DENSO

MAZDA SKYACTIV-D Engine (EURO 6)

Common Rail System (CRS) Service Manual

Issued : April 2012

Applicable Vehicle :

Vehicle Name	Release Date
CX-5	March 2012

DENSO CORPORATION

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Operation Section

1. Introduction

1.1 SKYACTIV

- The name SKYACTIV was chosen for several innovative next generation MAZDA technologies to evoke an image of vehicles that are not only "fun to drive", but achieve "superior environmental friendliness and safety." This manual introduces the following six key SKYACTIV technologies.

Technological Field	Name	Description
Engine	SKYACTIV-G	A next-generation, high efficiency Direct Fuel Injection (DFI) engine that suppresses knocking and achieves a high compression ratio (14:0).
	SKYACTIV-D	A next-generation clean diesel engine that achieves a low compression ratio (14:0).
Transmission	SKYACTIV-Drive	A next generation, high efficiency automatic transmission that achieves a high torque transmission ratio via lockup in all regions.
	SKYACTIV-MT	A next-generation manual transmission for FF vehicles that is both lightweight and compact.
Body	SKYACTIV-Body	A next-generation, lightweight body that achieves high rigidity combined with high collision safety.
Chassis	SKYACTIV-Chassis	A next-generation, high-performance, lightweight chassis that creates an effective balance between handling, and driving comfort.

1.2 SKYACTIV-D Features

- SKYACTIV-D takes the following measures to lower fuel consumption.
  - Use of a variable valve lift mechanism to improve ignition stability when the engine is cold.
  - Use of two-stage supercharging control to generate high levels of supercharging efficiently. As such low emissions performance, low fuel consumption performance, high torque, and high response are attained.
  - Use of Exhaust Gas Recirculation (EGR) to clean exhaust gas and improve fuel economy.
  - Use of i-stop to improve fuel economy, as well as to lower the amount of exhaust gas and idling noise.

Low Compression Ratio
- Combustion performance is improved via a low compression ratio (14:0).

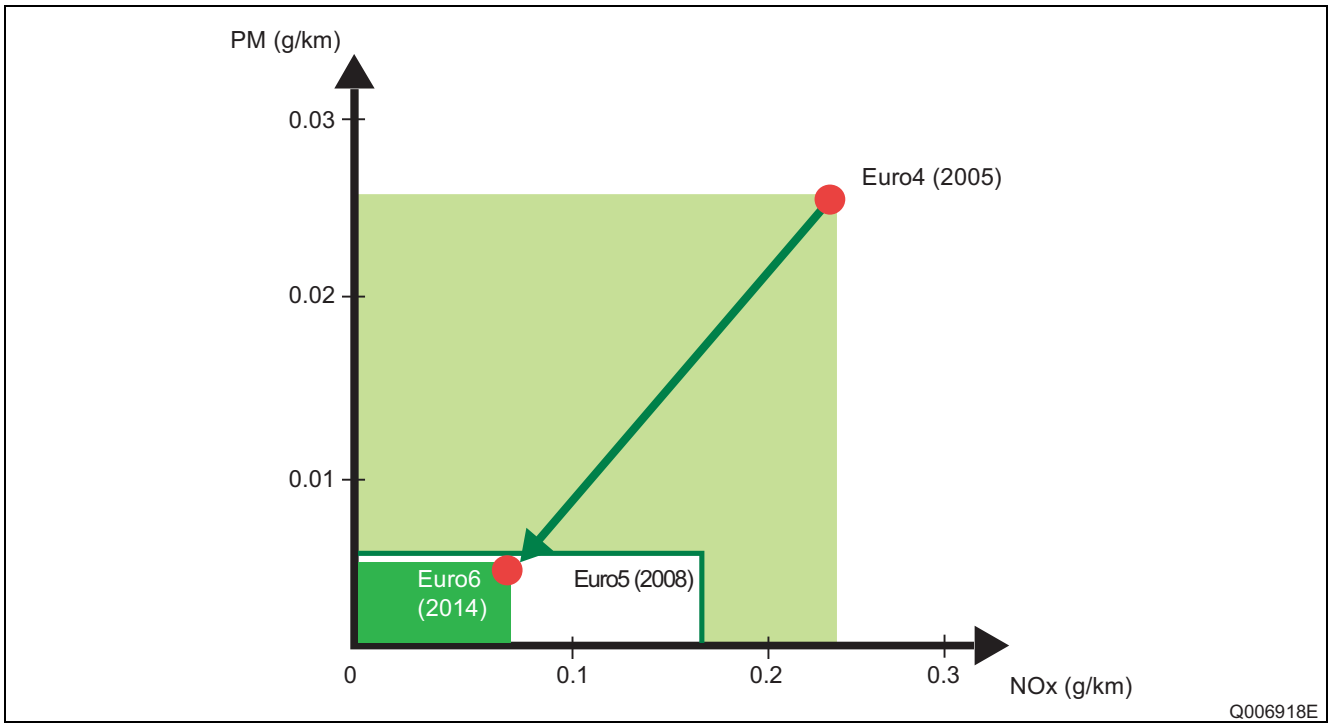
Weight Reductions
- Aluminum alloy cylinder block
- Integrated exhaust manifold and cylinder head

Weight Reductions and Reduced Mechanical Resistance Losses
- Optimized piston shape
- Lightweight crankshaft journals

2. Applicable Vehicles and Parts Information

2.1 Outline

- The SKYACTIV-D engine is equipped with the MAZDA CX-5 released in March 2012.
  As a result, a Common Rail System (CRS) for the SKYACTIV-D engine has been newly designated.
  This manual describes items specific to the parts used in the CRS for the SKYACTIV-D engine. For CRS basics, refer to the "COMMON RAIL SYSTEM SERVICE MANUAL -OPERATION (Doc ID: 00400534EA)."
- The SKYACTIV-D engine CRS has undergone the following improvements to comply with exhaust gas regulations for 2014 (Euro 6).
  - System pressure: 200 MPa
  - Supply pump (HP3): Complies with pressures up to 200 MPa, newly designated injector return system discharge port
  - Rail: Complies with pressures up to 200 MPa, use of pressure relief valve
  - Injectors: G3P (use of piezo injectors)
  - Use of DPF system
  - Use of injector return system



2.2 Applicable Vehicles

Vehicle Name	Vehicle	Engine Type	Exhaust Volume	Production Start Date
CX-5	LDA-KE2FW (2WD) LDA-KE2AW (4WD)	SH	2.2 L	March 2012

2.3 List of Primary Parts

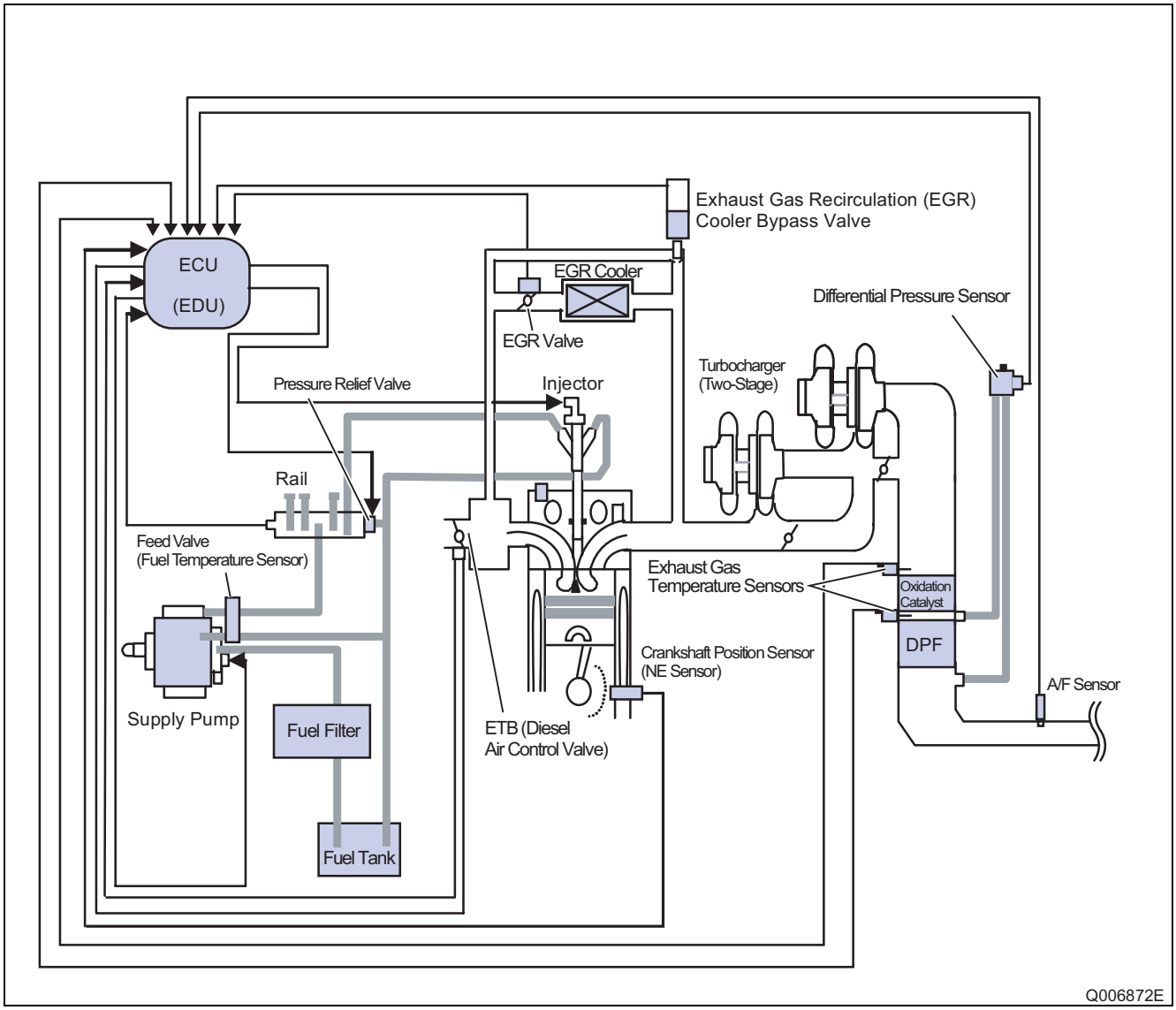
Part Name	DENSO Part Number	Customer Part Number	Remarks
Supply Pump	294000-166#	SH01-13800	HP3
Rail	095600-502#	SH01-13GC0	
Injector	295900-026#	SH01-13H50	G3P
ECU	275700-507#	SH02-18881	AT, 2WD Low power
	275700-511#	SH04-18881	AT, 4WD High power
	275700-508#	SH01-18881	MT, 2WD Low power
	275700-506#	SH1A-18881	MT, 4WD Low power
	275700-509#	SH1B-18881	AT, 4WD Low power
	275700-504#	SH1J-18881	MT, 4WD High power
	275700-502#	SH1K-18881	AT, 4WD High power
	275700-510#	SH1M-18881	AT, 2WD High power
Crankshaft Position Sensor	949979-066#	PE01-18221	NE Sensor
Cylinder Recognition Sensor	949979-188#	N3R4-18221	G Sensor
Coolant Temperature Sensor	179700-048#	SH01-18840	
Fuel Temperature Sensor	294009-010#	SH01-18822	With O-ring
A/F Sensor	211200-444#	SH01-188G1	
Exhaust Gas Temperature Sensor	265600-327#	SH01-187G0	Oxidation catalyst inlet
	265600-328#	SH02-187G0	DPF catalyst inlet
ETB (Diesel Air Control Valve)	197920-010#	SH01-136B0	
Exhaust Gas Recirculation (EGR) Valve	150100-020#	SH01-20300	

Part Name	DENSO Part Number	Customer Part Number	Remarks
Fuel Filter	186300-898#	SH01-13480	With heater, left-hand driver vehicles
	186000-707#	SH02-13480	Without heater, left-hand driver vehicles
	186300-706#	SH03-13480	Without heater, right-hand driver vehicles
Intercooler	127100-411#	SH01-13565	
Jet Pump	167750-106#	-	4WD
Electric Water Pump	113730-059#	KD-612FX	For the EU

2.4 System Configuration

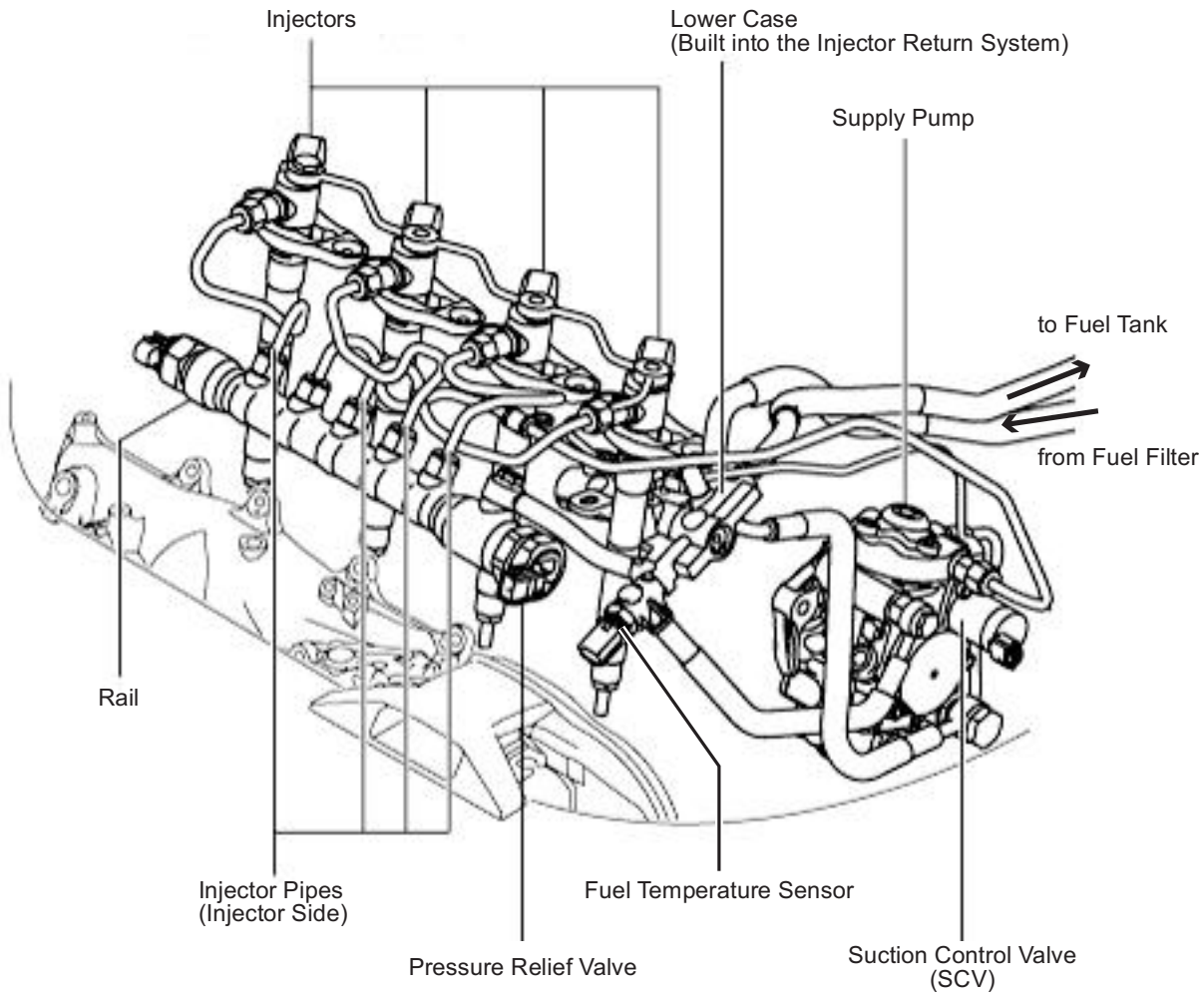
(1) Engine System Configuration

• The SKYACTIV-D engine system is configured as shown in the figure below.



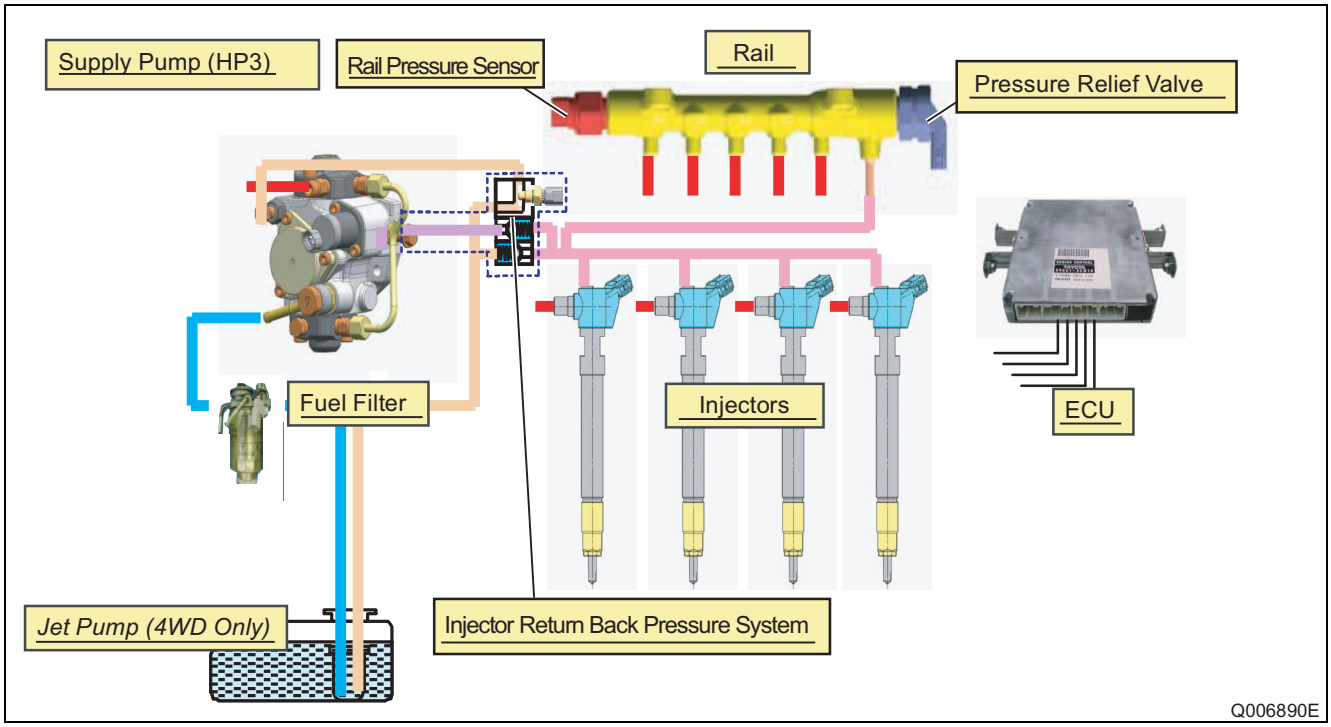
(2) Mounting Figure for Primary CRS Parts

• The primary parts for the SKYACTIV-D CRS are mounted as shown in the figure below.



(3) CRS Configuration

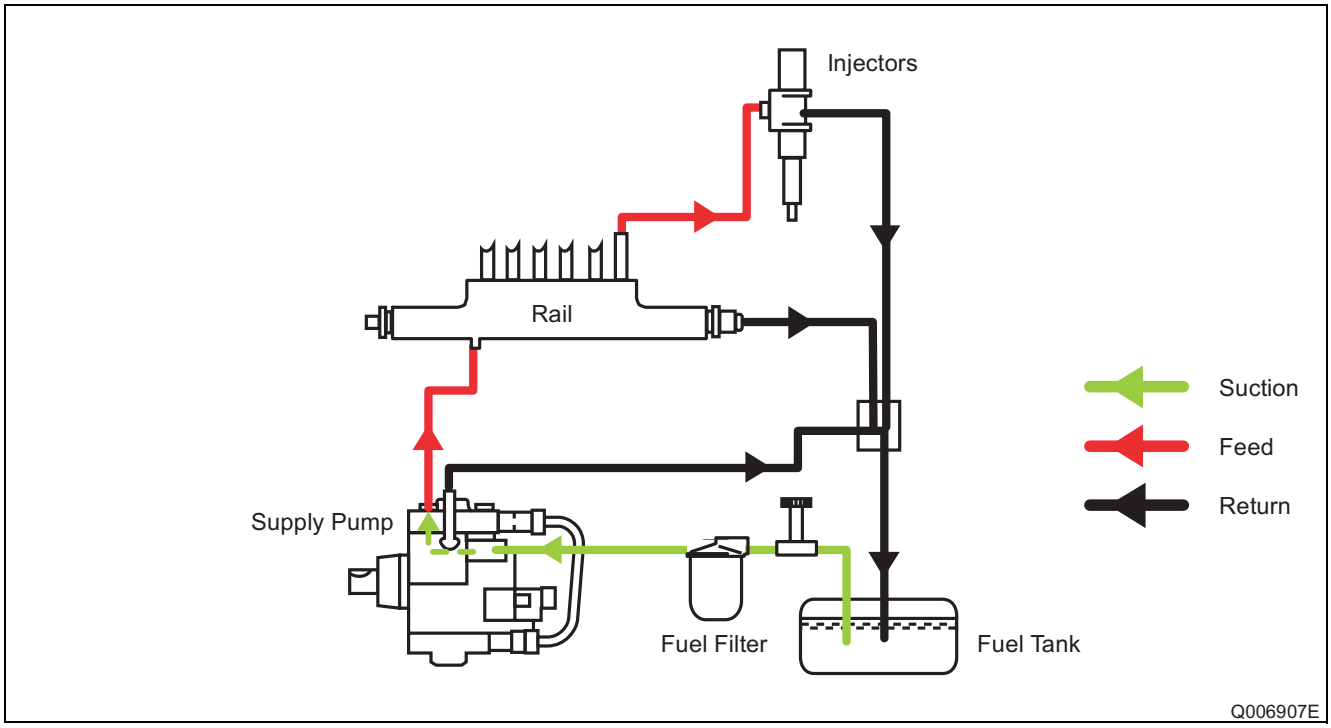
• The functional parts of the SKYACTIV-D CRS are shown in the figure below.



SKYACTIV-D

(4) Fuel Flow

• Fuel flows through the CRS as shown below.

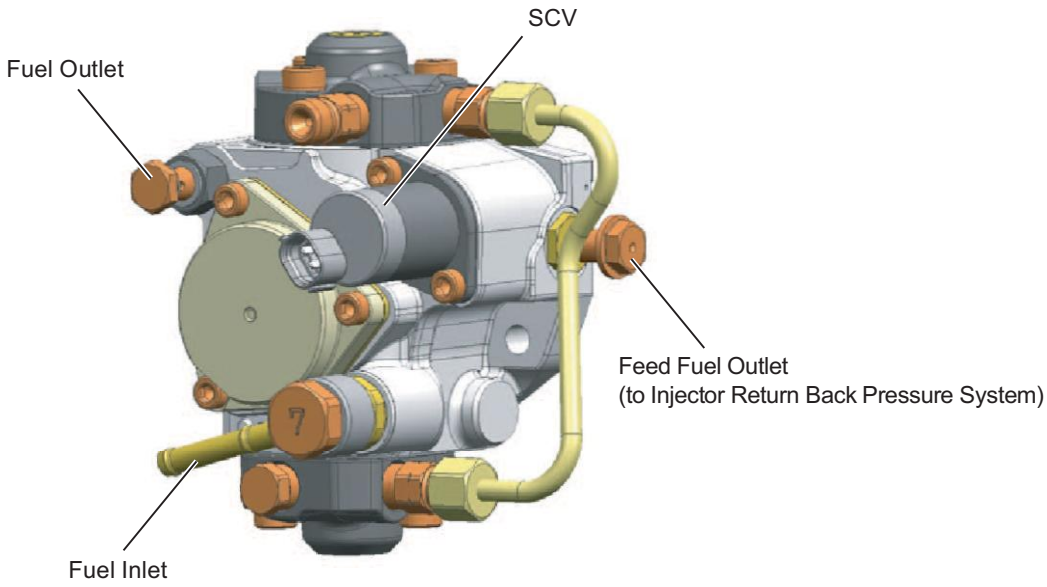


Conventional Type

3. Supply Pump

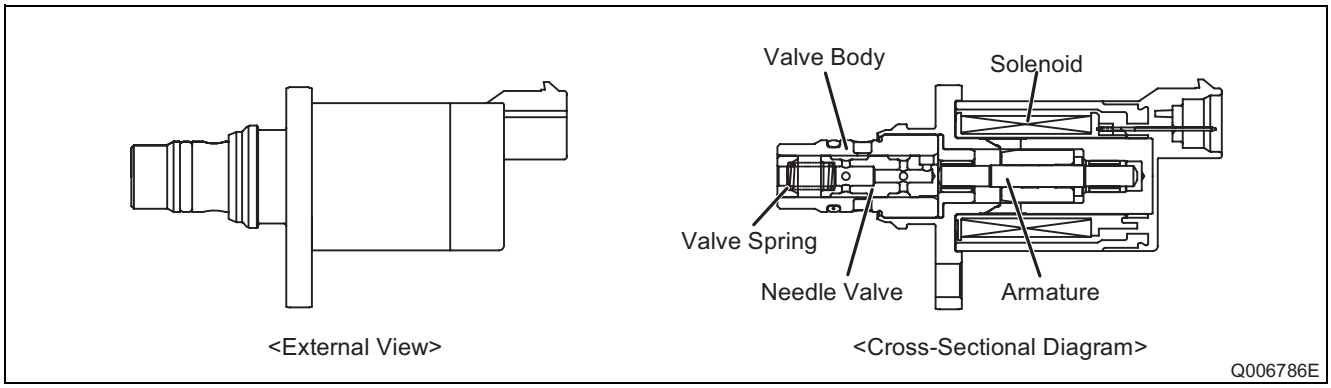
3.1 Outline

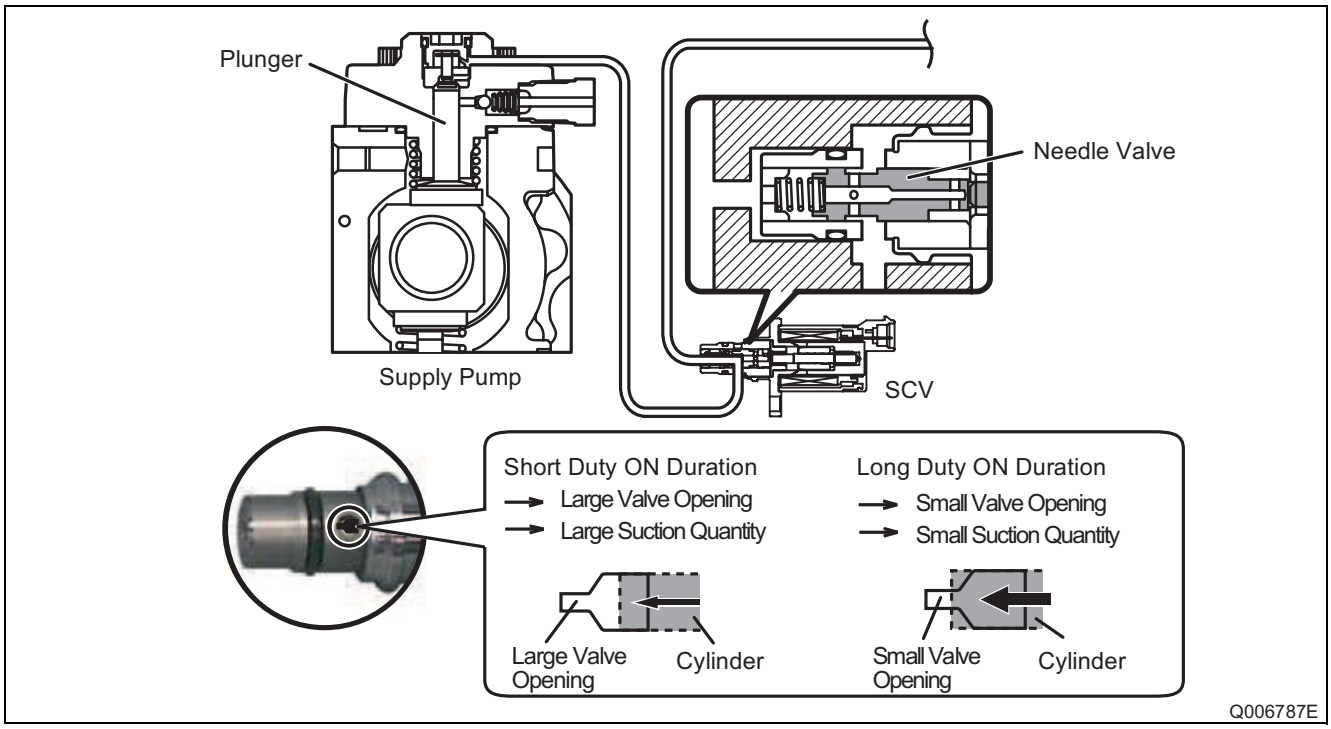
- The supply pump used with the SKYACTIV-D engine CRS (HP3) complies with pressures up to 200 MPa. In addition, a port has been established to feed fuel to the injector return system used with the CRS. The fuel temperature sensor is separate from the pump, and is now set in the path between the supply pump and the fuel return.



3.2 Suction Control Valve (SCV)

- The SCV used with the SKYACTIV-D engine CRS is a normally open SV3 type. The SV3 type has the following features.
  - A more compact design compared to the SV1 type due to a smaller solenoid
  - Improved valve sliding performance





Operation Concept Diagram

4. Rail

4.1 Outline

- The rail used with the SKYACTIV-D engine CRS is compliant with pressures up to 200 MPa. The rail uses a new model pressure relief valve.

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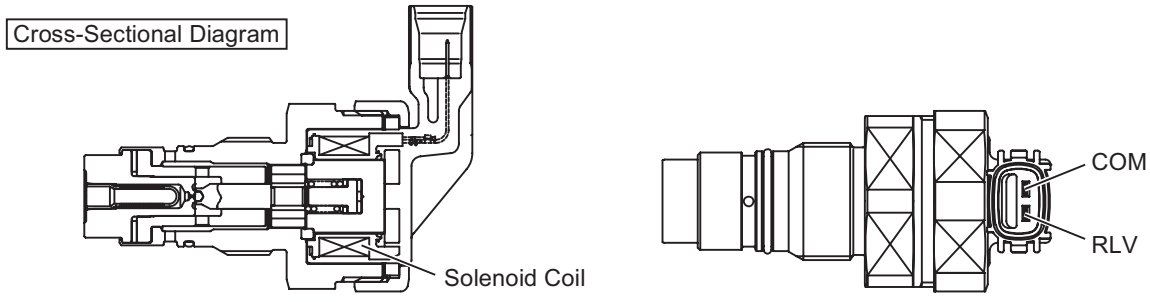
(1) Pressure Relief Valve

- The pressure relief valve controls rail fuel pressure. If rail pressure reaches or exceeds a specified value, a solenoid coil is energized to open a path in the valve and return fuel to the fuel tank, thereby reducing pressure to the specified value.



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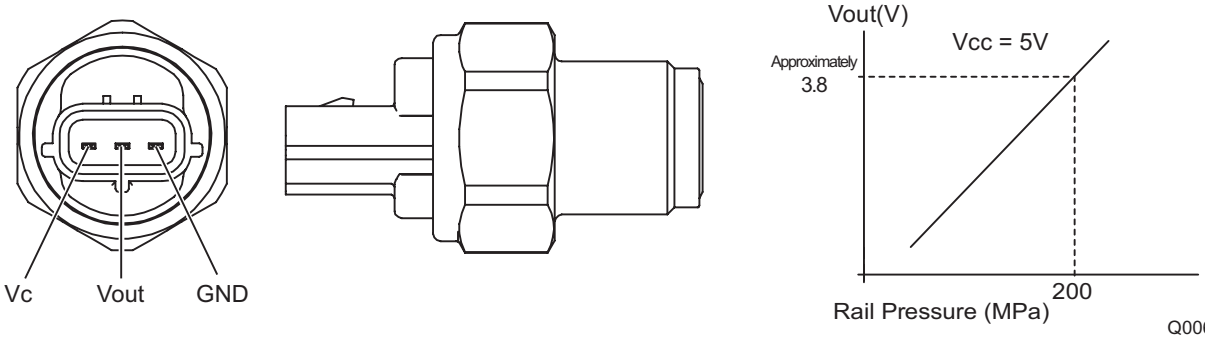
(2) Rail Pressure Sensor

- The rail pressure sensor is compliant with pressures up to 200 MPa.



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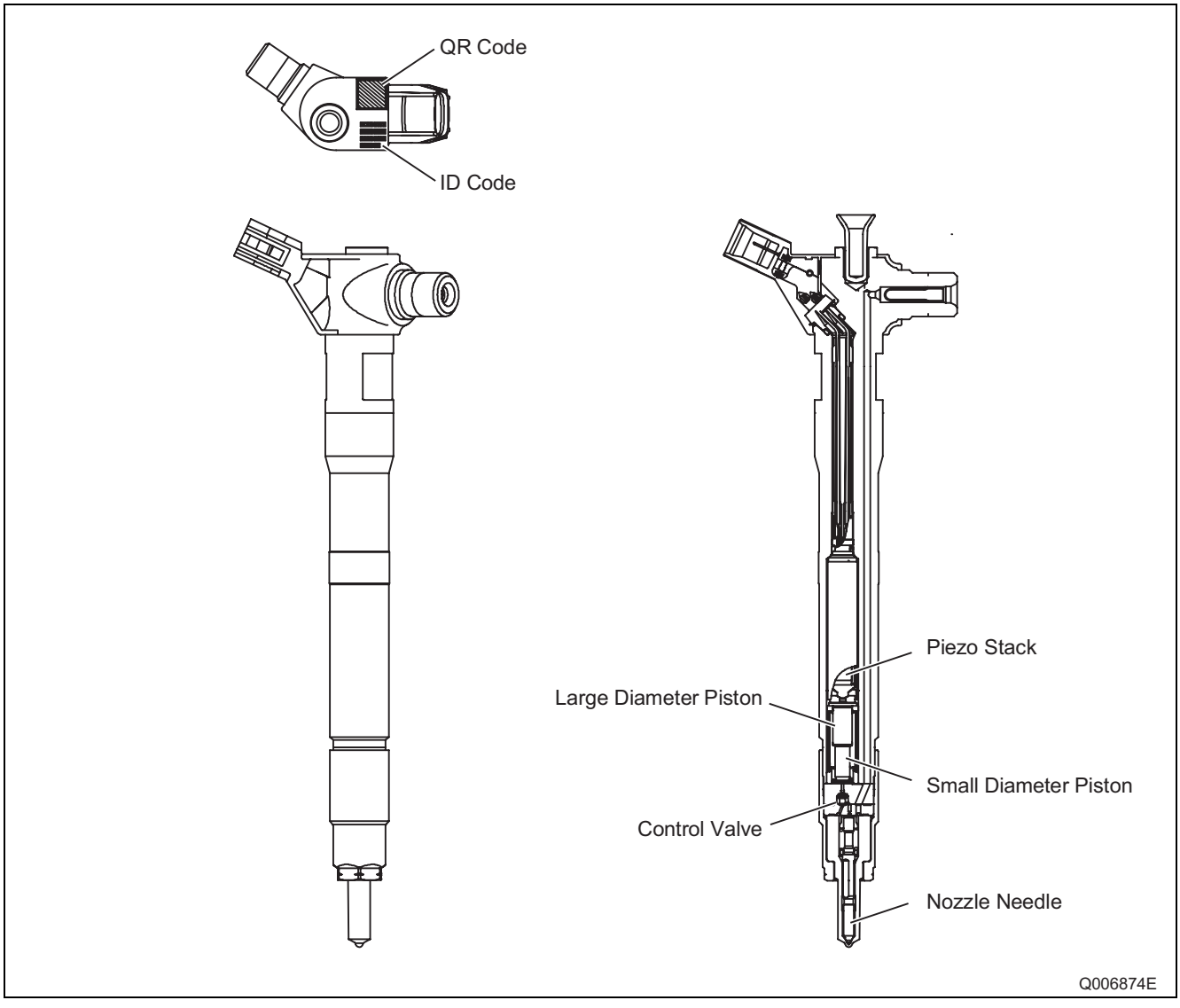
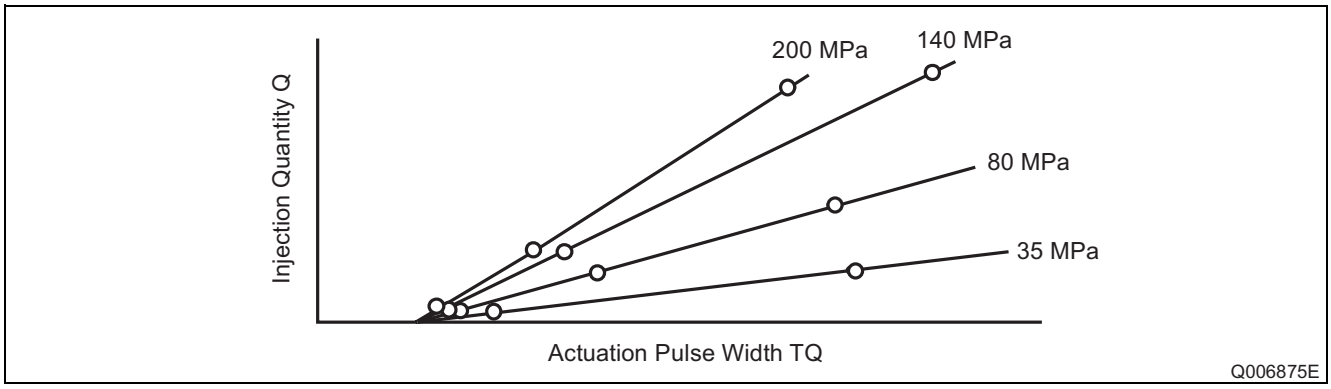
5. Injectors

5.1 Outline

- The G3P type piezo injectors equipped with the SKYACTIV-D engine CRS can inject fuel at extremely high pressure (200 MPa). As a result, the atomization of the fuel mist from the nozzle is improved, leading to increased combustion efficiency, and reduced exhaust gas quantity.
- A piezo injector primarily 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. By applying voltage, the characteristics of a piezo element are used to expand and shrink the stack via the inverse piezoelectric effect.
  - Small displacements of the piezo stack are expanded by transmitting actuation from the large diameter piston to the small diameter piston.
  - The small diameter piston moves the control valve to regulate the pressure inside the injector.
  - The nozzle needle is moved up and down via control valve pressure control.





Correction Points Using QR Codes

5.2 Operation

Non-Injection

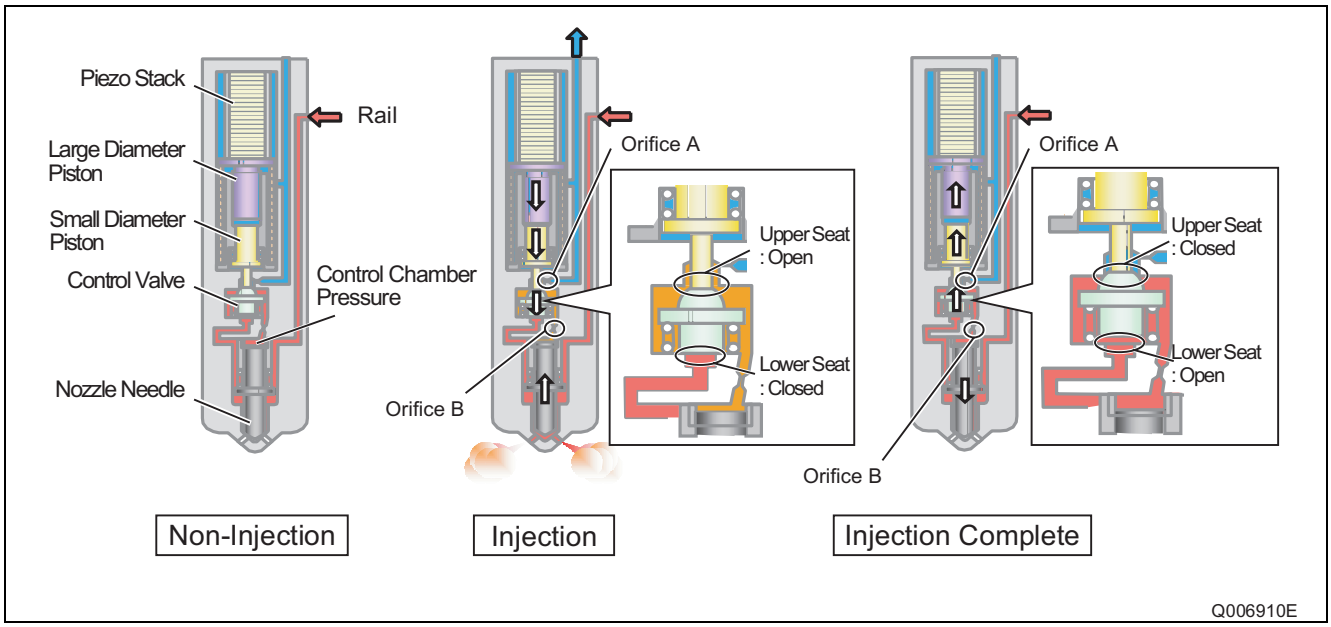
- When voltage is not applied to the piezo stack, the pressure in the control chamber and at the bottom of the nozzle needle is at the same value as fuel in the rail. The nozzle needle remains closed due to the difference in surface area exposed to pressure between the control chamber and bottom of the nozzle needle. Therefore, injection is not performed.

Injection

- When voltage is applied to the piezo stack, the stack expands. The transmission of actuation power from the large diameter piston to the small diameter piston expands the displacement of the piezo stack and pushes the control valve down, thereby opening the upper seat and closing the lower seat. As a result, fuel is discharged from the control chamber to the leak path via orifice A, and control chamber pressure decreases. Since pressure on the bottom of the nozzle needle becomes greater than that of the control chamber, the nozzle needle is pushed up and injection begins.

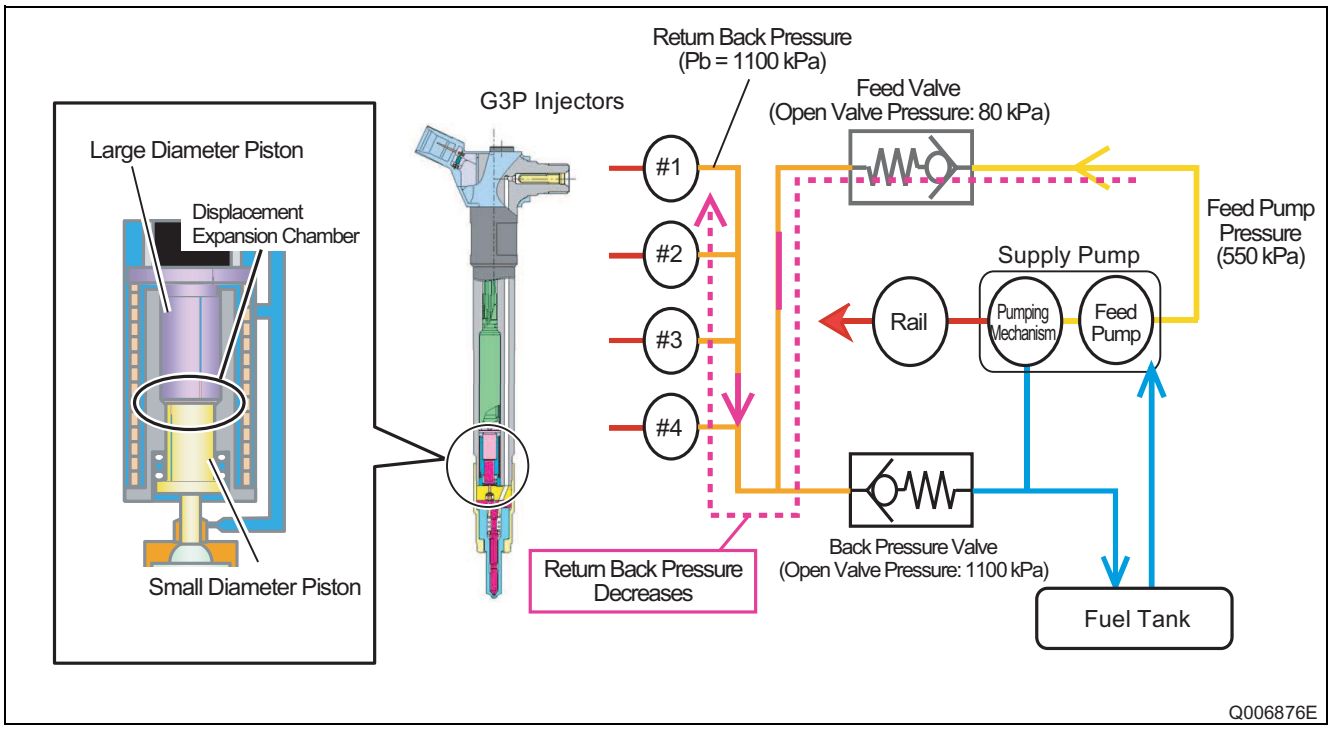
Injection Complete

- 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.



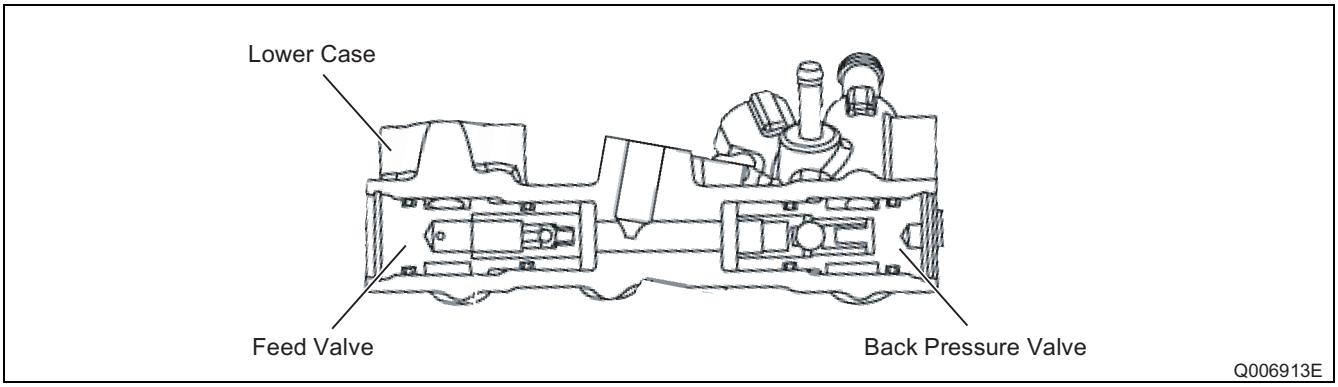
5.3 Injector Return Back Pressure System

- When the injector return side is dry (no fuel) and air enters the displacement expansion chamber inside the injector, the ability to transmit piezo stack displacement is lost, and injection is no longer possible. To prevent the aforementioned circumstances, fuel is sent to the injector return side from the supply pump via the feed valve to apply back pressure. The air is therefore compressed and eliminated to improve startability. The injector return system is built into the lower case of the engine compartment. Injector return system construction and operation are detailed below.



(1) Construction

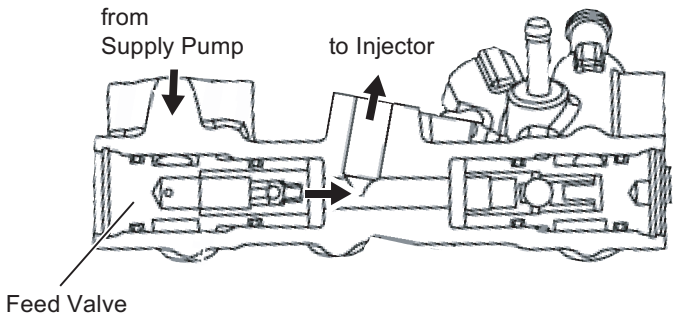
- Injector return system construction is shown in the figure below.



(2) Operation

When the Feed Valve Operates

• When the pressure in the lower case drops below a constant value, a ball inside the valve presses on a spring, and fuel flows into the lower case (injector side) from the supply pump.



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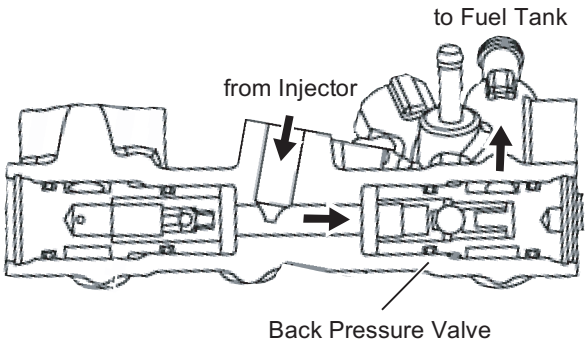
When the Back Pressure Valve Operates

• When the fuel returning from the injectors exceeds a constant value, a ball inside the valve presses on a spring, and a fuel path is opened to the fuel tank side.



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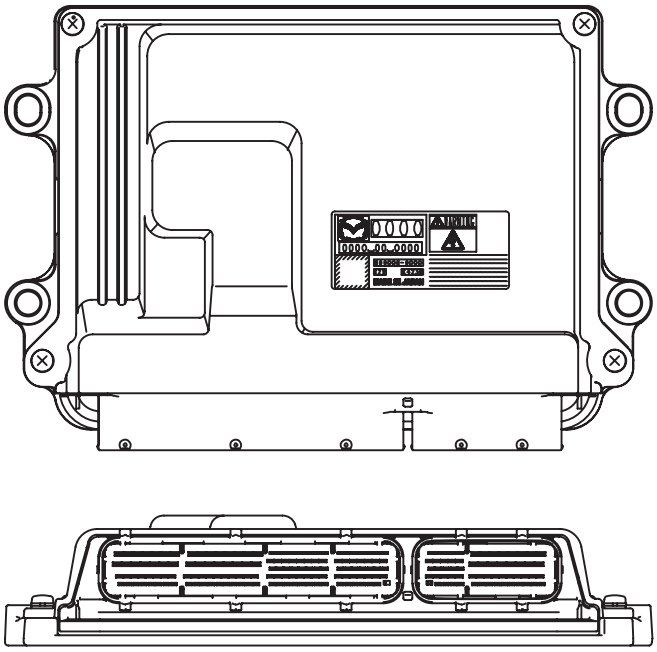
6. Control System Parts

6.1 Engine ECU

- The engine ECU regulates the fuel injection system and performs overall engine control.



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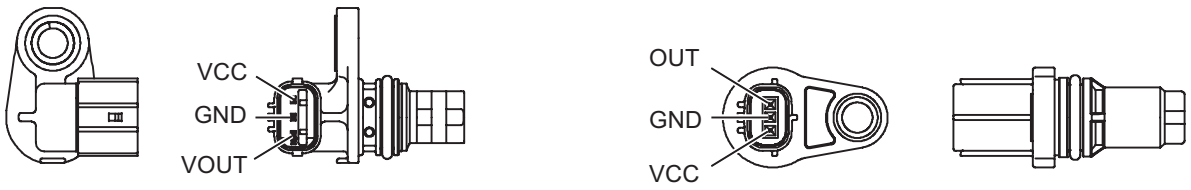
6.2 Sensors

(1) Crankshaft Position Sensor (NE Sensor) and Cylinder Recognition Sensor (G Sensor)

- The crankshaft position sensor and cylinder recognition sensor used with the SKYACTIV-D engine CRS are Magnetic Resistance Element (MRE) type devices.



Crankshaft Position Sensor
(NE Sensor)

Cylinder Recognition Sensor
(G Sensor)

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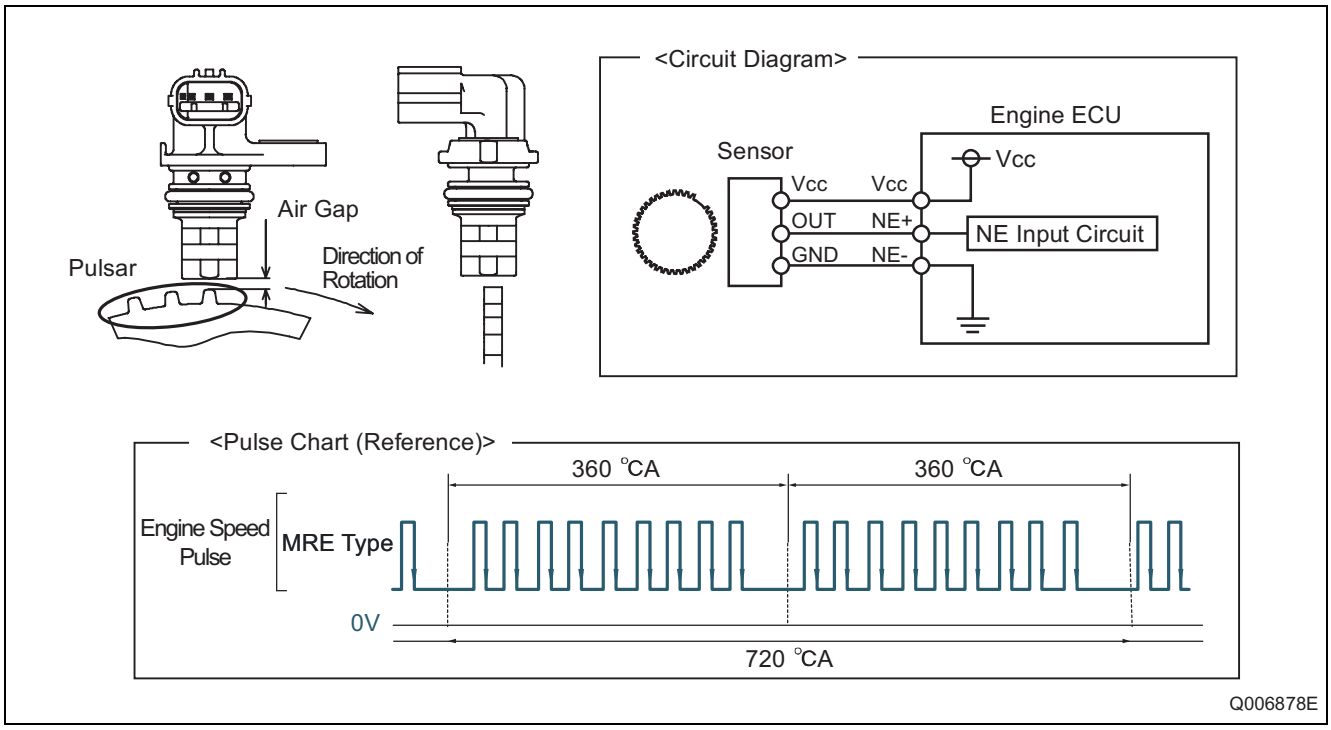
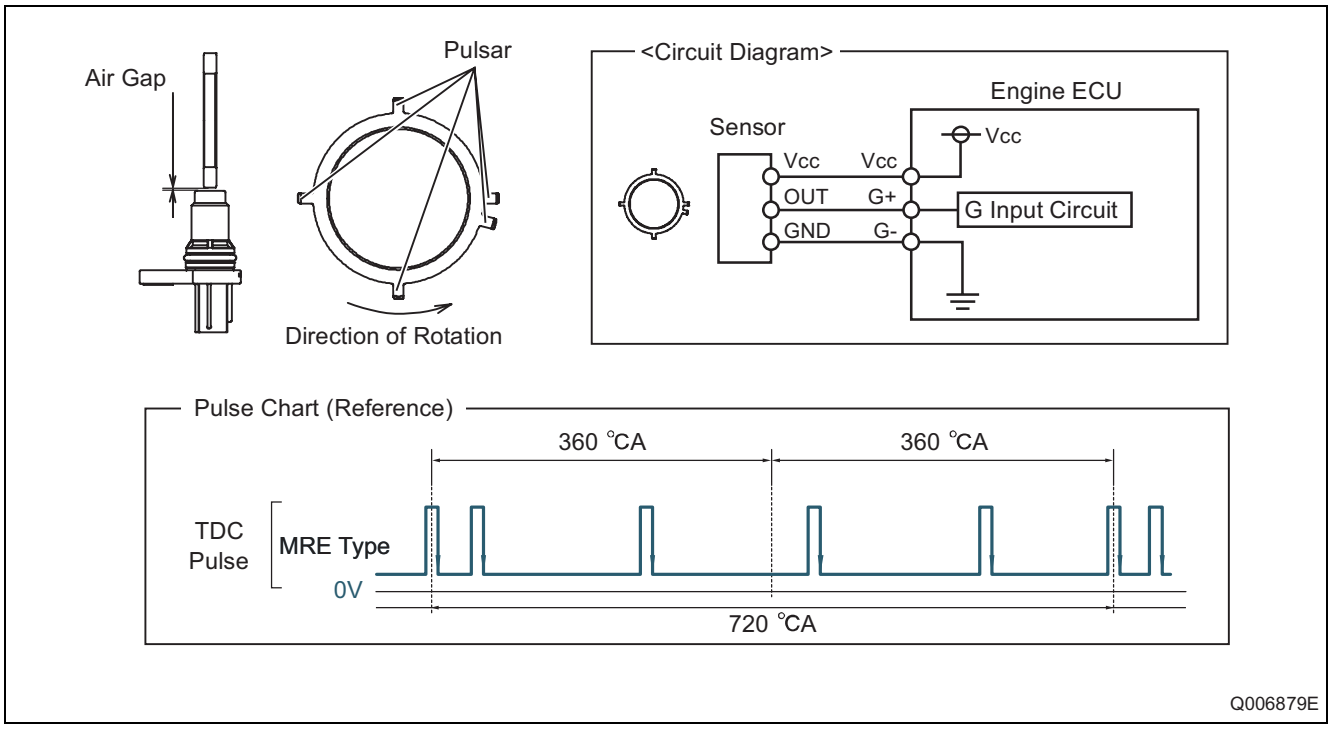
Crankshaft Position Sensor (NE Sensor)

• The crankshaft position sensor detects the crankshaft angle. The pulsar has 56 teeth (separated at 6°CA intervals, with four missing teeth to detect Top Dead Center [TDC] for cylinders no. 1 and no. 4).



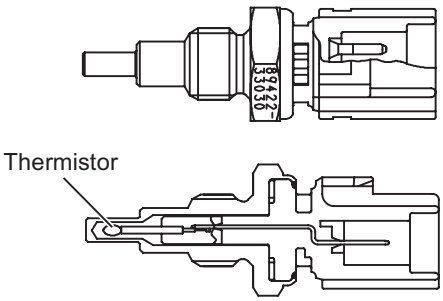
Cylinder Recognition Sensor (G Sensor)

• The cylinder recognition sensor identifies the engine cylinders. The pulsar has five teeth (recognition of TDC for each cylinder + recognition of cylinder no. 1).



(2) Coolant Temperature Sensor

- The coolant temperature sensor is attached to the engine cylinder block to detect engine coolant temperature.
- The coolant temperature sensor makes use of a thermistor. Thermistors display a characteristic in which the resistance value of the element changes in accordance with temperature. As such, the thermistor detects temperature by converting changes in coolant temperature into changes in resistance. As temperature increases, the thermistor resistance value decreases.



<Resistance Value Characteristics>

Temperature (℃)	Resistance Value (kΩ)
-20	15.0
20	2.5
80	0.3
110	0.1

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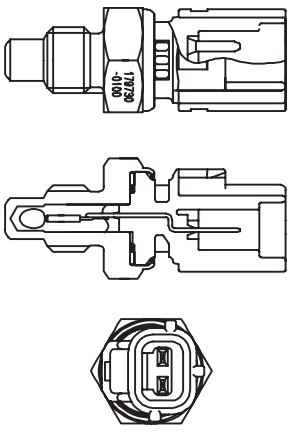
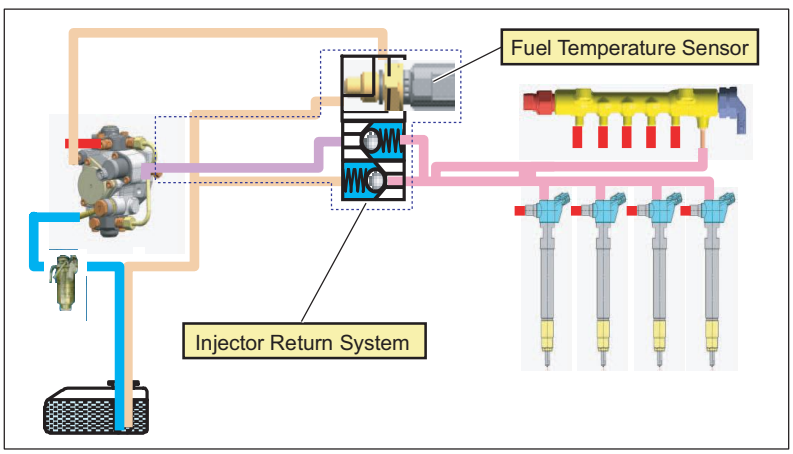
(3) Fuel Temperature Sensor

- The fuel temperature sensor detects the fuel temperature, and sends corresponding signals to the engine ECU. The ECU then calculates an injection correction suited to the fuel temperature based on the signal information. The SKYACTIV-D engine CRS has a fuel return path from the supply pump built into the engine compartment lower case.



<Reference: Temperature/Resistance Characteristics>

Temperature (℃)	Resistance Value (kΩ)
- 30	25.40
- 20	15.04
- 10	9.16
0	5.74
10	3.70
20	2.45
30	1.66
40	1.15
50	0.811
60	0.584
70	0.428
80	0.318
90	0.240
100	0.1836
110	0.1417
120	0.1108



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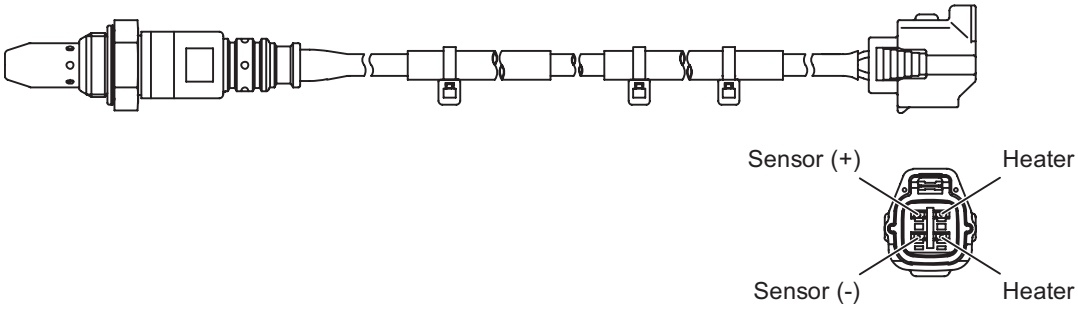
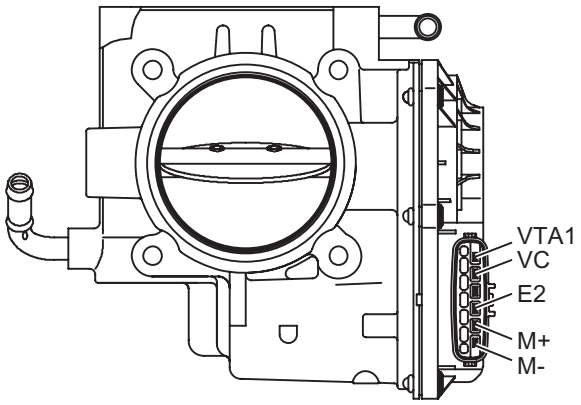
(4) A/F Sensor

• The A/F sensor detects the air-fuel ratio in the engine across all regions from rich to lean based on the oxygen concentration in the vehicle exhaust gas and the concentration of unburned fuel. The air-fuel ratio is fed back to the engine ECU to control combustion in a state optimized to the driving conditions.

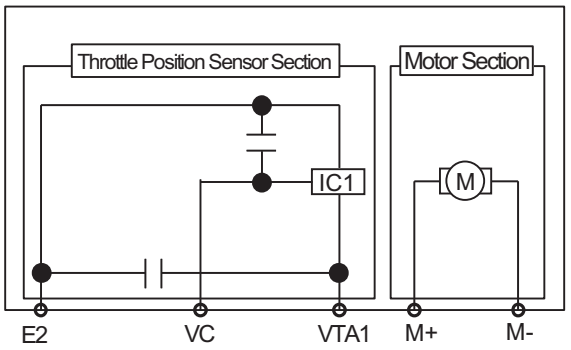


(5) ETB (Diesel Air Control Valve)

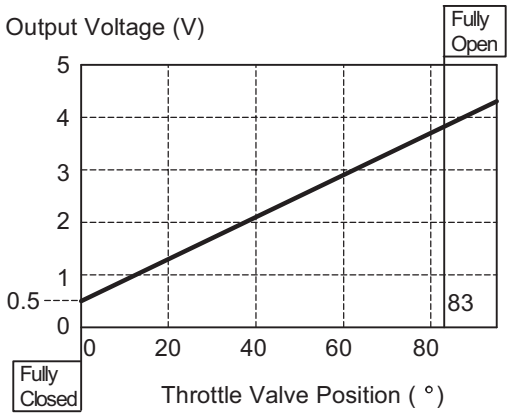
• The ETB operates a DC throttle motor to change the throttle position in accordance with signals from the ECU that correspond to the accelerator position. Additionally, the ETB is interlocked with the key switch to block intake air when stopping the engine to reduce engine vibration.



<Circuit Diagram>



Output Characteristics



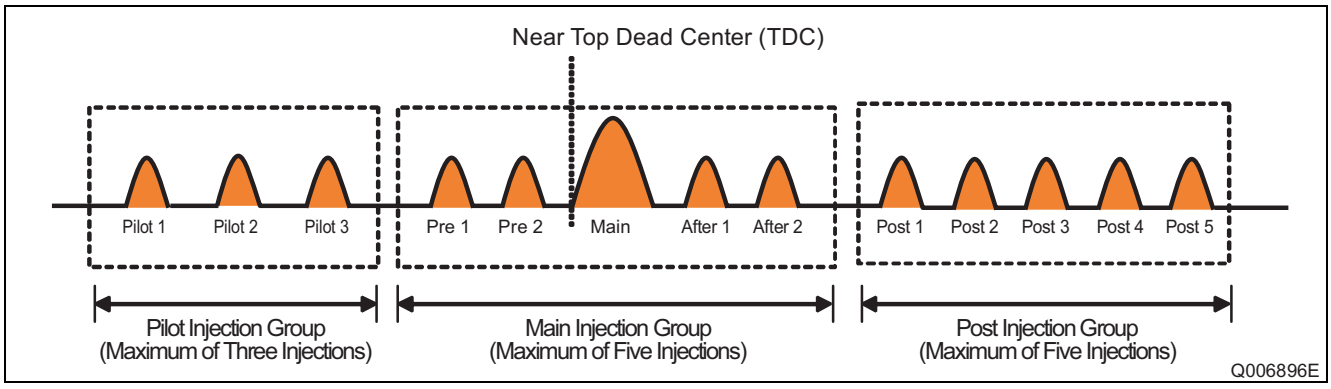
7. Fuel Injection Control

7.1 Injection Pattern

- The fuel injection system allows a maximum of nine separate injections (a limit exists for each injection group) to be set. However, injection settings are performed with a guard placed on the number of injections to prevent exceeding the following: 1) the charging capacity of the DC-DC converter for the piezo injector actuation circuit, and 2) the maximum actuation frequency limit due to ECU heat generation.

  Pilot and pre-injections are performed in accordance with engine load conditions and the environment to shorten the main injection ignition lag, to suppress NOx generation, as well as to decrease combustion noise and vibration.

  After-injection is performed to re-combust PM and CO, and to activate the oxidation catalyst at an early stage. Post-injection is performed to raise the DPF temperature to the necessary value required to combust the PM accumulated within the DPF.



7.2 Microinjection Quantity Correction Control

Outline

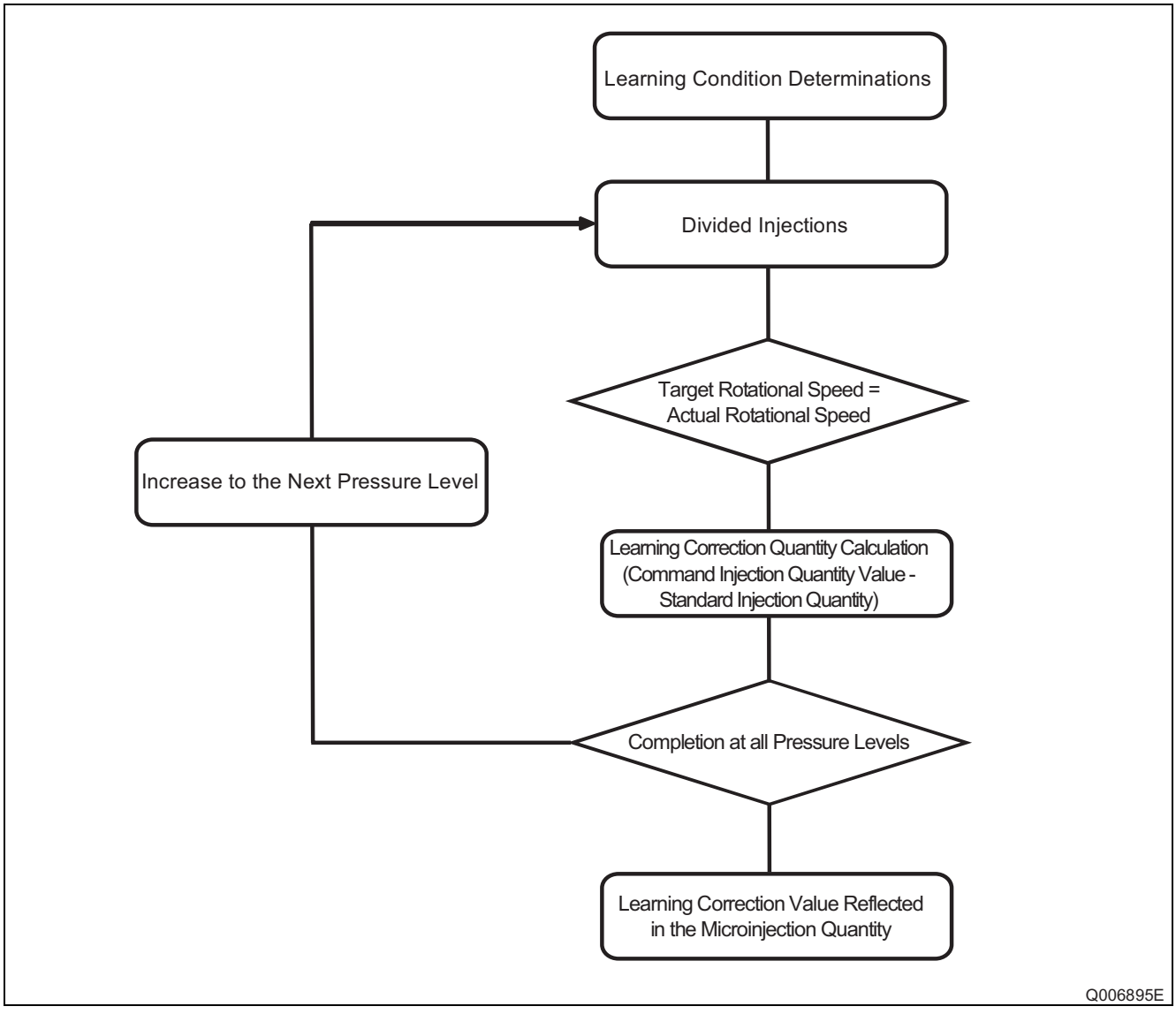
- Under microinjection quantity correction control, multiple injections are performed under stable idle conditions. The difference between the injection command value at the time of injection and the actual injection quantity (standard injection quantity) necessary to achieve equilibrium with the target idle rotational speed is learned by the system. The learning results are then used to correct the actual injection quantity.

Goal

- To reduce injection quantity disparity and to suppress engine noise and smoke generation.

Control Outline

- Learning is automatically performed every 2,000 km with the engine in an idle state. Rail pressure is raised in order from 35 MPa to 65 MPa, and finally to 95 MPa with learning being performed at each of the three pressure levels. Actual learning takes place under the following control flow.



Determinations for Learning Conditions

• Learning is performed when the engine is in an idle state and all environmental conditions such as temperature are satisfied.

The figure below shows the specific details for each learning determination.

<Determination Content>

Stable Idle Determination

- Engine rotational speed stability determination
- Rail pressure stability determination

Environmental Condition Determinations

- Water temperature within predefined range
- Fuel temperature within predefined range
- Suction temperature within predefined range
- Atmospheric pressure at predetermined value or higher

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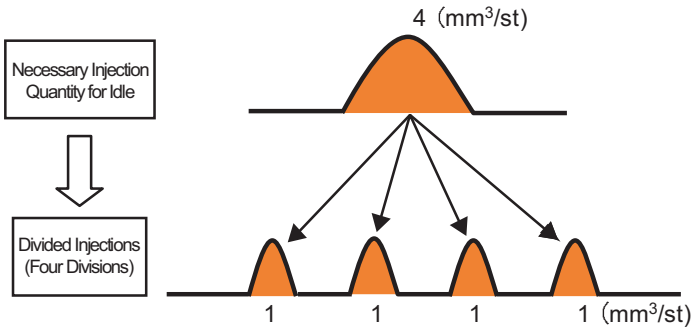
Performing Multiple Injections

• Learning is performed when the engine is in an idle state and all environmental conditions such as temperature are satisfied.

The figure below shows the specific details for each setting.

<Setting Content>

- Setting for number of injection levels (divided injections)
- Setting for injection quantity command value
- Injection timing, inverter setting
- Rail pressure setting



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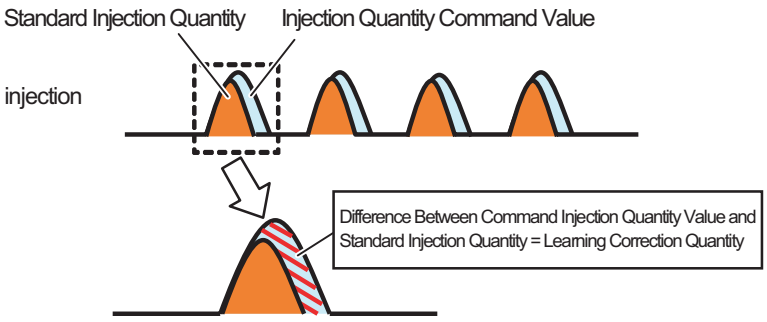
Learning Correction Quantity Calculation

• The learning correction quantity is calculated by detecting the difference between the injection command value setting for multiple injections and the actual injection quantity (standard injection quantity) necessary to achieve equilibrium with the target idle rotational speed.

The figure below shows the processing for the aforementioned corrections.

<Processing Content>

- Detection of the difference between the command injection quantity value and standard injection quantity
- Learning correction quantity calculation



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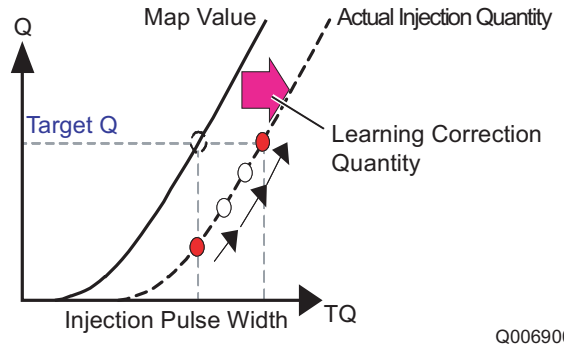
Reflection of the Learning Correction Quantity

- In this process, the learning correction quantity is reflected in the command injection pulse width (TQ) so that the actual injection quantity becomes the target injection quantity. The figure below shows the processing for the aforementioned corrections.

<Processing Content>

- Learning correction quantity reflected in the injection pulse width (TQ)



[REFERENCE]

In addition to the learning performed automatically at three different pressure levels, the learning performed by a dealer (with diagnostic tools) when an injector or the engine ECU is replaced adds learning at 140 MPa and 197 MPa for a total of five different levels.

However, learning at 140 MPa and 197 MPa is performed while the engine is in an idle-up state with an eye towards supply pump reliability.

7.3 Injector Temperature Characteristic Correction Control

Outline

- Injectors possess a characteristic under which the injection quantity changes according to the fuel temperature. As a result of fluctuations in this characteristic, a disparity occurs between the injection quantity command value and the actual injection quantity. Injector temperature characteristic correction control corrects any discrepancies due to temperature.

Goal

- To achieve the combustion target and to stabilize engine performance (emissions, output) by minimizing injection quantity discrepancies caused by fuel temperature fluctuations.

Control

- Control takes place as follows: 1) fuel temperature inside the injector is estimated, 2) the difference is calculated between the command injection quantity and the actual injection quantity at the estimated fuel temperature, 3) the calculated difference is passed along to injector control as the correction quantity.

1) Estimating Fuel Temperature Inside the Injector

- Injectors are heavily influenced by the engine temperature (roughly equivalent to engine coolant temperature). Additionally, combustion heat and heat generated by injector leak also act as influencing factors.

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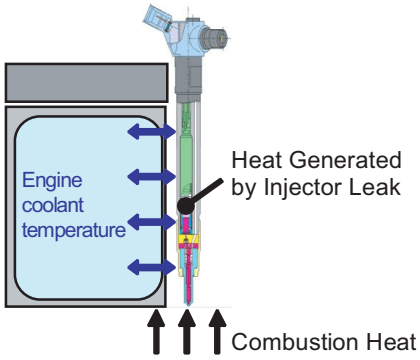
Fuel temperature inside the injector (°C)
= Engine coolant temperature + Influence of combustion heat
+ Influence of heat generated from leak



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2) Calculating the Difference in Injection Quantities

- To calculate the difference in injection quantities, first the actual injection quantity is estimated from the following: 1) the fuel temperature estimated in step 1 and, 2) the injection conditions (rail pressure, command injection quantity) from the pre-adjusted injection quantity fluctuation characteristics map. Finally the actual quantity is used to calculate the difference with the command quantity.

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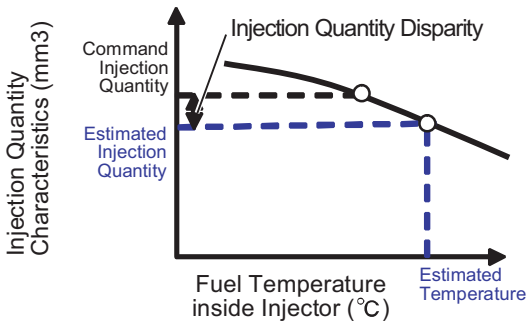
Injection quantity disparity (mm3)
= Command injection quantity - Estimated injection quantity



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3) Calculating the Difference in Injection Quantities

- The calculated difference in injection quantities is passed along to injector actuation control to adjust the actuation pulse duration for each injection stage.

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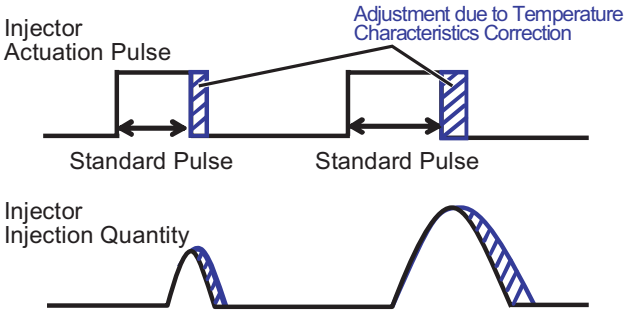
Injector actuation pulse (msec)
= Standard pulse* + Adjustment due to temperature characteristics correction

*The standard pulse is the injector actuation pulse time calculated from the command injection quantity.



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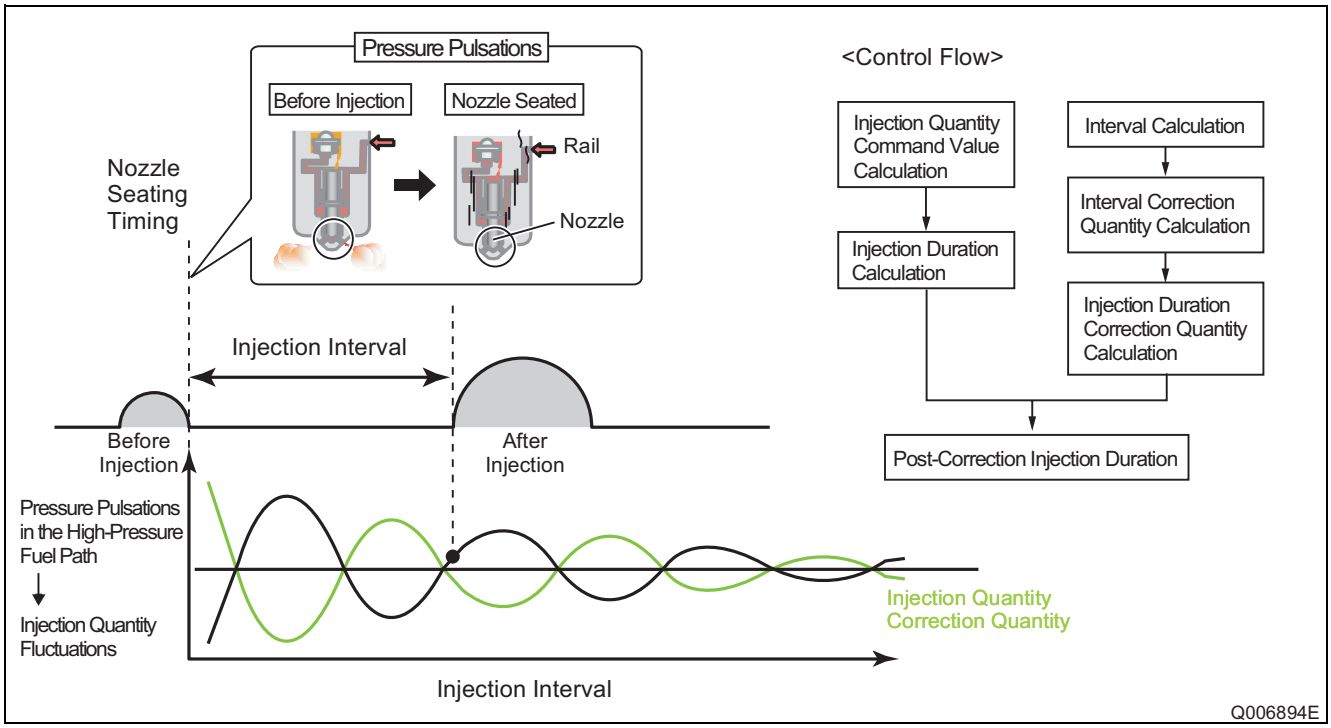
7.4 Interval Dependence Correction

Outline

- The interval dependence correction compensates for fluctuations in the post-injection quantity due to pressure pulsations that occur when an injector nozzle seats.

Control Outline

- The interval dependence correction performs control by calculating the pre-adjusted injection quantity correction based on the following: 1) the length of the high-pressure fuel path from the injector nozzle to the rail, 2) the pressure pulsation transmission interval calculated from the fuel environmental conditions (fuel temperature and pressure), and 3) injection conditions (fuel pressure, fuel injection quantity, injection interval).

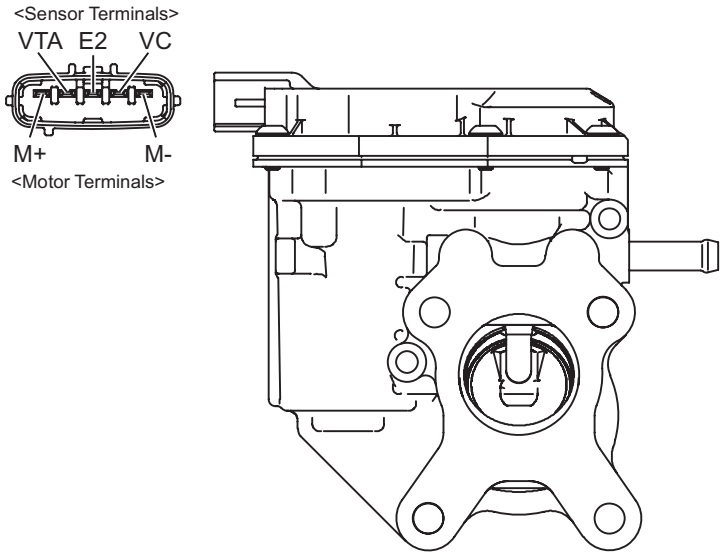


7.5 Exhaust Gas Recirculation (EGR) Control

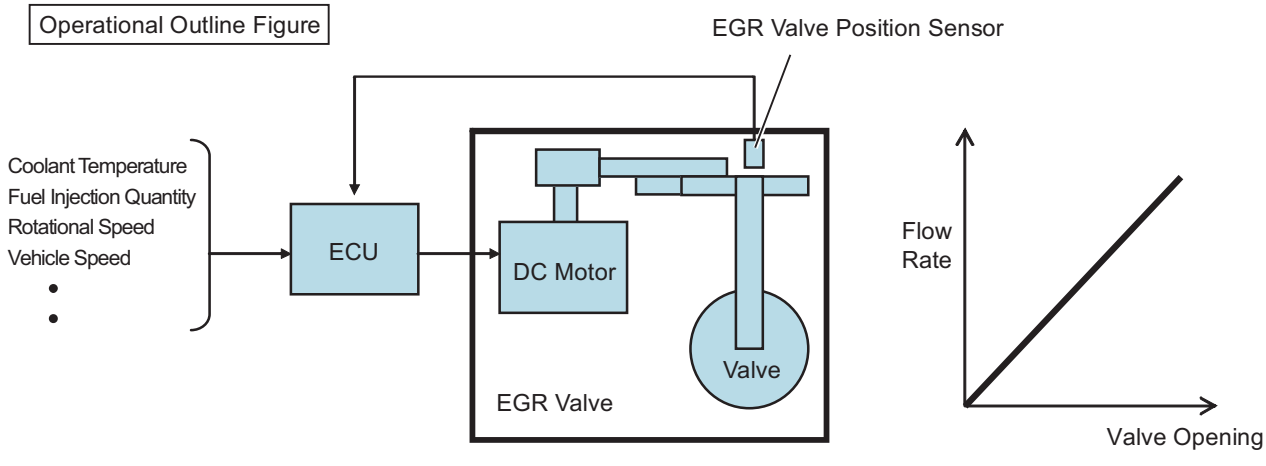
Outline

- EGR control decreases the NOx generated in large quantities at high temperatures by recirculating the exhaust gas through the combustion chamber and lowering the combustion temperature.
  Furthermore, the EGR cooler path contains an EGR valve with a DC motor to perform control that is optimized to the engine state. The EGR valve has an angle sensor that detects the valve position and outputs corresponding signals to the ECU. The ECU sends current through the DC motor so that the valve opens to the appropriate angle.

External View Figure



Operational Outline Figure



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7.6 i-stop Control

Outline

- i-stop control is a system that automatically stops and starts the engine when the vehicle is not moving to improve fuel economy, reduce exhaust gas, and decrease idling noise.

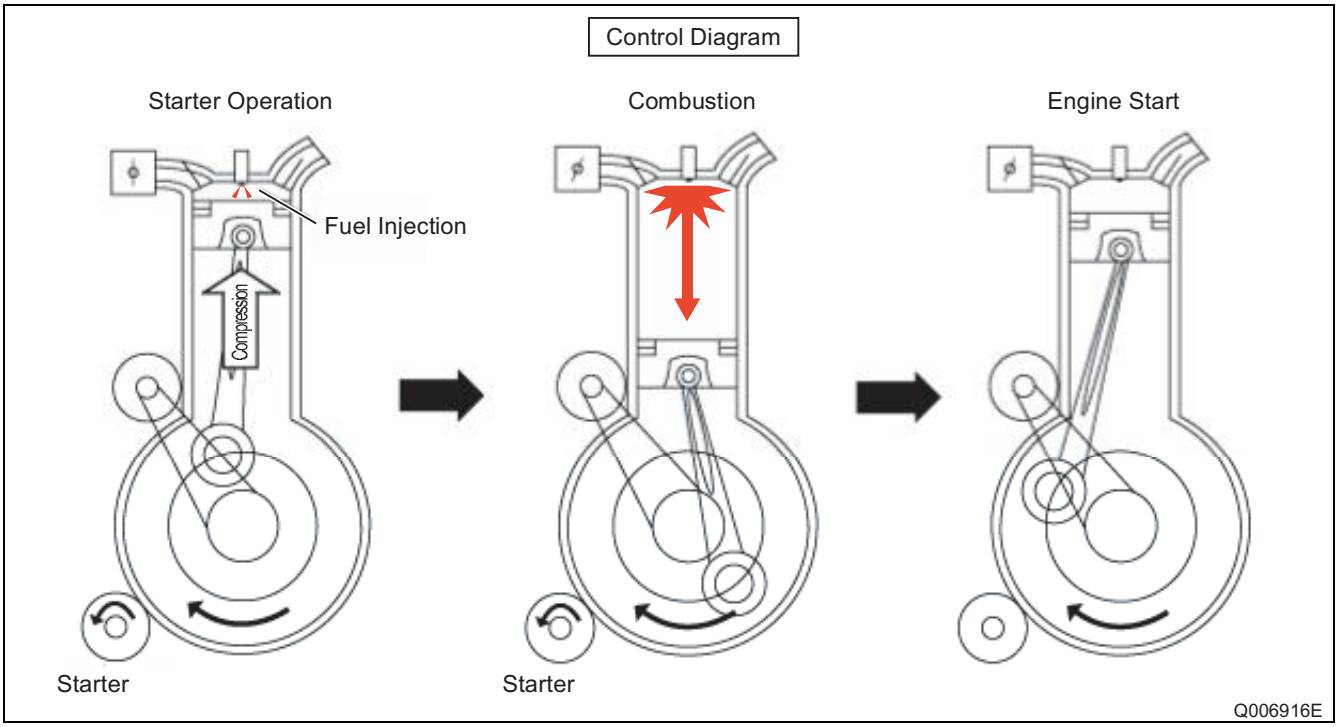
i-stop Operating Conditions

- i-stop operates under the conditions shown below.

	Engine Stop Conditions	Engine Restart Conditions
AT	• Brake pedal depressed • Shift position in the "D" or "M" range • Accelerator pedal not depressed • Vehicle speed within a predetermined range (0 km/h) • Coolant temperature within a predetermined range (30°C ~ 110°C) • A/C set temperature at a value other than MAX or MIN • Battery voltage at least 11.2 V • Steering angle 65° or less left to right • Altitude 1,500 m or less	When any of the following are detected: • Foot released from the brake pedal • Shift position in the "P" or "N" range • Accelerator pedal depressed • Accelerator pressed while in the "D" or "M" range • Shift position changed ("P" or "N" range - "D", "M" or "R" range) • When A/C set temperature is changed to MAX or MIN
MT	• Brake pedal depressed • Shift position in the "N" range • Accelerator pedal not depressed • Vehicle speed within a predetermined range (0 km/h) • Coolant temperature within a predetermined range (30°C ~ 110°C) • A/C set temperature at a value other than MAX or MIN • Battery voltage at least 11.2 V • Steering angle 65° or less left to right • Altitude 1,500 m or less	When any of the following are detected: • Clutch pedal depressed • Accelerator pedal depressed • When A/C set temperature is changed to MAX or MIN • Change in vehicle speed

Improved Engine Restarts When Under i-stop Control

- Smooth startability is required when restarting the engine with i-stop control. Therefore, the crankshaft position sensor identifies the cylinder prior to top dead center of compression so that injection to that cylinder can be pinpointed.

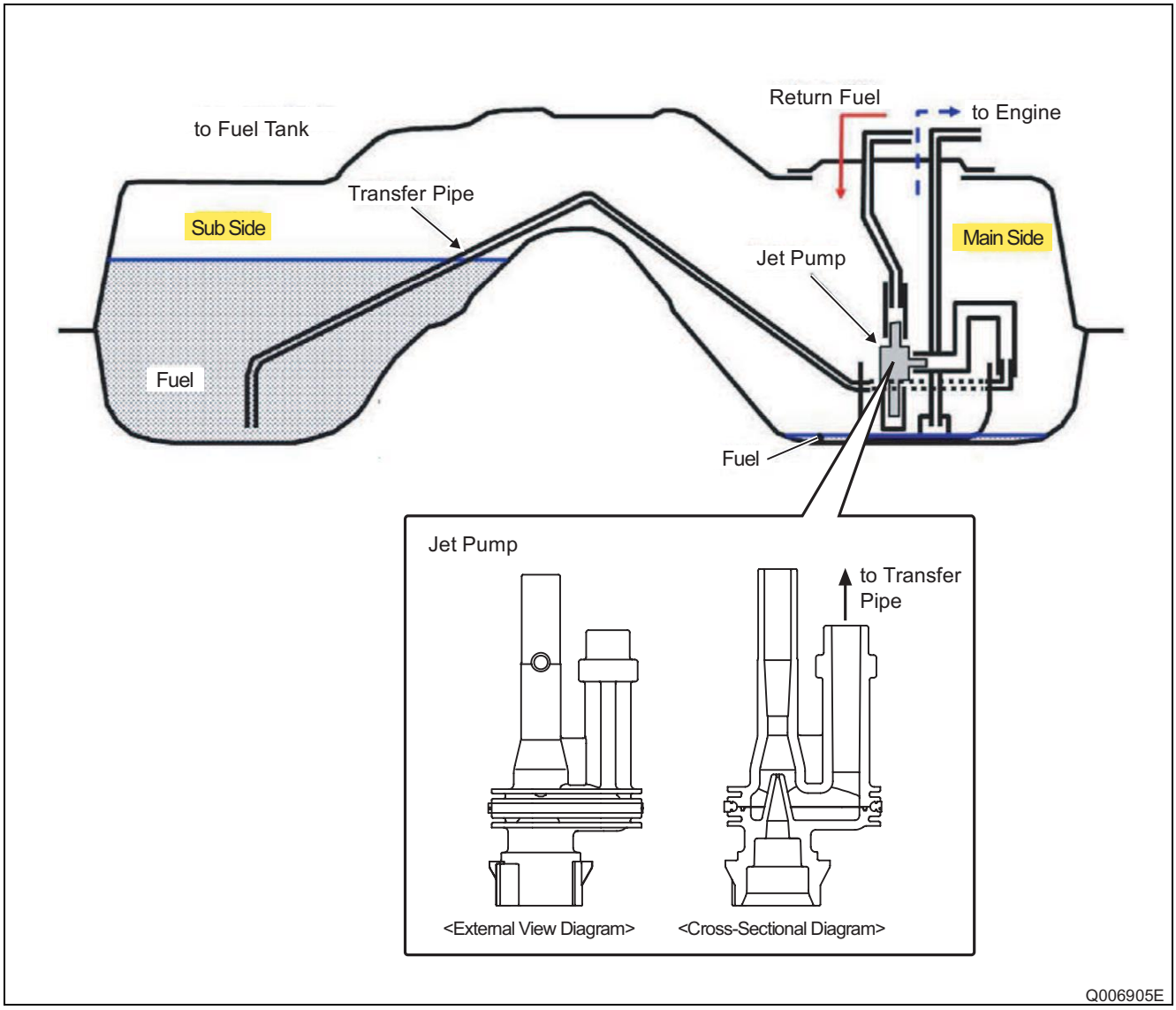


8. Other Controls

8.1 Jet Pump (4WD Only)

Outline

- When the fuel tank main-side level is low, the jet pump feeds fuel from the sub-tank side to the main side so that the fuel level inside the tank is always stable.



9. Exhaust Gas Treatment System

9.1 Diesel Particulate Filter (DPF) System

- The DPF system efficiently traps and purifies Particulate Matter (PM), CO, and HC contained in diesel engine exhaust gas. The DPF system comes with PM forced regeneration control that allows exhaust gas to be purified according to driving conditions.

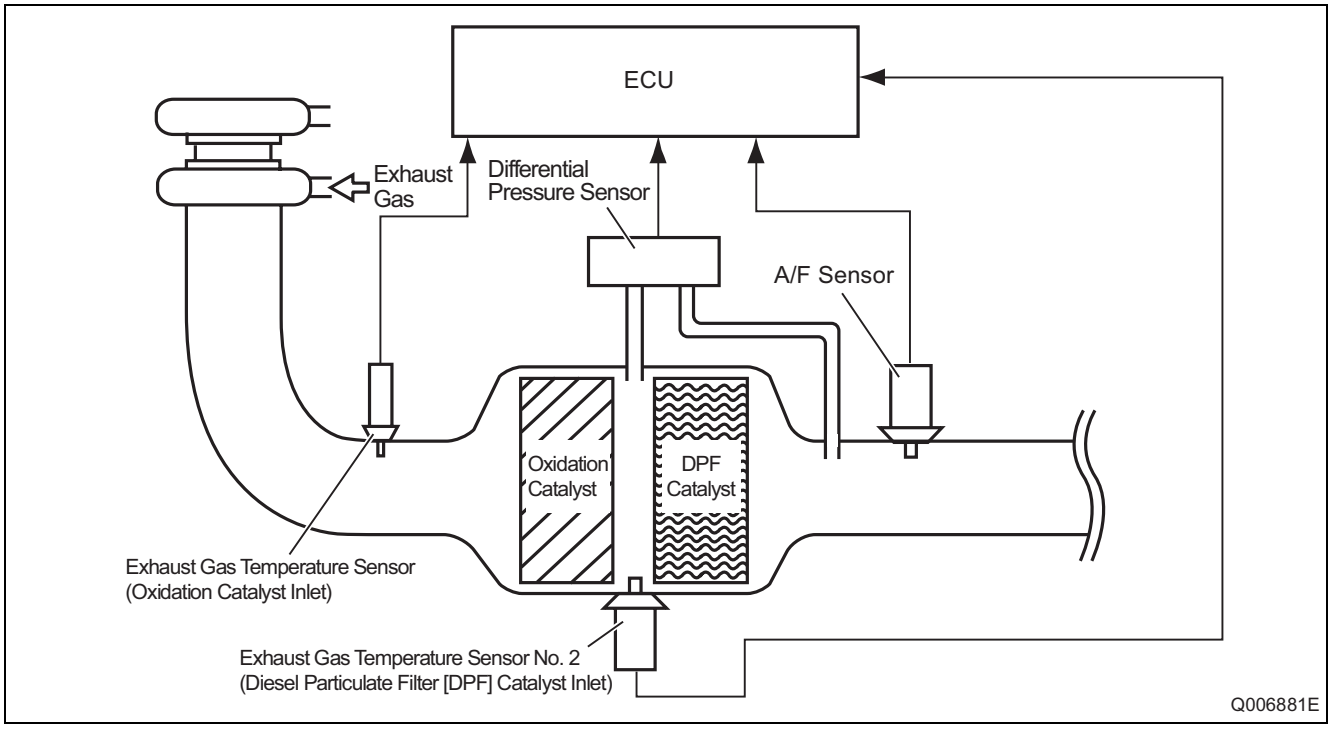
(1) System Configuration

Electronic Control Configuration

- Sensors: Exhaust gas temperature sensor, differential pressure sensor (non-DENSO products)
- ECU: Engine ECU
- Actuators: Injectors

Mechanical Configuration (Non-DENSO Products)

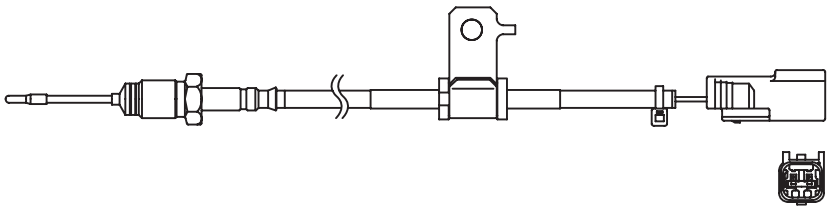
- DPF, Oxidation catalyst



(2) Sensors

Exhaust Gas Temperature Sensors

• Exhaust gas temperature sensors are installed before and after the oxidation catalyst to detect the exhaust gas temperature across the DPF. Temperature increase control signals are sent by the sensors to the engine ECU for use in NOx reduction and PM regeneration. The exhaust gas temperature sensor is a thermistor element in which the resistance value changes according to temperature variations.



Resistance Value Specifications	
Temperature	Resistance Value
50 °C	106 $^{+31}_{-24}$ kΩ
650 °C	346 $^{+14}_{-13}$ Ω
700 °C	287 $^{+22}_{-20}$ Ω

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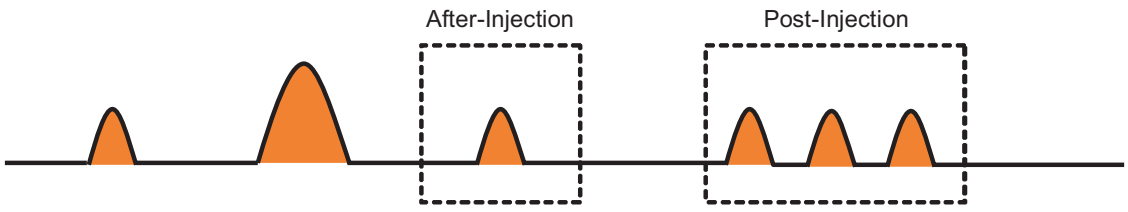
(3) Operation Outline

• Fuel injection patterns are optimized by using the common rail type fuel injection system so that after-injection increases the exhaust gas temperature to approximately 250°C, even from low exhaust gas temperatures. Post-injection adds HC to the catalyst to further increase the DPF temperature to 650°C, or the PM self-combustion temperature, thereby enabling the PM trapped in the DPF to be regenerated in a short time period.



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10. Diagnostic Trouble Codes (DTC)

10.1 DTC List

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P0016	○	Speed-G phase gap malfunction	Crank- cam pulse input relative position abnormality Crank-cam error correction quantity > 15°CA					○
P0030	○	A/F sensor heater abnormality: high	Actuation circuit voltage > 0.25 V (battery voltage)		○	○	○	○
	○	A/F sensor heater abnormality: low	Actuation circuit voltage < 0.25 V (battery voltage)		○	○	○	○
P0034	○	Two-stage turbocharger compressor bypass valve: open circuit, ground short	Actuation circuit voltage < 0.35 V (battery voltage)					○
P0035	○	Two-stage turbocharger compressor bypass valve: +B short	Actuation circuit current > 5.9 A					○
P0047	○	Two-stage turbocharger regulator valve: open circuit, ground short	Actuation circuit voltage < 0.35 V (battery voltage)					○
P0048	○	Two-stage turbocharger regulator valve: +B short	Actuation circuit current > 5.9 A					○
P004C	○	Two-stage turbocharger wastegate valve: ground short	Actuation circuit voltage < 0.35 V (battery voltage)					○
P004D	○	Two-stage turbocharger wastegate valve: +B short	Actuation circuit current > 3.5 A					○
P0072	—	A/C ambient temperature sensor: low	Sensor output voltage ≤ 0.182 V					

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P0073	—	A/C ambient temperature sensor high	Sensor output voltage ≥ 4.886 V					
P0079	○	Exhaust VVL valve ground short	Actuation circuit voltage < 0.35 V (battery voltage)			○		○
P007B	○	Abnormal intake air sensor characteristics	Difference in temperature between the intake air temperature sensor (with Mass Air Flow [MAF] meter) and the intake air temperature sensor (intake manifold) ≥ 50°C			○		○
P007C	○	Intake air temperature sensor: low	Sensor output voltage ≤ 0.041 V		○	○	○	○
P007D	○	Intake air temperature sensor: high	Sensor output voltage ≥ 4.900 V		○	○	○	○
P0080	○	Exhaust VVL valve +B short	Actuation circuit current > 5.9 A			○		○
P0087	○	Rail under-pressure abnormality	Rail pressure divergence (undershoot side) Š threshold level (ex.: 30 MPa) state continues	○				○
P0088	○	Rail over-pressure abnormality	Rail pressure divergence (overshoot side) Š threshold level (ex.: 30 MPa) state continues					○
P0089	○	Rail high-pressure abnormality	Actual rail pressure > 217 MPa	○	○			○
P0093	○	Fuel leak	Difference with calculated value for high-pressure fuel consumption (every 90°CA) > threshold level (ex.: 120 mm3/st)	○	○	○	○	○
P0096	○	Abnormal intake manifold temperature sensor characteristics	Difference in temperature between the intake air temperature sensor (with Mass Air Flow [MAF] meter) and the intake air temperature sensor (downstream of I/C) ≥ 50°C			○		○
P0097	○	Intake air temperature sensor (intake manifold): low	Sensor output voltage ≤ 0.044 V			○		○

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P0098	○	Intake air temperature sensor (intake manifold): high	Sensor output voltage ≥ 4.900 V			○		○
P009B	○	pressure relief valve coil short abnormality	Number of MOS switch actuation detections for the pressure reduction valve actuation circuit > threshold level (ex.: 190 times, energization time: 10 msec)	○	○			○
	○	pressure relief valve actuation line abnormality	Number of MOS switch actuation detections for the pressure reduction valve circuit < 4	○	○			○
	○	pressure relief valve MOS short abnormality (ECU)	Downstream voltage for the actuation circuit when the pressure reduction valve is not actuated: high	○	○			○
P009F	○	pressure relief valve pressure reduction function abnormality	Pressure reduction flow volume (calculated value from change in rail pressure) < threshold level (ex.: 40 mm^3/st)	○	○			○
P0101	○	Abnormal Mass Air Flow (MAF) meter characteristics	Air flow volume ≤ threshold level (ex.: 210 mg/cyl, engine rotational speed: 2,000 rpm)		○	○	○	○
P0102	○	MAF meter: low	Sensor output voltage ≤ 0.289 V		○	○	○	○
P0103	○	MAF meter: high	Sensor output voltage ≥ 4.624 V		○	○	○	○
P0106	○	Abnormal Manifold Absolute Pressure (MAP) sensor characteristics	Difference between MAP sensor (compressor outlet), atmospheric pressure sensor (built into ECU), and exhaust gas pressure sensor ≥ 50 kPa		○	○	○	○
P0107	○	MAP sensor (intake manifold): low	Sensor output voltage ≤ 0.136 V		○	○	○	○
P0108	○	MAP sensor (intake manifold): high	Sensor output voltage ≥ 4.910 V		○	○	○	○

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P0111	○	Intake air temperature sensor (with MAF meter) CCM diagnosis	Difference between intake air temperature sensor (intake manifold) and intake air temperature sensor (downstream of I/C) ≥ 50°C			○		○
P0112	○	Intake air temperature sensor (with MAF meter): low	Sensor output voltage ≤ 0.336 V		○	○	○	○
P0113	○	Intake air temperature sensor (with MAF meter): high	Sensor output voltage ≥ 4.511 V		○	○	○	○
P0116	○	Abnormal coolant temperature sensor characteristics 2	Difference between maximum and minimum coolant temperatures recorded in history ≤ 0.004°C		○	○	○	○
P0117	○	Coolant temperature sensor: low	Sensor output voltage < 0.090 V		○	○	○	○
P0118	○	Coolant temperature sensor: high	Sensor output voltage ≥ 4.826 V		○	○	○	○
P0121	○	Abnormal accelerator pedal position sensor 1 characteristics	Voltage difference between accelerator pedal position sensor systems 1 and 2 > 0.5 V		○	○		○
P0122	○	Accelerator pedal position sensor 1: low	Sensor output voltage ≤ 0.277 V		○	○		○
P0123	○	Accelerator pedal position sensor 1: high	Sensor output voltage ≥ 4.828 V		○	○		○
P0131	○	A/F sensor + terminal: low	Sensor output voltage ≤ 0.400 V		○	○	○	○
	○	A/F sensor - terminal: low	Sensor output voltage ≤ 0.400 V		○	○	○	○
P0132	○	A/F sensor + terminal: high	Sensor output voltage ≥ 4.400 V		○	○	○	○
	○	A/F sensor - terminal: high	Sensor output voltage ≥ 4.400 V		○	○	○	○
P0133	○	Poor A/F sensor activation	A/F sensor resistance value ≤ 100Ω (after heater activation: less than or equal to 40Ω)		○	○	○	○
P0134	○	A/F sensor +, - terminal short	Difference between sensor output terminal voltages ≤ 0.1 V		○	○	○	○
P0154	○	Atmospheric learning abnormality	Deviation from atmospheric O2 concentration ≥ 36.5%		○	○	○	○

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P0181	○	Abnormal fuel temperature sensor characteristics	Difference between maximum and minimum fuel temperatures recorded in history ≤ 1°C					○
P0182	○	Fuel temperature sensor: low	Sensor output voltage ≤ 0.118 V					○
P0183	○	Fuel temperature sensor: high	Sensor output voltage ≥ 4.833 V					○
P0191	○	Abnormal rail pressure sensor characteristics	Amount of change in sensor output voltage (compared to previous value) ≤ 0.00245 V	○	○	○	○	○
P0192	○	Rail pressure sensor: low	Sensor output voltage ≤ 0.514 V	○	○	○	○	○
P0193	○	Rail pressure sensor: high	Sensor output voltage ≥ 4.808 V	○	○	○	○	○
P0196	○	Abnormal oil temperature sensor characteristics	Difference with coolant temperature sensor ≥ 50°C					○
P0197	○	Oil temperature sensor: low	Sensor output voltage ≤ 0.211 V					○
P0198	○	Oil temperature sensor: high	Sensor output voltage ≥ 4.929 V					○
P0201	○	Injector 1 open circuit	Open circuit downstream of cylinder no. 1 injector circuit		○	○	○	○
	○	Cylinder switch 1 short	Short in ECU internal cylinder selection switch for cylinder no. 1 injector		○	○	○	○
P0202	○	Injector 4 open circuit	Open circuit downstream of cylinder no. 2 injector circuit		○	○	○	○
	○	Cylinder switch 4 short	Short in ECU internal cylinder selection switch for cylinder no. 2 injector		○	○	○	○
P0203	○	Injector 2 open circuit	Open circuit downstream of cylinder no. 3 injector circuit		○	○	○	○
		Cylinder switch 2 short	Short in ECU internal cylinder selection switch for cylinder no. 3 injector		○	○	○	○

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P0204	○	Injector 3 open circuit	Open circuit downstream of cylinder no. 3 injector circuit	○	○	○	○	○
		Cylinder switch 3 short	Short in ECU internal cylinder selection switch for cylinder no. 3 injector	○	○	○	○	○
P0219	—	Engine overrun abnormality	Engine rotational speed ≥ 5,670 rpm					
P0222	○	Accelerator pedal position sensor 2: low	Sensor output voltage ≤ 0.217 V		○	○		○
P0223	○	Accelerator pedal position sensor 2: high	Sensor output voltage ≥ 4.147 V		○	○		○
P0234	○	Excessive supercharging (compact turbocharger region)	The difference between the target manifold pressure and actual manifold pressure in the compact turbocharger range is below the specified value continuously for seven seconds			○		○
P0236	○	Abnormal MAP sensor (compressor outlet) characteristics	Difference between MAP sensor (intake manifold), pressure sensor (built into ECU), exhaust gas pressure sensor ≥ 50 kPa					○
P0237	○	MAP sensor (compressor outlet): low	Sensor output voltage ≤ 0.127 V					○
P0238	○	MAP sensor (compressor outlet): high	Sensor output voltage ≥ 4.092 V					○
P0299	○	Insufficient supercharging (compact turbocharger region)	The difference between the target manifold pressure and actual manifold pressure in the compact turbocharger range exceeds the specified value continuously for seven seconds			○		○

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P02CA	○	Excessive supercharging (heavy duty turbocharger region)	The difference between the target manifold pressure and actual manifold pressure in the heavy-duty turbocharger range is below the specified value continuously for seven seconds			○		○
P02CB	○	Insufficient supercharging (heavy duty turbocharger region)	The difference between the target manifold pressure and actual manifold pressure in the heavy-duty turbocharger range exceeds the specified value continuously for seven seconds			○		○
P0301	○	Injector function (non-injection) 1	Difference in rotational fluctuations between cylinders > 0.212 msec (MT vehicles; target rotational speed: 750 rpm, coolant temperature: 80°C)					○
P0302	○	Injector function (non-injection) 2	Difference in rotational fluctuations between cylinders > 0.212 msec (MT vehicles; target rotational speed: 750 rpm, coolant temperature: 80°C)					○
P0303	○	Injector function (non-injection) 3	Difference in rotational fluctuations between cylinders > 0.212 msec (MT vehicles; target rotational speed: 750 rpm, coolant temperature: 80°C)					○
P0304	○	Injector function (non-injection) 4	Difference in rotational fluctuations between cylinders > 0.212 msec (MT vehicles: target rotational speed: 750 rpm, coolant temperature: 80°C)					○
P0313	—	RDP control status 2	Remaining fuel quantity < 4 L		○			○
P0336	○	Crankshaft position sensor pulse count abnormality	NE pulse count between missing teeth does not equal 56					○

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P0337	○	Crankshaft position sensor pulse input failure	No NE pulse input		○	○	○	○
P0339	—	Crankshaft position sensor reverse pulse output failure abnormality	Deviation between recorded crankshaft position during an engine stall and crankshaft position during restart cylinder recognition ≥ 6 CA					○
		Crankshaft position sensor forward/reverse pulse inversion abnormality	Reverse rotation pulse input (during forward rotation)					○
P0341	○	Cylinder recognition sensor pulse count abnormality	G pulse count between extra teeth does not equal five					○
P0342	○	Cylinder recognition sensor pulse count input failure	No G pulse input					○
P0383	○	Actuation signal between ECU and glow unit: open circuit, ground short	Actuation circuit voltage < 0.35 V (battery voltage)					○
P0384	○	Actuation signal between ECU and glow unit: +B short	Actuation circuit current > 5.9 A					○
P0401	○	Low Exhaust Gas Recirculation (EGR) flow volume abnormality	EGR flow volume at or below a constant value in relation to the target value continuously for eight seconds					○
P0402	○	High EGR flow volume abnormality	EGR flow volume at or above a constant value in relation to the target value continuously for eight seconds			○		○
P0404	○	EGR DC motor abnormality	DC motor actuation current > 8 A			○		○
P0405	○	EGR lift sensor: low	Sensor output voltage ≤ 0.241 V			○		○
P0406	○	EGR lift sensor: high	Sensor output voltage ≥ 4.856 V		○	○	○	○

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P0421	○	Oxidation catalyst diagnosis	Difference in exhaust gas temperature before and after passing the oxidation catalyst is at or below the specified value continuously for between 60 and 80 seconds					○
P0471	○	Abnormal exhaust gas pressure sensor characteristics	Difference between MAP sensor (intake manifold), MAP sensor (compressor outlet), and atmospheric pressure sensor (built into ECU) ≥ 50 kPa			○		○
P0472	○	Exhaust pressure sensor: low	Sensor output voltage ≤ 0.117 V			○		○
P0473	○	Exhaust pressure sensor: high	Sensor output voltage ≥ 4.858 V			○		○
P0480	—	FANPWM1 malfunction (FANPWM1)	Radiator fan 1 actuation duty stuck in high/low					
P0481	—	FANPWM2 malfunction (FANPWM2)	Radiator fan 2 actuation duty stuck in high/low					
P0488	○	EGR valve (cooler side) energization duty abnormality detection	Energization duty continuously ≥ 90%			○		○
P0500	○	CAN communication vehicle speed malfunction	Vehicle speed signal error message received from ABS/DSC, or CAN ID217 received from ABS/DSC		○	○	○	○
P0522	○	Oil pressure sensor: low	Sensor output voltage ≤ 0.135 V		○			○
P0523	○	Oil pressure sensor: high	Sensor output voltage ≥ 4.809 V		○			○
P0524	○	Oil pressure zero abnormality	Engine oil pressure is less than 30 hPa		○	○	○	○
P0532	—	A/C compressor sensor: low	Sensor output voltage ≤ 0.053 V					
P0533	—	A/C compressor sensor: high	Sensor output voltage ≥ 4.950 V					
P053B	—	Blow-by heater relay: open circuit, ground short	Actuation circuit voltage < 0.35 V (battery voltage)					
		BBH circuit low abnormality	Circuit voltage is low when there is a relay ON command					

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P053C	—	Blow-by heater relay: +B short	Actuation circuit current > 1.5 A					
		BBH circuit high abnormality	Circuit voltage is high when there is a relay OFF command					
P0545	○	Exhaust gas temperature sensor: low	Sensor output voltage ≤ 0.134 V			○		○
P0546	○	Abnormal exhaust gas temperature sensor characteristics	Sensor output voltage ≥ 4.96 V			○		○
P0555	—	Master vacuum pressure sensor: low	Sensor output voltage ≤ 0.133 V					○
		Master vacuum pressure sensor: high	Sensor output voltage ≥ 4.906 V					○
P055F	○	Low oil pressure abnormality	After a determined amount of time has elapsed since engine start-up, the engine oil pressure is at or below the specified value. (Ex.: engine oil pressure is 80 kPa or less when engine rotational speed is 2,000 rpm or lower)		○			
P0571	○	Brake switch signal abnormality (1 and 2 correlation abnormality)	Inconsistency between brake switch 1 and brake switch 2					○
P057F	—	Battery deterioration (overall energy) (BMS_SOHCBF)	Battery charge/discharge abnormality					
P058A	—	Current sensor malfunction	Current sensor internal abnormality, battery voltage abnormality, battery fluid temperature abnormality					
P0601	○	Diesel Particulate Filter (DPF) related EEPROM abnormality	Data flash data corruption abnormality					○
P0602	○	VID writing abnormality	Data flash writing value abnormal					○
P0605	○	ECU flash ROM abnormality	Data flash checksum abnormal		○	○	○	○

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P0606	○	ECU abnormality (main IC abnormality)	Main IC run pulse input failure		○	○	○	○
P0607	○	ECU abnormality (monitoring IC abnormality)	Monitoring IC run pulse input failure					○
P0610	○	VID checksum abnormality	Data flash checksum abnormality					○
P0615	—	Starter malfunction (ISS_STA)	Engine start-up speed exceeds the guaranteed performance speed for the starter or starter relay					
P062A	○	SCV +B short	Diagnosis signal fixed at high		○	○	○	○
		SCV actuation system abnormality	Diagnosis signal fixed at low		○	○	○	○
P062B	○	Injector actuation circuit D3P communication abnormality	Communication abnormal between injector actuation IC and ECU		○	○	○	○
P0642	○	Sensor voltage 1: low	Sensor output voltage ≥ 3.894 V			○	○	○
P0643	○	Sensor voltage 1: high	Sensor output voltage ≥ 4.115 V			○	○	○
P0646	—	A/C magnetic clutch relay: open circuit, ground short	Actuation circuit voltage < 0.35 V (battery voltage)					
P0647	—	A/C magnetic clutch relay: +B short	Actuation circuit current > 1.5 A					
P0652	○	Sensor voltage 2: low	Sensor output voltage ≥ 3.894 V			○	○	○
P0653	○	Sensor voltage 2: high	Sensor output voltage ≥ 4.115 V			○	○	○
P0668	○	ECU internal temperature sensor: low	Sensor output voltage ≤ 0.100 V					○
P0669	○	ECU internal temperature sensor: high	Sensor output voltage ≥ 4.900 V					○
P0670	○	Glow unit control circuit abnormality	Abnormality due to diagnosis signal from glow unit					○
P0671	○	No. 1 cylinder glow plug circuit abnormality	Abnormality due to diagnosis signal from glow unit					○

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P0672	○	No. 2 cylinder glow plug circuit abnormality	Abnormality due to diagnosis signal from glow unit					○
P0673	○	No. 3 cylinder glow plug circuit abnormality	Abnormality due to diagnosis signal from glow unit					○
P0674	○	No. 4 cylinder glow plug circuit abnormality	Abnormality due to diagnosis signal from glow unit					○
P0683	○	DI signal between ECU and glow stuck high	Glow unit diagnosis signal stuck high					○
	○	DI signal between ECU and glow stuck low	Glow unit diagnosis signal stuck low					○
P0684	○	No DI signal connection between ECU and glow	Glow unit diagnosis signal not received					○
P06B8	○	Data flash abnormality	Data flash read/write abnormality Data flash writing counts ≥ 325,000 times					○
P06DB	○	Variable relief oil pump valve: ground short	Actuation circuit voltage < 0.35 V (battery voltage)					○
P06DC	○	Variable relief oil pump valve: +B short	Actuation circuit current > 5.9 A					○
P06DD	—	Oil pump switching high-pressure abnormality	Engine oil pressure exceeds 250 hPa					
P06DE	—	Oil pump switching low-pressure abnormality	Engine oil pressure is less than 250 hPa					
P0703	○	Brake switch diagnosis	No brake switch input even though the vehicle has been stopped several times at or above a constant vehicle speed value					○
P0704	○	Clutch switch diagnosis	No clutch switch input even though the vehicle has been stopped several times at or above a constant vehicle speed value					○
P07BE	—	Neutral switch malfunction	Inconsistency between neutral switch, neutral sub-switch					

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P0850	○	Neutral switch diagnosis	No neutral switch input even though there have been several clutch switch inputs at or above a constant vehicle speed value					○
P0A0F	—	IR run failure (ISS_IRFAIL) i-stop	i-stop restart fault					
P0A8D	—	Decreased battery voltage	When the battery voltage, ECU control voltage, or DC-DC converter control voltage is low at engine start-up					
P0A94	—	DC-DC malfunction (DCDC_FAIL1)	Abnormality received in communications from the DC-DC converter					
P1140	—	Water level switch diagnosis	When the water level switch (with fuel filter) is ON					
P115A	—	RDP control status 1	Remaining fuel quantity < 5 L		○			○
P115B	—	RDP control status 3	Remaining fuel quantity < 3.9 L		○			○
P1196	—	Main relay abnormality	Main relay stuck high during main relay OFF command					
P1200	—	Learning incomplete (failure to finish learning)	Incomplete injector microinjection Q learning					○
P1260	—	Immobilizer abnormality	Immobilizer verification failure					
P1282	○	Pump protective fail plug	Actual rail pressure > threshold level (ex.: 123 MPa, 750 rpm)	○	○			○
P1303	—	EGR valve initialize abnormality	Failure to learn EGR valve fully closed position					
P1329	○	Pump replacement fail flag	Actual rail pressure ≥ threshold level (ex.: 200 MPa, 750 rpm)	○	○			○
P132E	○	Wastegate valve function diagnosis	Wastegate valve is open when there is a wastegate valve close command in the compact turbocharger region					○

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P1336	—	Cylinder recognition sensor installation phase disparity abnormality	NE-G phase deviation > 4.56°CA					
P1378	○	Injector low charge	Low injector actuation circuit charge voltage		○	○	○	○
P1379	○	Injector overcharge	High injector actuation circuit charge voltage		○	○	○	○
P1589	○	Intake throttle valve sticking abnormality	Target opening - actual opening ≥ 4.2°		○	○	○	○
P1675	○	QR data write failure abnormality	No injector QR correction data		○	○	○	○
P1676	○	QR data abnormality	Injector QR correction data checksum abnormality		○	○	○	○
		QR correction information input abnormality	Injector QR correction data range abnormality		○	○	○	○
P167B	—	Learning execution failure (failure to start)	Injector microinjection Q learning cannot be executed					○
P176E	—	Clutch stroke sensor: low	Sensor output voltage ≤ 0.202 V					○
		Clutch stroke sensor: high	Sensor output voltage ≥ 4.852 V					○
		Clutch malfunction (ISS_CLAB)	Inconsistency between the clutch switch, clutch cut switch, clutch stroke sensor					
P1905	—	Test terminal short	Test terminal ON					
P2002	○	Differential pressure type DPF diagnosis	Pressure difference across the DPF is less than the specified value					○
P2032	○	Upstream oxidation catalyst temperature low	Sensor output voltage ≤ 0.107 V		○	○	○	○
P2033	○	Abnormal temperature characteristics upstream of oxidation catalyst	Sensor output voltage ≥ 4.960 V		○	○	○	○
P2101	○	DC motor overcurrent abnormality	DC motor actuation current > 8 A			○	○	○
P2105	—	Overrun diagnosis	Engine rotational speed ≥ 1,000 rpm when the key is OFF					

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P2118	○	Intake throttle valve energization duty abnormality	Energization duty continuously ≥ 90%			○	○	○
P2146	○	COM1 open circuit	Open circuit upstream of cylinders no. 1, 4 injector circuit		○	○	○	○
P2147	○	COM1 ground short	Ground short upstream of cylinders no. 1, 4 injector circuit		○	○	○	○
P2148	○	COM1 +B short	+B short upstream of cylinders no. 1, 4 injector circuit		○	○	○	○
P2149	○	COM 2 open circuit	Open circuit upstream of cylinders no. 2, 3 injector circuit		○	○	○	○
P2150	○	COM 2 ground short	Ground short upstream of cylinders no. 2, 3 injector circuit		○	○	○	○
P2151	○	COM 2 +B short	+B short upstream of cylinders no. 2, 3 injector circuit		○	○	○	○
P2227	○	Abnormal atmospheric pressure sensor (built into the engine ECU) characteristics	Difference between MAP sensor (intake manifold), MAP sensor (compressor outlet), and exhaust gas pressure sensor ≥ 50 kPa			○		○
P2228	○	Atmospheric pressure sensor (built into ECU): low	Sensor output voltage ≤ 1.151 V		○	○	○	○
P2229	○	Atmospheric pressure sensor (built into ECU): high	Sensor output voltage ≥ 4.656 V		○	○	○	○
P2261	○	Compressor bypass valve function diagnosis	Turbocharger compressor bypass valve is open during a close command, or closed during an open command			○		○

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P2263	○	Regulator valve lift feedback diagnosis	Difference between the target regulating valve position and the actual regulating valve position is 10 mm or more continuously for three seconds					○
P242C	○	Temperature upstream of DPF low	Sensor output voltage ≤ 0.107 V		○	○	○	○
P242D	○	Abnormal temperature characteristics upstream of the DPF	Sensor output voltage ≥ 4.960 V		○	○	○	○
P242F	○	DPF PM accumulation abnormality 3	PM volume ≥ 17 g/L		○	○	○	○
		DPF PM accumulation abnormality 4	PM volume ≥ 17 g/L		○	○	○	○
		DPF PM accumulation abnormality 5	PM volume ≥ 100 g/L		○	○	○	○
P244A	○	Differential pressure sensor upstream piping abnormality	Differential pressure ≤ 0.2 kPa		○	○	○	○
	—	Differential pressure sensor upstream piping abnormality	Differential pressure ≤ 0.2 kPa					
P2452	—	Differential pressure sensor offset abnormality	Differential pressure ≤ -5 kPa 5 kPa ≤ differential pressure					
P2453	—	Differential pressure sensor gain abnormality	Differential pressure ≥ threshold level (ex.: 100 kPa, exhaust gas flow rate: 10 m^3/min)					
P2454	○	Differential pressure sensors upstream/downstream of DPF low	Sensor output voltage ≤ 0.217 V		○	○	○	○
P2455	○	Differential pressure sensors upstream/downstream of DPF high	Sensor output voltage ≥ 4.843 V		○	○	○	○
P2456	○	Differential pressure sensor intermediate abnormality	Difference between differential pressure maximum and minimum ≤ 0.1 kPa		○	○	○	○
P2458	—	DPF PM accumulation abnormality 1	PM volume ≥ 10 g/L		○			

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P245A	○	EGR valve (cooler side) DC motor status abnormality	DC motor actuation current > 8 A			○		○
P245B	○	EGR DC motor temperature abnormality	DC motor actuation current > 8 A			○		○
	○	EGR bypass valve (ECU side) high duty abnormality diagnosis	Energization duty continuously ≥ 95%			○		○
P2463	○	DPF PM accumulation abnormality 2	PM volume ≥ 13 g/L		○	○		○
P246C	—	Oil dilution 6	Oil dilution quantity (calculated from injection quantity) ≥ threshold level (Ex.: 16,751 g, intake air temperature: 20°C)					
P2494	○	EGR lift sensor 2: low	Sensor output voltage ≤ 0.168 V			○		○
P2495	○	EGR lift sensor 2: high	Sensor output voltage ≥ 4.870 V		○	○	○	○
P24A5	○	EGR feedback abnormality	Energization duty continuously > 69%		○	○	○	○
	○	EGR bypass valve stuck open	EGR valve position sensor output value is not at fully closed during a fully closed command		○	○	○	
P2502	—	B terminal open circuit warning (ALC_BOPEN)	When the alternator generated voltage is at least 17 V and the battery voltage is 11 V or less continuously for five seconds					○
P2503	—	Alternator malfunction (ALC_ALTTF)	Alternator generated current is between 8 to 5 V or less continuously for five seconds, regardless of whether or not the alternator target power generation current is 20 A or more					○
P2504	—	Excessive voltage warning (ALC_OVCHG)	Alternator generated voltage is at least 18.5 V, or battery voltage is 16 V or more continuously for five seconds					○

DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
P2507	○	Back-up memory power supply malfunction determination (PBATTF)	Back-up power supply voltage ≤ 1/4 battery voltage					○
P252F	—	Oil dilution	Oil dilution quantity (calculated from injection quantity) ≥ 1,161 g					
P253F	—	Oil dilution 2	Oil dilution quantity (calculated from injection quantity) ≥ 2,236 g					
		Oil dilution 5	Oil dilution quantity (calculated from injection quantity) ≥ threshold level (ex.: 16,751 g, intake air temperature: 20°C)					
		Oil dilution	Engine oil pressure has dropped 50 kPa or more compared to when the oil was changed					
P2564	○	VNT lift sensor: low (two-stage turbocharger)	Sensor output voltage ≤ 0.214 V					○
P2565	○	VNT lift sensor: high (two-stage turbocharger)	Sensor output voltage ≥ 4.786 V					○
P2610	○	Soak timer abnormality diagnosis	HEC internal failure detection					○
P2621	○	Intake throttle valve position sensor: low	Sensor output voltage ≤ 0.113 V		○	○	○	○
P2622	○	Intake throttle valve position sensor: high	Sensor output voltage ≥ 4.812 V		○	○	○	○
U0073	—	CAN 1 communication bus off abnormality	When the HS-CAN (public) bus is off					
U0074	—	CAN 2 communication bus off abnormality	When the HS-CAN (private) bus is off					
U0101	—	CAN 1 communication no TCM reception abnormality	When the CAN (public) message is not received from TCM					
	○	CAN 2 communication no TCM reception abnormality	When the CAN (private) message is not received from TCM					○
U0104	—	CAN 1 communication no PCS reception abnormality	When the CAN message is not received from PCS					

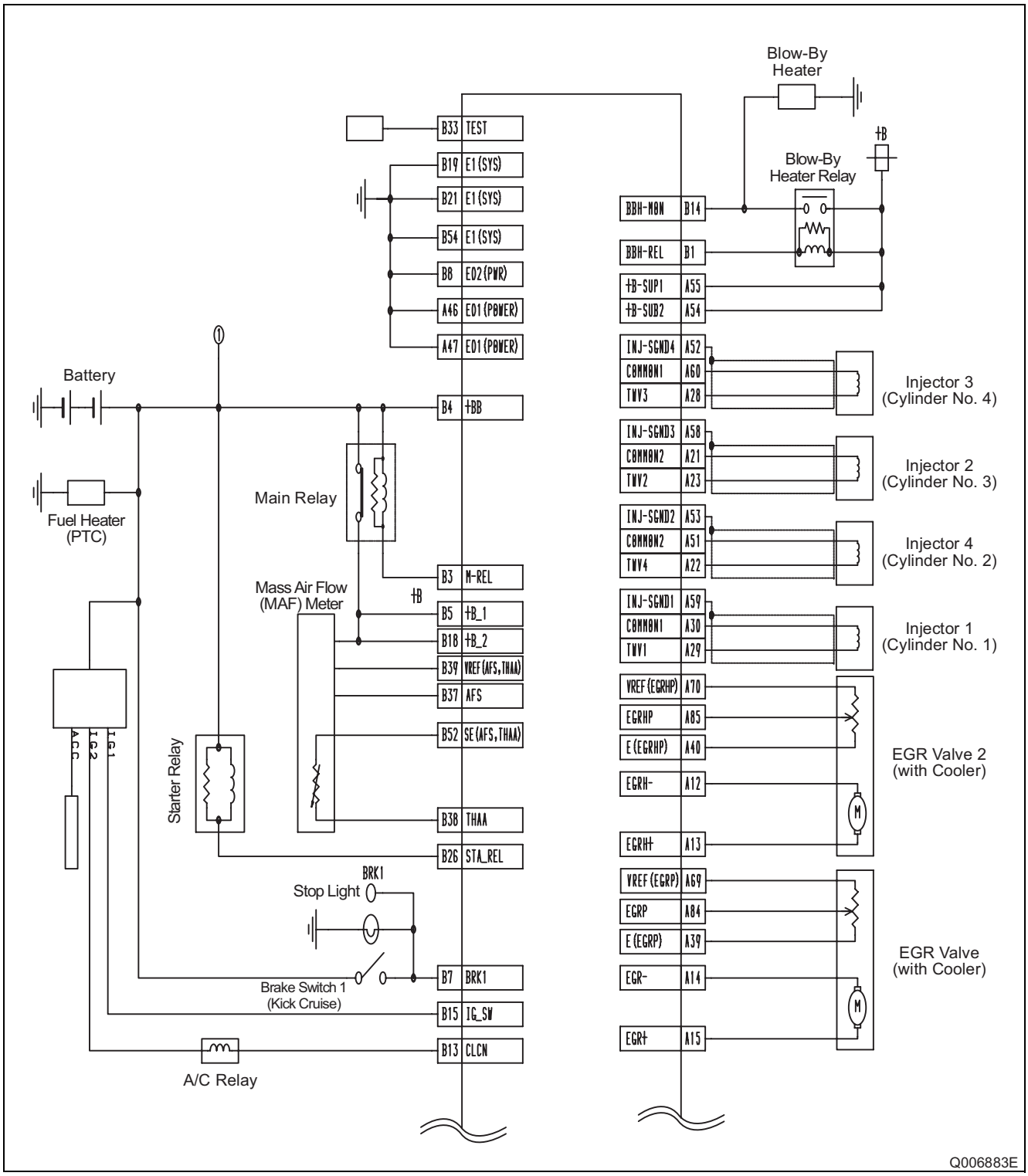
DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
U0121	○	CAN 1 communication no DSC reception abnormality	When the CAN message is not received from DSC					○
U0131	—	CAN 1 communication no EPAS reception abnormality	When the CAN message is not received from EPAS					
U0140	—	CAN 1 communication no FBCM reception abnormality	When the CAN message is not received from FBCM					
U0151	—	CAN 1 communication no RCM reception abnormality	When the CAN message is not received from RCM					
U0155	○	CAN 1 communication no HEC reception abnormality	When the CAN message is not received from HEC					○
U0214	—	CAN 1 communication no SSU reception abnormality	When the CAN message is not received from SSU					
U0235	—	CAN 1 communication no CVM reception abnormality	When the CAN message is not received from CVM					
U0298	—	DC-DC communication error	DC-DC converter information communication error from FBCM					
U0302	○	CAN communication CNTCS abnormality diagnosis (TCM)	When there is a CAN message checksum abnormality from TCM					○
U0305	—	CAN communication CNTCS abnormality diagnosis (PCS)	When there is a CAN message checksum abnormality from PCS					
U0315	—	CAN communication CNTCS abnormality diagnosis (ABS/ DSC)	When there is a CAN message checksum abnormality from ABS/ DSC					
U0320	—	CAN communication CNTCS abnormality diagnosis (EPAS)	When there is a CAN message checksum abnormality from EPAS					
U0323	—	CAN communication CNTCS abnormality diagnosis (HEC)	When there is a CAN message checksum abnormality from HEC					
U0336	—	CAN communication CNTCS abnormality diagnosis (RCM)	When there is a CAN message checksum abnormality from RCM					
U0338	—	CAN communication CNTCS abnormality diagnosis (SSU)	When there is a CAN message checksum abnormality from SSU					
U0433	—	ICA updatebit fail determination i-stop	Correct data cannot be received from RBCM					

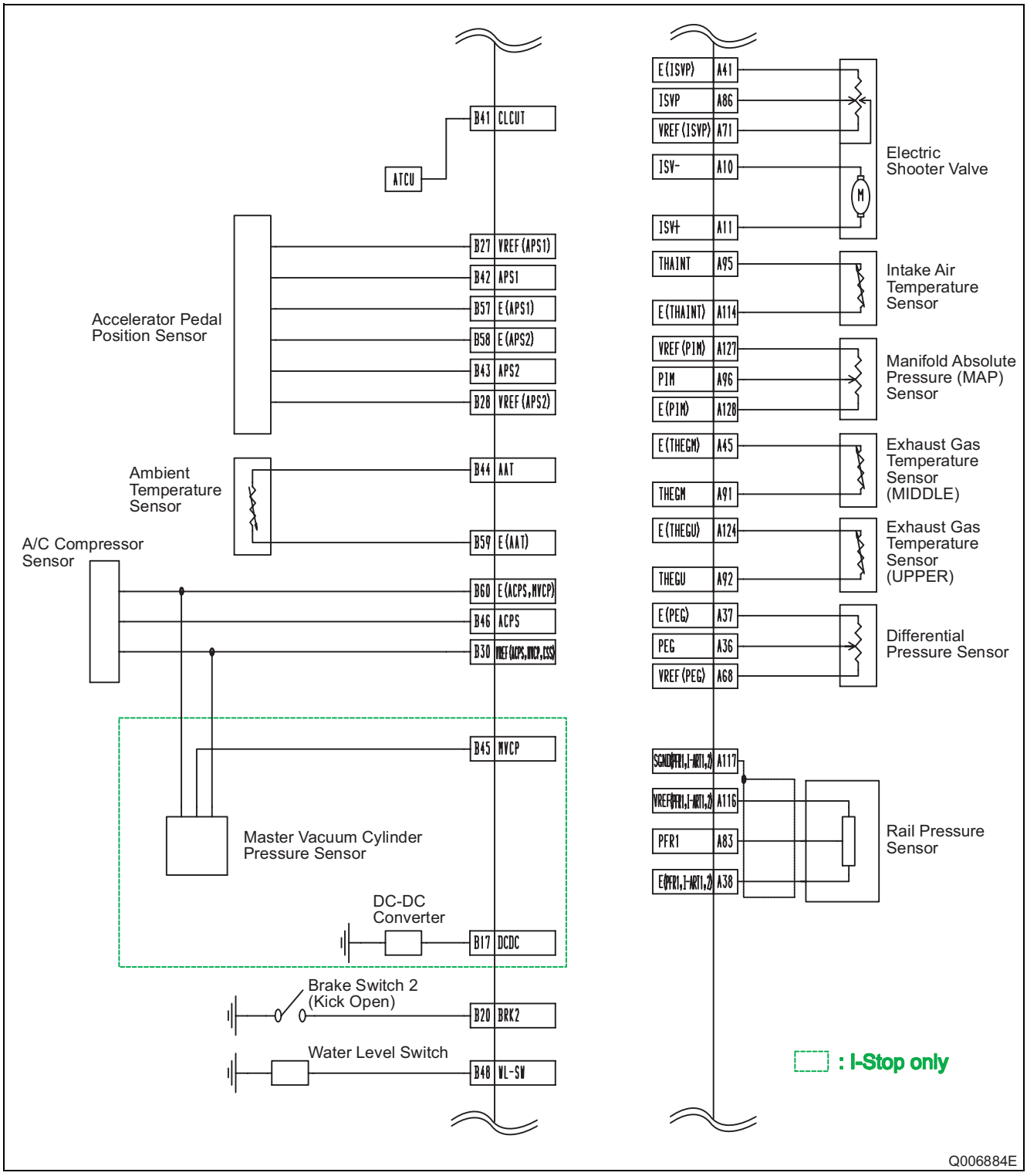
DTC		Diagnosis Item	Judgment Conditions	Fail-Safe				
SAE Code	Check Light			Target Rail Pressure Limit	Output Limit	EGR Valve Control Prohibition	Intake Throttle Control Prohibition	i-stop Prohibition
U2300	—	GCC abnormality diagnosis	HEC not configured or correct data cannot be received from HEC					
U3000	—	Immobilizer abnormality	Data flash three-point check abnormality					
B10A2	—	History of fuel cut-off control operation during a collision	Fuel cut-off command received from RCM					

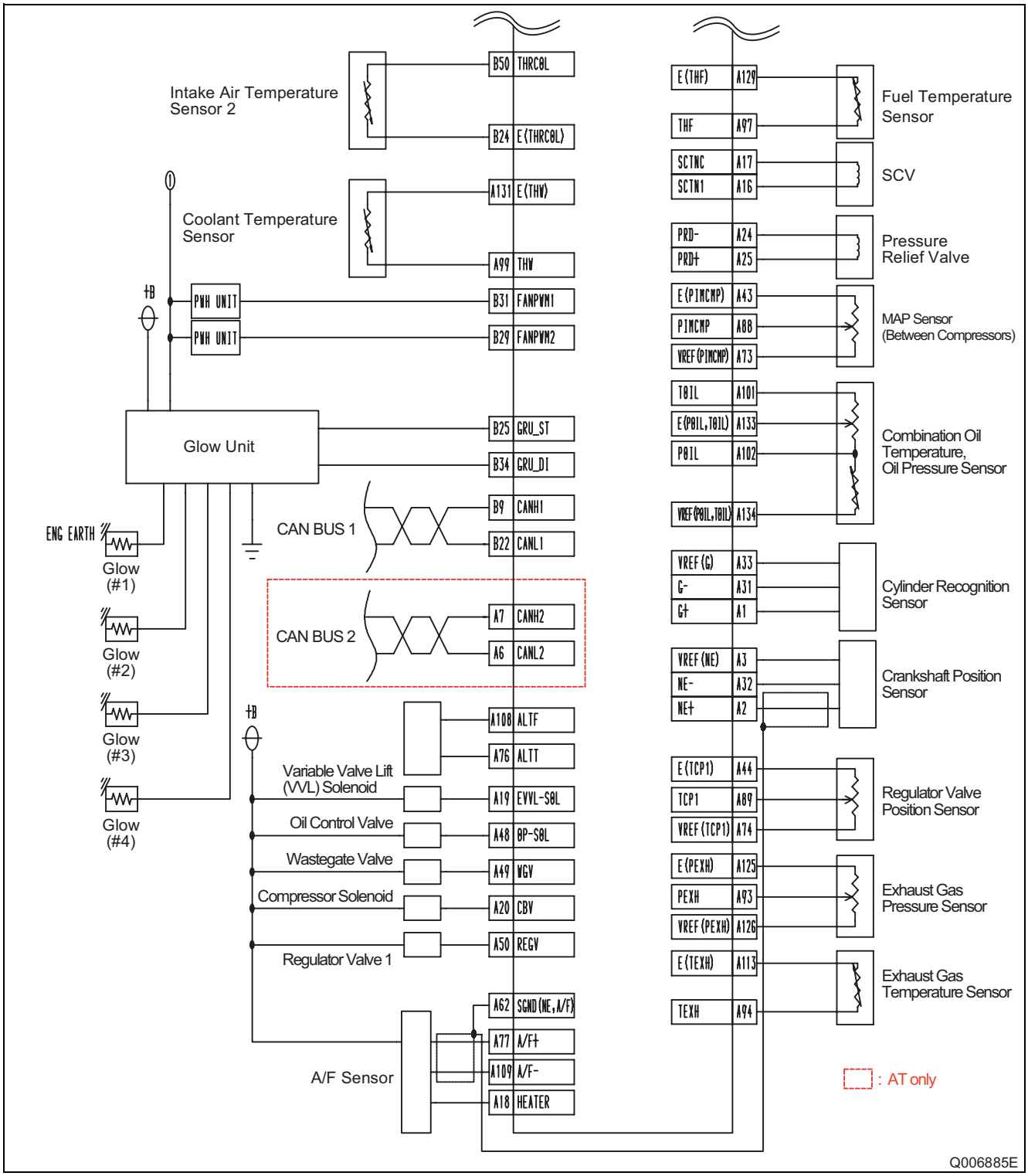
11. Wiring Diagrams

11.1 Engine ECU External Wiring Diagrams

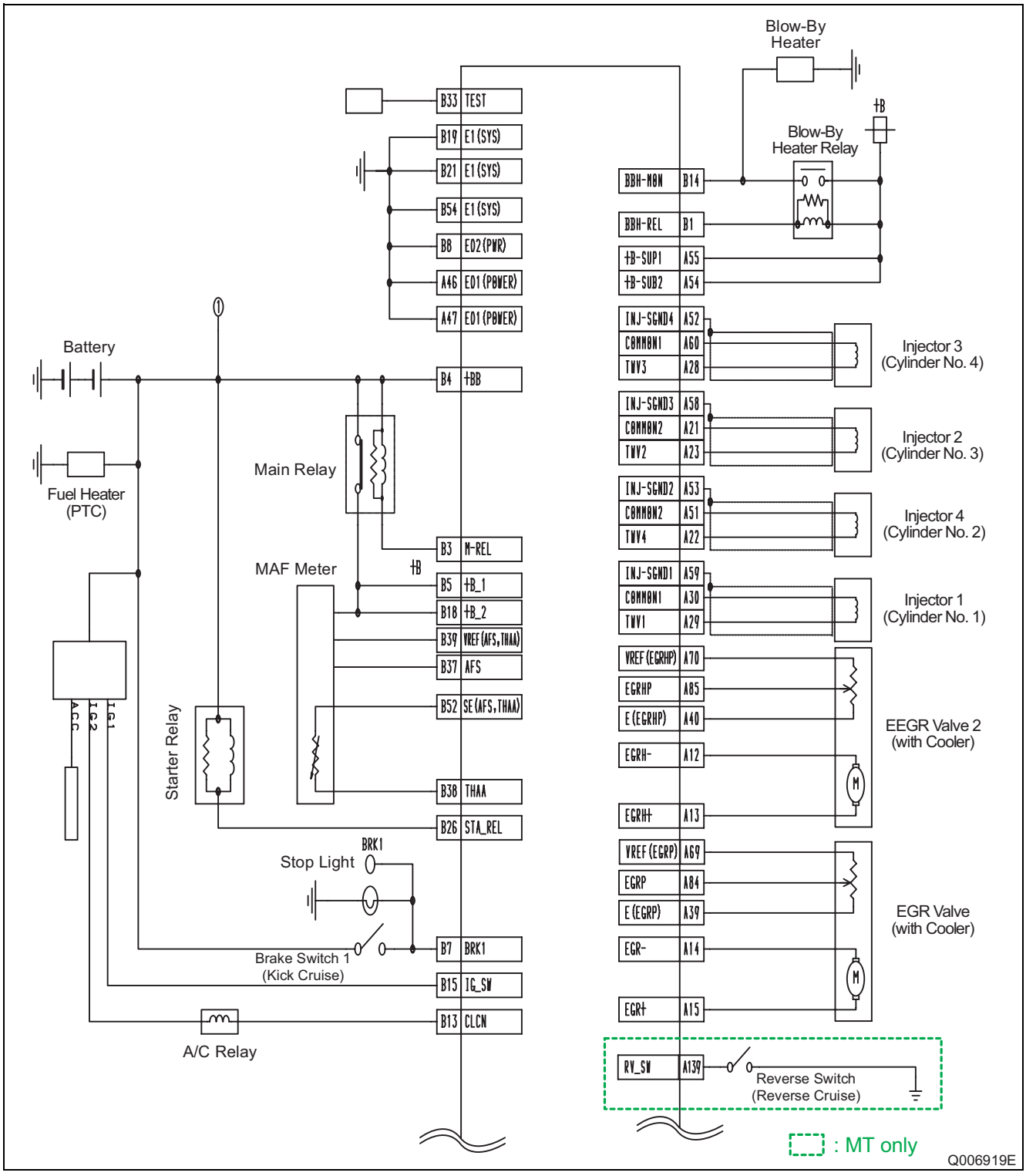
(1) AT

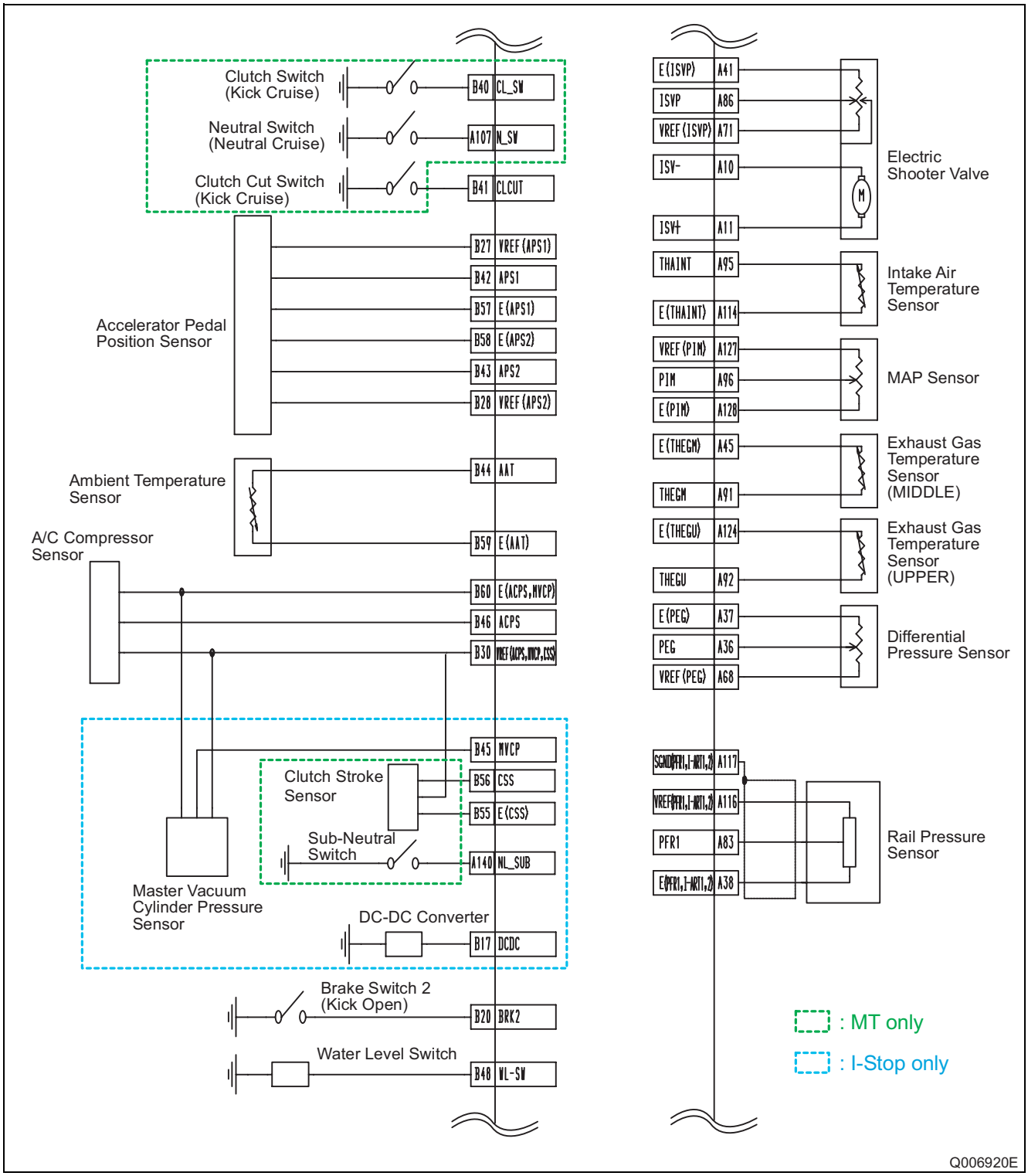


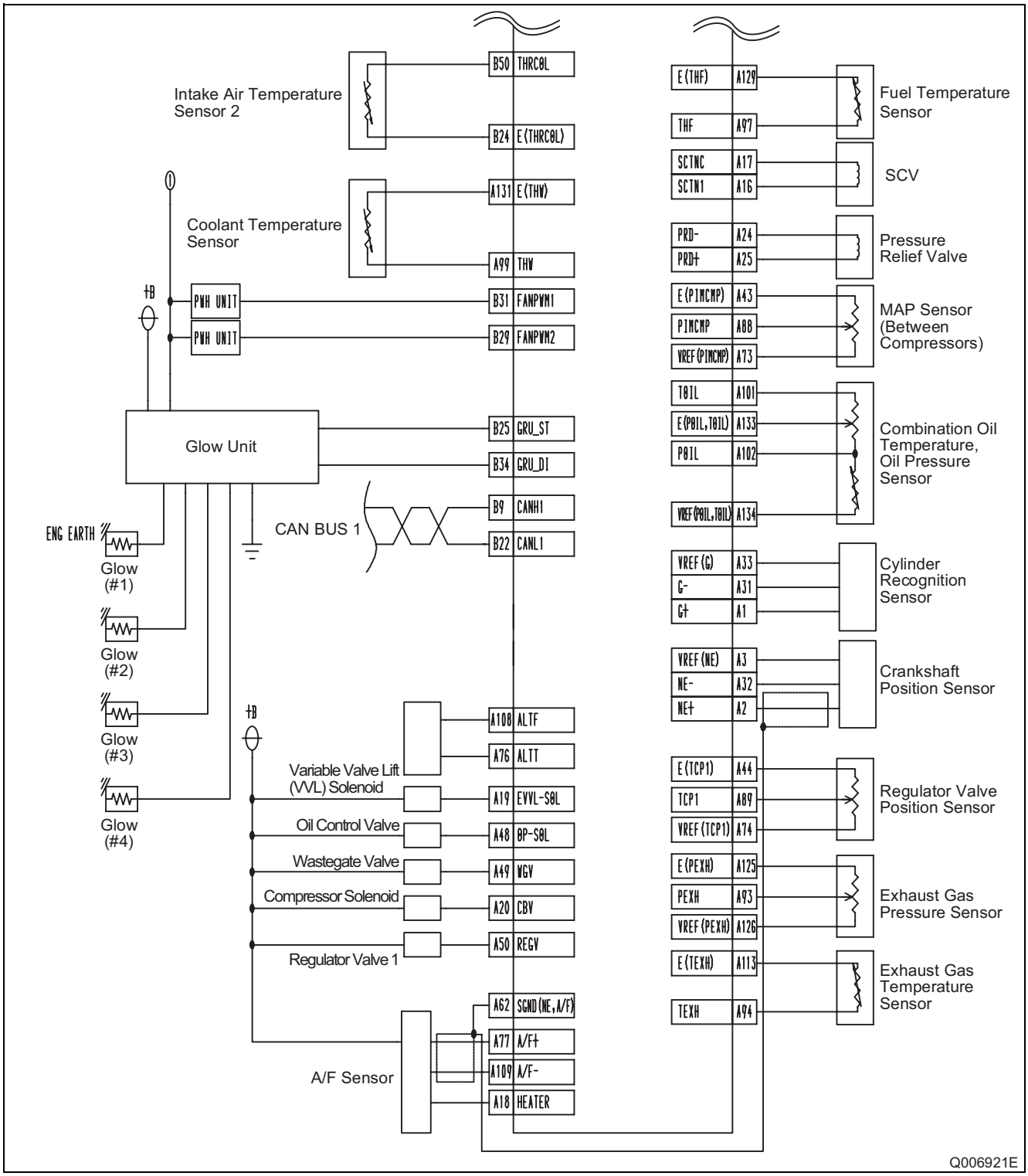

B41 CLCUT
ATCU
B27 VREF(APS1)
B42 APS1
B57 E(APS1)
B58 E(APS2)
B43 APS2
B28 VREF(APS2)
Accelerator Pedal Position Sensor
B44 AAT
Ambient Temperature Sensor
B59 E(AAT)
A/C Compressor Sensor
B60 E(ACPS,MVCP)
B46 ACPS
B30 VREF(ACPS,MVCP,CSS)
B45 MVCP
Master Vacuum Cylinder Pressure Sensor
DC-DC Converter
B17 DCDC
Brake Switch 2 (Kick Open)
B20 BRK2
Water Level Switch
B48 WL-SW
E(ISVP) A41
ISVP A86
VREF(ISVP) A71
ISV- A10
ISV+ A11
Electric Shooter Valve
THAINT A95
E(THAINT) A114
Intake Air Temperature Sensor
VREF(PIM) A127
PIM A96
E(PIM) A128
Manifold Absolute Pressure (MAP) Sensor
E(THEGM) A45
THEGM A91
Exhaust Gas Temperature Sensor (MIDDLE)
E(THEGU) A124
THEGU A92
Exhaust Gas Temperature Sensor (UPPER)
E(PEG) A37
PEG A36
VREF(PEG) A68
Differential Pressure Sensor
SCNDPFR1,T-MRT1,2 A117
VREFPFR1,T-MRT1,2 A116
PFR1 A83
E(PFR1,T-MRT1,2) A38
Rail Pressure Sensor
: I-Stop only
Q006884E


Intake Air Temperature Sensor 2
Coolant Temperature Sensor
+B
PWH UNIT
PWH UNIT
Glow Unit
ENG EARTH
Glow (#1)
Glow (#2)
Glow (#3)
Glow (#4)
CAN BUS 1
CAN BUS 2
Variable Valve Lift (VVL) Solenoid
Oil Control Valve
Wastegate Valve
Compressor Solenoid
Regulator Valve 1
A/F Sensor
B50 THRC8L
B24 E(THRC8L)
A131 E(THW)
A99 THW
B31 FANPWM1
B29 FANPWM2
B25 GRU_ST
B34 GRU_DI
B9 CANH1
B22 CANL1
A7 CANH2
A6 CANL2
A108 ALTF
A76 ALTT
A19 EVVL-S8L
A48 BP-S8L
A49 WGV
A20 CBV
A50 REGV
A62 SGND(NE,A/F)
A77 A/F+
A109 A/F-
A18 HEATER
E(THF) A129
THF A97
SCTNC A17
SCTN1 A16
PRD- A24
PRD+ A25
E(PIMCMP) A43
PIMCMP A88
VREF(PIMCMP) A73
T8IL A101
E(P8IL,T8IL) A133
P8IL A102
VREF(P8IL,T8IL) A134
VREF(G) A33
G- A31
G+ A1
VREF(NE) A3
NE- A32
NE+ A2
E(TCP1) A44
TCP1 A89
VREF(TCP1) A74
E(PEXH) A125
PEXH A93
VREF(PEXH) A126
E(TEXH) A113
TEXH A94
Fuel Temperature Sensor
SCV
Pressure Relief Valve
MAP Sensor (Between Compressors)
Combination Oil Temperature, Oil Pressure Sensor
Cylinder Recognition Sensor
Crankshaft Position Sensor
Regulator Valve Position Sensor
Exhaust Gas Pressure Sensor
Exhaust Gas Temperature Sensor
: AT only
Q006885E

(2) MT

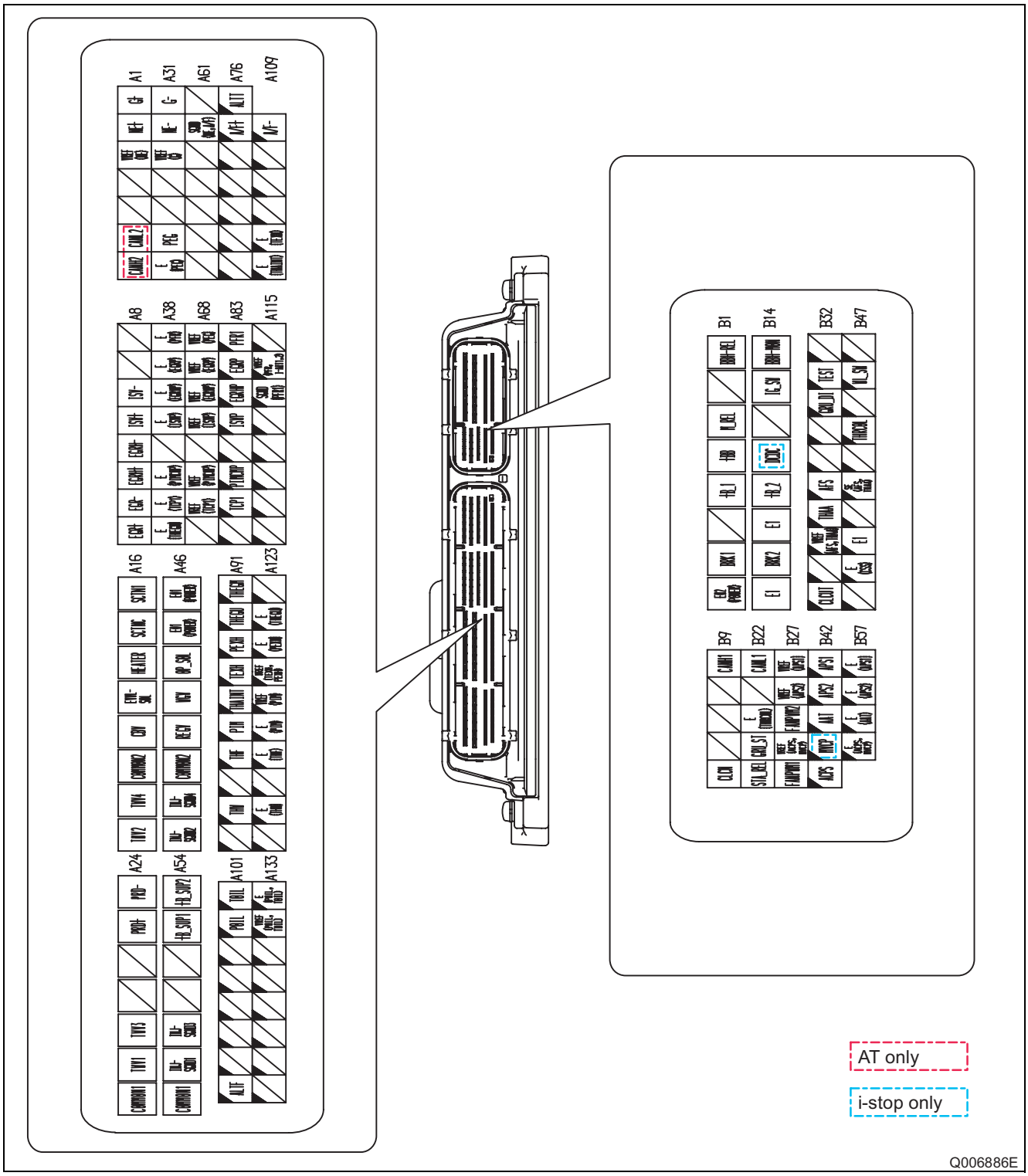

Blow-By Heater
+B
Blow-By Heater Relay
B33 TEST
B19 E1(SYS)
B21 E1(SYS)
B54 E1(SYS)
B8 E02(PWR)
A46 E01(PBWER)
A47 E01(PBWER)
BBH-MON B14
BBH-REL B1
+B-SUP1 A55
+B-SUB2 A54
INJ-SGND4 A52
COMMON1 A60
TWV3 A28
Injector 3 (Cylinder No. 4)
INJ-SGND3 A58
COMMON2 A21
TWV2 A23
Injector 2 (Cylinder No. 3)
INJ-SGND2 A53
COMMON2 A51
TWV4 A22
Injector 4 (Cylinder No. 2)
INJ-SGND1 A59
COMMON1 A30
TWV1 A29
Injector 1 (Cylinder No. 1)
VREF(EGRHP) A70
EGRHP A05
E(EGRHP) A40
EGRH- A12
EGRH+ A13
EEGR Valve 2 (with Cooler)
VREF(EGRP) A69
EGRP A04
E(EGRP) A39
EGR- A14
EGR+ A15
EGR Valve (with Cooler)
RV_SW A139
Reverse Switch (Reverse Cruise)
Battery
B4 +BB
Fuel Heater (PTC)
Main Relay
B3 M-REL
MAF Meter
+B
B5 +B_1
B18 +B_2
B39 VREF(AFS,THAA)
B37 AFS
B52 SE(AFS,THAA)
B38 THAA
B26 STA_REL
Starter Relay
ACC
IG2
IG1
BRK1
Stop Light
Brake Switch 1 (Kick Cruise)
B7 BRK1
B15 IG_SW
B13 CLCN
A/C Relay
: MT only
Q006919E


Clutch Switch (Kick Cruise)
B40 CL_SW
Neutral Switch (Neutral Cruise)
A107 N_SW
Clutch Cut Switch (Kick Cruise)
B41 CLCUT
Accelerator Pedal Position Sensor
B27 VREF (APS1)
B42 APS1
B57 E (APS1)
B58 E (APS2)
B43 APS2
B28 VREF (APS2)
Ambient Temperature Sensor
B44 AAT
B59 E (AAT)
A/C Compressor Sensor
B60 E (ACPS, MVCP)
B46 ACPS
B30 VREF (ACPS, MVCP, CSS)
B45 MVCP
Clutch Stroke Sensor
B56 CSS
B55 E (CSS)
Sub-Neutral Switch
A140 NL_SUB
Master Vacuum Cylinder Pressure Sensor
DC-DC Converter
B17 DCDC
Brake Switch 2 (Kick Open)
B20 BRK2
Water Level Switch
B48 WL-SW
E (ISVP) A41
ISVP A86
VREF (ISVP) A71
ISV- A10
ISV+ A11
Electric Shooter Valve
THAINT A95
E (THAINT) A114
Intake Air Temperature Sensor
VREF (PIM) A127
PIM A96
E (PIM) A128
MAP Sensor
E (THEGM) A45
THEGM A91
Exhaust Gas Temperature Sensor (MIDDLE)
E (THEGU) A124
THEGU A92
Exhaust Gas Temperature Sensor (UPPER)
E (PEG) A37
PEG A36
VREF (PEG) A68
Differential Pressure Sensor
SCNDPFR1, 2-NRTN, 2 A117
VREFPFR1, 2-NRTN, 2 A116
PFR1 A83
E (PFR1, 2-NRTN, 2) A38
Rail Pressure Sensor
: MT only
: I-Stop only
Q006920E

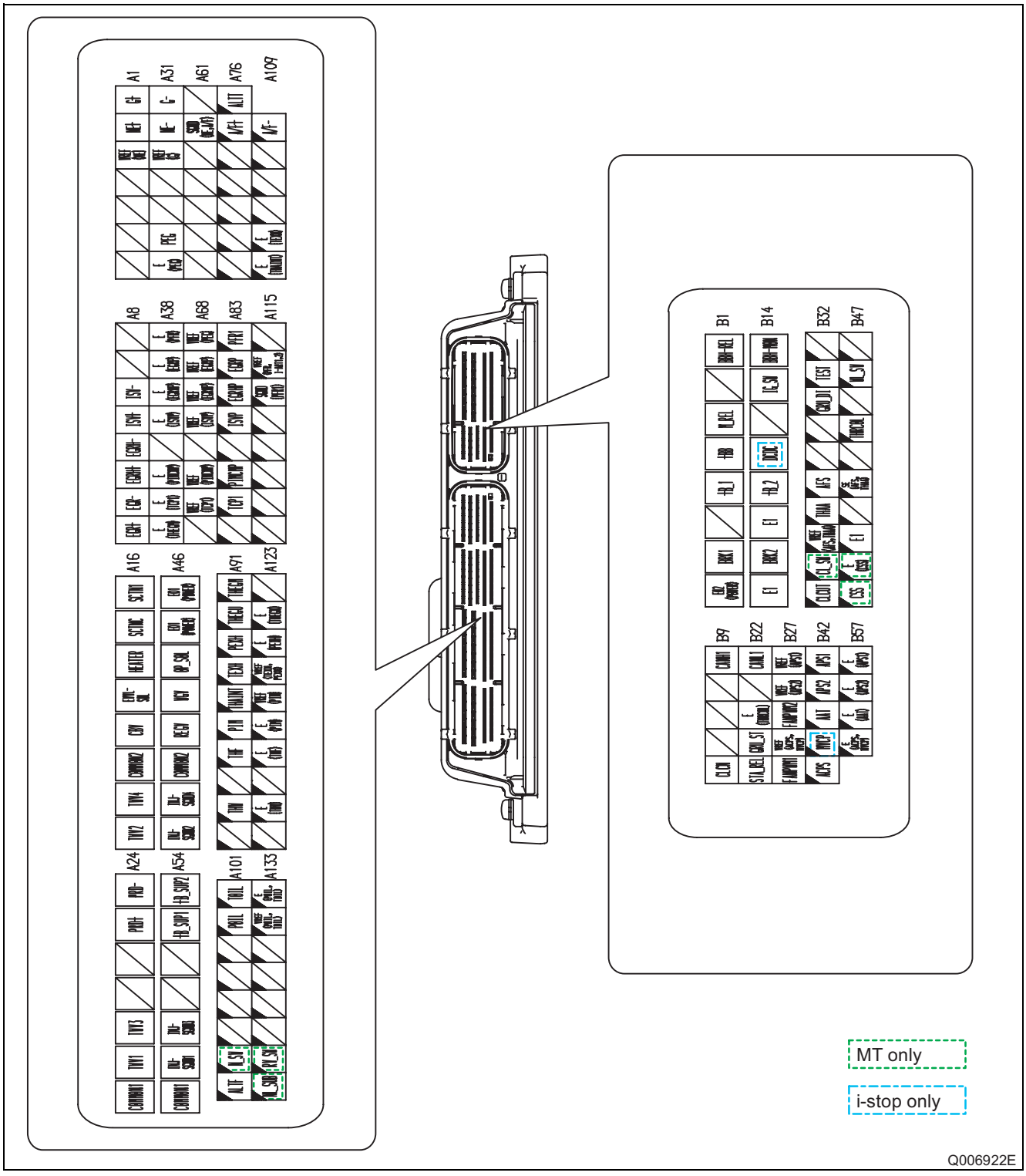

Intake Air Temperature Sensor 2
Coolant Temperature Sensor
+B
PWM UNIT
PWM UNIT
Glow Unit
ENG EARTH
Glow (#1)
Glow (#2)
Glow (#3)
Glow (#4)
CAN BUS 1
Variable Valve Lift (VVL) Solenoid
Oil Control Valve
Wastegate Valve
Compressor Solenoid
Regulator Valve 1
A/F Sensor
B50 THRC8L
B24 E(THRC8L)
A131 E(THW)
A99 THW
B31 FANPWM1
B29 FANPWM2
B25 GRU_ST
B34 GRU_DI
B9 CANH1
B22 CANL1
A108 ALTF
A76 ALTT
A19 EVVL-S8L
A48 BP-S8L
A49 WGV
A20 CBV
A50 REGV
A62 SGND(NE,A/F)
A77 A/F+
A109 A/F-
A18 HEATER
E(THF) A129
THF A97
SCTNC A17
SCTN1 A16
PRD- A24
PRD+ A25
E(PIMCMP) A43
PIMCMP A88
VREF(PIMCMP) A73
T8IL A101
E(P8IL,T8IL) A133
P8IL A102
VREF(P8IL,T8IL) A134
VREF(G) A33
G- A31
G+ A1
VREF(NE) A3
NE- A32
NE+ A2
E(TCP1) A44
TCP1 A89
VREF(TCP1) A74
E(PEXH) A125
PEXH A93
VREF(PEXH) A126
E(TEXH) A113
TEXH A94
Fuel Temperature Sensor
SCV
Pressure Relief Valve
MAP Sensor (Between Compressors)
Combination Oil Temperature, Oil Pressure Sensor
Cylinder Recognition Sensor
Crankshaft Position Sensor
Regulator Valve Position Sensor
Exhaust Gas Pressure Sensor
Exhaust Gas Temperature Sensor
Q006921E

11.2 Connector Diagrams

(1) AT



(2) MT



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