

## ■ ENGINE CONTROL SYSTEM

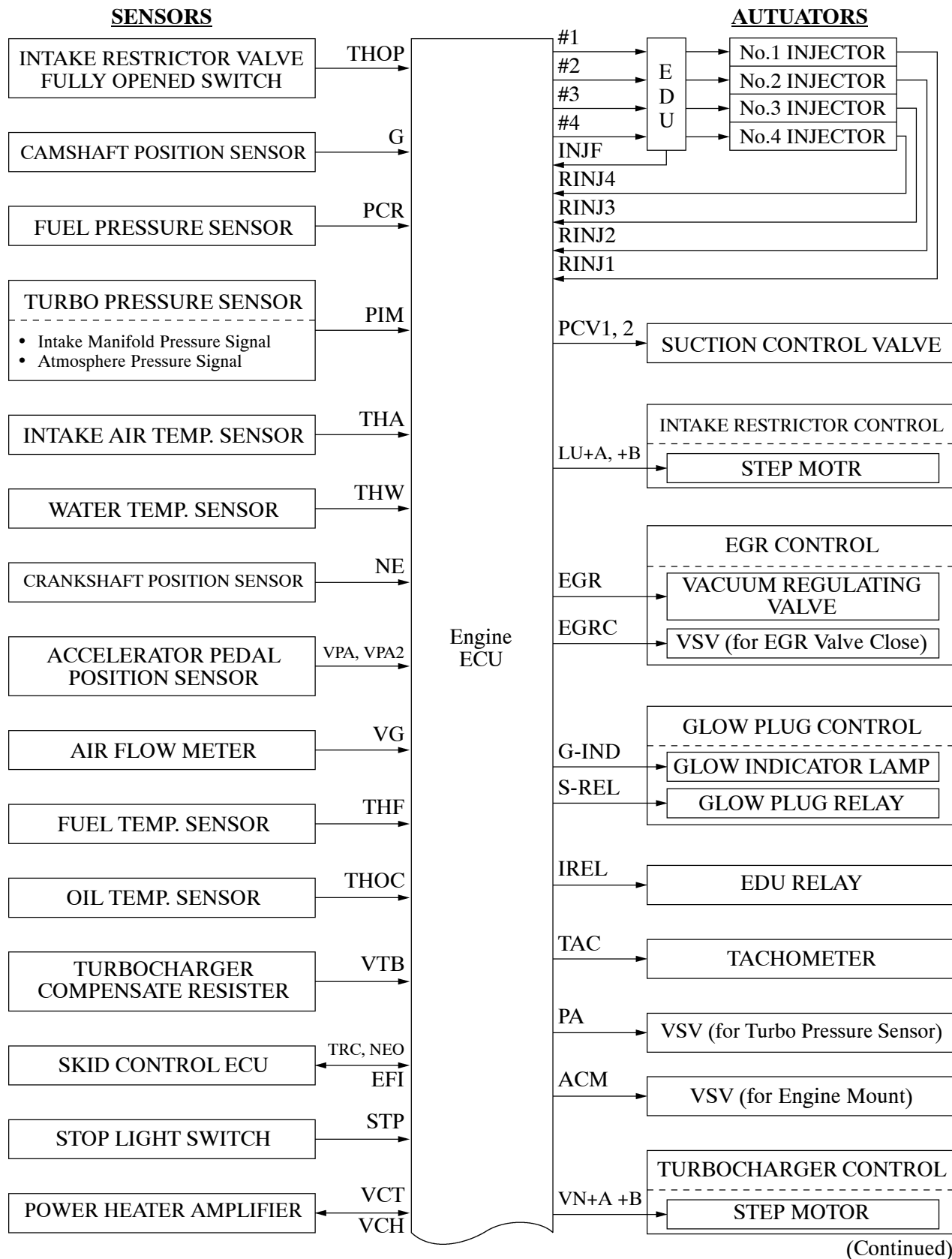
### 1. General

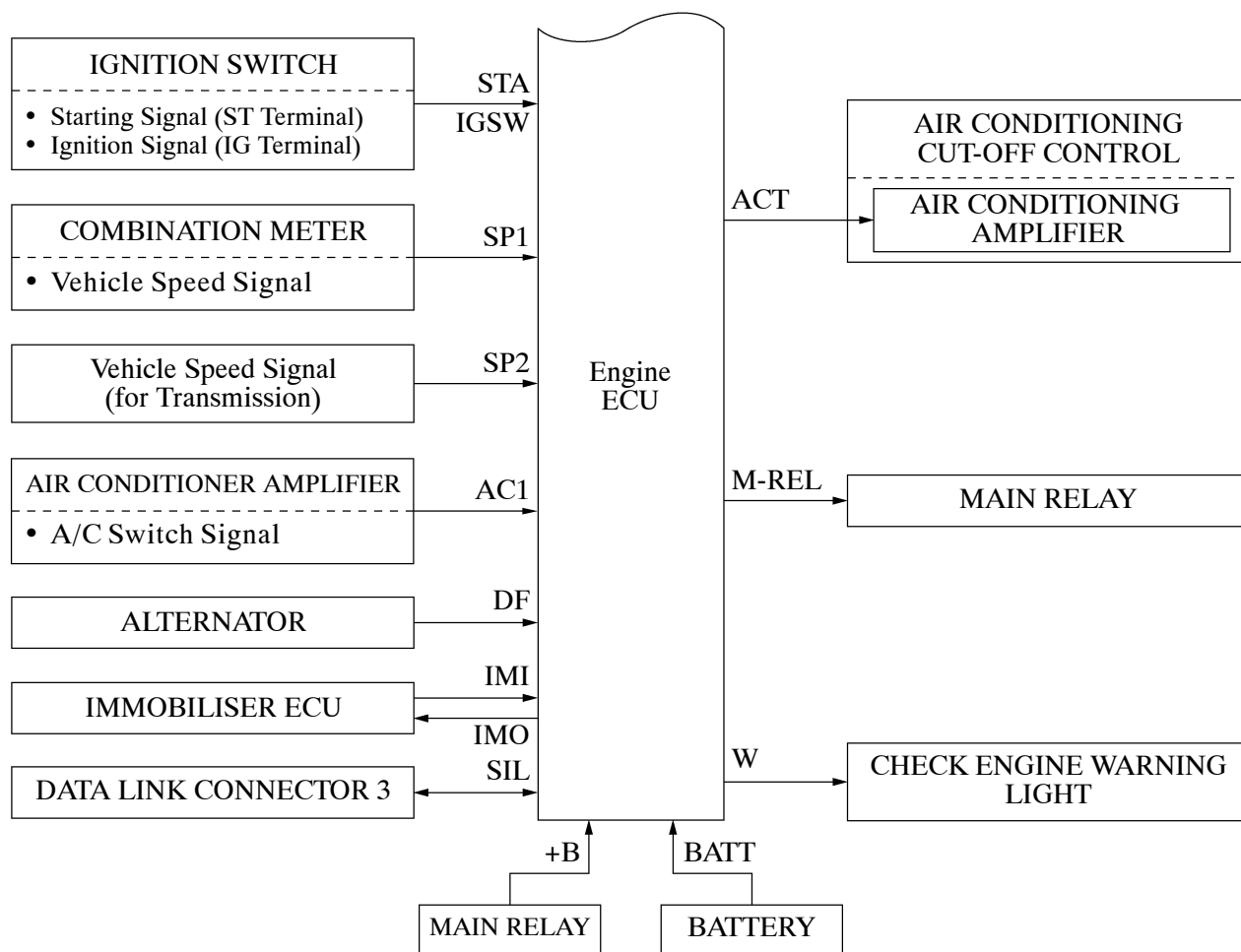
The engine control system for the KD-FTV engine has following system.

System	Outline	New	Previous
Fuel Injection Volume Control (See page EG-80)	Based on the signals received from the sensors, the engine ECU determines the fuel injection volume in accordance with the engine condition.	○	○
Fuel Injection Timing Control (See page EG-81)	Based on the signals received from the sensors, the engine ECU determines the fuel injection timing in accordance with the engine condition.	○	○
During Starting Control (See page EG-82)	To facilitate startability, the engine ECU optimally controls the injection volume and injection timing during starting.	○	○
Idle Speed Control (See page EG-83)	The engine ECU determines the idle speed in accordance with the engine condition, and controls the fuel injection volume in order to maintain the target idle speed.	○	○
Fuel Pressure Control (See page EG-84)	Based on the signals received from the sensors, the engine ECU determines the fuel pressure via SCV (Suction Control Valve) in accordance with the engine condition.	○	○
Pilot Injection Control (See page EG-85)	Based on the signals received from the sensors, the engine ECU determines pilot injection volume/timing, and interval (between pilot injection and main injection) in accordance with the engine condition.	○	○
Glow Plug Control	Controls the length of time when the current is applied to the glow plugs, in accordance with the coolant temperature.	○	○
Intake Restrictor Control (See page EG-86)	<ul style="list-style-type: none"> <li>Controls the intake restrictor valve opening angle in accordance with the engine condition.</li> <li>Fully close the throttle in order to reduce the vibration when the engine is stopped.</li> </ul>	○	○
Turbocharger Control (See page EG-87)	Based on the signals received from the sensors, the engine ECU controls the actuator in accordance with the engine condition.	○	○
EGR Control (See page EG-90)	Controls the EGR volume via EGR valve in accordance with the engine condition.	○	○
Air Conditioner Cut-Off Control	By controlling the air conditioner compressor ON or OFF in accordance with the engine condition, drivability is maintained.	○	○
Engine Mount Control (See page EG-91)	When the engine speed is low and the vehicle is operating at a low speed, this control utilizes vacuum to soften the engine mount characteristics in order to restrain the engine vibration at idle.	○	—
Power Heater Control (See page EG-93)	By controlling the power heater magnetic clutch ON or OFF in accordance with the engine condition.	○	○
Engine Immobiliser (See page EG-94)	Prohibits fuel injection if an attempt is made to start the engine with an invalid ignition key.	○	○
Diagnosis (See page EG-94)	When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section.	○	○
Fail-Safe (See page EG-94)	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in the memory.	○	○

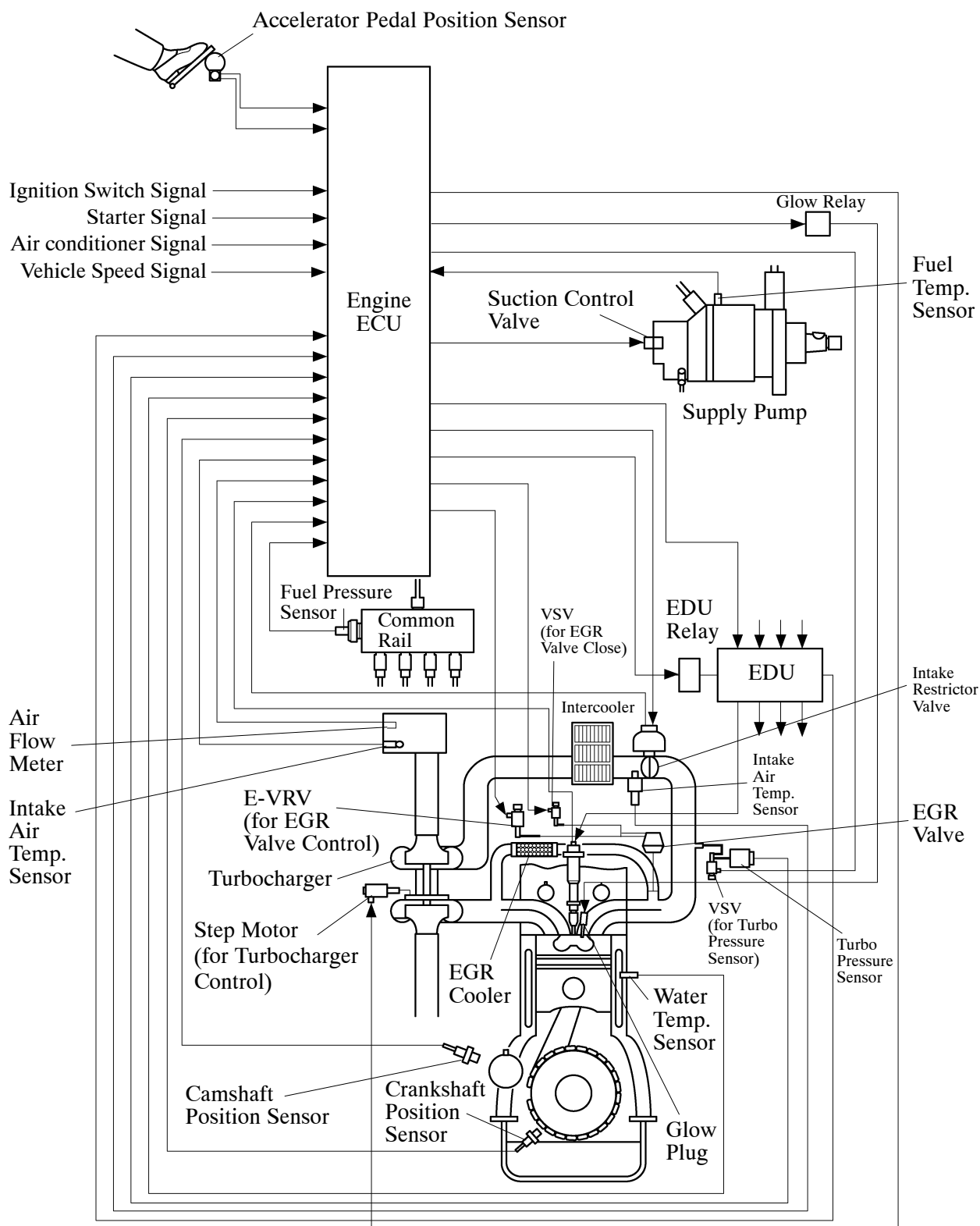
## 2. Construction

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



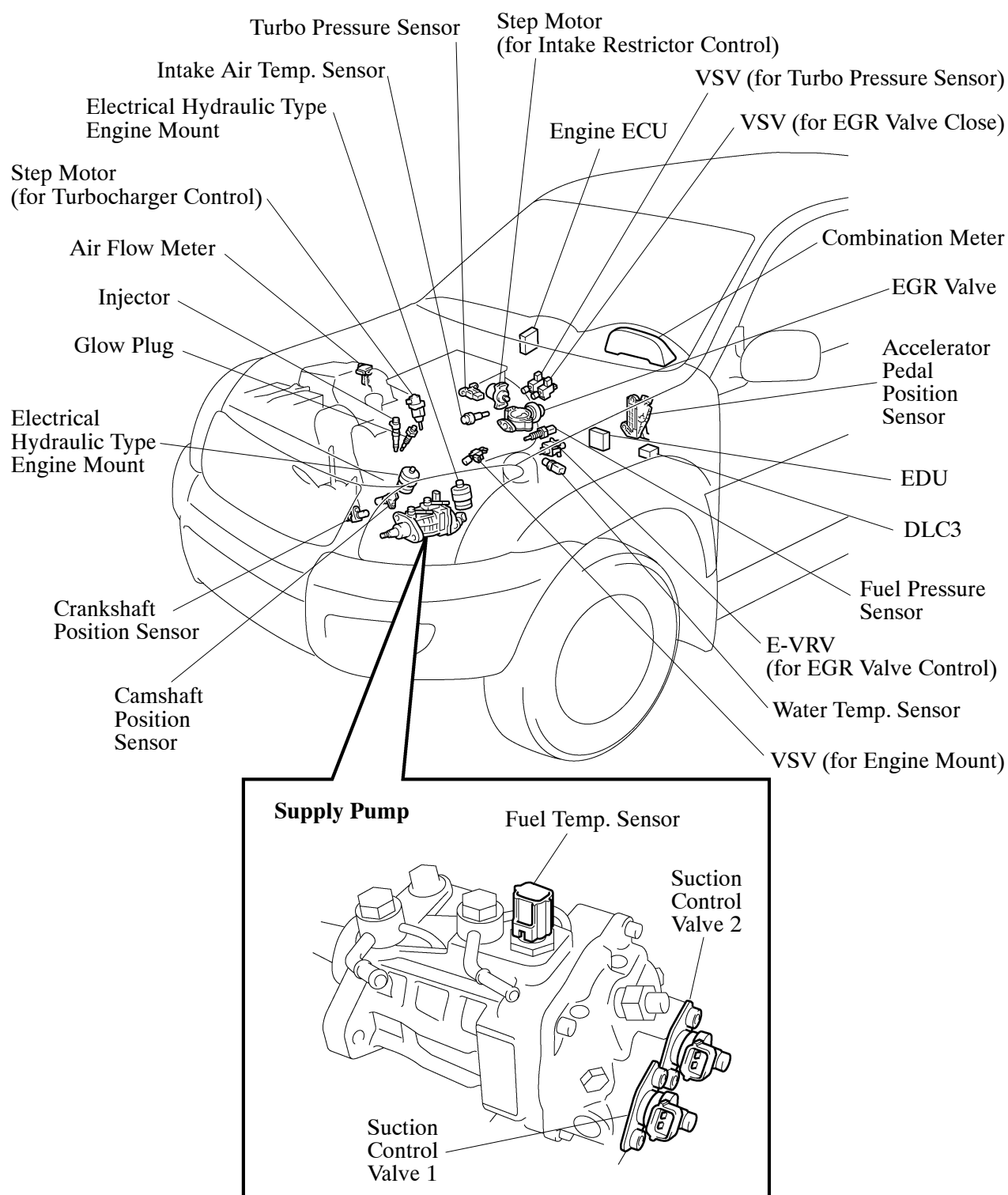


### 3. Engine Control System Diagram



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#### 4. Layout of Main Components



## 5. Main Component of Engine Control System

### General

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

Model	New		Previous	
Components	Outline	Quantity	Outline	Quantity
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 (5)	1	←	←
Accelerator Pedal Position Sensor	Linear Type	2 (Main, Sub)	←	←
EDU	DC/DC Converter	1	←	←

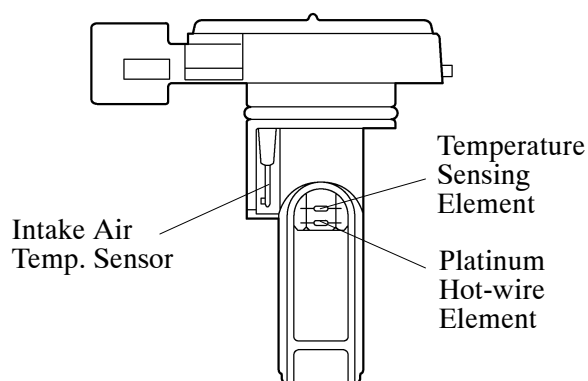
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### EDU (Electronic Driver Unit)

- The EDU is used to drive the injector at high speeds. The EDU has realized high-speed driving under high fuel pressure conditions through the use of a DC/DC converter that provides a high voltage, quick-charging system.
- The engine ECU constantly monitors the EDU and stops the engine in case an abnormal condition is detected.

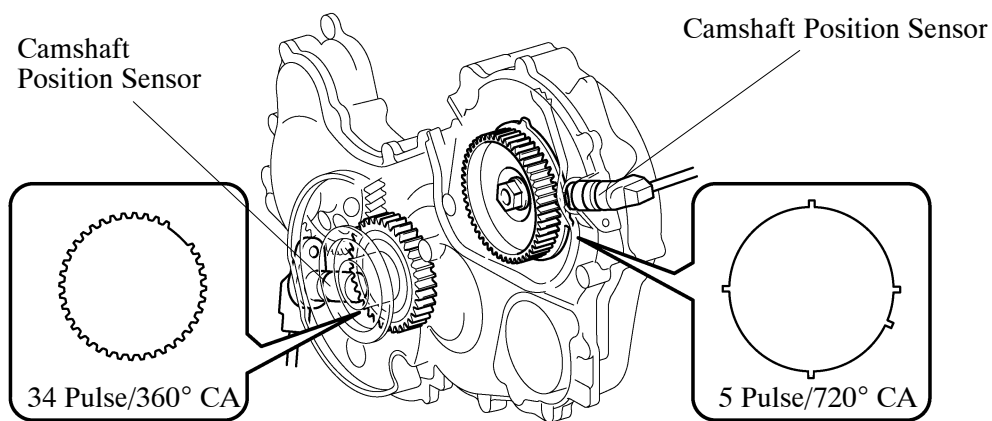
### Air Flow Meter

The 1KD-FTV engine uses the hot-wire type air flow meter designed for direct electrical measurement of the intake air mass flow.

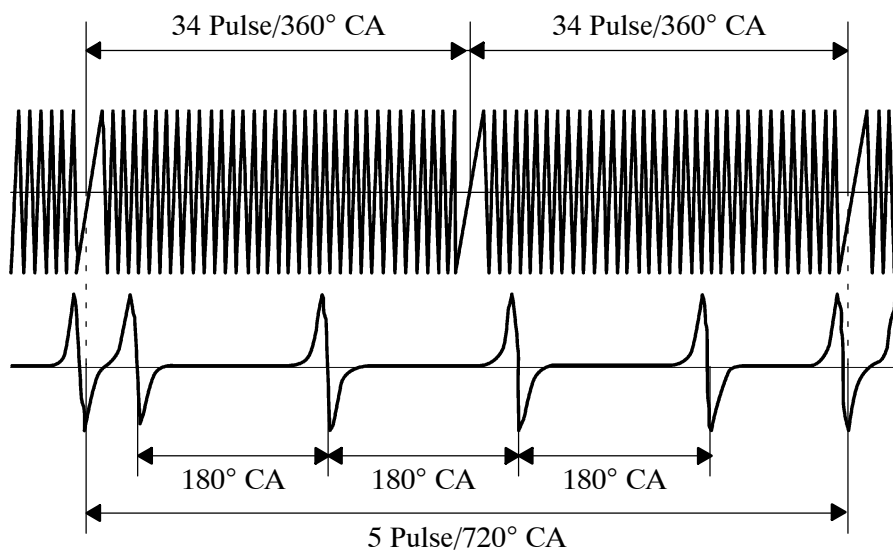


### Crankshaft Position Sensor and Camshaft Position Sensor

- The timing rotor of the crankshaft consists of 34 teeth, with 2 teeth missing. The crankshaft position sensor outputs the crankshaft rotation signals every 10°, and the missing teeth are used to determine the top-dead-center.
- To detect the camshaft position, a protrusion that is provided on the timing pulley is used to generate 5 pulse for every 2 revolution of the crankshaft.



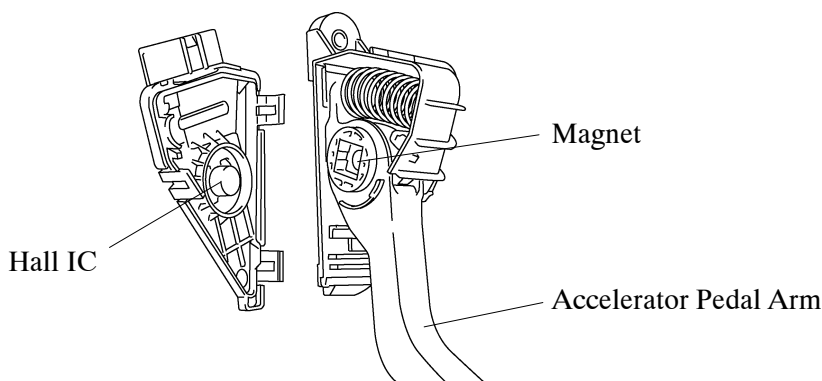
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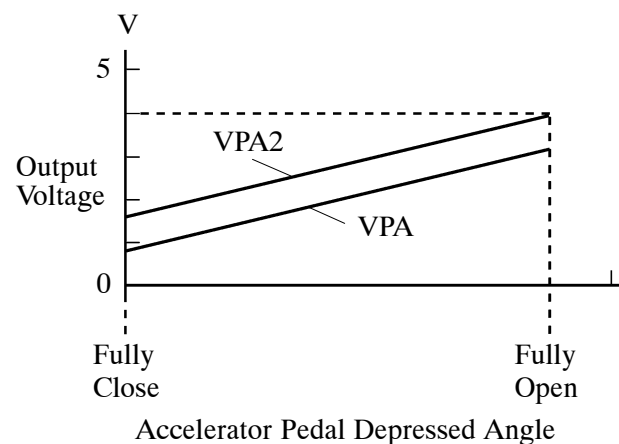
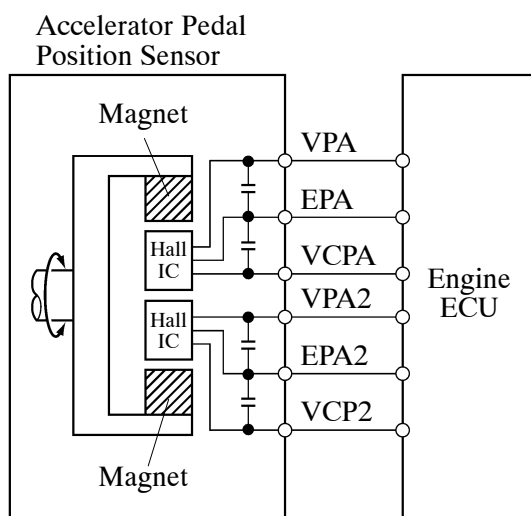
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## Accelerator Pedal Position Sensor

The magnetic yoke that is mounted at the base of the accelerator pedal arm 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 at that time into electrical signals, and outputs them in the form of accelerator pedal effort to the engine ECU.



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### Service Tip

The inspection method differs from the conventional accelerator pedal position sensor because this sensor uses a hall IC.

For details, refer to the 1KD-FTV Engine Repair Manual (Pub. No. RM992E.)

## 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 flow.

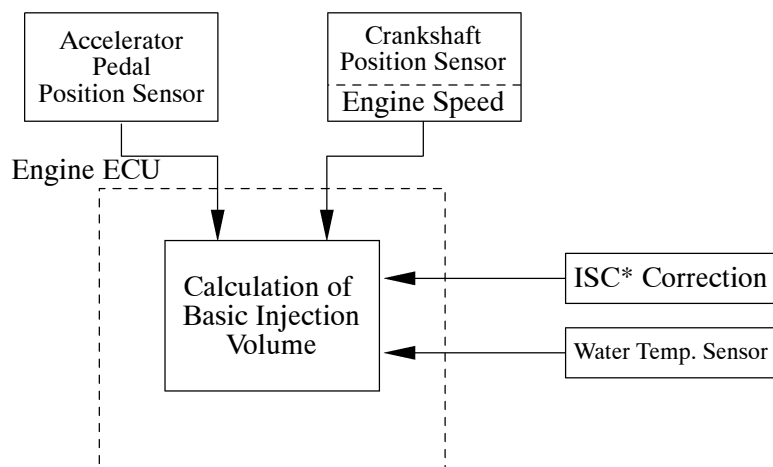
In addition, the atmospheric pressure can be detected by switching the piping passage through the operation of the VSV.



## 6. Fuel Injection Volume Control

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

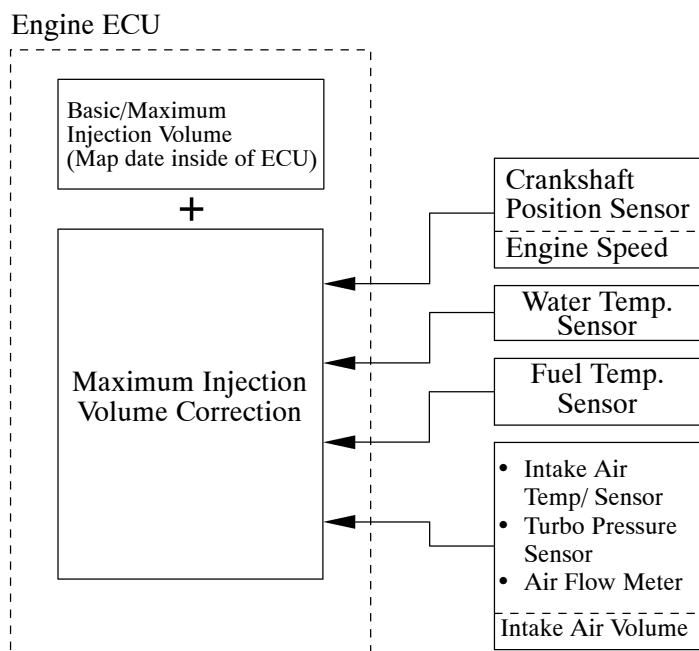
### ► Basic Injection Volume ◀



\*: Idle Speed Control

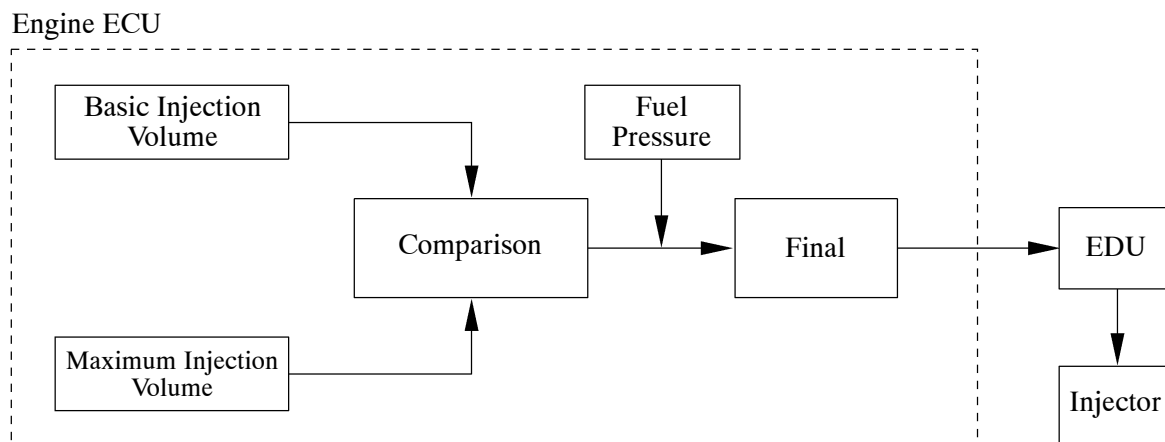
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### ► Maximum Injection Volume ◀



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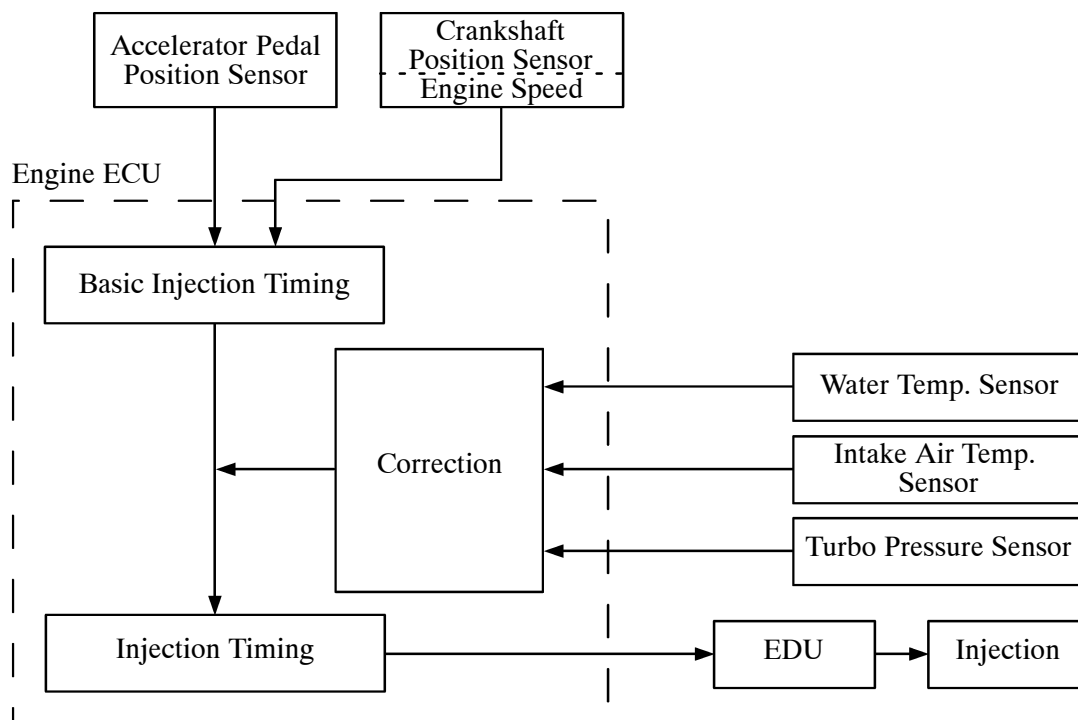
## ► Final Injection Volume Decision ◀



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## 7. Fuel Injection Timing Control

Fuel injection timing is controlled as shown below.

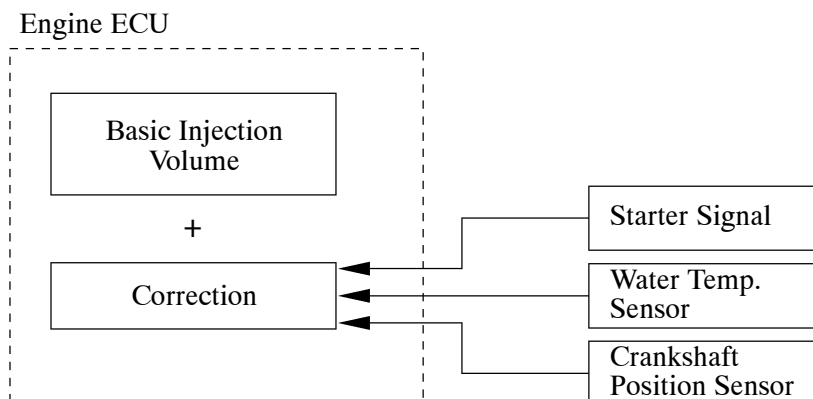


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## 8. During Starting Control

### Injection Volume Control

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

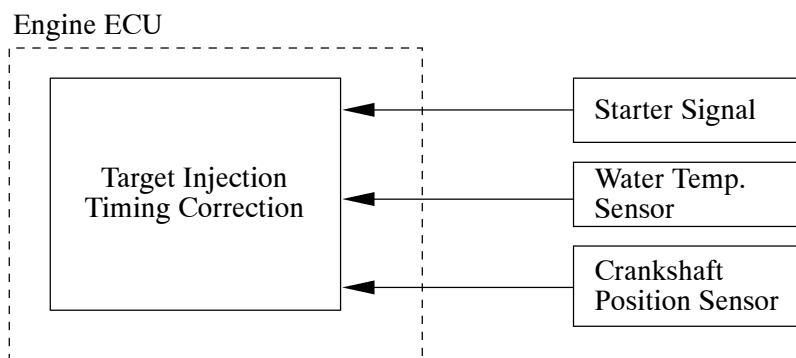


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### Injection Timing Control

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

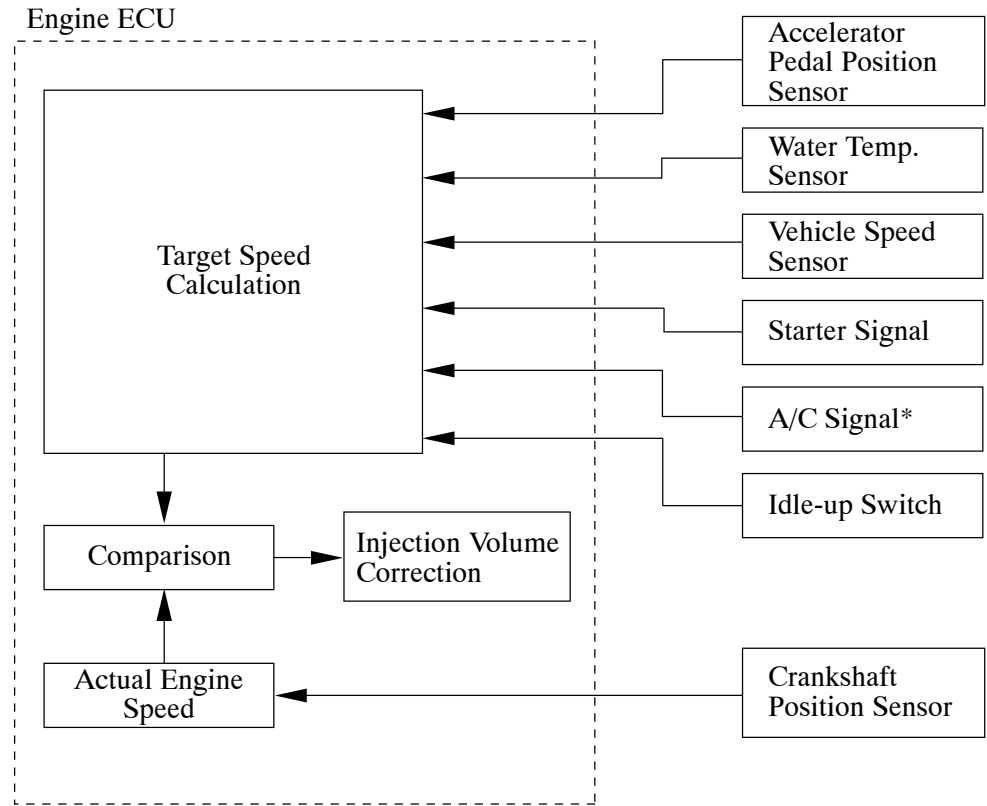
When the water temperature is low, if the engine speed is high, the injection timing is advanced.



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9. Idle Speed Control

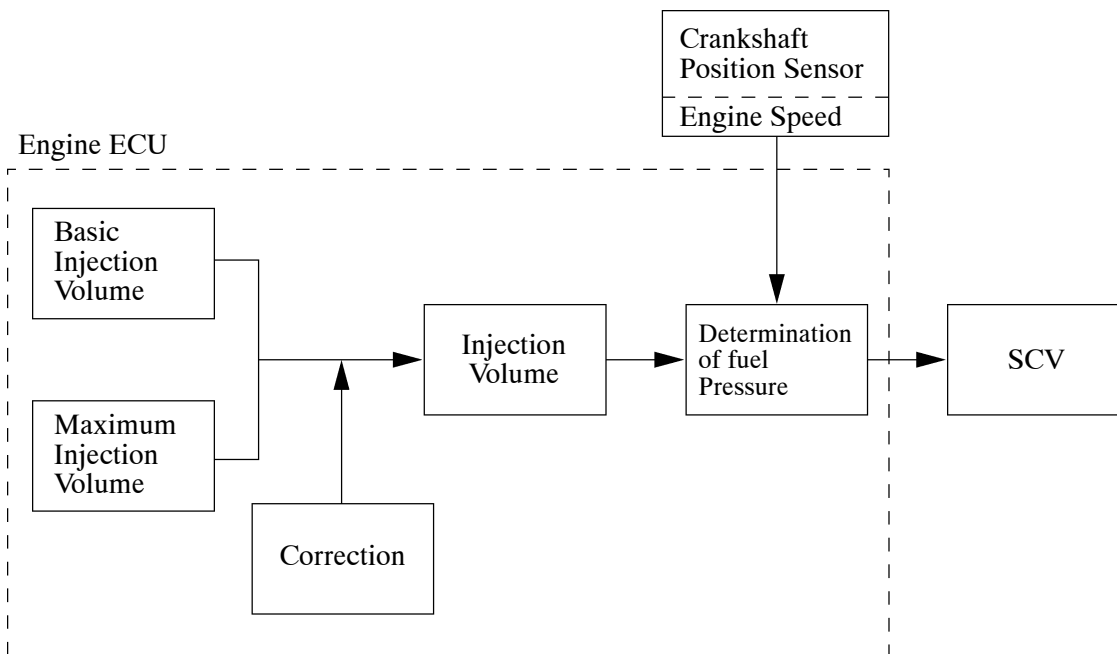
ISC correction is controlled as shown below.



\*: with Air Conditioner

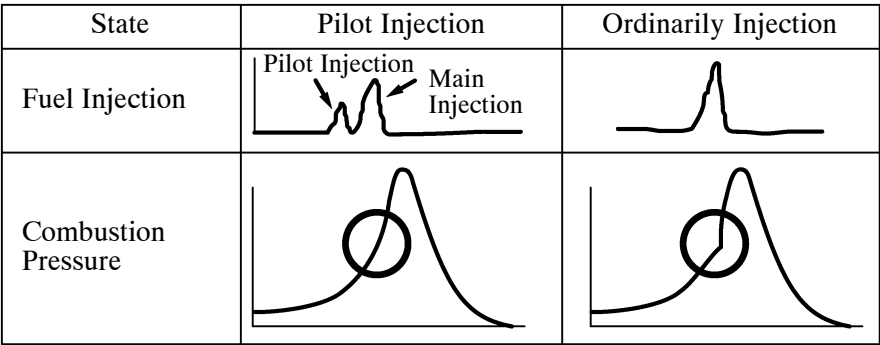
## 10. Fuel pressure Control

A fuel pressure that matches the operating conditions of the engine is calculated according to the actual injection volume that has been determined based on the signals from the sensors, and the engine speed. The ECU sends signals to the SCV to adjust the fuel pressure that is generated by the supply pump.



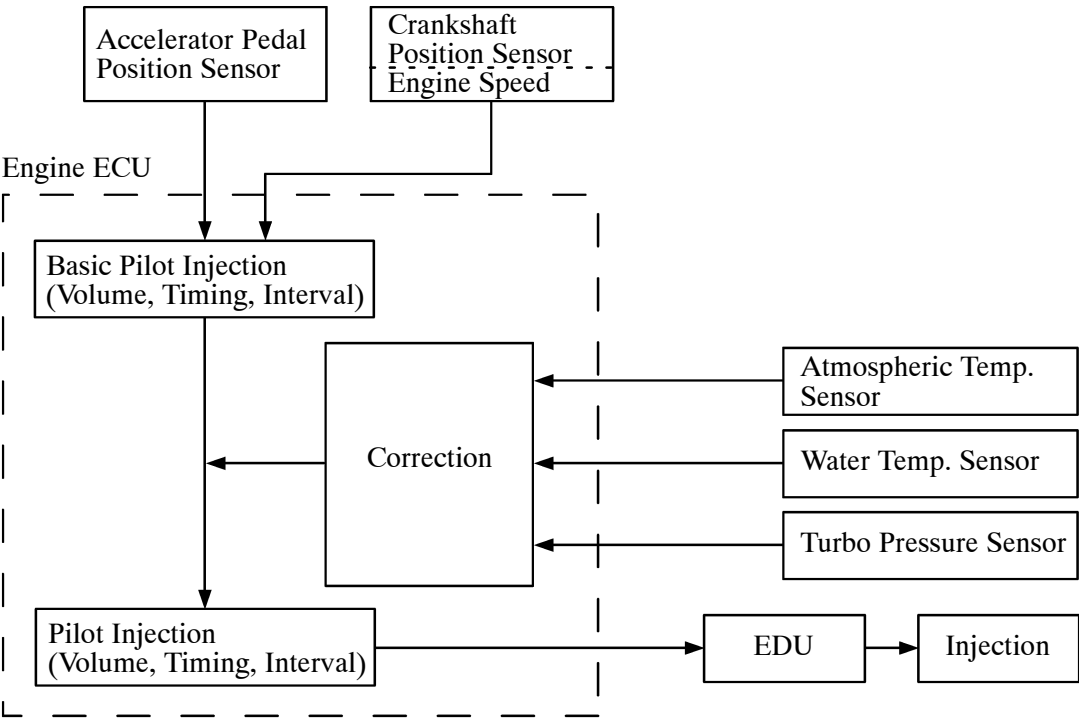
11. Pilot Injection Control

- Pilot injection is a method that provides an auxiliary fuel injection before the main fuel 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.



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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.

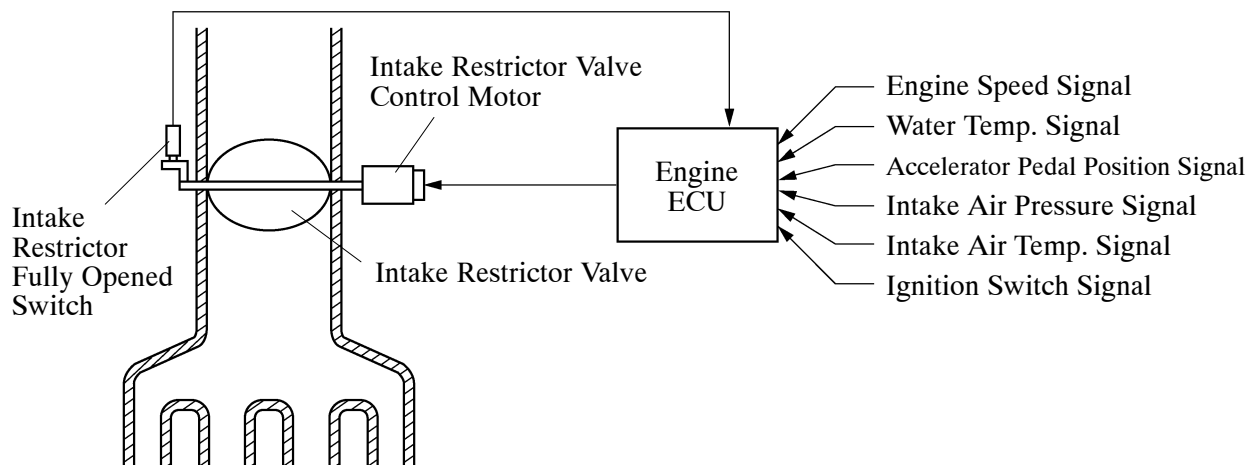


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## 12. Intake Restrictor Control

The opening of the intake restrictor valve that is installed on the intake manifold is controlled by the engine ECU in accordance with engine condition.

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 and this control makes it possible to re-circulate the exhaust gas in accordance with the driving condition.

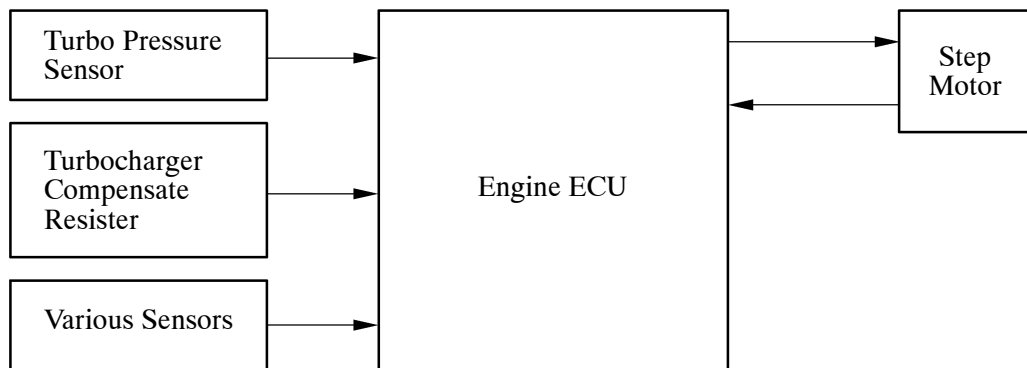


### 13. Turbocharger Control System

#### General

- A variable nozzle vane type turbocharger system is used. In response to the engine condition, by controlling the nozzle vane variably and making the most suitable velocity of the exhaust gas inflow to the turbine at all times, great improvements of low speed torque, maximum output, fuel consumption and noise and emission reductions have been realized.
- A step motor has been adopted to drive the nozzle vanes and it controls the most suitable opening for the vanes by the signal from the engine ECU.
- The engine coolant circuit has been established to cool the step motor.

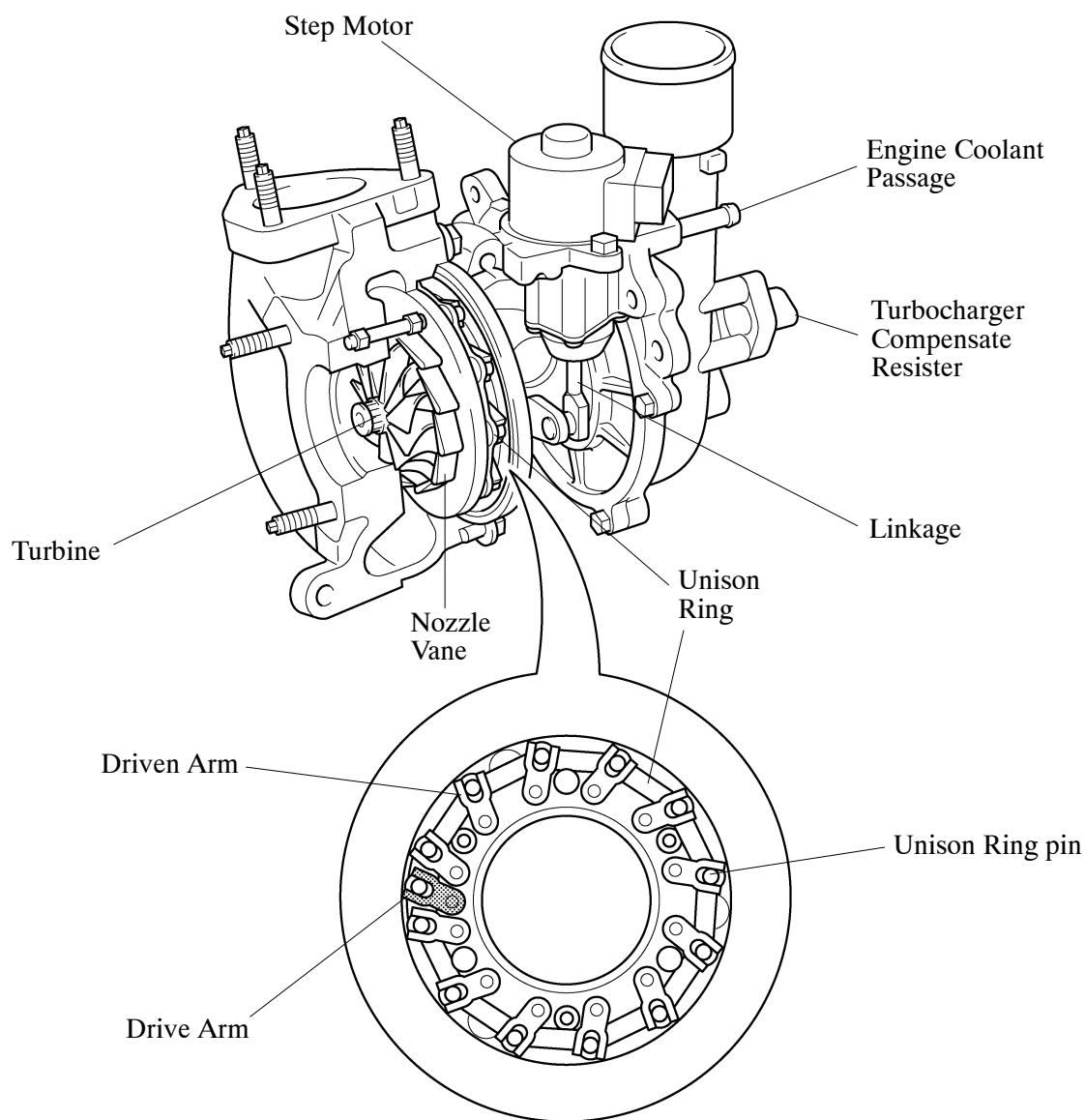
#### ► System Diagram ◀





## Construction

Variable nozzle vane device is established on the turbine (exhaust) side, and consisted of a step motor, linkage, drive arm unison ring, unison ring pins, driven arms and nozzle vanes. In order to adjust the unbalance of the exhaust gas flow generated among the solid bodies of each turbocharger, a turbocharger compensate resister is installed on the compressor housing.



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### Service Tip

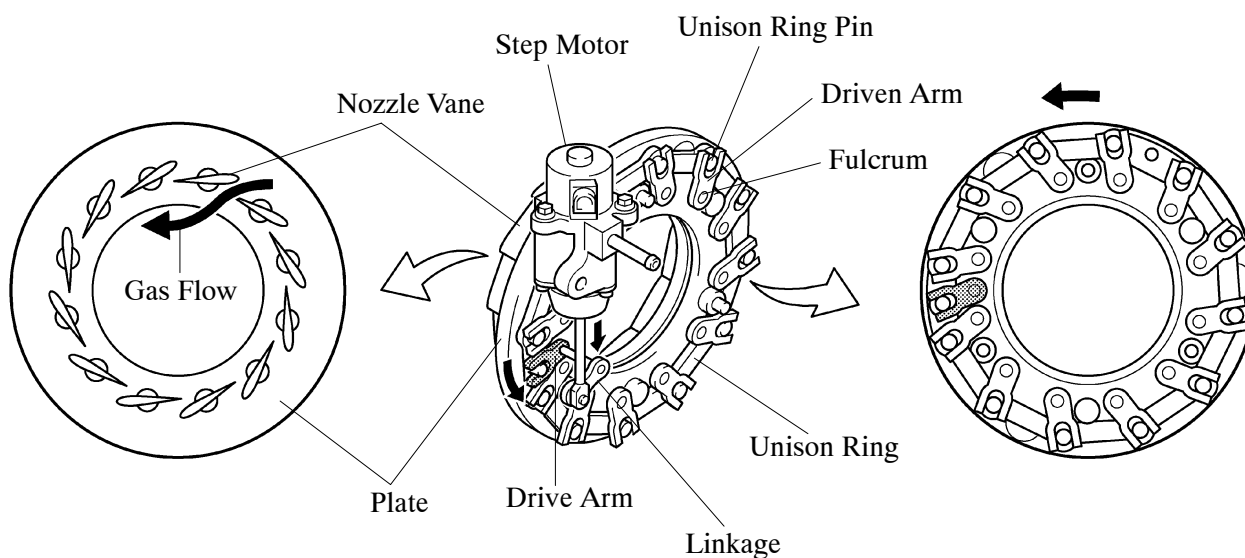
When exchanging the turbocharger compensate resister, select the new part with the same number\* of the turbocharger.

\*: The numbers are stamped on the side of the turbocharger compensate resister and on the intake side housing of the turbocharger.

## Operation

### 1) At Engine Low Speed Range

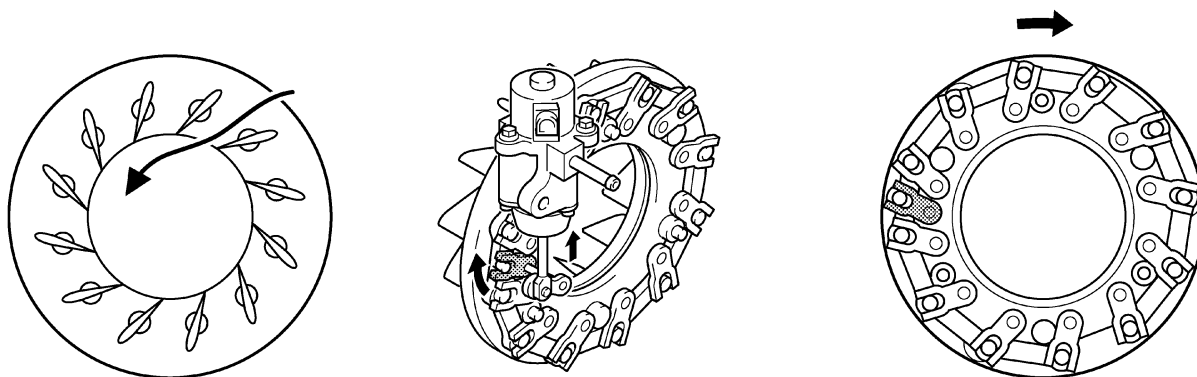
When the engine is running in a low speed range, the step motor press down the linkage by a signal from the engine ECU. The tip of the linkage will rotate the unison ring counterclockwise through a drive arm. The unison ring has a driven arm through the unison ring pin and this driven arm also moves according to the rotation direction of the unison ring. The fulcrum of the driven arm is an axis which is integrated with a nozzle vane behind the plate. When the driven arm moves counterclockwise, the nozzle vane moves toward closing direction resulting in increasing the velocity of the exhaust gas running to the turbine and speed of the turbine, and then the torque will be improved when the engine is running at a low speed.



233EG78

### 2) At Engine Medium-to-High Speed Range

When the engine is running in a medium-to-high speed range, the step motor pull up the linkage by a signal from the engine ECU. 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 out put and fuel consumption.



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## 14. EGR Control System

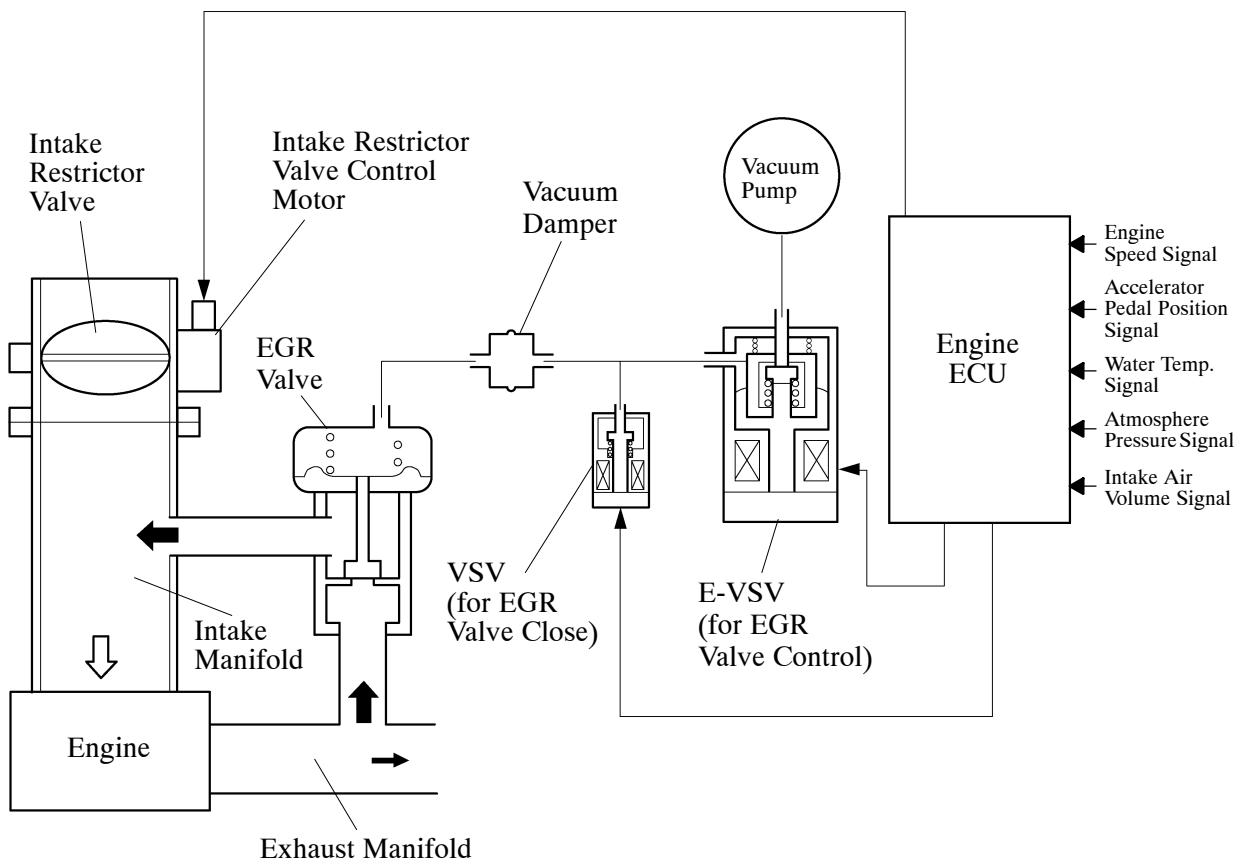
- This system is designed to reduce and control NO<sub>x</sub> formation due to a slight reduction of peak temperature in the engine combustion chamber, which is accomplished by introducing a small amount of inert gas into intake manifold.

By sensing the engine driving conditions, the control unit electrically operates both the E-VRV (for EGR valve control) and VSV (for EGR valve close), which controls the magnitude of vacuum introduced into diaphragm of EGR valve and throttle opening position with intake restrictor valve control motor and the amount of recirculating exhaust gas is regulated. EGR valve opening lift is controlled by modulated negative pressure.

- If even one of the following conditions is fulfilled, the VSV is turned ON by a signal from the ECM. This results in atmospheric air acting on the EGR valve, closing the EGR valve and shutting off the exhaust gas (EGR cut-off).

Under the following conditions, EGR is cut to maintain driveability.

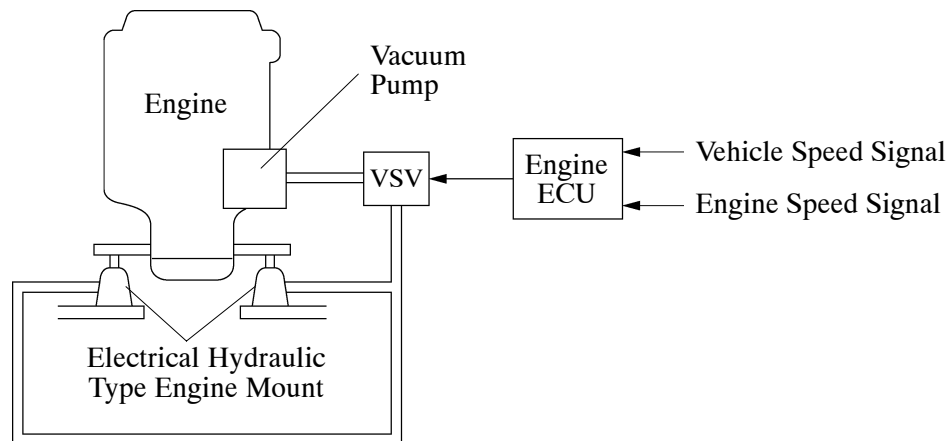
- Before the engine is warmed up
- Engine speed over 4,000 rpm



## 15. Engine Mount Control

### General

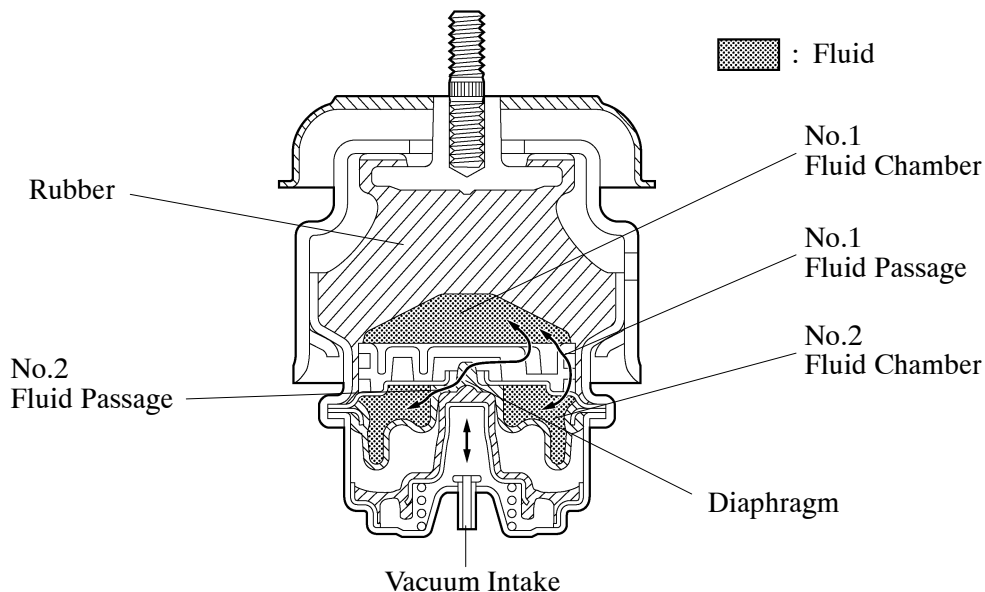
- Electrical hydraulic type engine mounts have been adopted for the front engine mounts.
- When the engine is idling and the vehicle is operating at a low speed, this engine mount utilizes the vacuum from the vacuum pump (for the engine) to move the diaphragm in the mount, which switches the passages for the fluid (Coolant) that is sealed in. By softening the dampening characteristics of the mount in this manner, this mount restrains engine vibration.



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### Construction

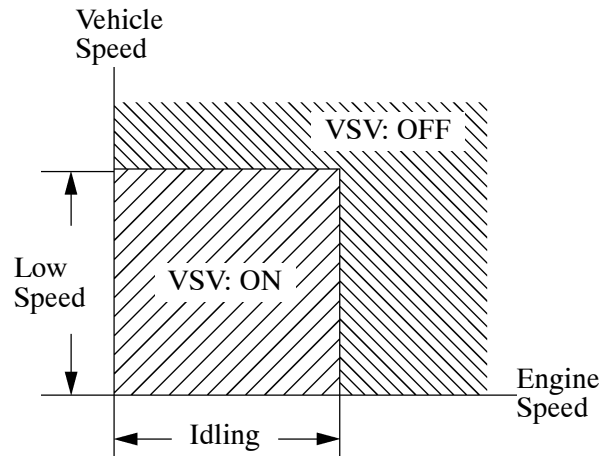
- This engine mount consists primarily of the rubber portion, No. 1 fluid chamber, No. 2 fluid chamber, and diaphragm. Fluid is sealed in the No. 1 and No. 2 fluid chambers.
- This engine mount obtains a vacuum from the vacuum pump via the VSV. It utilizes the vacuum to pull the diaphragm down in order 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.



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## Operation

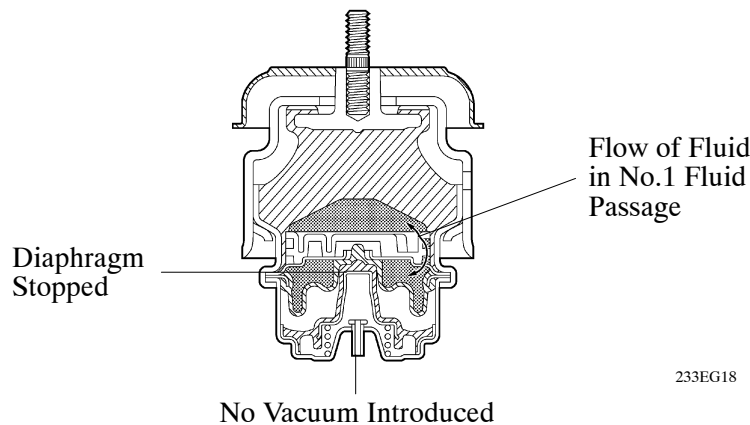
- The engine ECU determines the idling state of the engine and the low speed state of the vehicle in accordance with the engine speed and the vehicle speed. Thus, the engine ECU controls the introduction of vacuum from the vacuum pump (for the engine) to the engine mount by turning the VSV ON or OFF.
- 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.



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### 1) Engine speed other than idle (VSV = OFF)

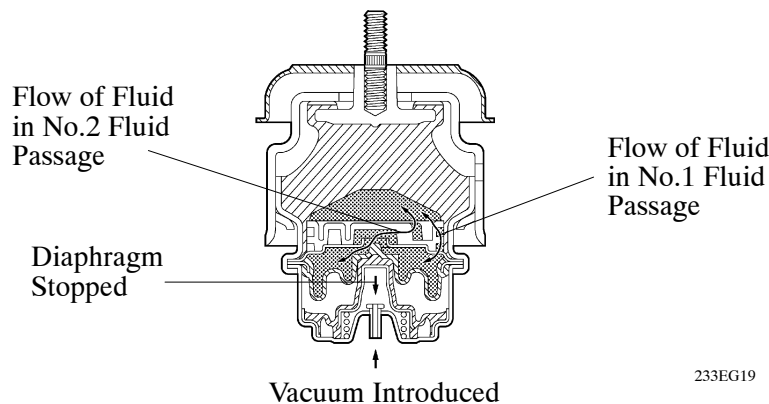
- When the engine ECU determines that the engine speed is other than idle in accordance with the engine speed and the vehicle speed, it stops the introduction of vacuum into the engine mount by turning the VSV OFF.
- When no vacuum is introduced into the engine mount, the diaphragm does not move, so 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.



233EG18

### 2) Engine idling (VSV = ON)

- When the engine ECU determines via the engine speed and the vehicle speed that the engine is idling, it turns the VSV ON to introduce vacuum into the engine mount.
- When a vacuum is introduced into the engine mount, 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 mount characteristics.



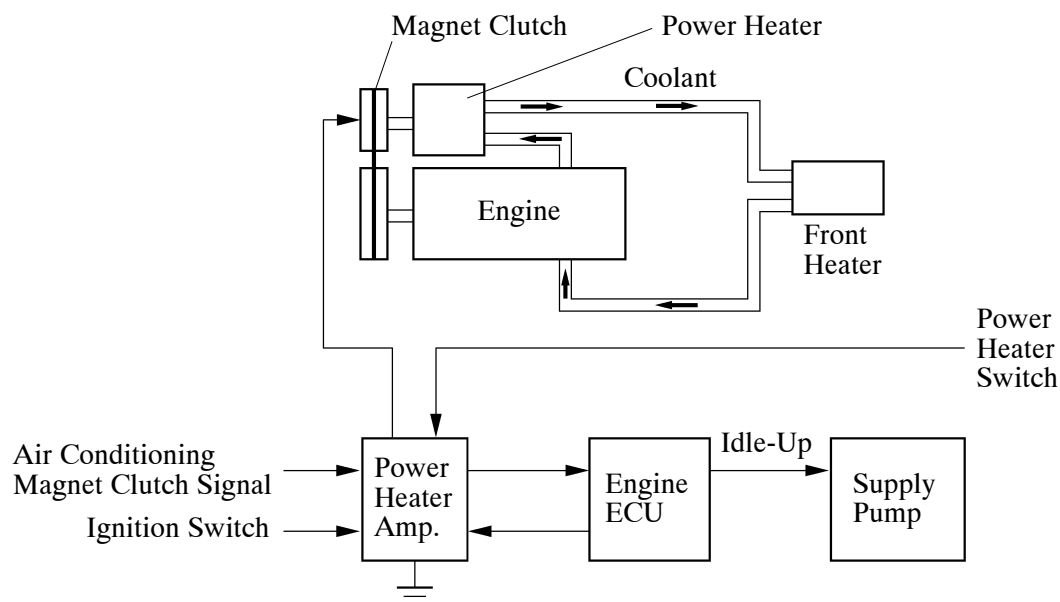
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## 16. Power Heater Control

### General

A viscous type power heater is used on the cold specification model. The power heater increases the coolant temperature by utilizing the shear heat of the silicon oil and by increasing the engine load.

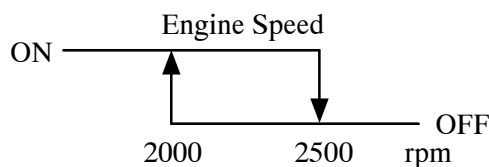
### ► System Diagram ◀



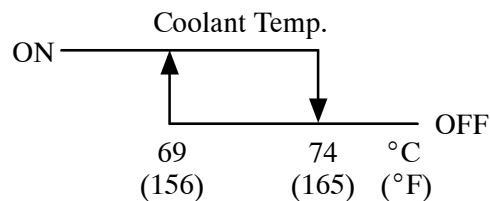
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### Construction

- The power heater, which is located on top of the engine, is driven by a drive belt. Pressing the power heater switch provided in the instrument panel engages the magnetic clutch, causing the rotor in the power heater to rotate and the silicon oil to mix. The shear heat that is thus generated heats the coolant.
- The power heater is controlled according to engine speed and coolant temperature as described below. While the power heater is engaged, the engine idling speed increases to 1200 rpm.



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However, the power heater is turned OFF when the engine is cranking or the vehicle is accelerating (for 5 seconds while the vehicle speed is under 30 km/h (19 mph) and the throttle opening angle is more than 45%).

## 17. Engine Immobiliser System

The engine immobiliser system has been designed to prevent the vehicle from being stolen. This system uses a transponder key computer that stores the ID code of the authorized ignition key. If an attempt is made to start the engine using an unauthorized key, the transponder key computer emits a signal to the engine ECU to prohibit both the supply pump and injector operation in order to disable the engine.

## 18. Diagnosis

When the engine ECU detects a malfunction, the engine ECU makes a diagnosis and memorizes the failed section. Furthermore, check engine warning light in the combination meter illuminates or blinks to inform the driver. The engine will also store the DTCs (Diagnosis Trouble Codes) of the malfunctions.

The DTCs can be accessed by connecting the SST (09843-18040) to the DLC3 terminals Tc and CG, and reading the blinking of the check engine warning light. They can also be accessed by connecting a hand-held tester.

## 19. 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 Control List ◀

Location of Malfunction	Description of Control
Accelerator Pedal Position Sensor	<p>The accelerator pedal position sensor comprises two (main, sub) circuits.</p> <ul style="list-style-type: none"> <li>• If a malfunction occurs in either one of the sensor circuits, the engine ECU detects, the abnormal signal voltage difference between these two sensor circuits and switches to the limp mode. In the limp mode, the remaining circuits is used to calculate the injection control, in order to operate the vehicle under limp mode control.</li> <li>• If both systems malfunction, the engine ECU considers that the accelerator pedal is depressed about 6%.</li> </ul>
Water Temp. Sensor	<p>In case of a signal malfunction, the engine ECU fixes the uses the constant values of 107°C (224.6°F) water temperature to perform the calculation. However, in case that the fuel temperature is less than 15°C (59.0°F), a fuel temperature sensor controls as a substitute for a water temperature sensor.</p>
Intake Air Temp. Sensor	<p>In case of a signal malfunction, the engine ECU fixes the uses the constant values of 80°C (176°F) intake air temperature to perform the calculation.</p>
Fuel Temp. Sensor	<p>In case of a signal malfunction, the engine ECU fixes the uses the constant values of 40°C (104.0°F) fuel temperature to perform the calculation.</p>
Turbo Pressure Sensor	<p>In case of a signal malfunction, the engine ECU calculates the injection Volume limited by the turbo pressure fixed value and continues effecting Injection control.</p>