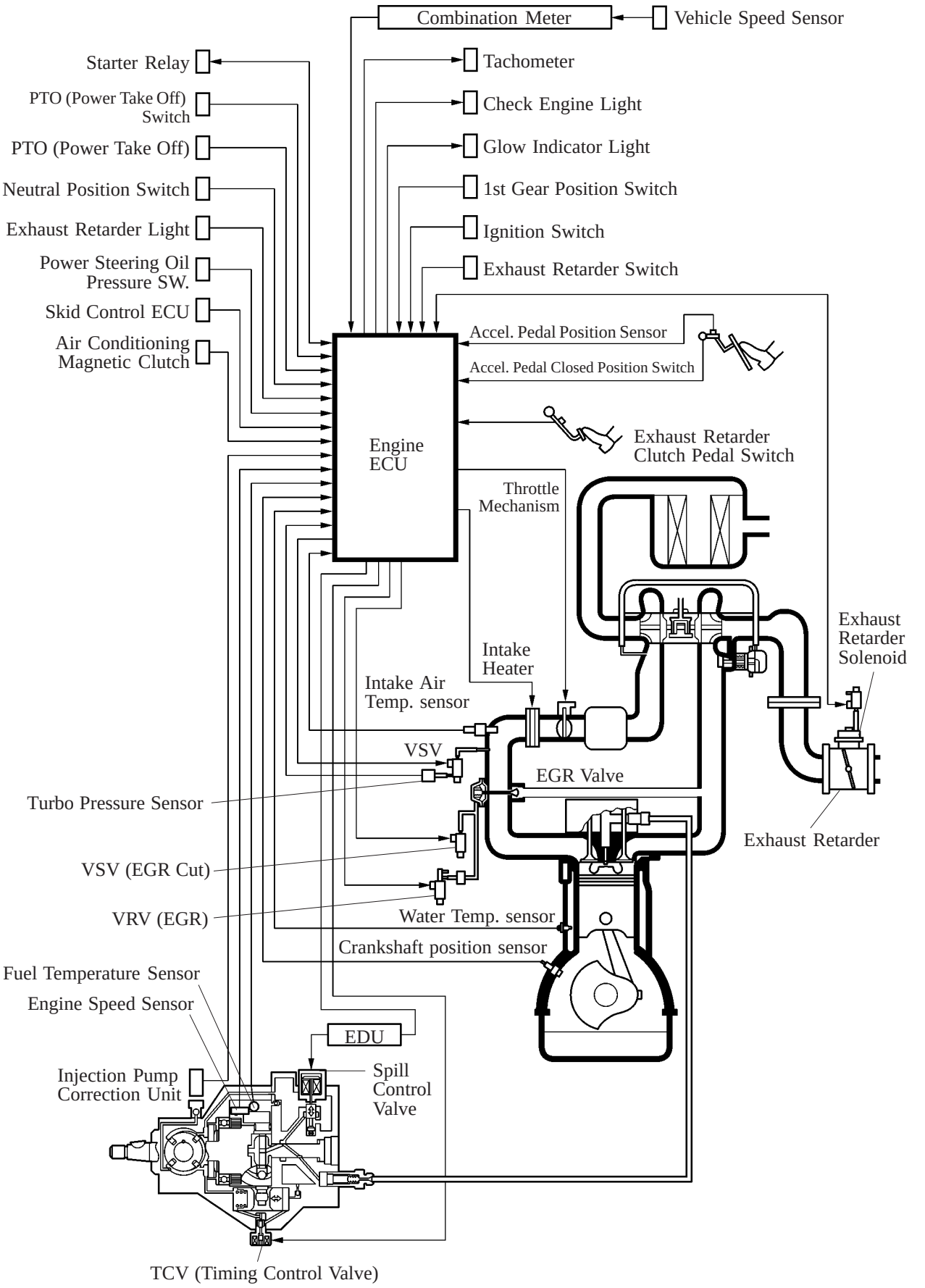
■ENGINE CONTROL SYSTEM

1. General

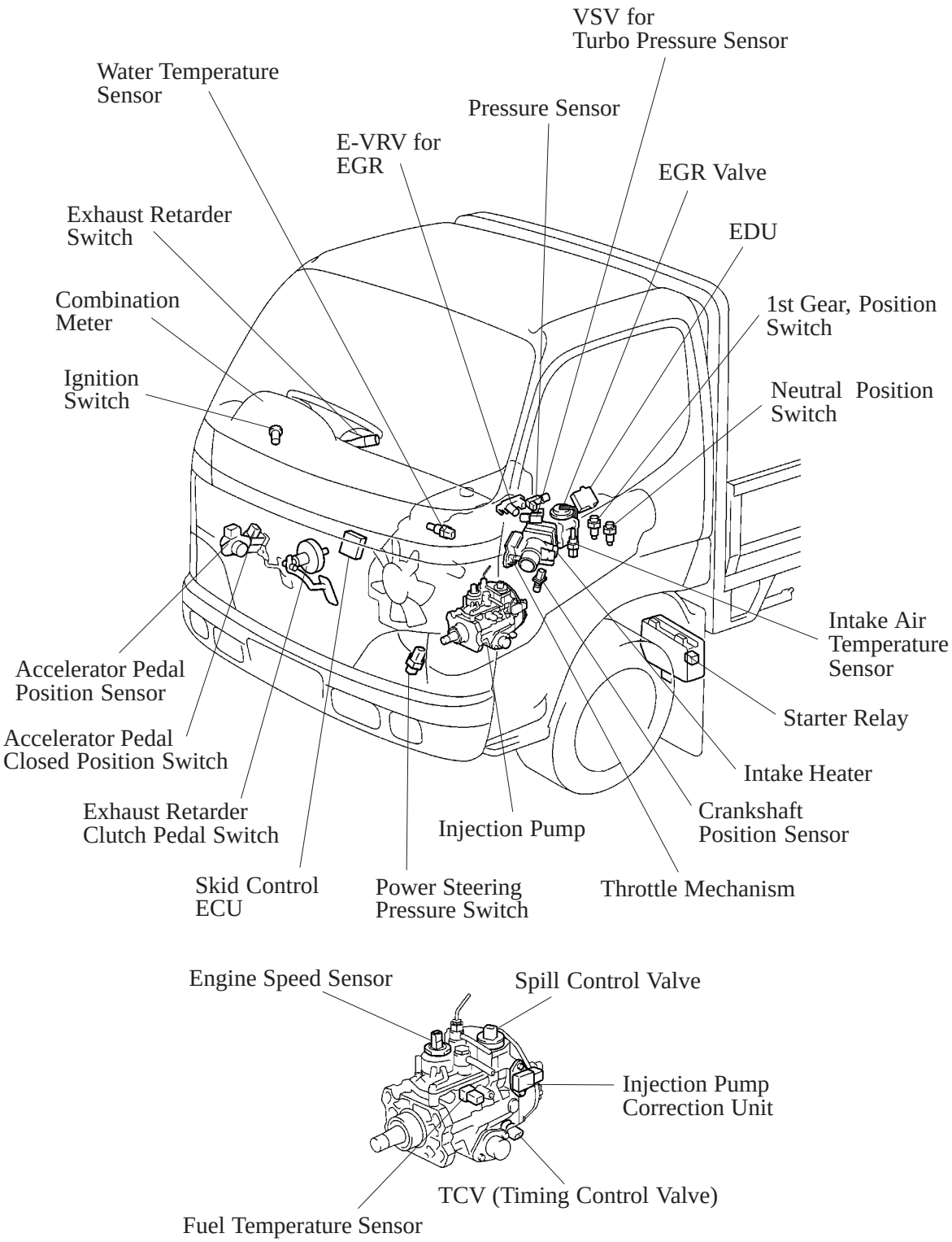
The engine control system for the 15B-FTE engine has following function.

Function	Outline
Fuel injection volume control	Controls the injection volume by calculating an optimal level in accordance with the conditions of the engine.
Engine torque control	Controls the engine torque when driving in the 1st or reverse gear.
Split injection control	Controls the nozzle to inject twice during cold starting.
Fuel injection timing control	Controls the injection timing by calculating an optimal fuel injection timing in accordance with the conditions of the engine.
Variable pre-stroke control	Controls the timing to start pumping fuel.
Idle speed control	Controls the idle speed by calculating the target speed in accordance with the conditions of the engine.
Idle speed fluctuation stabilization control	Detects the fluctuations of the engine speed for each cylinder and makes injection volume corrections.
Heater idle-up control	Causes the engine to idle-up while the vehicle is stopped, when the warm-up switch located at the driver's seat is pressed.
Intake throttle control	Controls the intake throttle mechanism, which is provided upstream of the EGR valve, to an opening that is suited to the driving conditions.
	Effects electronic control through the use of a step motor.
Starting auxiliary control	Controls the duration of the current applied to the intake heater in accordance with the conditions of the engine.
Air conditioning cut-off control	Cuts off the air conditioning during acceleration to improve drivability.
EGR control	Controls the volume of exhaust gas recirculation in accordance with the driving conditions.
Exhaust retarder control	Closes the exhaust retarder valve in order to apply the engine brake.
PTO (Power Take Off) support	The engine ECU supports PTO to enhance the ease of conversion of this vehicle as well as to reduce conversion costs. When a PTO signal is input, the ECU changes the governor pattern to the low-fluctuation type.
Fail-safe	If a failure occurs in the sensor signals, this function continues control through the use of the standard values stored in the engine ECU, or causes the engine to stop.

2. System Diagram



3. Layout of Main Components



EG

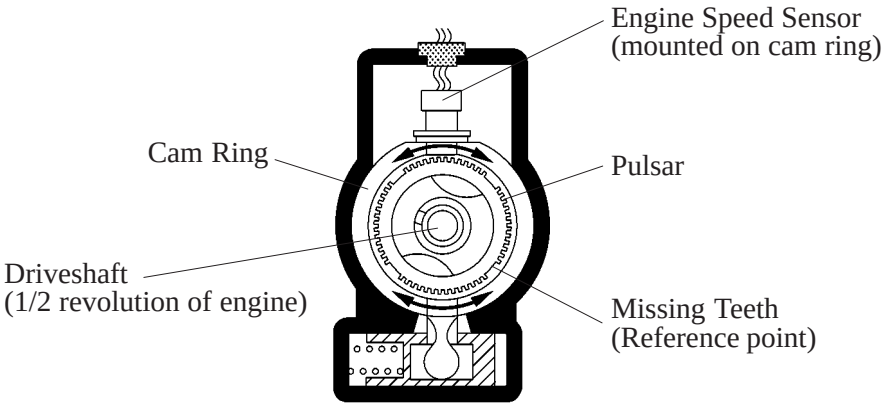
4. Function of Main Components

Function	Outline
Turbo pressure sensor	Detects intake air volume.
Engine speed sensor	Detects engine speed.
Crankshaft position sensor	Detects the reference position of the crankshaft.
Accelerator pedal position sensor	Detects the position of the accelerator.
Water temperature sensor	Detects water temperature.
Fuel temperature sensor	Detects fuel temperature.
Intake air temperature sensor	Detects intake air temperature.
Injection pump correction unit	Corrects individual injection pumps.
Starter relay	Starter voltage signal for starting.
1st gear, position switch	Detects 1st gear or reverse gear position.
Neutral switch	Detects neutral position.
Throttle mechanism (Wide-open position detection switch)	Detects the throttle valve position of the intake throttle mechanism.
Vehicle speed sensor	Detects vehicle speed.
Accelerator pedal closed position switch	Detects that the accelerator pedal is fully closed.
Exhaust retarder clutch pedal switch	Detects the clutch pedal position.
Exhaust retarder switch	Pull the wiper switch towards you to turn it ON.
EDU → Spill control valve	Controls the fuel injection ending timing (injection volume). Also controls the pumping timing.
Timing control valve	Controls the position of the timer piston.
Intake heater	Controls the duration of the current applied to the intake heater.
E-VRV and VSV for EGR	Controls the vacuum that is applied to the EGR valve.
Atmospheric pressure switching VSV for turbo pressure sensor	Switches the intake air pressure sensor to the boost pressure or atmospheric pressure.
Intake throttle mechanism step motor	Precisely controls the intake air volume in accordance with the driving conditions.
Exhaust retarder solenoid	Closes the exhaust retarder.
Air conditioning magnetic clutch	Cuts off the air conditioning during acceleration.
Engine speed output	Outputs speed signals to the tachometer.

5. Construction and Operation of Main Components

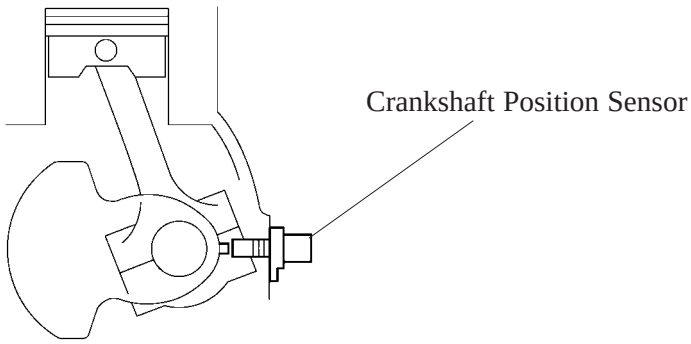
Engine Speed Sensor

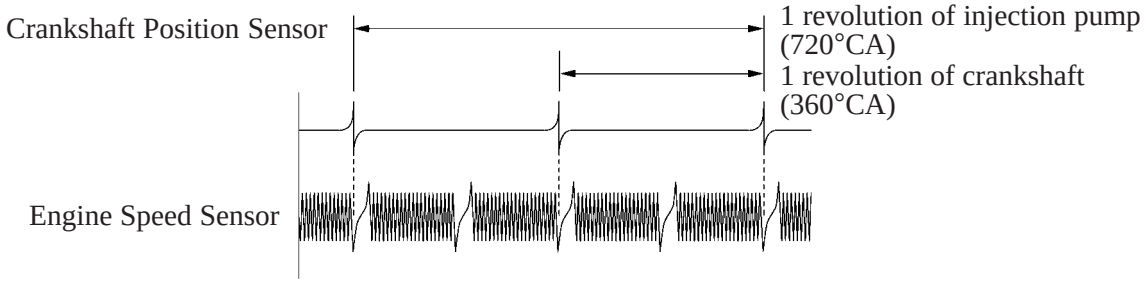
- This sensor, which detects the engine speed, is mounted on the cam ring in the injection pump. The protrusion of the pulsar, which is press-fit into the driveshaft, maintains the same phase as the plunger in order to generate electric signals, without being affected by the injection timing.
- The pulsar, which consists of 84 teeth, with 3 teeth missing at 4 locations, detects the angles at intervals of 7.5°CA.



Crankshaft Position Sensor

This sensor, which is mounted on the cylinder block, generates electrical signals through a protrusion that is provided on the crankshaft. It generates one pulse for each revolution of the engine, which is detected by the ECU as a crankshaft position reference signal.

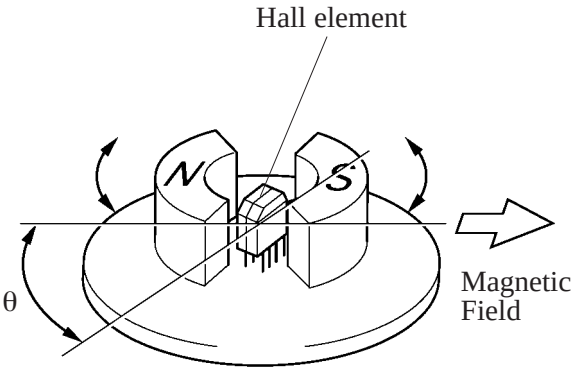




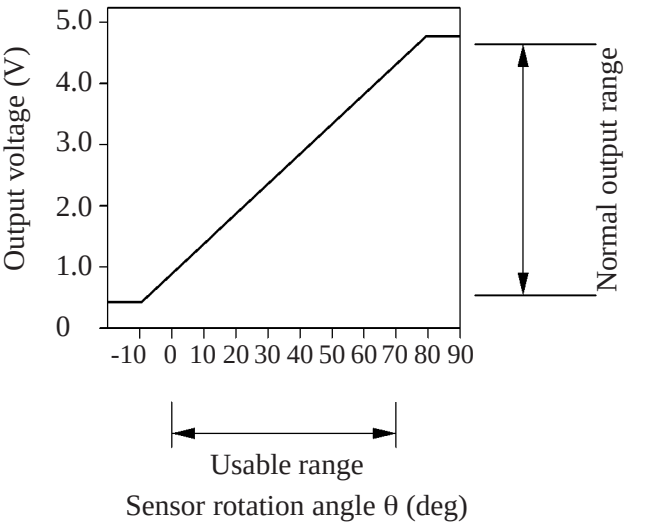
Accelerator Pedal Position Sensor

- A contactless accelerator position sensor is attached to the accelerator pedal. This sensor uses a Hall element* that outputs voltage linearly in relation to the movement of the accelerator pedal.
- This sensor outputs voltage in accordance with the amount of pedal effort that is applied to the accelerator, as well as the idle position.
- The accelerator position sensor contains a dual system to ensure the reliability of detection.

*: An electronic element that utilizes the electromotive force that is created by a potential difference in the magnetic field.



▶ Output characteristics ◀



Accelerator Pedal full-close switch

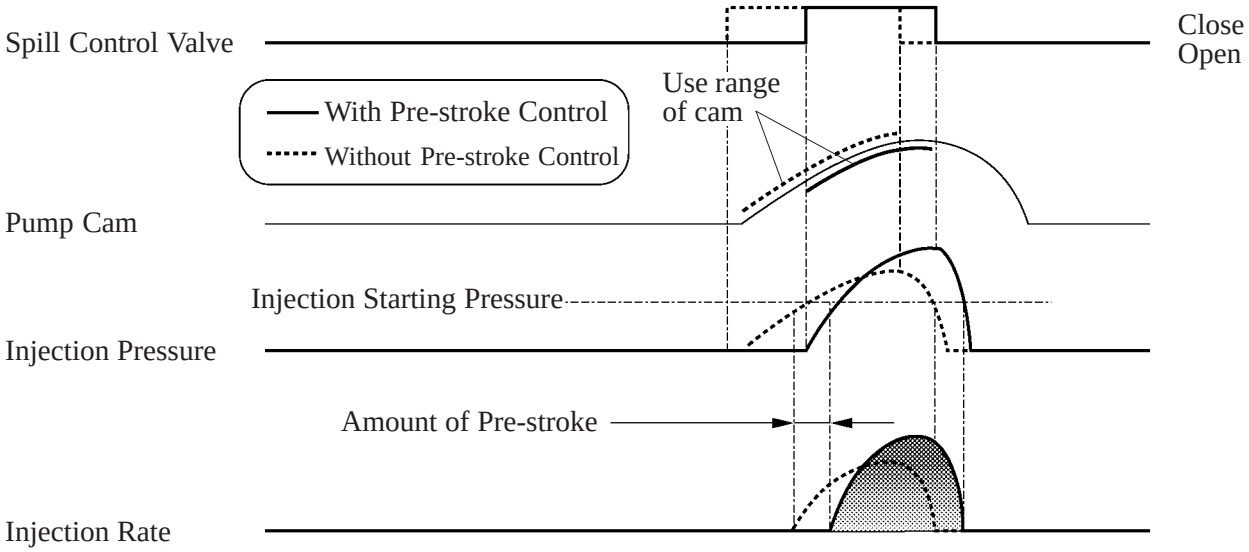
A switch that detects the full-close position of the accelerator pedal has been provided separately from the accelerator position sensor.

TCV (Timing Control Valve)

Provided in the injection pump, the timing control valve controls the position of the timer piston in order to control the fuel injection timing.

Spill Control Valve

- Provided in the passage that connects the pump chamber and the rotor of the injection pump, the spill control valve controls the suction of fuel (pre-stroke control) and the ending of injection (injection volume).
- Pre-stroke control regulates the timing at which the spill control valve closes during the suction of fuel (even after the compression of fuel has started, the spill control valve remains open). Thus, only the optimal portion of the cam profile of the pump is used. This results in a higher injection pressure without changing the injection volume in order to improve the injection rate and reduce black smoke in the high-load range.

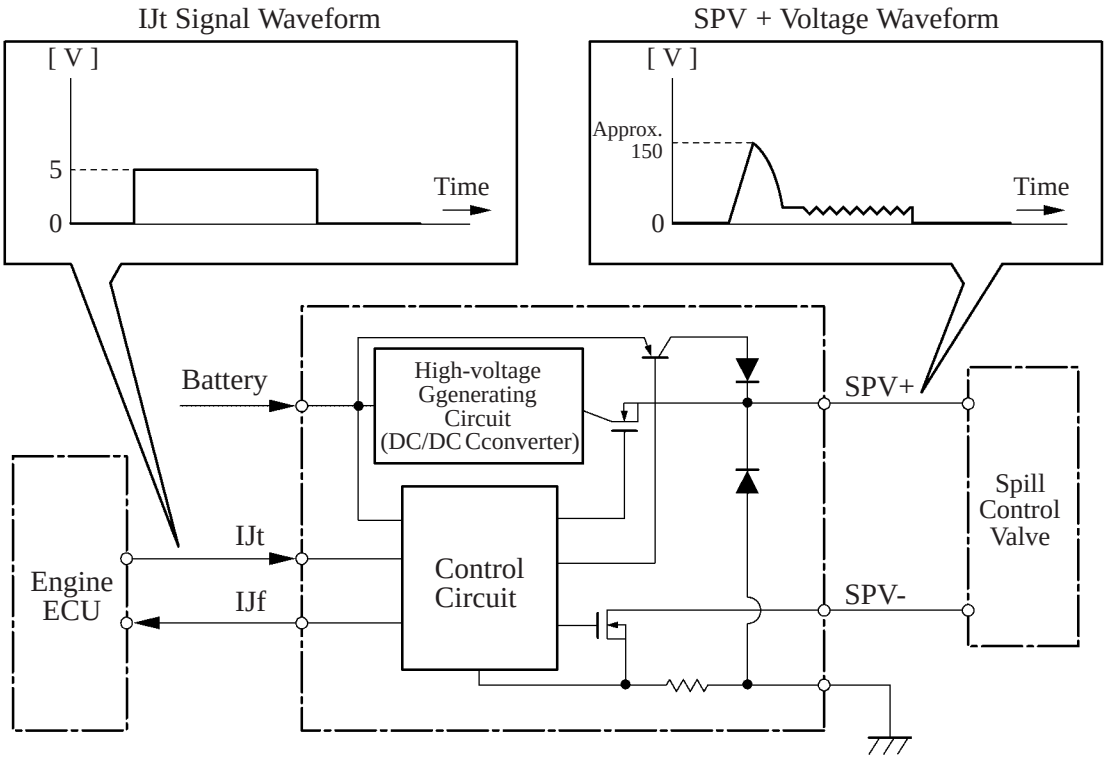


Injection Pump Correction Unit

Mounted on the injection pump, a correction unit corrects the phase difference of an individual injection pump in order to ensure the precision of the fuel injection volume and fuel injection timing control.

EDU (Electronic Driving Unit)

- The EDU is used in order to actuate the spill control valve, which operates at a high voltage, at high speeds.
- The EDU is a CDI-type high-voltage driver. A high-voltage and quick-charging system has been adopted through the use of a DC/DC converter in order to realize high-speed actuation of the spill control valve.
- The state of the EDU is constantly fed back to the engine ECU. Therefore, if the system fails, the engine stops.



Service Tip

The maximum charging voltage of the EDU is approximately 150V. Handle it carefully during inspection.

6. Fuel Injection Control

Constriction

1) Suction

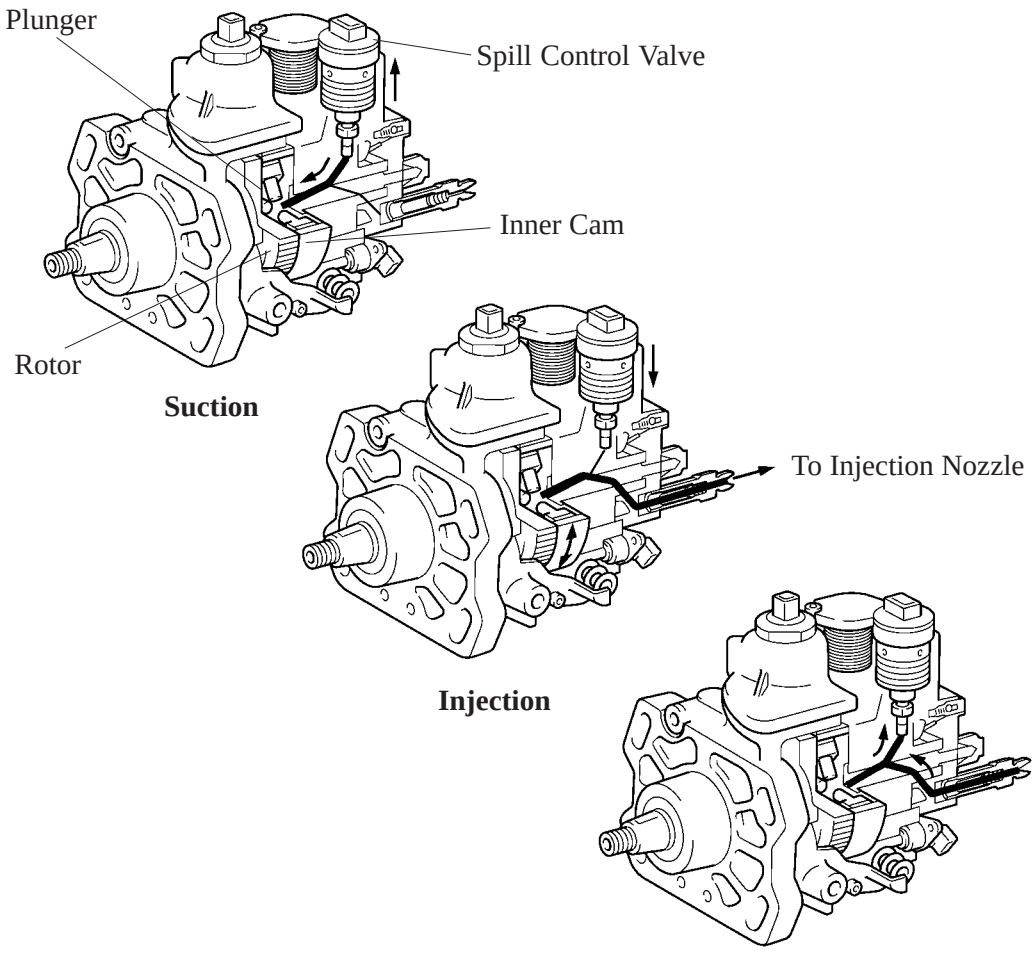
The spill control valve opens (OFF) and fuel flows to the rotor area. Upon the completion of the suction of fuel, the spill control valve closes (ON). Pre-stroke control that enables the efficient pumping of fuel by regulating the closing timing has been adopted.

2) Injection

When the rotor rotates, the inner cam causes the plunger to move towards the center to pump fuel. The injection timing is determined by the lift point of the plunger by the inner cam (when the fuel pressure exceeds the preset value of the injection nozzle).
The injection timing is controlled by operating the inner cam in the rotational direction of the rotor. The inner cam and the timer piston are connected. Therefore, as the timing control valve controls the position of the timer piston, the position (angle) of the inner cam changes.

3) End of injection

When the spill control valve turns OFF again, the pressurized fuel returns from the rotor to the pump chamber, thus reducing the pressure in the rotor and ending the pumping of fuel. In other words, controlling the OFF timing of the spill control valve determines the fuel injection volume.

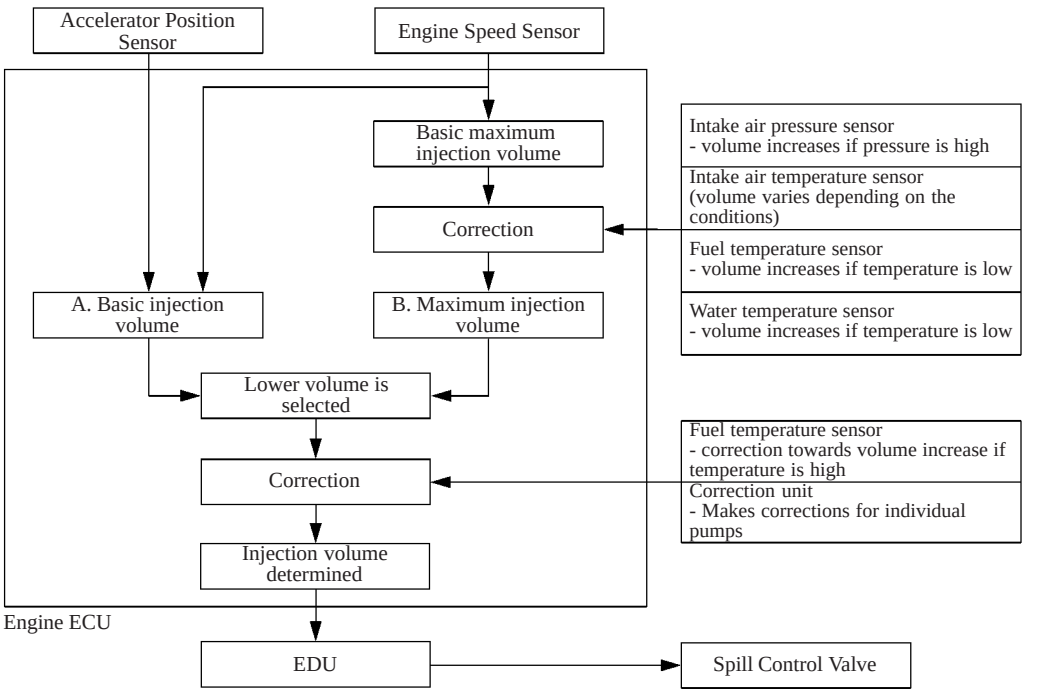


Fuel Injection Volume Control

- The engine ECU outputs signals that cause the spill control valve to open, which releases the pressure in the fuel pumping area (rotor area) and ends the injection of fuel. This timing controls the fuel injection volume.
- On manual transmission vehicles, a “1st gear, reverse switch” is provided to reduce the engine output when the vehicle is operating under a high load in the 1st gear or reverse.

Operation

- The engine ECU calculates the basic injection volume for the operating conditions of the engine and the maximum injection volume for the engine conditions. The lower of the two injection volumes obtained through the calculation is selected and a phase correction of the correction unit is added in order to determine the final injection volume.
- During the starting of the engine, the injection volume is determined by the coolant temperature. The lower the coolant temperature, the higher the injection volume.



Injection volume = (A. basic injection volume ← lower volume selected → B. maximum injection volume) + C. Correction

A. Basic injection volume

This is determined by the accelerator position and the engine speed.

B. Maximum injection volume

The corrections that are based on the signals from the sensors are added to the basic maximum injection volume (volume that is theoretically possible to inject) that is determined in accordance with the engine speed in order to determine the maximum injection volume.

C. Correction

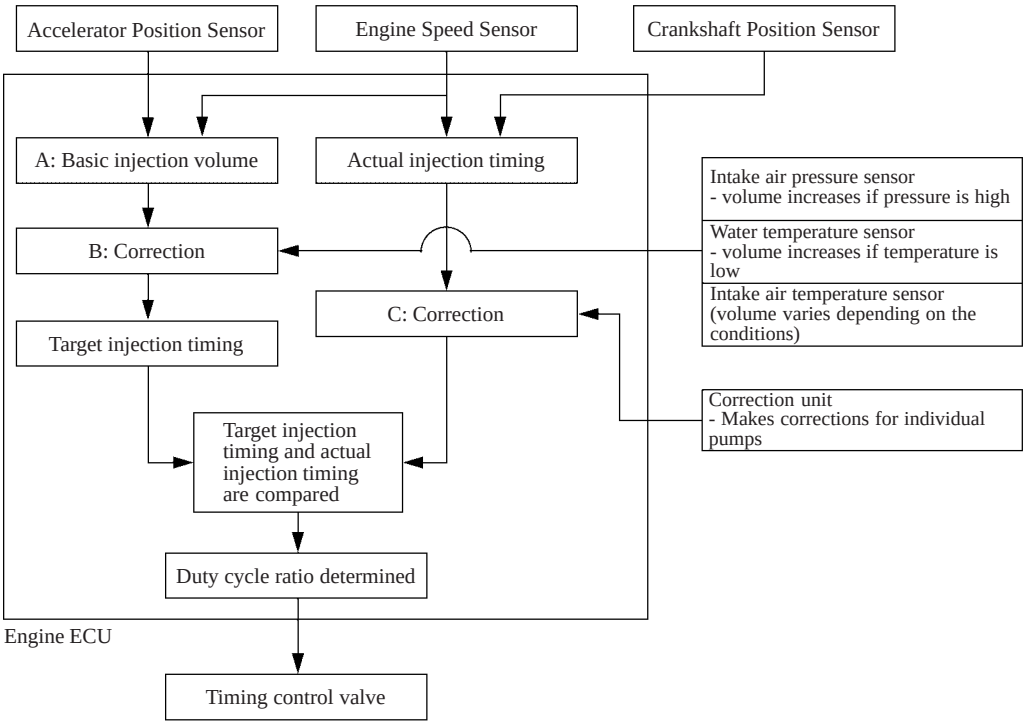
The correction unit makes a correction on the injection pump, and a correction is made in accordance with the fuel temperature (the higher the fuel temperature, the higher the injection volume, because the actual injection volume decreases).

Fuel Injection Timing Control

- The engine ECU outputs signals to effect duty cycle control of the timing control valve, which changes the position of the timer piston and regulates the fuel injection timing.
- The crankshaft position is fed back to the engine ECU to enable high-precision fuel injection timing control.

Operation

- The engine ECU adds corrections from the sensors to the basic target injection timing in accordance with the operating conditions of the engine in order to calculate the target injection timing. Also, the engine ECU calculates the actual injection timing so that it can be reflected in the target injection timing.
- At the time the engine is started, the injection timing is determined in accordance with the coolant temperature and the engine speed.



Target injection timing = A. basic target injection timing + B. correction + C. feedback correction

A. Basic target injection timing

This timing is determined in accordance with the accelerator position and the engine speed.

B. Correction

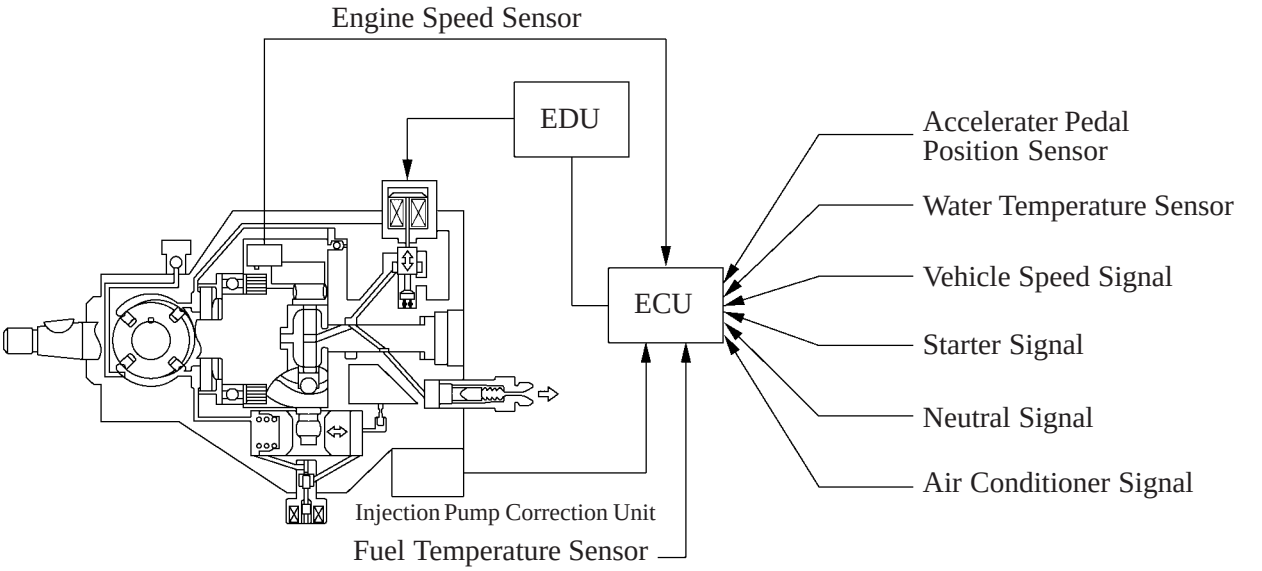
Intake air pressure correction: Timing advances when the intake air pressure is low.
Water temperature correction: Timing advances when the coolant temperature is low.
Intake air temperature correction: Timing advances when the intake air temperature is low.

C. Feedback Correction

A calculation is made so that the actual injection timing will match the target injection timing.

Idle Speed Control

- Similar to fuel injection volume control, the engine ECU outputs signals to open the spill control valve in order to regulate the idle speed.
- Speed fluctuation stabilization control has been adopted. This function detects the engine speed fluctuations that are caused during idle by the variances in the injection pump or nozzles in order to correct the injection volume for each cylinder, thus reducing vibrations and noise.
- When the engine is operating at a fast idle immediately after it has been started, this control increases the idle speed if the air conditioning is operating or the warm-up switch (option) is ON.



1) Fast idle control

This function controls the idle speed that suits the warming-up conditions of the engine in accordance with the coolant temperature.

2) Feedback control

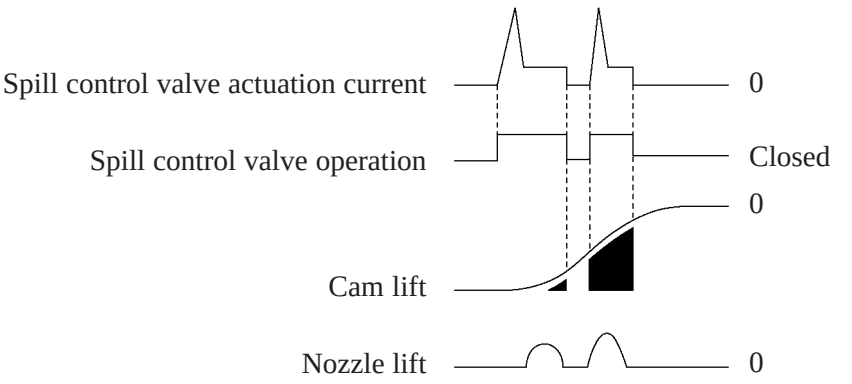
This function feeds back the engine speed and makes a correction if there is a difference from the target speed. Also, it effects idle-up control in accordance with the engine conditions.

3) Prospective control

If a load that might apply to the engine is expected to change, such as the operation of the air conditioning, this function changes the injection volume to prevent the idle speed from fluctuating.

Split Injection control

- When the engine is started at an extremely low temperature {below -10°C (14.0°F)}, a high-response spill control valve is used to effect split injection, which improves starting performance and significantly reduces the discharge of white smoke and black smoke.
- In contrast to the normal injection that sprays once during a single pumping stroke, the split injection sprays twice in accordance with the signals that are output by the engine ECU.

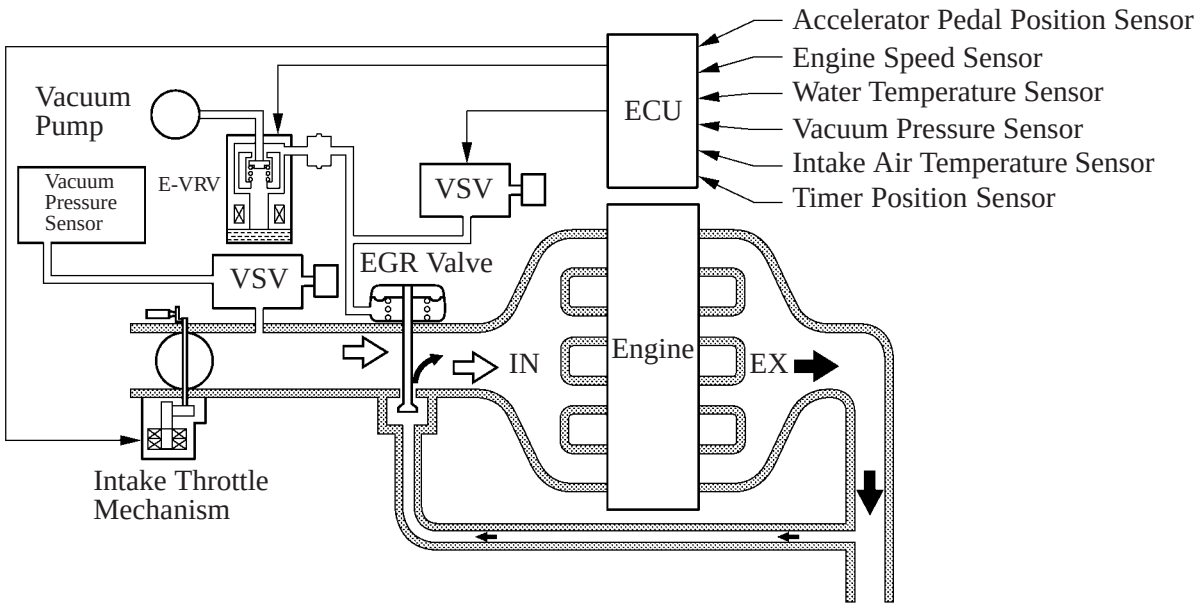


7. EGR System

General

- The EGR recirculates exhaust gas that has been regulated to an appropriate amount in accordance with the driving conditions into the intake manifold in order to slow down the combustion. This lowers the combustion temperature and reduces NOx.
- The engine ECU controls the current that flows to the E-VRV in accordance with the signals from the sensors in order to regulate the vacuum that acts on the vacuum chamber of the EGR valve. This changes the opening of the EGR valve in order to control the exhaust gas recirculation volume that suits the operating conditions of the engine.
- When the engine coolant temperature is low, the EGR stops in the high-load operating range and during deceleration. (It remains ON during idle.) Thus, it ensures the proper drivability or reduces the discharge of black smoke.

▶ System Diagram ◀



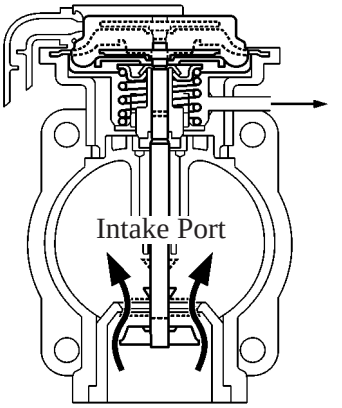
▶ Function of Main Components ◀

Components	Function
Accelerator Pedal Position Sensor	Mounted on the accelerator pedal, this sensor detects the position of the accelerator.
Engine Speed Sensor	Built into the injection pump, this sensor detects the engine speed.
Water Temperature Sensor	Mounted on the thermostat, this sensor detects the water temperature.
Vacuum Pressure Sensor	Mounted on top of the engine, this sensor detects the atmospheric pressure, the E-VRV control vacuum, and the boost pressure.
Intake Air Temperature Sensor	Mounted on the intake port, this sensor detects the intake air temperature.
EGR Valve	Mounted on the intake manifold, this valve controls the EGR at an optimal volume.
E-VRV	This valve controls the vacuum to the EGR valve.
VSV	This valve releases the vacuum from the EGR valve when the EGR is stopped.

Construction and Operation of Main Components

EGR Valve

- The EGR valve is provided in the intake port so that it can be cooled by the intake air. Thus the EGR operating range has been extended to a high-load range in order to improve reliability.
- The opening of the EGR valve has been directed towards the exhaust side. This prevents the EGR from operating unintendedly due to the back pressure that is created during the operation of the exhaust brake.

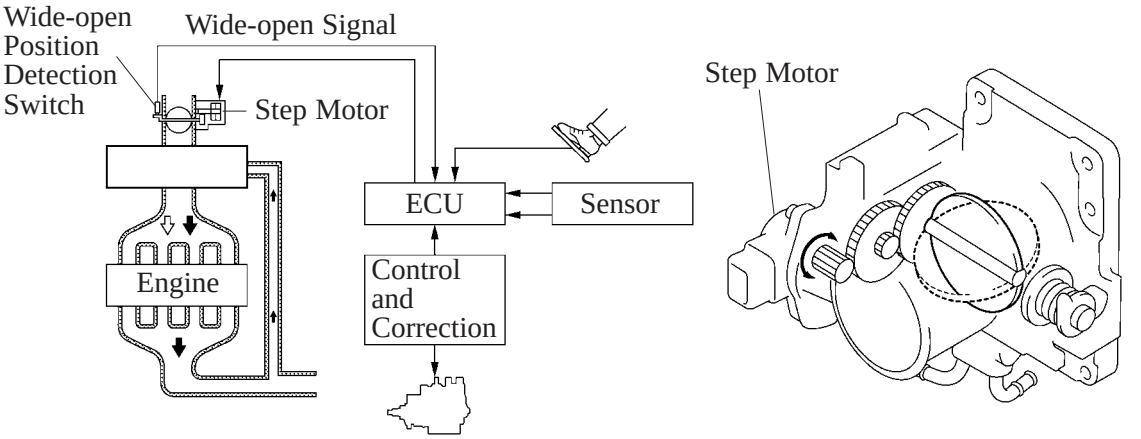


Intake Air Pressure Sensor

The intake air pressure sensor detects the switching of the intake air pressure, boost pressure, and atmospheric pressure in accordance with the driving conditions. According to the result of this detection, the ECU effects control to achieve the proper injection volume and optimal EGR volume in order to realize high power output and low exhaust emissions.

8. Intake Throttle Mechanism

- An electronically controlled intake throttle mechanism has been adopted to ensure the proper exhaust emission performance and reduce vibrations when the engine is stopped.
- The ECU actuates the step motor in accordance with the driving conditions in order to open or close the throttle valve and control the intake throttle mechanism.
- The intake throttle mechanism has been provided in order to improve exhaust emission performance. This mechanism controls the throttle valve to an optimal position in accordance with the driving conditions. By providing an appropriate amount of intake air that maintains a good balance with the fuel injection volume, this mechanism helps to reduce exhaust smoke. When the engine is stopped, the throttle valve closes fully or almost fully to ensure the smooth stopping of the engine.



9. Diagnostic

A diagnostic system that outputs 2-digit DTCs (Diagnostic Trouble Codes) has been adopted.

DTC No.	Detection Item	Trouble Area	Check Engine Warning Light*1 (Normal Mode/ Test Mode)	Memory*2
12	Engine Speed Sensor Circuit Malfunction 1 (TDC or G1 Circuit)	• Open or short in crankshaft position sensor circuit • Engine speed sensor • ECU	ON/ON	○
13	Engine Speed Sensor Circuit Malfunction 2 (NE Circuit)	• Open or short in engine speed sensor circuit • Crankshaft position sensor • ECU	ON/ON	○
14	Timing Control System Malfunction	• Open or short in timing control valve circuit • Fuel filter (Clogging) • Fuel (Freezing, Air in) • Injection pump (Internal pressure and timing control valve) • ECU	ON/ON	○
15	Throttle Motor Circuit Malfunction	• Open or short in throttle control motor circuit • Throttle control motor • Throttle valve • ECU	ON/ON	○
19(1)	Accel. Position Sensor Circuit (Open/Short)	• Open or short in accelerator pedal position sensor circuit	ON/ON	○
19(2)	Accel. Position Sensor Circuit (IDL SW/Range)	• Accelerator pedal position sensor • ECU	ON/ON	○
19(3)	Accel. Closed Position SW Circuit (Short)	• Open in accelerator pedal position sensor circuit	ON/ON	○
19(4)	Accel. Closed Position SW Circuit (Open)	• Accelerator pedal closed position sensor • ECU	ON/ON	○
22	Water Temperature Sensor Circuit Malfunction	• Open or short in water temp. sensor circuit • Water temp. sensor • ECU	ON/ON	○
24	Intake Air Temperature Circuit Malfunction	• Open or short in intake air temp. sensor circuit • Intake air temp. sensor • ECU	OFF/ON	○

DTC No.	Detection Item	Trouble Area	Check Engine Warning Light*1 (Normal Mode/ Test Mode)	Memory*2
32	Injection Pump System Malfunction	• Open or short in injection pump correction resistance circuit • Injection pump correction resistance • ECU	OFF/ON	○
35	Turbo Pressure Sensor Circuit Malfunction	• Open or short in turbo pressure sensor circuit • Turbo pressure sensor • Open or short in VSV circuit for turbo pressure sensor • VSV for turbo pressure sensor • Vacuum hose disconnected or blocked • ECU	ON/ON	○
39	Fuel Temperature too High	• Open or short in fuel temp. sensor circuit • Fuel Temp. Sensor • ECU	ON/ON	○
42	Vehicle Speed Sensor Signal Circuit Malfunction	• Combination meter • Open or short in vehicle speed sensor circuit • Vehicle speed sensor • ECU	ON/ON	○
97	EDU Circuit Malfunction	• Open or short in EDU circuit • EDU • Spill control valve	ON/ON	○

*1: "ON" displayed

*2: "○" in the memory column indicates that a DTC code is recorded in the ECU memory when a malfunction occurs. Accordingly, diagnostic results in the normal or test mode is output with the ignition switch ON.

10. Fail-Safe

If a failure occurs in the sensor signals (and if there is the likelihood of causing the engine to fail if control is continued with that signal), the fail-safe function continues control through the use of the standard values stored in the engine ECU, or causes the engine to stop.

Fail-safe	Failure
Continues control through the use of preset values	Water temperature sensor system
	Intake air temperature sensor system
	Accelerator position sensor system
	Fuel temperature sensor system
	Intake air pressure sensor system
Reduced fuel injection volume	Correction unit system
	Crankshaft position sensor system (Timing control valve feedback control stopped)
Idle speed control stopped	Timing advance control system
Shifting torque control stopped	Intake throttle mechanism and wide-open detection switch system
	Vehicle speed signal system
	Communication system with ETC CPU
Fuel injection stopped	Engine speed sensor system
	EDU system