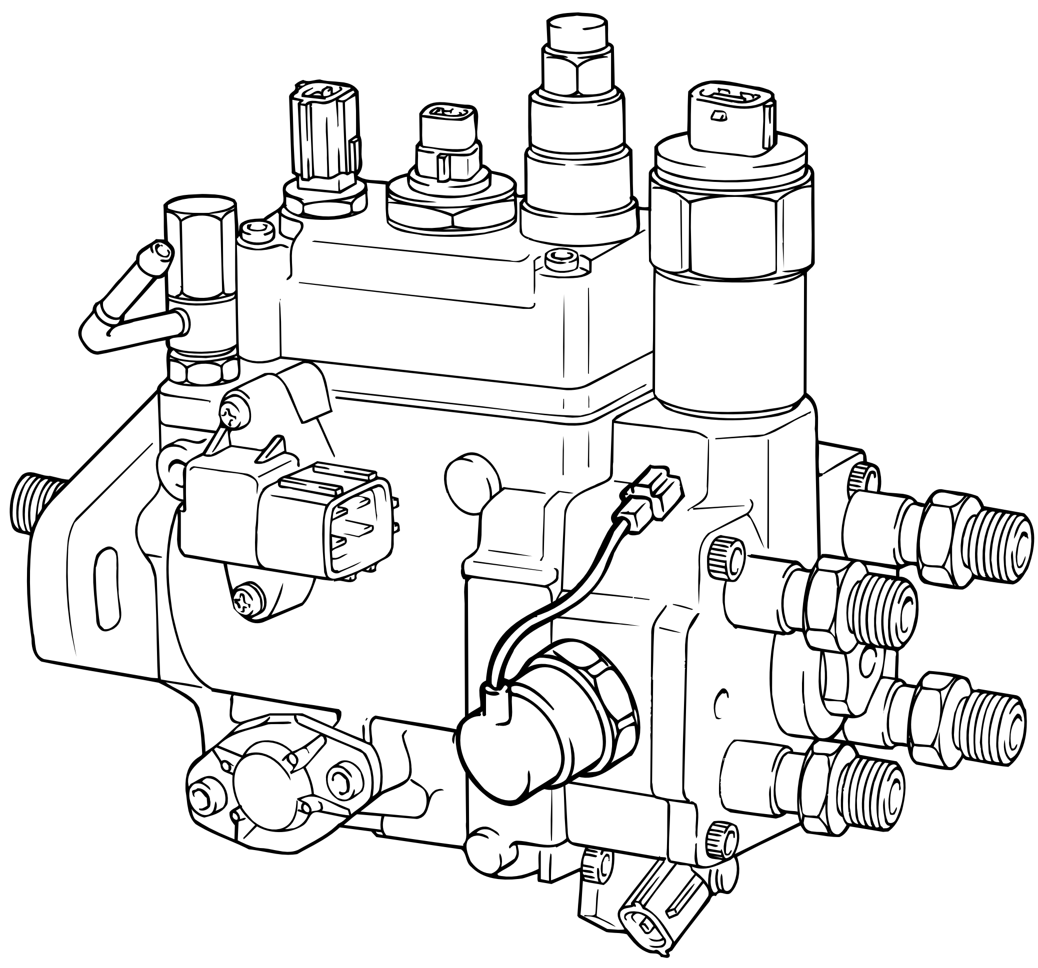
Chapter 2

ECD-V5



Chapter 2 - Table of Contents

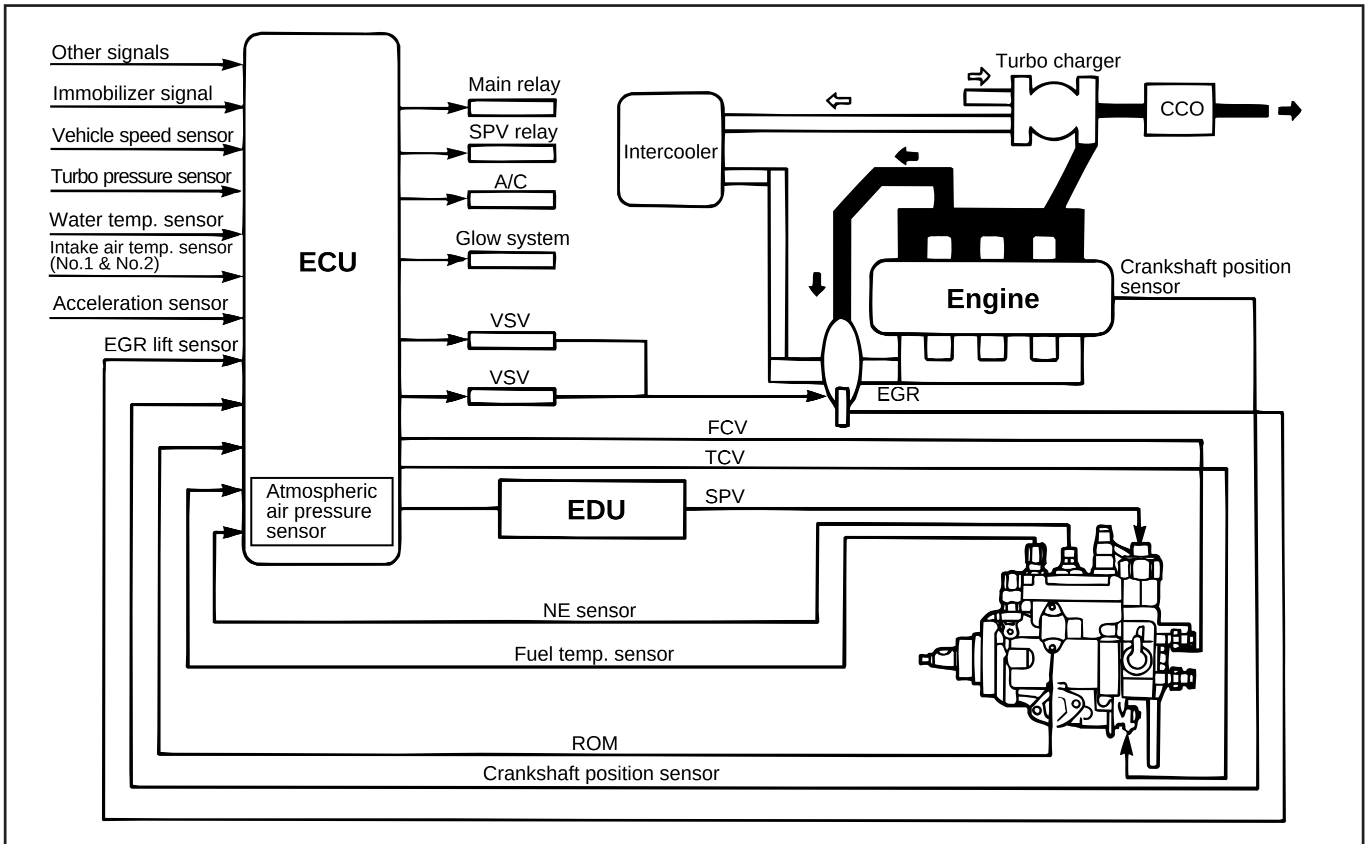
1. General Descriptions

The ECD-V5 system detects the engine condition (engine speed, accelerator opening, intake air pressure, cooling water temperature, etc.) through sensors, and controls the fuel injection quantity, the fuel injection timing and all other factors with microcomputers to run the engine in the optimum condition.

(1) Fuel injection quantity control
(2) Fuel injection timing control
(3) Idling speed control
(4) EGR control
(5) Glow plug control

In addition, the system also following functions;
(6) Fail-safe function
(7) Diagnosis function

The ECD-V5 system is divided into four major electric components: sensors; computers; electronic driving unit; and actuators.

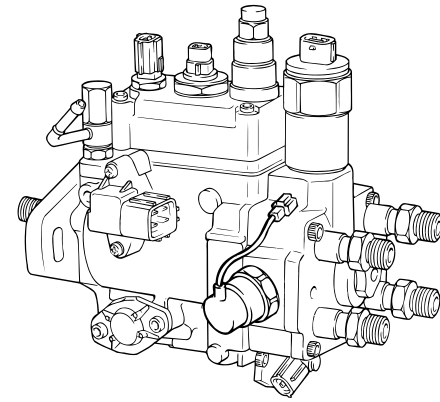


QT0266E

Sensors	Detect the engine condition and the running state, and convert them into electric signals.
Actuators	Operate in response to the electric signals from the computers.
EDU	Actuates the solenoid valve (SPV) using high amperage in accordance with the signals from the computer.
Computers	Perform calculations based on electric signals from the sensors, and transmit electric signals for optimization to the actuators.

1-1. Construction of ECD-V5 Pump

ECD-V5 pump is equipped with following electrical parts.



QT0267E

(1) Actuators

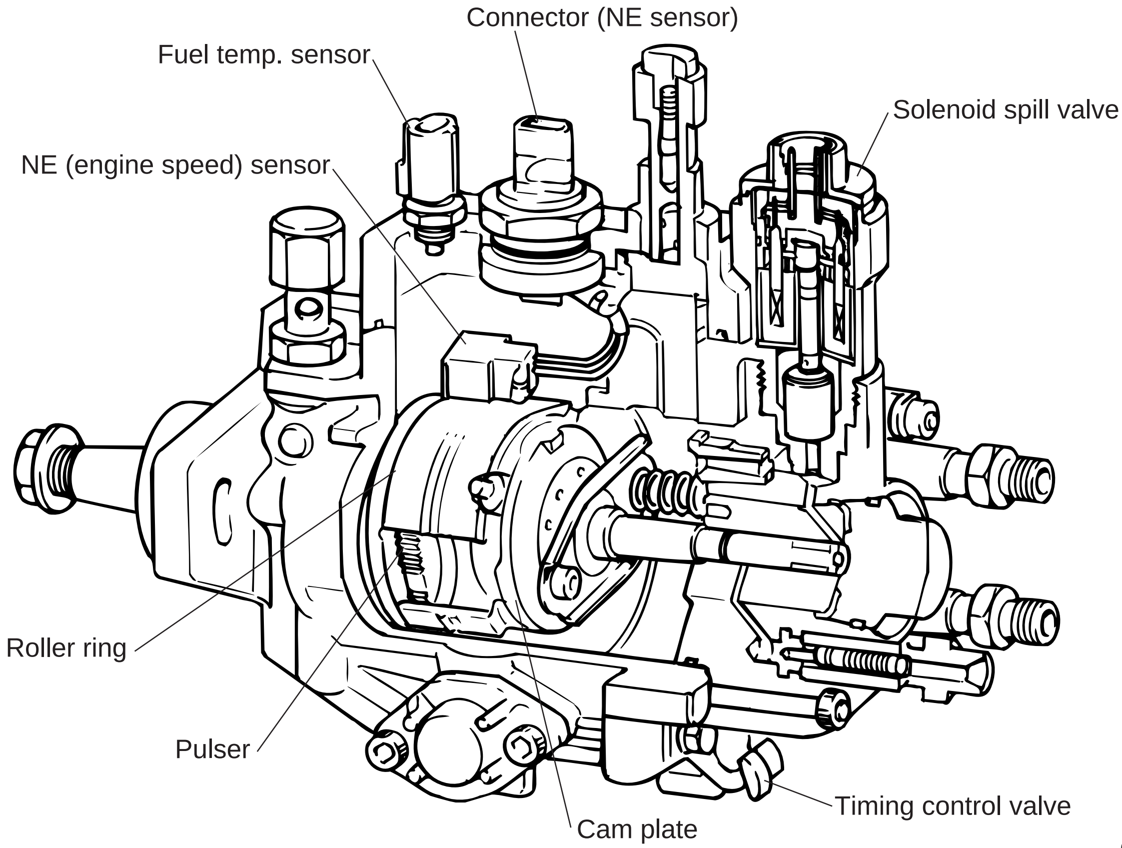
a. Solenoid spill valve (SPV) for injection quantity control
b. Timing control valve for injection timing control
c. Fuel cutoff valve (FCV) that cuts off the fuel injection.

(2) Sensors

a. Engine speed (NE) sensor
b. Fuel temperature sensor

(3) ROM

New part on behalf of conventional correction resistors (θ & τ)



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1-2. Fuel Pressure-Feed and Injection

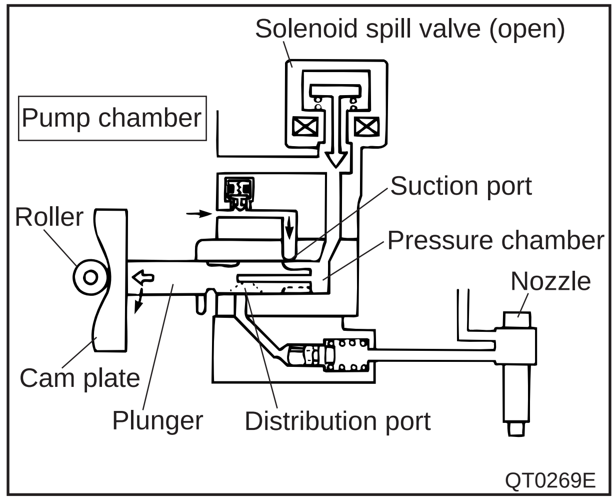
The solenoid spill valve is located in the middle of the passage connecting the pump chamber and the plunger pressure chamber.

The valve is a normal open type by the operation of the spool spring (return spring) in the solenoid spill valve, and closes when its coil is energized.

(1) Suction

When the plunger moves down, the fuel enters the pressure chamber.

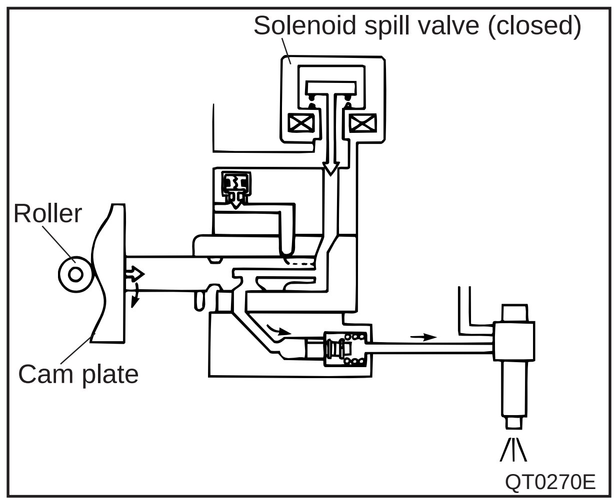
•Suction port : Open
•Distribution port : Closed
•Solenoid spill valve : Open (deenergized)



(2) Injection

Turning and rising, the plunger compresses and feeds the fuel.

•Suction port : Closed
•Distribution port : Open
•Solenoid spill valve : Closed (energized)



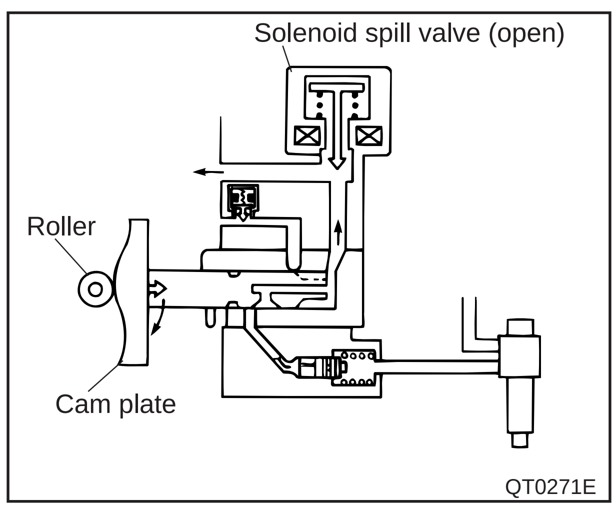
(3) End of Injection

As soon as the solenoid spill valve is deenergized, it opens. The pressurized fuel remaining in the plunger chamber is compressed back to the pump chamber, completing the pressure-feed cycle.

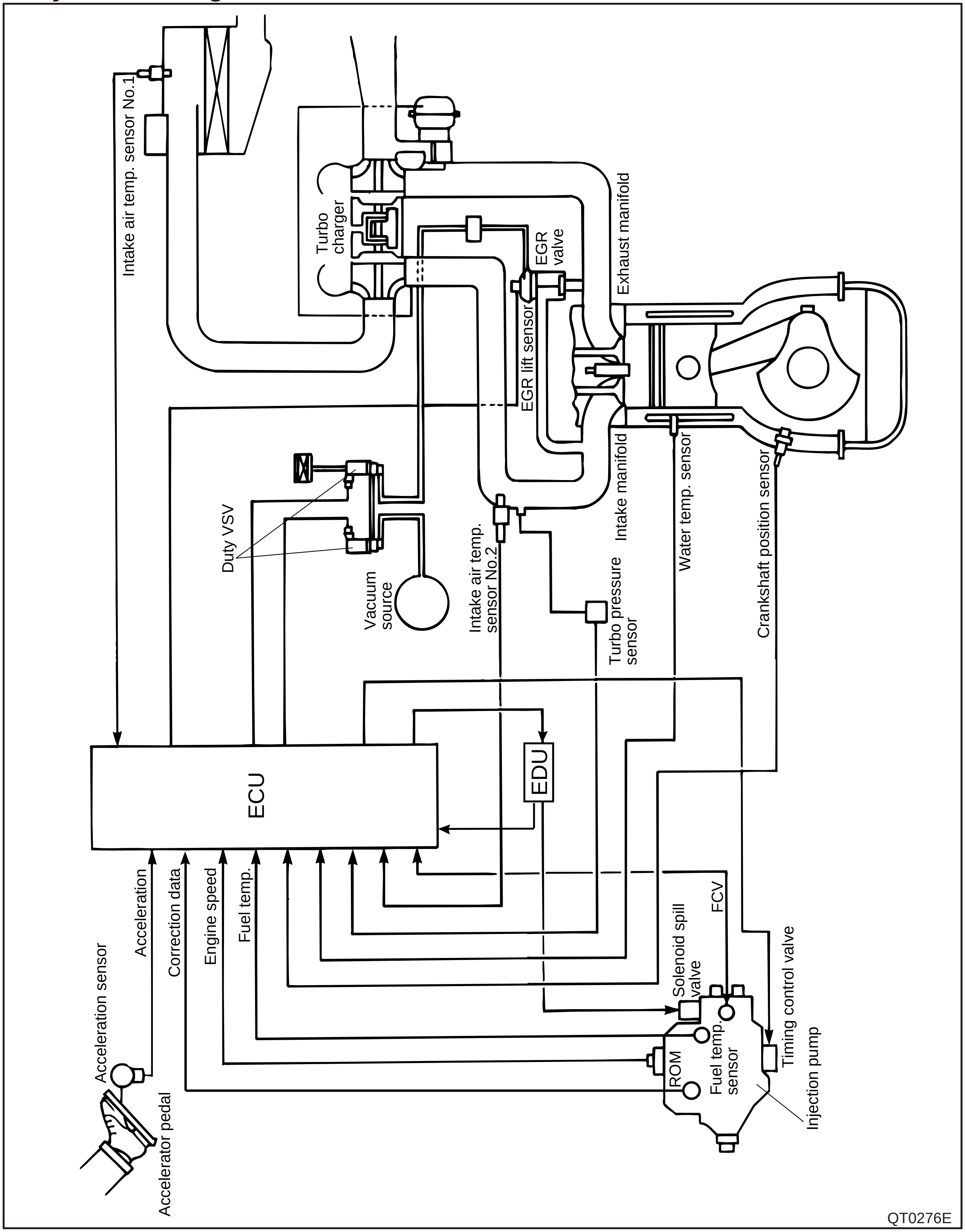
•Suction port : Closed
•Distribution port : Open
•Solenoid spill valve : Open (deenergized)

(4) Fuel Cutoff

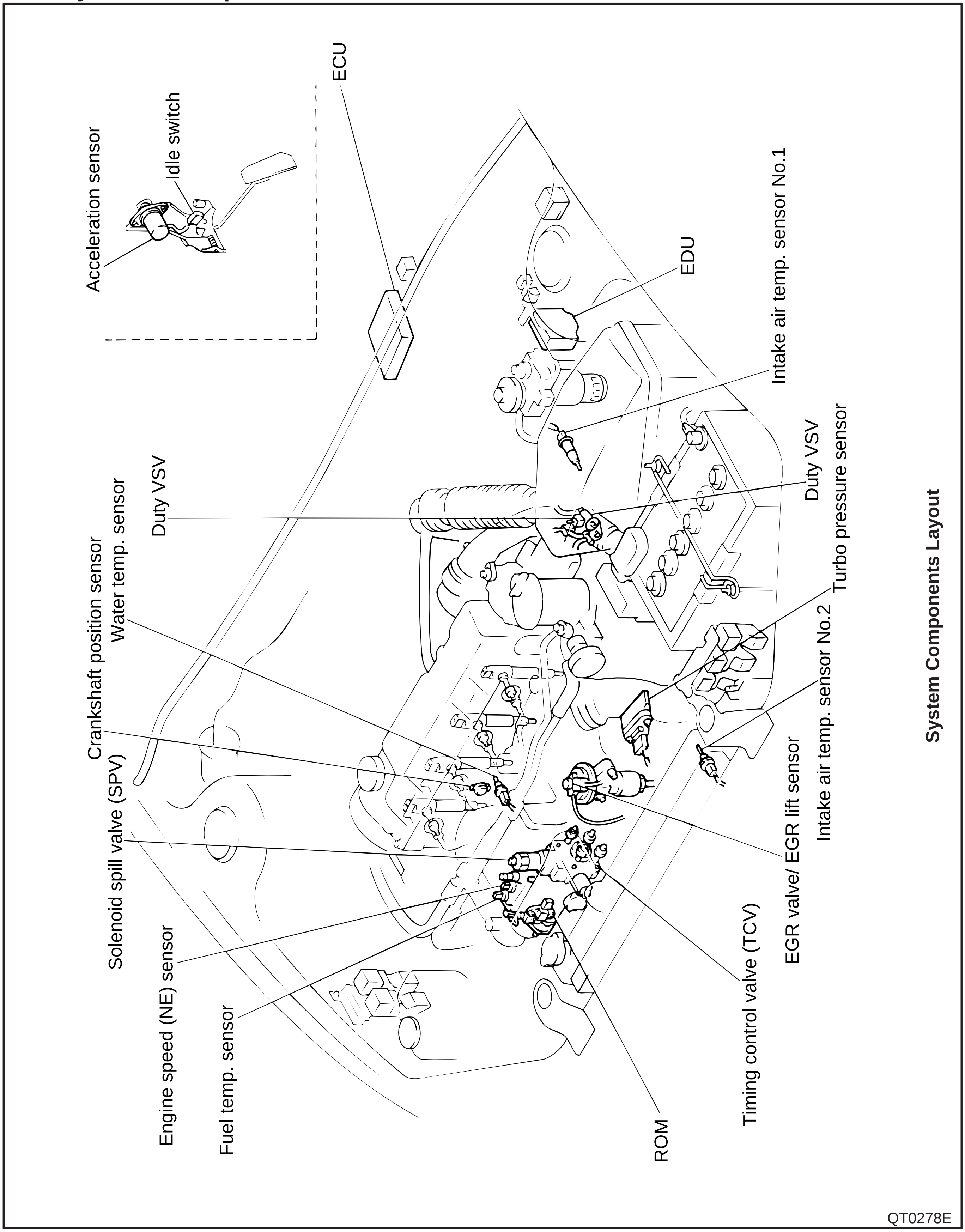
While the injection of fuel is cut off, the current does not flow to the solenoid spill valve, thus allowing the spill port to remain open. Therefore, the fuel is not pumped even when the plunger ascends. When the solenoid spill valve is closed, the fuel cutoff valve (FCV) closes to cut off the fuel.



2. System Configuration



2-1. System Components

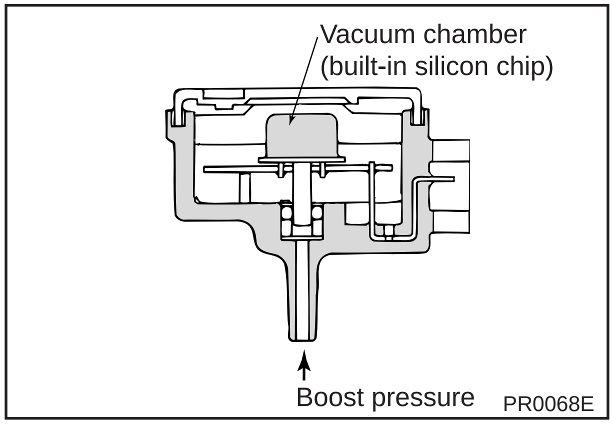


System Components Layout

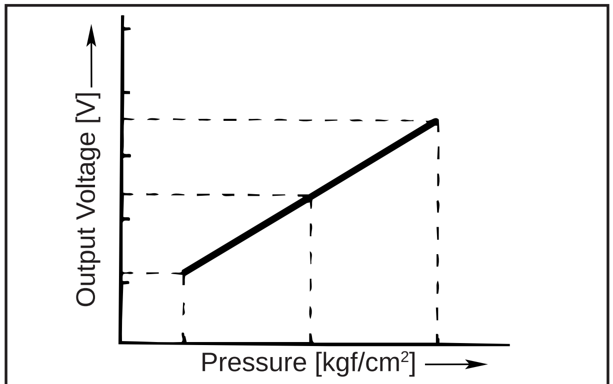
(1) Turbo Pressure Sensor

The turbo pressure sensor detects the intake air pressure at the absolute pressure* and sends it to the computer in the form of an intake air pressure signal.

* Absolute pressure: A pressure in which vacuum is 0.



A crystal (silicon) is sealed inside the sensor. This crystal has the characteristic of changing its electric resistance when pressure is applied to it. The turbo pressure sensor is a type of semi-conductor pressure sensor that utilizes this characteristic.

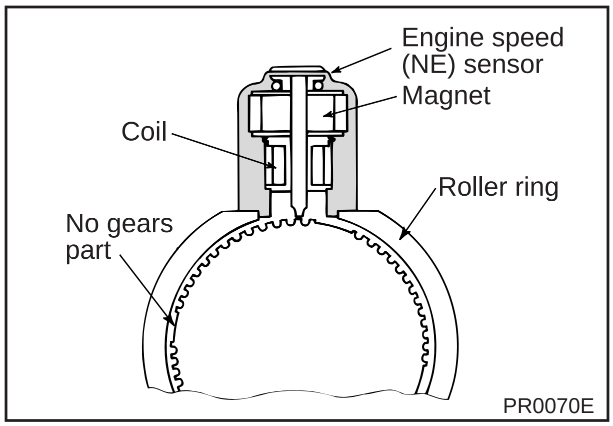


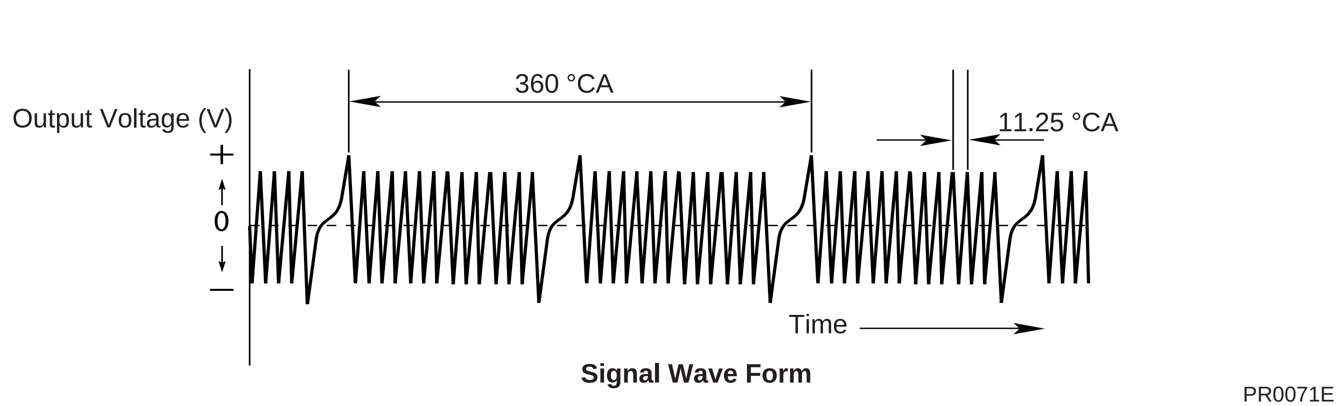
Sensor Output Characteristics

(2) Engine Speed (NE) Sensor

The engine speed (NE) sensor is mounted opposite the gears of the pulser (gear) that is pressed on to the driveshaft of the pump.

The sensor contains a magnet and a coil. The magnetic flux that passes through the coil varies with the rotation of the pulser, thus generating an alternating current voltage in the coil. The computer counts the number of these pulses to detect the engine speed. The pulser has 52 gears, with 3 gears missing at 4 locations, enabling the pulser rotation angle to be detected at 11.25 ¡CA intervals.



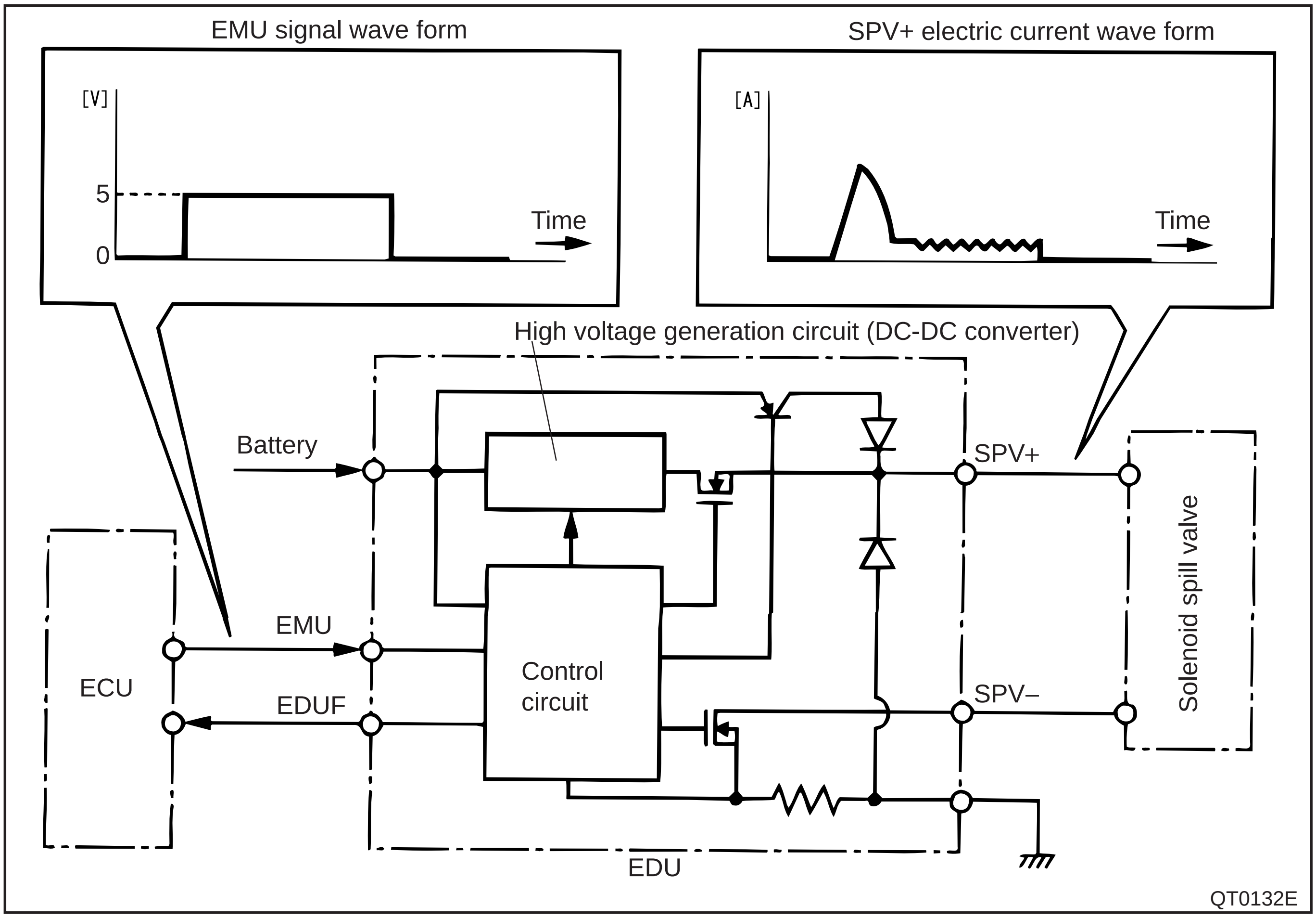


Signal Wave Form

(3) EDU (Electronic Driving Unit)

a. The ECD-V4 uses an EDU (CDI type high voltage driver) for high speed driving of the electromagnetic spill valve that works under high pressure. The introduction of high voltage and quick charge systems using a DC/DC converter enables high speed driving of the spill valve that controls the high fuel pressure. The precise control of the timing of injection of highly pressurized and finely atomized fuel decreases the particulates* and exhaust gas emissions, and improves maneuverability.

b. The ECU constantly monitors the EDU status and stops the engine if an EDU abnormality is detected.



*Particulates: fine particles of various materials (average size 0.1 υm) contained in higher quantities in diesel engine exhaust than in gasoline engine exhaust.

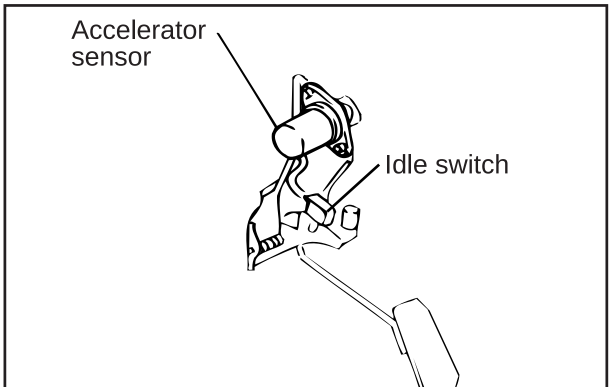
•EDU operation

The battery voltage is boosted to a high voltage by a high voltage generation circuit (DC-DC converter). The ECU controls the EDU according to inputs from various sensors, via the EMU signal that it outputs to the EMU terminal of the EDU.

The output of the IJt signal causes the high voltage (approx. 150 V) to be output from the SPV+ terminal of the EDU, which drives the solenoid spill valve. At this time, the EDUF terminal outputs the injection confirmation signal.

(4) Accelerator Sensor

On the ECD-V3, the sensor was mounted on the venturi to detect the accelerator opening. However, on the ECD-V5, the accelerator opening is detected at the accelerator pedal.
In either case, the voltage of the output terminal changes in accordance with the accelerator opening.



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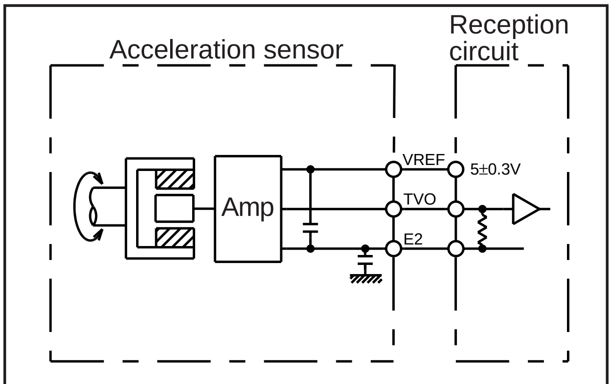

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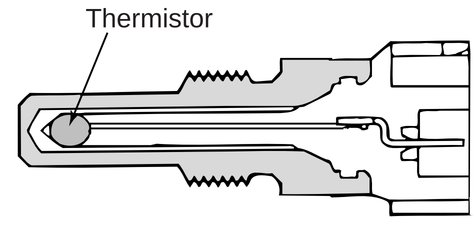
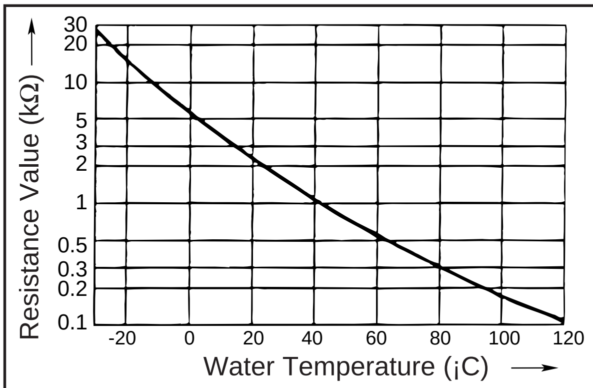
(5) Water Temperature Sensor

This sensor includes a thermistor and detects the temperature of the cooling water. The thermistor utilizes a semiconductor, the electrical resistance of which changes significantly with temperature. This change in the electrical resistance is used for determining the cooling water temperature.

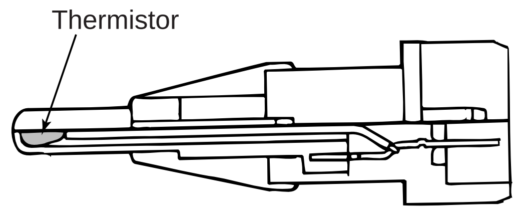


Structure
PR0075E



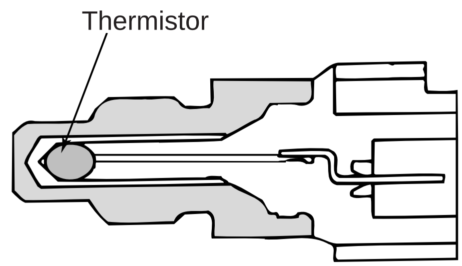
Characteristic
B6202E

(6) Intake Air Temperature Sensors No.1, No.2
These sensors contain a built-in thermistor that has the same characteristic as that of the water temperature sensor. They are mounted at 2 locations of the intake manifold of the engine to detect the intake air temperature before and after the intake manifold.



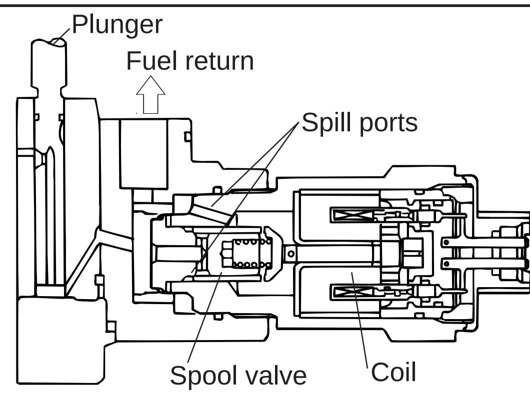
PR0077E

(7) Fuel Temperature Sensor
This sensor includes a thermistor having properties similar to that of the thermistor included in the water temperature sensor.



PR0078E

(8) Solenoid Spill Valve (SPV)
Highly pressure resistant and highly responsive, the solenoid spill valve is a direct-acting solenoid valve that directly controls the injection volume.
When the solenoid spill valve opens, the highly pressurized fuel in the plunger returns to the pump chamber, thus ending the injection of fuel.
*Refer to page 5 about SPV operation.



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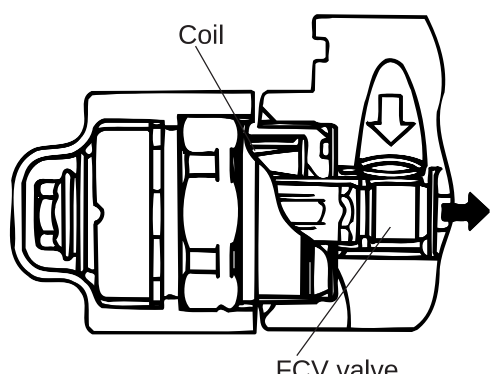
(9) Fuel Cutoff Valve (FCV)
It is a solenoid valve that cuts off the fuel injection when the engine is stopped.
When the current is applied, its valve opens, allowing the fuel to be drawn into the pressure chamber.



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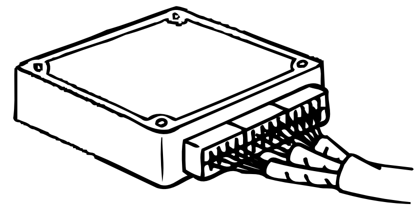
(10) Computer (ECU)

ECU calculates injection quantity by using signals from accelerator sensor, engine speed sensor and other sensors.

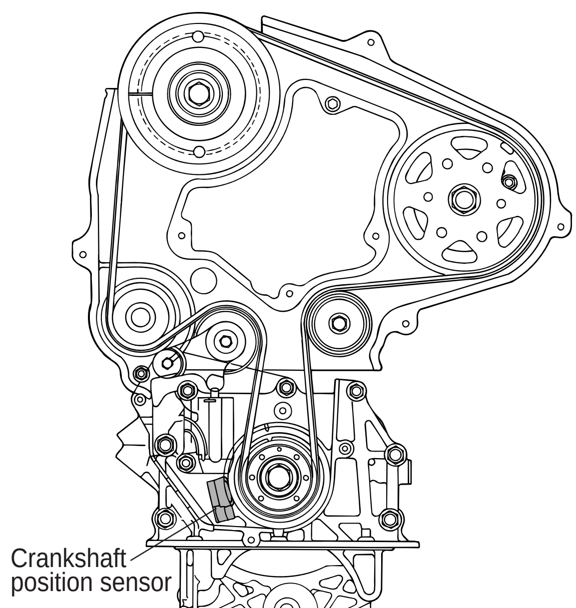


PR0081E

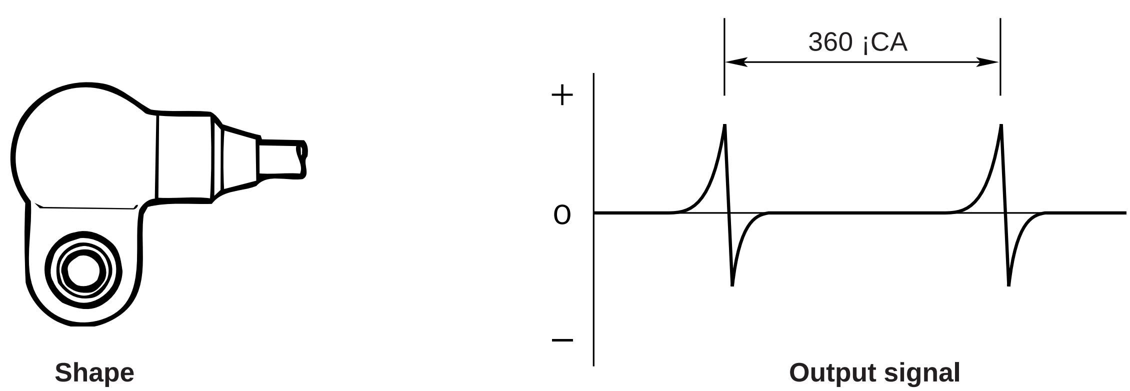
(11) Crankshaft Position Sensor

This sensor is mounted in the front of the engine. A protrusion that is provided on the crankshaft pulley causes 1 pulse to be generated each time the engine makes 1 revolution.

This pulse is then sent to the computer as the standard crankshaft angle signal.



QT0283E



QT0284E, PR0089E

(12) Timing Control Valve (TCV)

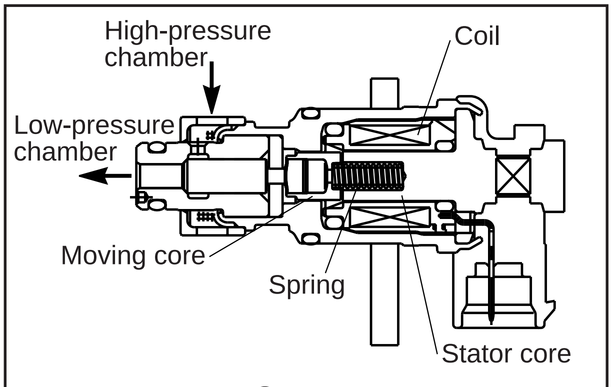
The timing control valve is installed in the fuel injection pump. According to the signals from the engine control computer, the valve opens/closes the fuel passage between the timer piston high-pressure chamber side and low-pressure chamber side.

When the coil is energized, the spring is compressed by the moving core, thus the fuel passage opens. One end of the timer control valve is connected to the main relay, and the other end is connected to engine control computer terminal TCV.

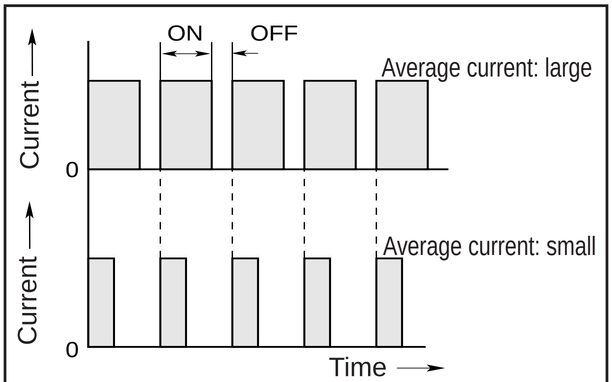
Current that flows to the stator core is duty-controlled by this terminal, and as the longer the ON time (time which engine control computer terminal TCV is grounded), the longer is the length of the valve opening time.

The timing control valve opening is controlled by the ratio of the ON/OFF duration (duty ratio) of the current supplied to the coil by the computer.

A longer ON duration produces a longer valve opening duration.



Structure PS0051E



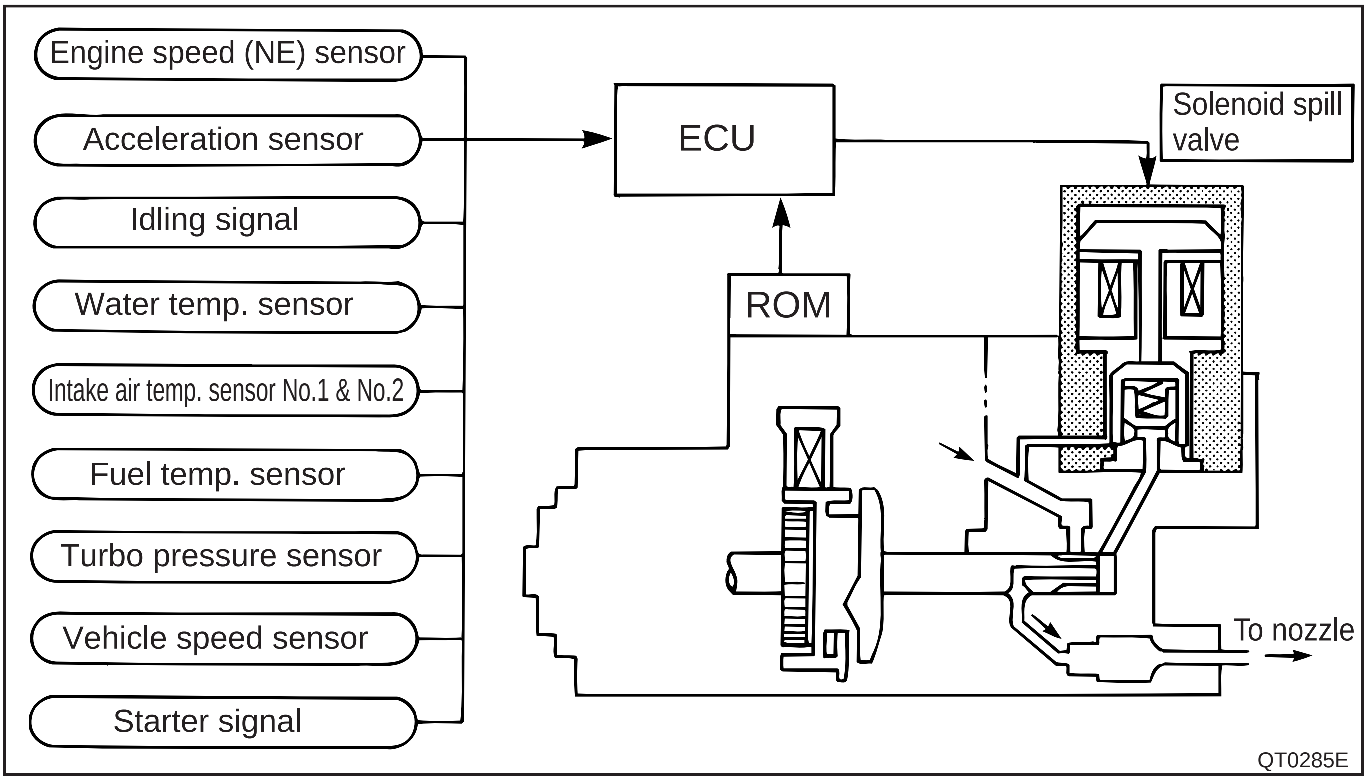
Duty Control PR0095E

3. Control Function

3-1. Fuel Injection Quantity Control

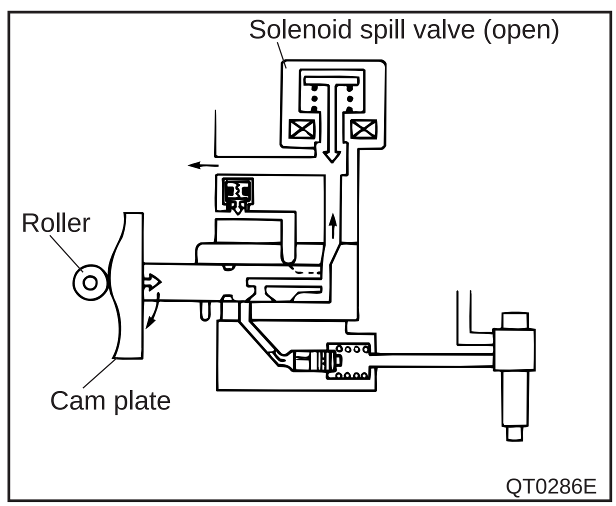
(1) General Description of Fuel Injection Quantity Control

Correcting the basic fuel injection quantity calculated based on the engine condition (accelerator opening, engine speed, etc.) in response to the water temperature, the fuel temperature, the intake air temperature and pressure, etc., the engine control computer transmits the optimum output signal for the engine condition to the solenoid spill valve of the ECD-V5 pump.
Especially, ROM on the pump instead of conventional correction resistors has correction data for injection quantity and timing.



(2) Fuel Injection Quantity Control Method

The cam position of the cam plate determines the fuel injection start timing.
Fuel injection stops after the solenoid spill valve is deenergized (opens) and the pressurized fuel spills out (is released) into the pump chamber.
Consequently, the computer controls the fuel injection quantity by adjusting the fuel injection end timing.



(3) Basic Calculation of Fuel Injection Quantity Control

The fuel injectionquantity is determined based on two values (basic fuel injection quantity and maximum fuel injection quantity).

a. Basic Fuel Injection Quantity

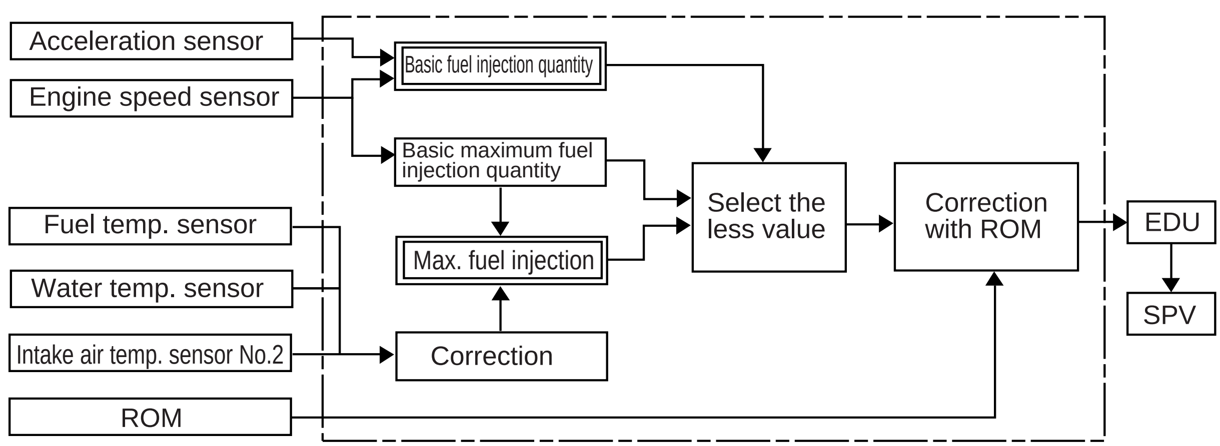
The basic fuel injection quantity is determined by the engine speed and the accelerator opening.

b. Maximum Fuel Injection Quantity

The maximum fuel injection quantity is determined in response to the intake air into the engine calculated based on the engine speed, the intake air pressure and temperature, etc.

Final fuel injection quantity is determined by the comparison between the basic fuel injection quantity and the maximum fuel injection quantity. The minimum value is adopted.

(4) Fuel Injection Quantity Control Flow



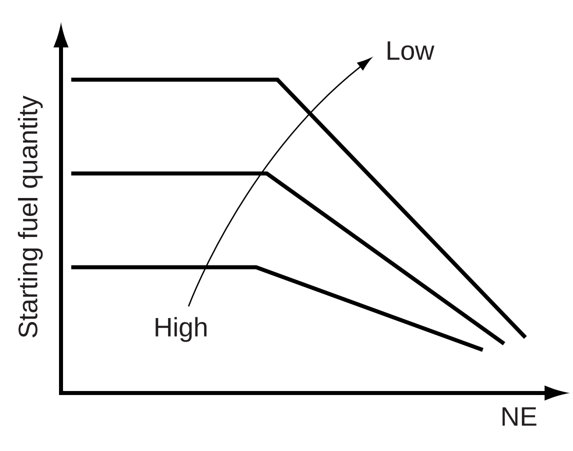
QT0289E

a. Except Starting (Same as the previous ECD-V3)

Compares the basic fuel injection quantity and the maximum injection, and the governor pattern of the map for the less injection quantity is used for determining the injection quantity.

b. Starting (Same as the previous ECD-V3)

Calculates the injection quantity in accordance with the engine speed and water temperature.



QT0290E

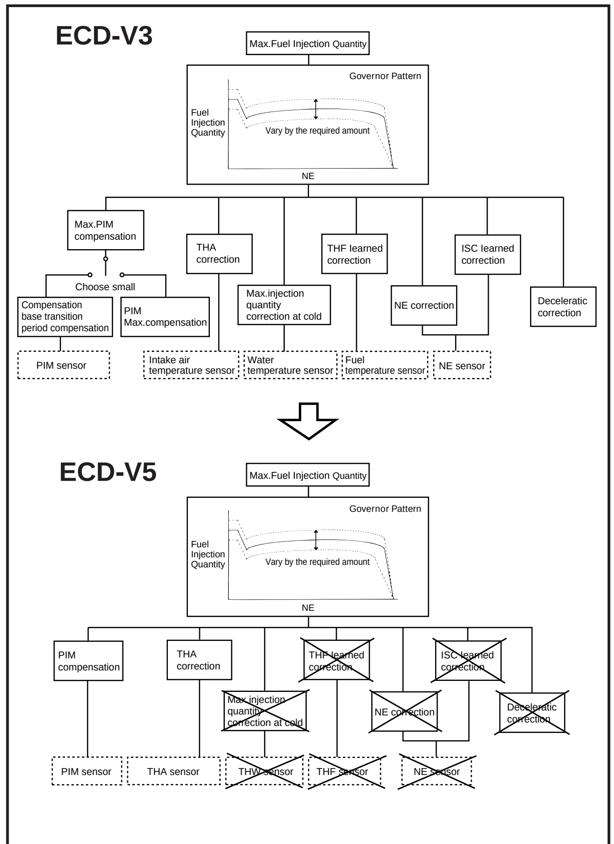
(5) Various Types of Maximum Injection Quantity

a. Intake air pressure (PIM) compensation

Based on the signals received from the turbo pressure sensor, the intake air volume iscalculated in order to correct the maximum injection quantity towards enrichment during turbocharging.

b. Intake air temperature (THA) correction

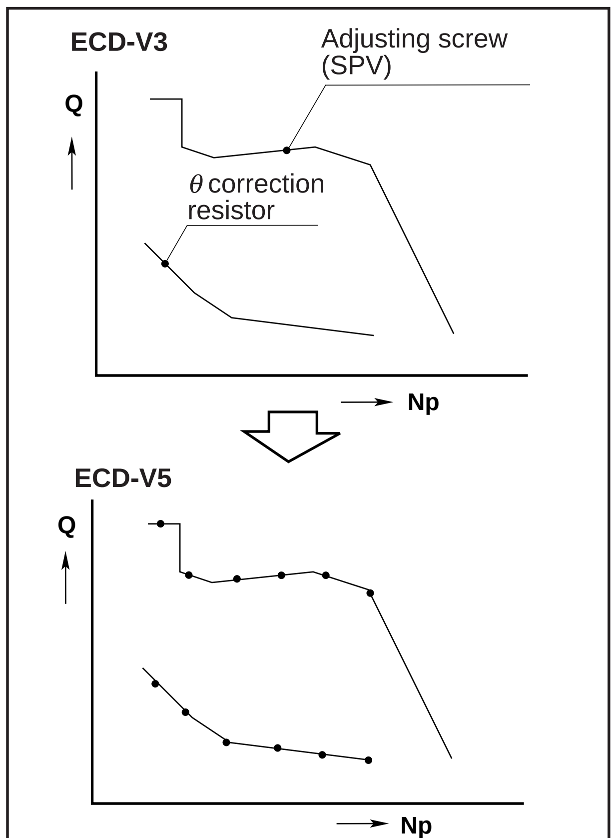
It is the same as ECD-V3.



PS0047E

(6) Correction with ROM Data

The new ECD-V5 is equipped with a ROM in place of the correction resistor used in the previous ECD-V3 system. Accordingly, the points on which the individual pumps can be controlled have been increased to realize a high level of precision.
Furthermore, the data in the ROM can be modified to make delicate injection quantity corrections easily, thus realizing a greater freedom of adjustment.

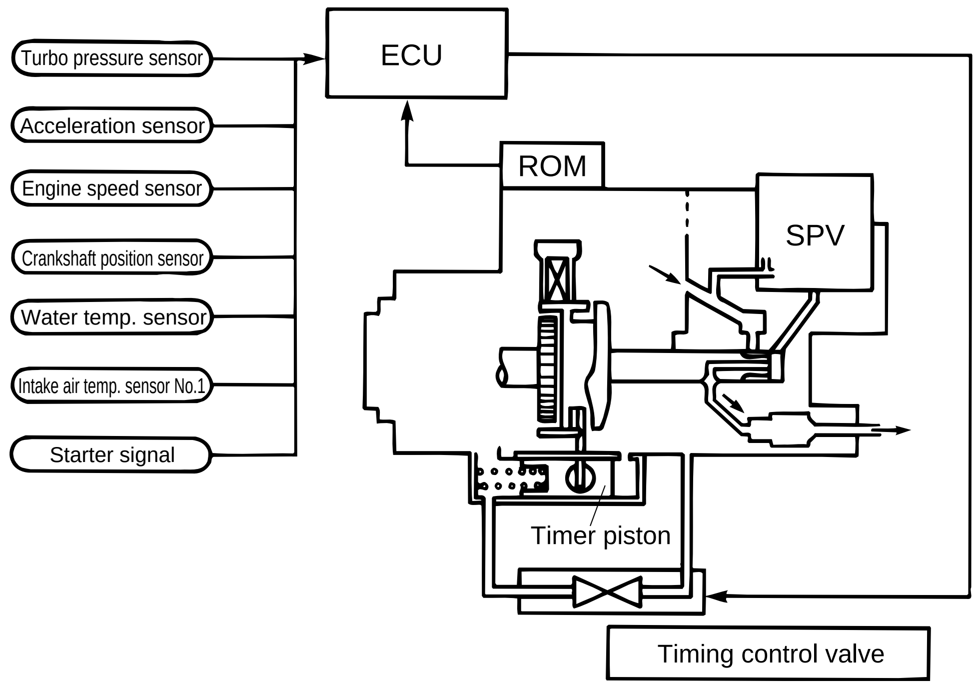


PS0048E

3-2. Fuel Injection Timing Control

(1) General Description of Fuel Injection Timing Control

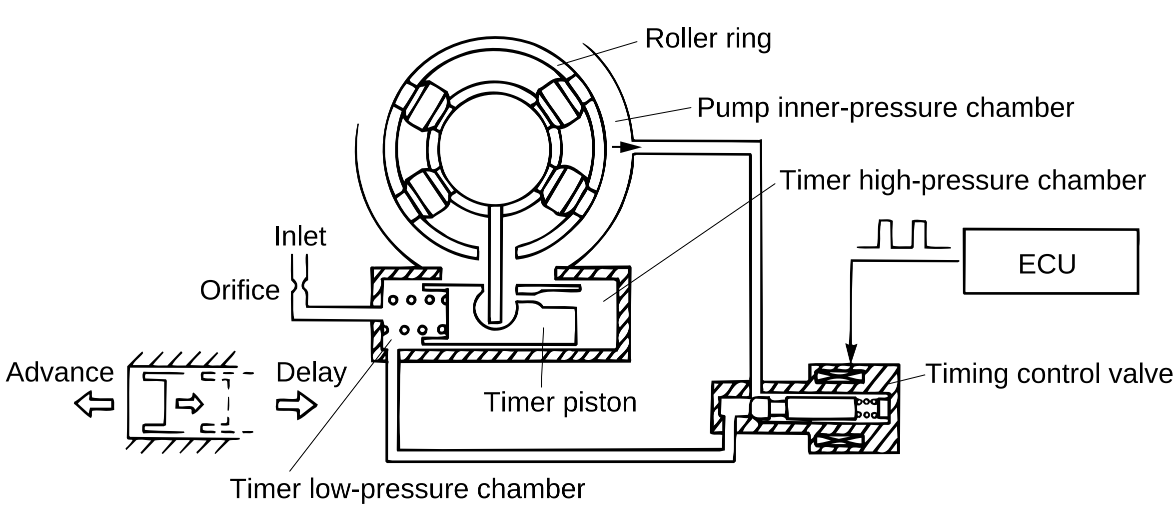
The engine control computer (ECU) calculates the fuel injection timing, and transmits a signal to the timing control valve (TCV) to maintain the optimum fuel injection timing.



QT0292E

(2) Injection Timing Control Method

To control the injection timing, the fuel pressure of the timer low-pressure chamber that is applied to the timer piston is regulated by varying the length of time in which the TCV is open, thus moving the roller ring. When the length of time in which the TCV is open is long, the volume of fuel that bypasses from the pump inner-pressure chamber to the timer low-pressure chamber increases, causing the pressure in the timer low-pressure chamber to increase. As a result, the timer piston moves in the retard direction. When the length of time in which the TCV is open is short, the timer piston moves in the advance direction.



QT0293E

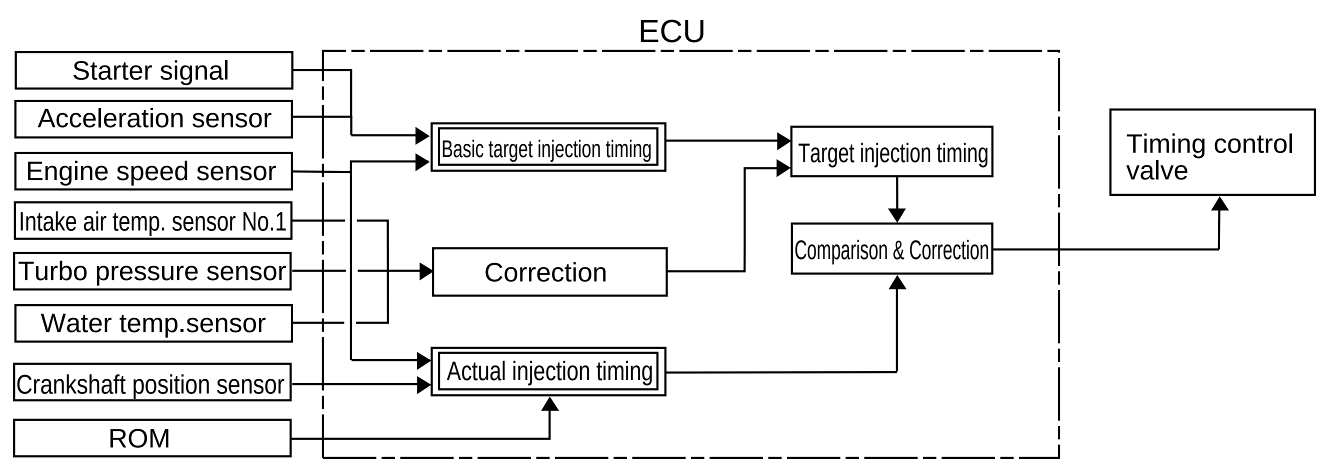
(3) Basic Calculation of Fuel Injection Timing Control

Correcting the basic fuel injection timing calculated from the engine conditions (accelerator opening, engine speed, etc.) according to the water temperature, the intake air pressure, etc., the computer controls the following factors:

¥Optimum fuel injection timing according to fuel injection quantity (engine load) and engine speed
¥Advance before engine warm-up
¥Advance at engine start-up
¥Advance at higher altitude where intake air density is lower

To provide accurate control, the actual fuel injection timing is computed from an input signal issued by the TDC sensor and transmitted to the computer.(Refer to page 38,39.)

(4) Determine Target Injection Timing



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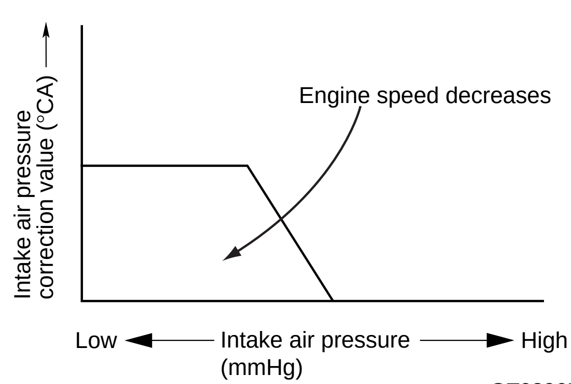
(5) Various Types of Injection Timing Correction

a. Intake air pressure correction advance

The basics of calculating the amount of timing advance correction based on the turbo pressure sensor signal.



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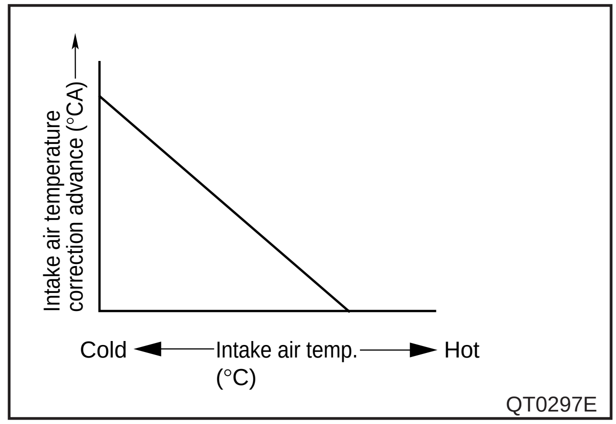
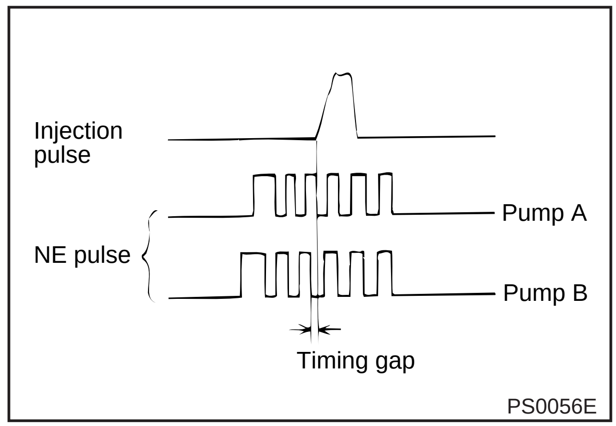
b. Intake air temperature correction advance

The amount of timing advance correction based on the intake air temperature sensor signal.

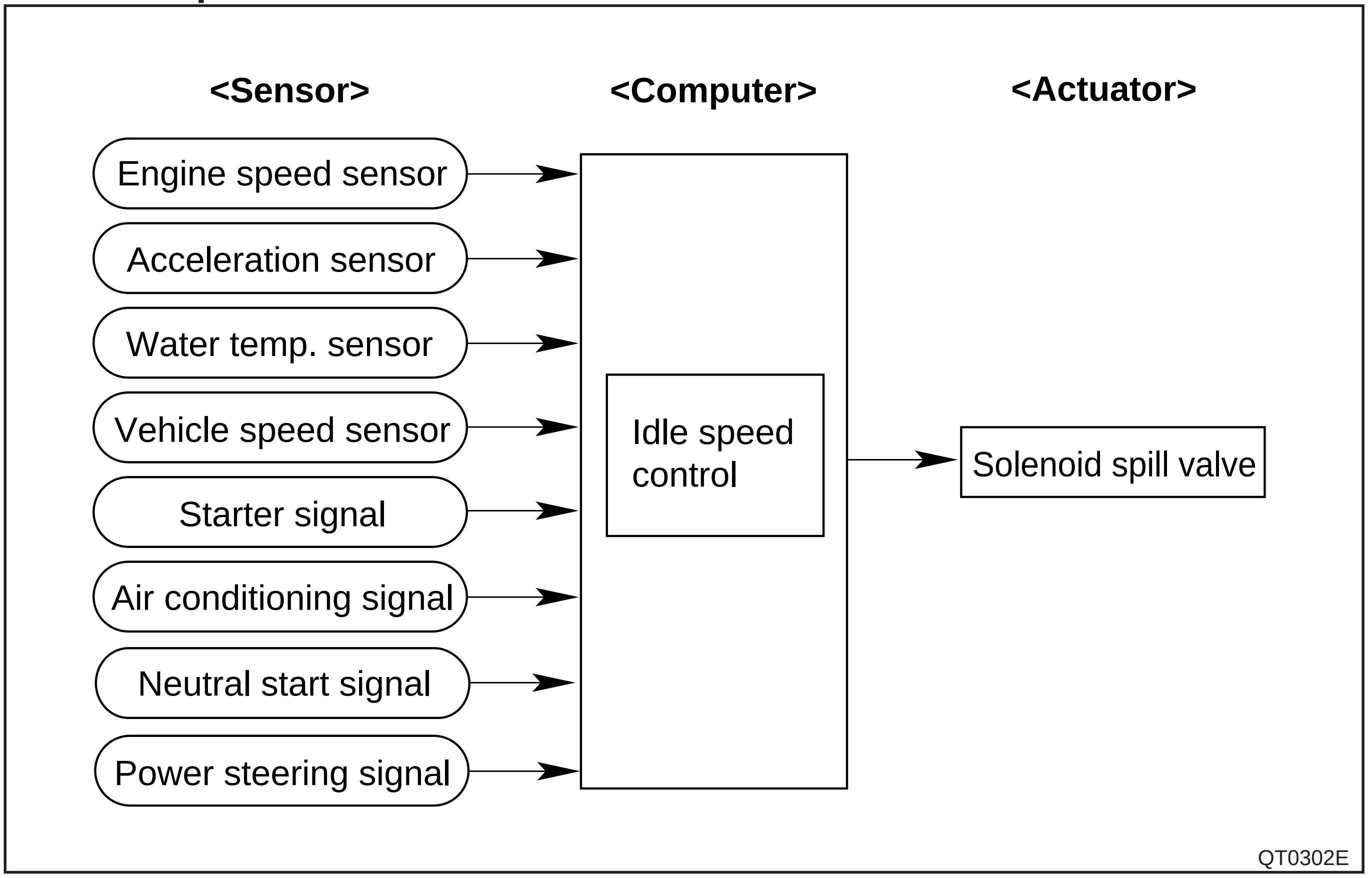


c. Crankshaft angle correction

The NE pulse (camshaft angle signal) that is detected by the rpm sensor is used for controlling the injection timing. However, the correlation between the camshaft angle signal and the injection wave form deviates from one pump to another, causing a deviation in the injection timing. This deviation is corrected through the use of the correction data on the ROM that is attached to the pump.



3-3. Idle Speed Control



(1) Feedback Control

The computer compares the desirable idling speed and the current idling speed (engine speed sensor signal). If any difference is found between them, the computer adjusts the injection quantity to obtain the desirable idling speed.

(2) Warming Up Control

During warm-up, the computer sets a fast idling speed deemed optimum according to the cooling water temperature.

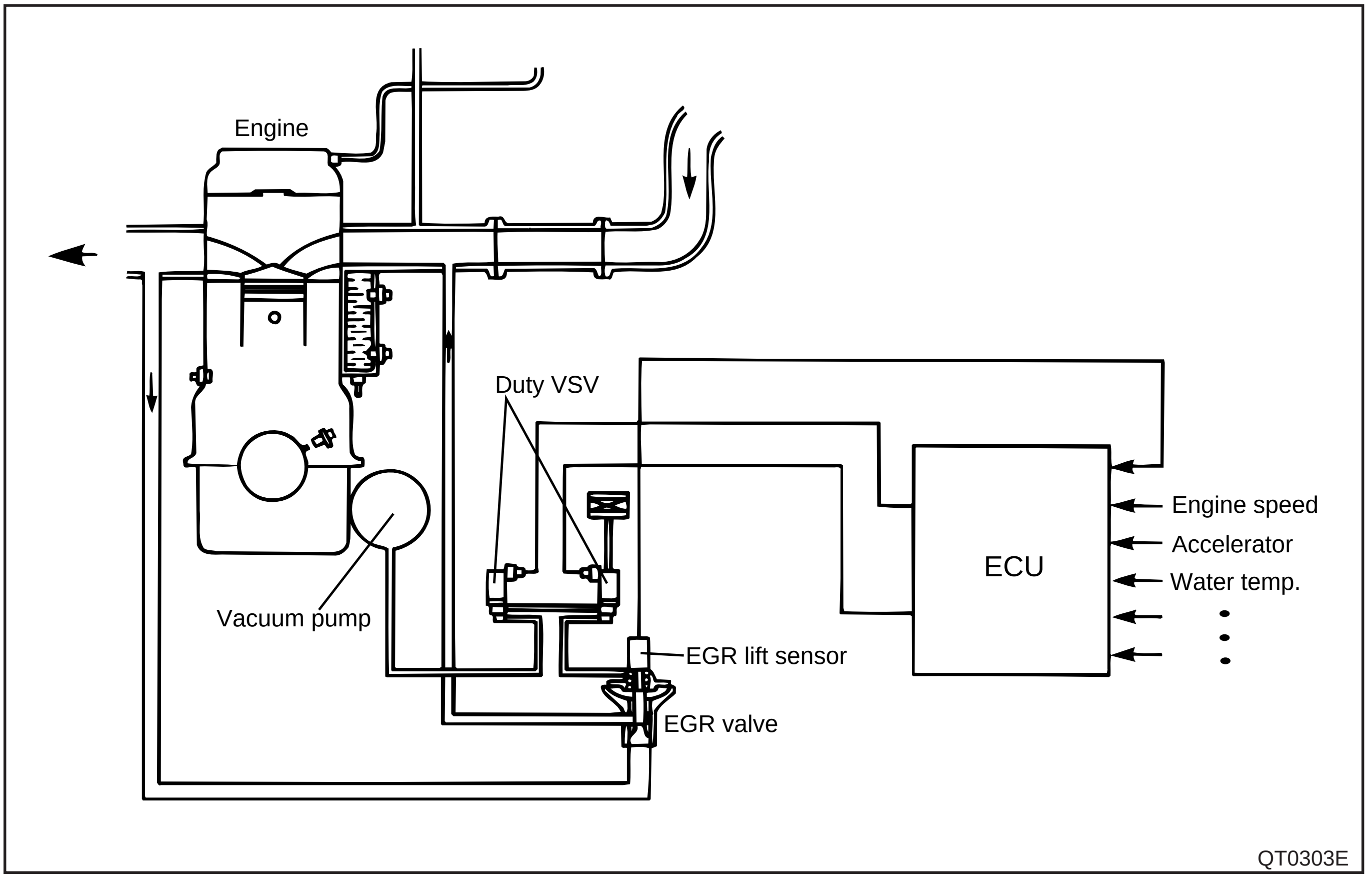
(3) Expectation Control

To prevent a fluctuation in the idling speed due to a load fluctuation following an A/C switch operation, the computer changes the injection quantity by a preset amount immediately after the switch operation but before the idling speed fluctuates.

(4) Idle Speed Stabilization Control

While the engine is running at the idling speed, the computer detects the speed fluctuation at each cylinder and corrects it by adjusting the injection quantity for each cylinder. This results in reduced vibrations at the idling speed.

3-4. EGR Control

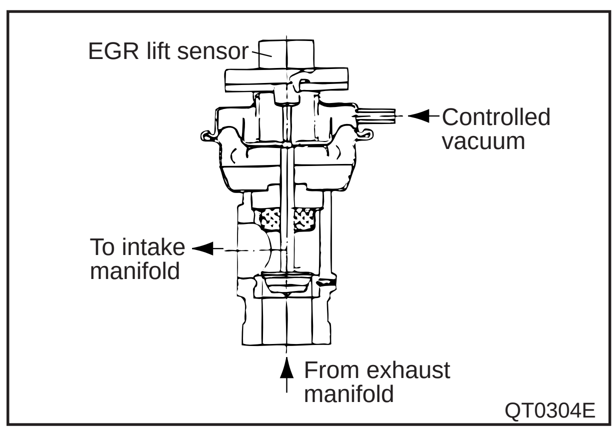


(1) Outline

The EGR system itself is almost identical to that of the previous system. Basically, the ECU calculates the target EGR valve lift value in accordance with the signals from the sensors, monitors the actual amount of lift, and controls the 2 duty cycle VSVs to achieve the target lift value.

(2) EGR Valve

When the vacuum in the diaphragm chamber of the EGR valve increases, the EGR valve has the characteristic to open. Consequently, the exhaust gases flow from the exhaust manifold to the intake manifold.



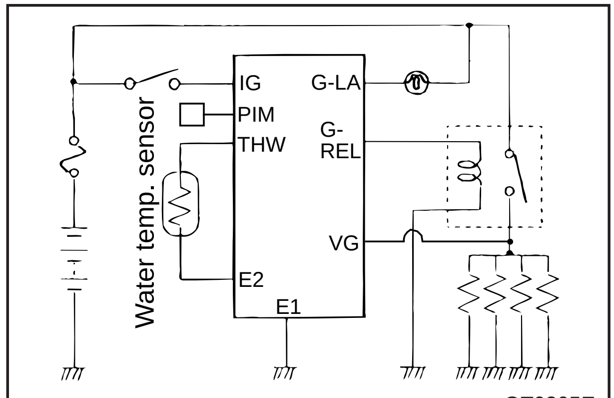
(3) Control Outline

a. The operation of the EGR is stopped at low and high temperatures.
b. The volume of EGR is reduced at high altitudes.

3-5. Other Controls

(1) Glow Plug Control

This control is intended to warm up the air in the combustion chamber when starting the engine at low temperatures and to make the glow plugs the source for igniting the fuel in order to ensure startability.



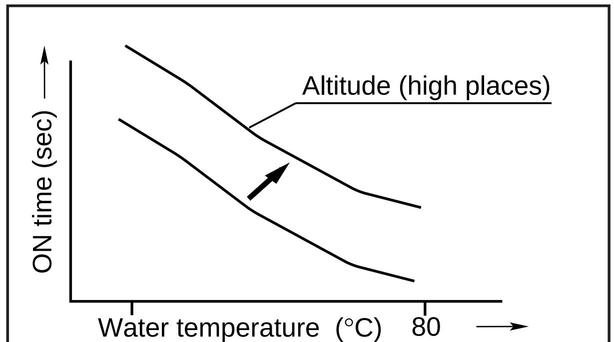
QT0305E

a. Glow plug indicator illumination time control

When the ignition switch is turned ON, the glow plug indicator light illuminates only for the length of time that is determined by the coolant water temperature and the atmospheric pressure. However, the indicator light turns OFF at the time the starter is turned ON.

b. Glow plug relay control

When the ignition switch is turned ON, super-glow is implemented by applying current only for the length of time that is determined by the coolant water temperature.
After the engine is started and the starter is turned OFF, after-glow is implemented from that point.

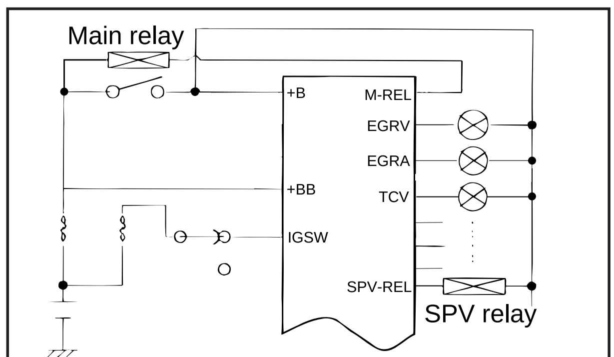


Glow Plug Indicator Illumination Time Control

QT0306E

(2) Main Relay Control

Controls the systemÕs main power supply relay. Does not control the power supply to the computerÕs IGSW terminal, +BB terminal, and to the glow plugs.

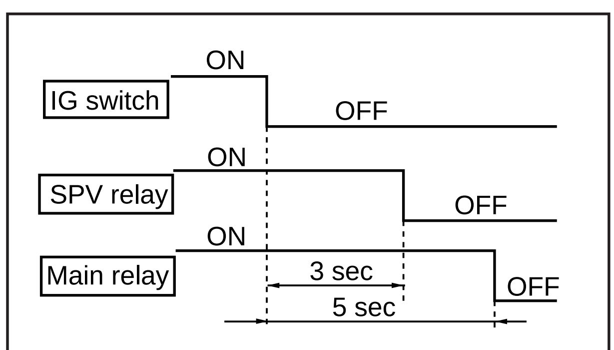


Main Relay Control

QT0307E

•Control time chart

a. When the IGSW is turned ON, the main relay turns ON.
b. When the IGSW is turned OFF, the main relay turns OFF after 5 seconds have elapsed from the time SPD=0 is established.



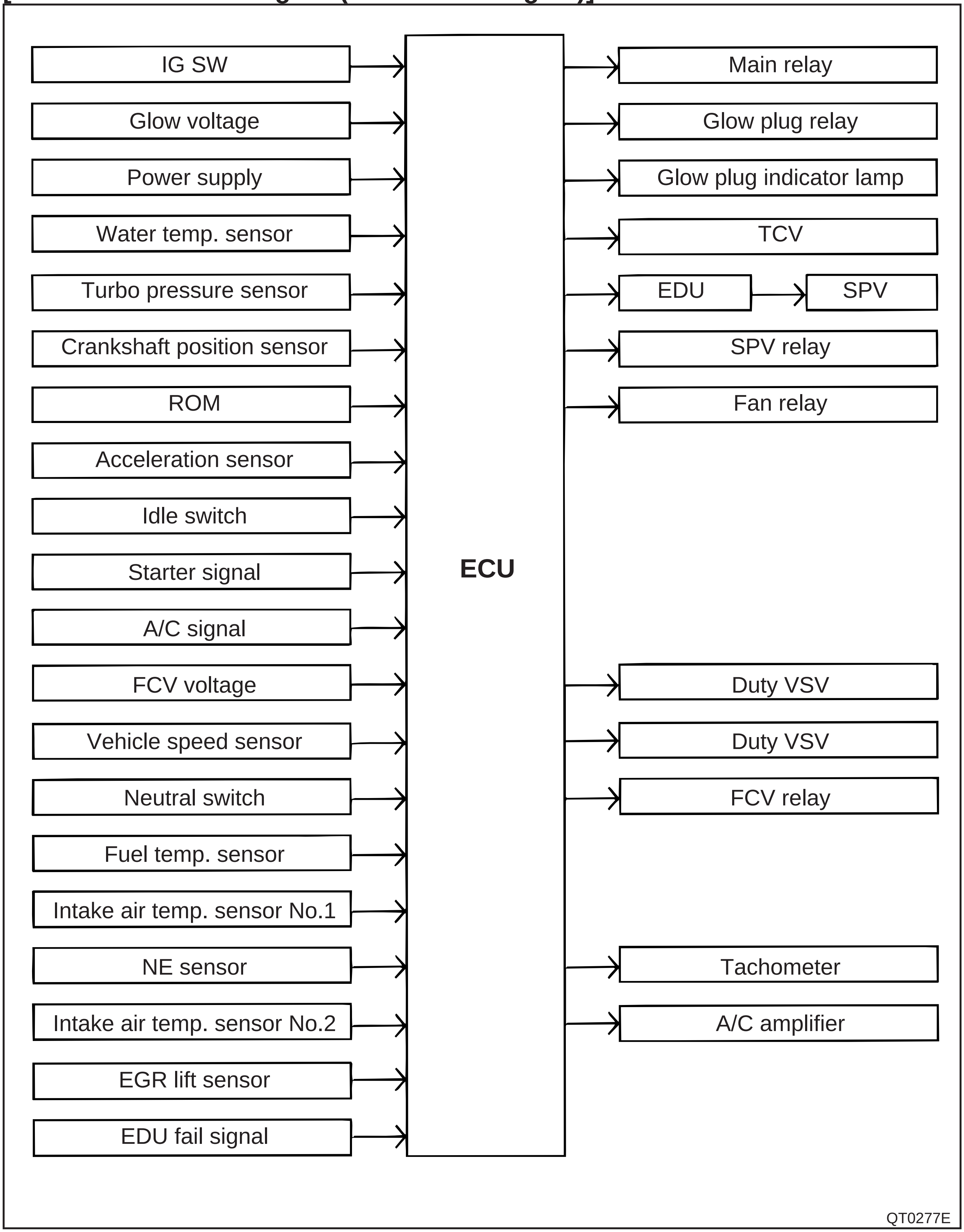
Control Time Chart

QT0308E

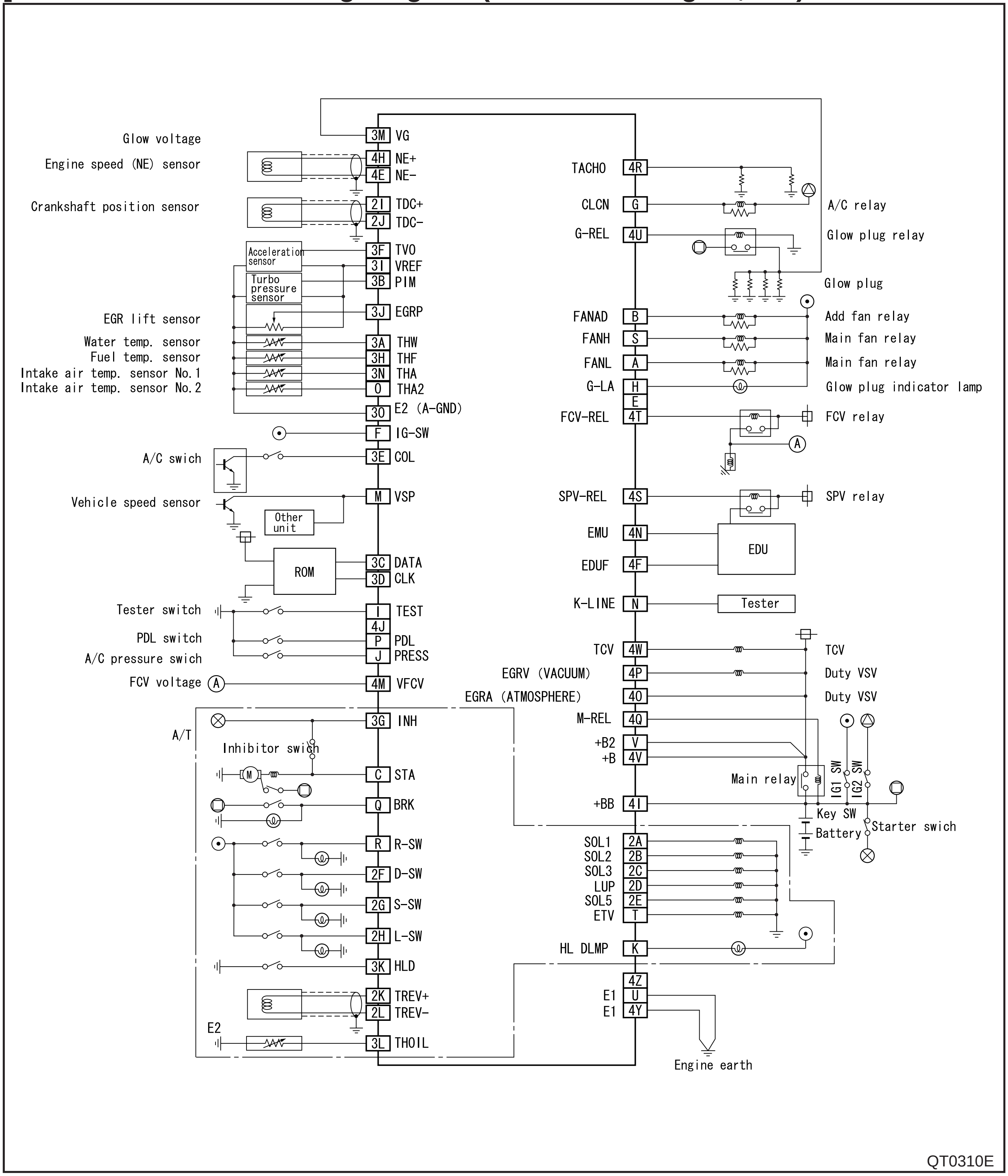
(3) A/C Cut Control

When the ECU judges that vehicle acceleration has reached a preset value, it signals the A/C ECU to cut the compressor OFF for 5 seconds.

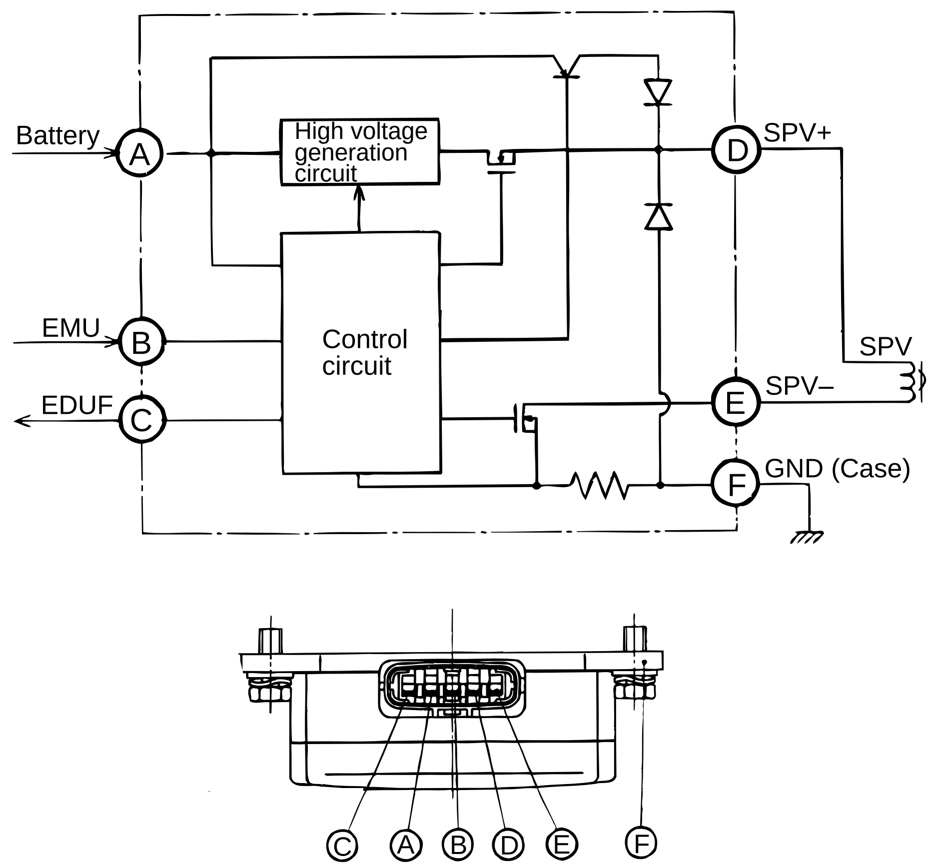
[Reference: Block Diagram(ex.RF-MDT engine)]



[Reference:External Wiring Diagram (ex. RF-MDT engine, A/T)



[Reference:EDU External Wiring Diagram (ex. RF-MDT engine)]



QT0129E