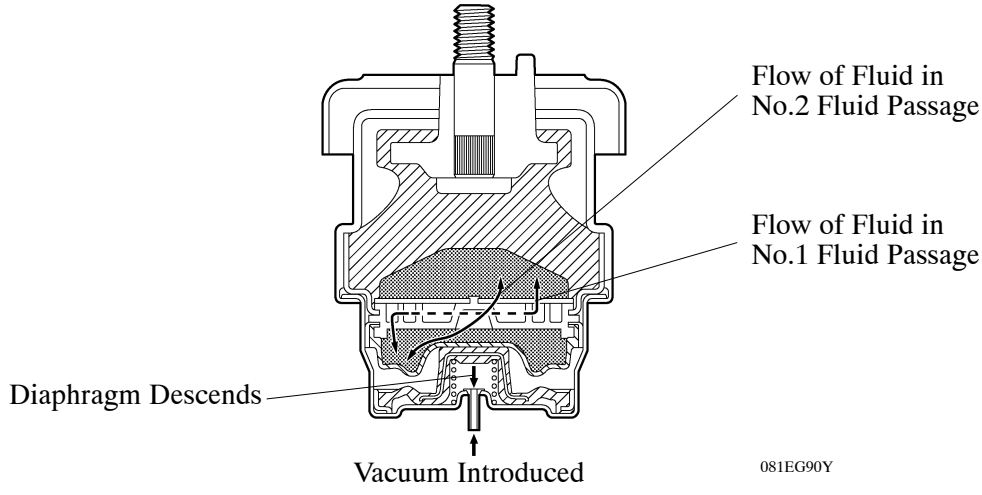
2) When the VSV is OFF

- When the ECM determines that the engine speed and vehicle speed exceed the specified value, it stops the introduction of vacuum into the engine mounting by turning the VSV OFF.
- When no vacuum is introduced into the engine mounting, the diaphragm does not move, so the No.1 fluid passage remains closed. In this state, the fluid passes only through the No.1 fluid passage in order to flow back and forth between the No.1 and No.2 fluid chambers.



3) When the VSV is ON

- When the ECM determines that the engine speed and the vehicle speed are equal to or less than the specified value, it turns the VSV ON to introduce vacuum into the engine mounting.
- When a vacuum is introduced into the engine mounting, it pulls the diaphragm down, causing the No.2 fluid passage to open. As a result, a large volume of fluid flows back and forth between the No.1 and No.2 fluid chambers, thus minimizing the fluid resistance and softening the engine mounting characteristics.

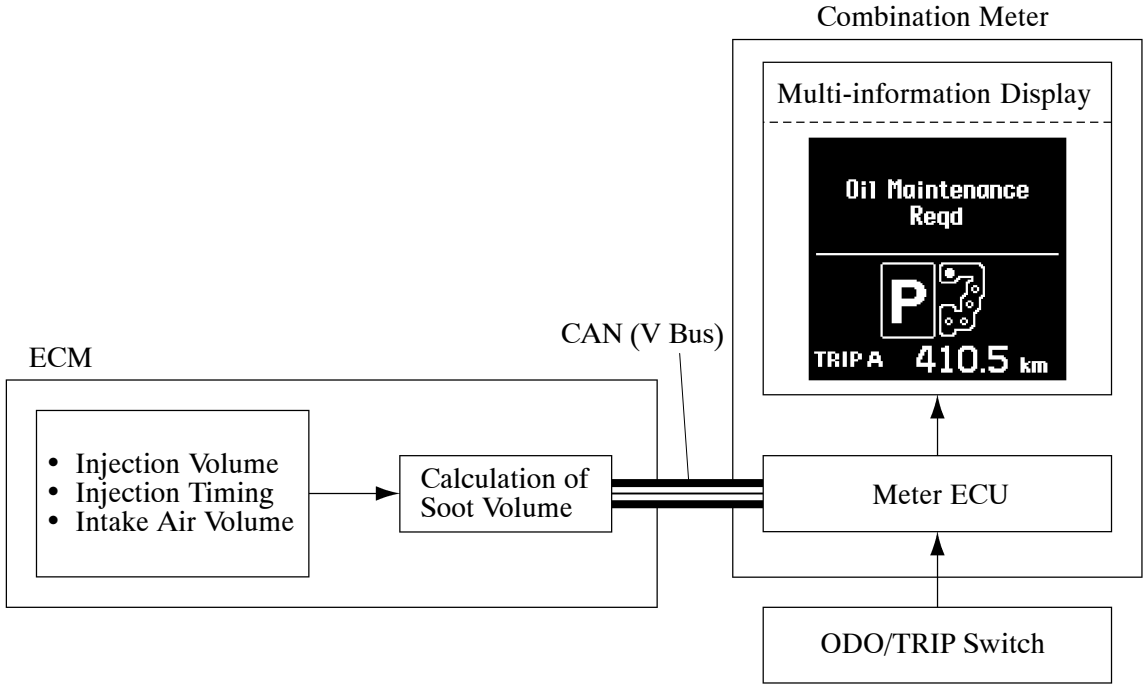


17. Oil Maintenance Management System

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 ECM displays an "Oil Maintenance Reqd" warning on the multi-information display to inform the driver when it is necessary to change the engine oil.
- The ECM calculates soot volume from the injection volume, injection timing and intake air volume in order to operate this system.

▶ System Diagram ◀



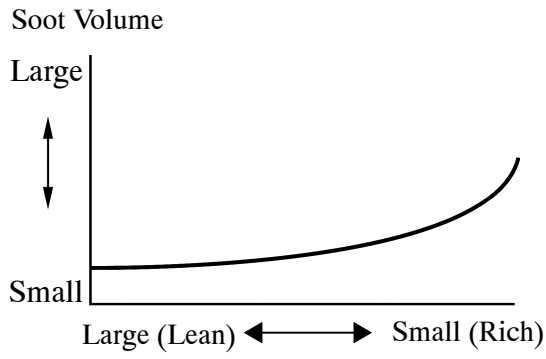
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Service Tip

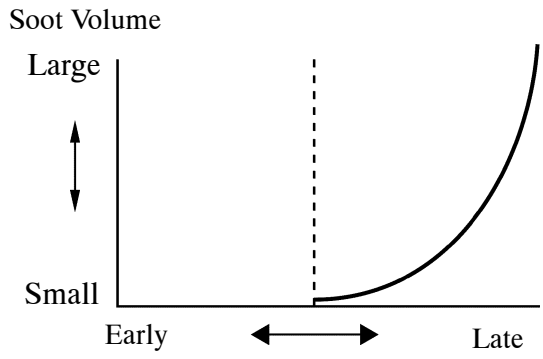
Since this system is controlled based on engine operating conditions, the "Oil Maintenance Reqd" warning may be displayed before driving 30,000 km (the maximum travel distance after oil maintenance). If the "Oil Maintenance Reqd" warning is displayed, immediately replace the oil and oil filter.

Soot Volume Calculation Method

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



Calculation of Air-Fuel Ratio 288EG63C



Injection Ending Timing 288EG64C

Service Tip

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

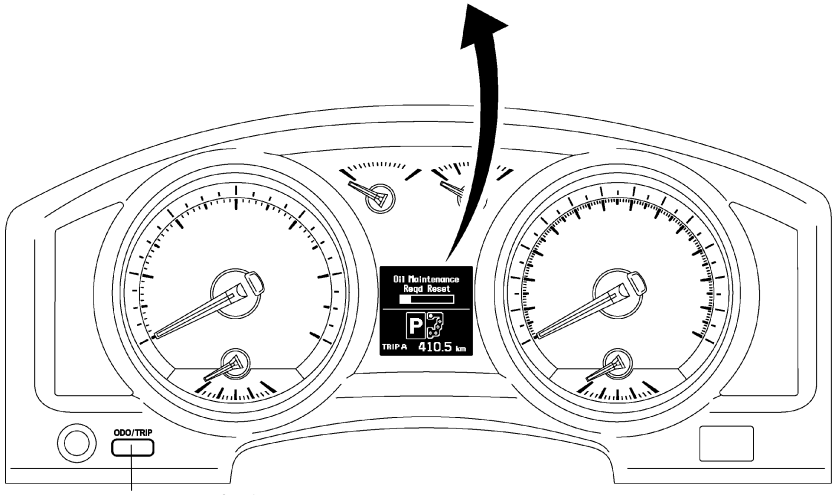
1) Switch the power source to IG-ON. Then, use the ODO/TRIP switch to turn ON the "TRIP A" display on the multi-information display.
2) Switch the power source to OFF. While pushing the ODO/TRIP switch, switch the power source to IG-ON.
3) With the power source in the IG-ON mode, keep holding the ODO/TRIP switch (for at least five seconds) with the multi-information display counting down as shown below.
4) When the resetting is completed, the multi-information display will display "COMPLETE" for one second and the buzzer built into the combination meter will sound.



5 seconds before | 4 seconds before | 3 seconds before



2 seconds before | 1 second before | Reset complete



ODO/TRIP Switch 081EG92H

18. Diagnosis

- When the ECM detects a malfunction, the ECM 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 ECM will also store the DTC (Diagnostic Trouble Code) of the malfunctions. The DTC can be accessed by using the intelligent tester II.
- For details, refer to the Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).

Service Tip

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

19. Fail-safe

When a malfunction is detected at any of the sensors, there is a possibility of an engine or other malfunction occurring if the ECM were to continue to control the engine control system in the normal way. To prevent such a problem, the fail-safe function of the ECM 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 Land Cruiser (Station Wagon) Repair Manual (Pub. No. RM0810E).