■ENGINE CONTROL SYSTEM

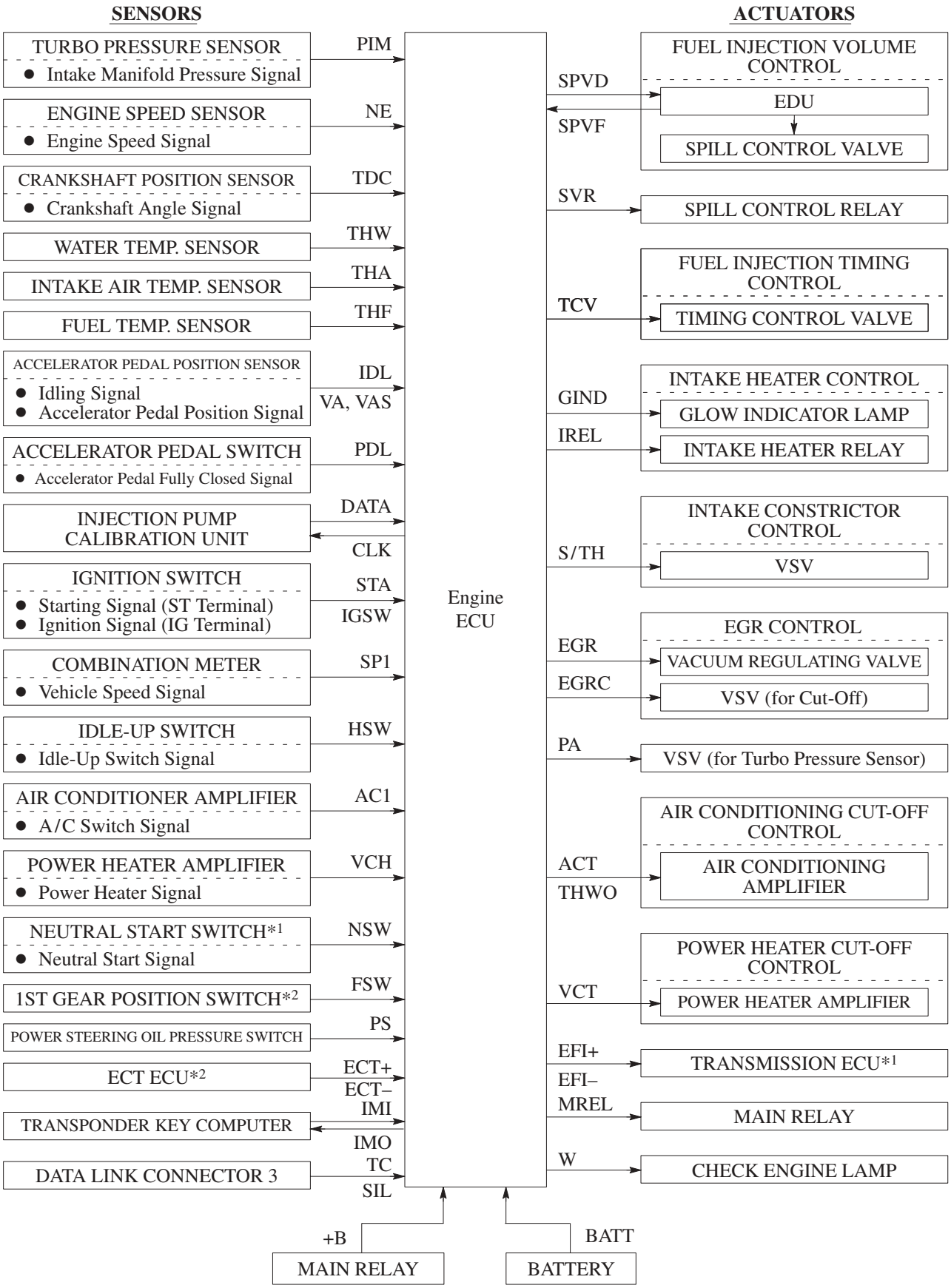
1. General

To operate the engine is an optimal condition. The engine control system of the 1HD-FTE engine have general control of the following functions: fuel injection volume control, fuel injection timing control and idle speed control. In addition, a diagnosis function has been added to improve the serviceability of the engine. Furthermore, the cruise control system has been enclosed in the engine ECU.

System	Outline
Fuel Injection Volume Control	● Based on the signals received from the sensors, the engine ECU determines the fuel injection volume in accordance with the engine condition. ● In vehicles equipped with automatic transmission, torque control compensation during gear shifting is used to minimize the shift shock.
Fuel Injection Timing Control	Based on the signals received from the sensors, the engine ECU determines the fuel injection timing in accordance with the engine condition.
Idle Speed Control	The engine ECU determines the idle speed in accordance with the engine condition, and controls the fuel injection volume in order to achieve the target idle speed.
Stable Idling Control	Corrects the fuel injection volume that is directed to each cylinder during idling, thus reducing engine vibration.
Cruise Control	Controls the vehicle speed by regulating the injection volume in accordance with the instructions received from the cruise control computer that is integrated in the engine ECU.
Intake Constrictor Control	Shuts off the intake air to reduce the vibration when the engine stopped.
Intake Heater Control	Controls the length of time when the current is applied to the Intake Heater in accordance with the coolant temperature.
EGR Control	Controls the engine EGR volume in accordance with the engine condition.
Air Conditioning Cut-Off Control	● By controlling the air conditioning compressor ON or OFF in accordance with the engine condition, drivability is maintained. ● Also controls the power heater on the models equipped with a power heater.
Engine Immobiliser	Prohibits fuel delivery if an attempt is made to start the engine with an invalid ignition key.
Diagnosis	● When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section. ● A newly developed diagnostic system which utilizes a high speed bi-directional communication line to provide extended diagnostic capabilities and features.
Fail-Safe	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 which can be broadly divided into three groups: the engine ECU, the sensors and the actuators, is shown in the following chart.



*1: Only for Automatic Transmission Model *2: Only for Manual Transmission Model

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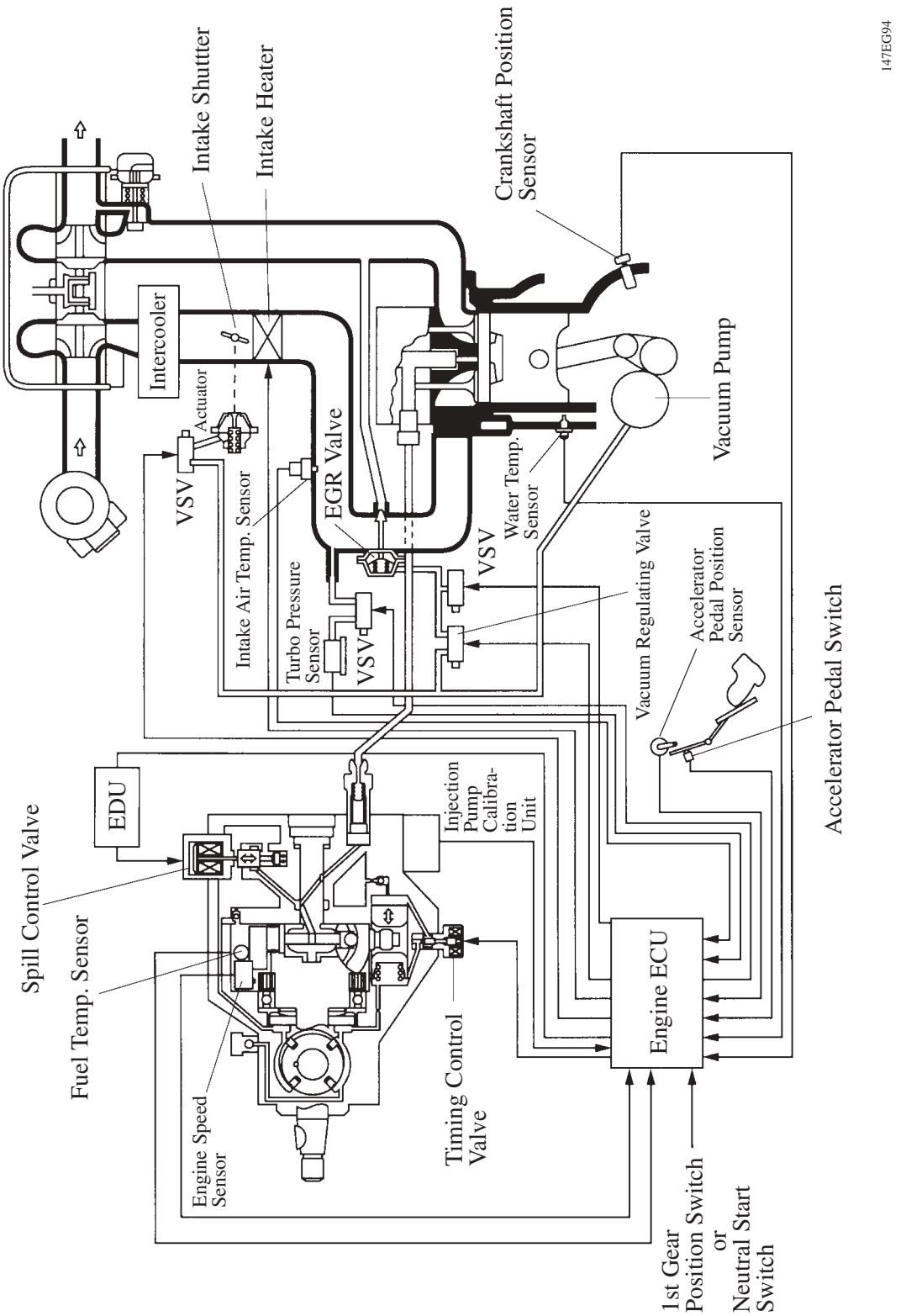
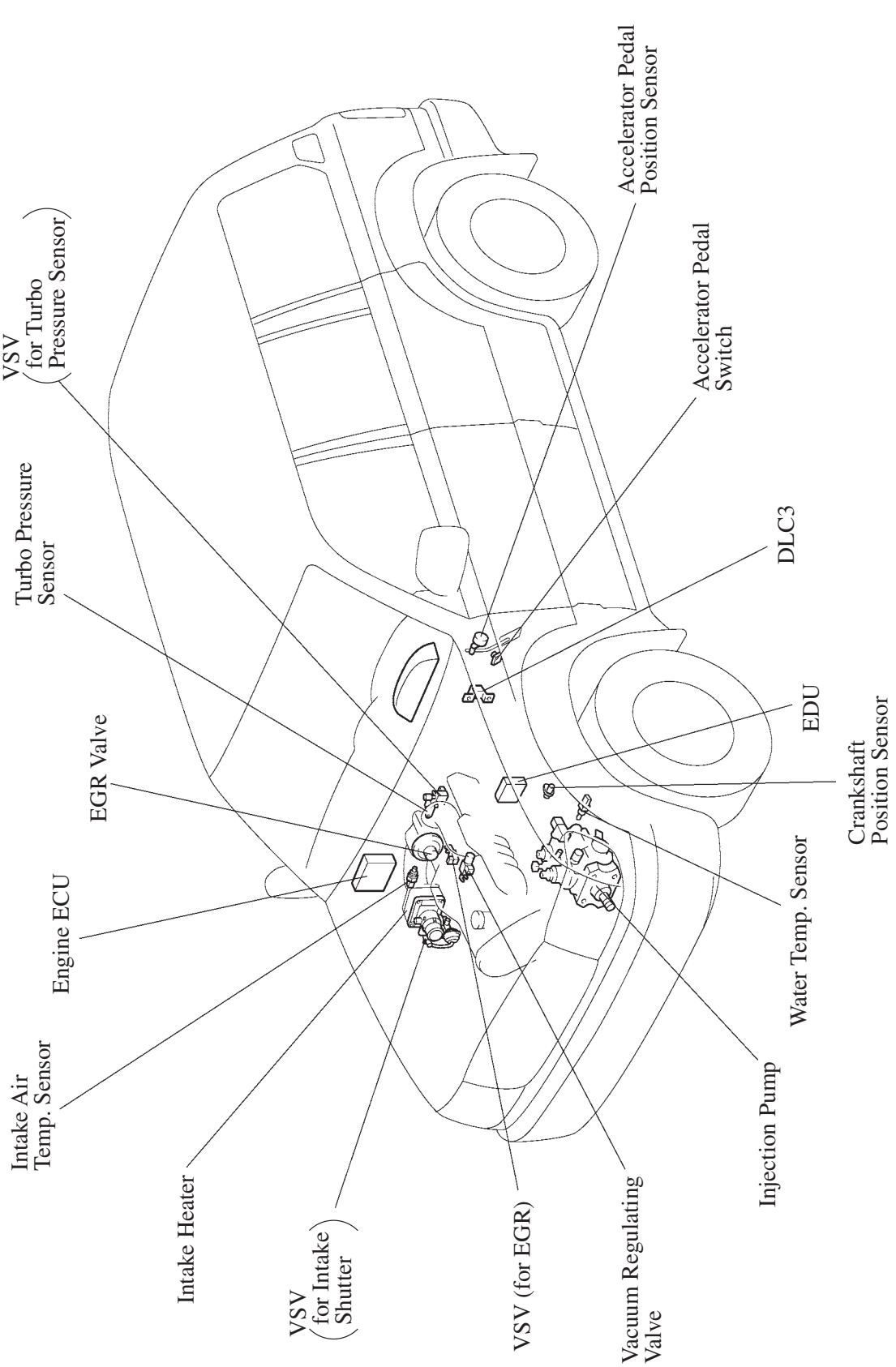
3. Engine Control System Diagram



4. Layout of Components



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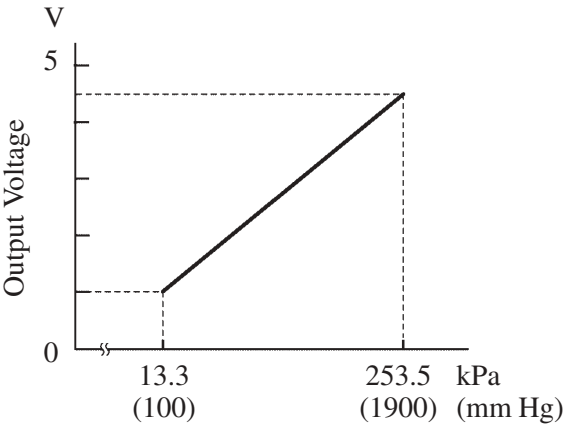
5. Main Components of Engine Control System

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.
In addition, the atmospheric pressure can be detected by switching the piping passage through the operation of the VSV.

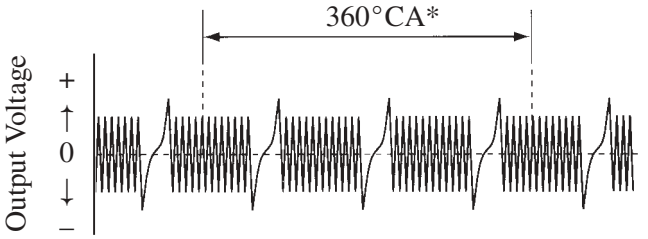


147EG103

Turbo Pressure Sensor Output Characteristics

Engine Speed Sensor

The engine speed sensor is attached to the roller ring in the injection pump to detect the engine speed. The timing rotor is attached to the drive shaft. Missing 3 teeth at each of the 6 locations, the timing rotor generates a signal every 7.5° (crankshaft angle) with its 78 teeth.



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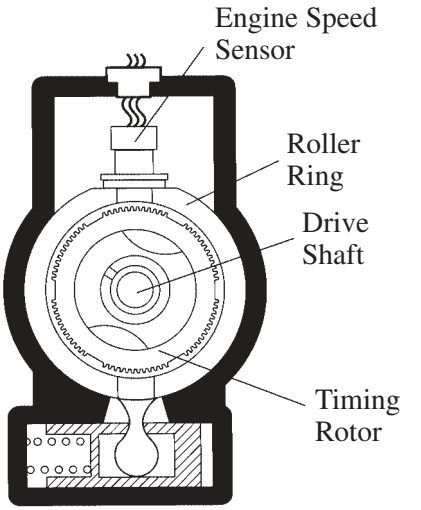

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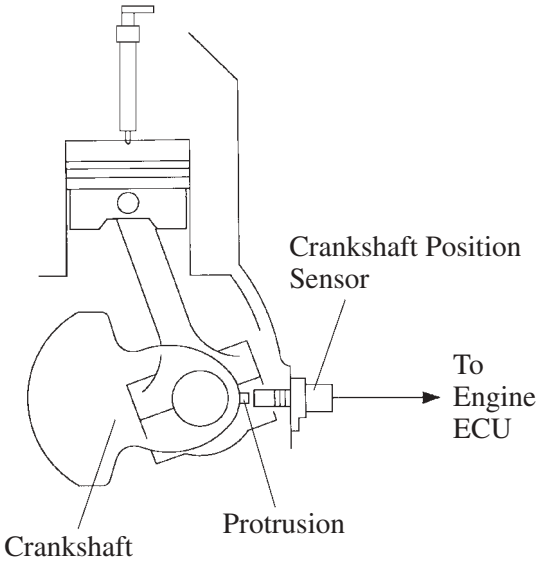
*: CA (Crankshaft Angle)

Crankshaft Position Sensor

The crankshaft position sensor is attached to the cylinder block. Using the protrusion that is provided on the crankshaft, the sensor generates 1 signal for every revolution. This signal is then sent to the engine ECU as a crankshaft position signal.



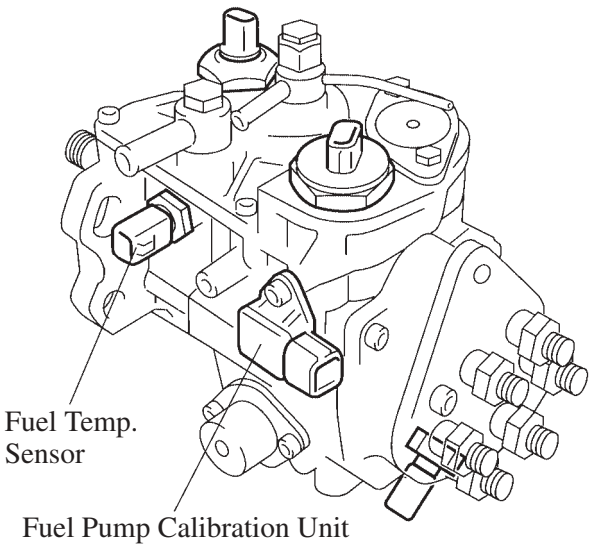
147EG91

Fuel Temperature Sensor

The fuel temperature sensor is attached to the injection pump, and uses an internal thermistor to detect the fuel temperature.

Fuel Pump Calibration Unit

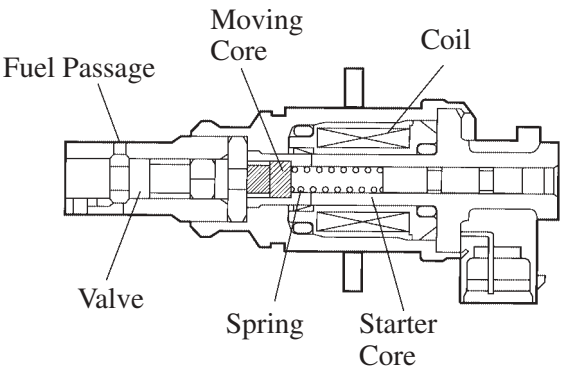
To compensate for the shift in injection volume and injection timing caused by the variances in the injection pump itself, a correction is made by using the data that is stored in the ROM in the fuel pump calibration unit.



147EG97

Timing Control Valve

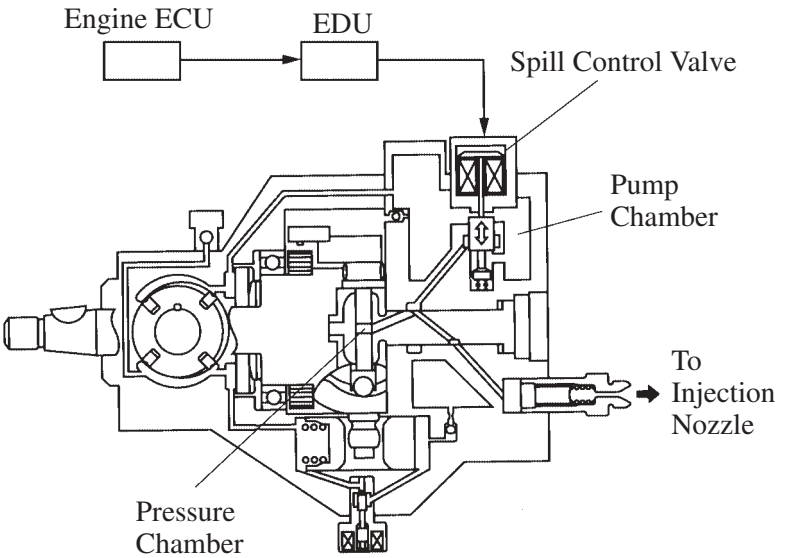
The timing control valve is attached to the injection pump. In accordance with the signals from the engine ECU, it opens the valve in the fuel passage between the pump chamber and the suction side, thus controlling the injection timing. When the current flows to the coil of the timing control valve, the starter core becomes an electromagnet to push and compress the spring. This causes the moving core to retract and open the fuel passage.



147EG99

Spill Control Valve

The spill control valve is attached to the injection pump to control the fuel injection volume in a accordance with the signals received from the engine ECU.
When the spill control valve is turned OFF, the passage between the high-pressure chamber and the pump chamber opens, causing the pressure in the high-pressure chamber to drop. This completes the injection of the fuel from the injection nozzle.
The length of time till the spill control valve is turned OFF becomes the fuel injection time. Thus, the fuel injection volume is controlled by increasing or decreasing the length of time till the spill control valve is turned OFF.



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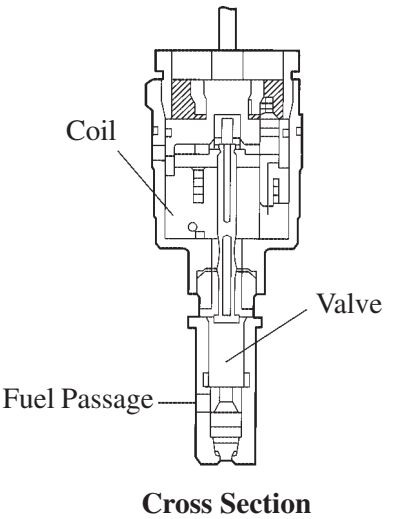


Cross Section

147EG96

Acceleration Position Sensor

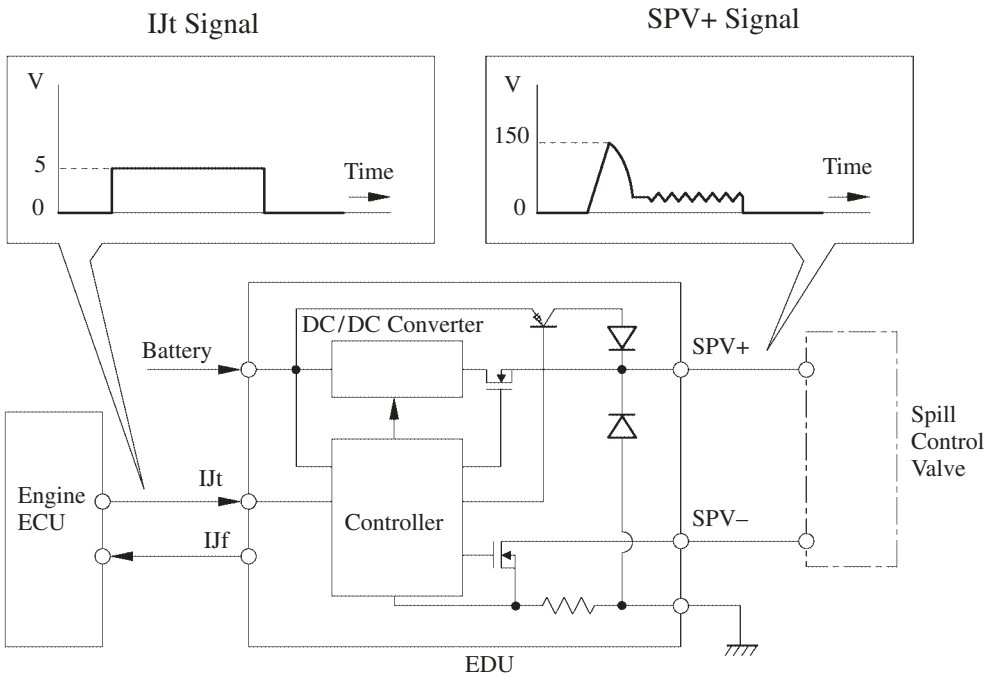
- The accelerator position sensor uses a Hall element that outputs voltage that changes linearly in relation to the amount of pedal effort that is applied to the accelerator pedal.
  The accelerator position sensor uses a duplex system to ensure its reliability.
- An idle switch that detects the fully closed condition of the accelerator pedal is enclosed in the accelerator pedal position sensor.

Accelerator Pedal Switch

Attached to the accelerator pedal in addition to the accelerator pedal position sensor, the accelerator pedal switch detects the fully closed condition of the accelerator pedal.

EDU (Electronic Driving Unit)

- The EDU has been adopted to drive the spill control valve 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.
- The engine ECU constantly monitors the EDU and stops the engine in case an abnormal condition is detected.



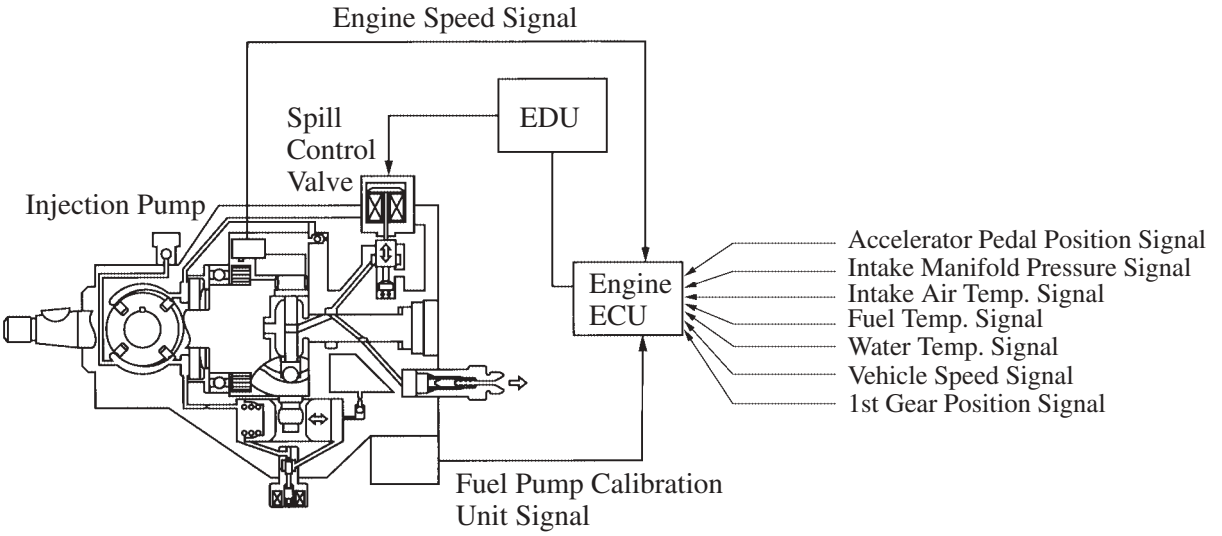
147EG126

Operation

The battery voltage is increased by the DC/DC converter. A voltage of approximately 150V is applied to the spill control valve in accordance with the IJt signal received from the engine ECU. Also at this time, the injection verification signal (IJf) is sent to the engine ECU.

6. Fuel Injection Volume Control

- Based on sensor signals, the engine ECU controls the fuel injection volume by calculating the fuel injection volume that is appropriate for the engine condition.
- On the manual transmission model, the engine's output is limited in 1st gear.



Function of Engine ECU

The engine ECU calculates the basic injection volume based on the throttle opening and engine speed, and the maximum injection volume for the engine condition. The two injection volumes are then compared, and the lesser of the two is selected. A correction value, which is obtained via the correction resistors, is added to that injection volume, thus determining the final injection volume.

1) Basic Injection Volume

Determined in accordance with the throttle opening and the engine speed.

2) Maximum Injection Volume

Based on the signals received from the sensors, correction values are added to the theoretically required injection volume (basic maximum injection volume) to determine the maximum injection volume during engine operation.

a. Basic Maximum Injection Volume

Determined in accordance with the engine speed.

b. Intake Manifold Pressure Correction

Corrects the basic maximum injection volume in accordance with the intake manifold pressure. The higher the intake manifold pressure becomes, the larger the injection volume becomes.

c. Intake Air Temperature Correction

Corrects the variance in the air-fuel ratio that is created by the difference in the density of the intake air in accordance with the intake air temperature. The higher the intake air temperature becomes, the smaller the injection volume becomes.

d. Fuel Temperature Correction

Corrects the variance in the injection volume that is created by the difference in the density of the fuel in accordance with the fuel temperature. The higher the fuel temperature becomes, the smaller the injection volume becomes.

e. Water Temperature Correction

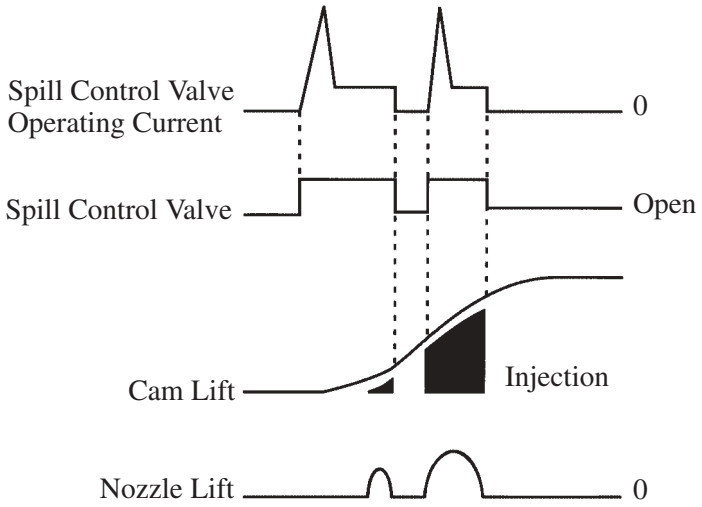
The lower the engine coolant temperature, the greater the injection volume becomes in order to ensure drivability immediately following cold-starting.

3) Starting Injection Volume Control

Determines the fuel injection volume during starting in accordance with the starting signal and the water temperature signal. When the engine is cold, the lower the coolant temperature becomes, the larger the injection volume becomes.

4) Split Injection Control

Split injection is performed when starting the engine at extremely low temperatures in order to improve the startability and greatly reduce the emission of white smoke and black smoke. In contrast to the ordinary injection that occurs once, fuel is injected twice during split injection.



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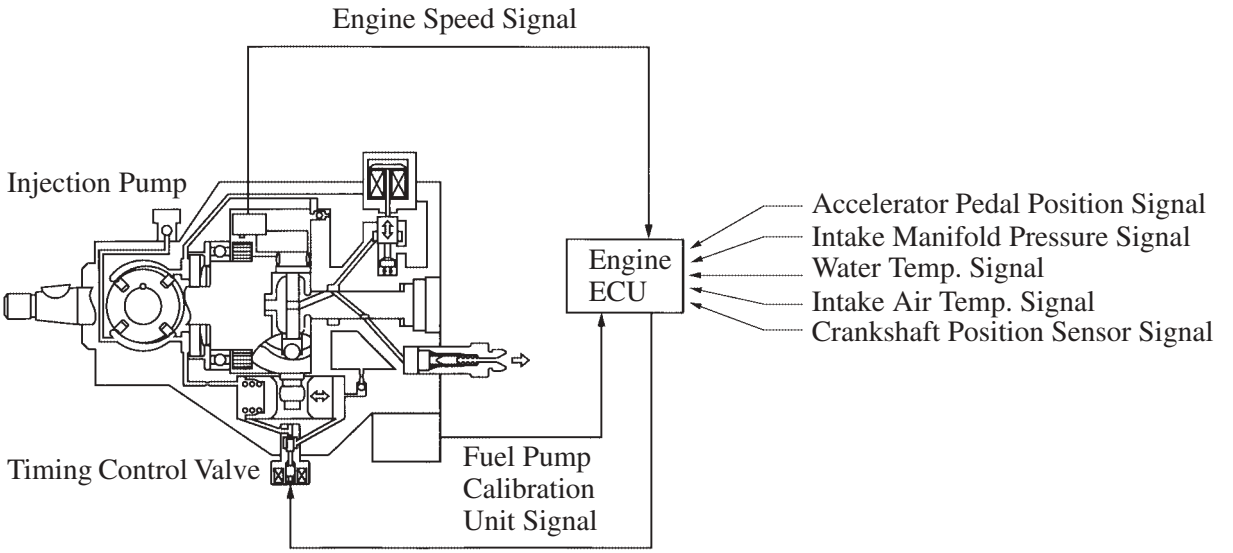
7. Fuel Injection Timing Control

Based on the signals received from the sensors, the engine ECU calculates and controls the fuel injection timing to be optimal for the engine condition.



Function of Engine ECU

The engine ECU adds the corrections from the sensor signals to the basic fuel injection timing to calculate the fuel injection timing that is optimal for the engine condition.

1) Basic Injection Timing

The basic injection timing is determined in accordance with the throttle opening and the engine speed.

2) Injection Timing Correction

a. Intake Manifold Pressure Correction

Corrects the basic fuel injection timing in accordance with the intake air pressure. The injection timing is advanced when the intake air pressure is low in such the case as of high altitude areas.

b. Water Temperature Control

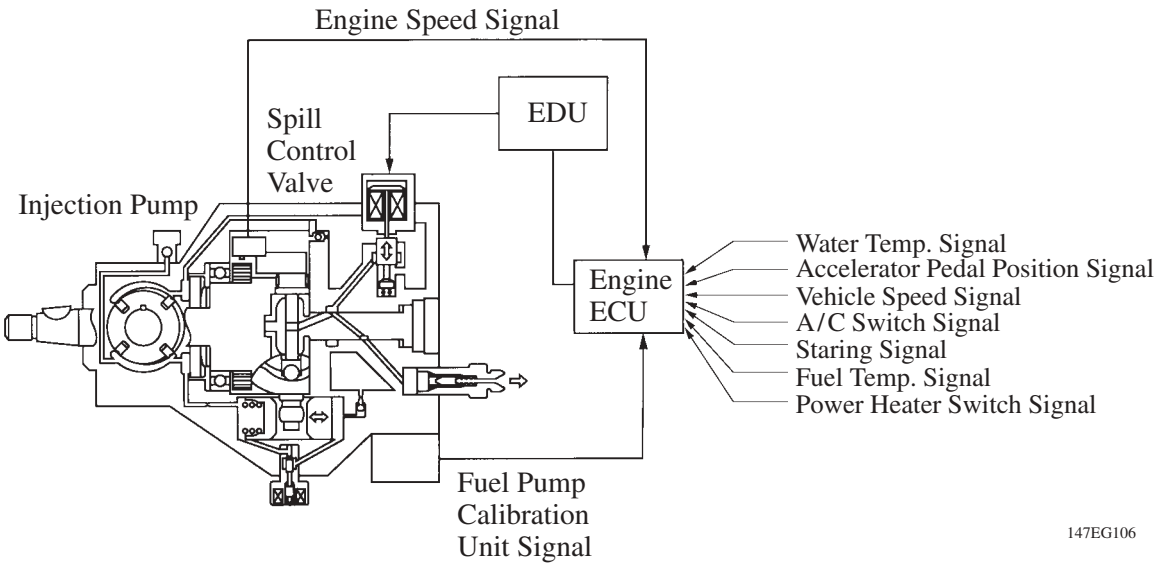
Corrects the basic fuel injection timing in accordance with the water temperature. The injection timing is advanced when the water temperature is low.

3) Starting Injection Timing Control

The starting injection timing is determined in accordance with the starting signal, water temperature signal, and engine speed. The injection timing is advanced when the engine speed is high.

8. Idle Speed Control

- In this system, the engine ECU calculates the target engine speed in accordance with the engine condition, and determines the fuel injection volume, thus controlling the idle speed rpm.
- Increases the idle speed during the operation of the power heater to improve its heating performance.



Function of Engine ECU

1) Feedback Control

During idling, the feedback control controls the injection volume to achieve the target idle speed, if there is a difference between the target idle speed calculated by the engine ECU and the actual idle speed.

2) Warm-Up Control

Controls the injection volume during warm-up to achieve an optimal fast idle speed in accordance with water temperature.

3) Engine Speed Change Estimate Control

Immediately after the air conditioning switch is engaged, the idle speed can be affected by the change in the load that is applied to the engine. To prevent this symptom, the engine speed-change estimate control increases or decreases the injection volume before the idle speed changes.

9. Stable Idling Control

Immediately after the air conditioning switch is turned ON or OFF, the load applied to the engine changes, causing the idle speed to fluctuate. To prevent this symptom, the engine speed-change estimate control increases or decreases the injection volume before the idle speed fluctuates.

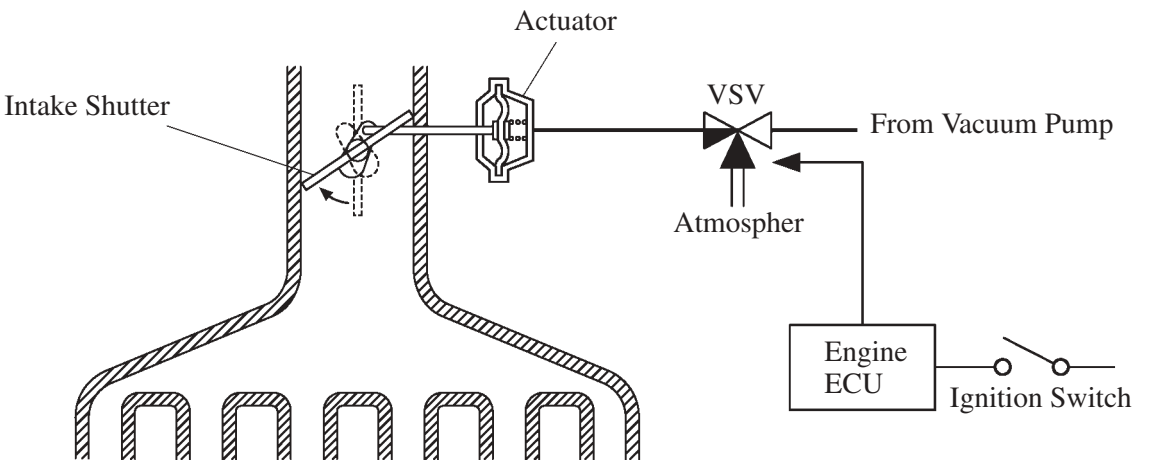
10. Cruise Control

In the previous cruise control system, the cruise control actuator moved the adjusting lever to control the vehicle speed. On this model, however, the injection volume is controlled in accordance with the instructions received from the cruise control computer that is integrated in the engine ECU in order to control the vehicle speed.

11. Intake Air Control

When the engine is stopped, the intake air control system closes the intake shutter that is provided in the intake pipe to shut off the intake air and reduce vibrations.

▶ System Diagram ◀



147EG104

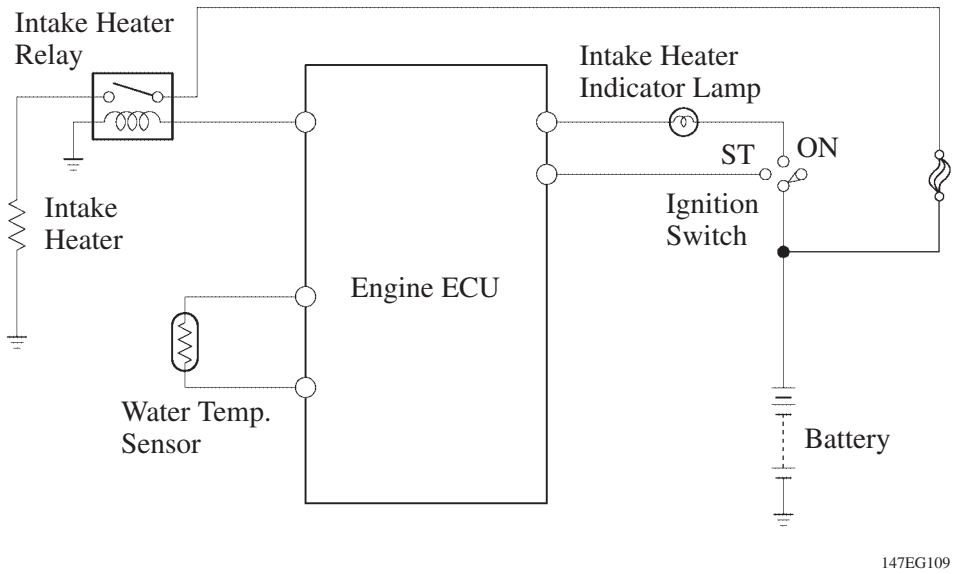
Operation

When the engine is stopped, the engine ECU turns the VSV ON to introduce air to the actuator, thus closing the intake shutter.

12. Intake Heater Control

Applies current to the intake heater during cold-starting to increase the intake air temperature and improve the engine's startability.

▶ System Diagram ◀



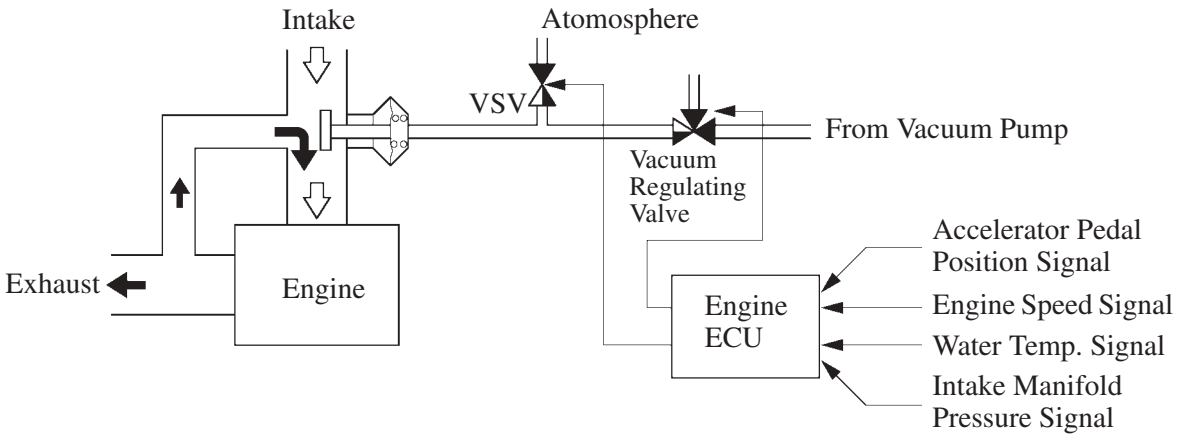
Operation

- When the engine coolant temperature is below 40°C, turning the ignition switch ON causes the intake heater relay to turn ON, allowing the intake heater to operate. The intake heater operates until the engine coolant temperature becomes higher than 40°C, or the maximum of 90 seconds.
- At the same time, the intake heater indicator lamp is illuminated in accordance with the engine coolant temperature (maximum 10 seconds).

13. EGR Control

In the EGR control system, the engine ECU controls the vacuum regulating valve to recirculate an appropriate amount of exhaust gas to the combustion chamber in accordance with the engine condition. This results in slower combustion rate, lower combustion temperature, and reduced NOx emissions.

▶ System Diagram ◀

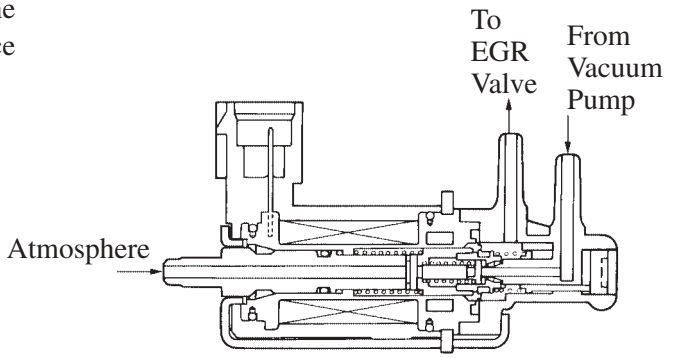


147EG110

Construction

1) Vacuum Regulating Valve

Controls the vacuum that is applied by the vacuum pump to the EGR valve in accordance with the signals from the engine ECU.



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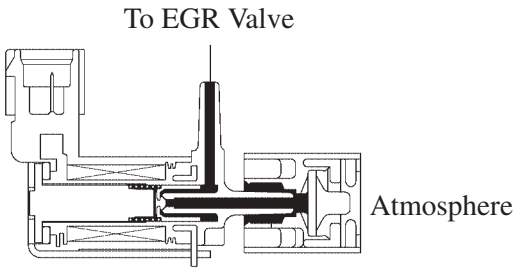
2) VSV

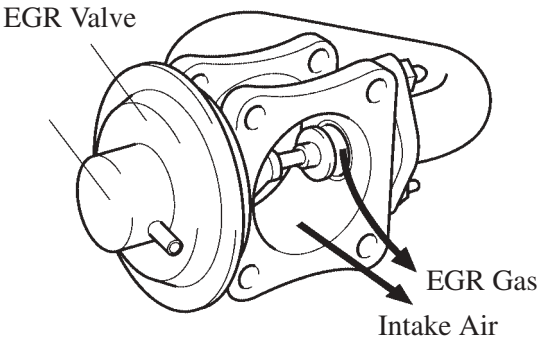
Releases the vacuum that is applied to the EGR valve when the EGR is OFF in order to improve the response when the valve is closed.



147EG115

3) EGR Valve

- Using the vacuum from the vacuum regulating valve, the EGR valve opens and closes the valve to introduce exhaust gas into the intake manifold.
- By providing the EGR valve in the intake passage, the various parts in the EGR valve are cooled by the intake air, thus enabling EGR control at higher load conditions.



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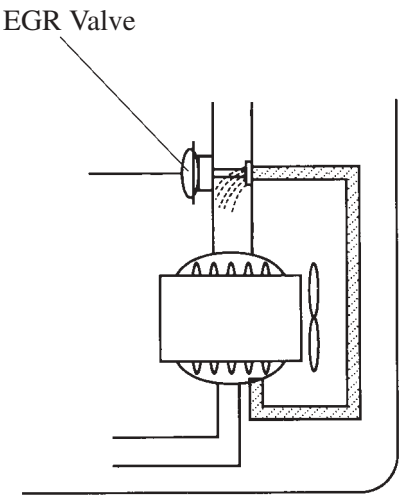
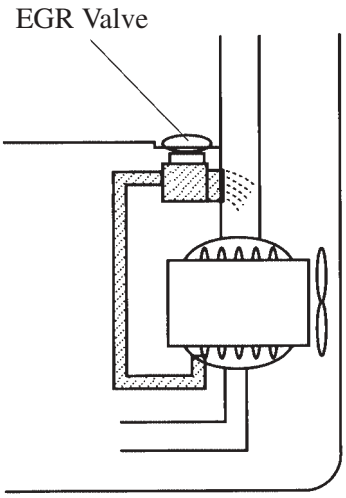


1HD-FTE Engine



Ordinary Engine

147EG112

Operation

1) Based on the signals from the sensors, the engine ECU applies duty control to the current that is applied to the vacuum regulating valve, thus regulating the vacuum that is applied to the EGR valve. Thus, the EGR valve opening is controlled to provide the volume of EGR gas that is appropriate for the engine condition.
2) The EGR function is stopped under the conditions given below to ensure drivability and to reduce diesel smoke.

- The water temperature is low.
- The vehicle is driven under high load condition.
- During deceleration (The EGR operates at idle)

14. Engine Immobiliser System

The engine immobiliser system has been designed to prevent the vehicle from being stolen. This system uses a engine ECU that stores the ID code of the authorized ignition key. If an attempt is made to start the engine using an unauthorized key, the engine ECU to prohibit fuel delivery effectively in order to disable the engine. For details, see page 277 in the Engine Immobiliser system section.

15. Diagnosis

- If the engine ECU detects any problem with a sensor or an electrical circuit, it turns ON the CHECK ENGINE lamp in the combination meter to inform the driver. In addition, the malfunction code will be stored in memory.
- An M-OBD (Multiplex On-Board Diagnostic) System has been adopted to improve serviceability. The operation of the M-OBD system is basically the same as the 1FZ-FE engine.
  For details, see page 60.