

ENGINE CONTROL SYSTEM

1. General

The engine control system of the 1KD-FTV and 2KD-FTV engines has the following system.

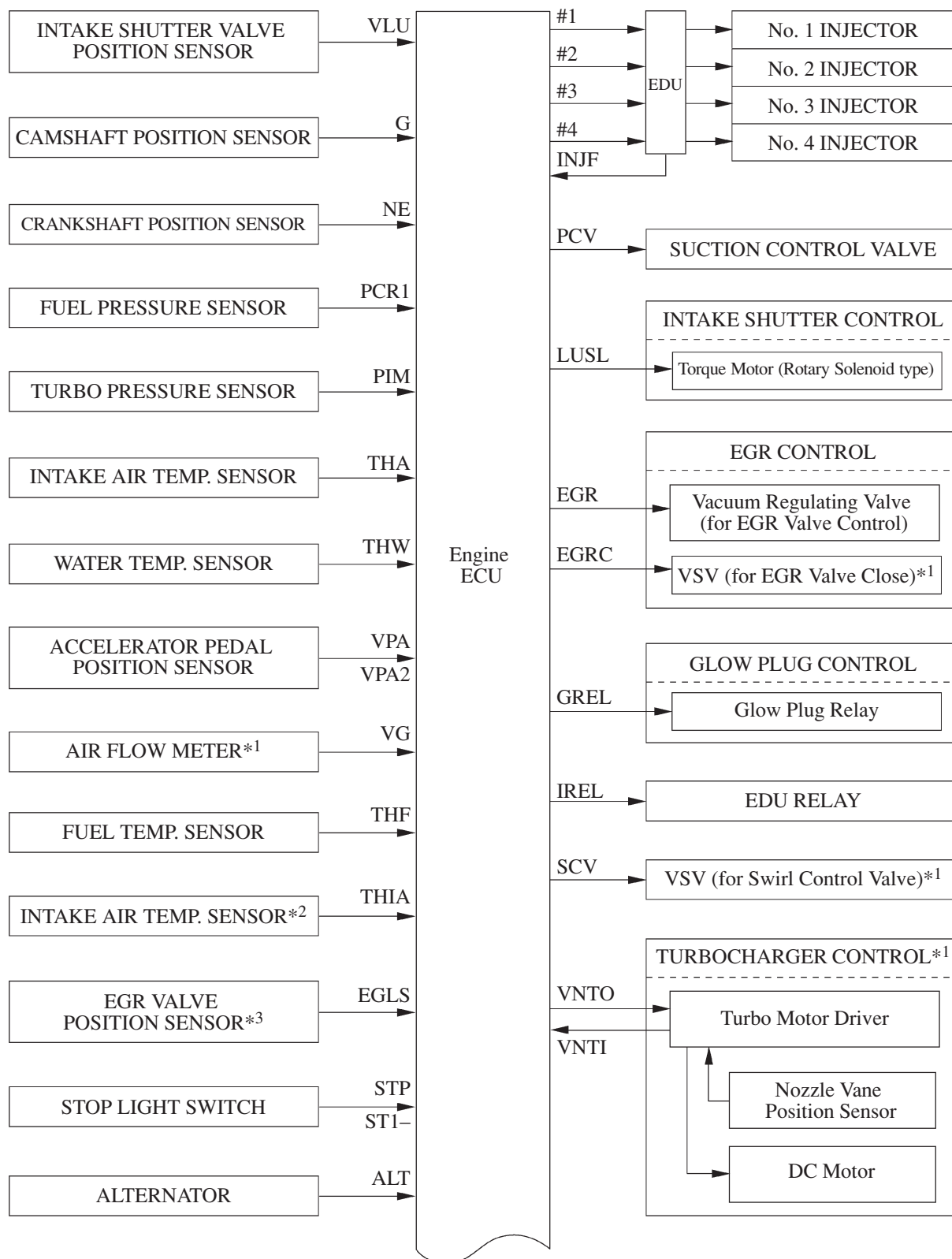
System	Outline	1KD-FTV	2KD-FTV 2KD-FTV High Version
Fuel Injection Volume Control (See page EG-156)	Based on the signals received from the sensors, the engine ECU determines the fuel injection volume in accordance with the engine condition.	○	○
Fuel Injection Timing Control (See page EG-157)	Based on 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-158)	To facilitate startability, the engine ECU optimally controls the injection volume and injection timing during starting.	○	○
Idle Speed Control (See page EG-159)	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-160)	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-163)	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 Shutter Control (See page EG-164)	- Controls the intake shutter valve (throttle valve) opening angle in accordance with the engine condition. - Fully close the intake shutter valve (throttle valve) in order to reduce the vibration when the engine is stopped.	○	○
Swirl Control (See page EG-164)	Based on the signals received from the sensors, the engine ECU controls the vacuum that is directed to the actuator via the VSV, in order to open and close the valve.	○	—
Turbocharger Control (See page EG-165)	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-169)	Controls the EGR volume via EGR valve in accordance with the engine condition.	○	○
Air Conditioner Cut-Off Control*1	By controlling the air conditioner compressor ON or OFF in accordance with the engine condition, drivability is maintained.	○	○
Engine Immobilizer*2	Prohibits fuel injection if an attempt is made to start the engine with an invalid ignition key.	○	○
Diagnosis (See page EG-171)	When the engine ECU detects a malfunction, the engine ECU diagnoses and memorizes the failed section.	○	○
Fail-Safe (See page EG-171)	When the engine ECU detects a malfunction, the engine ECU stops or controls the engine according to the data already stored in the memory.	○	○

*1: Models with Air Conditioner

*2: Models with Engine Immobilizer System

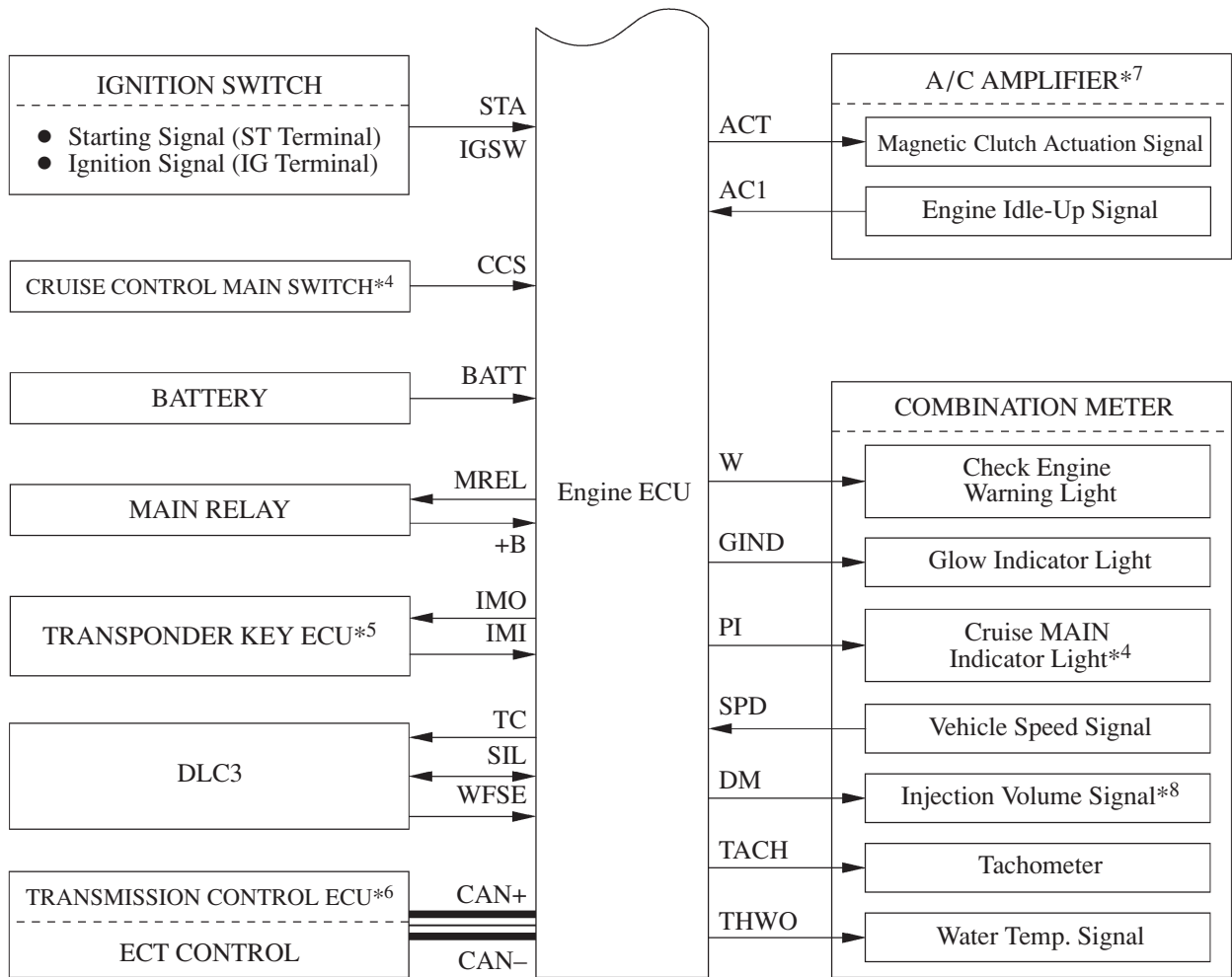
2. Construction

The configuration of the engine control system in the 1KD-FTV and 2KD-FTV engines is as shown in the following chart.



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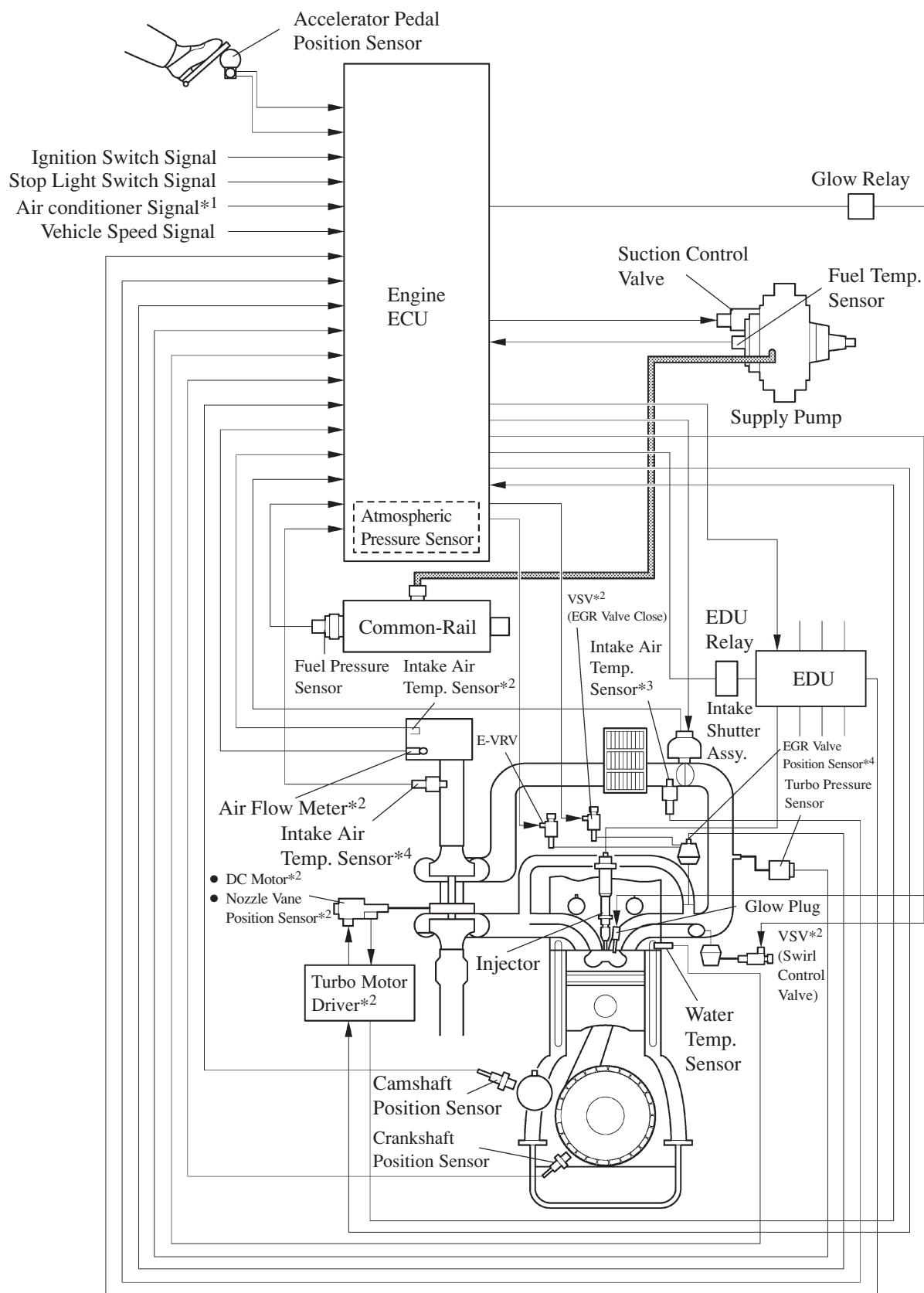
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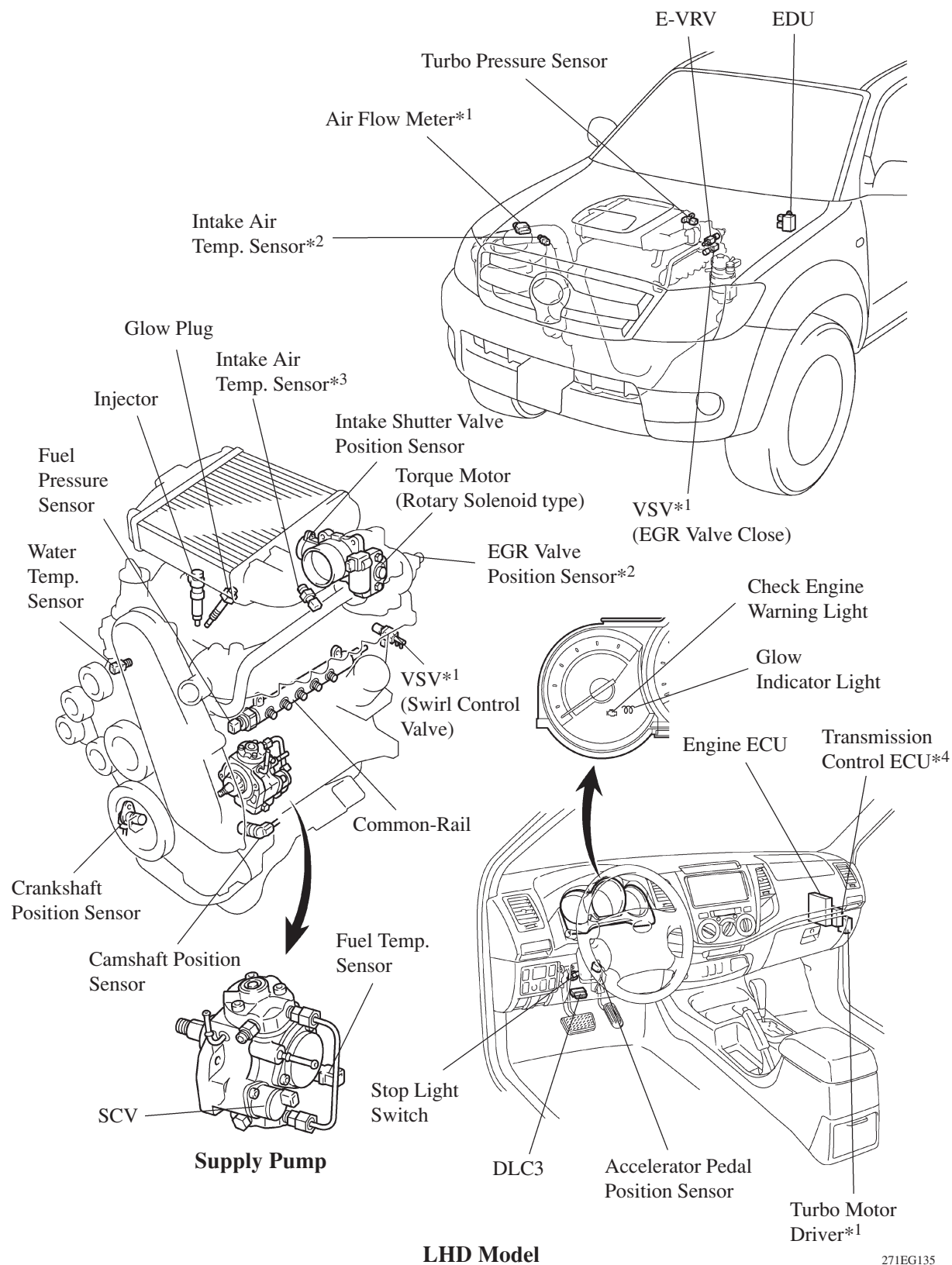
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- *1: Only for 1KD-FTV Engine
- *2: Only for Models with Intercooler
- *3: Only for 2KD-FTV Engine
- *4: Only for Models with Cruise Control System
- *5: Only for Models with Engine Immobilizer System
- *6: Only for Models with Automatic Transmission
- *7: Only for Models with Air Conditioner System
- *8: Only for Models with Multi Information Display

3. Engine Control System Diagram



4. Layout of Main Components



*1: Only for 1KD-FTV Engine

*2: Only for 2KD-FTV Engine

*3: Only for Models with Intercooler

*4: Only for Models with Automatic Transmission

5. Main Components of Engine Control System

General

The main components of the 1KD-FTV and 2KD-FTV engine control system are as follows:

Components	Outline	Quantity	Function
Engine ECU	32-bit CPU	1	The engine ECU effects overall control of the engine control system to suit the operating conditions of the engine in accordance with the signals provided by the sensors.
EDU	DC/DC Converter	1	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.
Turbo Pressure Sensor	Semiconductor Silicon Chip Type	1	This sensor uses built-in semiconductors to detect the intake manifold pressure.
Atmospheric Pressure Sensor	Semiconductor Silicon Chip Type	1	This sensor, which is built into the engine ECU, uses semiconductors to detect the atmospheric pressure.
Fuel Pressure Sensor	Semiconductor Strain Gauge Type	1	This sensor uses built-in semiconductors to detect the internal pressure of the common-rail.
Crankshaft Position Sensor	Pick-up Coil Type (Rotor Teeth /36-2)	1	This sensor detects the engine speed and performs the cylinder identification.
Camshaft Position Sensor	Pick-up Coil Type (Rotor Teeth /5)	1	This sensor performs the cylinder identification.
Air Flow Meter (1KD-FTV Engine)	Hot-wire Type	1	This sensor uses a built-in hot-wire to directly detect the intake air volume.
Water Temperature Sensor	Thermistor Type	1	This sensor detects the engine coolant temperature by means of an internal thermistor.
Intake Air Temperature Sensor	Thermistor Type	1	- This sensor, which is provided at the air cleaner outlet, detects the intake air temperature by means of an internal thermistor. - On the 1KD-FTV engine, this sensor is built into the airflow meter.
Intake Air Temperature Sensor (for Intercooler)	Thermistor Type	1	This sensor, which is provided only on the models with an intercooler, detects the intake air temperature past the intercooler.
Fuel Temperature Sensor	Thermistor Type	1	This sensor detects the fuel temperature in the supply pump by means of an internal thermistor.
Intake Shutter Valve Position Sensor	No-contact Type	1	This sensor detects the intake shutter valve (throttle valve) opening angle.
Accelerator Pedal Position Sensor	No-contact Type	1	- This sensor detects the amount of pedal effort applied to the accelerator pedal. - The basic construction and operation of this sensor are the same as in the 1TR-FE and 2TR-FE engines. For details, see page EG-46.
EGR Valve Position Sensor (2KD-FTV Engine)	Contact Type	1	This sensor detects the actual amount of the EGR valve opening.
SCV (Suction Control Valve)	Linear Solenoid Valve	1	The SCV position is controlled by the signals from the ECU, and a fuel volume that suits the SCV position is drawn into the pumping portion (plunger portion).
Injector	8-hole Type (1KD-FTV Engine) 6-hole Type (2KD-FTV Engine)	4	The injector contains a solenoid valve that opens and closes to increase or decrease the pressure in the control chamber. This causes the nozzle needle to open and close the valve, which results in fuel injection.

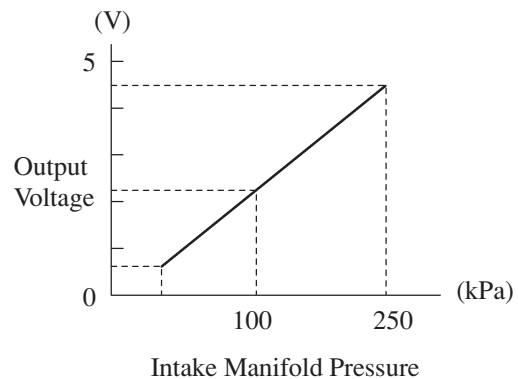
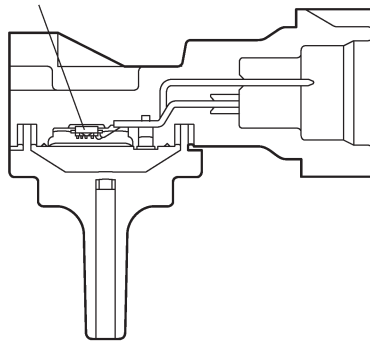
Engine ECU

- The 32-bit CPU of the engine ECU is used to increase the speed for processing the signals.
- Each of the 2KD-FTV engine and the 2KD-FTV High Version engine is equipped with an engine ECU that contains an engine control program that differs from each other. However, both engine models share the same mechanical components.
- On the models equipped with the A340E and A340F automatic transmissions, the engine ECU maintains communication with a separate, independent ECT ECU through CAN (Controller Area Network). Thus, engine control is effected in coordination with ECT control.

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.

Sensor Unit

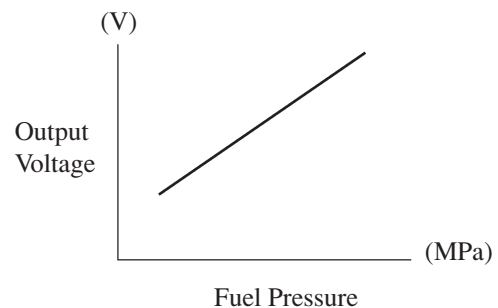
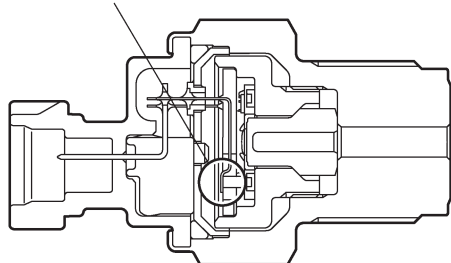


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Fuel Pressure Sensor

The fuel pressure sensor consists of a semiconductor which utilizes the characteristic of a silicon chip that changes its electrical resistance when pressure is applied to it. This sensor is mounted on the common-rail, outputs a signal that represents the fuel pressure in the common-rail to the engine ECU, in order to constantly regulate the fuel at an optimal pressure.

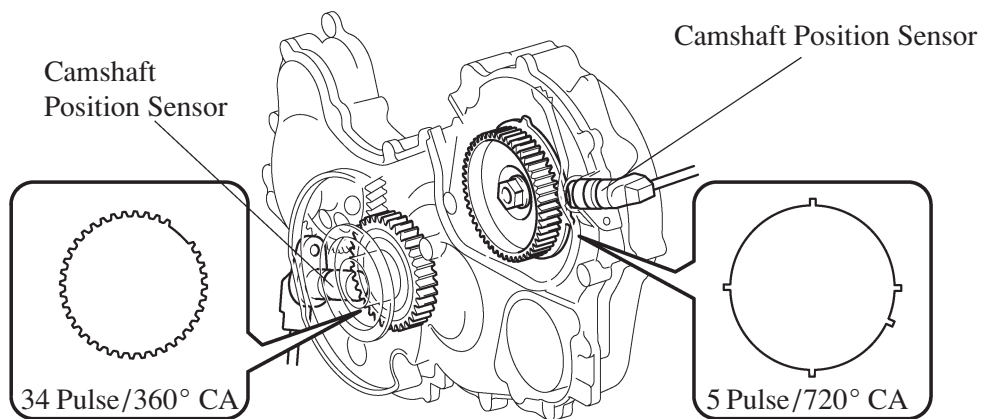
Detection Portion



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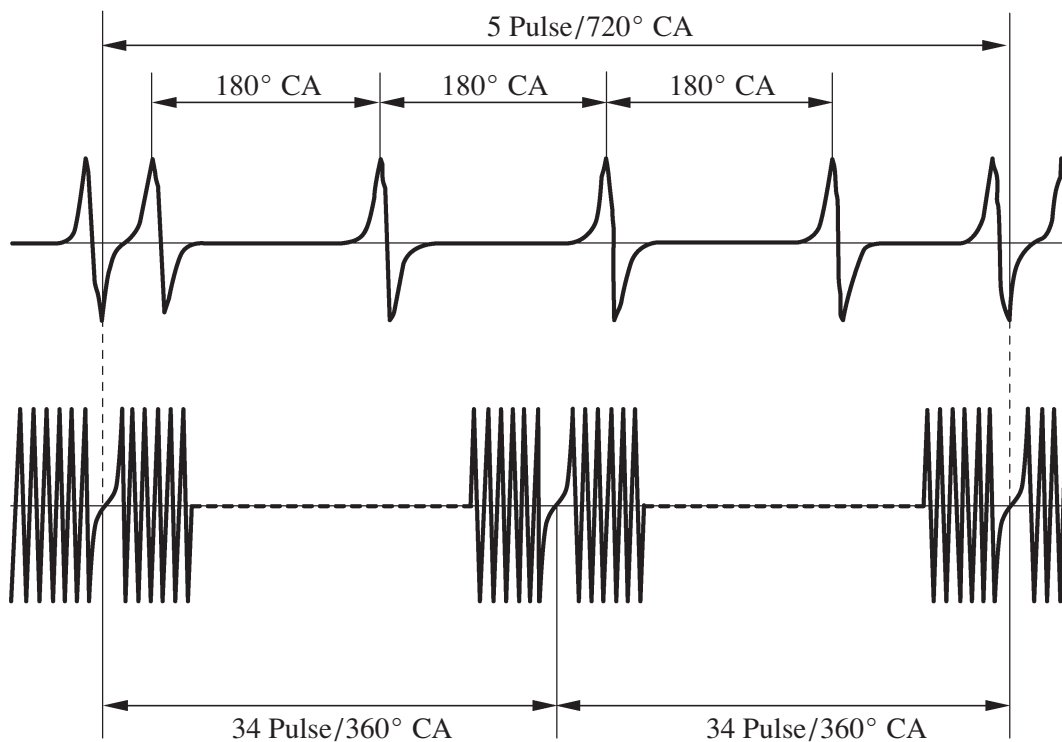
Crankshaft Position Sensor and Camshaft Position Sensor

- 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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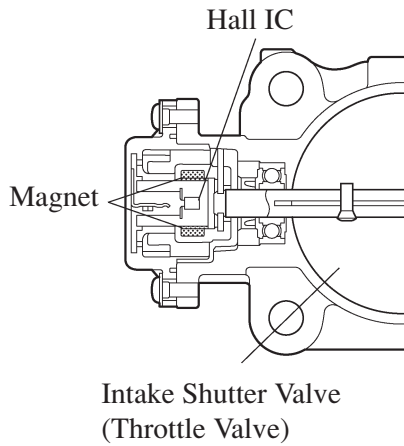
► Sensor Output Waveforms ◀



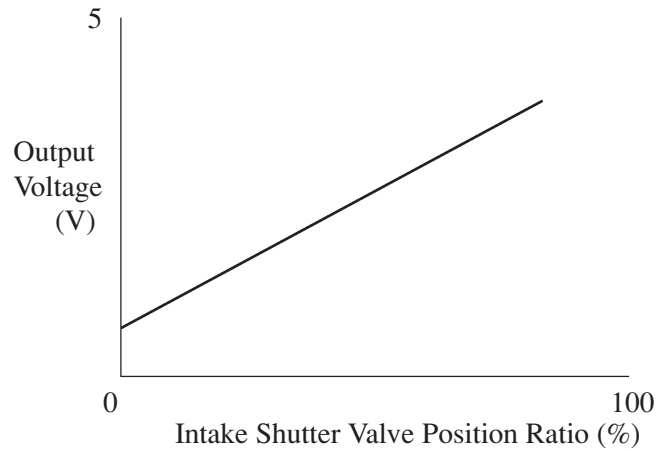
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Intake Shutter Valve Position Sensor

The intake shutter valve position sensor is mounted on the intake shutter assembly, to detect the opening angle of the intake shutter valve (throttle valve), the intake shutter valve position sensor converts the magnetic flux density that changes when the magnetic yoke (located on the same axis as the intake shutter valve shaft) rotates around the hall IC into electric signals to operate the intake shutter valve control motor.



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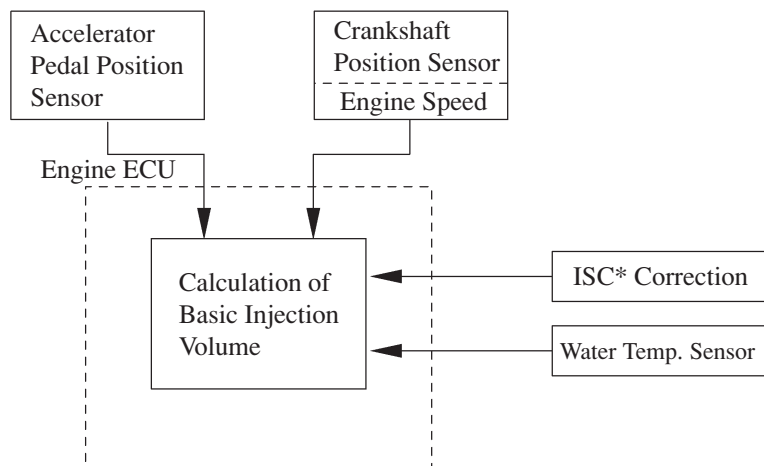


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6. Fuel Injection Volume Control

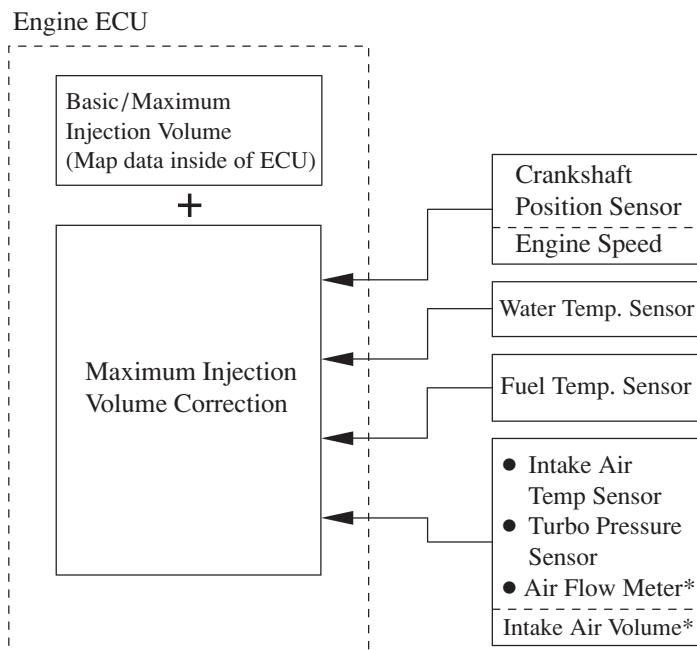
The engine ECU calculates two types of values: the basic injection volume and the maximum injection volume. Then, the engine ECU compares the basic and maximum injection volumes, and determines the smaller calculated value to be the final injection volume.

► Basic Injection Volume ◀



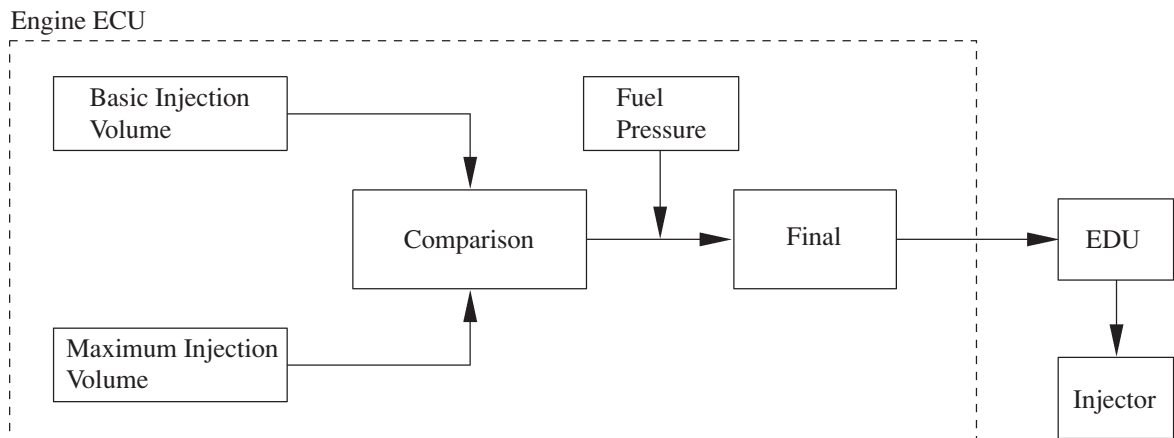
*: Idle Speed Control

► Maximum Injection Volume ◀



*: Only for 1KD-FTV Engine

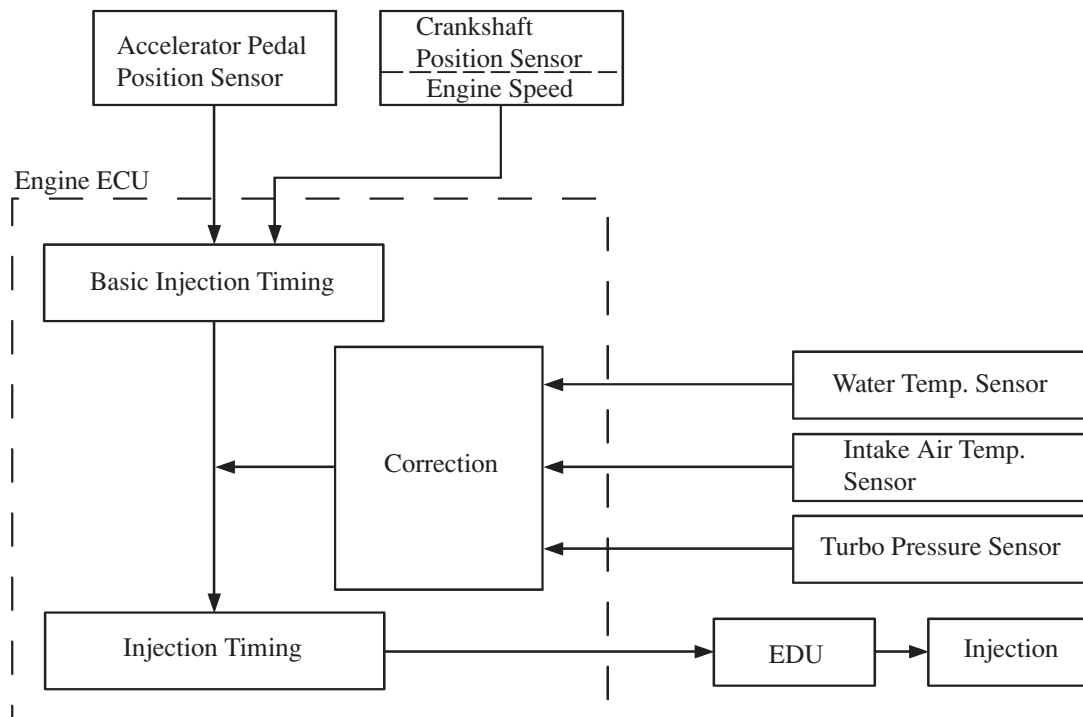
► Final Injection Volume Decision ◀



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7. Fuel Injection Timing Control

Fuel injection timing is controlled as shown below.

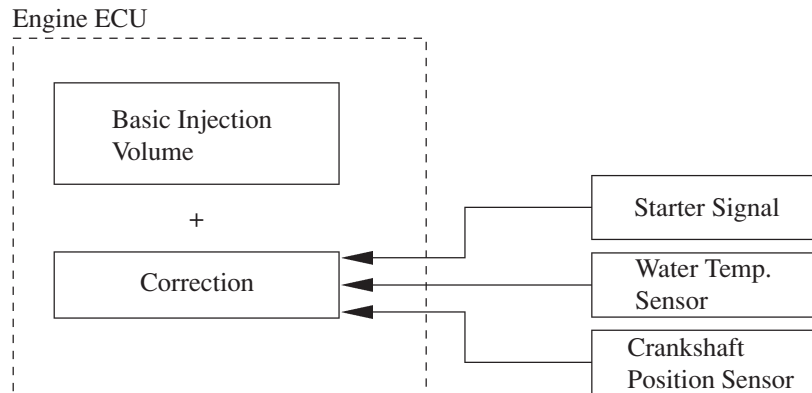


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8. During Starting Control

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.

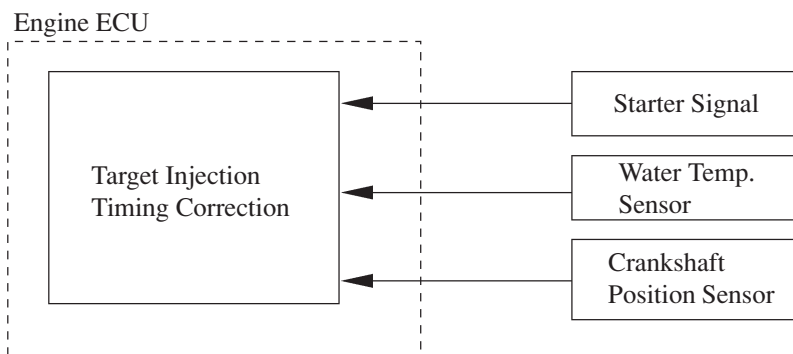


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Injection Timing Control

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

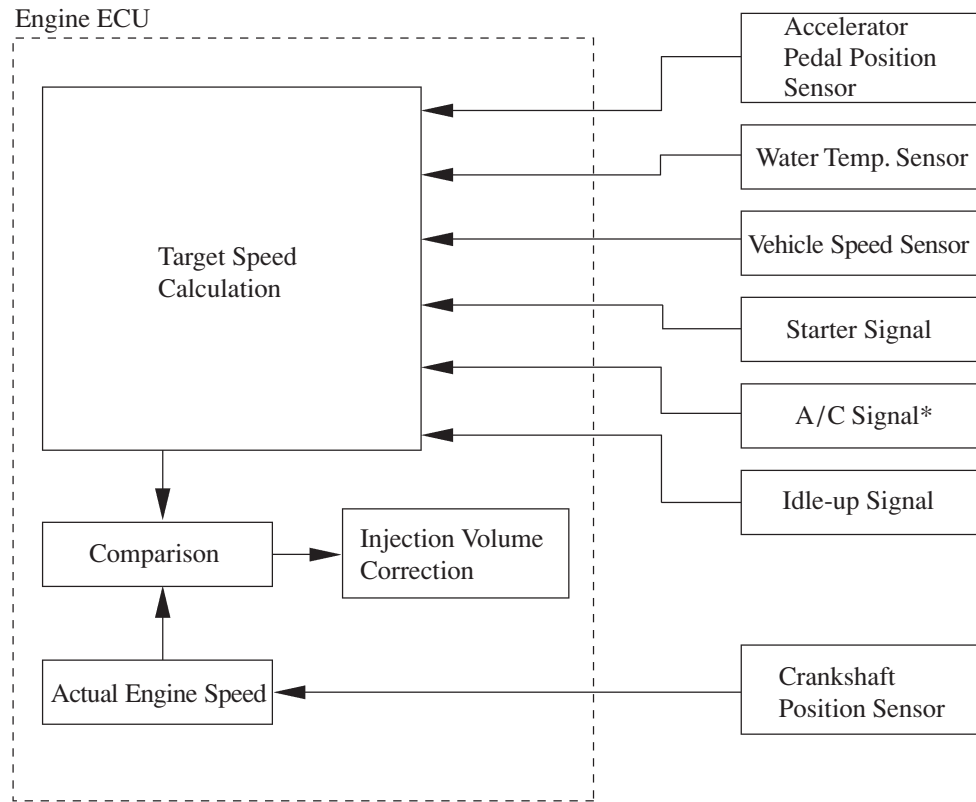
When the water temperature is low, if the engine speed is high, the injection timing is advanced.



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9. Idle Speed Control

Fuel injection timing is controlled as shown below.



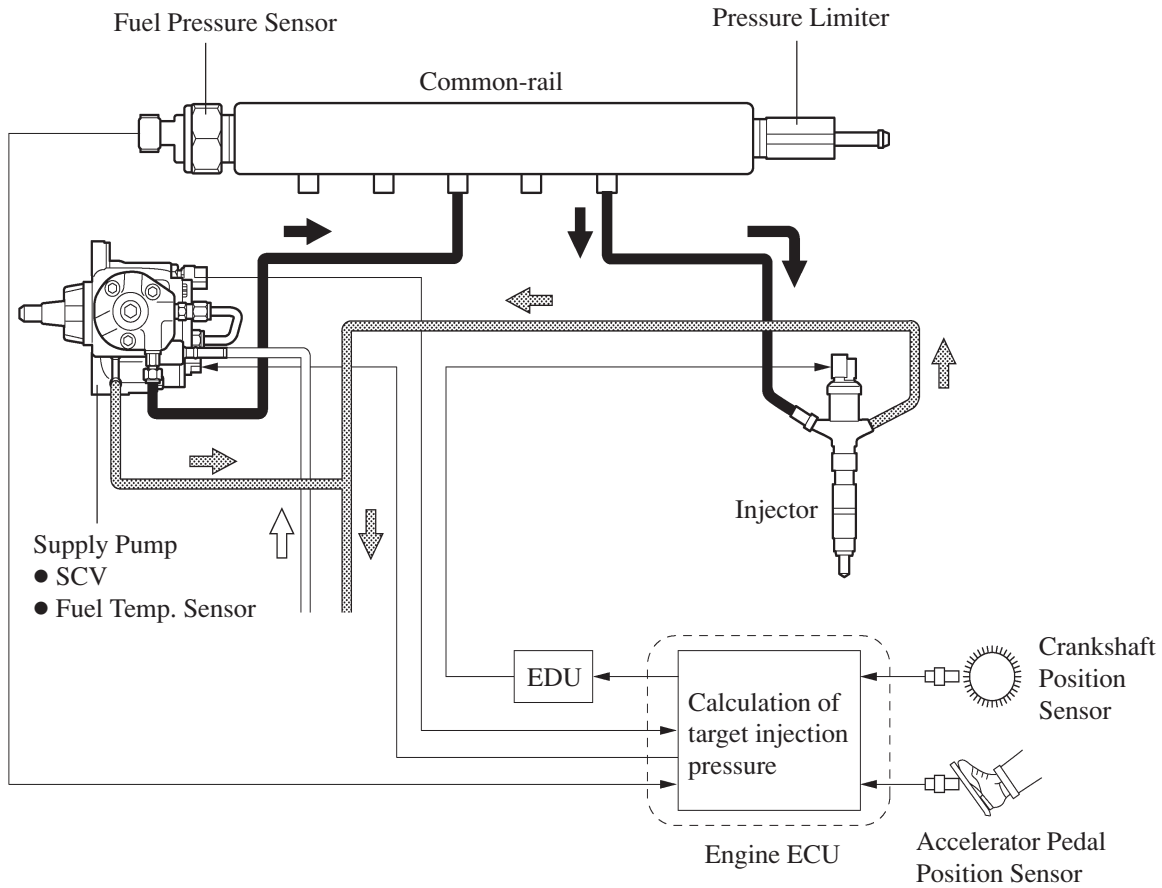
*: with Air Conditioner

10. Fuel Pressure Control

General

Engine ECU calculates the target injection pressure (32 ~ 160 MPa/1KD-FTV, 30 ~ 160 MPa/2KD-FTV) base on the engine conditions, that are the signals from the acceleration pedal position sensor and the crankshaft position sensor.

To control fuel pressure, signals sent to SCV (Suction Control valve) of the supply pump regulate the pumping volume, so that the pressure detected by the pressure sensor matches the target injection pressure.



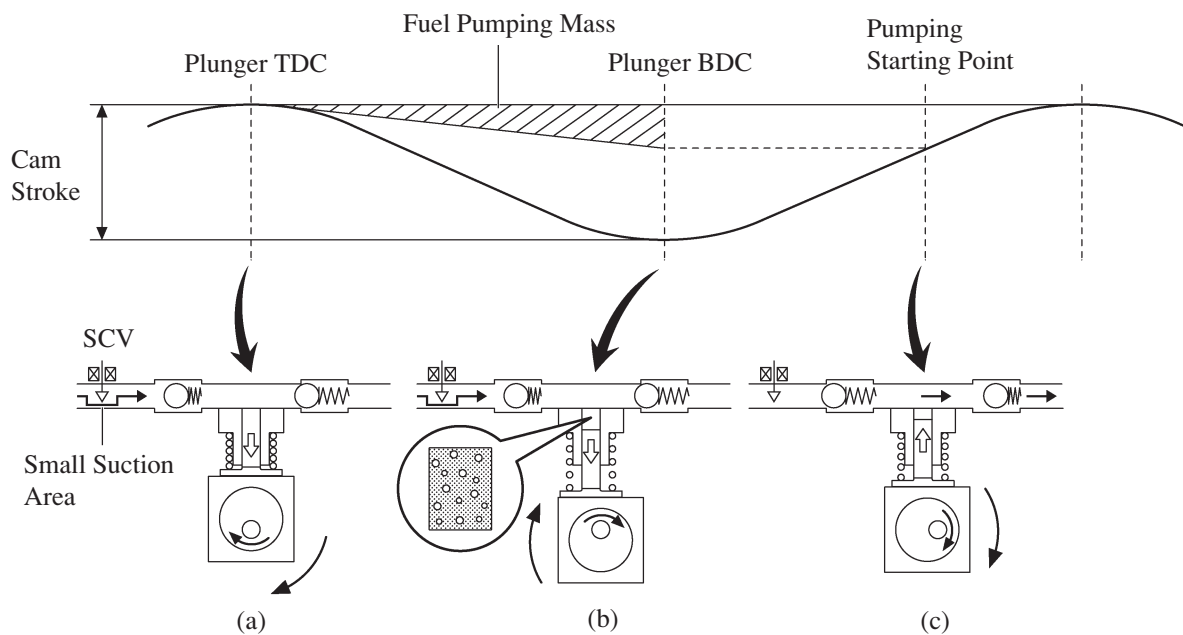
System Operation

1) General

The engine ECU controls the opening of the SCV in order to regulate the volume of fuel that is pumped by the supply pump to the common-rail. Consequently, the fuel pressure in the common-rail is controlled to the target injection pressure.

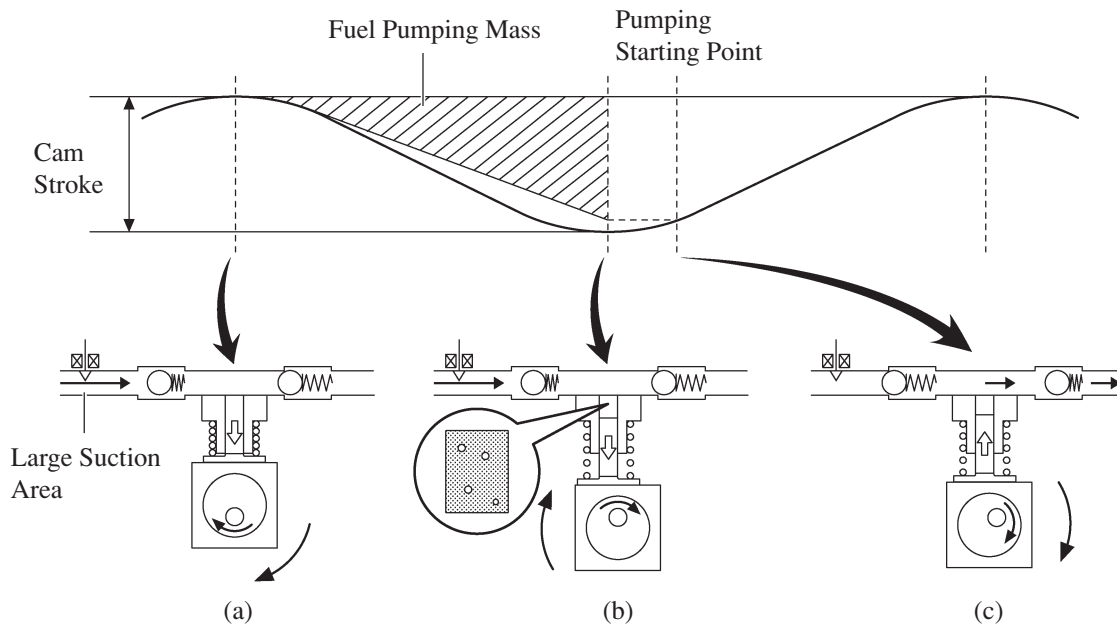
2) SCV Opening Small

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



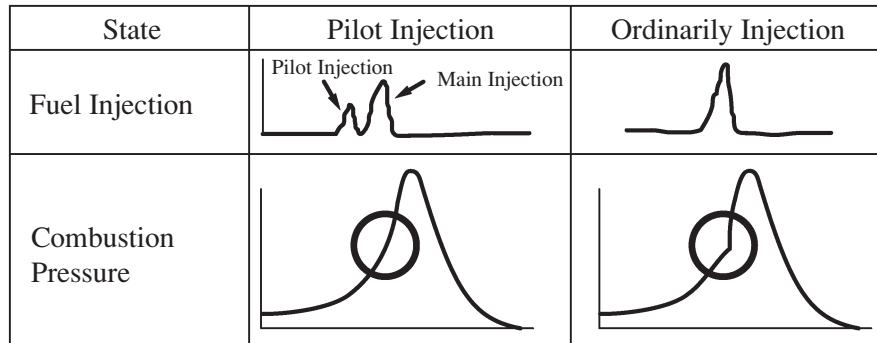
3) SCV Opening Large

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



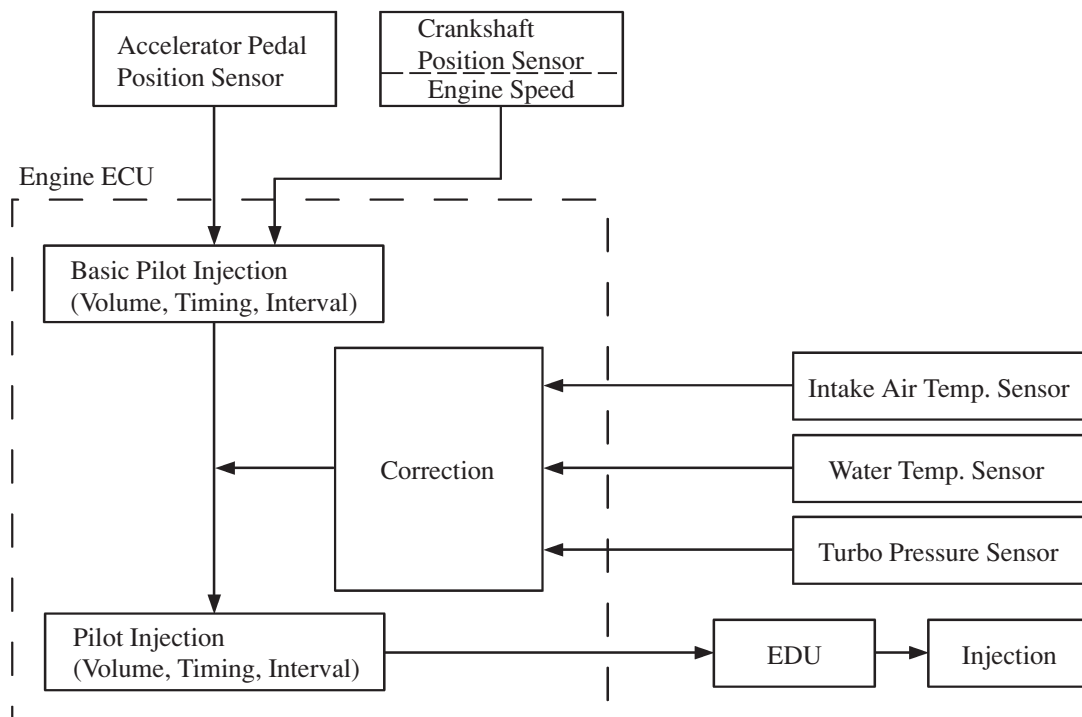
11. Pilot Injection Control

- Pilot injection is a method that provides 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.

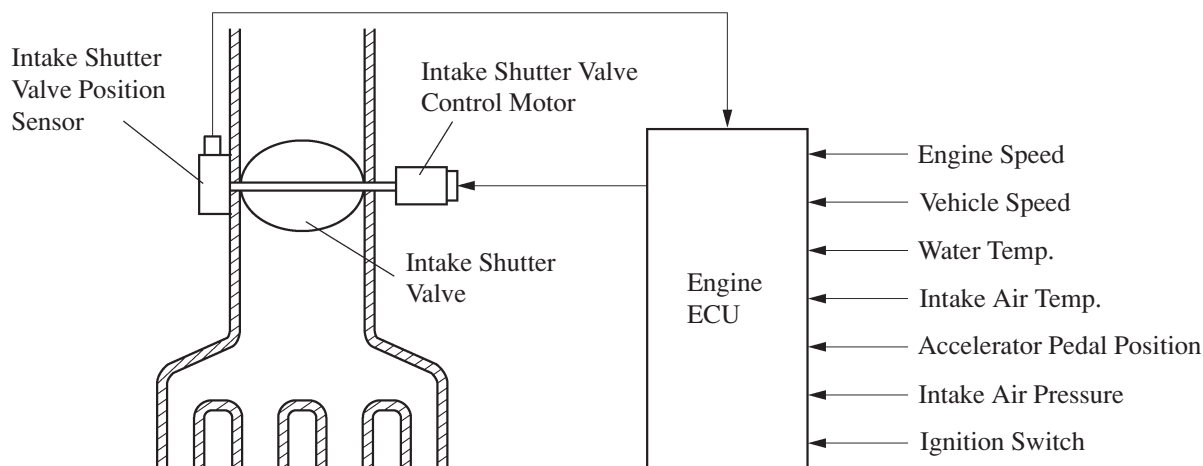


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12. Intake Shutter Control

The opening of the intake shutter valve (throttle 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.

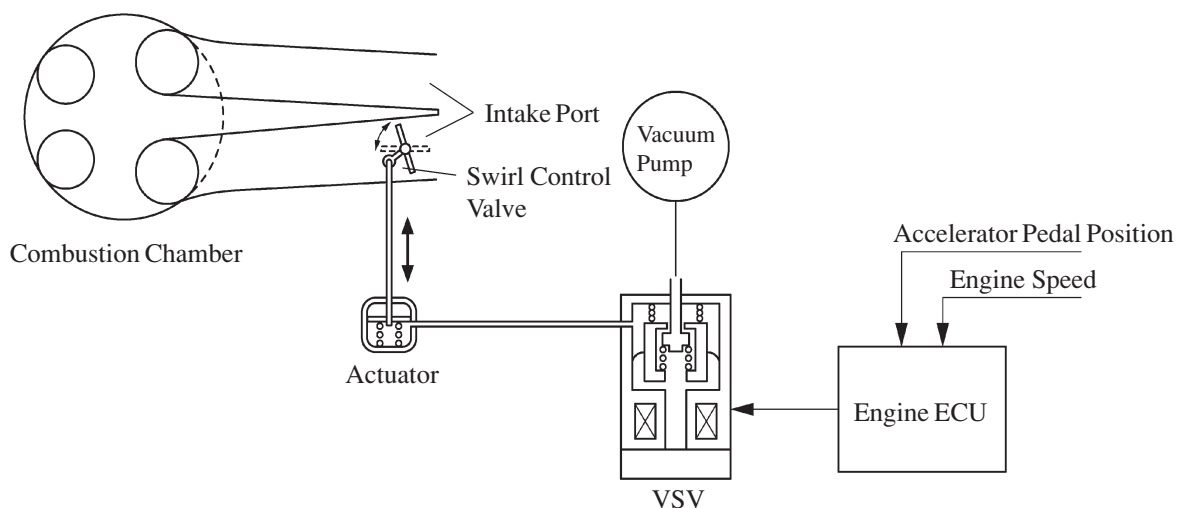


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13. Swirl Control (Only for 1KD-FTV Engine)

The engine ECU determines the swirl control valve position (open or closed) based on the engine conditions (engine speed and accelerator pedal effort). Then, it switches the vacuum that is applied to the actuator diaphragm via the VSV, in order to open and close the swirl control valve.

In the low engine speed range, the engine ECU closes the swirl control valve to strengthen the swirl in the combustion chamber, thus promoting the mixture of fuel and air and stabilizing combustion. When the engine speed increases to the medium or high-speed range, the engine ECU fully opens the swirl control valve. On a cold engine, the engine ECU fully closes the swirl control valve to reduce the amount of white smoke emissions.

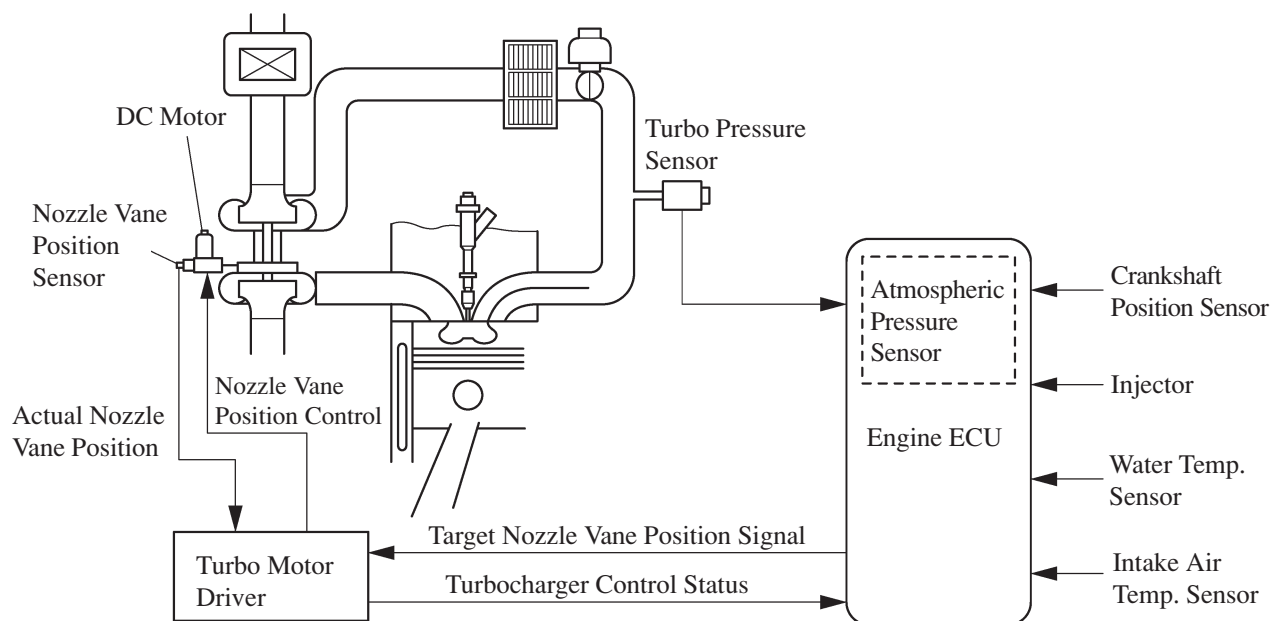


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14. Turbo Charger Control (Only for 1KD-FTV Engine)

General

- The engine ECU controls the nozzle vane position using the turbo motor driver, in order to obtain the calculated target turbo pressure appropriate to the engine operating condition.
- The engine ECU calculates the optimal nozzle vane position in accordance with the driving conditions (engine speed, injection volume, atmospheric pressure, and water temperature etc), and sends a target nozzle vane position signal to the turbo motor driver. The turbo motor driver controls the nozzle vane position in accordance with this signal and the actual nozzle vane position signal provided by the nozzle vane position sensor.

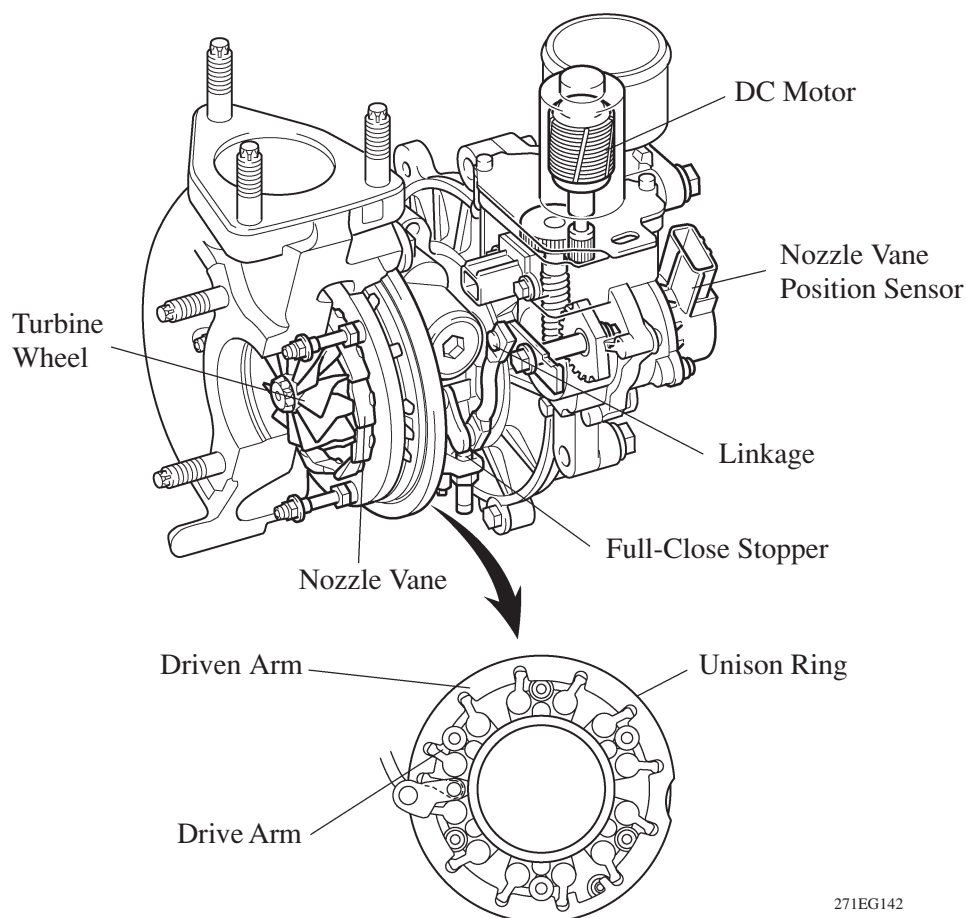


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Construction

1) General

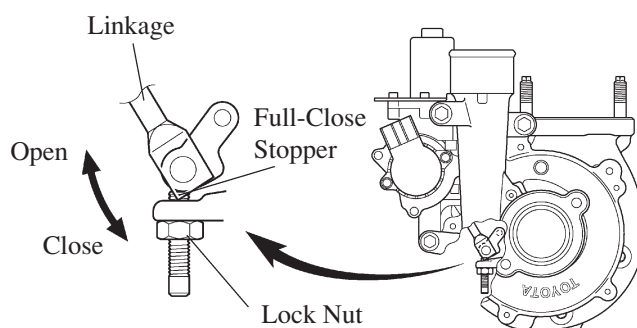
Variable nozzle vane device is established on the turbine (exhaust) side, and consisted of a DC motor, nozzle vane position sensor, linkage, drive arm, unison ring, driven arms and nozzle vanes.



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Service Tip

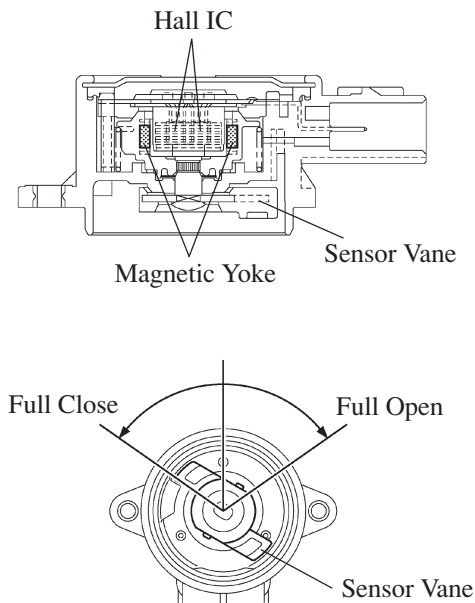
- To control the nozzle vane position, the turbo motor driver renders the contact position of the linkage with the full-close stopper (thus fully closing the nozzle vane) as the zero point for the nozzle vane position sensor.
- If the turbocharger has been reinstalled or replaced, turn the ignition switch from ON to OFF once, and make sure that the linkage comes in contact with the full-close stopper.
- The full-close stopper position, which is adjusted at the factory at the time of shipment, is not serviceable in the field. For this reason, if the linkage does not come in contact with the full-close stopper during an inspection, the turbocharger assembly must be replaced. Never attempt to loosen or tighten the locknut of the full-close stopper because it will adversely affect the performance of the engine.
- For details, see the Hilux Repair Manual.



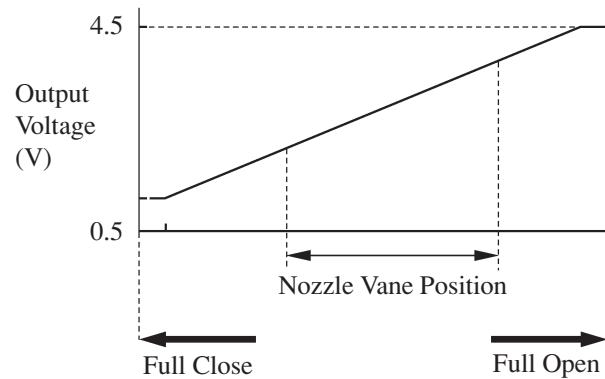
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2) Nozzle Vane Position Sensor

The nozzle vane position sensor consists of a Hall IC and a magnetic yoke that rotates in unison with the movement of the linkage that actuates the nozzle vane. The nozzle vane position sensor converts the changes in the magnetic flux that are caused by the rotation of the DC motor (hence, the rotation of the magnetic yoke) into electric signals, and outputs them to the turbo motor driver. The turbo motor driver determines the actual nozzle vane position from the electric signals in order to calculate the target nozzle vane position.

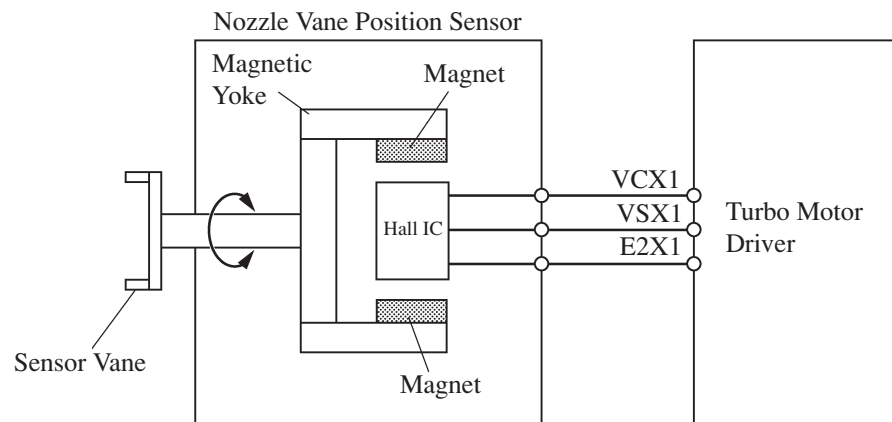


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► System Diagram ◀



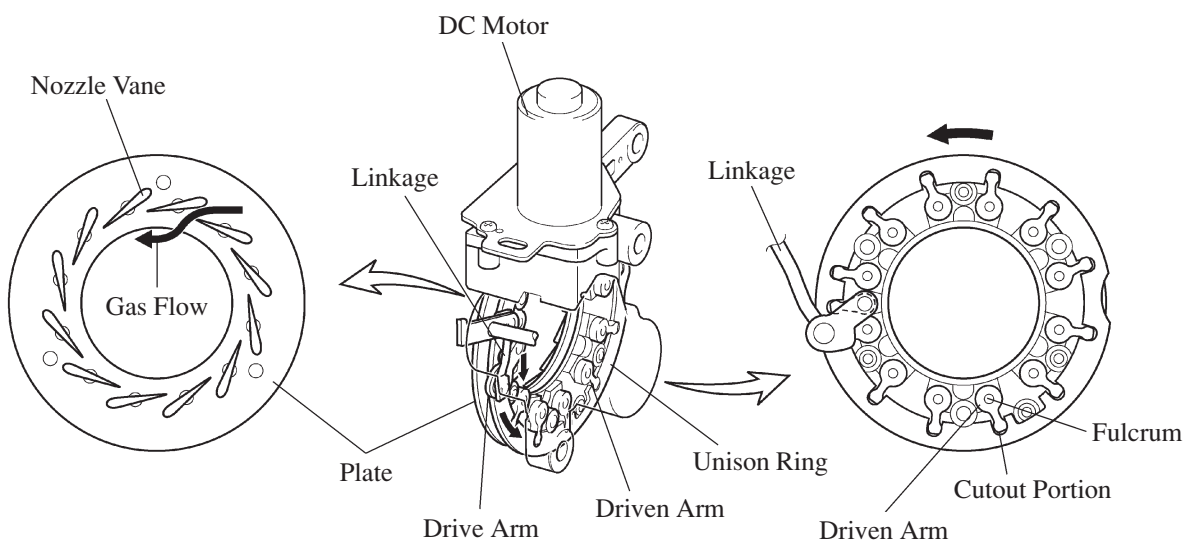
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Operation

1) At Engine Low Speed Range

When the engine is running in a low speed range, the DC motor presses down the linkage by a signal from the turbo motor driver. The tip of the linkage rotates the unison ring counterclockwise through a drive arm.

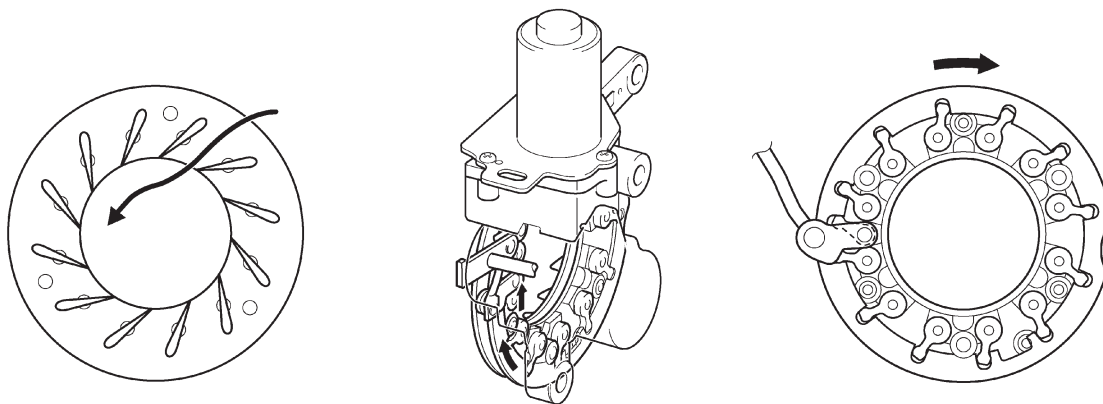
The unison ring contains a driven arm, which is placed through the cutout portion of the unison ring. This driven arm also moves in the direction of the rotation of the unison ring. The fulcrum of the driven arm is an axis that is integrated with the nozzle vane behind the plate. When the driven arm moves counterclockwise, the nozzle vane moves toward the closing direction. This results in increasing the velocity of the exhaust gas flowing to the turbine, as well as the speed of the turbine. As a result, torque is improved when the engine is running at low speeds.



271EG144

2) At Engine Medium-to-High Speed Range

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



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15. EGR Control System

General

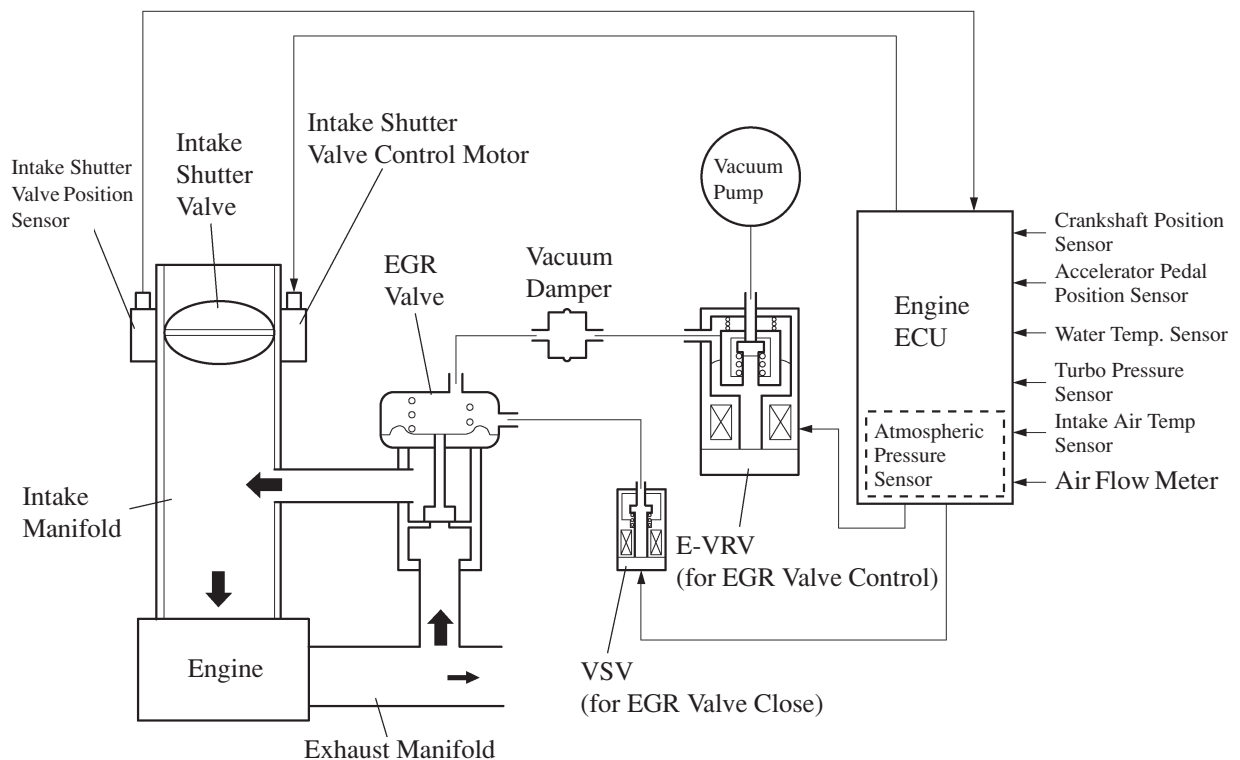
The table below lists the differences between the EGR system on the 1KD-FTV and 2KD-FTV engines, as well as the differences in their control contents.

Engine	Differences
1KD-FTV	A VSV (Vacuum Switching Valve) is provided for EGR valve close control.
2KD-FTV	An EGR valve position sensor is provided for detecting the EGR valve position.
2KD-FTV High Version	

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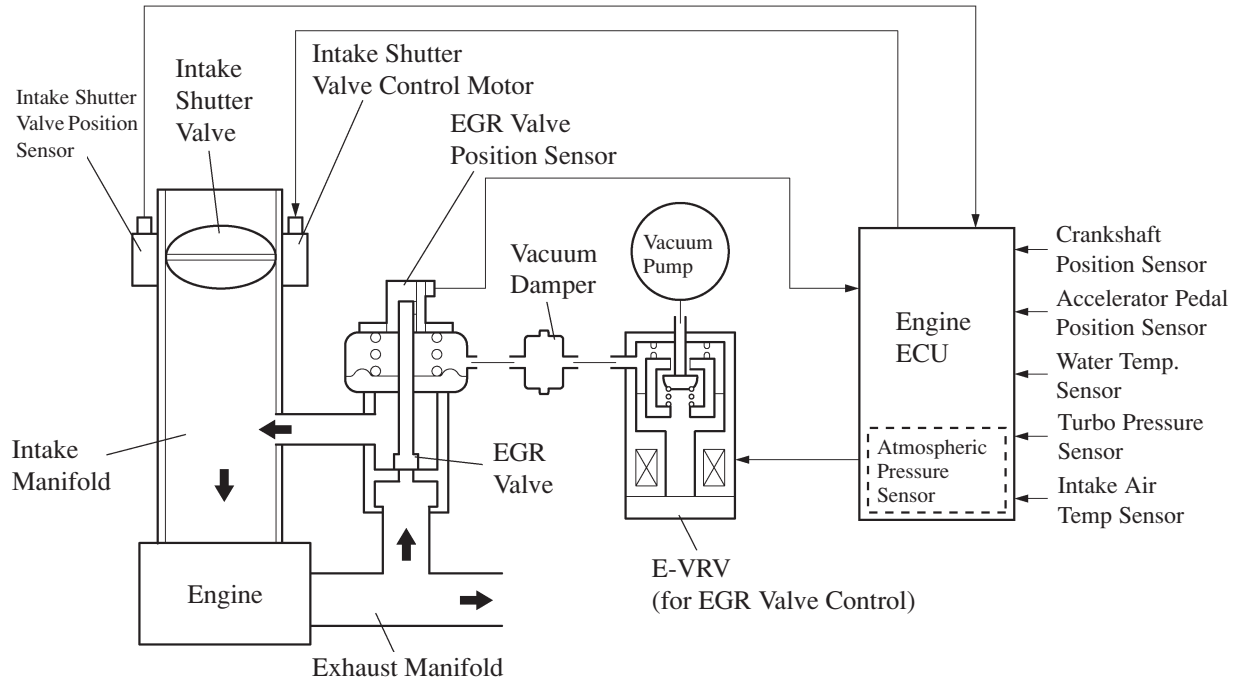
EGR Control for 1KD-FTV Engine

- By sensing the engine driving conditions, the engine ECU 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 intake shutter valve (throttle valve) opening position with intake shutter valve control motor and the amount of recirculating exhaust gas is regulated. EGR valve opening lift is controlled by modulated negative pressure.
- On the 1KD-FTV engine, the VSV (for EGR valve close) is activated when the EGR control is stopped, in order to introduce the atmospheric pressure to the EGR valve diaphragm and improve EGR valve closure response.



EGR Control for 2KD-FTV Engine

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



16. Diagnosis

- The diagnosis system of the 1KD-FTV and 2KD-FTV engines uses the M-OBD (Multiplex On-Board Diagnosis).
- When the Engine ECU detects a malfunction, the engine ECU makes a diagnosis and memorizes the failed section. Furthermore, the check engine warning light in the combination meter illuminates or blinks to inform the driver.
- The 2-digit DTCs (Diagnostic Trouble Codes) 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.
- By using the intelligent tester II, the 5-digit DTCs and ECU data can be read out. Moreover, the ACTIVE TEST can be used to drive the actuator by means of the intelligent tester II.
- The Engine ECU can output freeze-frame data to the intelligent tester II. This data is stored in the engine ECU at the very moment when the engine ECU has detected its last data of malfunction.
- All the DTCs have been made to correspond to the SAE controlled codes. Some of the DTCs have been further divided into smaller detection areas than in the past, and new DTCs have been assigned to them.
- For details, see the Hilux Repair Manual.

Service Tip

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

17. Fail-Safe

When a malfunction is detected by any of the sensors, there is a possibility of an engine or other malfunction occurring if the ECU were to continue to control the engine control system in the normal way. To prevent such a problem, the fail-safe function of the ECU either relies on the data stored in memory to allow the engine control system to continue operating, or stops the engine if a hazard is anticipated. For details, see the Hilux Repair Manual.