




DENSO



TOYOTA AVENSIS

COMMON RAIL SYSTEM (CRS) SERVICE MANUAL : Operation



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Revision History

Date	Revision Contents
2009.09	<ul style="list-style-type: none">• Visual contents addition Visual contents are video and animation used for manual explanation. Visual contents can be viewed by clicking the appropriate button.• Items added to the visual contents The following items have been added to "Microinjection Quantity Learning Control" under "FUEL INJECTION CONTROL".<ul style="list-style-type: none">✓ Determinations for learning conditions✓ Single microinjection operation✓ Detecting the change in rotational speed via injection✓ Correcting the injection pulse width (TQ), and actual injection quantity (Q) characteristics
2009.12	<ul style="list-style-type: none">• Visual contents added to "Operation" under "INJECTOR."

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1. PRODUCT APPLICATION INFORMATION

1.1 Outline

- The TOYOTA AVENSIS has undergone a model change. As a result, the 2AD-FHV, 2AD-FTV, and 1AD-FTV specifications have changed. In addition, the Common Rail System (CRS) has also changed due to the aforementioned change in engine specifications.

This manual explains items specific to parts used in the TOYOTA AVENSIS. For CRS basics, refer to the "COMMON RAIL SYSTEM SERVICE MANUAL -OPERATION 00400534EA". Modifications made prior to the model change are listed below.

- Maximum injection pressure increased to 200 MPa.
- The pressure discharge valve is now common to all rails.
- The G3 Piezo injector is now used.
- Microinjection quantity learning control has been added to the system.

1.2 Application

Vehicle Name	Vehicle Model	Engine Model	Engine Displacement	Transmission	Start of Production
Avensis	ADT271	2AD-FHV	2.2L	MT	October 2008
		2AD-FTV		AT	
	ADT270	1AD-FTV	2.0L	MT	

1.3 Exhaust Gas Purification System

TOYOTA D-CAT System (2AD-FHV)

System	Outline
DPNR Catalyst Support Control	Based on the signals received from the sensors, the engine ECU controls the exhaust fuel addition injector to purify the NO _x , HC, CO, and Particulate Matter (PM.)
Air Fuel Ratio Sensor Heater Control	Maintains the temperature of the air-fuel ratio sensor at an appropriate level to increase accuracy of exhaust gas oxygen concentration detection.
EGR Control	Based on the signals received from the sensors, the engine ECU determines the EGR volume via the EGR valve and EGR cooler bypass valve in accordance with engine conditions.

DPF System (2AD-FTV, 1AD-FTV (not Including CCO Specification Vehicles))

System	Outline
DPF Catalyst Support Control	Based on the signals received from the sensors, the engine ECU controls the exhaust fuel addition injector to purify the Particulate Matter (PM.)
Air Fuel Ratio Sensor Heater Control	Maintains the temperature of the air fuel ratio sensor at an appropriate level to increase accuracy of detection of the oxygen concentration in exhaust gas.
EGR Control	Based on the signals received from the sensors, the Engine ECU determines the EGR volume via EGR valve and EGR cooler bypass valve in accordance with the engine condition.

1.4 System Component Part Numbers

Part Name	DENSO Part Number	Manufacturer Part Number	Engine Model	Remarks
Supply Pump	HU294000-071#	22100-0R040	Common	HP3
Rail	HU095440-122#	23810-0R040-A		
EDU	101310-584#	89870-20160		
Exhaust Fuel Addition Injector	297700-003#	23710-26011		
A/F Sensor	211200-135#	89467-20100		
Exhaust Gas Temperature Sensor	071500-237#	894246-0010		
	265600-177#	894252-0380		
	265600-178#	894252-0390		
Differential Pressure Sensor	104990-166#	894802-0040		
Coolant Temperature Sensor	179700-045#	894223-3030		
Crankshaft Position Sensor	029600-147#	909190-5029		
Camshaft Position Sensor	029600-074#	909190-5029		
Manifold Absolute Pressure (MAP) Sensor	079800-780#	894212-0200		
EGR Valve	HU150100-007#	258000-R010		
Check Valve	029700-001#	2376A2-6010		
Monolith Carrier	069800-011#	A99452-2011		
DPF Base Material	253600-003#	A99452-2014		

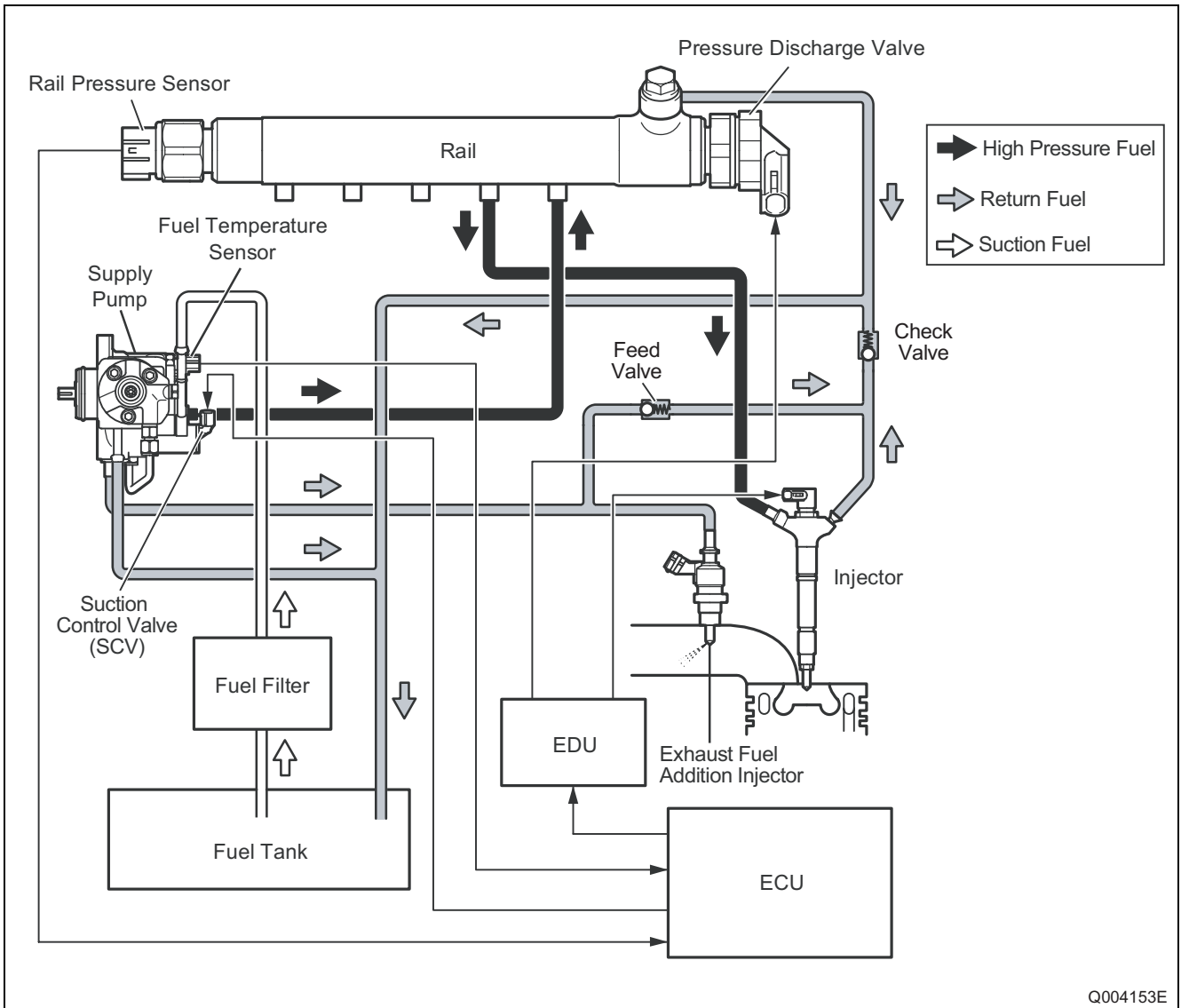
Part Name	DENSO Part Number	Manufacturer Part Number	Engine Model	Remarks
Injector	HU295900-007#	23670-0R080	2AD-FHV Only (For TOY- OTA D-CAT system)	G3P
Engine ECU	MB275900-015#	89661-05D00-A		Transmission = MT for Europe
	MB275900-016#	89661-05D10-A		Transmission = AT for Europe
	MB275900-044#	89661-05B80		Transmission = AT for hilly regions like Greece
Injector	HU295900-008#	23670-0R090	2AD-FTV Only (For DPF sys- tem)	G3P
Engine ECU	MB275900-020#	89661-05D50-A		for Europe
	MB275900-021#	89661-05F00-A		for other regions
Injector	HU295900-009#	23670-0R100	1AD-FTV Only (For DPF and CCO system)	G3P
Engine ECU	MB275900-017#	89661-05D20-A		for Europe
	MB275900-018#	89661-05D30-A		for Europe
	MB275900-019#	89661-05D40-A		for other regions

2. SYSTEM OUTLINE

2.1 Construction and Operation

(1) 2AD-FHV, 2AD-FTV, 1AD-FTV

- The primary CRS components are shown in the figure below.

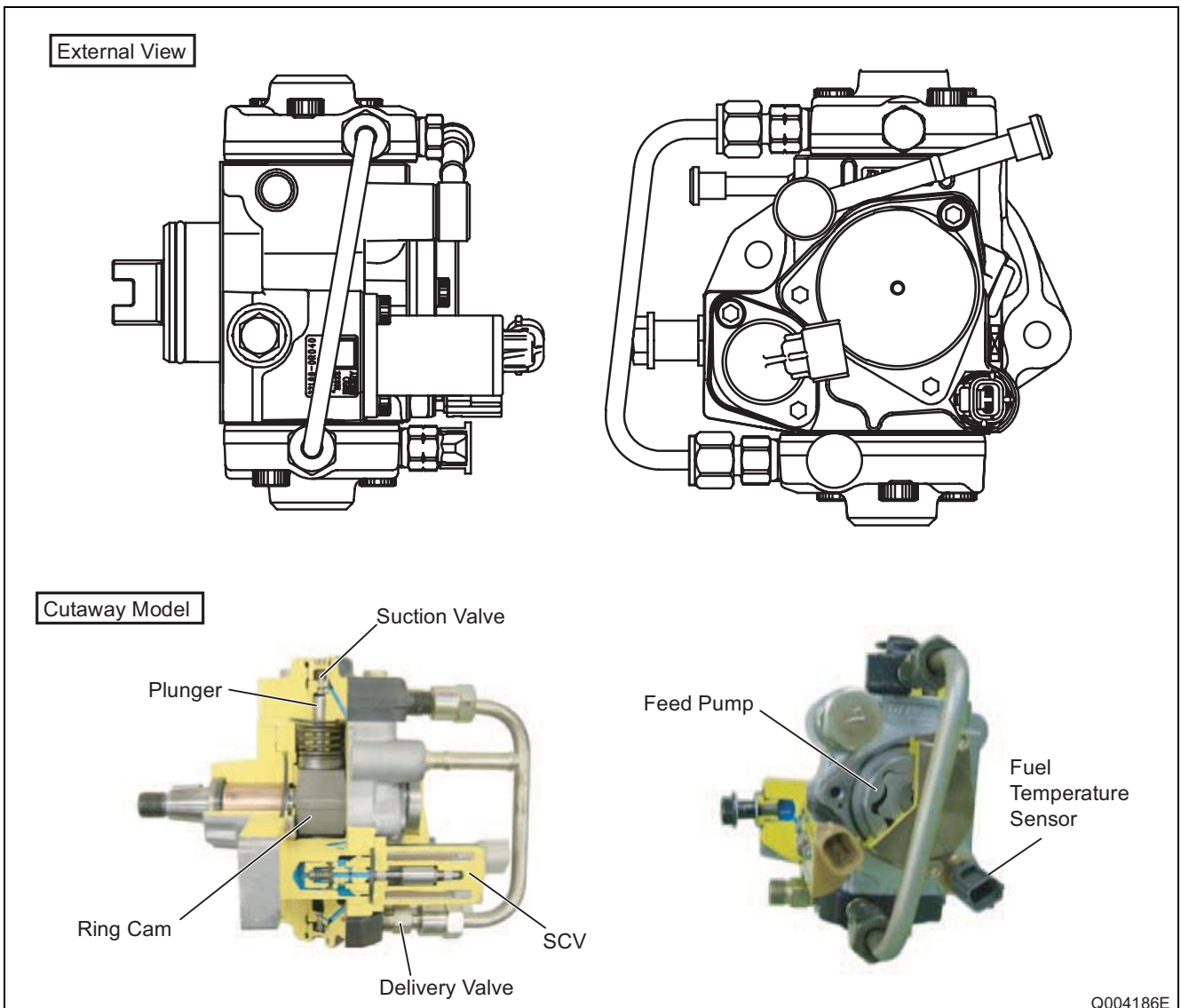


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3. SUPPLY PUMP

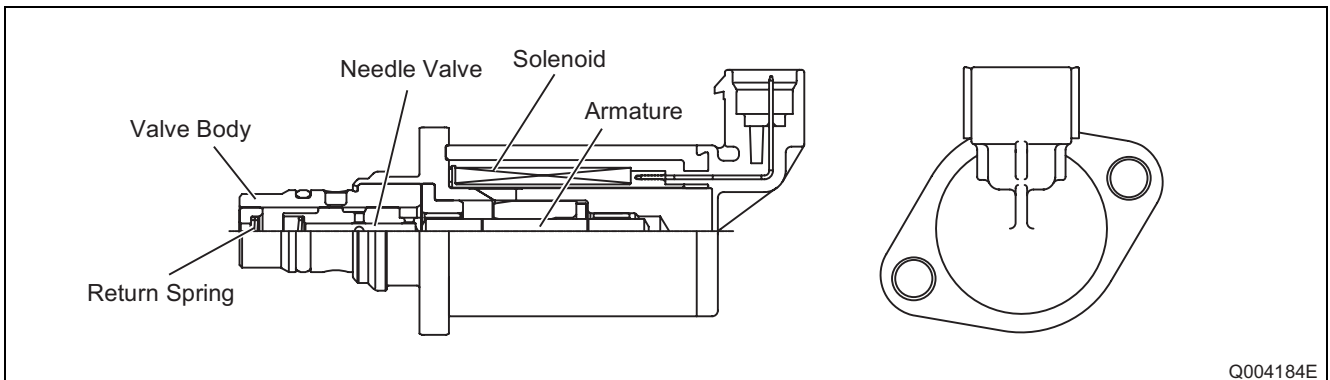
3.1 Outline

- The supply pump is equipped with a SV1 type Suction Control Valve (SCV). The connector has changed from the conventional perpendicular type to a horizontal type.



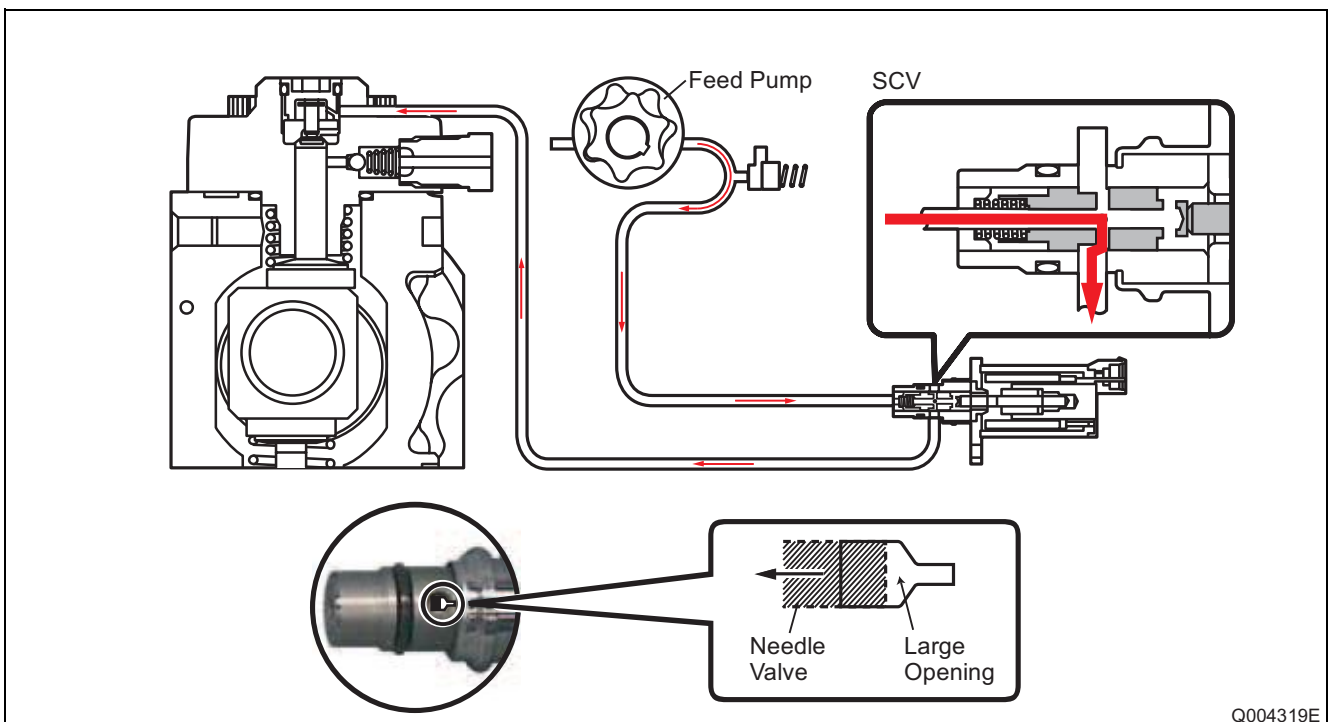
3.2 SCV

- The supply pump is equipped with a normally closed type SCV.
- When the solenoid is energized, the needle valve is pressed upon (in the compact SCV, the cylinder is pulled upon) by the armature, completely opening the fuel passage and supplying fuel to the plunger. (Total quantity suctioned → Total quantity discharged)
- When power is removed from the solenoid, the return spring presses the needle valve back to the original position, closing the fuel passage.
- The solenoid is actuated by duty ratio control. Fuel is supplied in an amount corresponding to the open surface area of the passage, which depends on the duty ratio. The fuel is then discharged by the plungers.



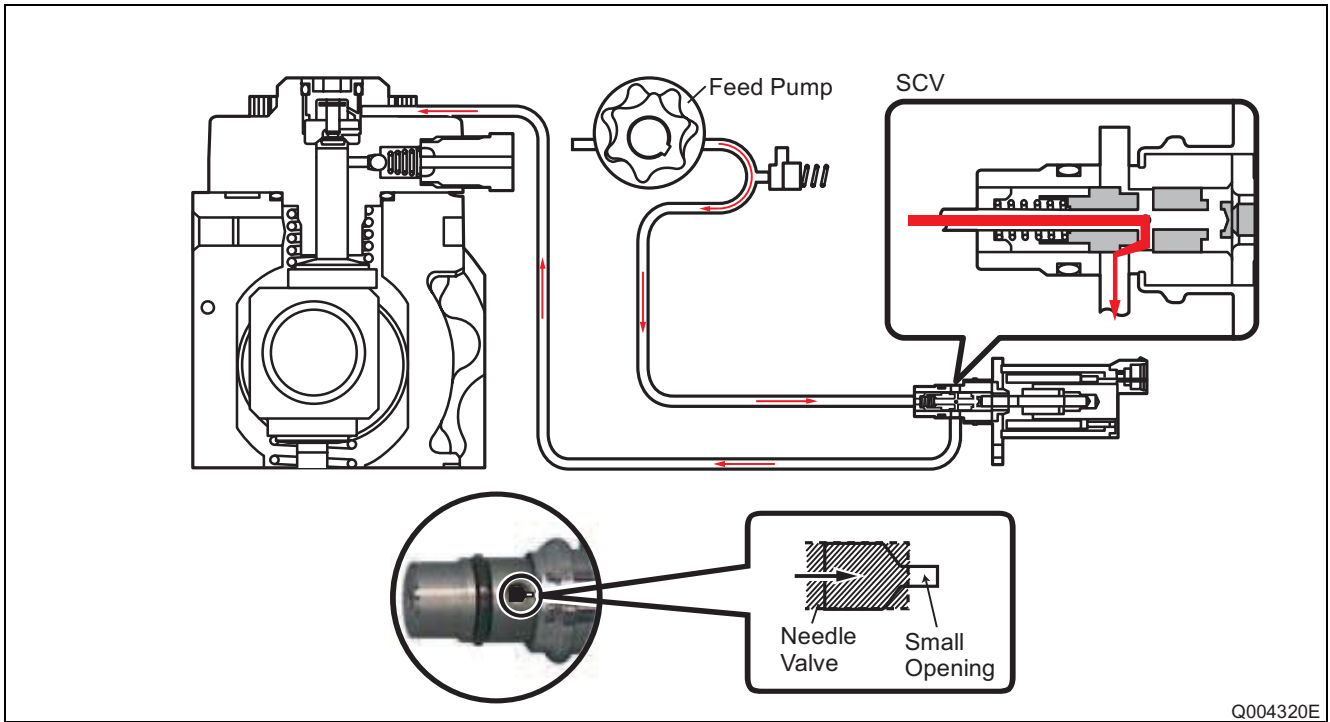
(1) When the SCV energization duration (duty on time) is long

- When the energization time is long, the average current flowing to the solenoid is large. As a result, the needle valve is pushed out (in the compact SCV, the needle valve is pulled), creating a large valve opening. Subsequently, the fuel suction quantity increases.



(2) When the SCV energization duration (duty on time) is short

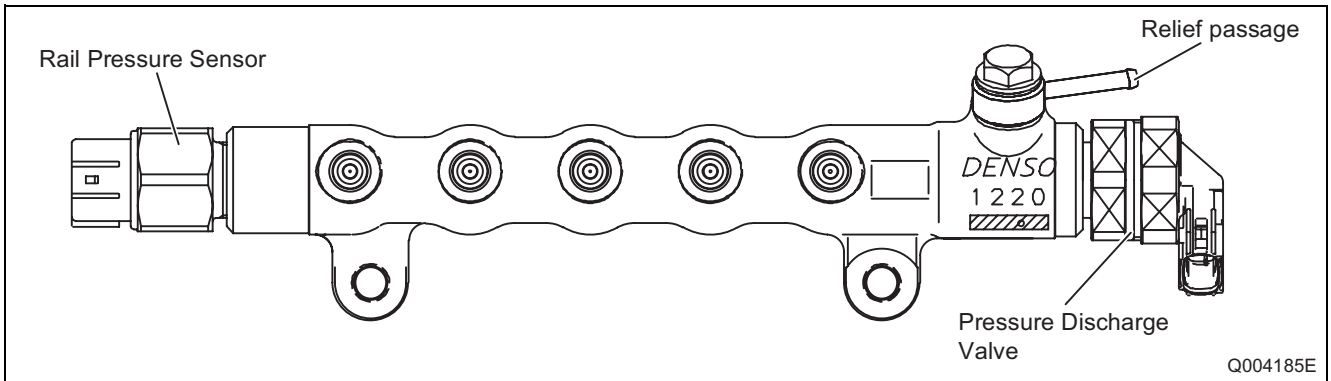
- When the energization time is short, the average current flowing through the solenoid is small. As a result, the needle valve is returned to the original position by spring force, creating a small valve opening. Subsequently, the fuel suction quantity decreases.



4. RAIL

4.1 Outline

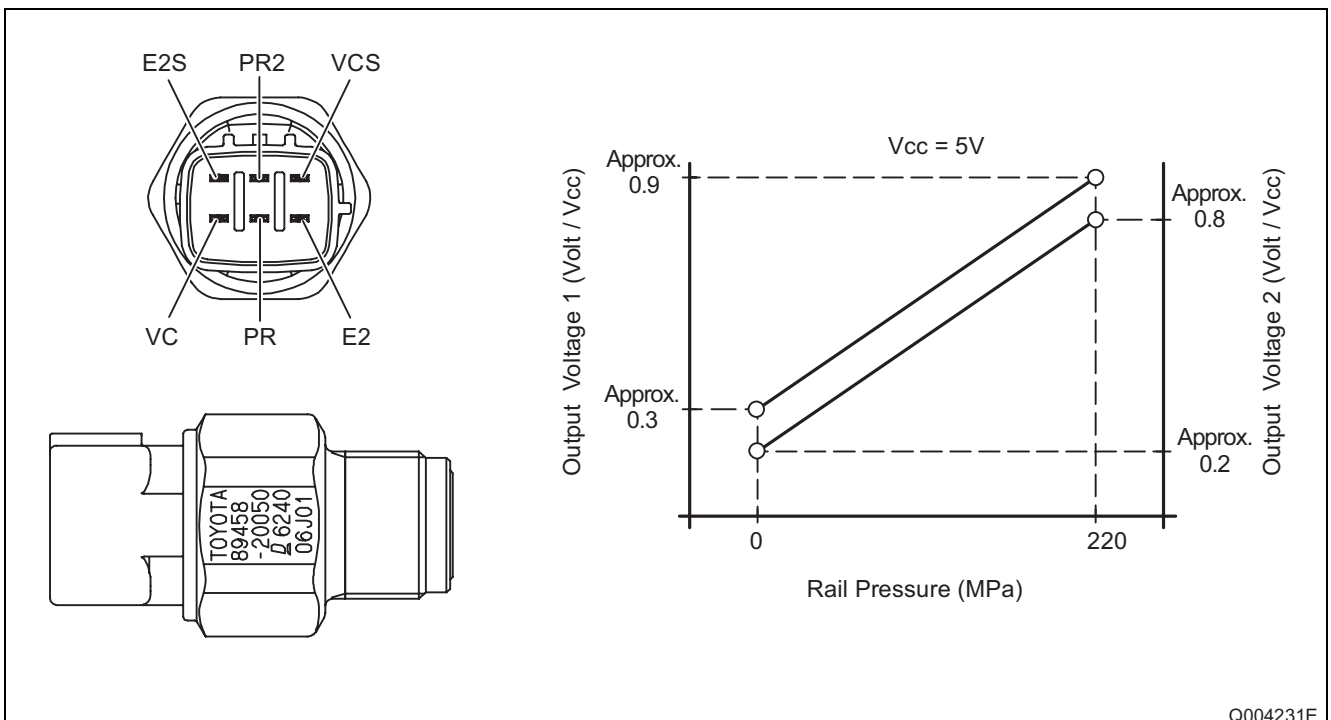
- The 2AD-FTV, 2AD-FTV, and 1AD-FTV are equipped with a pressure discharge valve. Therefore, the appropriate engine ECU control, and actuation circuit (EDU) have been designated to control the pressure discharge valve.



4.2 Rail Pressure Sensor

- The rail pressure sensor detects fuel pressure within the rail, and sends pressure signals to the ECU. The rail pressure sensor is a Piezo resistance type semiconductor pressure sensor that uses the pressure added to a metal diaphragm, and the accompanying changes in electrical resistance to detect rail pressure. As a backup during a failure, the rail pressure sensor has redundant systems for output voltage.

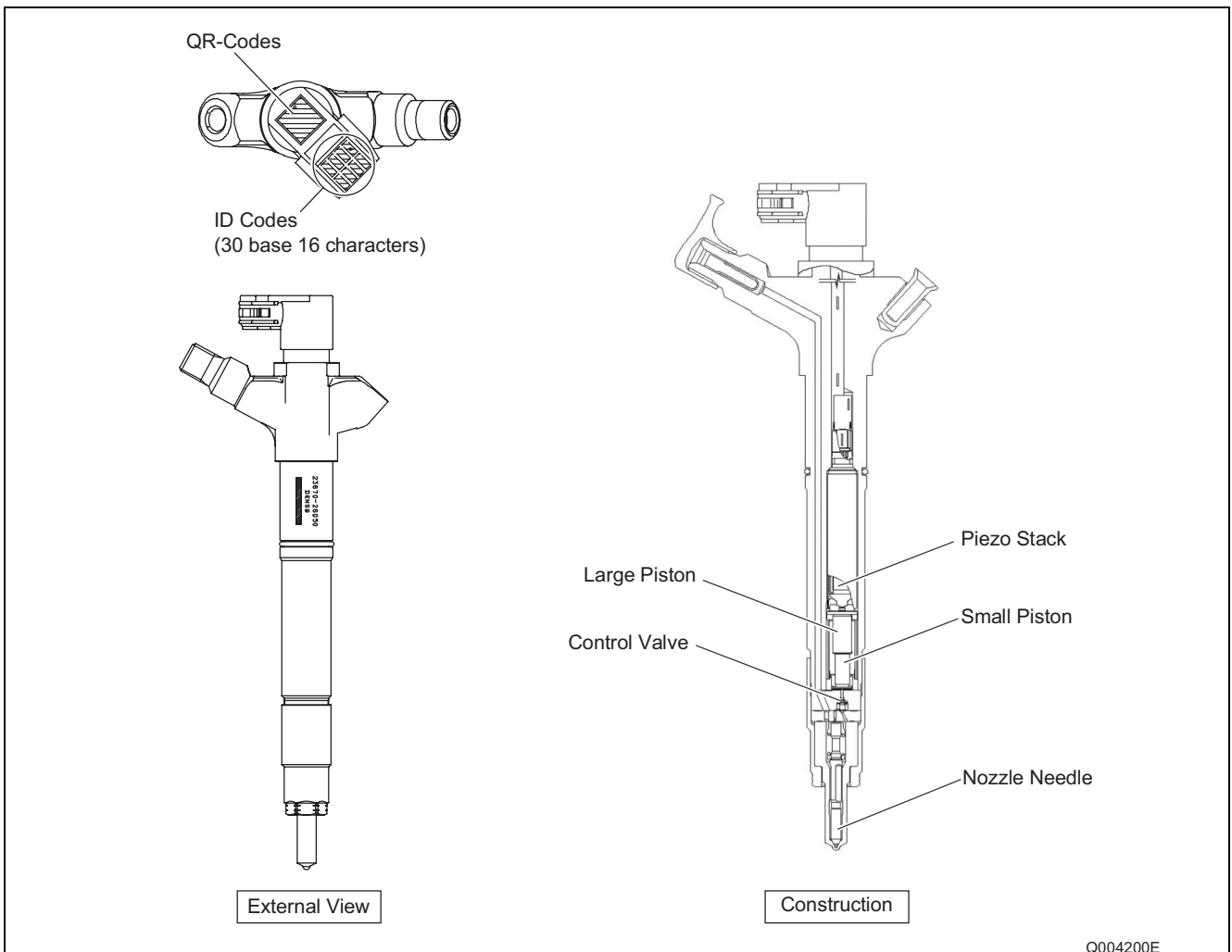
The output characteristics for the 2005 model year have been changed.



5. INJECTOR

5.1 Outline

- The G3 type Piezo injectors equipped in the TOYOTA AVENSIS can inject fuel at extremely high pressure (200 MPa). As a result, the atomization of the fuel mist from the nozzle has been improved, leading to increased combustion efficiency, and reduced exhaust gas quantity.
- The Piezo injector consists of a Piezo stack, large diameter piston, small diameter piston, control valve, and nozzle needle.
 - The Piezo stack is a laminated body consisting of alternating layers of a substance called PZT (PbZrTiO₃), and thin electrodes. The characteristics of a Piezo element are used to expand and shrink the stack via the inverse Piezoelectric effect.
 - The large and small diameter pistons move up and down in accordance with the expansion and shrinking of the Piezo stack.
 - The control valve is moved by the Piezo stack and the large and small diameter pistons to control pressure inside the injector.
 - The nozzle needle is in turn moved up and down via control valve pressure control. When the nozzle needle is pushed up, fuel is injected.



5.2 Operation

Non-injection

- When voltage is not applied to the Piezo stack, the pressure in the control chamber and at the bottom of the nozzle needle is the same pressure as fuel in the rail. Therefore, the nozzle needle is held closed by nozzle spring force, and fuel is not injected.

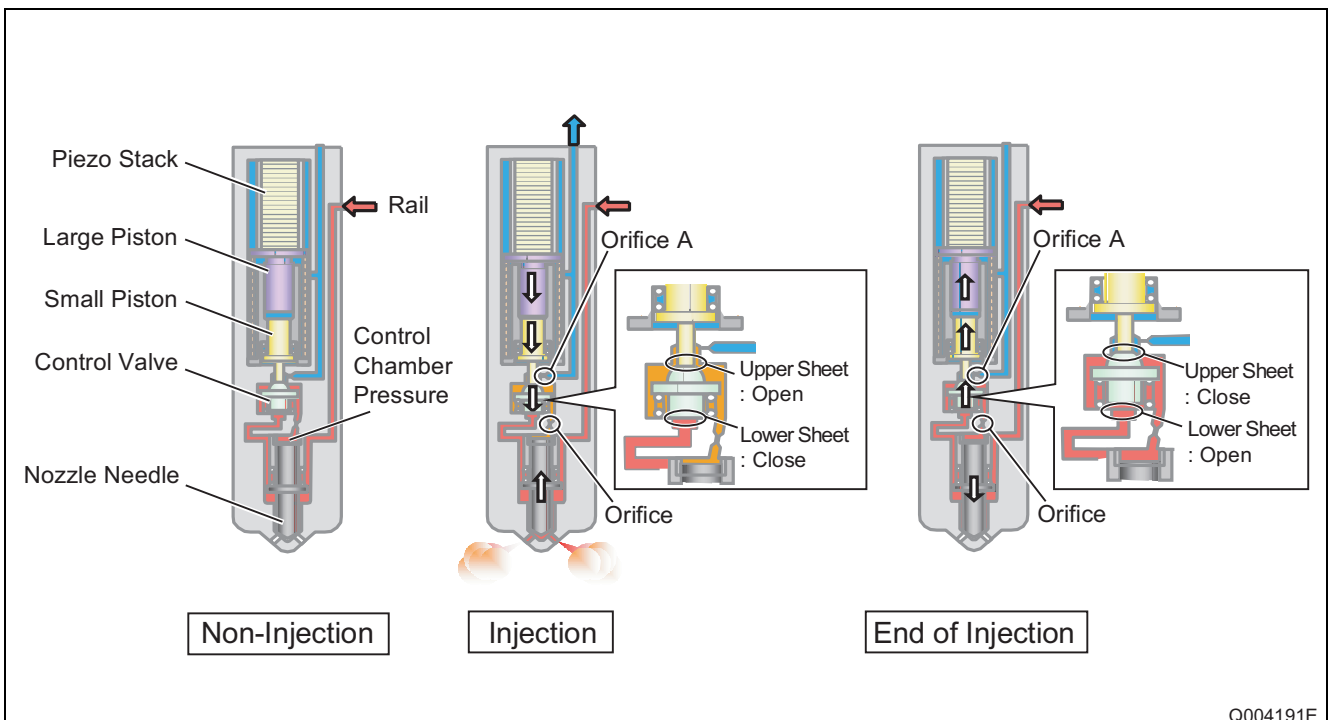
Injection

- When voltage is applied to the Piezo stack, the stack expands, pushing both the large and small diameter pistons downward. In addition, the control valve is also pushed downward, opening the upper seat, and closing the lower seat. As a result, a fuel path is opened to the control chamber.

Since the pressure is not rapidly transmitted to the control chamber due to the presence of orifice "A", control chamber pressure decreases. The decrease in control chamber pressure causes pressure at the bottom of the nozzle needle to rise. As such, the nozzle needle is pushed upward, and fuel injection begins.

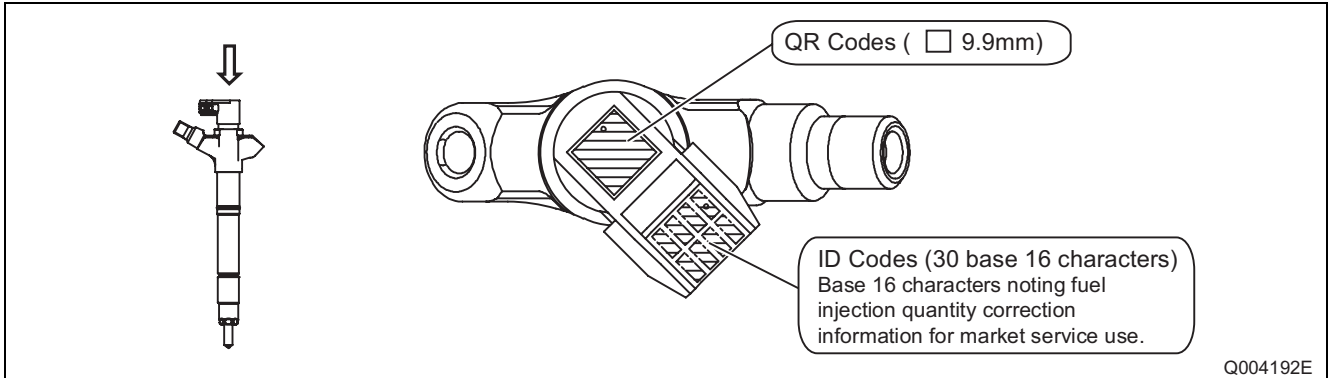
End of injection

- When the voltage applied to the Piezo stack is removed, the stack shrinks, and both the large and small diameter pistons, as well as the control valve rise. Additionally, the lower seat opens, and the upper seat closes. As a result, a fuel path to the control chamber opens, and fuel pressure in the control chamber quickly returns to the same pressure as the rail. Therefore, the nozzle needle is pushed downward, and fuel injection stops.

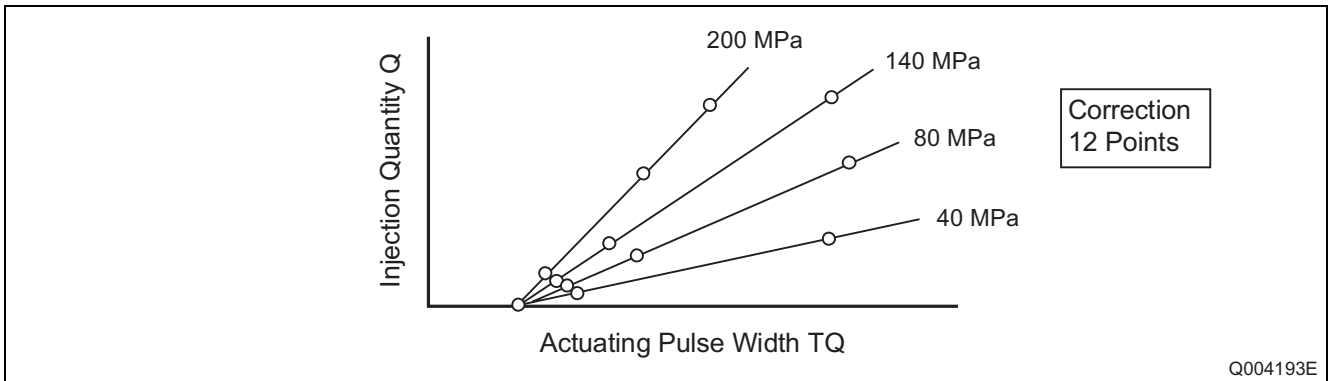


5.3 Quick Response (QR) Codes

- QR codes are used to improve the accuracy of the injector injection quantity. The code from the vehicle assembly line is read, then entered into the engine ECU. Similar to the assembly line process, when performing service, the ID code is read by a diagnostic tool, and entered into the engine ECU.

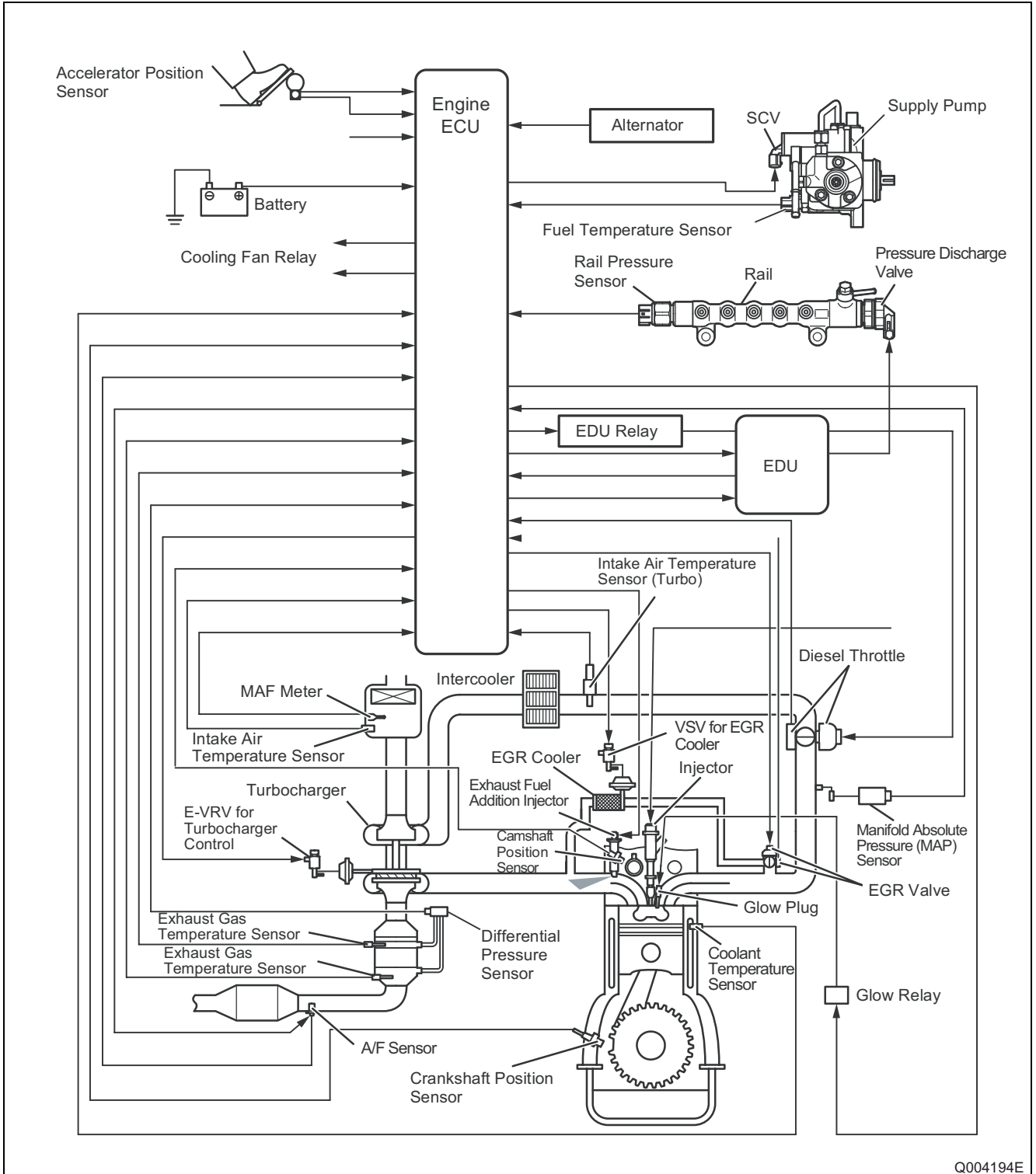


- The injection quantity correction points contained in the injector QR code are shown in the figure below.



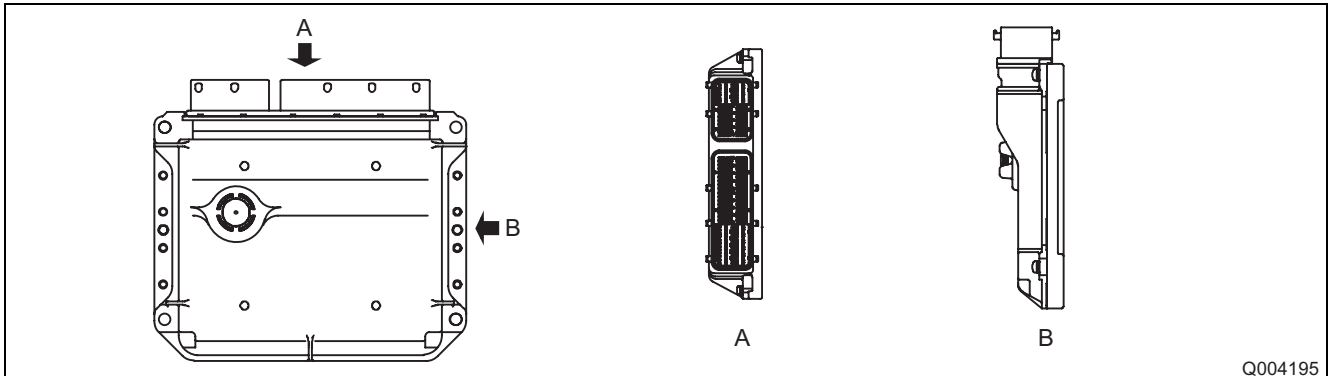
6. CONTROL SYSTEM

6.1 Control System Diagram



6.2 Engine ECU

- The figure below is an external view of the engine ECU. For the external wiring diagram and connector terminal layout: Refer to [Engine ECU External Wiring Diagrams] on P1-39.

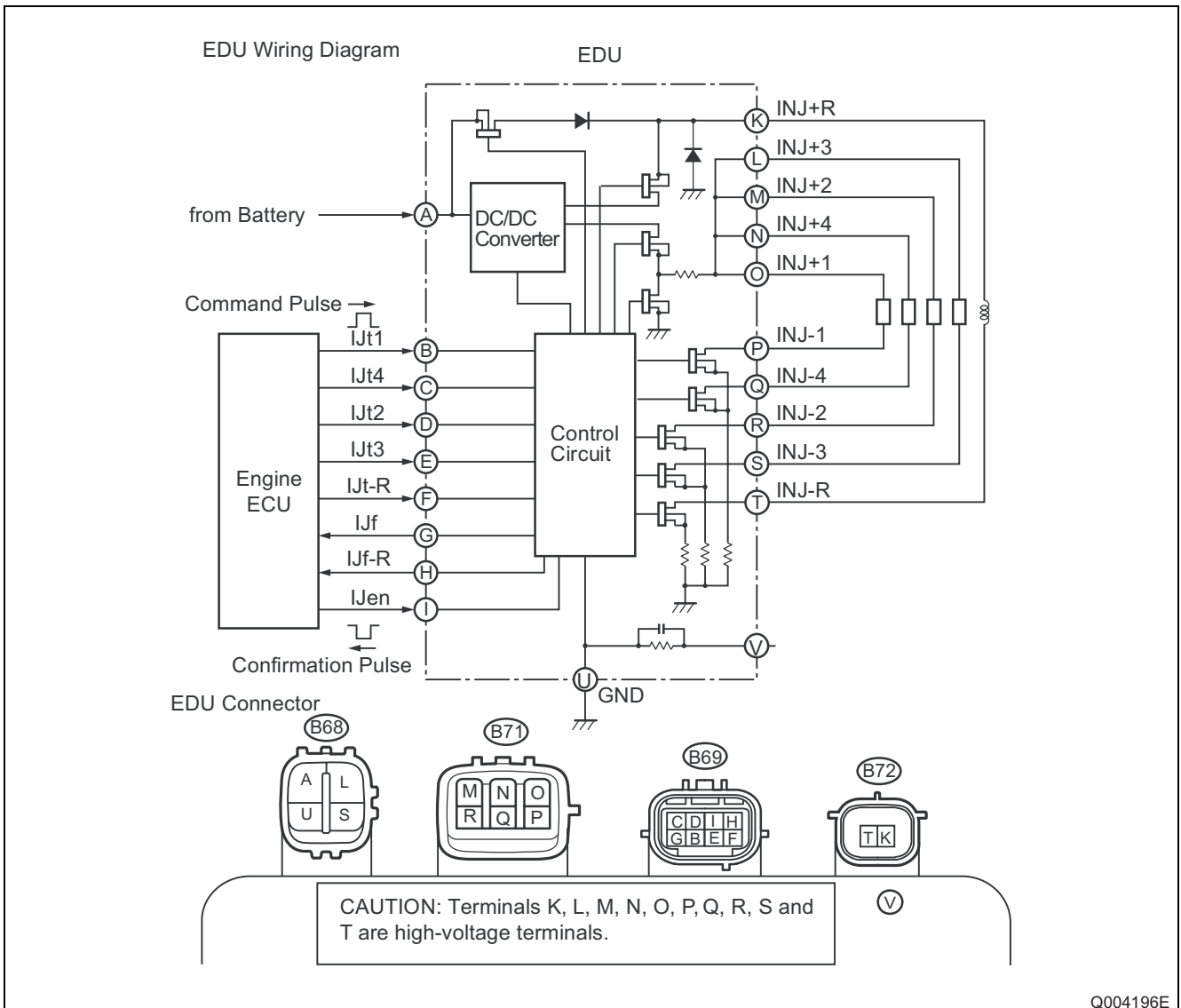


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6.3 Electronic Drive Unit (EDU)

- The EDU controls the pressure discharge valve installed on the supply pump to help regulate fuel pressure.
- To achieve noise reduction, the EDU also controls the injectors at low speed when the engine is idling based on signals from the ECU.
- The EDU delivers drive signals to fuel injectors using the DC/DC converter, which provides a high-voltage, quick-charging system.

Soon after the EDU receives a fuel injection command (IJT) signal from the engine ECU, the EDU responds to the command with an injector injection confirmation (IJF) signal when current is applied to the fuel injector.



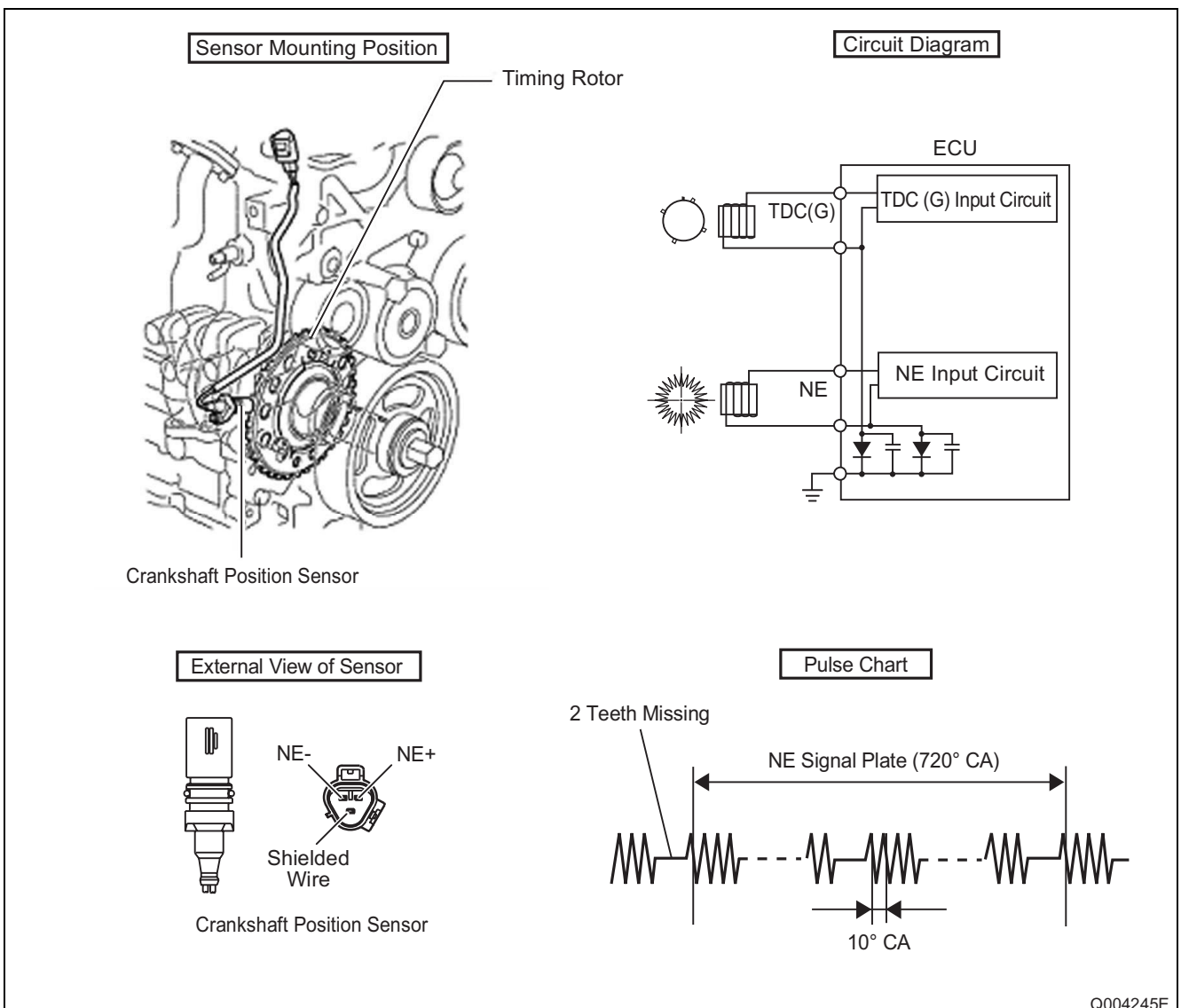
6.4 Sensors

(1) Crankshaft position sensor and camshaft position sensor

Crankshaft Position Sensor (NE Sensor)

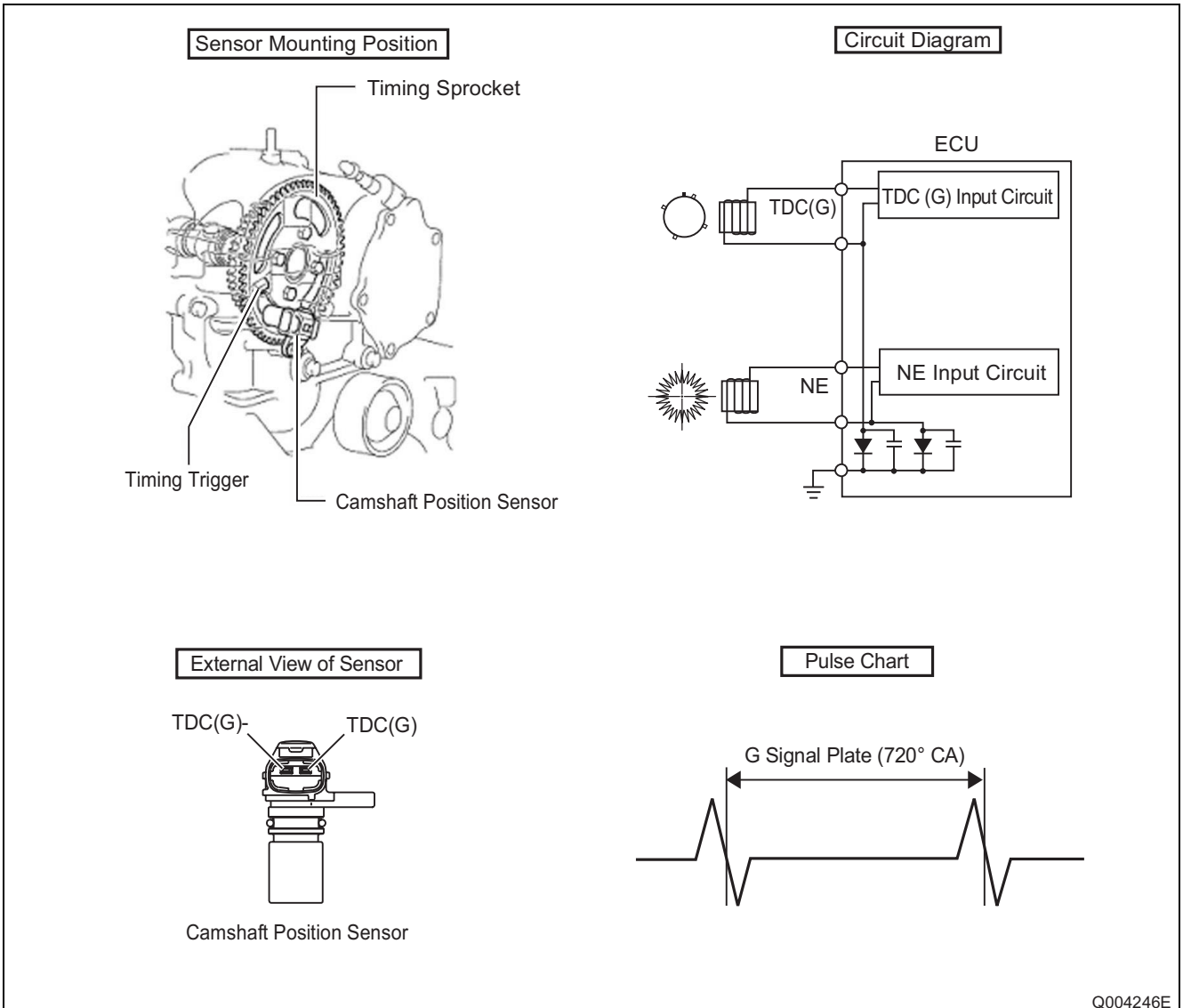
- The crankshaft position sensor unit is a Magnetic Pick UP (MPU) type. When the engine speed pulsar gear installed on the crankshaft passes the sensor section, the magnetic field of the coil within the sensor changes, generating an AC voltage. This AC voltage is detected by the engine ECU as the detection signal.

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 Top Dead Center (TDC.)



Camshaft position sensor (G sensor)

- The camshaft position sensor is an MPU type identical to the crankshaft position sensor. The camshaft position sensor generates one signal for every two revolutions of the crankshaft by using the timing trigger of the timing sprocket.

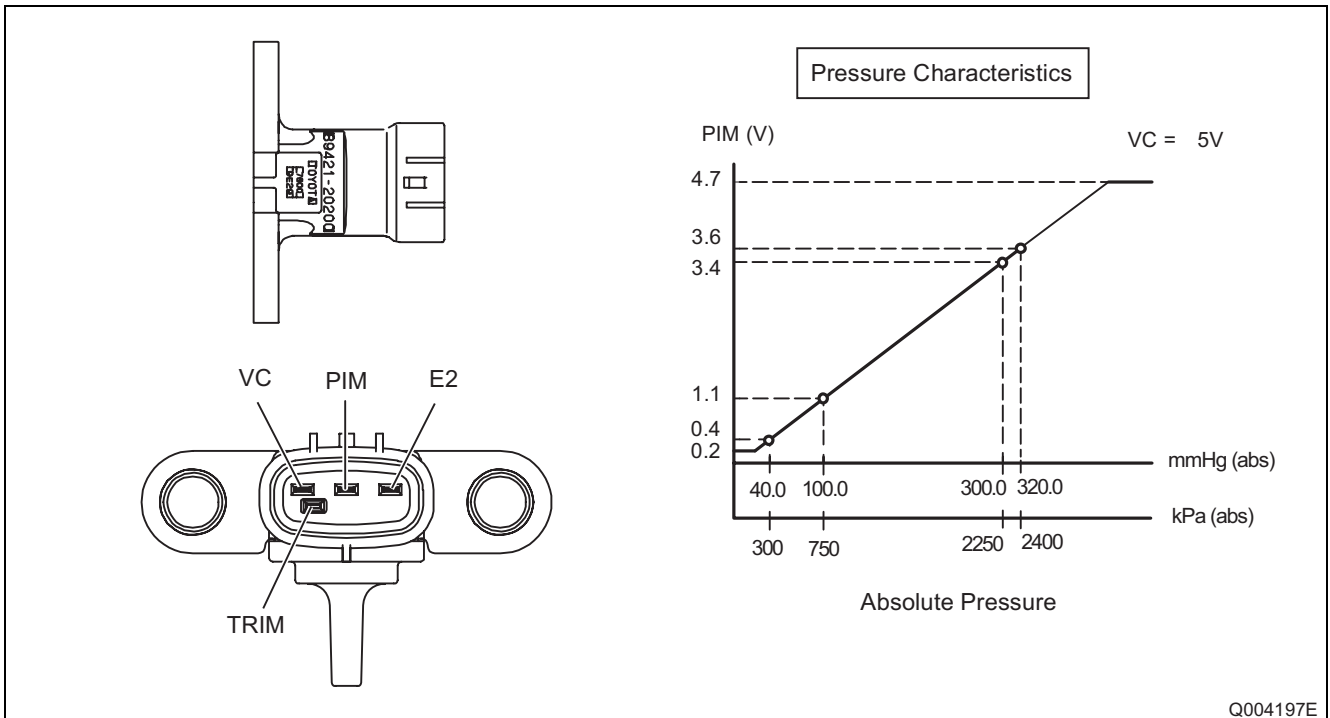


(2) Manifold Absolute Pressure (MAP) Sensor

- The MAP sensor is a semiconductor type sensor. Pressure is measured utilizing the piezoelectric effect under which when the pressure on the silicon element in the sensor changes, the electrical resistance also changes. In addition, the air pressure on the MAP sensor is switched between the pressure within the intake manifold and atmospheric pressure. As a result, both the intake air pressure and atmospheric pressure are detected with one sensor. Switching between the intake air pressure and atmospheric pressure is controlled by the Vacuum Switching Valve (VSV). When any one of the conditions listed below is established, the VSV is switched on for 150 milliseconds (via command from the engine ECU) to detect atmospheric pressure. When none of the conditions below are established, the VSV is switched off to detect the intake air pressure.

Atmospheric Pressure Measurement Conditions

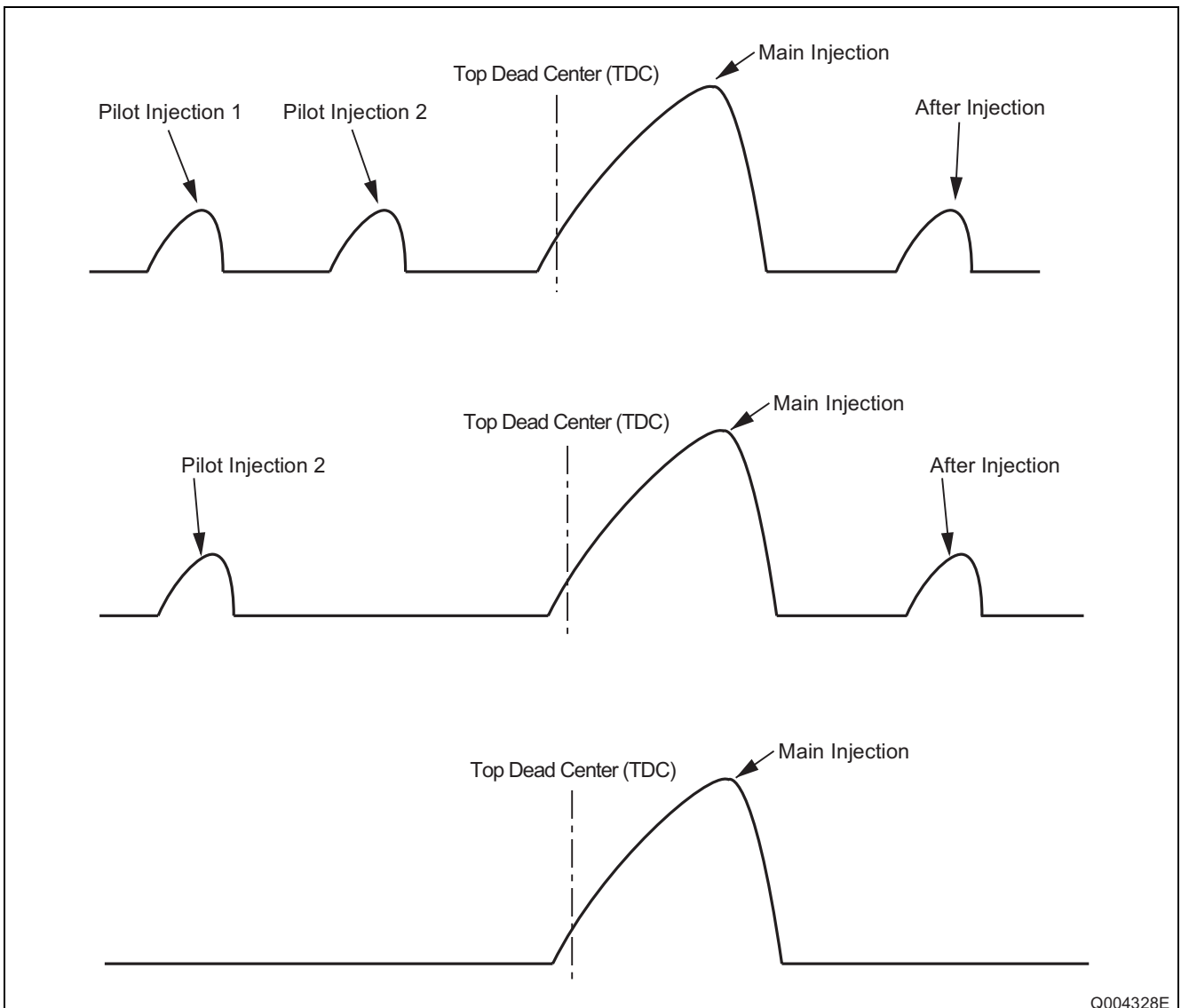
- ✓ Engine speed = 0 rpm
- ✓ Starter on
- ✓ Stable idling state



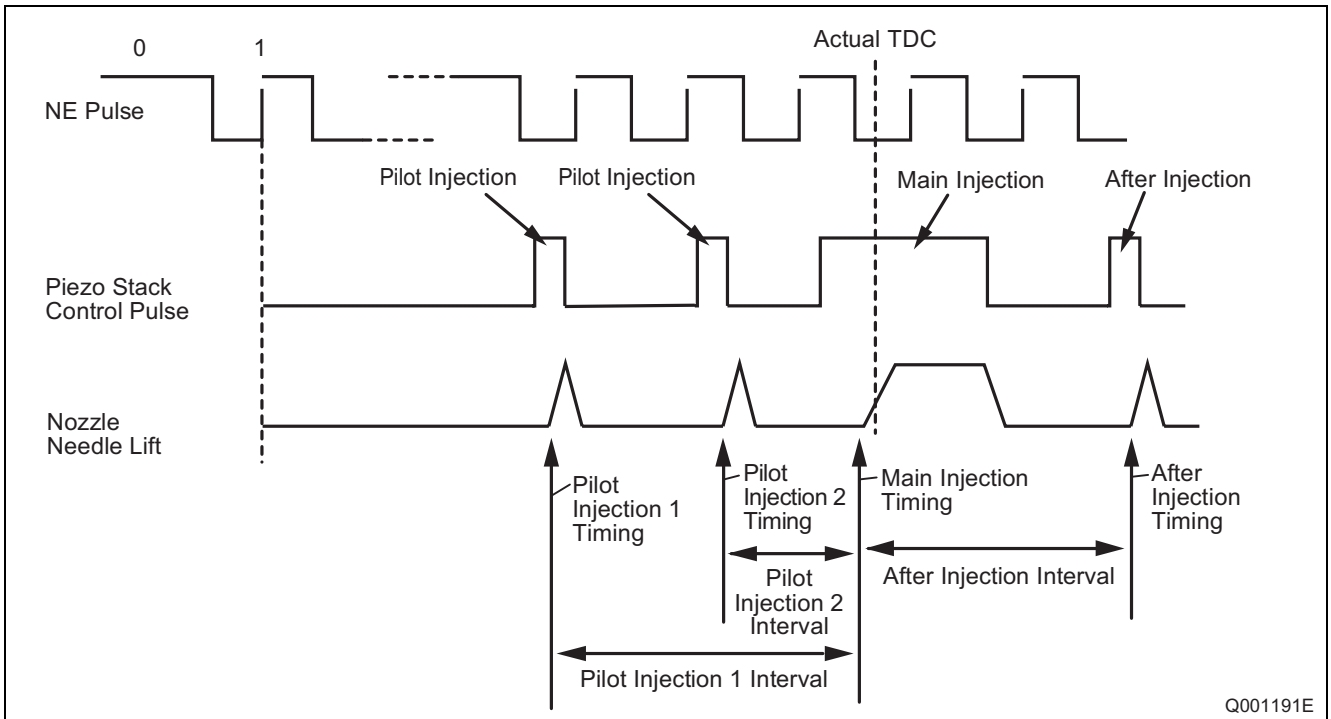
7. FUEL INJECTION CONTROL

7.1 Injection Pattern (Reference)

- The figure below shows representative injection patterns. Injection patterns change according to engine load conditions.



7.2 Control Timing



7.3 Microinjection Quantity Learning Control

Outline

- In microinjection quantity learning control, the actual injector injection quantity is estimated from the change in engine rotation accompanying a very small injection. The difference between the estimated actual injection quantity, and the injection quantity command value at that time are learned by the engine ECU. This difference is then used to correct the actual injection quantity.

Goal

- Microinjection quantity learning control is used to accomplish the following: 1) to minimize injection quantity deviations due to injector deterioration over time, and 2) to prevent both engine running noise due misfires, and exhaust smoke.

Control

- Microinjection quantity learning control is automatically performed approximately every 2000 km of normal vehicle operation, and is completed after the vehicles has traveled approximately 500 km. Actual learning takes place during the following processes.

[REFERENCE]

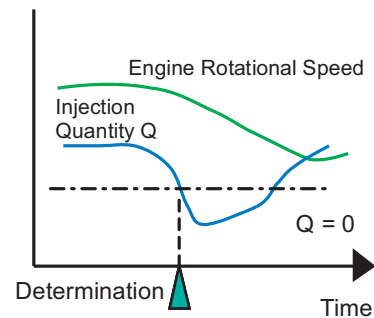
Until the vehicle has traveled approximately 500 km, automatically performed approximately every 500 km.

Determinations for learning conditions

- Microinjection quantity learning control is performed when the following two engine operations are established: 1) a reduction in vehicle speed, and 2) injection is cut off. In the determination process, the engine ECU then judges whether or not the conditions for learning have been met. The figure below shows the specific details for learning determinations.

Determination Content

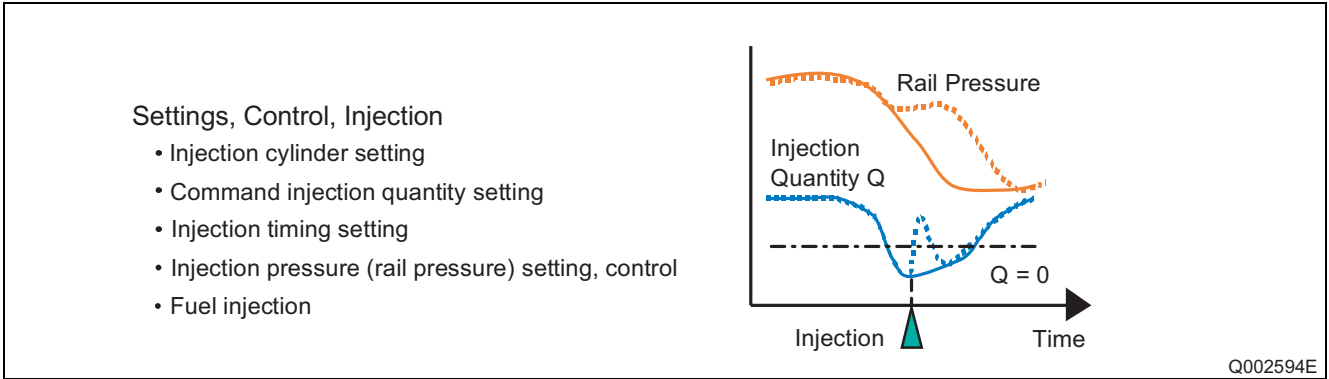
- Non-injection determination
- Deceleration determination
- Clutch position determination
*For manual transmission vehicles



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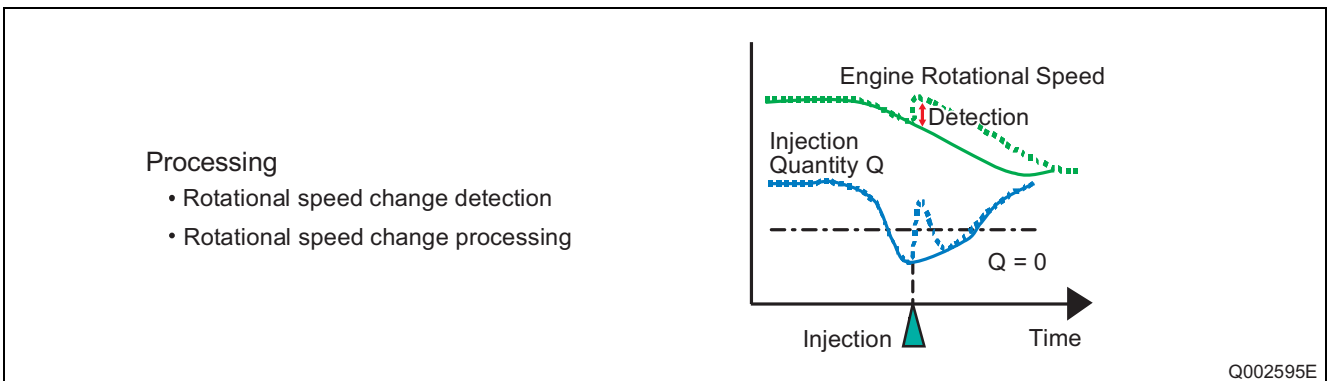
Single microinjection operation

- Under the single microinjection operation process, the cylinder for which learning will be performed, as well as the injection quantity are set, then microinjection is performed. The figure below shows the specific settings and controls for a single microinjection.



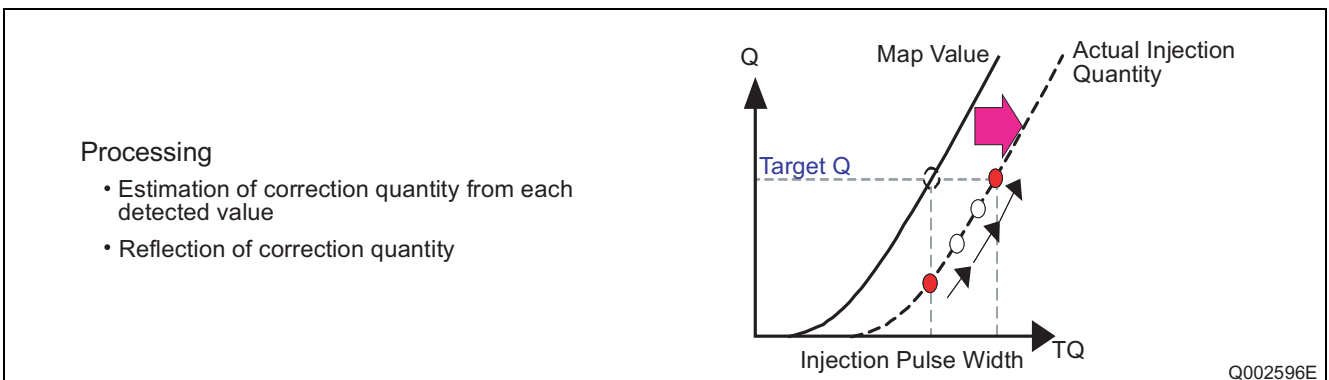
Detecting the change in rotational speed via injection

- In this process, the change in rotational speed can be detected using the set microinjection. The figure below shows the processing for calculating changes in rotational speed.



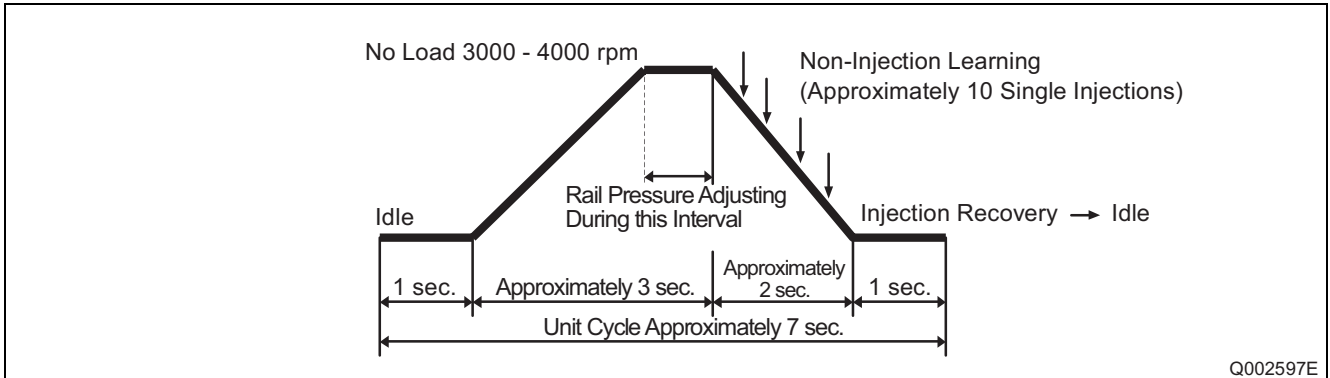
Correcting the injection pulse width (TQ), and actual injection quantity (Q) characteristics

- In this process, the actual injection quantity is estimated from the set microinjection, and the change in rotational speed. The actual injection quantity is then corrected such that the value equals the target injection quantity. The figure below shows the processing for the aforementioned corrections.



[REFERENCE]

Learning must be performed manually when either an injector (or injectors), or the engine ECU has been replaced. As per the figure below, diagnostic tools are used to perform learning while the engine is operating.



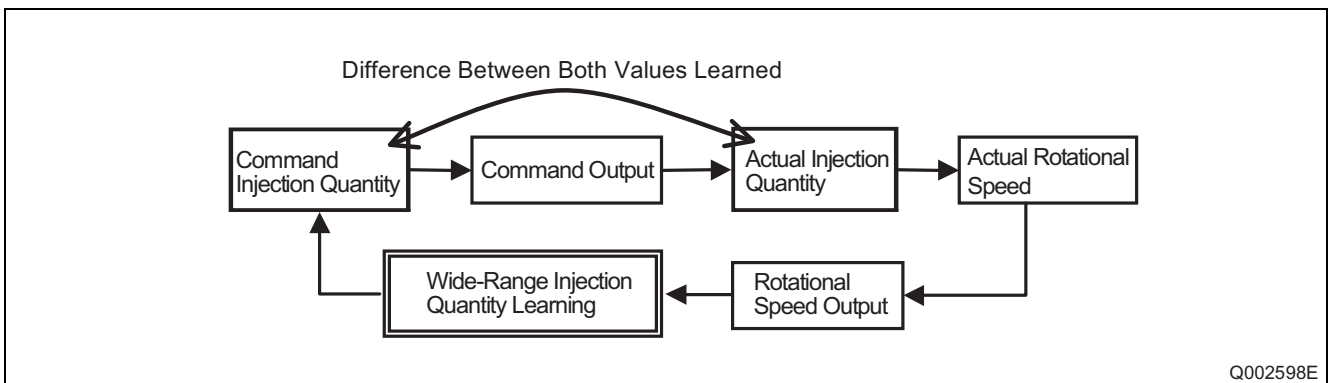
7.4 Wide-Range Cylinder Correction Control

Outline

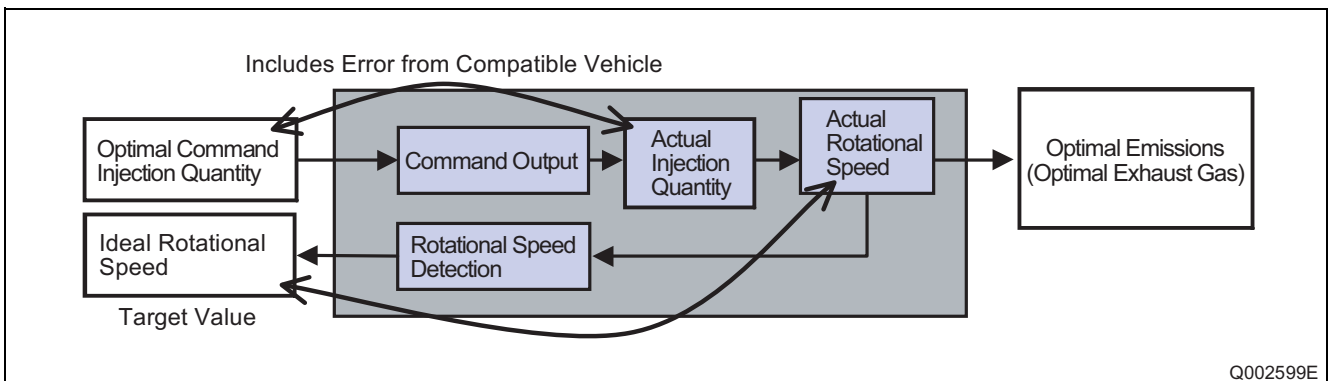
- In wide-range cylinder correction control, the combustion state for each cylinder is detected based on the crankshaft position sensor (NE) signal. The injection quantity across all the cylinders can then be averaged by correcting the injection quantity for each injector. Wide-range cylinder correction control corrects the conventional FCCB control (idle speed stabilization control) performed at idle speed in all regions of rotation.

Control outline

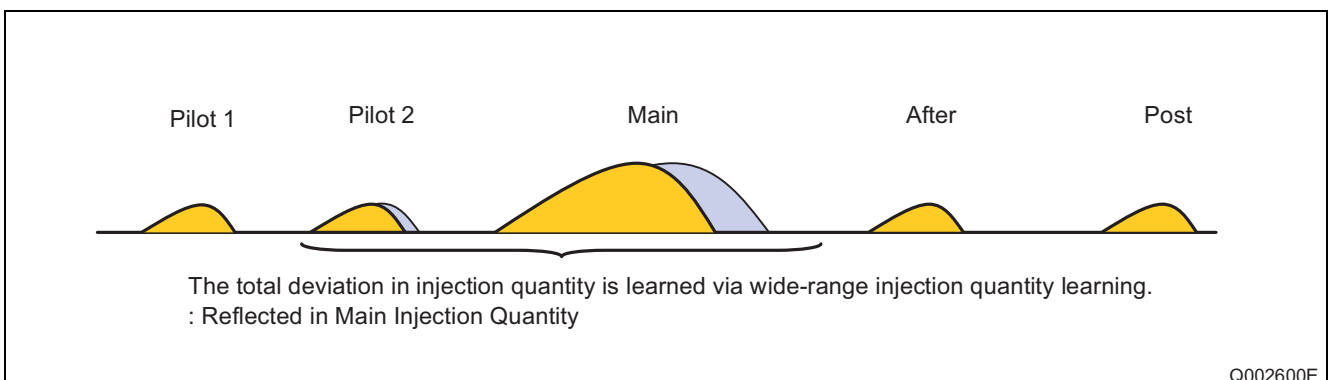
- The difference between the final injection quantity, and the actual injection quantity are learned based on the loop in the figure below. Next, the following two items are compared: 1) the results of the actual injection quantity estimate based on the ideal state for NE input, and 2) the results of the actual injection quantity estimate based on the actual NE input (detected value.)



- Finally, the optimal emission state is found as shown in the figure below.



- The correction below shows one pilot injection, and two main injections.



8. EXHAUST GAS PURIFICATION SYSTEM

8.1 Configuration

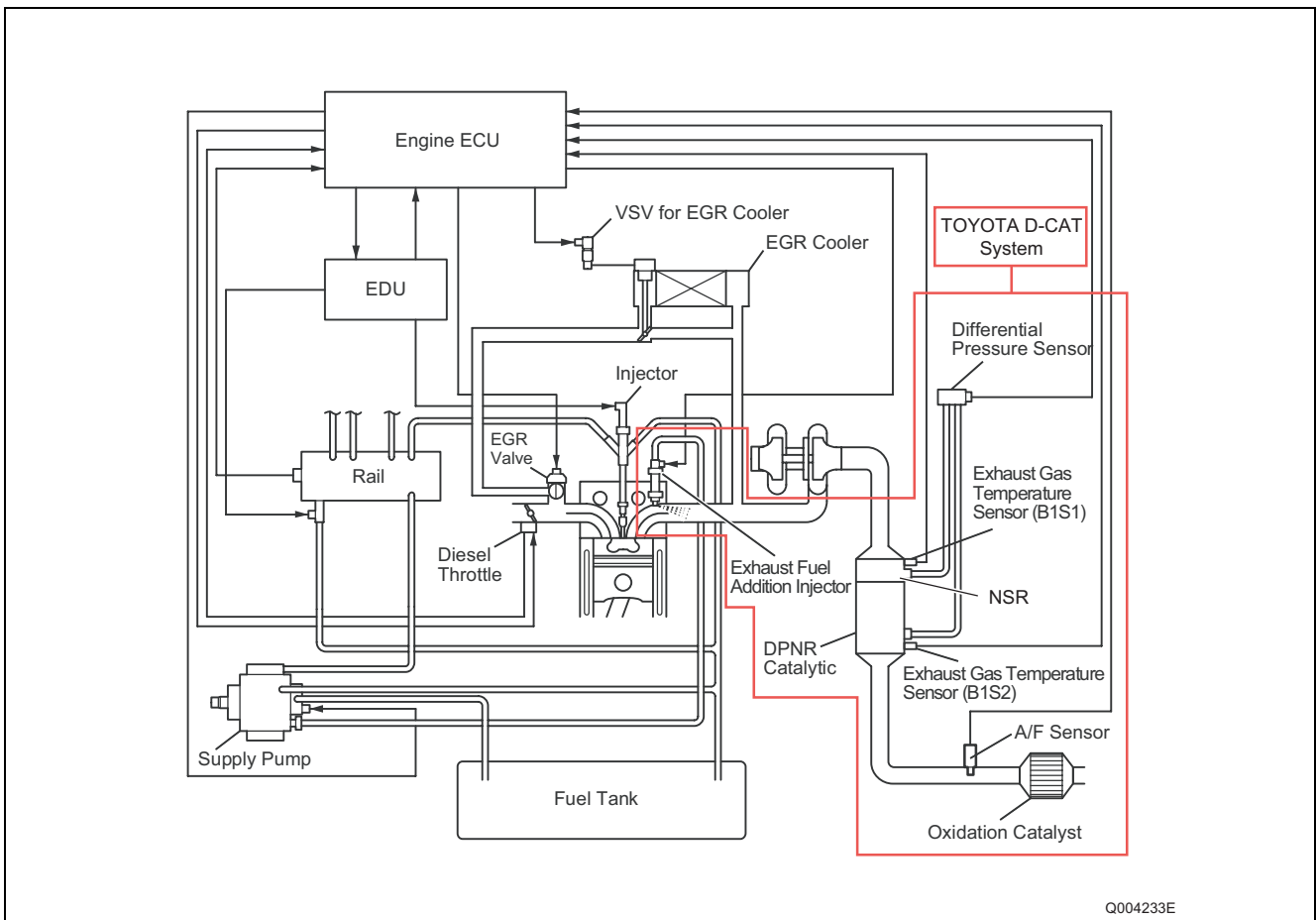
- The exhaust gas purification system for the 2AD-FHV engine consists of the TOYOTA Diesel-Clean Air Technology (D-CAT) system, and the Exhaust Gas Recirculation (EGR) control system. For the 2AD-FTV, and 1AD-FTV engines (excluding CCO specification vehicles), the exhaust gas purification system consists of the Diesel Particulate Filter (DPF) system, and the EGR control system.

8.2 TOYOTA D-CAT (Diesel Clean Advanced Technology) System

Outline

- The TOYOTA D-CAT system used in for the 2AD-FHV engine reduces Particulate Matter (PM), and NO_x emissions.

TOYOTA D-CAT comprehensively regulates engine control (consisting of a catalytic system and a fuel injection system) that purifies both particulate matter (PM) and nitrogen oxides (NO_x) discharged by diesel engines. The catalytic system purifies hydrocarbons (HC) and carbon monoxides (CO), and reduces PM and NO_x with a catalytic converter with the DPNR system. The fuel injection system adds fuel into the exhaust port using the exhaust fuel addition injector to produce a rich state for NO_x reduction and maintain a proper catalyst temperature for DPNR catalyst regeneration.

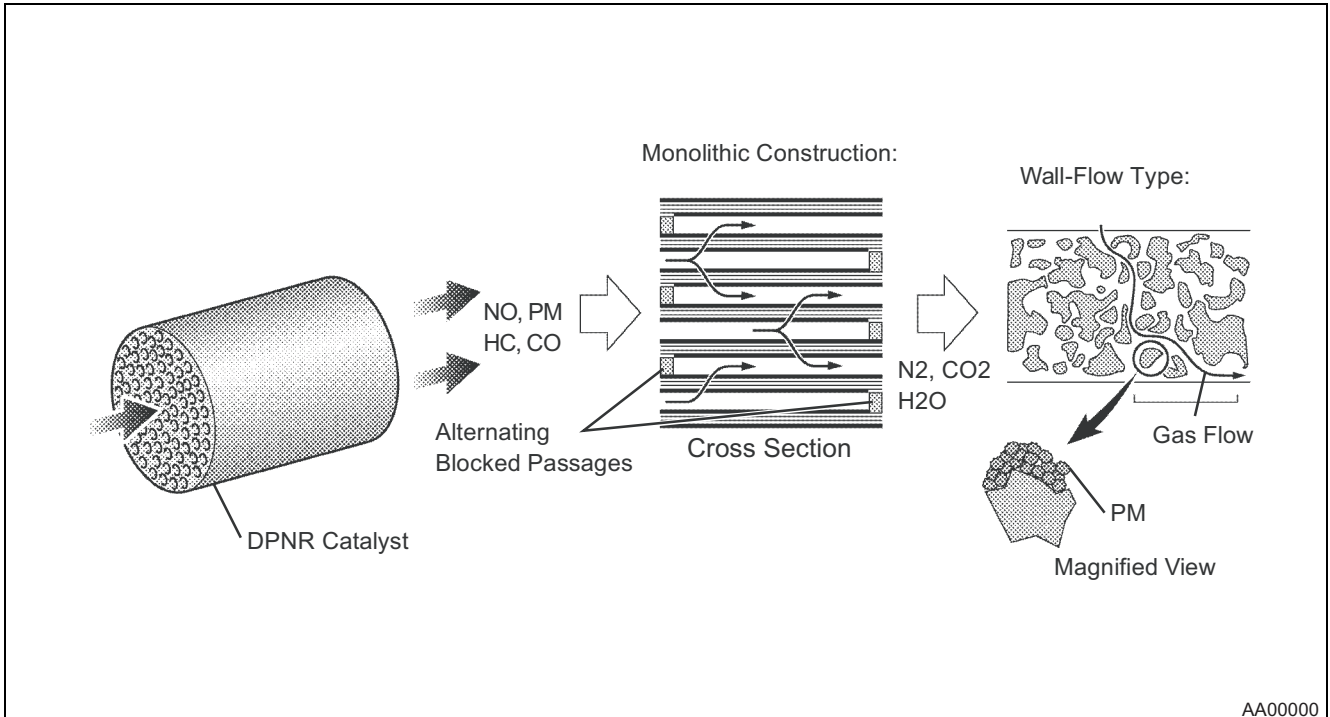


System Configuration

(1) Components

DPNR Catalyst

- The DPNR catalyst suppresses drops in exhaust gas pressure, and accumulates over 95% of PM by using a porous ceramic filter with high accumulation efficiency, and a low pressure drop. In addition, by coating the surface of the filter with a NO_x adsorber catalyst, NO_x can be reduced through adsorption.



Exhaust Gas Temperature Sensor

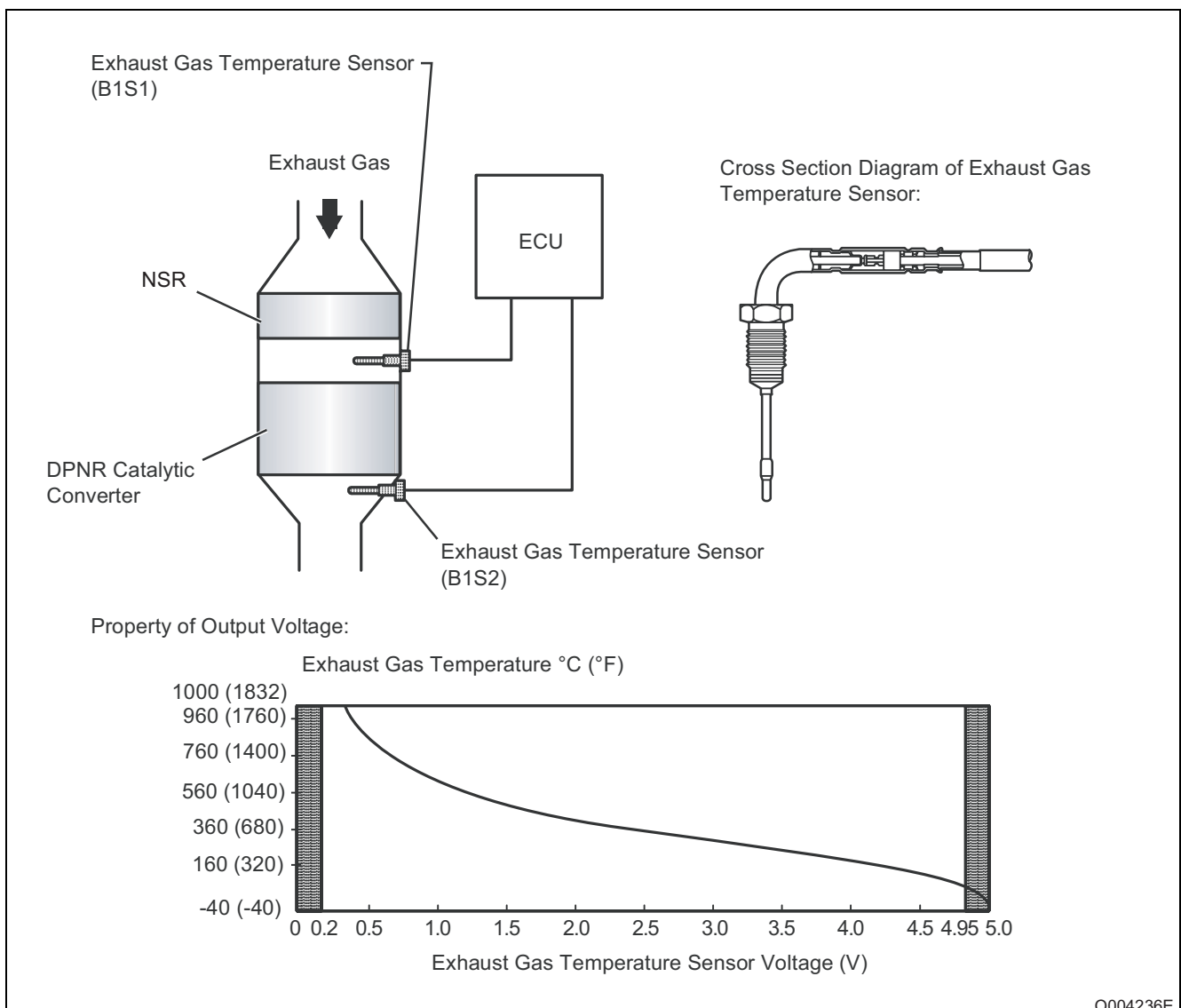
- The exhaust gas temperature sensors are installed before and after the DPNR catalytic converter to sense the exhaust gas temperature.

A thermistor built into the exhaust gas temperature sensor changes resistance value in accordance with changes in the exhaust gas temperature.

The lower the exhaust gas temperature, the higher the thermistor resistance value. Conversely, the higher the exhaust gas temperature, the lower the thermistor resistance value.

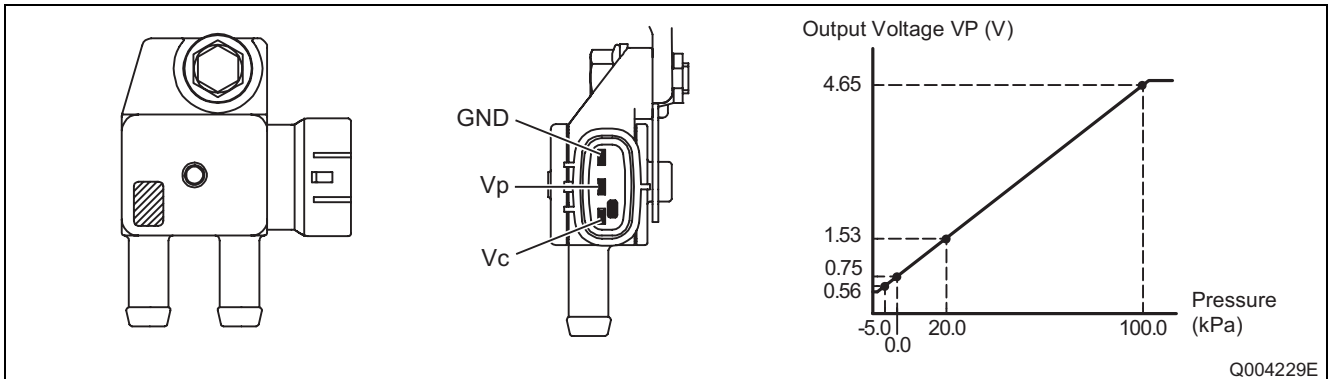
The exhaust gas temperature sensor is connected to the ECU. The 5 V power source voltage in the ECU is applied to the exhaust gas temperature sensor from terminal THCI (B1S1) and THCO (B1S2) via resistor R.

Resistor R and the exhaust gas temperature sensor are connected in series. When the resistance value of the exhaust gas temperature sensor changes in accordance with the exhaust gas temperature, the voltage at terminals THCI (B1S1) and THCO (B1S2) also changes. When DPNR catalyst regeneration is needed, the ECU operates the exhaust fuel addition injector to obtain the target upstream temperature for the DPF catalytic converter (as monitored through sensor 1). In addition, the ECU monitors the temperature increase of the DPNR catalytic converter using sensor 2.



Differential Pressure Sensor

- The differential pressure sensor detects the difference in pressure at the front and rear of the catalyst, and outputs a signal to the engine ECU. The sensor portion is a semiconductor type pressure sensor that utilizes the piezoelectric effect via a silicon element, and amplifies and outputs a voltage with an IC circuit. When PM is collected and accumulated in the catalyst, the filter clogs and the difference in pressure at the front and rear of the catalyst increases. Therefore, the engine ECU judges whether or not to subject the PM to combustion processing based on the sensor signals.



A/F Sensor

- The A/F sensor outputs a voltage* that is proportional to the air-fuel ratio. The A/F sensor output voltage is used to control the A/F mixture.

The A/F sensor is located after the DPNR catalytic converter. The A/F sensor was developed based on the structure and technology of the A/F sensor used in gasoline engines.

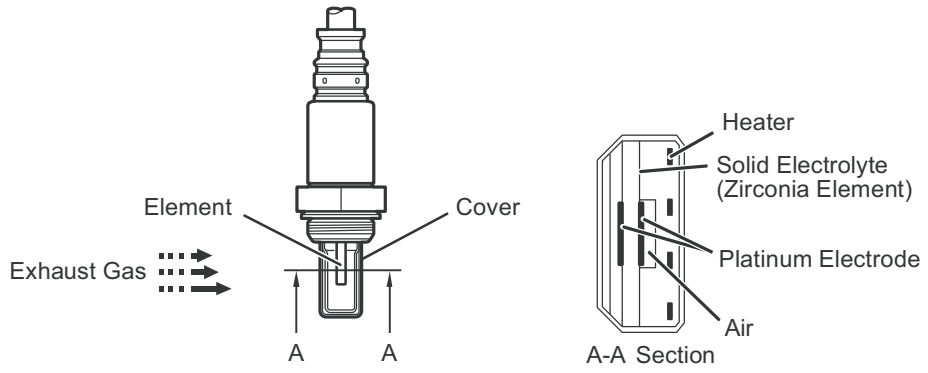
The cover for the A/F sensor electrode has been modified for diesel engine use. As a result, the A/F sensor functions more effectively in the DPNR type diesel engine, and also avoids problems with sensor temperature and PM.

In order to reduce PM, the ECU adjusts the air-fuel ratio to a value slightly richer than normal (note that this mixture is still leaner than the stoichiometric air-fuel ratio.)

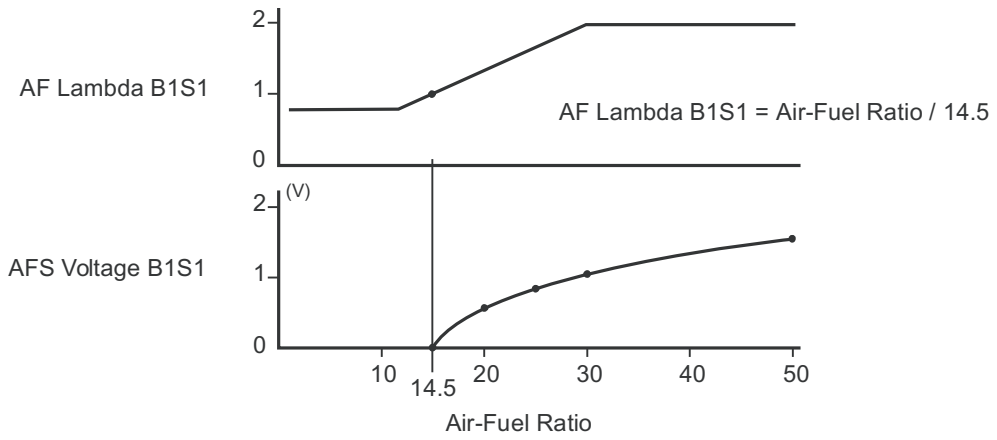
The ECU controls the aforementioned adjustments based on signals from the A/F sensor.

When the ECU performs DPNR catalyst regeneration (cleaning) by adding fuel from the exhaust fuel addition injector, the A/F sensor feedback is used to ensure that an appropriate air-fuel ratio is maintained.

*: This voltage change occurs only inside the ECU. It is not possible to measure this voltage at the sensor.



Air-Fuel Ratio Displayed on Tester:



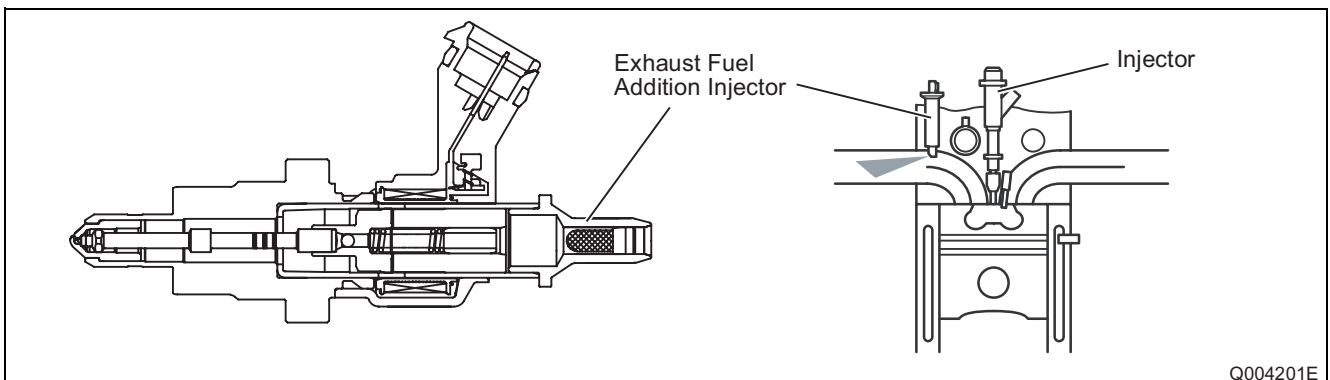
AFS Voltage B1S1 (V)	0	0.065	0.174	0.274	0.361	0.513	0.787	1.013	1.579
Air-Fuel Ratio	14.5	15	16	17	18	20	25	30	50

Exhaust Fuel Addition Injector

- The exhaust fuel addition injector receives signals from the engine ECU, and controls the catalyst A/F and temperature in accordance with the CPU program. A pre-determined amount of fuel is injected from the injector into the exhaust gas pipes during pre-determined conditions. As shown below, the exhaust fuel addition injector is installed on the engine exhaust side, and fuel from the supply pump is sent through the pipe.

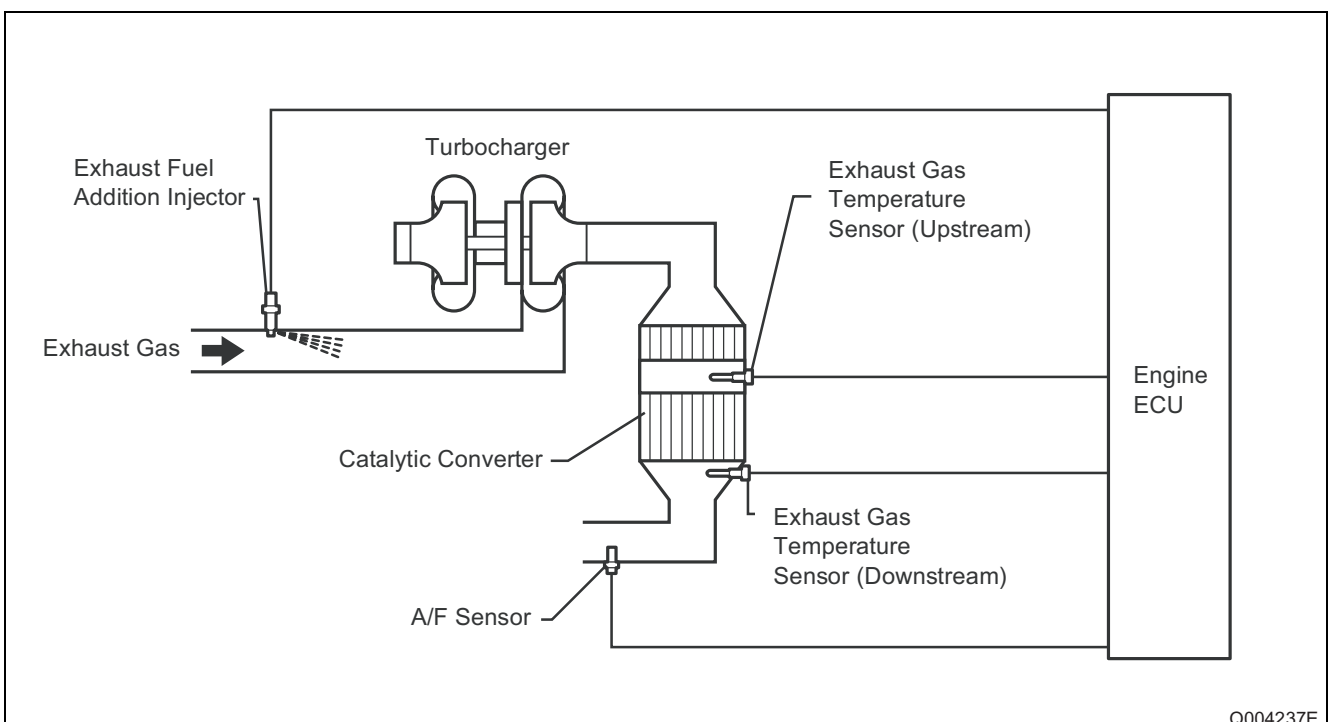
A pressure of 1 MPa is constantly applied to the exhaust fuel addition injector.

The exhaust fuel addition injector receives output signals from the ECU (time variable pulse) to generate an electromagnetic force in the interior coil. As a result, the needle moves left and right, thus moving the valve body integrated with the needle in the same direction. As such, fuel is injected from the nozzle.



- The exhaust fuel addition injector is mounted on the exhaust port of the cylinder head, and low-pressure fuel is provided to the injector by the feed pump inside the supply pump. Fuel is added from this injector via control signals from the ECU to perform catalyst regeneration.

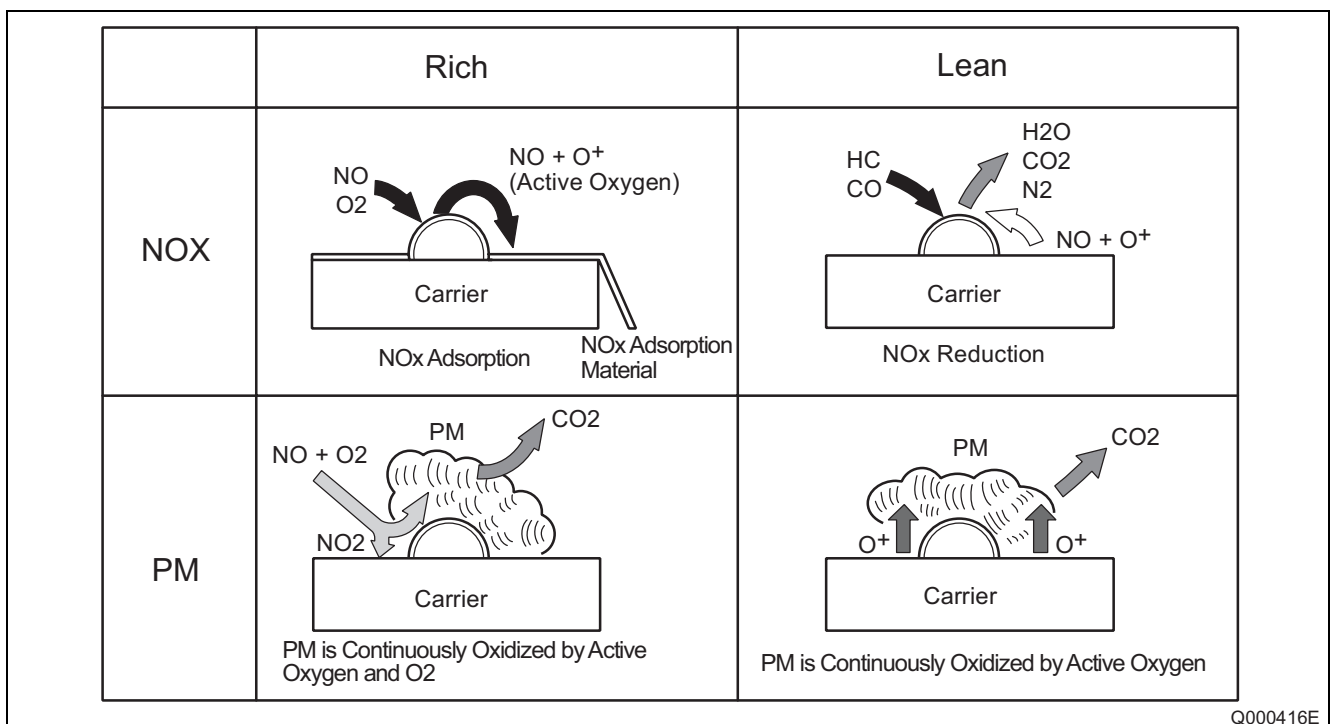
During catalyst regeneration, the exhaust fuel addition injector adds fuel to raise the catalyst temperature.



(2) Operation

Continuous PM regeneration, and NOx reduction

- The D-CAT system is a combination of an NOx adsorption three-way catalyst, and a porous ceramic construction. As exhaust gas passes through the gaps in the porous ceramic construction, the catalyst oxidizes the PM, and reduces the NOx, drastically reducing the quantity of both substances.
- Lean combustion (excessive oxygen state) is normally performed in diesel engines. In a lean state, oxidation occurs easily, but reduction is difficult to produce. Therefore, it is necessary to temporarily adsorb NOx with the DPNR catalyst. When the NOx is adsorbed, PM oxidation is promoted by the generation of active oxygen.
- To reduce the NOx, first fuel is injected by the exhaust fuel addition injector to create a rich state (where the quantity of oxygen is relatively small). In this rich state, NO, as well as a large quantity of active oxygen are generated by the NSR and DPNR catalysts. The NO is then reduced to N₂, and the PM is oxidized by the active oxygen. As a result, NOx and PM are simultaneously reduced.



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S (Sulfur) regeneration

- When sulfur contained in the diesel fuel accumulates in the catalyst, NOx purification capacity decreases. S regeneration is used to restore the NOx purification capacity. By injecting fuel into the catalyst using the exhaust fuel addition injector, the air-fuel ratio in the catalyst can be made rich, and the catalyst temperature can be raised (to 650°C). As a result, the sulfur from the fuel temporarily accumulated in the catalyst is eliminated. S regeneration control is performed simultaneously with PM regeneration control. When S regeneration takes place, the idling rotational speed increases.

8.3 Diesel Particulate Filter (DPF) System

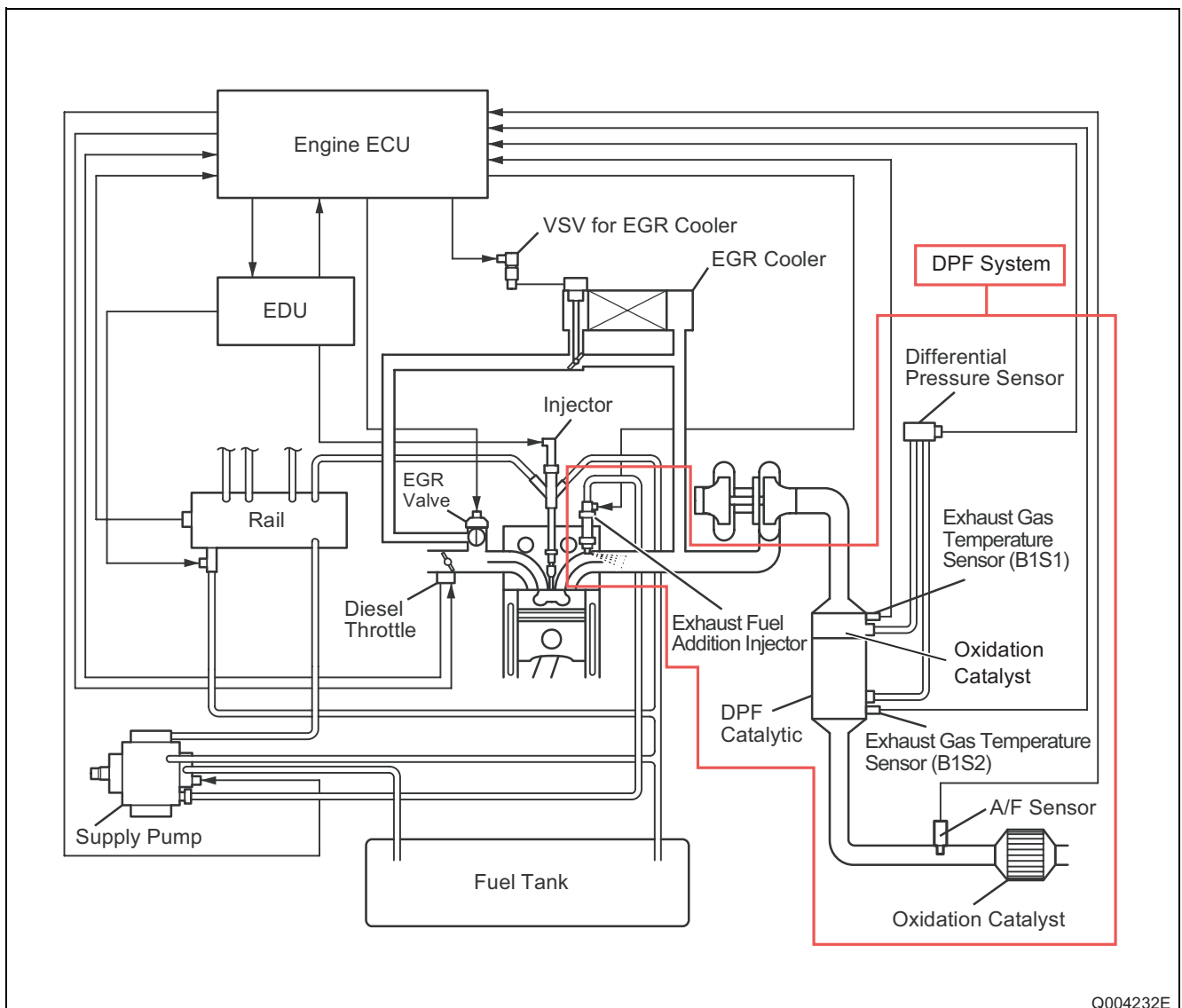
Outline

- The DPF system reduces Particulate Matter (PM) emissions. The DPF system is used with the 2AD-FTV, and 1AD-FTV engines (excluding CCO specification vehicles.)

The DPF system comprehensively regulates the engine controls (consists of a catalytic system and a fuel injection system) that purify the PM from diesel engines.

The catalytic system purifies Hydro Carbon (HC) and Carbon Monoxide (CO), as well as reduces the PM with a catalytic converter in the DPF.

The fuel injection system adds fuel into the exhaust port using the exhaust fuel addition injector to maintain a proper catalyst temperature for DPF catalyst regeneration.



System Configuration

(1) Components

Exhaust Gas Temperature Sensor

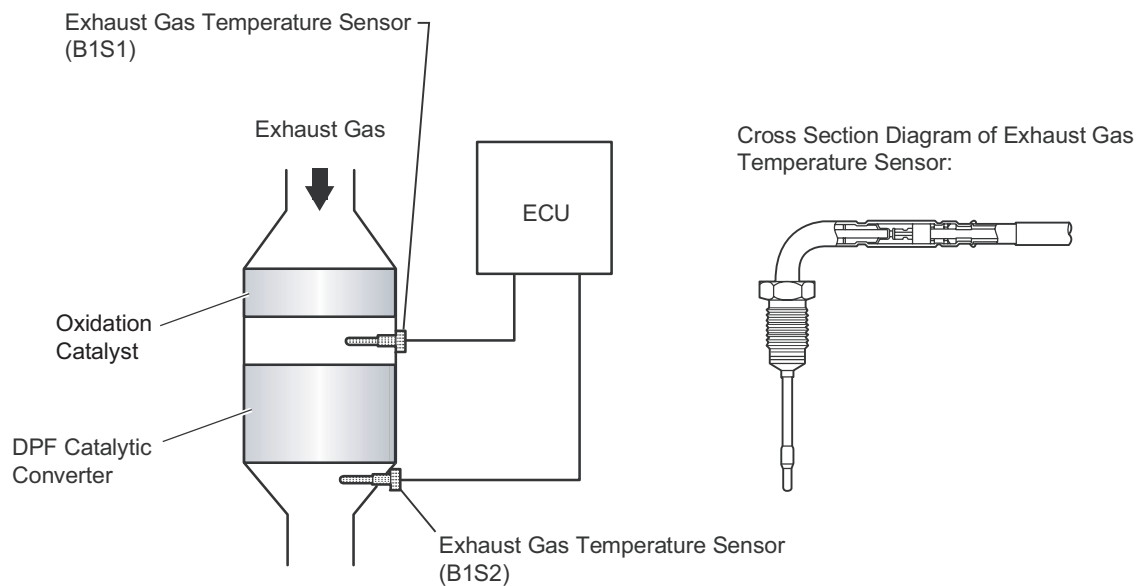
- The exhaust gas temperature sensors are installed before and after the DPF catalytic converter to sense the exhaust gas temperature.

A thermistor built into the exhaust gas temperature sensor changes resistance value according to the exhaust gas temperature.

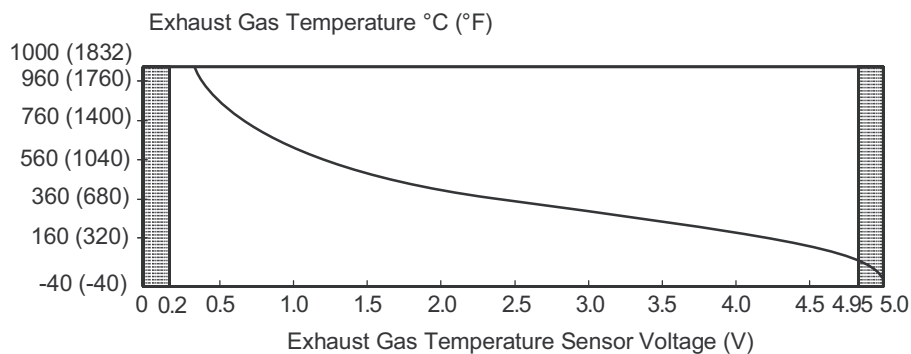
The lower the exhaust gas temperature, the higher the thermistor resistance value. Conversely, the higher the exhaust gas temperature, the lower the thermistor resistance value.

The exhaust gas temperature sensor is connected to the ECU. The 5 V power source voltage in the ECU is applied to the exhaust gas temperature sensor from terminal THCI (B1S1) and THCO (B1S2) via resistor R.

Resistor R and the exhaust gas temperature sensor are connected in series. When the resistance value of the exhaust gas temperature sensor changes in accordance with the exhaust gas temperature, the voltage at terminals THCI (B1S1) and THCO (B1S2) also changes. When DPF catalyst regeneration is needed, the ECU operates the exhaust fuel addition injector to obtain the target upstream temperature for the DPF catalytic converter (as monitored through sensor 1). In addition, the ECU monitors the temperature increase of the DPF catalytic converter using sensor 2.



Property of Output Voltage:



Differential Pressure Sensor

- The same type of sensor is used for differential pressure sensor as in the TOYOTA D-CAT system.
Refer to [Components] on P1-25.

A/F Sensor

- The A/F sensor outputs a voltage* that is proportional to the air-fuel ratio. The A/F sensor output voltage is used to control the A/F mixture.

The A/F sensor is located after the DPF catalytic converter. The A/F sensor was developed based on the structure and technology of the A/F sensor used in gasoline engines.

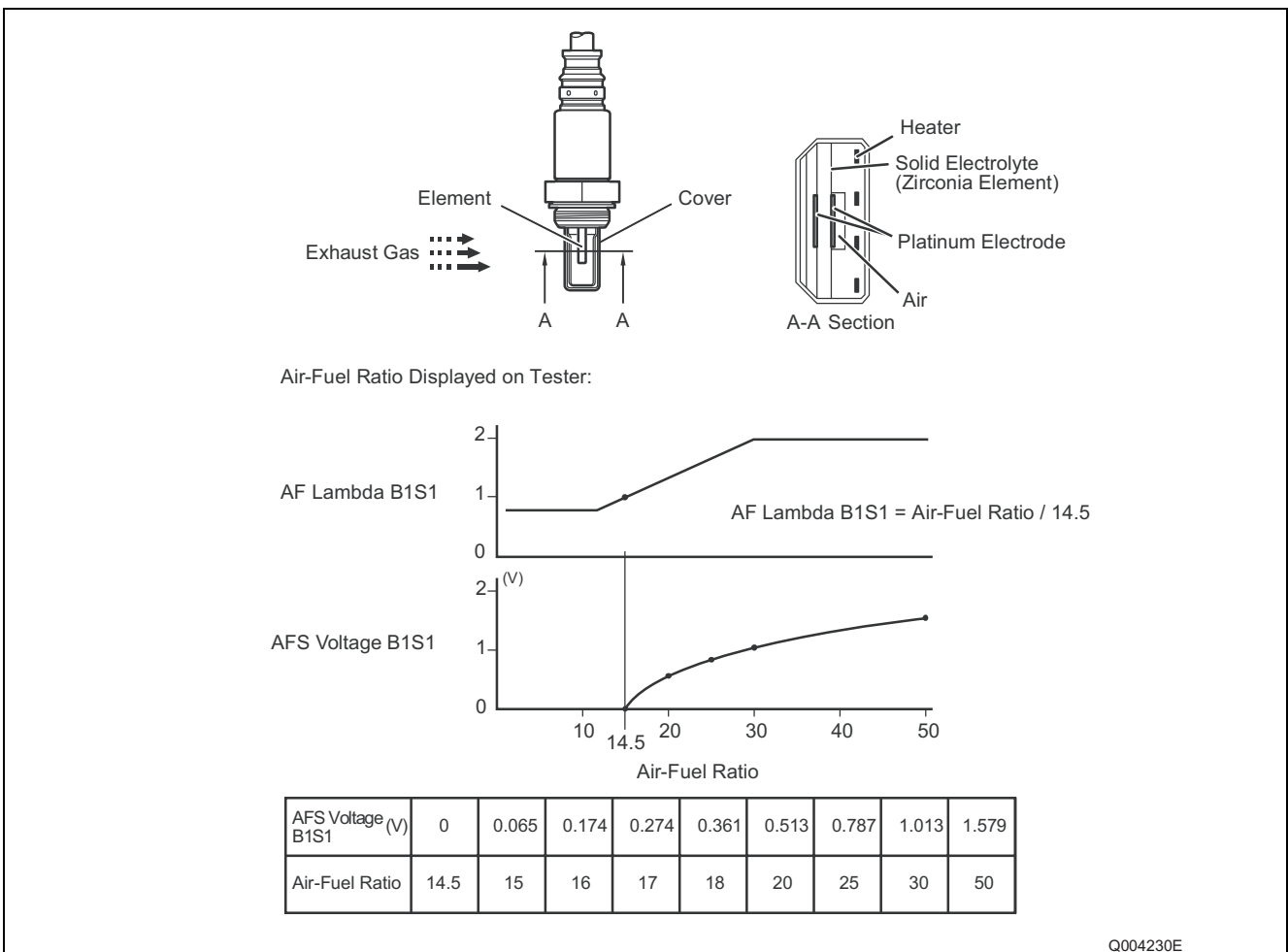
The cover for the A/F sensor electrode has been modified for diesel engine use. As a result, the sensor functions more effectively in the DPF type diesel engine, and also avoids problems with sensor temperature and PM.

In order to reduce PM, the ECU adjusts the air-fuel ratio to a value slightly richer than normal (note that this mixture is still leaner than the stoichiometric air-fuel ratio).

The ECU controls the aforementioned adjustments based on signals from the A/F sensor.

When the ECU performs DPF catalyst regeneration (cleaning) by adding fuel from the exhaust fuel addition injector, the A/F sensor feedback is used to ensure an appropriate air-fuel ratio is maintained.

*: This voltage change occurs only inside the ECU. It is not possible to measure this voltage at the sensor.

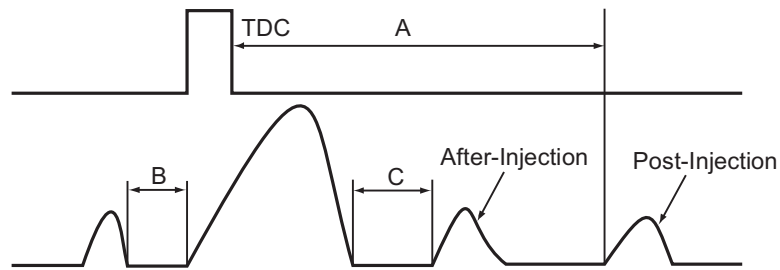


Exhaust Fuel Addition Injector

- The same type of injector is used for exhaust fuel addition injector as in the TOYOTA D-CAT system.
Refer to [Components] on P1-25

(2) Operation

- In the DPF system PM is collected, oxidized, and self-combusted by optimizing the injection pattern and controlling the exhaust gas temperature based on the following: 1) the exhaust gas temperature and, 2) the difference in pressure at the front and rear of the DPF. When the exhaust temperature is low, adding an after-injection after the main injection raises the exhaust gas temperature to approximately 250°C to promote PM oxidation. When the PM is collected and accumulated, a post-injection and HC are added to the catalyst to raise the catalyst temperature to 600°C, which is the self-combustion temperature for PM. Therefore, the accumulated PM is combusted in a short amount of time. The engine ECU controls times A, B, and C shown below, as well as the injection duration.

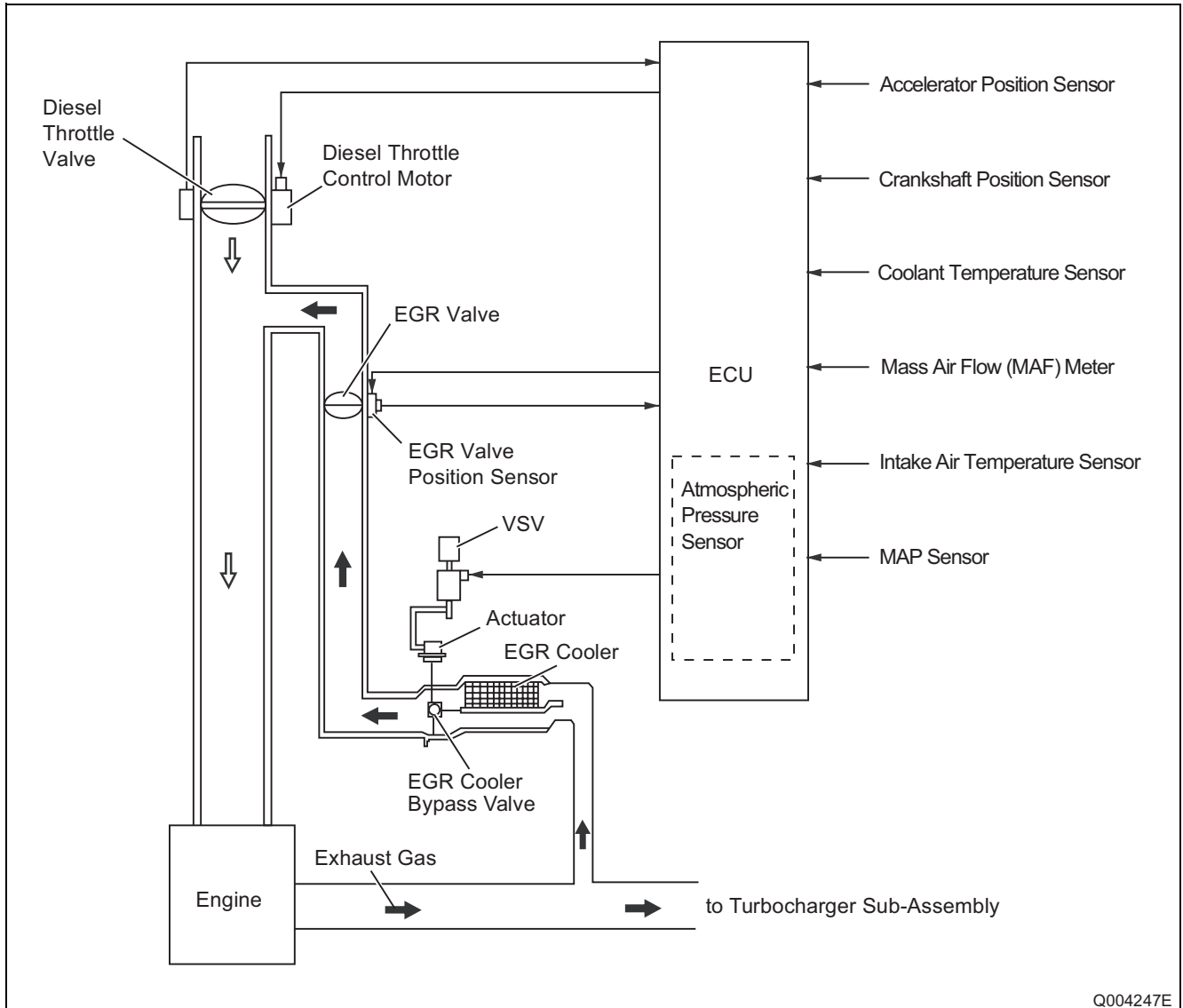


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8.4 Exhaust Gas Regeneration (EGR) Control System

- The engine ECU actuates the EGR valve, which regulates the EGR gas recirculation volume in accordance with engine conditions.

The engine ECU controls the VSV for the EGR cooler, which switches the bypass passage and cooler passage in the EGR cooler to optimize the EGR gas temperature.



9. DIAGNOSTIC TROUBLE CODES (DTC)

9.1 DTC Interpretation

- DTCs (SAE codes) that utilize the Intelligent Tester II STT are displayed as output codes.
- If multiple DTCs are outputted, the codes are shown in order starting with the lowest number.

9.2 DTC Table

DTC (SAE code)	Detection Item
P0031	HO2S Heater Control Circuit Low
P0032	HO2S Heater Control Circuit High
P0045	Turbocharger/Supercharger Boost Control Solenoid "A" Circuit/Open
P0069	MAP - Barometric Pressure Correlation
P0087	Fuel Rail/System Pressure - Too Low
P0088	Fuel Rail/System Pressure - Too High
P0093	Fuel System Leak Detected - Large Leak
P0101	Mass or Volume Air Flow "A" Circuit Range/Performance
P0102	Air Flow (MAF) Meter Circuit Low Input
P0103	Air Flow (MAF) Meter Circuit High Input
P0106	MAP / Barometric Pressure Circuit Range/Performance
P0107	MAP / Barometric Pressure Circuit Low Input
P0108	MAP / Barometric Pressure Circuit High Input
P0112	Intake Air Temperature Sensor 1 Circuit Low
P0113	Intake Air Temperature Sensor 1 Circuit High
P0115	Engine Coolant Temperature 1 Circuit
P0116	Engine Coolant Temperature 1 Circuit Range/Performance
P0117	Engine Coolant Temperature 1 Circuit Low
P0118	Engine Coolant Temperature 1 Circuit High
P011C	Charge Air Temperature/Intake Air Temperature Correlation (Bank 1)
P0122	Throttle/Pedal Position Sensor/Switch "A" Circuit Low
P0123	Throttle/Pedal Position Sensor/Switch "A" Circuit High
P0168	Fuel Temperature Too High
P0180	Fuel Temperature Sensor "A" Circuit
P0182	Fuel Temperature Sensor "A" Circuit Low
P0183	Fuel Temperature Sensor "A" Circuit High
P0190	Rail Pressure Sensor "A" Circuit
P0191	Rail Pressure Sensor "A" Circuit Range/Performance

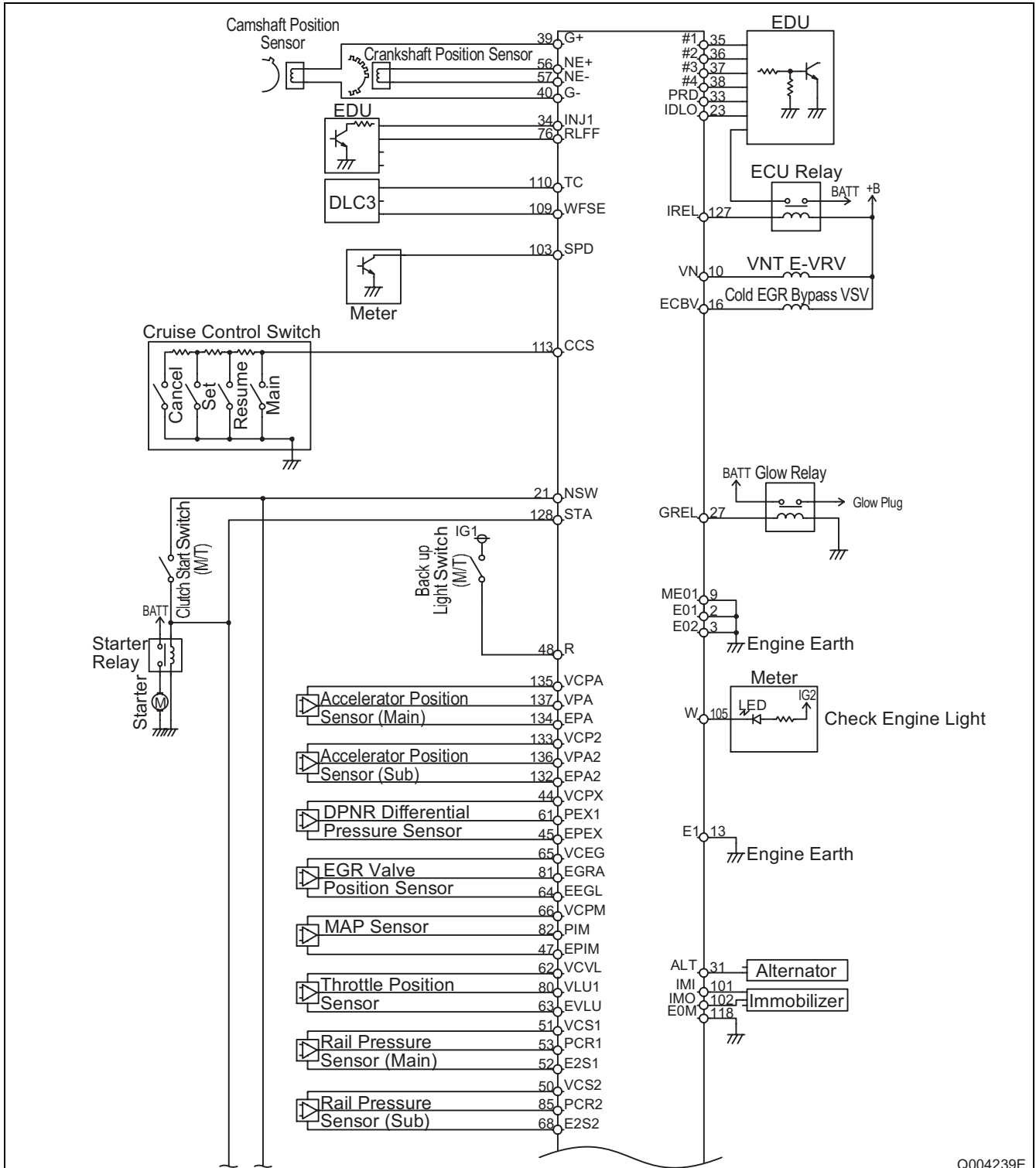
DTC (SAE code)	Detection Item
P0192	Rail Pressure Sensor "A" Circuit Low
P0193	Rail Pressure Sensor "A" Circuit High
P0234	Turbocharger/Supercharger Overboost Condition
P0299	Turbocharger/Supercharger Underboost
P0335	Crankshaft Position Sensor "A" Circuit
P0339	Crankshaft Position Sensor "A" Circuit Intermittent
P0340	Camshaft Position Sensor "A" Circuit
P0400	Exhaust Gas Recirculation Flow
P0405	Exhaust Gas Recirculation (EGR) Sensor "A" Circuit Low
P0406	Exhaust Gas Recirculation (EGR) Sensor "A" Circuit High
P0488	Exhaust Gas Recirculation (EGR) Throttle Position Control Circuit "A" Range/Performance
P0489	Exhaust Gas Recirculation (EGR) Control Circuit "A" Low
P0490	Exhaust Gas Recirculation (EGR) Control Circuit "A" High
P0500	Vehicle Speed Sensor "A"
P0504	Brake Switch "A"/"B" Correlation
P0545	Exhaust Gas Temperature Sensor Circuit Low
P0546	Exhaust Gas Temperature Sensor Circuit High
P0560	System Voltage
P0606	ECM/PCM (Engine ECU) Processor
P060A	Internal Control Module Monitoring Processor Performance
P060B	Internal Control Module A/D Processor Performance
P0617	Starter Relay Circuit High
P0627	Fuel Pump "A" Control Circuit /Open
P062D	Fuel Injector Driver Circuit Performance
P0724	Brake Switch "B" Circuit High
P1229	Fuel Pump System
P1238	Injector Malfunction
P1251	Turbocharger / Supercharger Overboost Condition (Too High)
P1271	Fuel Regulator Circuit Malfunction (EDU Drive)
P1272	Fuel Pressure Regulator Circuit Malfunction
P1386	Injector for Exhaust Fuel Addition
P1496	Intake Air Temperature Sensor 1 Circuit Low
P1497	Intake Air Temperature Sensor 1 Circuit High
P1601	Injector Correction Circuit Malfunction (EEPROM)
P1604	Startability Malfunction
P1607	Cruise Control Input Processor
P1625	Idle Signal Transmitter Circuit

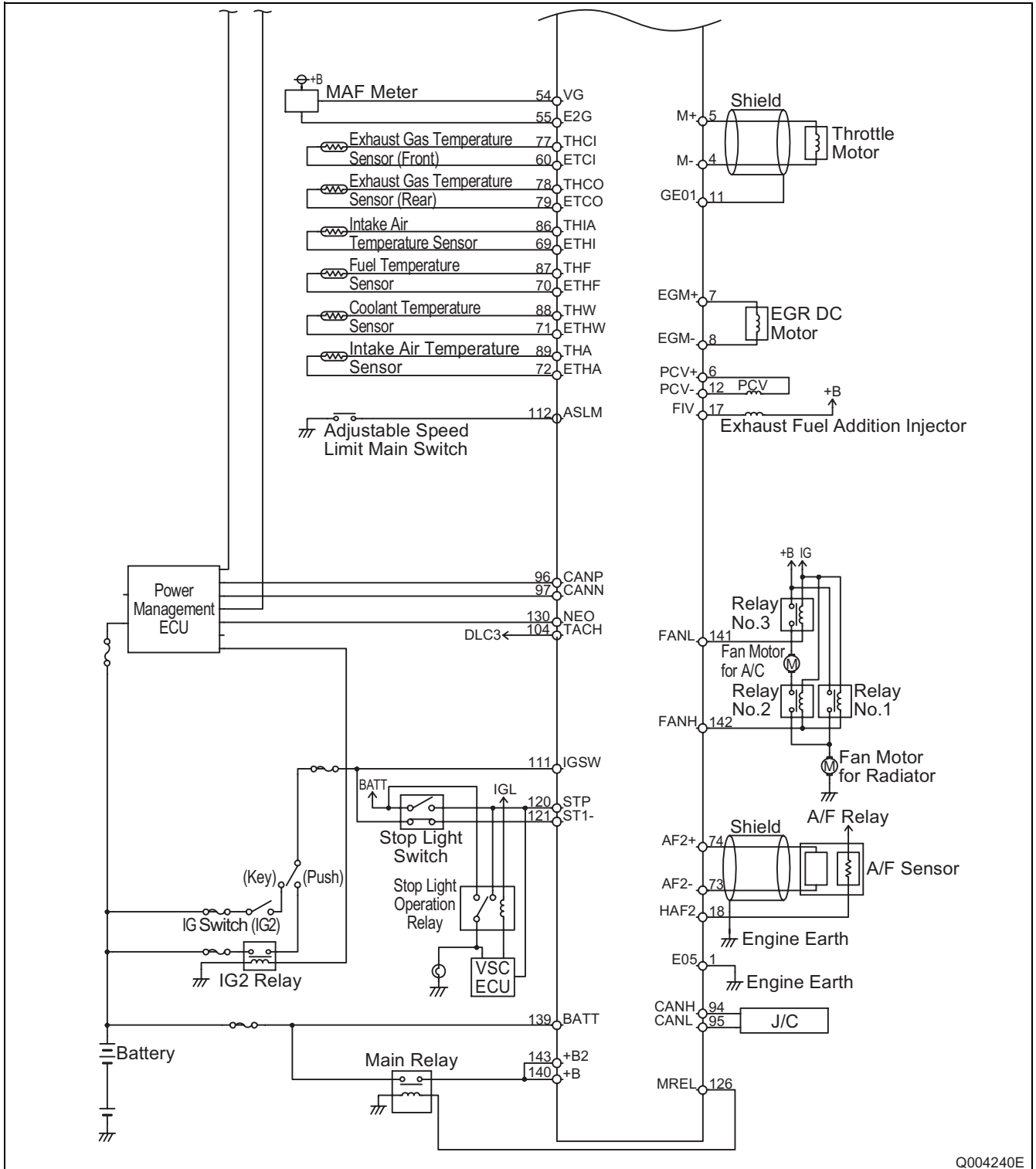
DTC (SAE code)	Detection Item
P2002	Particulate Trap Efficiency Below Threshold
P2032	Exhaust Gas Temperature Sensor Circuit Low
P2033	Exhaust Gas Temperature Sensor Circuit High
P2047	Reductant Injector Circuit/Open
P2048	Reductant Injector Circuit Low
P2049	Reductant Injector Circuit High
P2120	Throttle/Pedal Position Sensor/Switch "D" Circuit
P2121	Throttle/Pedal Position Sensor/Switch "D" Circuit Range/Performance
P2122	Throttle/Pedal Position Sensor/Switch "D" Circuit Low Input
P2123	Throttle/Pedal Position Sensor/Switch "D" Circuit High Input
P2125	Throttle/Pedal Position Sensor/Switch "E" Circuit
P2127	Throttle/Pedal Position Sensor/Switch "E" Circuit Low Input
P2128	Throttle/Pedal Position Sensor/Switch "E" Circuit High Input
P2138	Throttle/Pedal Position Sensor/Switch "D" / "E" Voltage Correlation
P2141	Exhaust Gas Recirculation Throttle Control Circuit "A" Low
P2142	Exhaust Gas Recirculation Throttle Control Circuit "A" High
P2226	Barometric Pressure Circuit
P2228	Barometric Pressure Circuit Low
P2229	Barometric Pressure Circuit High
P2237	O2 Sensor (A/F Sensor) Positive Current Control Circuit/Open
P2238	O2 Sensor (A/F Sensor) Positive Current Control Circuit Low
P2239	O2 Sensor (A/F Sensor) Positive Current Control Circuit High
P2252	O2 Sensor (A/F Sensor) Negative Current Control Circuit Low
P2253	O2 Sensor (A/F Sensor) Negative Current Control Circuit High
P2453	Diesel Particulate Filter (DPF) Differential Pressure Sensor Circuit Range/Performance
P2454	Diesel Particulate Filter (DPF) Differential Pressure Sensor Circuit Low
P2455	Diesel Particulate Filter (DPF) Differential Pressure Sensor Circuit High
P245C	Exhaust Gas Recirculation (EGR) Cooler Bypass Control Circuit Low
P245D	Exhaust Gas Recirculation (EGR) Cooler Bypass Control Circuit High

10. CONTOROL SYSTEM COMPONENTS

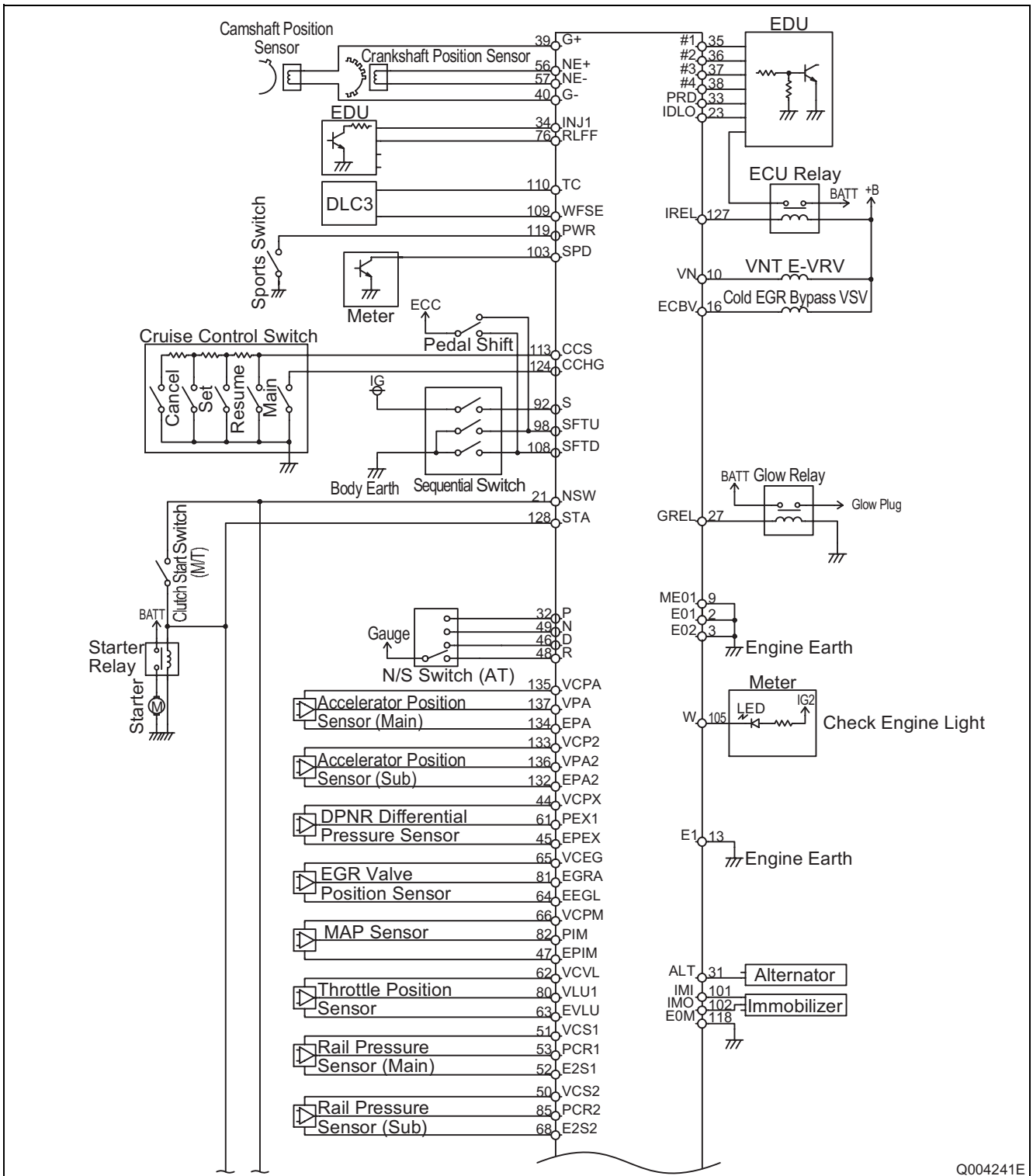
10.1 Engine ECU External Wiring Diagrams

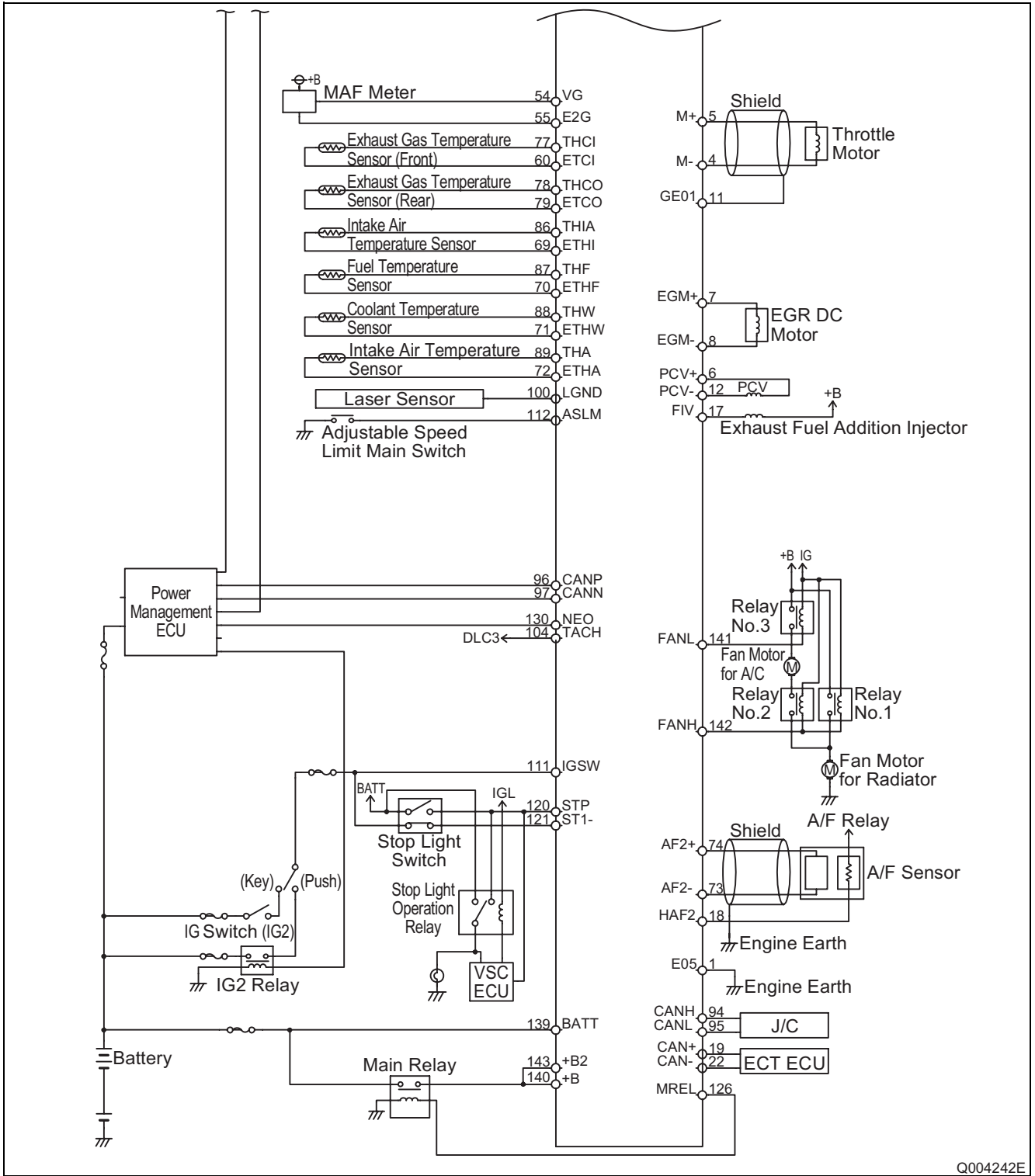
(1) 2AD-FHV (for TOYOTA D-CAT, MT), 2AD-FTV (for DPF System), 1AD-FTV (for DPF System)



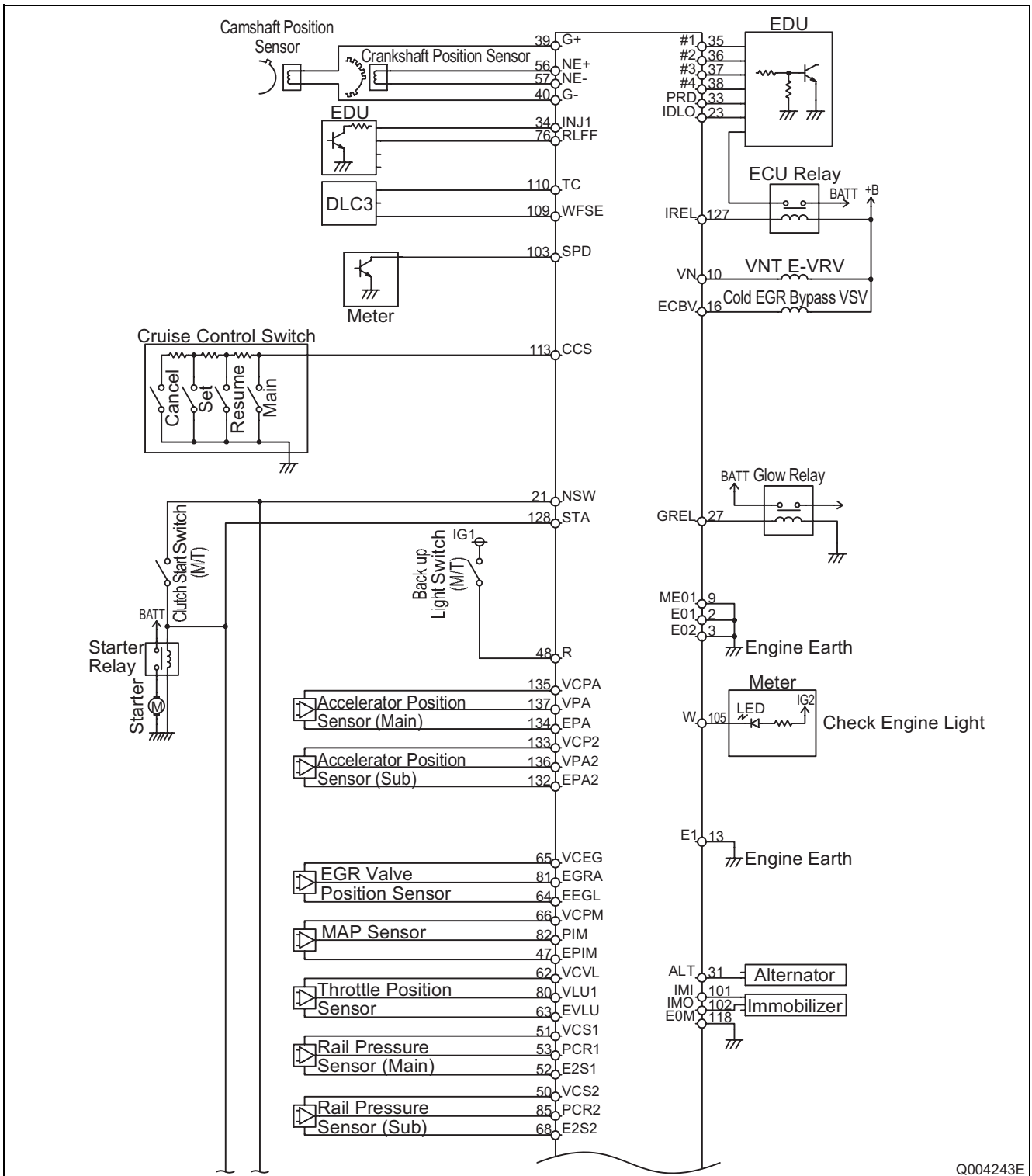


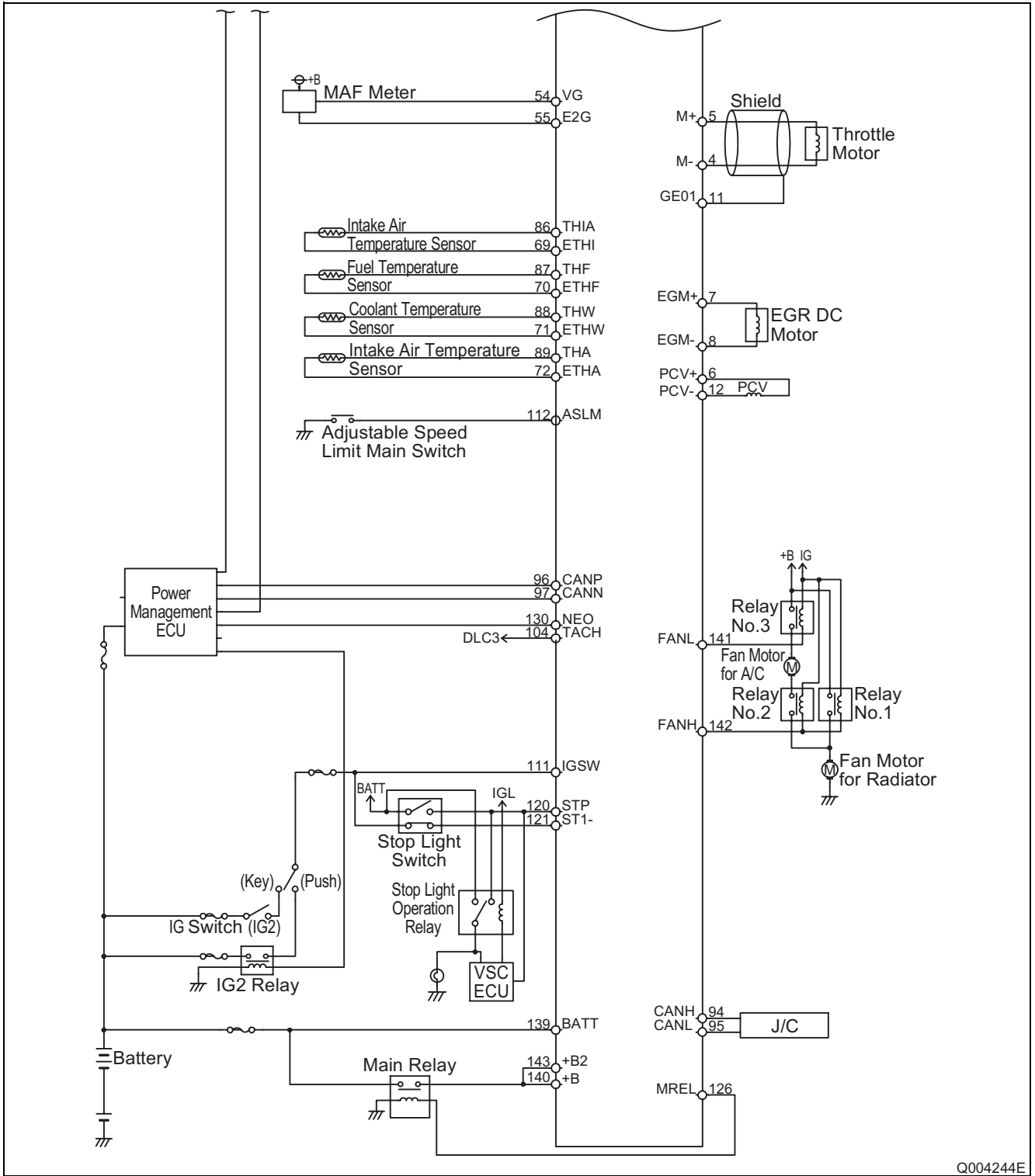
(2) 2AD-FHV (For TOYOTA DCAT, AT)





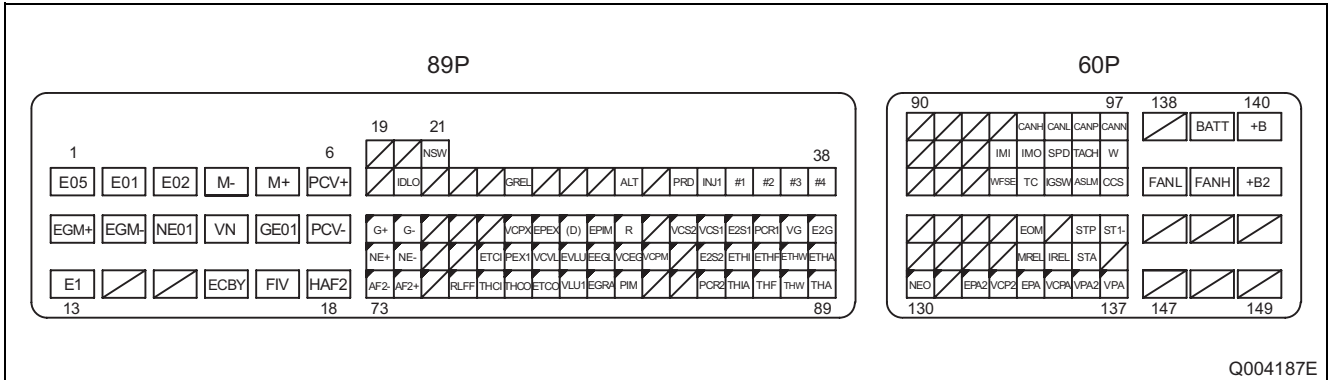
(3) 1AD-FTV (For CCO)



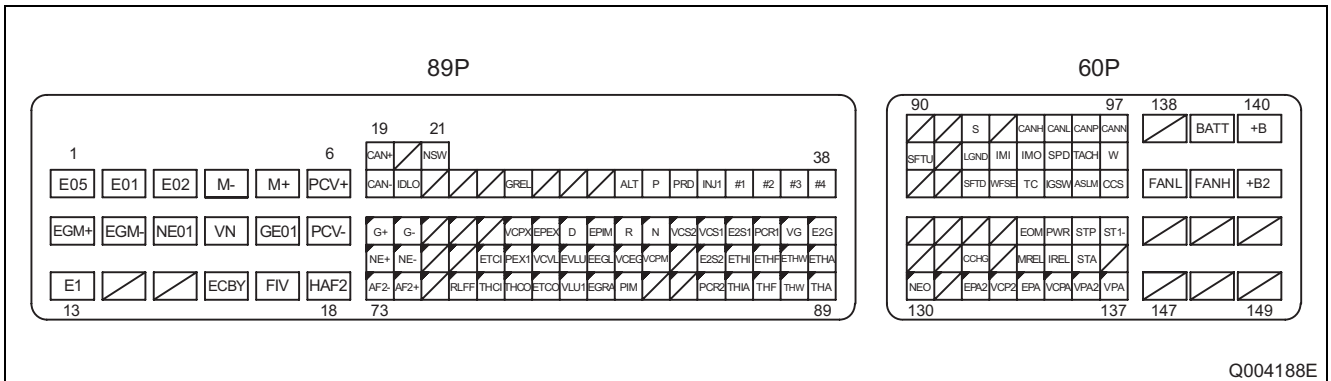


10.2 ECU Connector Terminal Layout

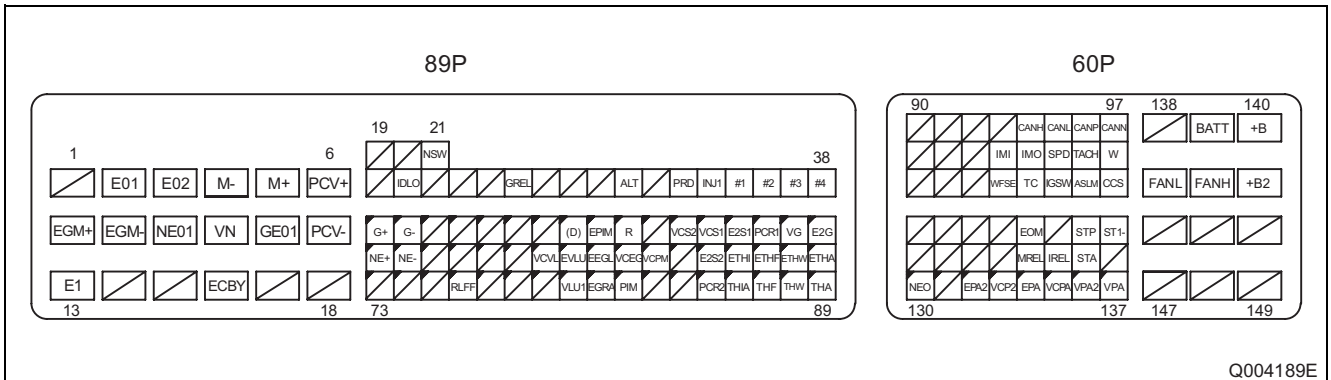
- Changes have been made to the ECU. The terminal layout is as per the diagram below.



2AD-FHV (For TOYOTA DCAT System, MT), 2AD-FTV (For DPF System), 1AD-FTV (For DPF System)



2AD-FHV (For TOYOTA DCAT System, AT)



1AD-FTV (For CCO)

Terminal Connections

Terminal No.	Terminal Code	Connection
1	E05	A/F Sensor (Out) Earth
2	E01	Power Earth (Engine Earth)
3	E02	Power Earth (Engine Earth)
4	M-	Throttle Motor (-)
5	M+	Throttle Motor (+)
6	PCV+	PCV
7	EGM+	EGR DC Motor (+)
8	EGM-	EGR DC Motor (-)
9	ME01	EGR DC Motor Ground
10	VN	E-VRV
11	GE01	Throttle Motor Shield Earth
12	PCV-	PCV
13	E1	Earth (Engine Earth)
14	-	-
15	-	-
16	ECBV	Cold EGR Bypass VSV
17	FIV	Fuel Injection Valve
18	MAF2	A/F Sensor (Out) Heater
19	CAN+	ECT ECU
20	-	-
21	NSW	Starter Relay and Power Management ECU
22	CAN-	ECT ECU
23	IDLO	EDU
24	-	-
25	-	-
26	-	-
27	GREL	Glow Plug Relay
28	-	-
29	-	-
30	-	-
31	ALT	Alternator
32	P	N/S Switch (P)
33	PRD	EDU
34	INJ1	EDU
35	#1	EDU
36	#2	EDU
37	#3	EDU
38	#4	EDU

Terminal No.	Terminal Code	Connection
39	G+	Camshaft Position Sensor (+)
40	G-	Camshaft Position Sensor (-)
41	-	-
42	-	-
43	-	-
44	VCPX	DPNR Differential Pressure Sensor (Power Supply)
45	VPEX	DPNR Differential Pressure Sensor Earth
46	D	N/S Switch (D)
47	EPIM	MAP Sensor Earth
48	R	N/S Switch (R)
49	N	N/S Switch (N)
50	VCS2	Rail Pressure Sensor (Sub) (Power Supply)
51	VCS1	Rail Pressure Sensor (Main) (Power Supply)
52	E2S1	Rail Pressure Sensor (Main) Earth
53	PCR1	Rail Pressure Sensor (Main)
54	VG	MAF Meter
55	E2G	MAF Meter Earth
56	NE+	Crankshaft Position Sensor (+)
57	NE-	Crankshaft Position Sensor (-)
58	-	-
59	-	-
60	ETCI	Exhaust Gas Temperature Sensor (Fr) Earth
61	PEX1	DPNR Differential Pressure Sensor
62	VCVL	Throttle Position Sensor (Power Supply)
63	EVLU	Throttle Position Sensor Earth
64	EEGL	EGR Valve Position Sensor Earth
65	VCEG	EGR Valve Position Sensor (Power Supply)
66	VCPH	MAP Sensor (Power Supply)
67	-	-
68	E2S2	Rail Pressure Sensor (Sub) Earth
69	ETHI	Intake Air Temperature Sensor Earth
70	ETHF	Fuel Air Temperature Sensor Earth
71	ETHW	Coolant Temperature Sensor Earth
72	ETHA	Intake Air Temperature Sensor Earth
73	AF2-	A/F Sensor (Out) Ground
74	AF2+	A/F Sensor (Out)
75	-	-
76	RLFF	EDU
77	THCI	Exhaust Gas Temperature Sensor (Fr)

Terminal No.	Terminal Code	Connection
78	THCO	Exhaust Gas Temperature Sensor (Rr)
79	ETCO	Exhaust Gas Temperature Sensor (Rr) Earth
80	VLU1	Throttle Position Sensor
81	EGRA	EGR Valve Position Sensor
82	PIM	MAP Sensor
83	-	-
84	-	-
85	PCR2	Rail Pressure Sensor (Main)
86	THIA	Intake Air Temperature Sensor
87	THF	Fuel Temperature Sensor
88	THW	Coolant Temperature Sensor
89	THA	Intake air temperature sensor
90	-	-
91	-	-
92	S	Sequential Switch
93	-	-
94	CANH	J/C
95	CANL	J/C
96	CANP	Power Management ECU
97	CANN	Power Management ECU
98	SFTU	Sequential Switch
99	-	-
100	LGND	Radar Sensor
101	IMI	Immobilizer
102	IMO	Immobilizer
103	SPD	Vehicle Speed Sensor (MRE)
104	TACH	DLC3
105	W	Check Engine Light
106	-	-
107	-	-
108	SFTD	Sequential Switch
109	WFSE	DLC3
110	TC	DLC3
111	IGSW	IG2 Relay
112	ASLM	Adjustable Speed Limit Main Switch
113	CCS	Cruise Control Switch
114	-	-
115	-	-
116	-	-

Terminal No.	Terminal Code	Connection
117	-	-
118	EOM	Earth
119	PWR	Sports Switch
120	STP	Stop Light Switch
121	ST1-	Stop Light Switch
122	-	-
123	-	-
124	CCHG	Cruise Control Switch
125	-	-
126	MREL	Main Relay
127	IREL	EDU Relay
128	STA	Starter Relay and Power Management ECU
129	-	-
130	NEO	Power Management ECU
131	-	-
132	EPA2	Accelerator Position Sensor (Sub) Earth
133	VCP2	Accelerator Position Sensor (Sub) (Power Supply)
134	EPA	Accelerator Position Sensor (Main) Earth
135	VCPA	Accelerator Position Sensor (Main) (Power Supply)
136	VPA2	Accelerator Position Sensor (Sub)
137	VPA	Accelerator Position Sensor (Main)
138	-	-
139	BATT	Battery
140	+B	Battery Main Relay
141	FANL	Fan Relay
142	FANH	Fan Relay
143	+B2	Main Relay
144	-	-
145	-	-
146	-	-
147	-	-
148	-	-
149	-	-

