ENGINE CONTROL

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GENERAL INFORMATION

OVERVIEW AND OPERATINF PROCESS

CONFIGURATION AND FUNCTION

REMOVAL AND INSTALLATION

ENGINE CONTROL

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GENERAL INFORMATION

1. ENGINE DATA LIST

Data	Unit	Value
Coolant temperature	℃	0.436 V (130℃) to 4.896 V (-40℃)
Intake air temperature	℃	-40 to 130℃ (varies by ambient air temperature or engine mode)
Idle speed	rpm	750 ± 20
Engine load	%	18~25%
Mass air flow	kg/h	16 to 25 kg/h
Throttle position angle	°TA	0° (Full Open) to 78° (Close)
Engine torque	Nm	varies by engine conditions
Injection time	ms	3 to 5ms
Battery voltage	V	13.5 V to 14.1 V
Accelerator pedal position 1	V	0.4. to 4.8V
Accelerator pedal position 2	V	0.2 to 2.4 V
Throttle position 1	V	0.3 to 4.6 V
Throttle position 2	V	0.3 to 4.6 V
Oxygen sensor	mV	0 to 5 V
A/C compressor switch	1=ON / 0=OFF	-
Full load	1=ON / 0=OFF	-
Gear selection (A/T)	1=ON / 0=OFF	-
Knocking control	1=ON / 0=OFF	-
Brake switch	1=ON / 0=OFF	-
Cruise control	1=ON / 0=OFF	-

OVERVIEW AND OPERATINF PROCESS

1. MAJOR COMPONENTS

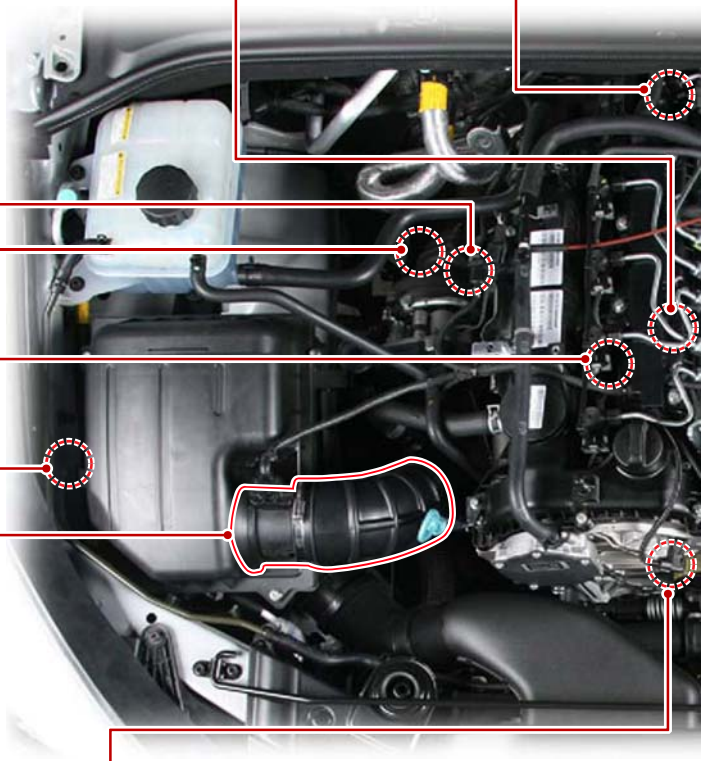
Rear EGT sensor

Front EGT sensor

Glow plug

IMV

Oxygen sensor



Injector (C3I)

Differential pressure sensor

HFM (air mass/ temperature)

Camshaft position sensor

Variable swirl valve actuator

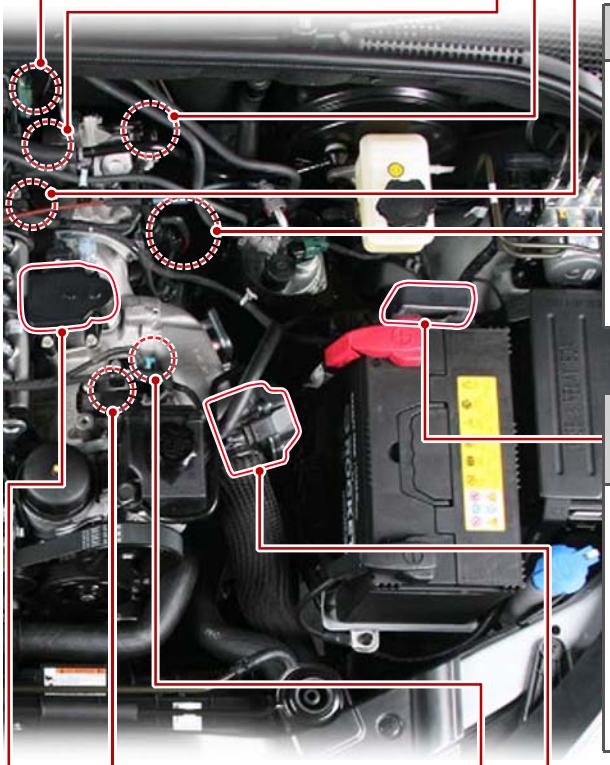
Modification basis	
Application basis	
Affected VIN	

Coolant temperature sensor

Fuel temperature sensor

EGR valve

Fuel rail pressure sensor



E-EGR bypass valve

E-VGT actuator

GCU (Preglow control unit)

Water sensor

T-MAP sensor

Knock sensor (2 ea)

Electric throttle body

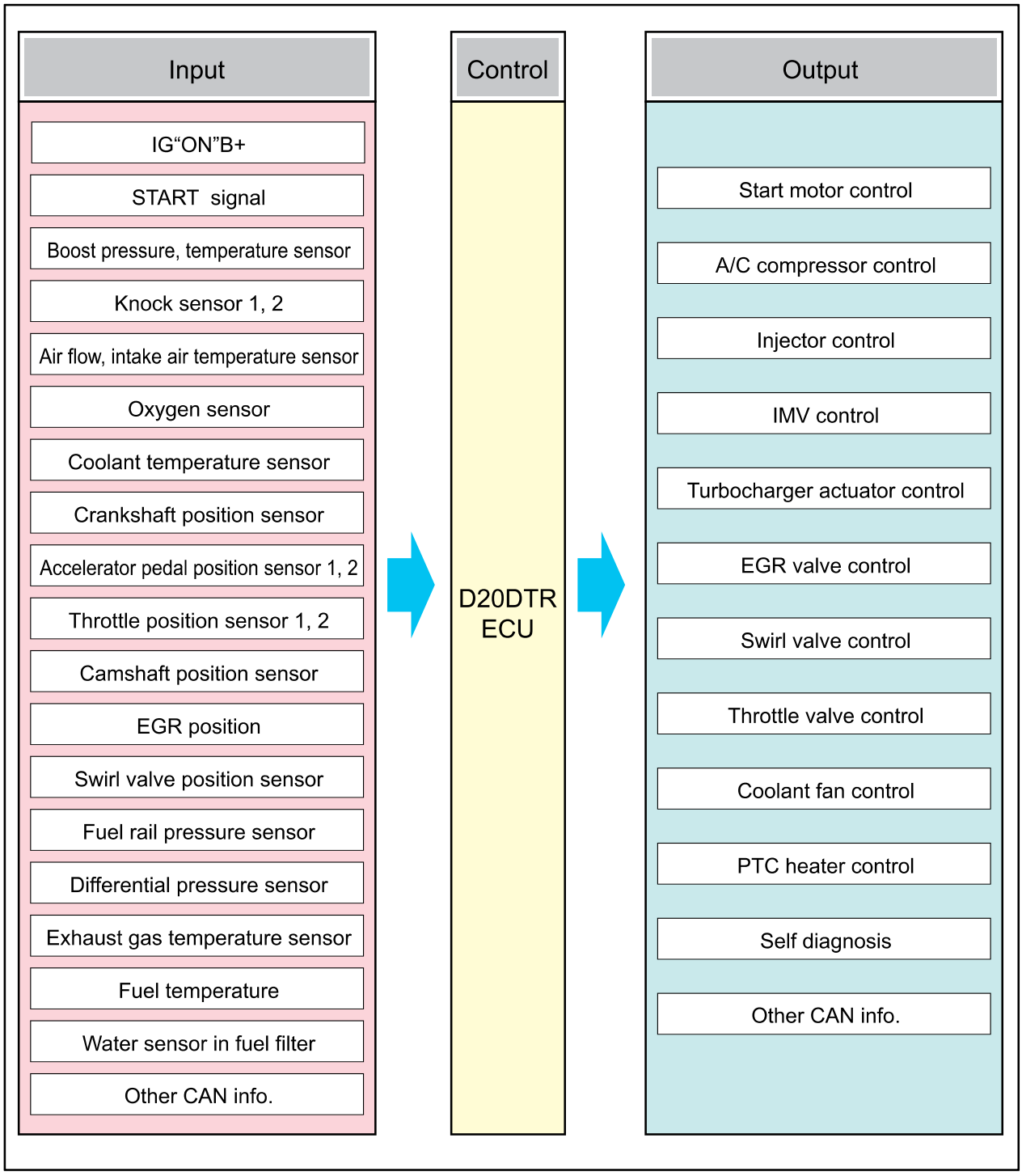
D20DTR ECU

Modification basis	
Application basis	
Affected VIN	

2. SYSTEM OPERATION

1) Input/Output of ECU

(1) ECU Block diagram



Modification basis	
Application basis	
Affected VIN	

(2) Components for ECU Input

-Auto cruise switch
- Rear right wheel speed (without ABS)
- Refrigerant pressure sensor
- Clutch pedal signal
- Blower switch signal
- Brake pedal signal

Crankshaft position sensor	**Accelerator pedal sensor**	**Throttle position sensor**	**Knock sensor**
			
Exhaust gas temperature sensor	**HFM sensor**	**T-MAP sensor**	**Oxygen sensor**
			
Differential pressure sensor	**E-EGR valve position sensor**	**Camshaft position sensor**	**Coolant temperature sensor**
			
Fuel rail pressure sensor	**Swirl valve position sensor**	**Water sensor**	**CAN**
			- ABS & ESP - GCU - Instrument cluster - TCU

(3) Components for ECU Output

E-EGR valve	A/C compressor	Injector	Throttle position sensor
			

E-EGR cooler bypass valve	Variable swirl valve	E-VGT actuator	IMV valve
			

PTC heater	Cooling fan
	

CAN	
- Glow plug unit	- Instrument cluster
- ABS & ESP unit	- TCU
- GCU	- Self diagnosis

Modification basis	
Application basis	
Affected VIN	

2) ECU Control

(1) Function

a. ECU Function

ECU receives and analyzes signals from various sensors and then modifies those signals into permissible voltage levels and analyzes to control respective actuators.
ECU microprocessor calculates injection period and injection timing proper for engine piston speed and crankshaft angle based on input data and stored specific map to control the engine power and emission gas.
Output signal of the ECU microprocessor drives pressure control valve to control the rail pressure and activates injector solenoid valve to control the fuel injection period and injection timing; so controls various actuators in response to engine changes. Auxiliary function of ECU has adopted to reduce emission gas, improve fuel economy and enhance safety, comforts and conveniences. For example, there are EGR, booster pressure control, autocruise (export only) and immobilizer and adopted CAN communication to exchange data among electrical systems (automatic T/M and brake system) in the vehicle fluently. And Scanner can be used to diagnose vehicle status and defectives.
Operating temperature range of ECU is normally −40 to +85°C and protected from factors like oil, water and electromagnetism and there should be no mechanical shocks.
To control the fuel volume precisely under repeated injections, high current should be applied instantly so there is injector drive circuit in the ECU to generate necessary current during injector drive stages.
Current control circuit divides current applying time (injection time) into full-in-current-phase and hold-current-phase and then the injectors should work very correctly under every working condition.

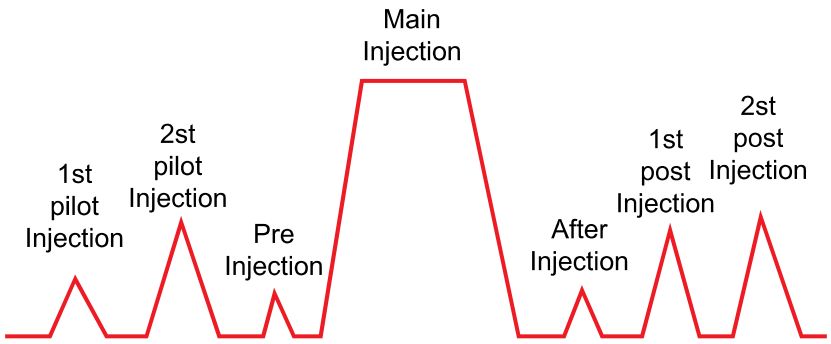
b. Control Function

- Controls by operating stages
  To make optimum combustion under every operating stage, ECU should calculate proper injection volume in each stage by considering various factors.
- Starting injection volume control
  During initial starting, injecting fuel volume will be calculated by function of temperature and engine cranking speed. Starting injection continues from when the ignition switch is turned to ignition position to till the engine reaches to allowable minimum speed.
- Driving mode control
  If the vehicle runs normally, fuel injection volume will be calculated by accelerator pedal travel and engine rpm and the drive map will be used to match the drivers inputs with optimum engine power.

(2) Fuel injection control

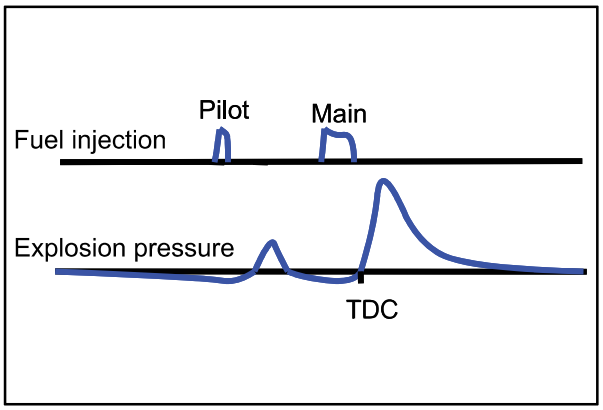
a. Multi injection

Fuel injection process consists of 3 steps: Main Injection, Pilot Injection, Post Injection

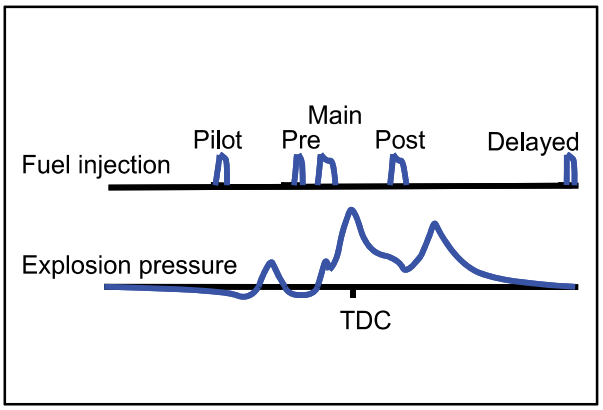


Injection	Function	Main	Produces engine power
Pilot 1	Reduces PM by injecting before main injection.	**After**	PM control
Pilot 2	Reduces NOx and noise by shortening main injection delay due to flammability	**Post 1**	Reduces PM by enabling fuel activation.
Pre	Controls NOx emission level, Combustion noise and Stable idle	**Post 2**	Activates CDPF by increasing exhaust gas temperature and supplying reduction material

▶ **Pilot injection**



▶ **Multi injection**



Modification basis	
Application basis	
Affected VIN	

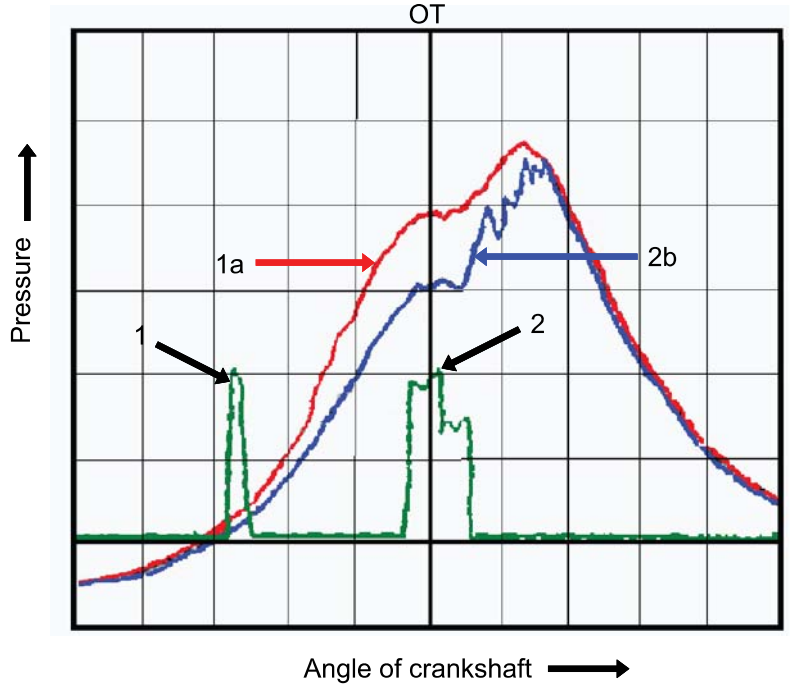
b. Pilot Injection

Injection before main injection. Consists of 1st and 2nd pilot injection, and Pre-injection
Inject a small amount of fuel before main injection to make the combustion smooth. Also, called as preliminary injection or ignition injection. This helps to reduce Nox, engine noise and vibration, and to stabilize the idling.
The injected fuel volume is changed and stopped according to the coolant temperature and intake air volume.

Stop conditions

- Pilot injection is much earlier than main injection due to higher engine rpm
- Too small injection volume (insufficient injection pressure, insufficient fuel injection volume in main injection, engine braking)
- System failure (fuel system, engine control system)

▶ **Combustion pressure characteristic curve for pilot injection**



1. Pilot injection
2. Main injection

1a. Combustion pressure with pilot injection
2b. Combustion pressure without pilot injection

c. Main Injection

The power of the vehicle is determined by the main fuel injection volume.
Main injection calculates the fuel volume based on pilot injection. The calculation uses the value for accelerator pedal position, engine rpm, coolant temperature, intake air temperature, boost pressure, boost temperature and atmospheric pressure etc.

d. Post Injection

Injection after main injection. Consists of After injection, Post 1, Post 2 injection.
Post injection reduces PM and smoke from exhaust gas. No actual output is generated during these injections, instead, fuel is injected to the unburned gas after main injection to enable fuel activation. The PM amount in the emission and smoke can be reduced through these processes.
Only up to 5 types of injections can be performed within 1 cycle. If these 7 injections are all performed, fuel economy and emission performance becomes poor.

Modification basis	
Application basis	
Affected VIN	

(3) Fuel Pressure Control

▶ Fuel Pressure

Fuel pressure is controlled by IMV opening according to the calculated value by ECU.

▶ Pressure in the fuel rail is determined according to engine speed and load on the engine.

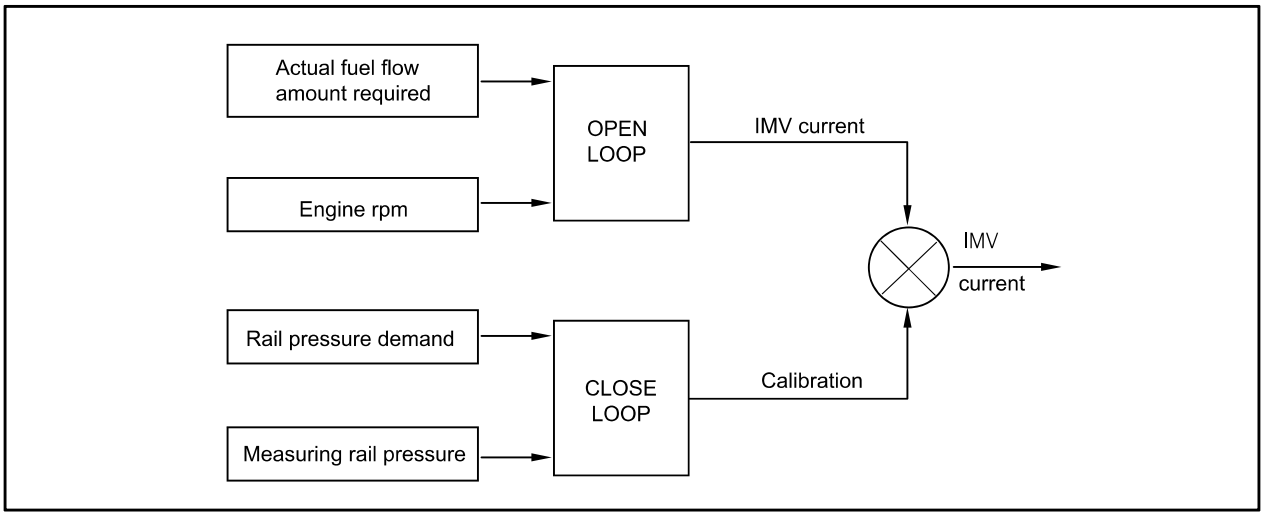
- When engine speed and load are high
  The degree of turbulence is very great and the fuel can be injected at very high pressure in order to optimize combustion.
- When engine speed and load are low
  The degree of turbulence is low. If injection pressure is too high, the nozzle's penetration will be excessive and part of the fuel will be sprayed directly onto the sides of the cylinder, causing incomplete combustion. So there occurs smoke and damages engine durability.

Fuel pressure is corrected according to air temperature, coolant temperature and atmospheric pressure and to take account of the added ignition time caused by cold running or by high altitude driving. A special pressure demand is necessary in order to obtain the additional flow required during starts. This demand is determined according to injected fuel and coolant temperature.

▶ Open loop determines the current which needs to be sent to the actuator in order to obtain the flow demanded by the ECU.

▶ Closed loop will correct the current value depending on the difference between the pressure demand and the pressure measured.

- If the pressure is lower than the demand, current is reduced so that the fuel sent to the high pressure pump is increased.
- If the pressure is higher than the demand, current is increased so that the fuel sent to the high pressure pump is reduced.



(4) Injection Timing Control

▶ **Injection timing is determined by the conditions below.**

1. Coolant temperature
   Hot engine - Retarded to reduce Nox
   Cold engine - Advanced to optimize the combustion
2. Atmospheric pressure
   Advanced according to the altitude
3. Warming up
   Advanced during warming up in cold engine
4. Rail pressure
   Retarded to prevent knocking when the rail pressure is high
5. EEGR ratio
   Advanced to decrease the cylinder temperature when EGR ratio increases

▶ **Pilot injection timing control**

The pilot injection timing is determined as a function of the engine speed and of the total flow.
The elements are:

- A first correction is made according to the air and coolant temperatures. This correction allows the pilot injection timing to be adapted to the operating temperature of the engine.
- A second correction is made according to the atmospheric pressure. This correction is used to adapt the pilot injection timing as a function of the atmospheric pressure and therefore the altitude.

▶ **Main injection timing control**

The pulse necessary for the main injection is determined as a function of the engine speed and of the injected flow.
The elements are:

- A first correction is made according to the air and coolant temperatures.
  This correction makes it possible to adapt the timing to the operating temperature of the engine. When the engine is warm, the timing can be retarded to reduce the combustion temperature and polluting emissions (NOx). When the engine is cold, the timing advance must be sufficient to allow the combustion to begin correctly.
- A second correction is made according to the atmospheric pressure.
  This correction is used to adapt the timing advance as a function of the atmospheric pressure and therefore the altitude.
- A third correction is made according to the coolant temperature and the time which has passed since starting.
  This correction allows the injection timing advance to be increased while the engine is warming up (initial 30 seconds). The purpose of this correction is to reduce the misfiring and instabilities which are liable to occur after a cold start.

Modification basis	
Application basis	
Affected VIN	

- A fourth correction is made according to the pressure error.
  This correction is used to reduce the injection timing advance when the pressure in the rail is higher than the pressure demand.
  A fifth correction is made according to the rate of EGR.
- This correction is used to correct the injection timing advance as a function of the rate of exhaust gas recirculation.

When the EGR rate increases, the injection timing advance must in fact be increased in order to compensate for the fall in termperature in the cylinder.

(5) Fuel Control

A. Main Flow Control

The main flow represents the amount of fuel injected into the cylinder during the main injection.
The pilot flow represents the amount of fuel injected during the pilot injection.

The total fuel injected during 1 cycle (main flow + pilot flow) is determined in the following manner.

- When the driver depress the pedal, it is his demand which is taken into account by the system in order to determine the fuel injected.
- When the driver release the pedal, the idle speed controller takes over to determine the minimum fuel which must be injected into the cylinder to prevent the enigne from stalling.

It is therefore the greater of these 2 values which is retained by the system. This value is then compared with the lower flow limit determined by the ESP system.

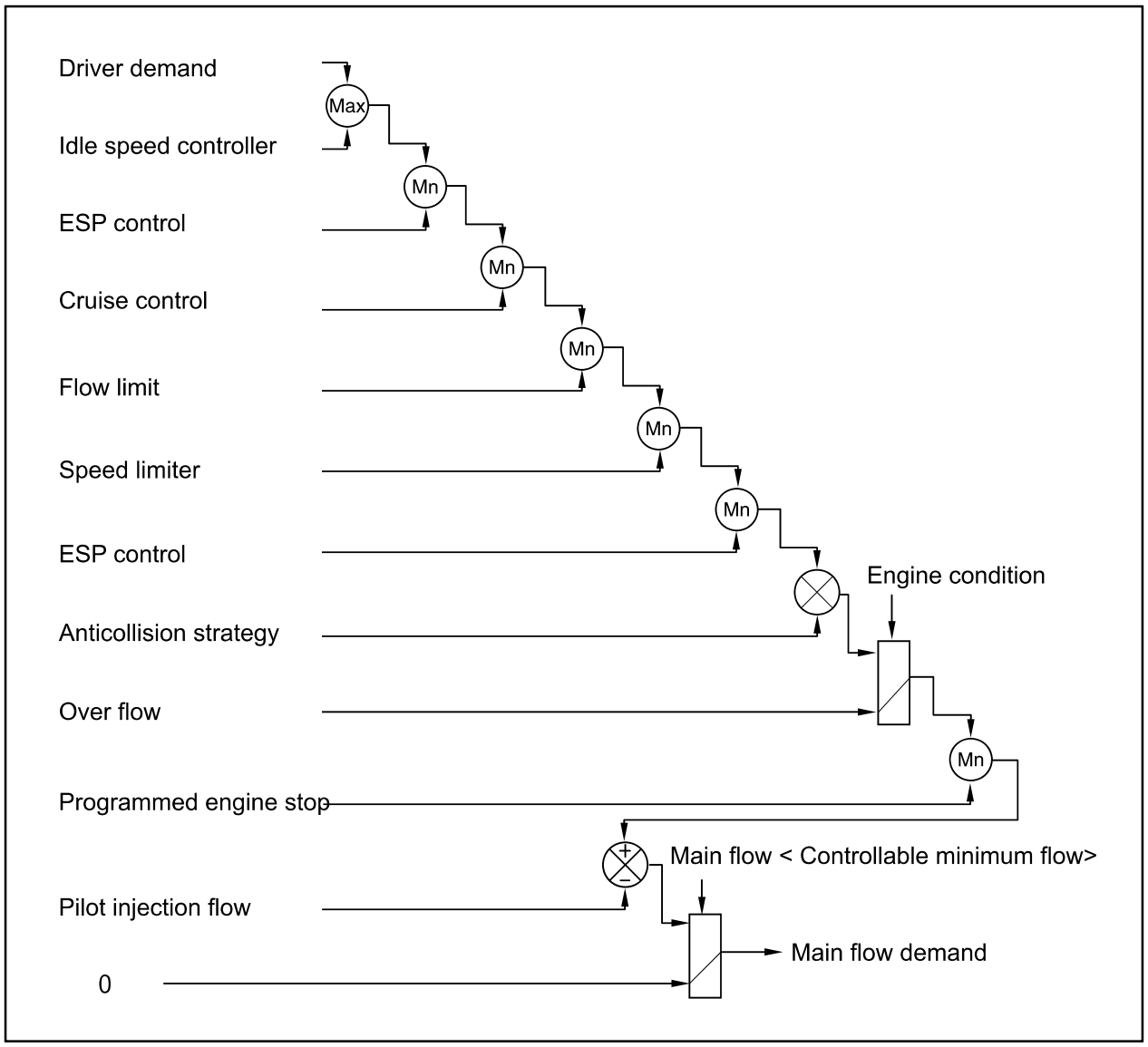
As soon as the injected fuel becomes lower than the flow limit determined by the ESP system, the antagonistic torque (engine brake) transmitted to the drive wheels exceeds the adherence capacity of the vehicle and there is therefore a risk of the drive wheels locking.
The system thus chooses the greater of these 2 values (main flow & pilot flow) in order to prevent any loss of control of the vehicle during a sharp deceleration.

As soon as the injected fuel becomes higher than the fuel limit determined by the ASR trajectory control system, the engine torque transmitted to the wheels exceeds the adhesion capacity of the vehicle and there is a risk of the drive wheels skidding. The system therefore chooses the smaller of the two values in order to avoid any loss of control of the vehicle during accelerations.
The anti-oscillation strategy makes it possible to compensate for fluctuations in engine speed during transient conditions. This strategy leads to a fuel correction which is added to the total fuel of each cylinder.

A switch makes it possible to change over from the supercharge fuel to the total fuel according to the state of the engine.

- Until the stating phase has finished, the system uses the supercharged fuel.
- Once the engine changes to normal operation, the system uses the total fuel.

The main fuel is obtained by subtracting the pilot injection fuel from the total fuel.
A mapping determines the minimum fuel which can control an injector as a function of the rail pressure. As soon as the main fuel falls below this value, the fuel demand changes to 0 because in any case the injector is not capable of injecting the quantity demand.



B. Driver Demand

The driver demand is the translation of the pedal position into the fuel demand. It is calculated as a function of the pedal position and of the engine speed. The driver demand is filtered in order to limit the hesitations caused by rapid changes of the pedal position. A mapping determines the maximum fuel which can be injected as a function of the driver demand and the rail pressure. Since the flow is proportional to the injection time and to the square root of the injection pressure, it is necessary to limit the flow according to the pressure in order to avoid extending the injection for too long into the engine cycle. The system compares the driver demand with this limit and chooses the smaller of the 2 values. The driver demand is then corrected according to the coolant temperature. This correction is added to the driver demand.

Modification basis	
Application basis	
Affected VIN	

C. Idle Speed Controller

The idle speed controller consists of 2 principal modules:

- The first module determines the required idle speed according to:
  * The operating conditions of the engine (coolant temperature, gear engaged)
  * Any activation of the electrical consumers (power steering, air conditioning, others)
  * The battery voltage
  * The presence of any faults liable to interface with the rail pressure control or the injection control. In this case, increase the idle speed to prevent the engine from stalling.
- The second module is responsible for providing closed loop control of the engine's idle speed by adapting the minimum fuel according to the difference between the required idle speed and the engine speed.

D. Flow Limitation

The flow limitation strategy is based on the following strategies:

- The flow limitation depending on the filling of the engine with air is determined according to the engine speed and the air flow. This limitation allows smoke emissions to be reduced during stabilized running.
- The flow limitation depending on the atmospheric pressure is determined according to the engine speed and the atmospheric pressure. It allows smoke emissions to be reduced when driving at altitude.
- The full load flow curve is determined according to the gear engaged and the engine speed. It allows the maximum torque delivered by the engine to be limited.
- A performance limitation is introduced if faults liable to upset the rail pressure control or the injection control are detected by the system. In this case, and depending on the gravity of the fault, the system activates:

Reduced fuel logic 1: Guarantees 75 % of the performance without limiting the engine speed.
Reduced fuel logic 2: Guarantees 50 % of the performance with the engine speed limited to 3,000 rpm.
Reduce fuel logic 3: Limits the engine speed to 2,000 rpm.

The system chooses the lowest of all values.
A correction depending on the coolant temperature is added to the flow limitation. This correction makes it possible to reduce the mechanical stresses while the engine is warming up.
The correction is determined according to the coolant temperature, the engine speed and the time which has passed since starting.

E. Superchager Flow Demand

The supercharge flow is calculated according to the engine speed and the coolant temperature. A correction depending on the air temperature and the atmospheric pressure is made in order to increase the supercharge flow during cold starts. It is possible to alter the supercharge flow value by adding a flow offset with the aid of the diagnostic tool

F. Pilot Flow Control

The pilot flow represents the amount of fuel injected into the cylinder during the pilot injection.
This amount is determined according to the engine speed and the total flow.

- A first correction is made according to the air and water temperature.
  This correction allows the pilot flow to be adapted to the operating temperature of the engine. When the engine is warm, the ignition time decreases because the end-of-compression temperature is higher. The pilot flow can therefore be reduced because there is obviously less combustion noise when the engine is warm.
- A second correction is made according to the atmospheric pressure.

During starting, the pilot flow is determined on the basis of the engine speed and the coolant temperature.

G. Cylinder Balancing Strategy

▶ Balancing of the point to point flows

The pulse of each injector is corrected according to the difference in instantaneous speed measured between 2 successive injectors.

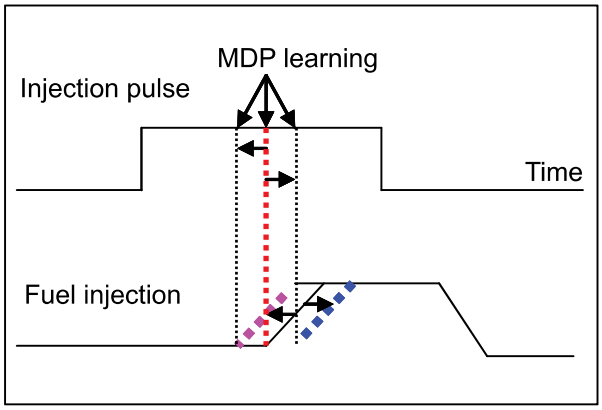
The instantaneous speeds on two successive injections are first calculated.
The difference between these two instantaneous speeds is then calculated.
Finally, the time to be added to the main injection pulse for the different injectors is determined.
For each injector, this time is calculated according to the initial offset of the injector and the instantaneous speed difference.

▶ Detection of an injector which has stuck closed

The cylinder balancing strategy also allows the detection of an injector which has stuck closed.
The difference in instantaneous speed between 2 successive injections then exceeds a predefined threshold. In this case, a fault is signaled by the system.

Modification basis	
Application basis	
Affected VIN	

(6) MDP Learning Control



MDP (Minimum Drive Pulse) refers to the minimum power supply pulse for injection which the injector can perform. It is possible to control the fuel volume for each injector accurately through correct learning for the MDP value. The basic process of MDP learning is that the pulse slightly higher than MDP is supplied and then (b) the vibration generated from the cylinder is detected. The knock sensor detects the vibration from the engine after a small volume of fuel is injected. And the time interval between the points of injection and vibration is measured so that MDP can be learned. MDP learning is helpful to prevent engine vibration, high emission and power reduction through performing calibration for the old injectors. During MDP learning, a little vibration and noise can be occur for a while. This is because the fuel pressure is increased instantaneously and the exact injection value is not input, so that the exact engine vibration timing can be detected.

A. MDP Learning

When the pulse value that the injector starts injection is measured, it is called minimum drive pulse (MDP). Through MDP controls, can correct pilot injections effectively. Pilot injection volume is very small, 1 to 2 mm/str, so precise control of the injector can be difficult if it gets old. So there needs MDP learning to control the very small volume precisely through learning according to getting older injectors.

B. Purpose of MDP learning

The system measures the pulse at initial injection to reduce the engine vibration.

- Control the fuel injection volume precisely by MDP learning even for the old injector.
- ECU corrects the pilot injection effectively by MDP control.
- MDP learning is performed by the signal from knock sensor.

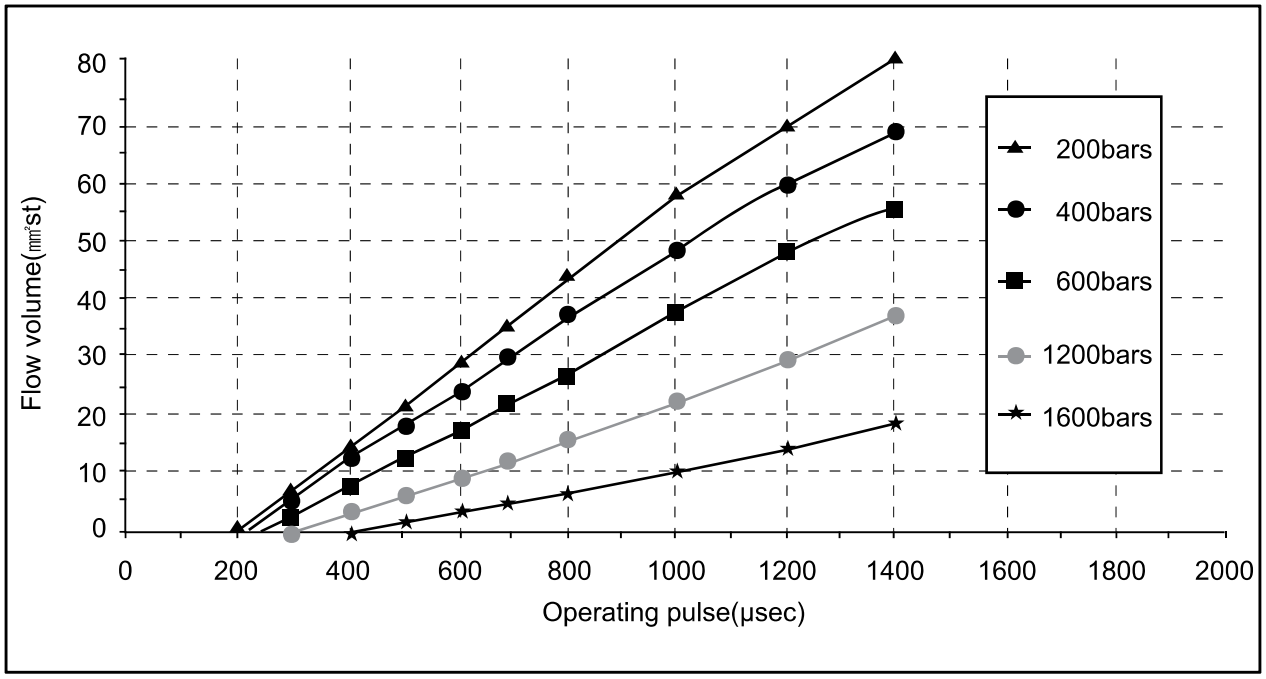
C. Learning Conditions

	Idle MDP learning	Drive MDP learning
Coolant temperature	over 60℃	over 60℃
Vehicle speed	Idling	over 50km/h (over 5 seconds)
Engine rpm		2,000 to 2,500 rpm
Fuel temperature	0 < Fuel temperature < 80℃	
Learning	2 times for each cylinder (every 5 seconds)	2 times for each cylinder (every 5 seconds)

CAUTION

- If MDP learning is not properly performed, engine vibration and injection could be occurred.
- MDP learning should be performed after replacing ECU, reprogramming and replacing injector.

D. Injector characteristic curve for rail pressure



Modification basis	
Application basis	
Affected VIN	

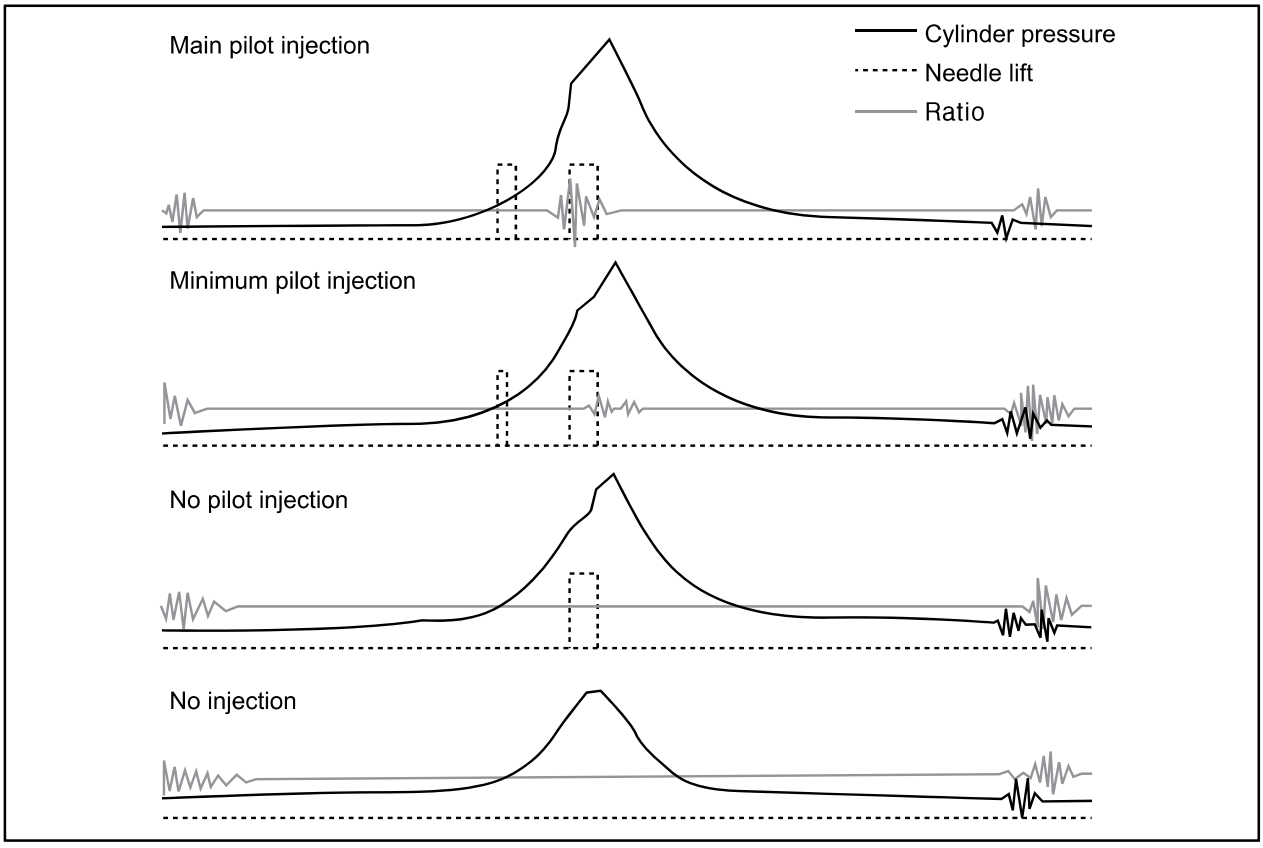
(7) Knocking Control

A. Resetting the pilot injection

The knocking control is used to reset the pilot injection flow in closed loop for each injector. This method allows the correction of any injector deviations over a period of time. The principle of use of the knocking control is based on the detection of the combustion noises.
The sensor is positioned in such a way as to receive the maximum signal for all the cylinders. The raw signals from the knock sensor are processed to obtain a variable which quantifies the intensity of the combustion. This variable, known as the ratio, consists of the ratio between the intensity of the background noise and the combustion noise.

1. A first window is used to establish the background noise level of the knocking control signal for each cylinder. This window must therefore be positioned at a moment when there cannot be any combustion.
2. The second window is used to measure the intensity of the pilot combustion. Its position is such that only the combustion noises produced by the pilot injection are measured . It is therefore placed just before the main injection.

The knock sensor does not allow any evaluation of the quantity injected. However, the pulse value will be measured when the injector starts injection and this pulse value is called the MDP (Minimum Drive Pulse). On the basis of this information, it is possible to efficiently correct the pilot flows. The pilot injection resetting principle therefore consists of determining the MDP, in other words the pulse corresponding to the start of the increase in value of the ratio (increase of vibration due to fuel combustion).



This is done periodically under certain operating conditions. When the resetting is finished, the new minimum pulse value replaces the value obtained during the previous resetting. The first MDP value is provided by the C3I. Each resetting then allows the closed loop of the MDP to be updated according to the deviation of the injector.

B. Detection of leaks in the cylinders

The accelerometer is also used to detect any injector which may have stuck open. The detection principle is based on monitoring the ratio. If there is a leak in the cylinder, the accumulated fuel self-ignites as soon as the temperature and pressure conditions are favorable (high engine speed, high load and small leak).
This combustion is set off at about 20 degrees before TDC and before main injection.
The ratio therefore increases considerably in the detection window. It is this increase which allows the leaks to be detected. The threshold beyond which a fault is signaled is a percentage of the maximum possible value of the ratio.
Because of the severity of the recovery process (engine shut-down), the etection must be extremely robust.
An increase in the ratio can be the consequence of various causes:

- Pilot injection too much
- Main combustion offset
- Fuel leak in the cylinder

If the ratio becomes too high, the strategy initially restricts the pilot injection flow and retards the main injection. If the ratio remains high despite these interventions, this shows that a real leak is present, a fault is signaled and the engine is shut down.

C. Detection of an accelerometer fault

This strategy permits the detection of a fault in the sensor or in the wiring loom connecting the sensor to the ECU.
It is based on detection of the combustion. When the engine is idling, the detection window is set too low for the combustion caused by the main injection. If the ratio increases, this shows that the knock sensor is working properly, but otherwise a fault is signaled to indicate a sensor failure.
The recovery modes associated with this fault consist of inhibition of the pilot injection and discharge through the injectors.

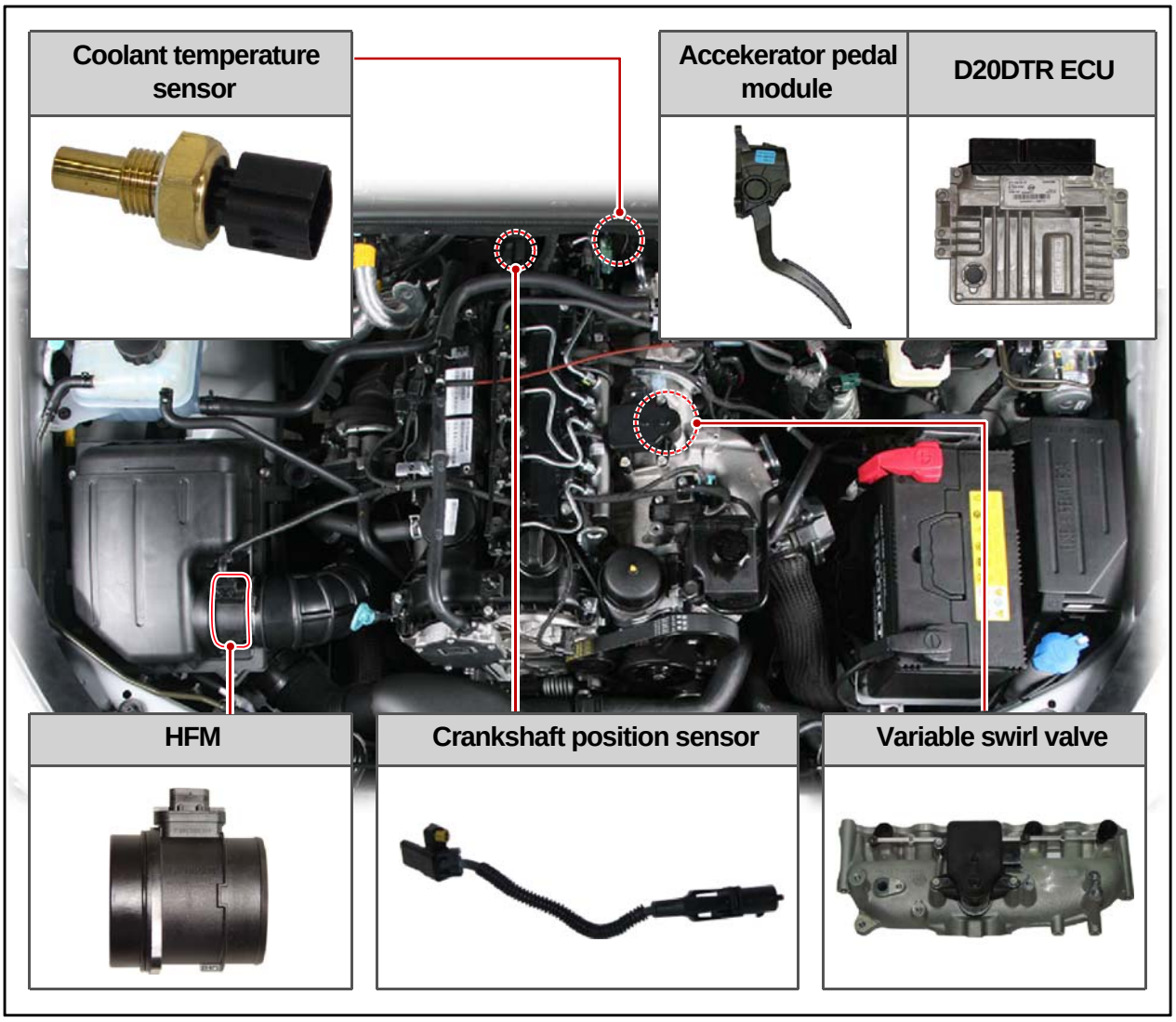
(8) Swirl control

A. Overview

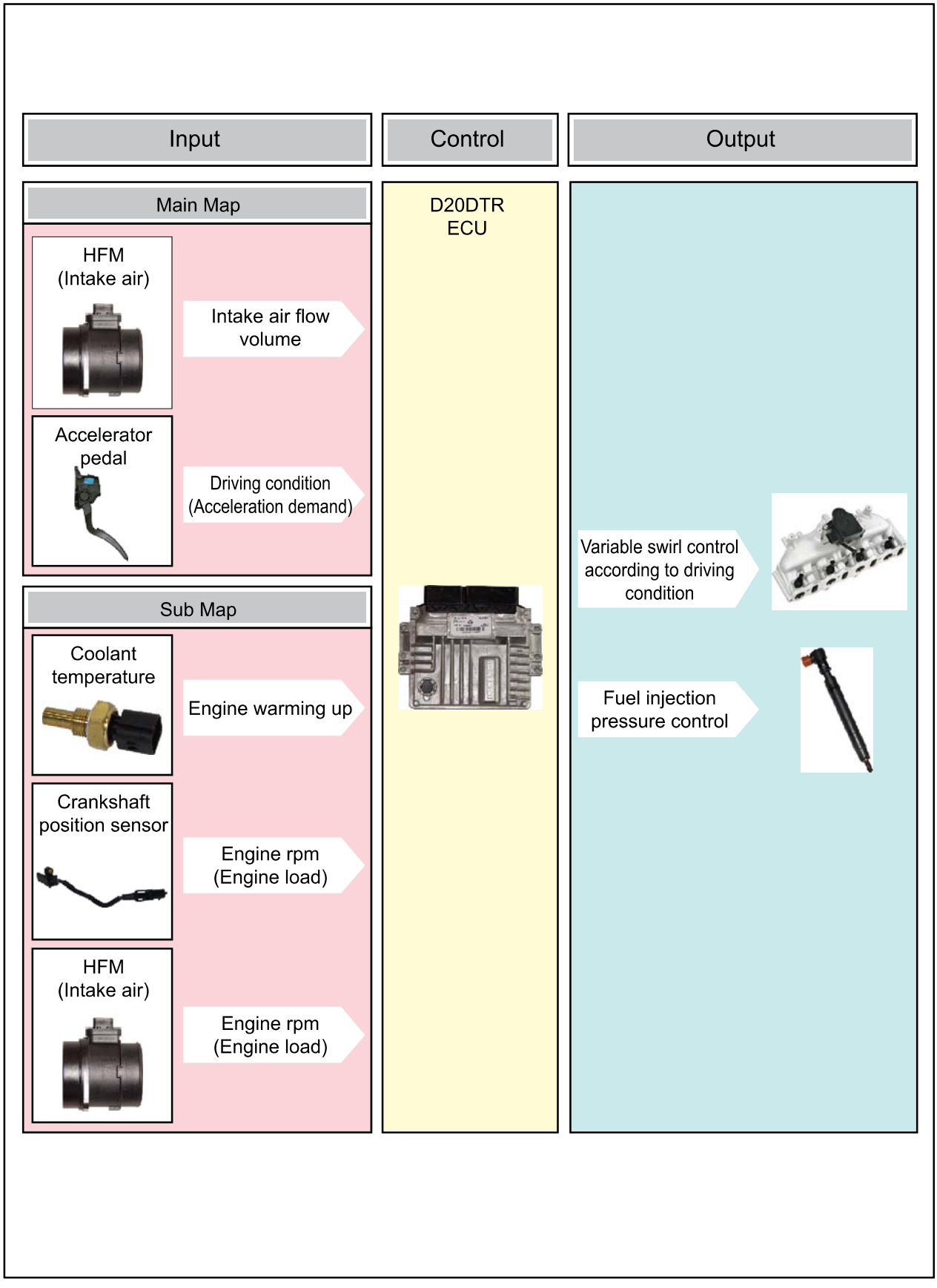
▶ Variable swirl valve

The strong swirl caused by intake air is important element for anti-locking function in diesel engine. The swirl control valve partially closes the intake port to generate the swirl according to the engine conditions. When the engine load is in low or medium range, the swirl could not be generated because the air flow is slow. To generate strong swirl, there are two passages in intake manifold, and one of them has the valve to open and close the passage. When the valve closes the passage, the air flow through the another passage will be faster, and the strong swirl will be generated by the internal structure of the passage. This swirl makes the better mixture of air and fuel, eventually the combustion efficiency in combustion chamber could be improved. This provides the enhanced fuel consumption, power and EGR ratio.

▶ Components

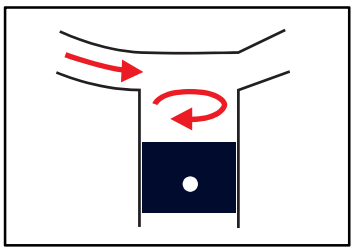


B. Input/Output for variable swirl valve

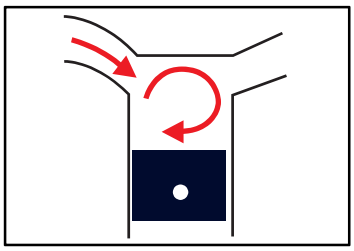


Modification basis	
Application basis	
Affected VIN	

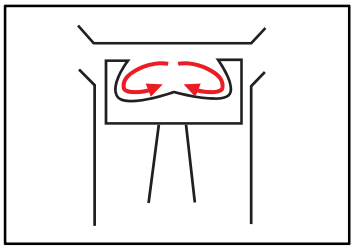
C. Types of swirl



Swirl: One cylinder has two intake air ports, one is set horizontally and the other one is set vertically. Swirl is the horizontal air flows in cylinder due to the horizontal intake air ports.



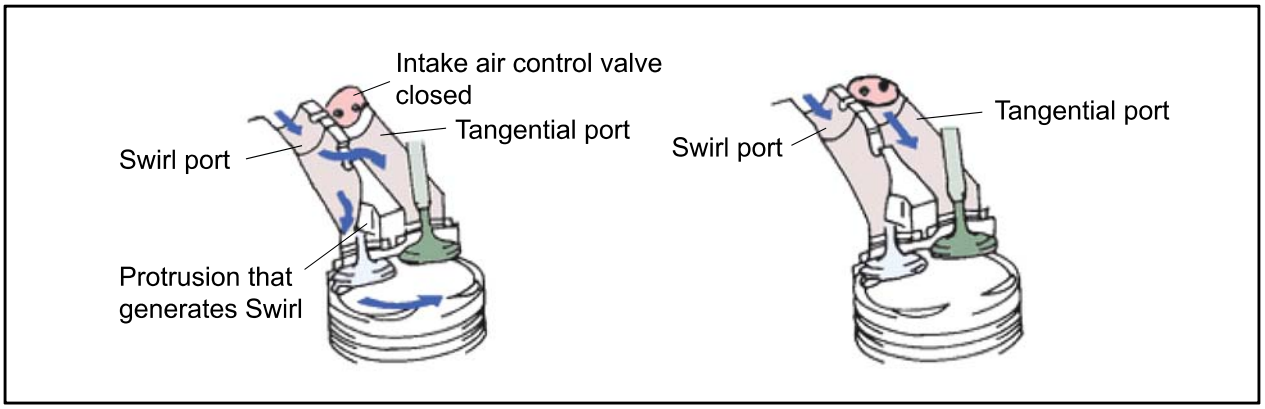
Tumble: Tumble is the vertical air flows in cylinder due to the vertical intake air port



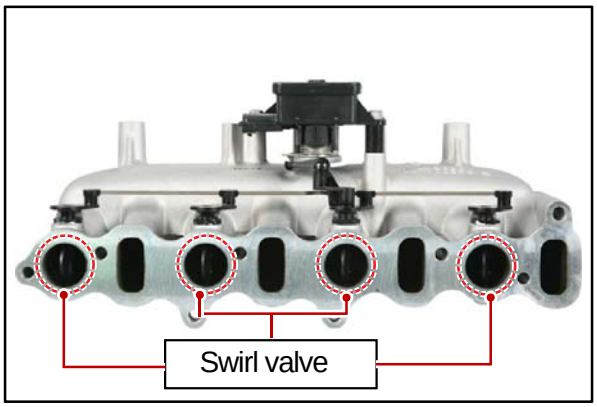
Tumble: Tumble is the vertical air flows in cylinder due to the vertical intake air port

D. Swirl control

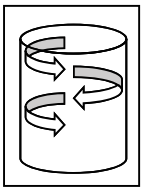
In DI type diesel engine, the liquefied fuel is injected into the cylinder directly. If the fuel is evenly distributed in short period, the combustion efficiency could be improved. To get this, there should be good air flow in cylinder. In general, there are two intake ports, swirl port and tangential port, in each cylinder. The swirl port generates the horizontal flow and the tangential port generates the longitudinal flow. In low/mid load range, the tabgential port is closed to increase the horizontal flow. Fast flow decreases the PM during combustion and increases the EGR ratio by better combustion efficiency.



Load	Engine speed	Swirl valve	Amount of swirl	Remarks
Low speed, Low load	below 3,000 rpm	Closed	Heavy	Increased EGR ratio, better air-fuel mixture (reduce exhaust gas)
High speed, High load	over 3,000 rpm	Open	Light	Increase charge efficiency, higher engine power



The variable swirl valve actuator operates when turning the ignition switch ON/OFF position to open/close the swirl valve. In this period, the soot will be removed and the learning for swirl valve position is performed.



NOTE

Swirl: This is the twisted (radial) air flow along the cylinder wall during the intake stroke.
This stabilizes the combustion even in lean air-fuel mixture condition.

E. Features

- Swirl and air intake efficiency
  To generate the swirl, the intake port should be serpentine design. This makes the resistance in air flow. The resistance in air flow in engine high speed decreases the intake efficiency. Eventually, the engine power is also decreased, Thus, the swirl operation is deactivated in high speed range to increase the intake efficiency.
- Relationship between swirl and EGR
  To reduce Nox, it is essential to increase EGR ratio. However, if EGR ratio is too high, the PM also could be very higher. And, the exhaust gas should be evenly mixed with newly aspired air. Otherwise, PM and CO are dramatically increased in highly concentrated exhaust gas range and EGR ratio could not be increased beyond a certain limit. If the swirl valve operates in this moment, the limit of EGR ratio will be higher.

F. Relationship between swirl and fuel injection pressure

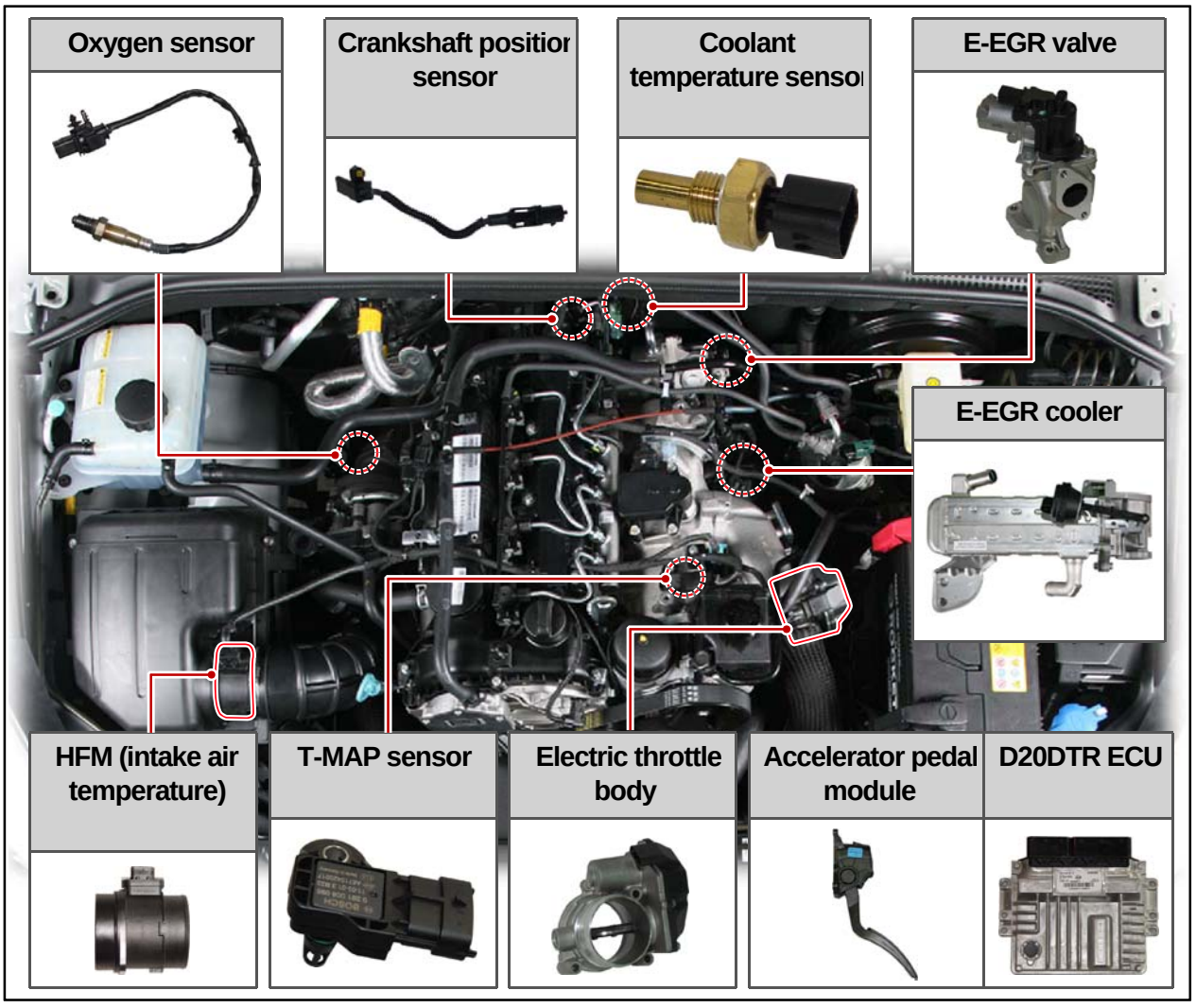
The injector for DI engine uses the multi hole design. For this vehicle, there are 8 holes in injector. If the swirl is too strong, the injection angles might be overlapped and may cause the increased PM and insufficient engine power. Also, if the injection pressure is too high during strong swirl, the injection angles might be overlapped. Therefore, the system may decreases the fuel injection pressure when the swirl is too strong.

(9) EGR control

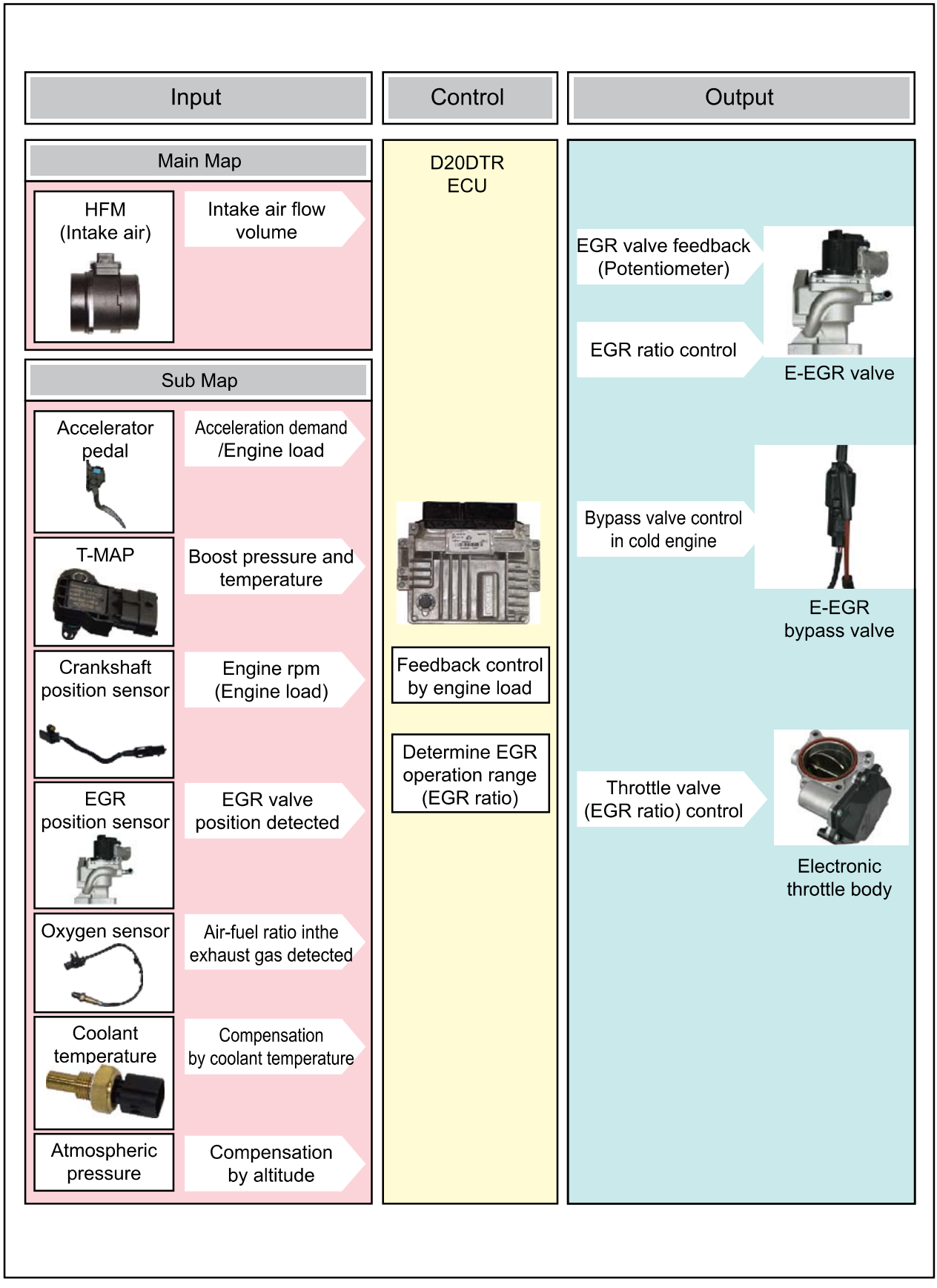
A. Overview

The EGR (Electric-Exhaust Gas Recirculation) valve reduces the NOx emission level by recirculating some of the exhaust gas to the intake system.
To meet Euro-V regulation, the capacity and response rate of E-EGR valve in D20DTR engine have been greatly improved. The EGR cooler with high capacity reduces the Nox, and the bypass valve reduces the CO and HC due to EGR gas before warming up.
Also, the engine ECU adjusts the E-EGR opening by using the air mass signal through HFM sensor. If the exhaust gas gets into the intake manifold when the EGR valve is open, the amount of fresh air through HFM sensor should be decresed.

B. Components



C. Input/Output of E-EGR system

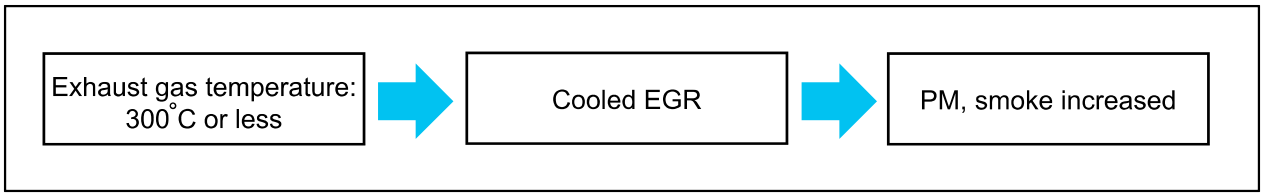


Modification basis	
Application basis	
Affected VIN	

D. Bypass control for EGR cooler

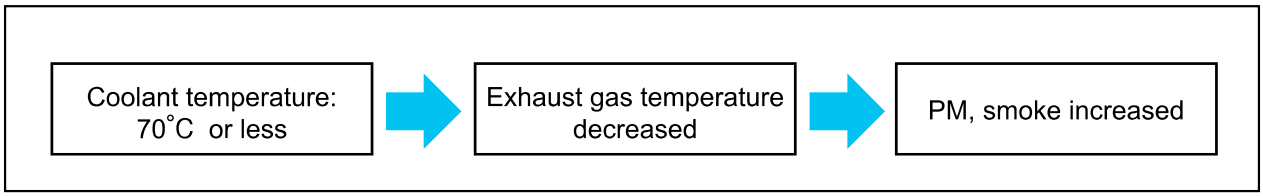
▶ Cooler temperature

When the coolant temperature is below 70℃, the exhaust gas is bypassed the EGR cooler.



▶ Exhaust gas temperature

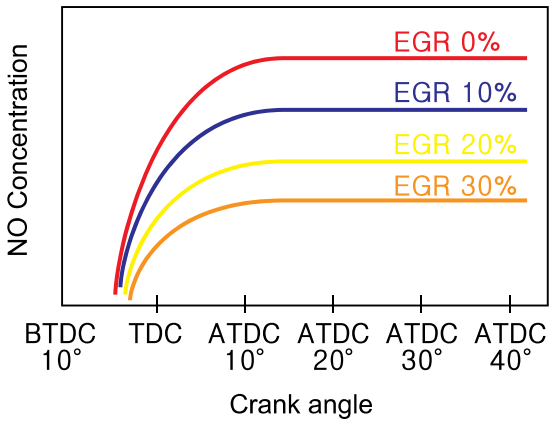
When the exhaust gas temperature is below 300℃, the exhaust gas is bypassed the EGR cooler. Otherwise, PM could be increased due to too low exhaust gas temperature.



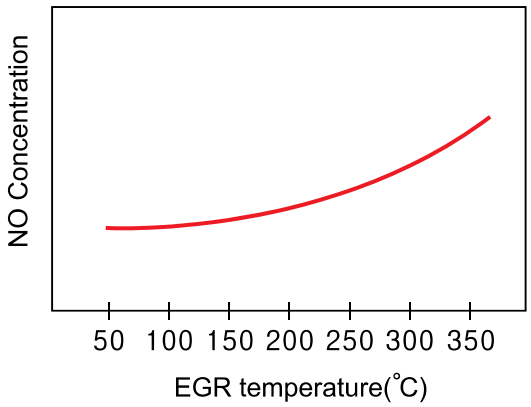
E. Control elements for EGR system

- Accelerator pedal (engine load) - Indicates the driver's intention and engine load. If the load goes up, the EGR ratio is decreased.
- T-MAP (boost pressure map stored in ECU) - Compensates the difference in boost pressure by adjusting EGR ratio.
- Engine rpm - Used as the signal for determining EGR operating range.
- Coolant temperature - When the coolant temperature is low, NOx is decreased but PM could be increased. So, to reduce PM, decrease EGR ratio when the coolant temperature is low. Intake air mass and temperature - HFM sensor measures the intake air mass to calculate the actual EGR volume. If the air mass is larger than programmed value in map, EGR ratio will be higher.
- EGR position sensor - Detects the actual opening angle of EGR valve and performs feedback function according to PWM control by ECU.
- Wide band oxygen sensor - Detects the oxygen volume in exhaust gas to check if the EGR ratio is proper.
- Electronic throttle body - Keeps EGR ratio to optimized level by controlling the throttle body in EGR operating range (decreasing pressure in intake manifold).

F. Features



As EGR ratio goes up, smoke volume will be higher. But, this lowers the combustion chamber temperature and accordingly the concentration of NOx is decreased. The point with highest NOx is immediately after TDC.



As EGR temperature goes up, the concentration of NOx will be higher. Thus, it is necessary to cool down the exhaust gas. However, during engine cooled, it may cause large amount of PM. To prevent this, the exhaust gas is bypassed the EGR cooler.

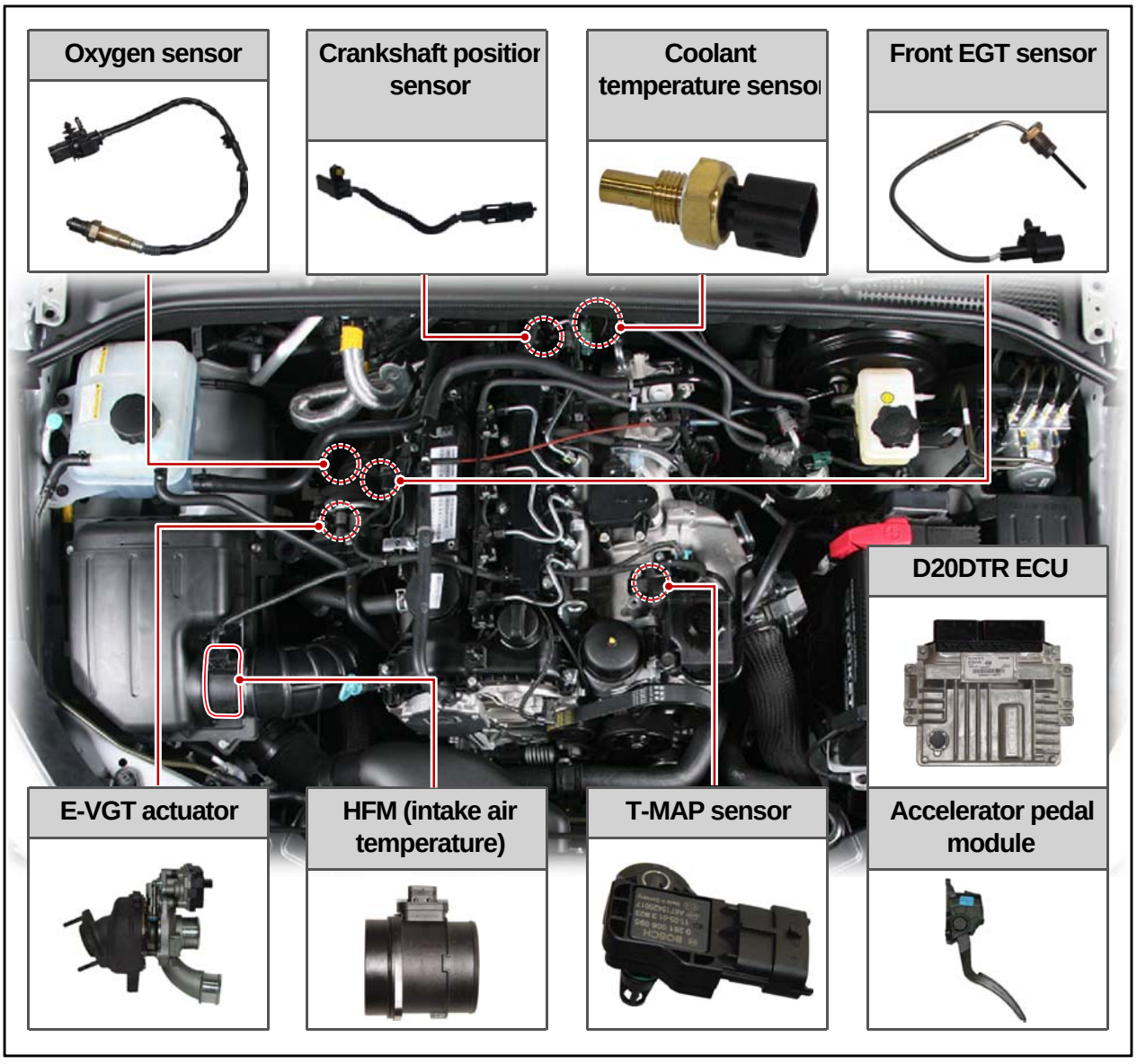
Modification basis	
Application basis	
Affected VIN	

(10) E-VGT control

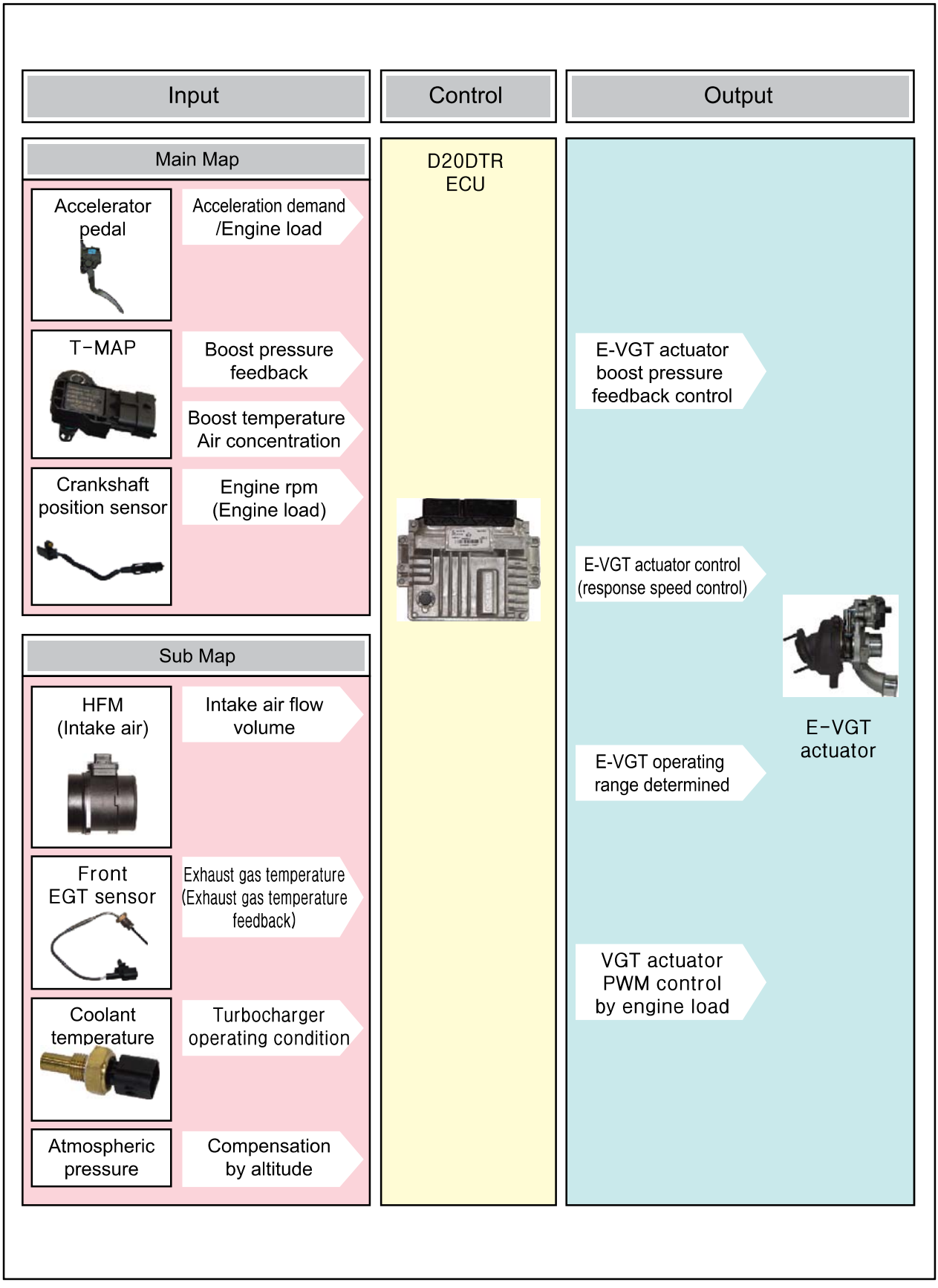
A. Overview

E-VGT (Electric-Variable Geometry Turbine) turbocharger system in D20DTF engine uses the venturi effect that controls the flow rate of exhaust gas by adjusting the passage in turbine housing. The newly adopted DC motor actuator (E-actuator) controls the E-VGT system more precisely and faster. To get the high operating power from turbine, the ECU reduces the exhaust gas passage In low speed range and increases it in high speed range.

B. Components



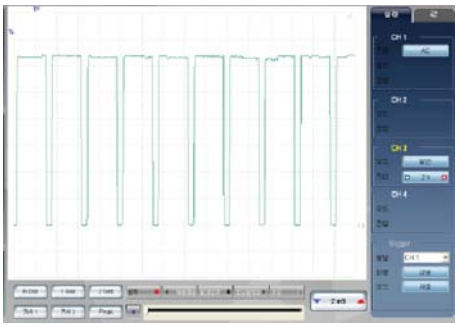
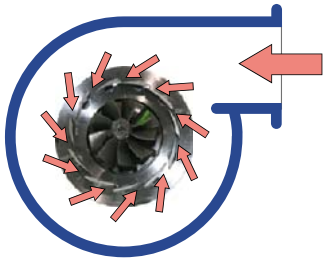
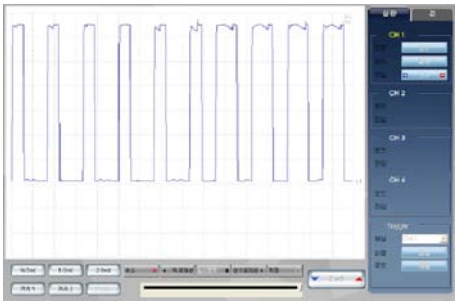
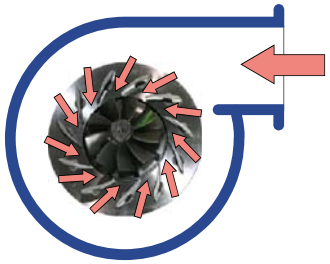
C. Input/Output for E-VGT system



Modification basis	
Application basis	
Affected VIN	

D. E-VGT system control

Turbocharger system operates the E-VGT actuator according to the signals for engine epm, accelerator pedal position, atmospheric pressure, T-MAP, coolant temperature and intake air temperature.
Turbocharger actuator is performed PWM control by ECU.
In general, the boost pressure feedbacks the turbocharger operation and the boost temperature is used for calculating the precise density.
E-VGT provides higher engine power with faster reaction speed compared to conventional VGT.

	Operating wave	Vane	Control
Low speed range			In low speed range: retract the vane to increase boost pressure. The vane has low (-) duty, and the unison ring moves to retract the vane in weak PWM signal.
High speed range			The unison ring moves to extend the vane in strong PWM signal. Maximum pressure is 3 bar and the system controls it according to the input signals.

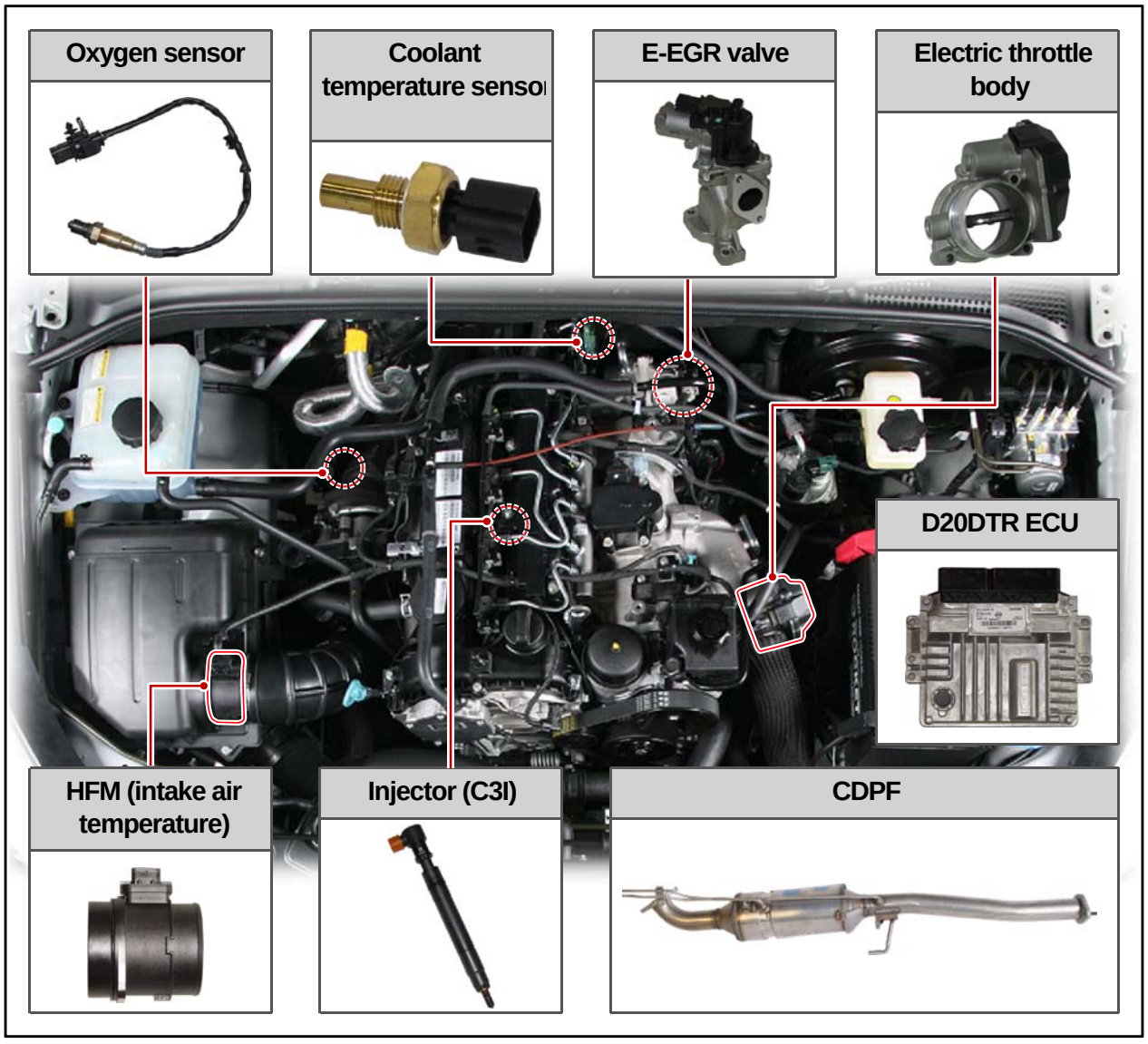
(11) Wide band oxygen sensor control

A. Overview

For diesel engine, combustion is not performed at the optimum (theoretically correct) air-fuel ratio and the oxygen concentration is thin in most cases. So the wide-band oxygen sensor is used for this kind of engine, and this sensor is a little different from the one that used for gasoline engine. The combustion in diesel engine is controlled by fuel injection volume. Therefore, the wide band oxygen sensor should be used in diesel engine. This sensor measures the air-fuel ratio in very wide range, and is also called full range oxygen sensor.

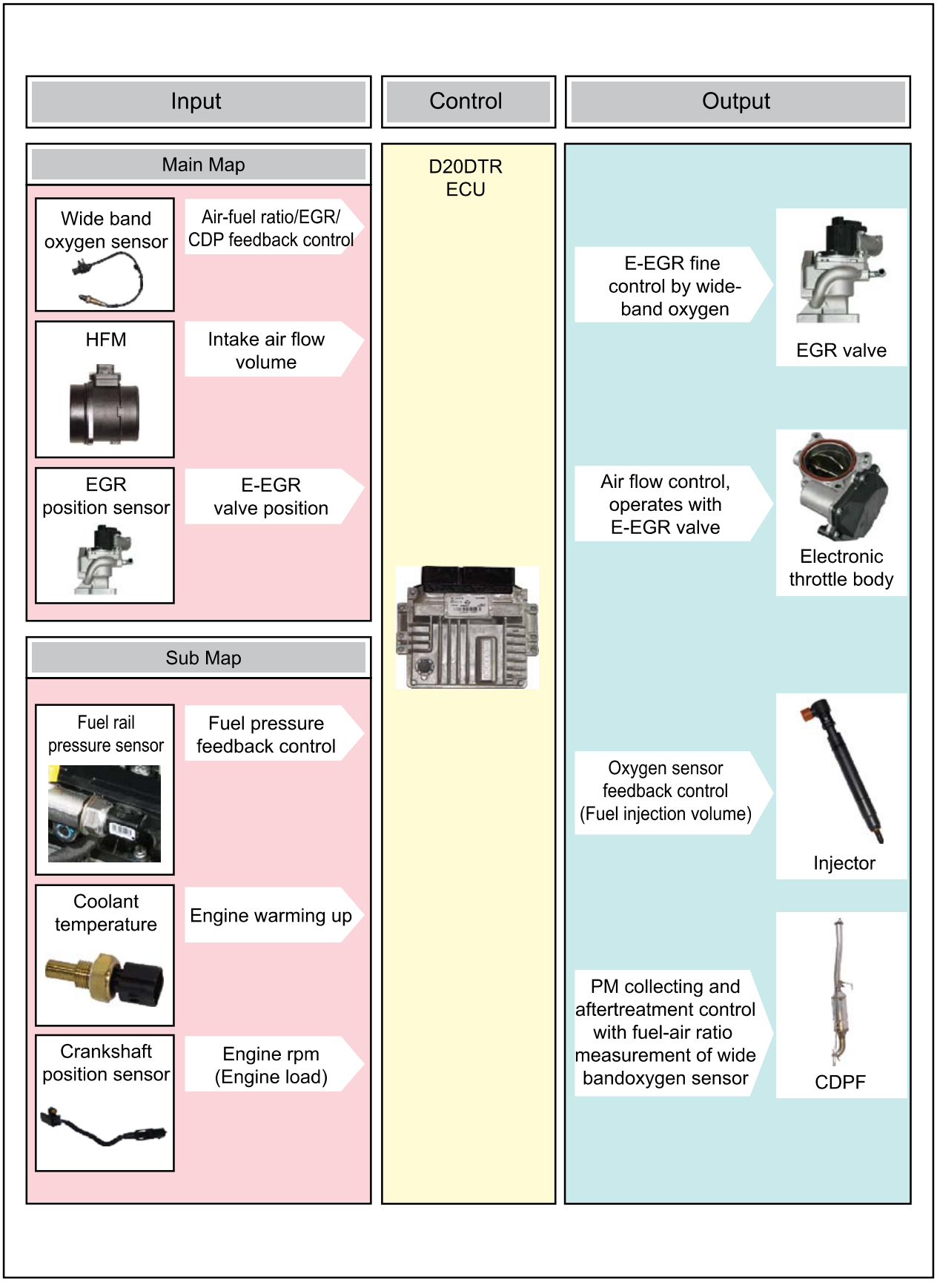
- The wide band oxygen sensor measures the oxygen density in exhaust gas and sends it to ECU to control the EGR more precisely.

B. Components



Modification basis	
Application basis	
Affected VIN	

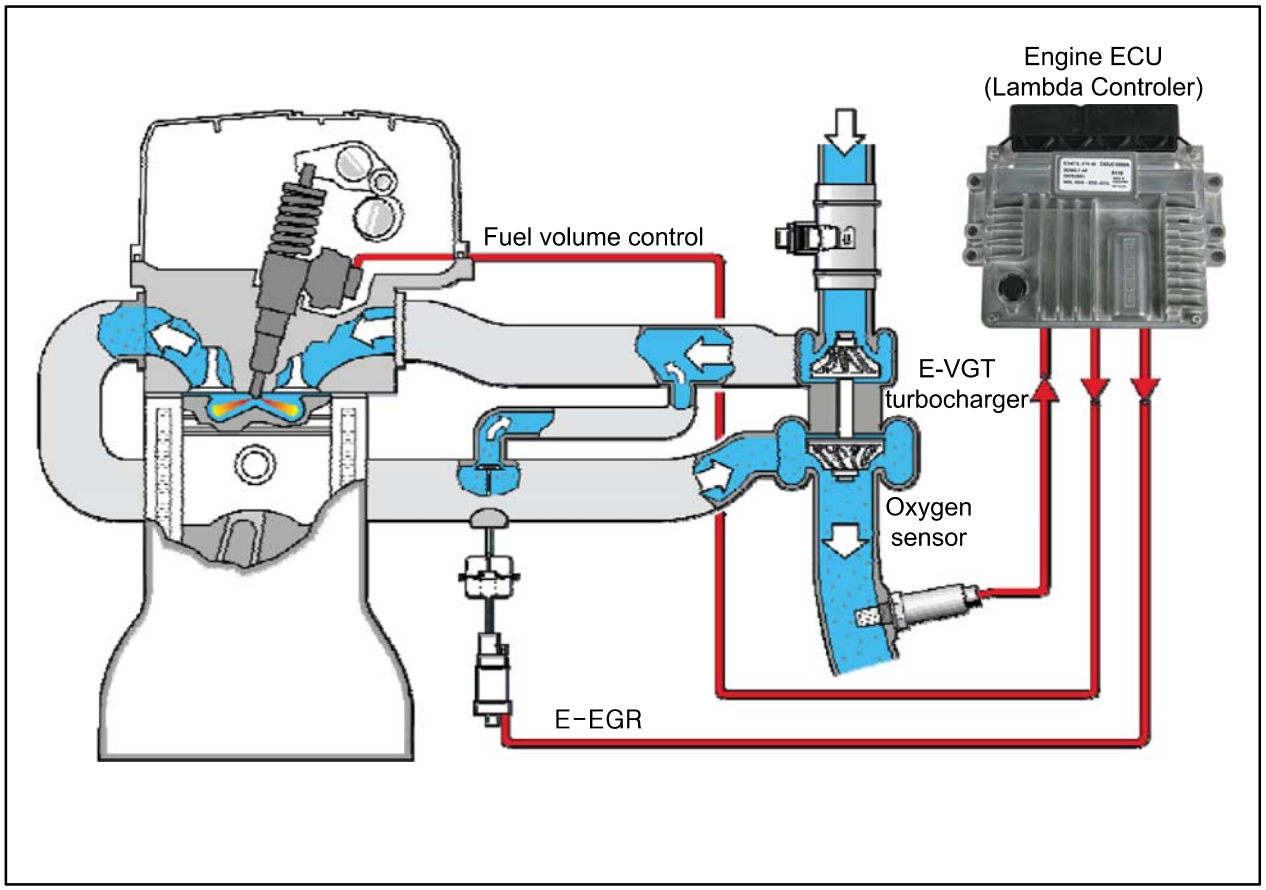
C. Input/Output for oxygen sensor



Modification basis	
Application basis	
Affected VIN	

D. Oxygen sensor control

The wide band oxygen sensor uses ZnO2. It produces the voltage by movement of oxygen ions when there is oxygen concentration difference between exhaust gas and atmosphere.
If a certain voltage is applied to the sensor, the movement of oxygen ions occurs regardless of the oxygen density. The current generated through this flow of ions, is called pumping current (IP), and the oxygen sensor measures this value.



Modification basis	
Application basis	
Affected VIN	

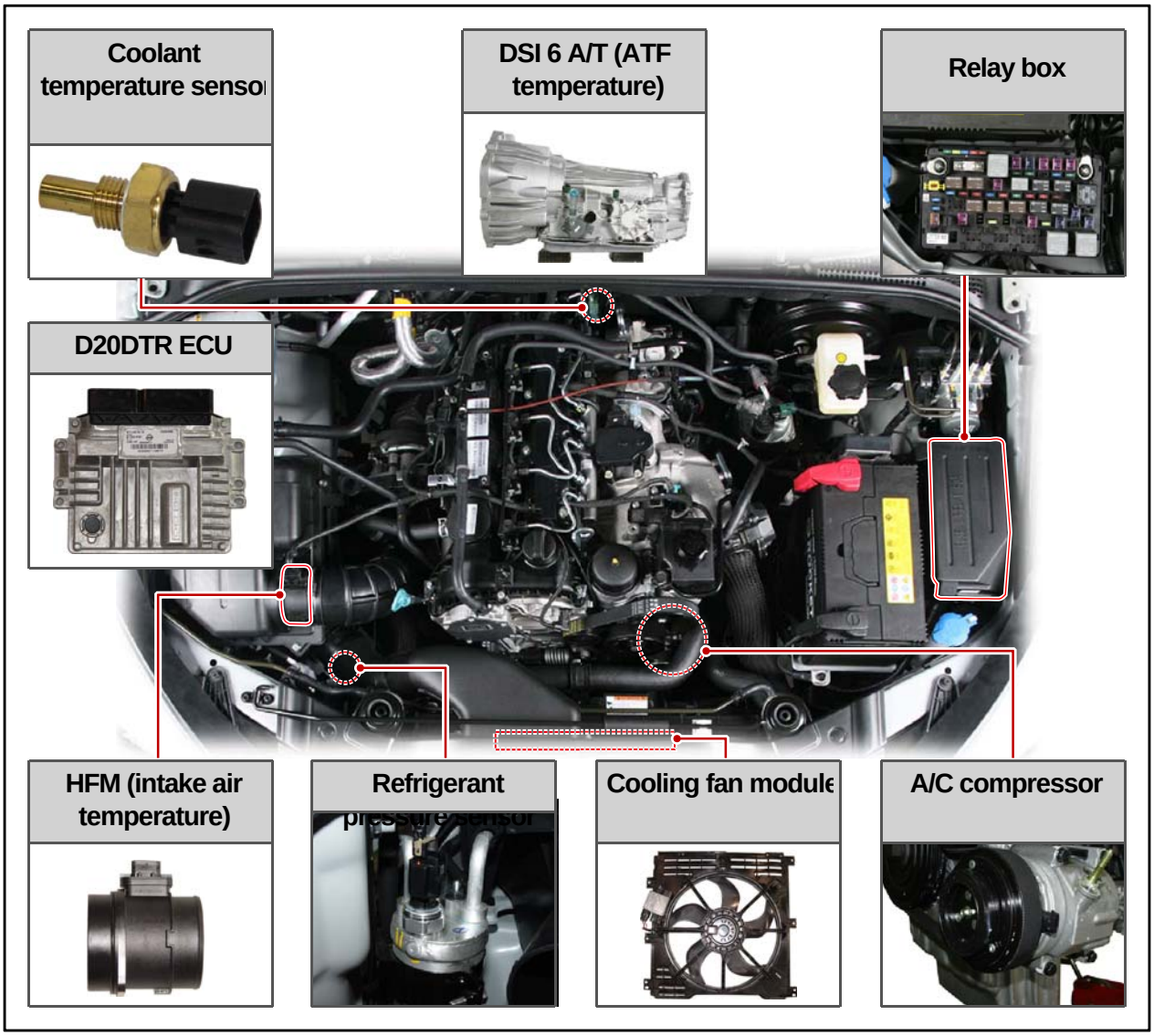
(12) Cooling fan control

A. Overview of cooling fan and A/C compressor

The cooling system maintains the engine temperature at an efficient level during all engine operating conditions. The water pump draws the coolant from the radiator. The coolant then circulates through water jackets in the engine block, the intake manifold, and the cylinder head. When the coolant reaches the operating temperature of the thermostat, the thermostat opens. The coolant then goes back to the radiator where it cools. The heat from automatic transmission is also cooled down through the radiator by circulating the oil through the oil pump. ECU controls the electric cooling fans with three cooling fan relays to improve the engine torque and air conditioning performance.

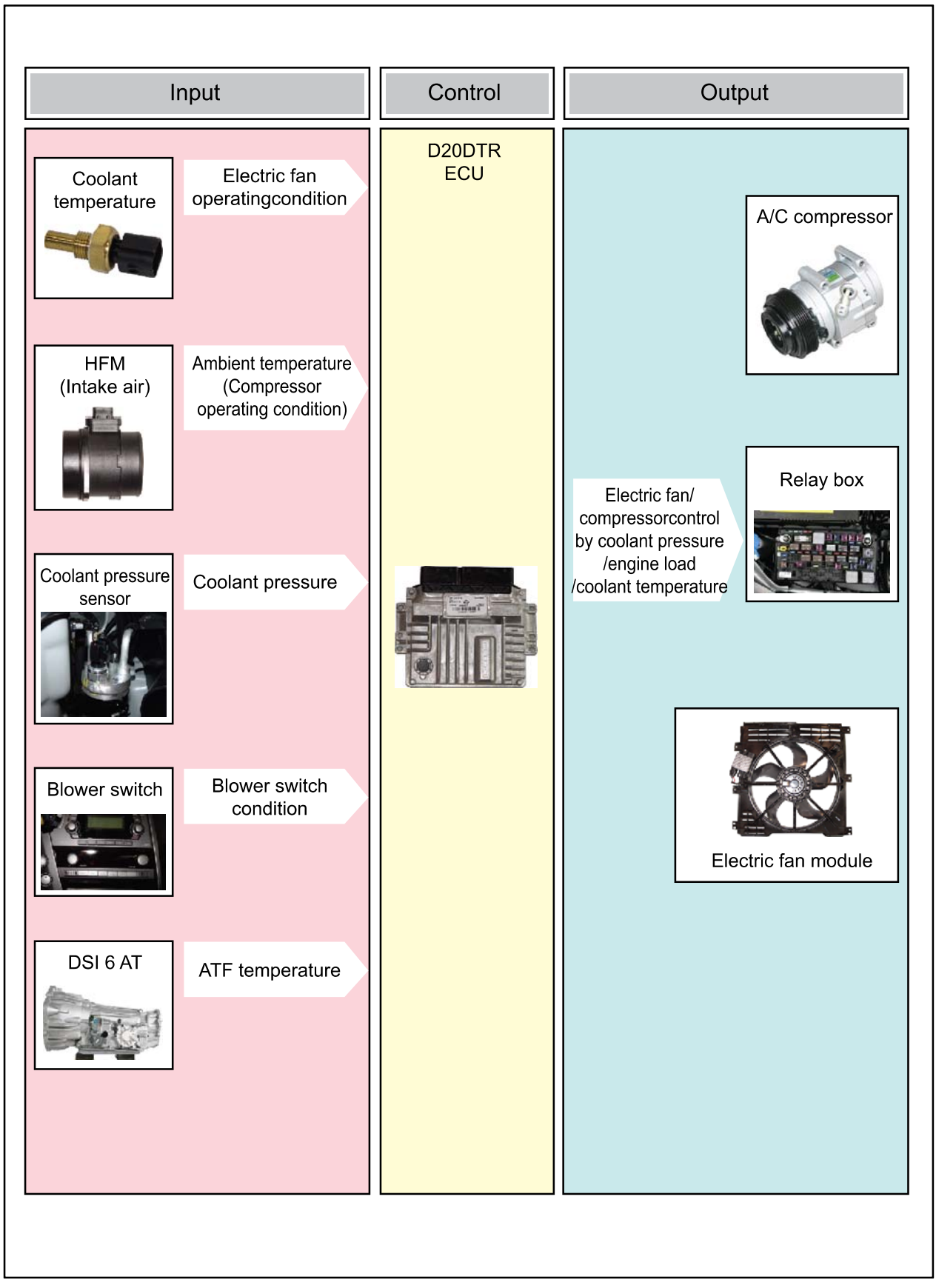
reference For detailed information, refer to Chapter "Air Conditioning System".

B. Components



Modification basis	
Application basis	
Affected VIN	

C. Input/Output for cooling fan and A/C compressor



Modification basis	
Application basis	
Affected VIN	

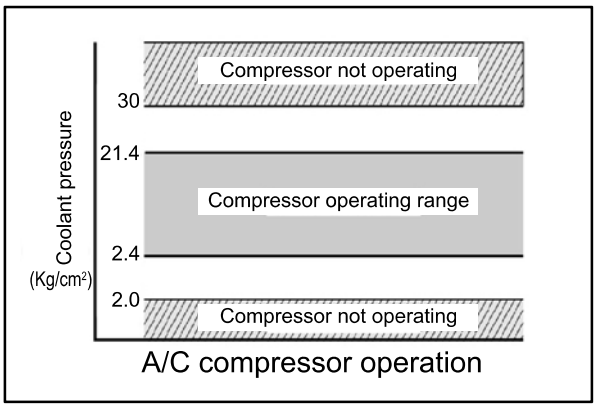
D. Cooling fan and A/C compressor control

▶ Conditions for cooling fan

The cooling fan module controls the cooling fan relay, high speed relay and low speed relay. The cooling fan is controlled by the series and parallel circuits.

A/C switch	Cooling fan	Coolant temperature	Refrigerant pressure	A/C compressor
OFF	OFF	Coolant temp. < 90℃	-	
	LO	90℃ ≤ Coolant temp. < 105℃	-	
	HI	105℃ ≤ Coolant temp.	-	
ON	LO	Coolant temp. < 105℃	Refrigerant pressure < 18 bar	ON
	HI		18 bar ≤ Refrigerant pressure	
	HI	105℃ ≤ Coolant temp. < 115℃	-	
	HI	115℃ ≤ Coolant temp.	-	OFF (cut)

▶ A/C compressor OFF conditions



A/C compressor operation

- Coolant temperature: below −20℃ or over 115℃
- Approx. 4 seconds after starting the engine
- Engine rpm: below 650 rpm or over 4500 rpm
- When abrupt acceleration
- Refrigerant pressure:
  * OFF below 2.0 kg/㎠, then ON over 2.4 kg/㎠
  * OFF over 30 kg/㎠, then ON below 21.4 kg/㎠

▶ Output voltage according to refrigerant pressure

The output voltage from refrigerant pressure sensor is 1.7 V to 3.5 V when the refrigerant pressure is 10 to 24 kgf/㎠ with A/C "ON".

▶ Cooling fan controls according to ATF

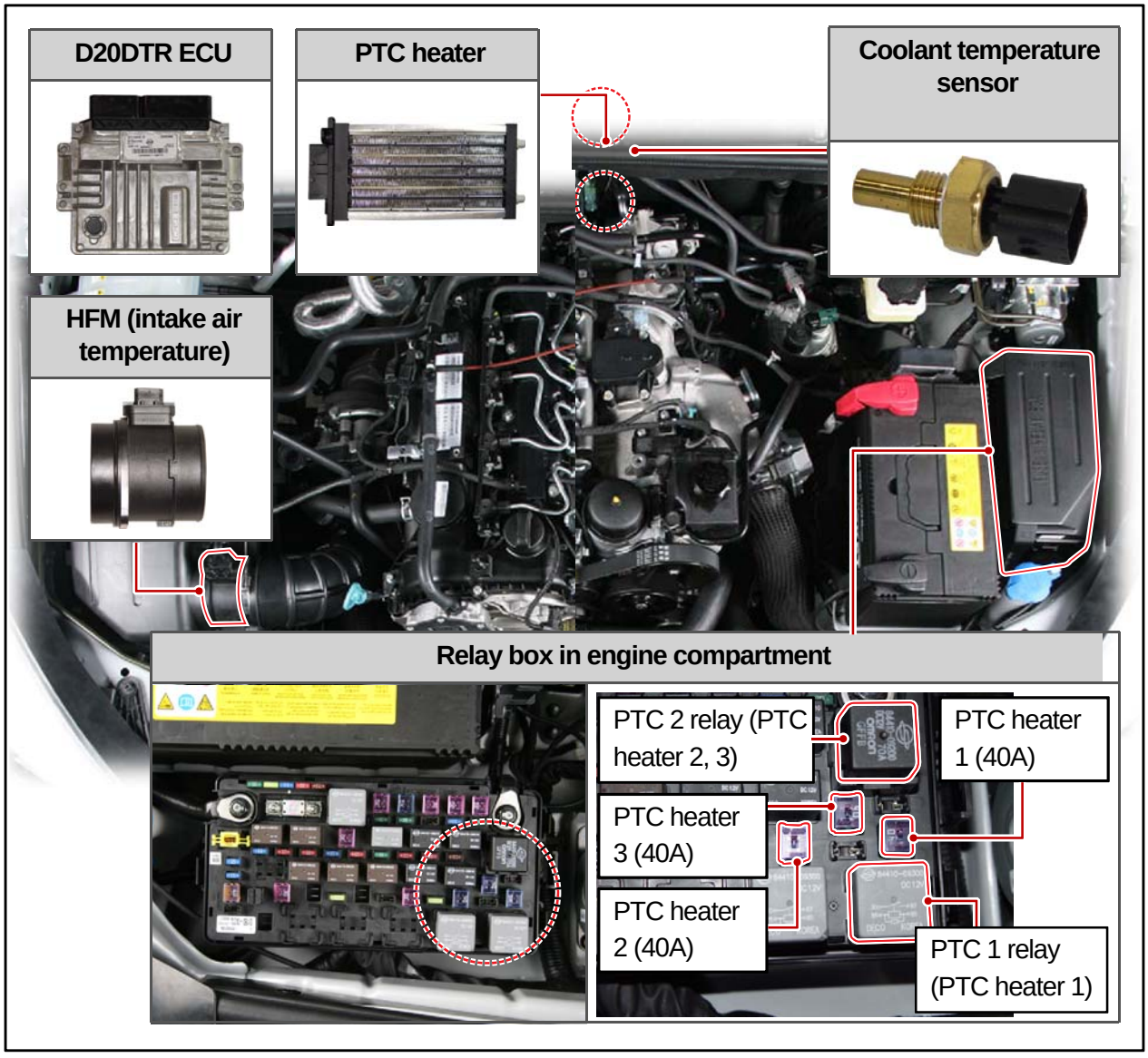
ATF temperature	Fan condition	Remark
Over 110˚C	High speed	-

(13) High speed

A. Overview

The supplementary electrical heater is installed in DI engine equipped vehicle as a basic equipment. The PTC system is operated according to two temperature values measured at the coolant temperature sensor and HFM sensor. This device is mounted in the heater air outlet and increase the temperature of air to the passenger compartment. Because PTC system is heated by electrical power, high capacity alternator is required. PTC does not operate during engine cranking, while the battery voltage is lower than 11 V or during preheating process of glow plugs.

B. Components

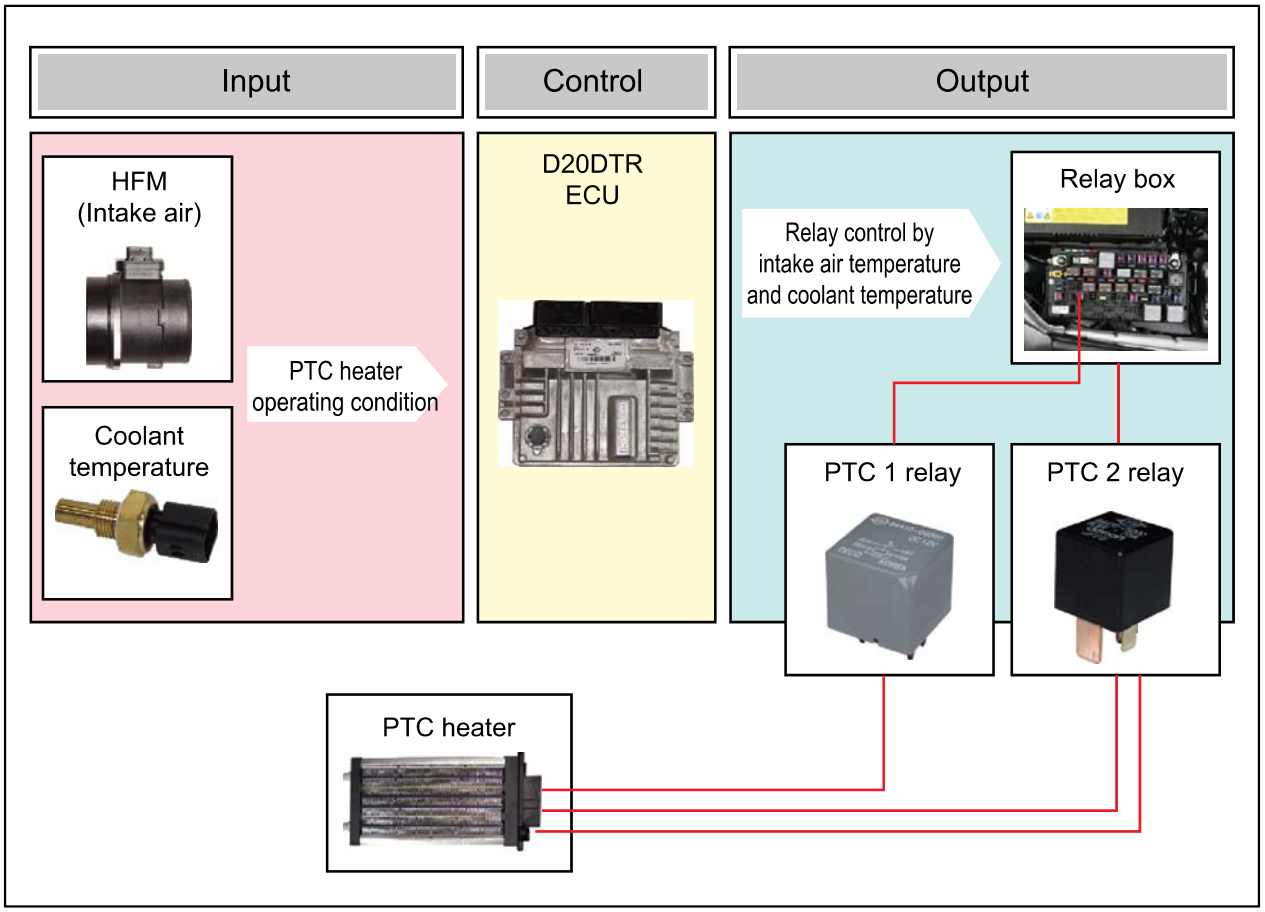


Modification basis	
Application basis	
Affected VIN	

C. Operation process

The ceramic PTC has a feature that the resistance goes up very high at a certain temperature. There are three circuits in PTC heater. Only one circuit is connected when PTC1 relay is ON, and two circuits are connected when PTC2 relay is ON.

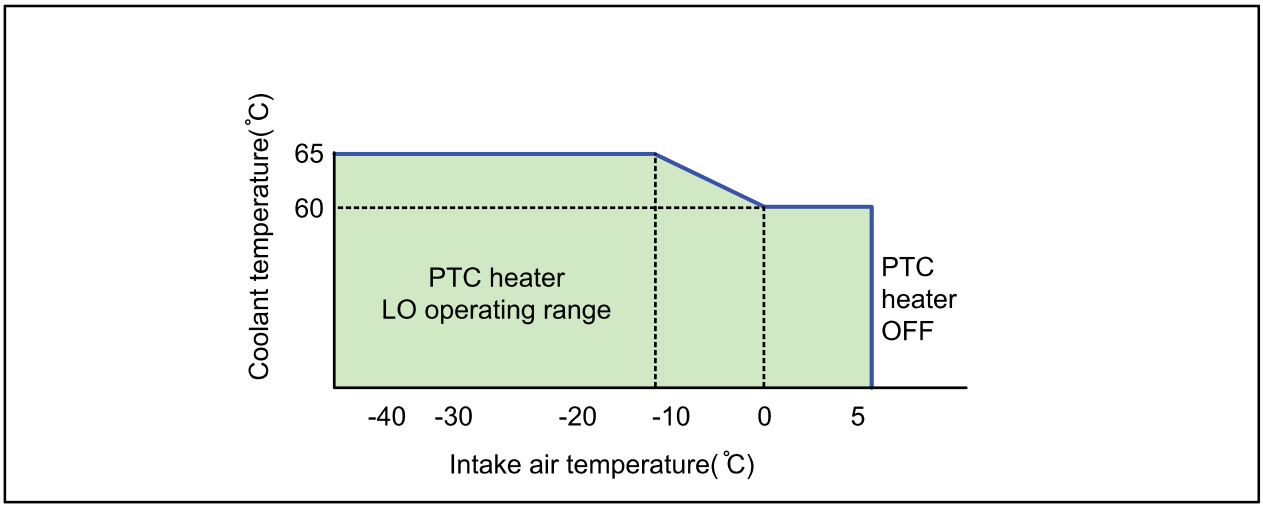
Operation process: reaches at a certain temperature→high resistance→low current→less heat radiation→temperature down→high resistance→high current→temperature up



D. Control conditions

Operation	Operating condition	PTC Heater
HI (PTC2)	- Coolant temperature < 15℃	PTC HI ON
LO (PTC1)	- Coolant temperature 15℃ ≤ 65℃, intake air temperature ≤ −10℃ - Coolant temperature 15℃ < 65 to 60℃, intake air temperature <−10℃ to 0℃ - Coolant temperature 15℃ ≤ 60℃, intake air temperature ≤ 0℃ to 5℃	PTC LO ON
Stop	- A/C blower switch OFF - Defective ambient air temperature sensor (including open or short circuit) - Engine cranking - Low battery voltage (below 11V) - During pre-glow process (glow indicator ON)	

▶ **Operation diagram for PTC heater LO (step 2)**



Modification basis	
Application basis	
Affected VIN	

(14) Immobilizer control

A. Overview

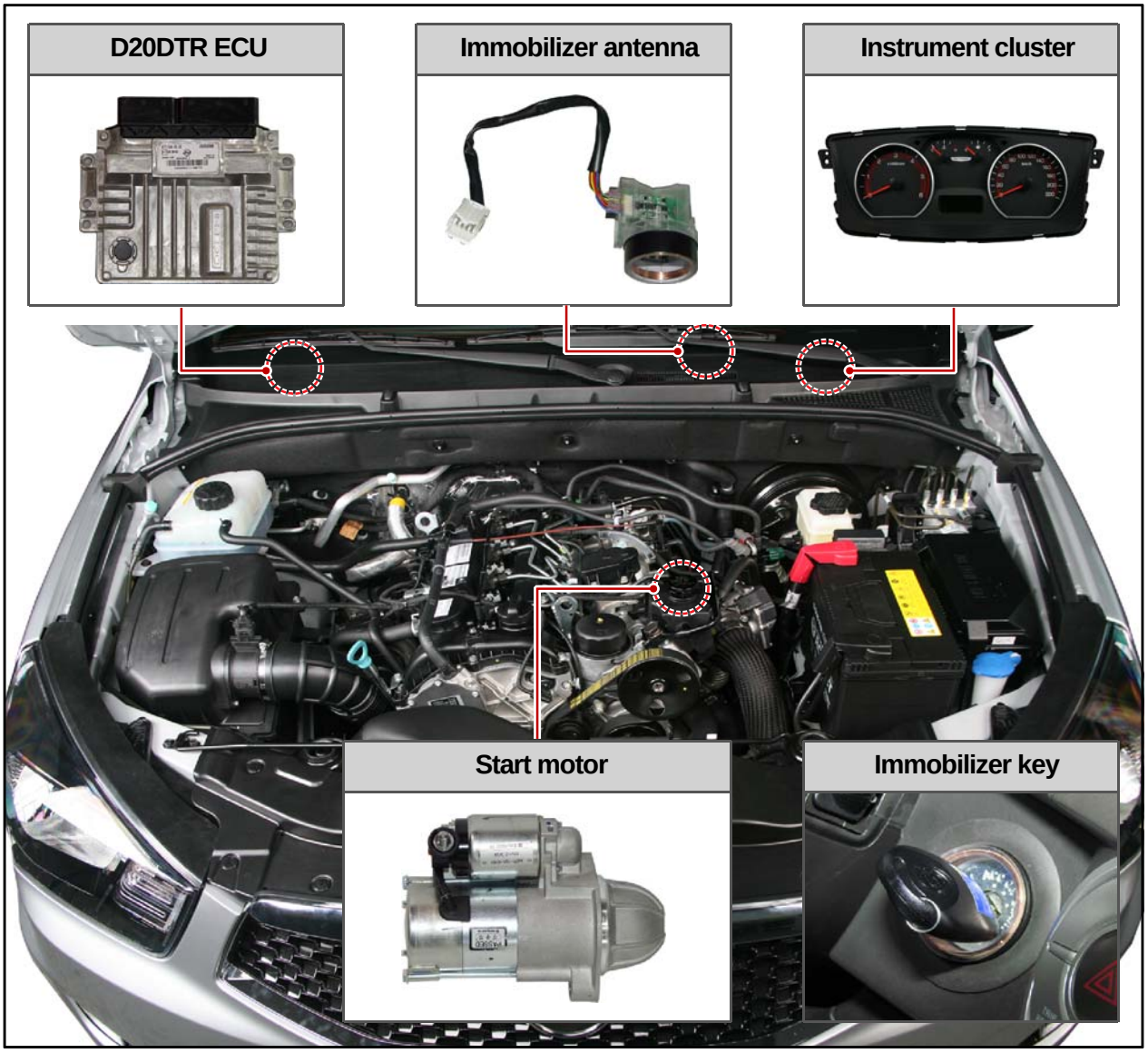
The Immobilizer System provides an additional theft deterrent to the vehicle in which it is installed and prevents it from being started by unauthorized persons. The transponder integrated in the key and the engine control unit have the same code. When the ignition key with the integrated transponder is turned to the ON position, the ECU (Engine Control Unit) checks the crypto code of the key and, if correct, allows the vehicle to start the engine.

NOTE

For details, refer to Chapter "Immobilizer".

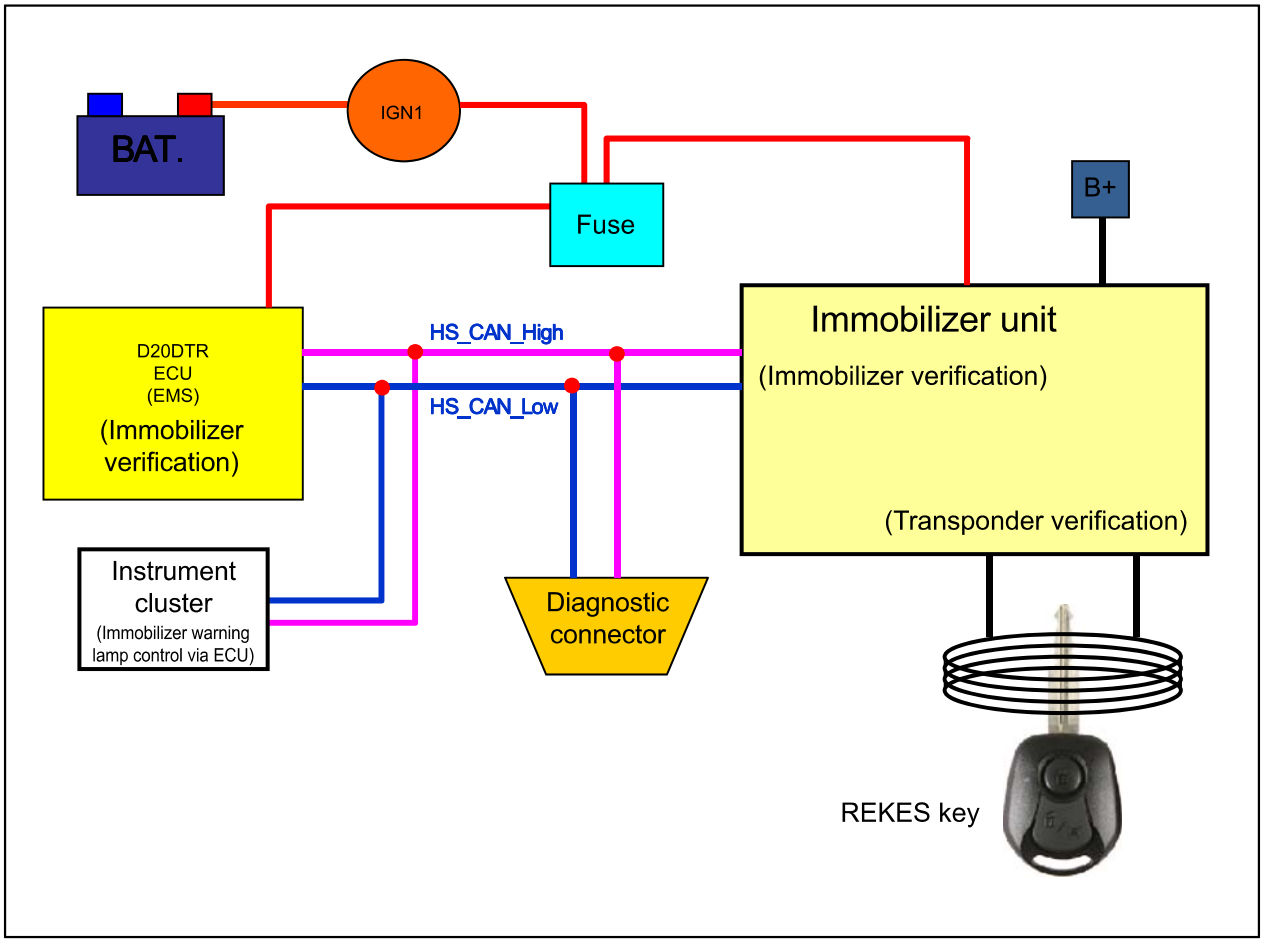
B. Components

▶ **Basic components (ignition key system)**



▶ Key approval process

When turning the ignition switch to ON position, the power is supplied to BCM and ECU. ECU communicate with the immobilizer key to check if it is valid crypto code. If it is valid, ECU start to control the engine when turning the ignition switch to START position. The system has 10 seconds of valid time-out period. If the engine does not start in this period, the key approval process should be done again.



Modification basis	
Application basis	
Affected VIN	

(15) CDPF control

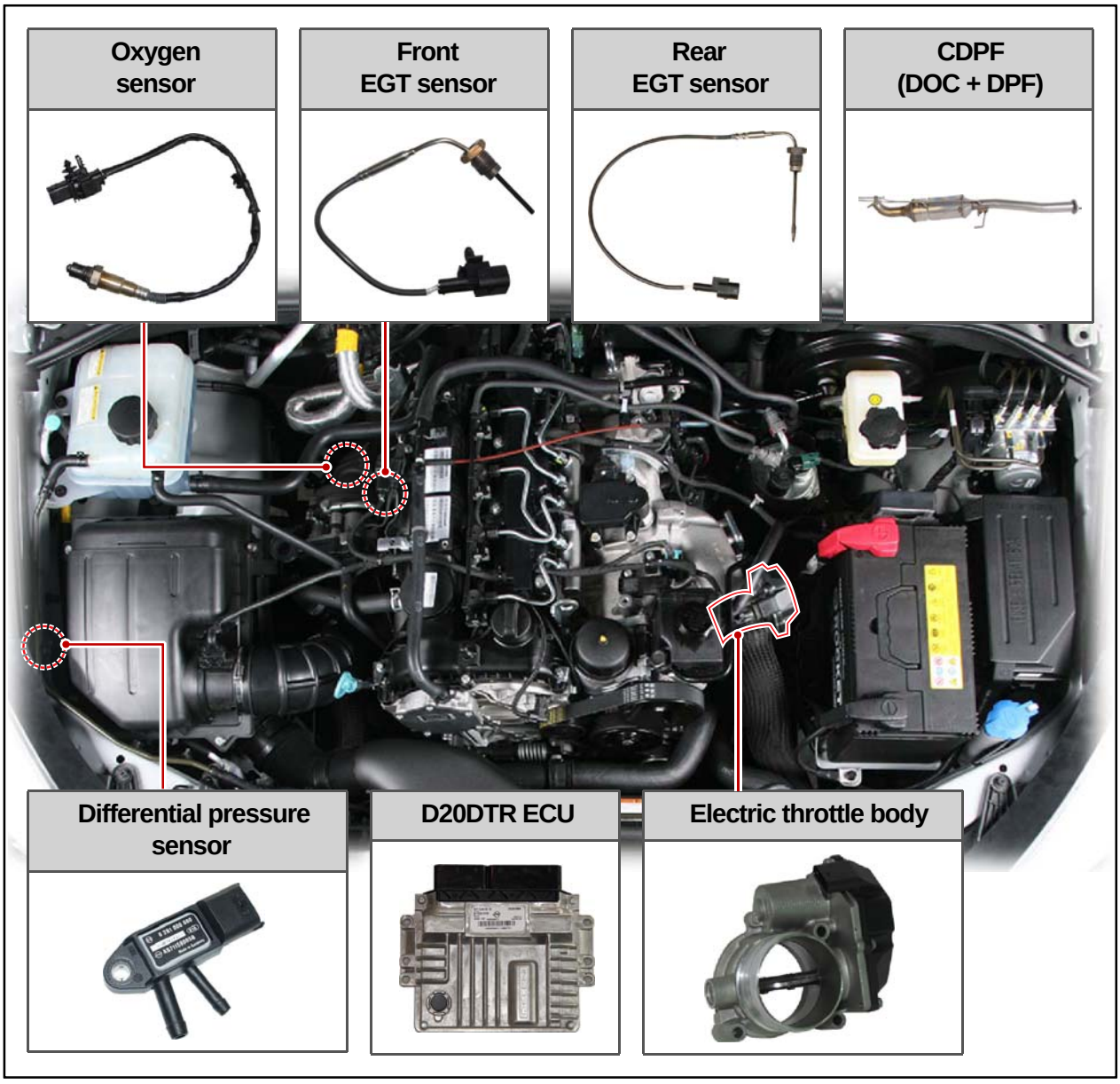
A. Overview

As the solution for environmental regulations and PM Particle Material) of diesel engine, the low emission vehicle is getting popular. This vehicle is equipped with an extra filter to collect the soot and burn it again so that the amount of PM in the exhaust gas passed through the DOC (Diesel Oxidation Catalyst) is reduced. The CDPF (Catalyst & Diesel Particulate Filter) is an integrated filter including DOC (Diesel Oxidation Catalyst) and DPF (Diesel Particulate Filter).

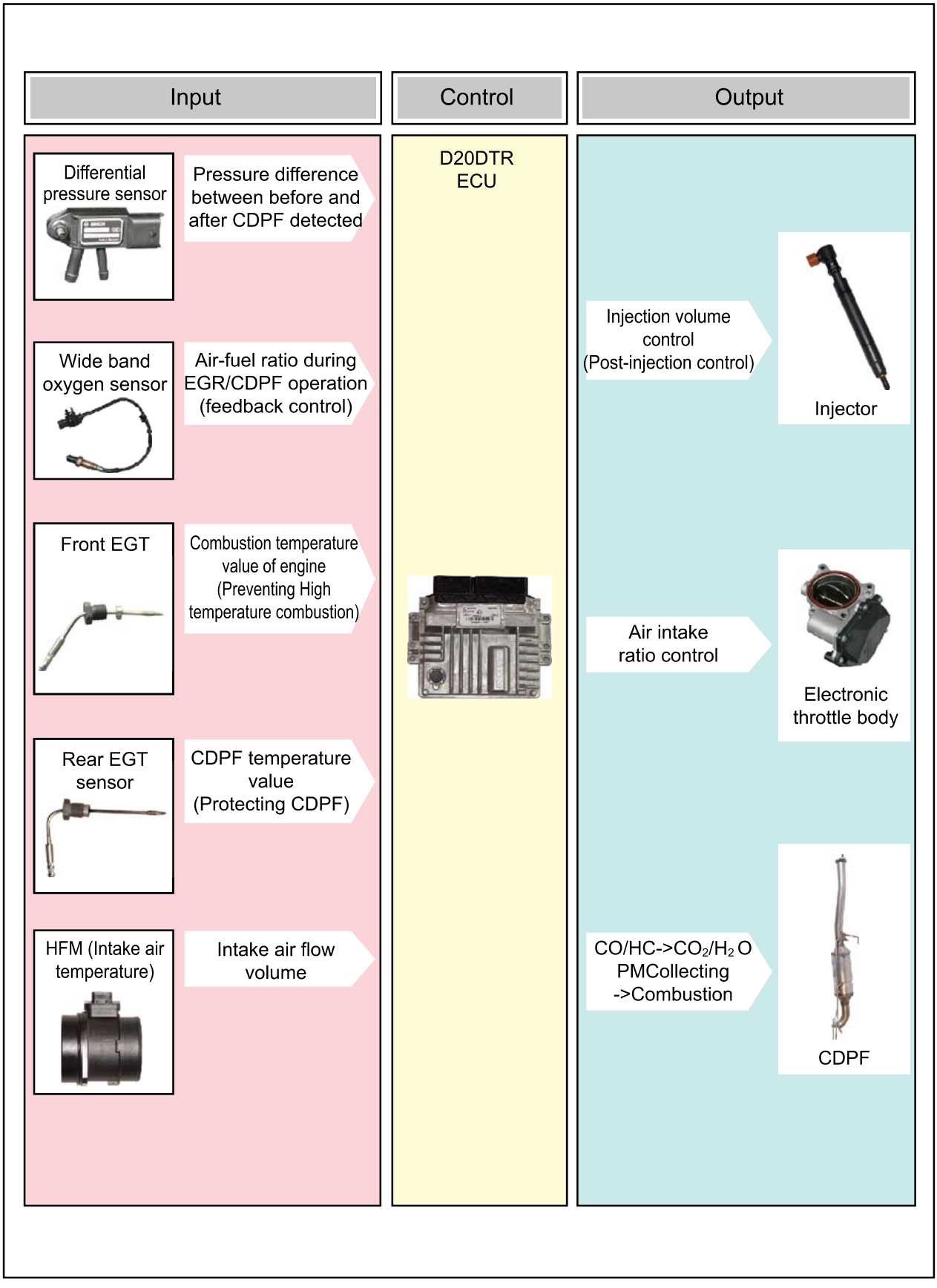
NOTE

For details, refer to Chapter "CDPF".

B. Components



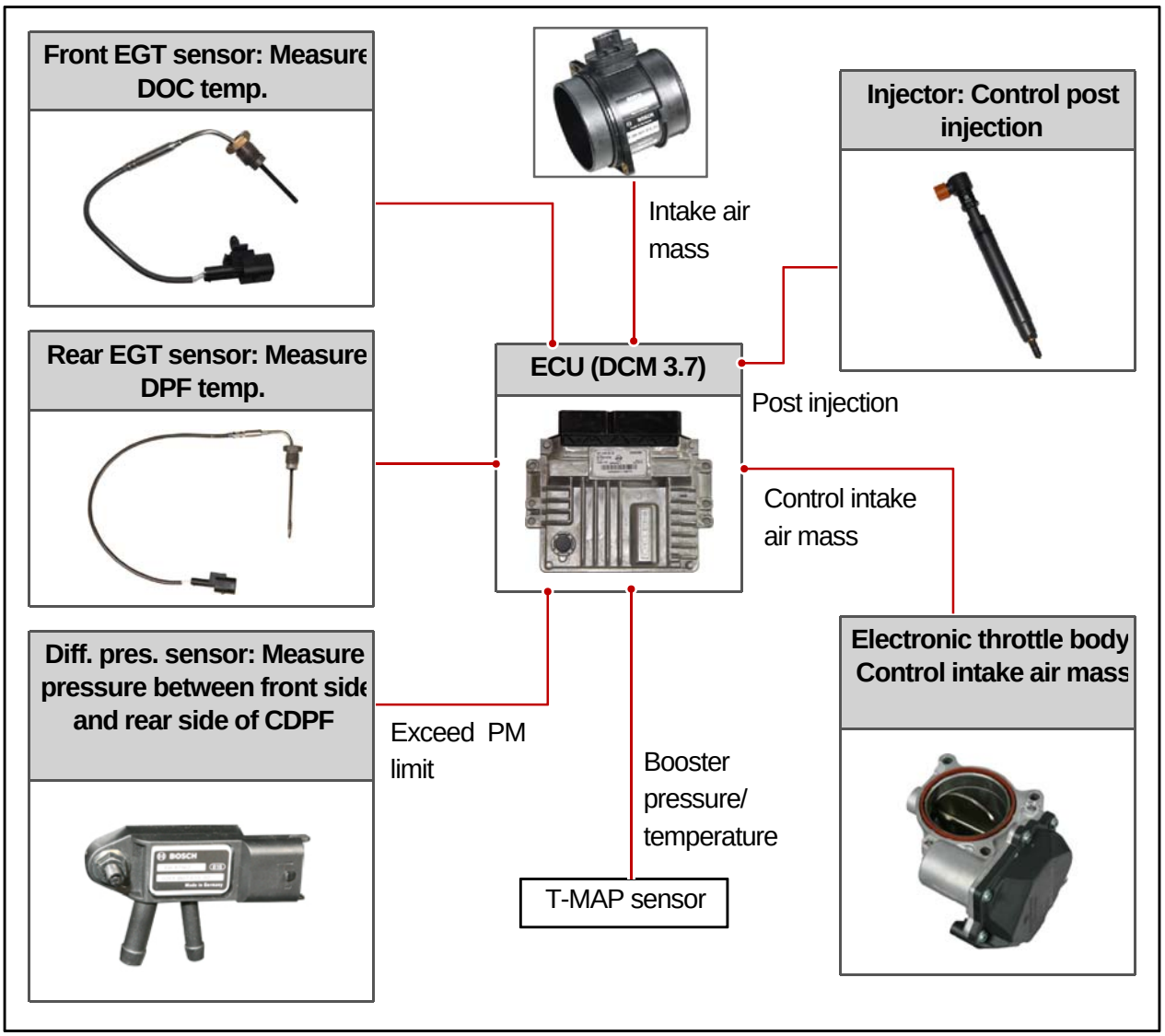
C. Input/Output for CDPF control



Modification basis	
Application basis	
Affected VIN	

D. Operation process

When the differential pressure sensor detects the pressure difference between the front and the rear side of CDPF, the sensor sends signal indicating the soot is accumulated and the post injection is performed to raise the temperature of exhaust gas. The amount of fuel injected is determined according to the temperature of exhaust gas detected by the rear temperature sensor. If the temperature is below 600°C, the amount of fuel injected is increased to raise the temperature. If the temperature is over 600°C, the amount of fuel injected is decreased or not controlled. When the engine is running in low load range, the amount of post injection and the amount of intake air are controlled. It is to raise the temperature by increasing the amount of fuel while decreasing the amount of intake air.



E. Cautions

- Use only specified Engine Oil (approved by MB Sheet 229.51) for CDPF.

▶ Use only specified engine oil (Low Ash Oil)

- The vehicle equipped with CDPF should use specific engine oil to improve the engine performance and fuel economy, and ensure the service life of CDPF.

▶ Issue with normal engine oil

- Sulfur, one of the contents of engine oil is burned and generates soot that is not regenerated by the DPF. This remains on the filter as ashes and keeps accumulating. Eventually, this ashes will block the filter.

▶ Benefit for specified engine oil

- Minimized the sulfur content of engine oil which reduces the service life.
- Improved fuel economy and emission level of CO2 with high performance and low viscosity.
- Increased service life of engine oil with high resistance to temperature.

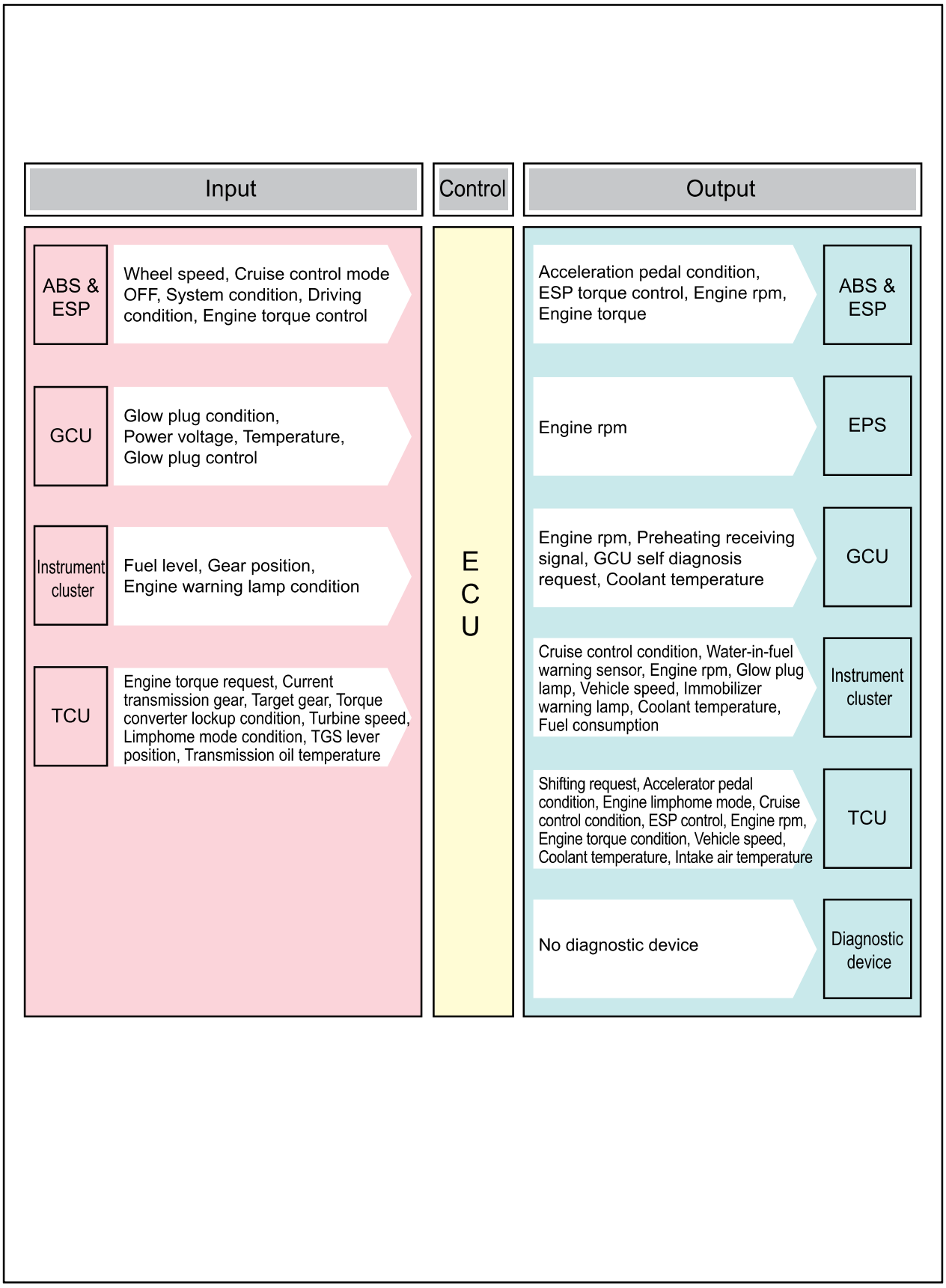
▶ Problems when using unspecified engine oil

- The service life of filter may be reduced by 30% or more by the ashes accumulated on the filter.
- The fuel economy may be reduced because of engine rolling resistance, frequent regeneration of DPF.

  * These problems are also caused by oil with high sulfur content, such as tax exemption oil and heating oil, etc.

Modification basis	
Application basis	
Affected VIN	

3) Input/Output for CAN communication



CONFIGURATION AND FUNCTION

S.G.N. 1491-01 ECU

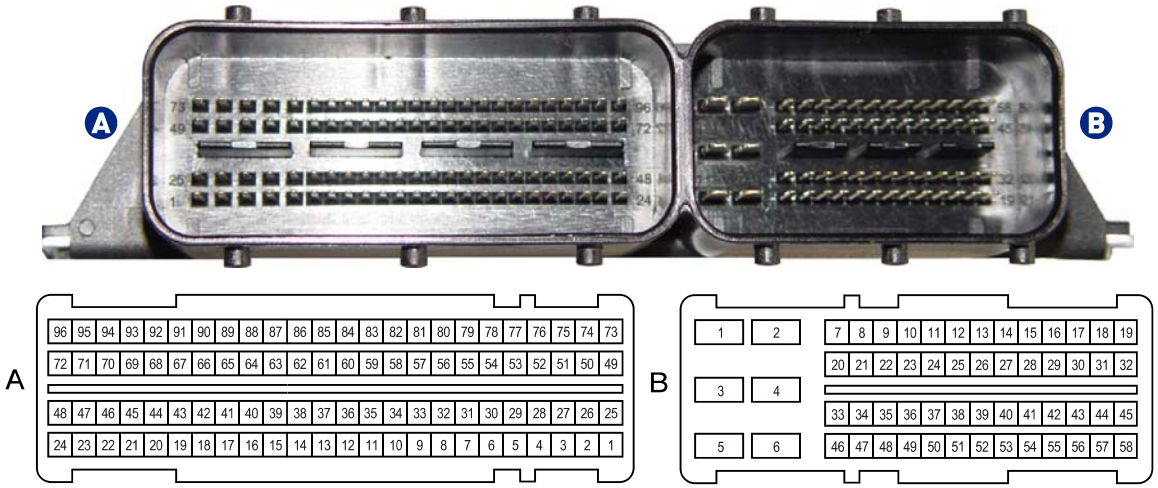
1) Overview

ECU receives and analyzes signals from various sensors and then modifies those signals into permissible voltage levels and analyzes to control respective actuators. ECU microprocessor calculates injection period and injection timing proper for engine piston speed and crankshaft angle based on input data and stored specific map to control the engine power and emission gas. Output signal of the ECU microprocessor drives pressure control valve to control the rail pressure and activates injector solenoid valve to control the fuel injection period and injection timing; so controls various actuators in response to engine changes. ECU controls EGR, CDPF, swirl valve and EGR bypass valve to meet EURO V regulation.

2) Location

Modification basis	
Application basis	
Affected VIN	

3) Connector



Connector	Pin No	Function	Connector	Pin No	Function
A	01	-	A	15	Signal, throttle valve position sensor
	02	-		16	Signal, EGR valve position sensor
	03	Power, #4 injector		17	-
	04	Signal, Intake air temperature (analog)		18	-
	05	Signal, ehxhaust gas temperature sensor (rear)		19	Ground, fuel rail pressure sensor
	06	Signal, ehxhaust gas temperature sensor (front)		20	Ground, crankshaft position sensor
	07	-		21	-
	08	Signal, differential pressure sensor		22	Ground, ehxhaust gas temperature sensor (rear)
	09	Signal, coolant temperature		23	Ground, ehxhaust gas temperature sensor (front)
	10	Signal, fuel temperature sensor		24	-
	11	-		25	Ground/control, #4 injector
	12	Boost pressure sensor (T-MAP sensor)		26	Ground/control, #1 injector
	13	-		27	Power, #1 injector
	14	Swirl valve motor (-)		28	-

Connector	Pin No	Function	Connector	Pin No	Function
A	29	-	A	49	-
	30	Ground, #1 knock sensor		50	Power, #2 injector
	31	Signal, #1 knock sensor		51	Power, #3 injector
	32	Signal, #2 knock sensor		52	-
	33	Ground, #2 knock sensor		53	Signal, intake air temperature sensor (digital)
	34	Intake air temperature sensor (T-MAP sensor)		54	Oxygen sensor trimming resistance (RT: TRIM RES1 STO2)
	35	Signal, fuel rail pressure sensor		55	Oxygen sensor pumping current (APE: Pumping Current)
	36	-		56	Oxygen sensor Nernst voltage (RET: Nernst Voltage)
	37	-		57	Oxygen sensor virtual ground (IPN: Virtual Ground)
	38	Power, fuel railpressure sensor (REF3)		58	Signal, intake air mass
	39	Power, crankshaft position sensor		59	Signal, camshaft position sensor
	40	Power, camshaft position sensor (REF1)		60	Signal, crankshaft position sensor
	41	Power, T-MAP sensor (REF2)		61	-
	42	-		62	Power, swirl valve position sensor (REF3)
	43	-		63	Power, throttle valve position sensor (REF1)
	44	Ground, differential pressure sensor		64	Power, EGR valve position sensor (REF1)
	45	Ground, coolant temperature sensor		65	-
	46	Ground, fuel temperature sensor		66	Power, differential pressure (REF1)
	47	Ground, camshaft position sensor		67	Ground, T-MAP sensor
	48	-		68	-

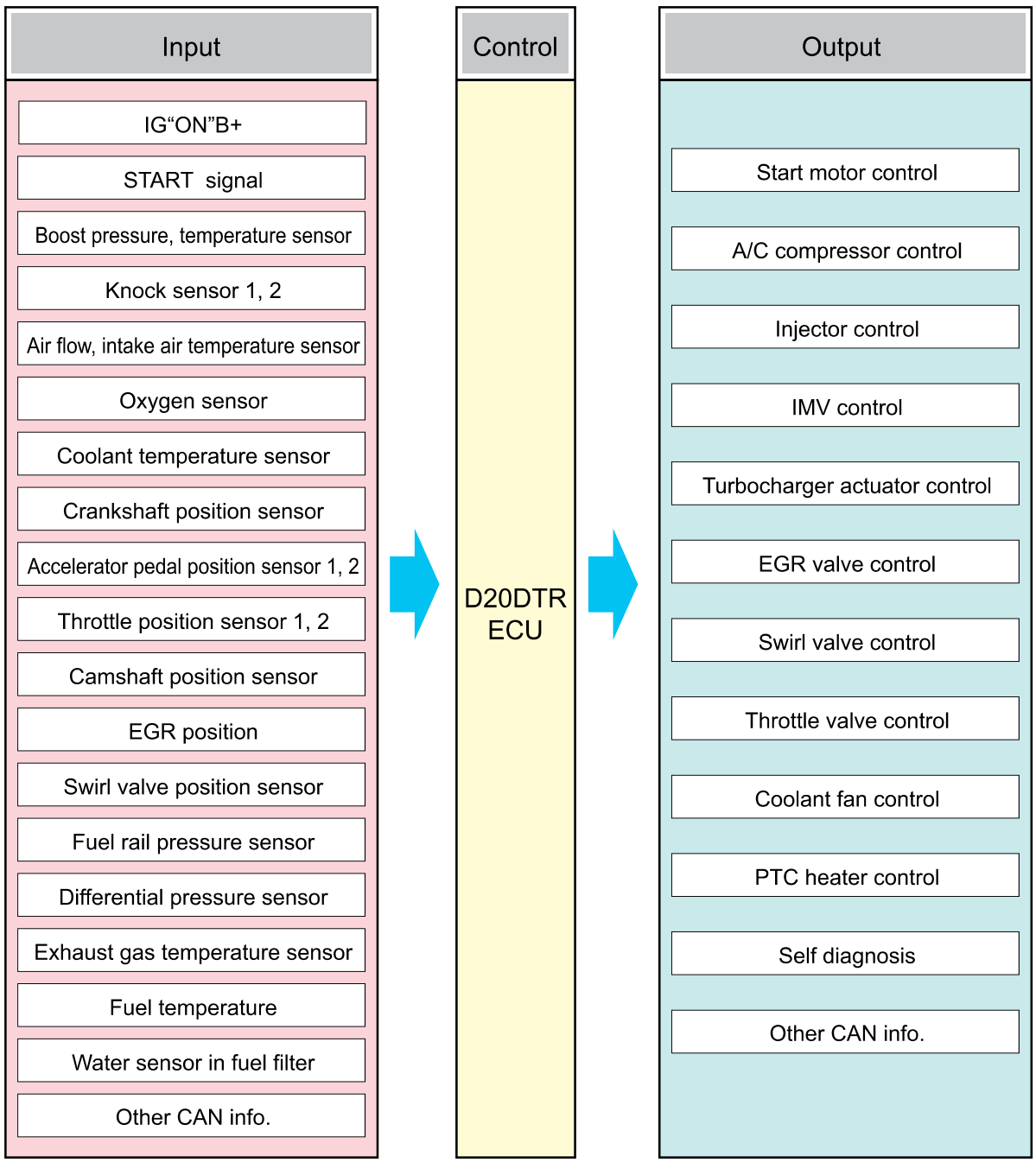
Modification basis	
Application basis	
Affected VIN	

Connector	Pin No	Function	Connector	Pin No	Function
A	69	Swirl valve motor (+)	A	91	Signal, swirl valve position sensor
	70	Ground, throttle valve position sensor		92	EGR valve motor (+)
	71	Ground, intake air mass/temperature sensor		93	EGR valve motor (-)
	72	Ground, EGR position sensor		94	-
	73	-		95	-
	74	Ground/control, #2 injector		96	-
	75	Ground/control, #3 injector	B	1	Power, ECU
	76	-		2	Ground, ECU
	77	Ground, IMV valve PWM control		3	Power, ECU
	78	-		4	Ground, ECU
	79	-		5	Power, ECU
	80	-		6	Ground, ECU
	81	VGT actuator monitoring		7	-
	82	Ground, oxygen sensor heating		8	Signal, A/C refrigerant pressure sensor
	83	Throttle valve motor (-)		9	Signal, water sensor
	84	Throttle valve motor (+)		10	-
	85	-		11	-
	86	Ground, EGR cooler bypass solenoid		12	-
	87	-		13	Signal, #2 accelerator pedal sensor
	88	Ground, VGT actuator PWM control		14	Ground, #2 accelerator pedal sensor
	89	-		15	Signal, cruise control switch
	90	Ground, swirl valve position sensor		16	Signal, blower switch

Connector	Pin No	Function	Connector	Pin No	Function
B	17	Start relay/clutch switch	B	38	-
	18	Clutch switch (TOP: NC/MT, auto cruise)		39	-
	19	Signal. key switch (IGN1)		40	-
	20	Ground, A/C refrigerant pressure sensor		41	-
	21	Ground, vehicle speed sensor (w/o ABS)		42	-
	22	Power, A/C refrigerant pressure sensor (REF1)		43	-
	23	Power, cruise control switch (REF1)		44	-
	24	Power, #1 accelerator pedal sensor (REF2)		45	Ground, main relay
	25	Signal, #1 accelerator pedal sensor		46	PWM motor control signal output
	26	Ground, #1 accelerator pedal sensor		47	CAN Low (P-CAN)
	27	Signal, vehicle speed sensor (w/o ABS)		48	CAN High (P-CAN)
	28	-		49	-
	29	Power, #2 accelerator pedal sensor (REF1)		50	-
	30	Signal, brake pedal switch (NO)		51	Ground/control, A/C compressor relay
	31	-		52	-
	32	Signal, brake pedal switch (NC)		53	-
	33	Ground, cruise control switch		54	-
	34	Ground, water sensor		55	-
	35	-		56	PTC relay #1
	36	-		57	PTC relay #2, 3
	37	-		58	Signal, A/C switch

Modification basis	
Application basis	
Affected VIN	

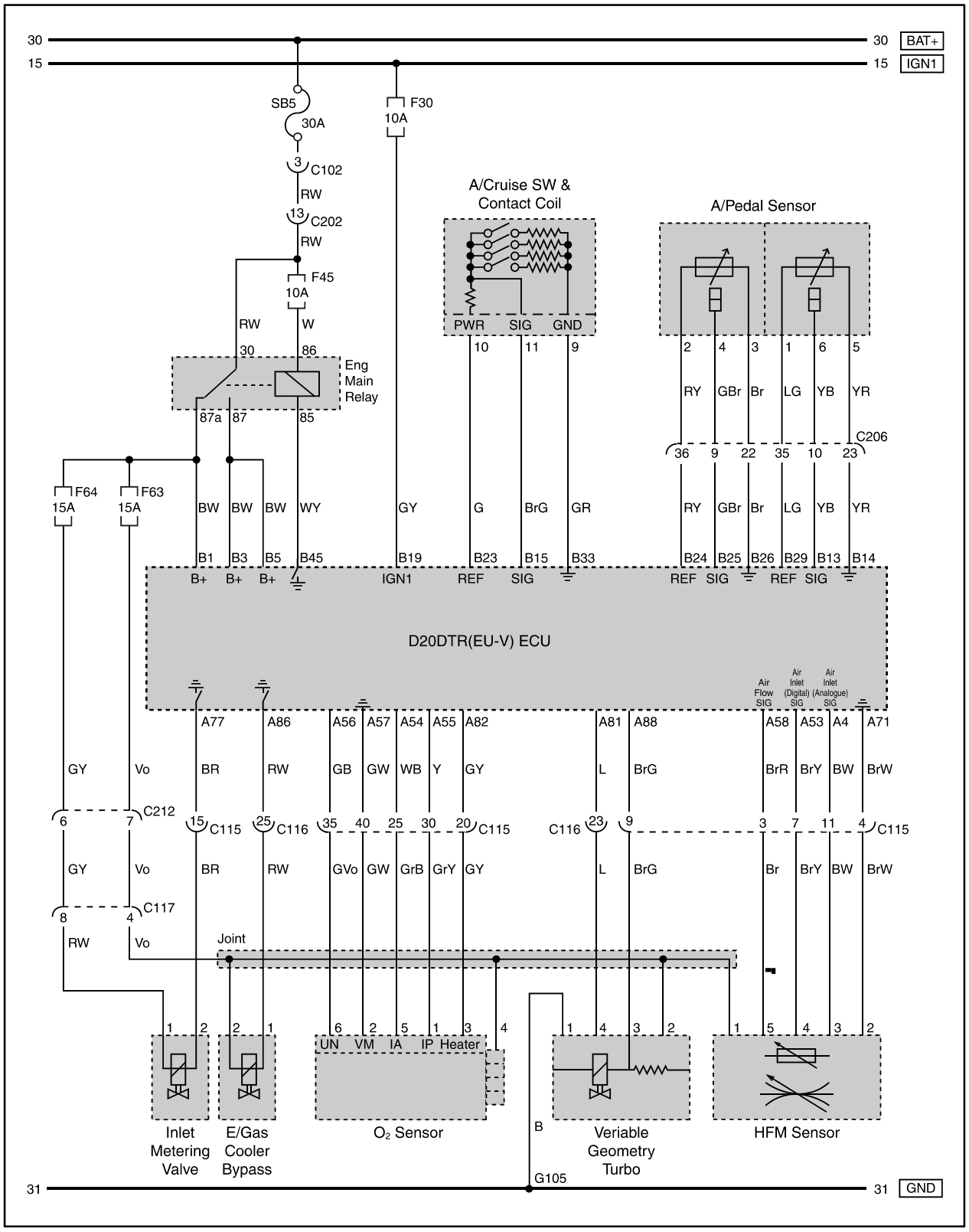
4) Input/Output for ECU



Modification basis	
Application basis	
Affected VIN	

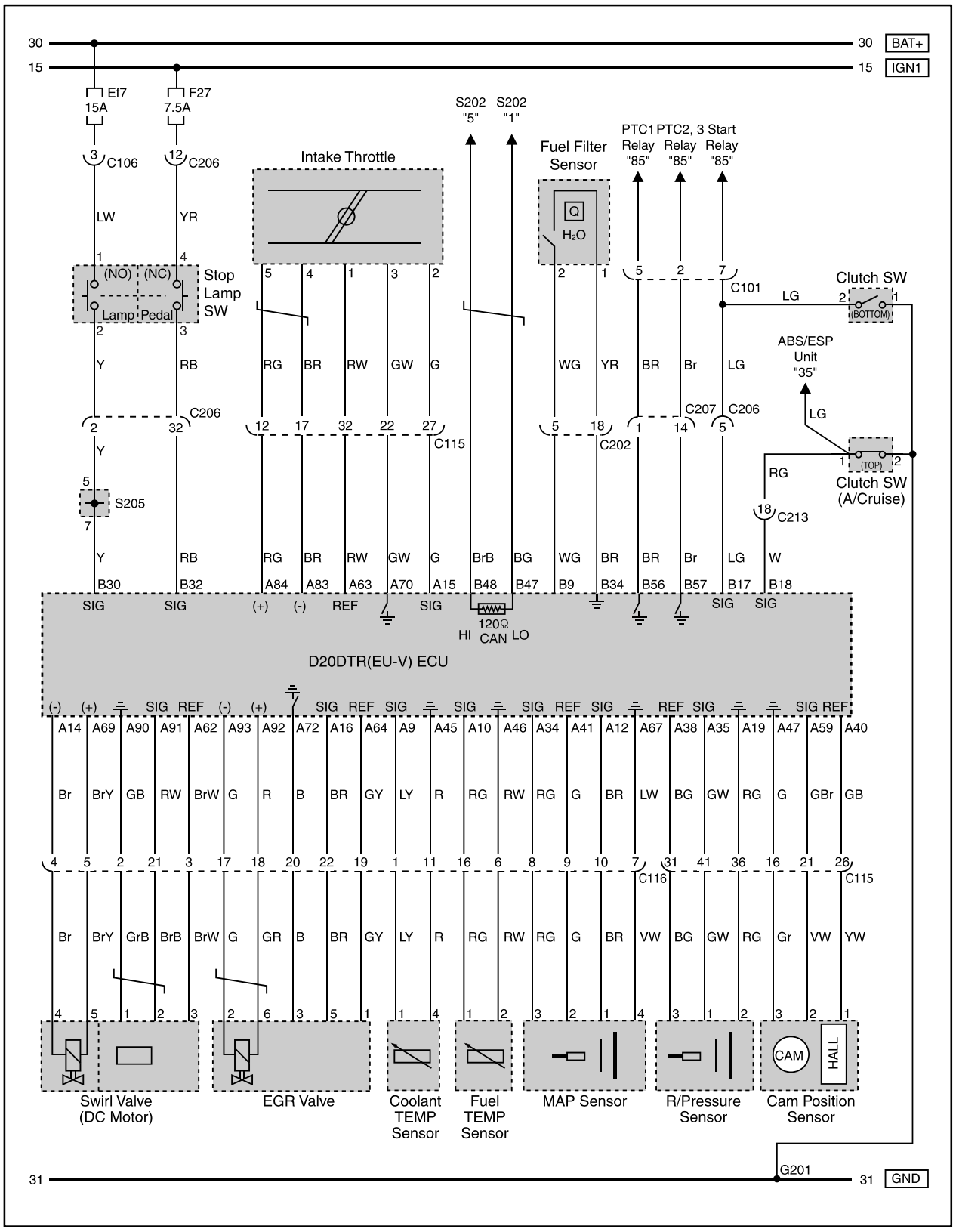
5) Circuit Diagram of D20DTR ECU

(1) Engine main relay, Pedal sensor, HFM sensor, Inlet metering valve, Exhaust gas cooler bypass, VGT, O2 sensor



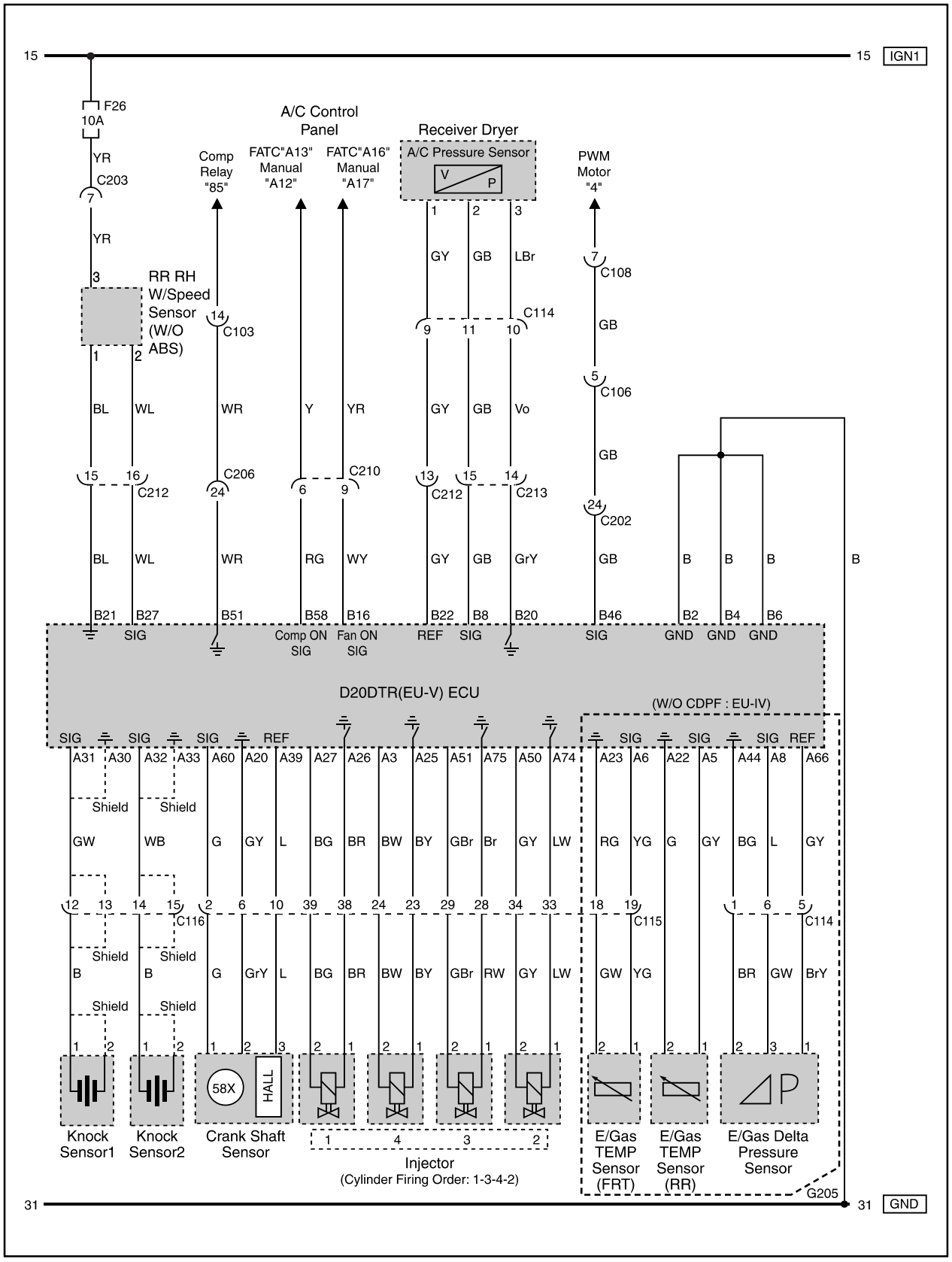
Modification basis	
Application basis	
Affected VIN	

(2) Valves (Intake, Swirl, EGR), Sensors (Fuel filter, Coolant temperature, Fuel temperature, Map, Fuel rail pressure, Camshaft position), Switches (Stop lamp, Clutch)



Modification basis	
Application basis	
Affected VIN	

(3) Wheel speed sensor, Refrigerant pressure sensor, Injector, Sensors (Knock, Crankshaft, Differential pressure, Exhaust gas temperature)



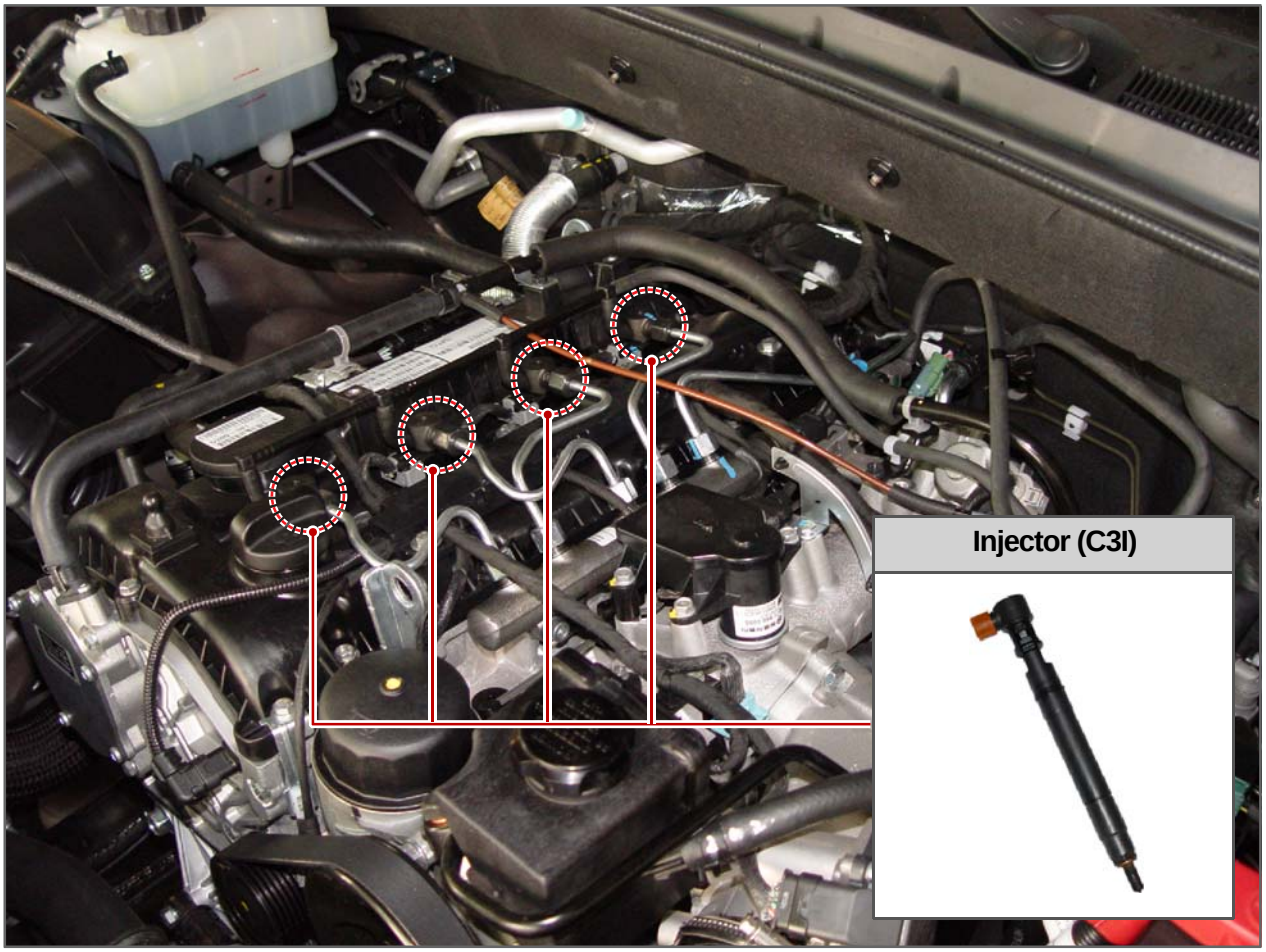
Modification basis	
Application basis	
Affected VIN	

S.G.N.
1882-09 INJECTOR (C3I)

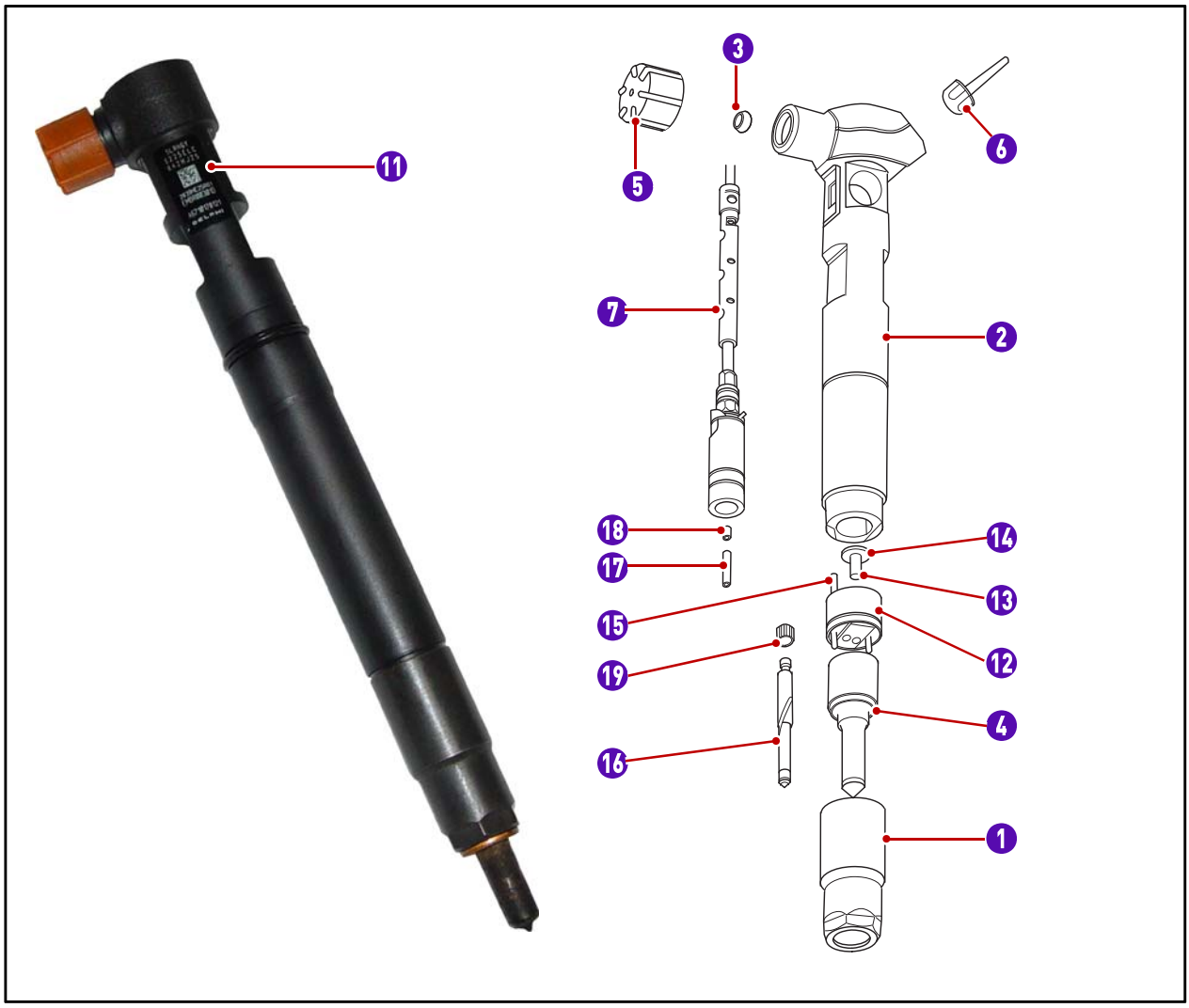
1) Overview

The injectors are installed on the cylinder head cover and fixed by clamp. To meet EURO V regulation, the injector in D20DTF engine has different features in fuel injection pressure, injection angle, sealing and high pressure pipe compared to conventional engine. The injector coding is C3I (Calibration Improved Individual Injector) type. The fuel from high fuel pressure pump is supplied to injector through high pressure pipe and fuel rail. Then, the Engine ECU opens the solenoid valve to inject the fuel into the combustion chamber through multi nozzle. The back-leak fuel returns to the fuel filter through fuel return line to go back to injector again. Some fuel lubricate the high pressure pump and the fuel from the pressure limit valve returns to the fuel tank through the return line.

2) Location



3) Components



1 Cap nut
2 Nozzle holder body
3 Filter
4 Nozzle body
5 Protective cap
6 Backleak cap
7 Actuator bobbin
11 C3I sticker
12 Control valve body
13 Control valve stem
14 Control valve armature
15 Dowel pin
16 Nozzle valve
17 Actuator spring
18 Adjust pin
19 Injector spring

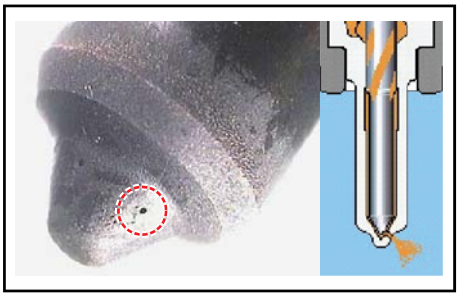
	Specification
Control type	Current control type (PWM)
Installation	Clamping type
Operating pressure	1,800 bar

Modification basis	
Application basis	
Affected VIN	

4) Features

(1) C3I (Calibration Improved Individual Injector)

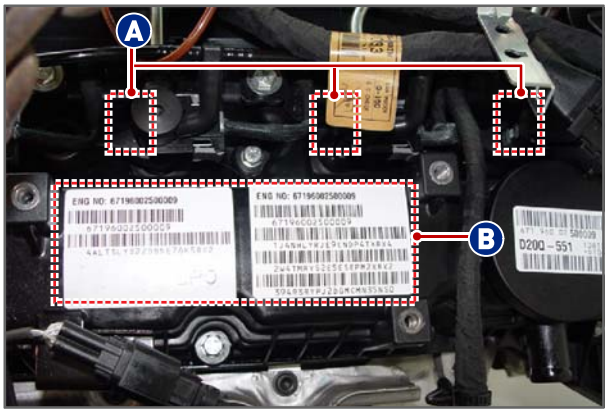
The injector in engine equipped with common rail system is very precise component. It is able to inject the 0.5~100mg/st of fuel with 1800 bar. To control this process precisely, the machining tolerance for injector nozzle is very important element (unit of ㎛).



The fuel injection volume is needed to be corrected because there could be differences in nozzles during the machining. To do this, the initial characteristics of injector is coded. This coding is called C3I.

C3I [Improved Individual Injector Calibration]	
C3I code	Totally 20 digits (use Arabian numbers (1~9) and Alphabet except I, O, Q, V)
MDP learning	When idling and driving
Numbers of nozzle	Eight

a. C3I code on injector



(A) on injector	(B) on cylinder head cover
	ENG NO:00000000000000 1. 12345678901234567890 2. 12345678901234567890 3. 12345678901234567890 ENG NO:00000000000000 4. 12345678901234567890
C3I code marked on the upper side of injector	Engine serial number and C3I code for each injector on two labels in cylinder head cover

NOTE

C3I code are located on the injector and cylinder head cover. C3i code consists of 20 digits of number (1~9) and alphabet (except I/O/Q/V).

(2) Injection

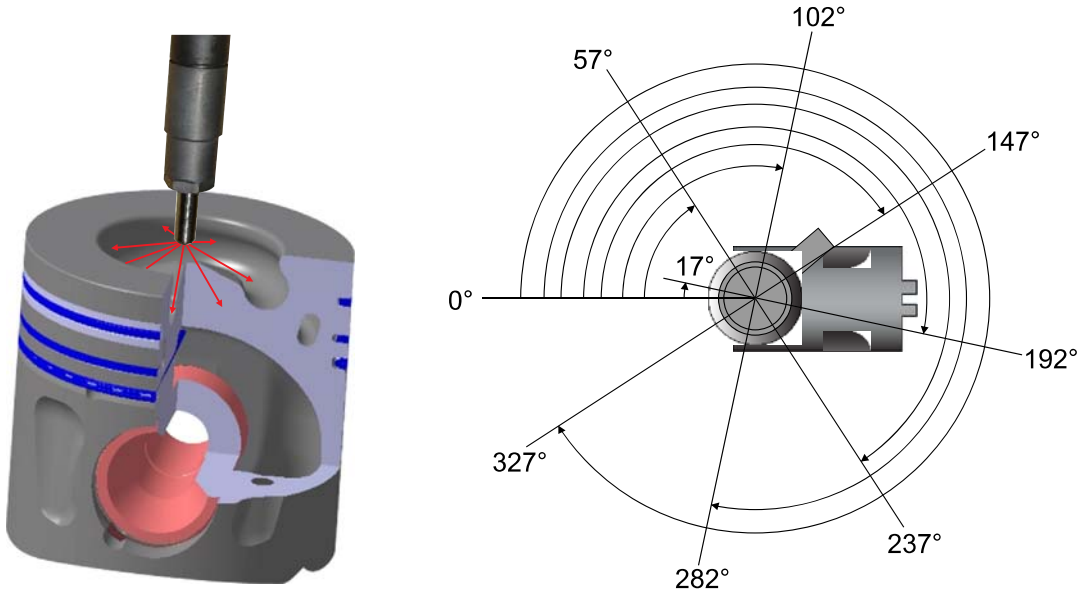
A. Fuel injection pressure

- Minimum operating pressure: start injection from 100 bar
- Maximum operating pressure: 1,800 bar
- Pressure limit: 2,100 bar

B. Maximum fuel volume for each cycle

- Pilot Injection ≤ 5 mm3
- Main Injection ≤ 85 mm3 (at 200 to 1,800 bar)
- Operating pressure: 2,100 bar

Injection angle of injector nozzle



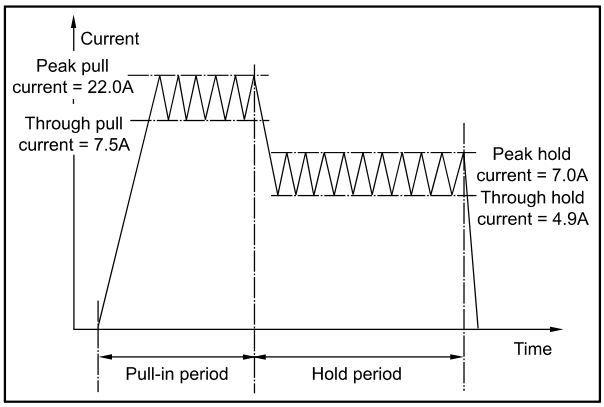
CAUTION

- Injector is clean sensitive component. Make sure to seal the openings with caps when removing the hoses and pipes
- Replace the copper washer at bottom of injector with new one once the injector has been removed.
- Tighten the bolt for clamp with specified tightening torque.
- Be careful not to drop the injector.

Modification basis	
Application basis	
Affected VIN	

(3) Injector control

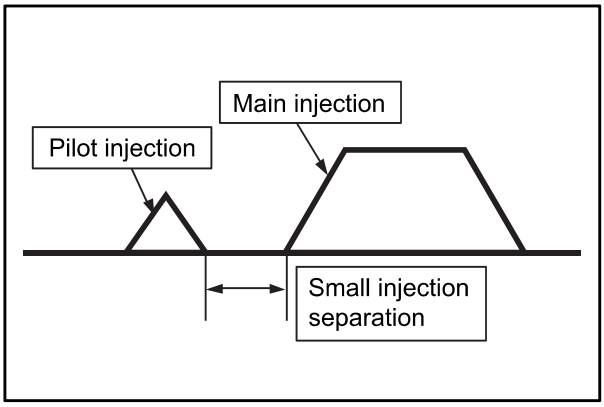
Pull in current: lift the needle valve in injector, approx. 20 A
Hold in current: keep the needle valve operated, approx. 10 A
The low current can reduce the loss due to Joule effect from ECU and injector. Pull in timing is later than hold in timing.



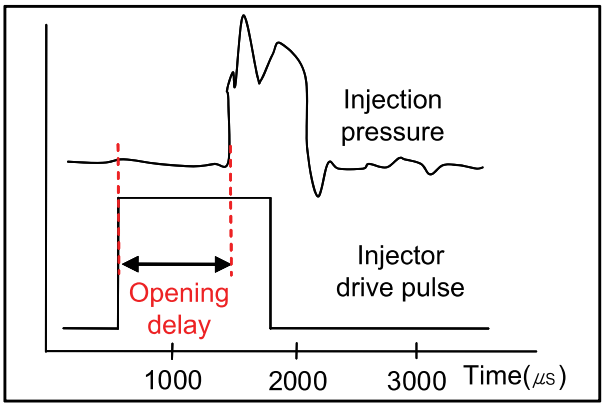
- The air gap between the valve and the coil is reduced and the electromagnetic force to be applied to the valve can thus be reduced. It is no longer necessary to overcome the valve inertia.

NOTE

Joule Effect is a physical law expressing the relationship between the heat generated by the current flowing through a conductor
Heat (H) = 0.24 I2RT

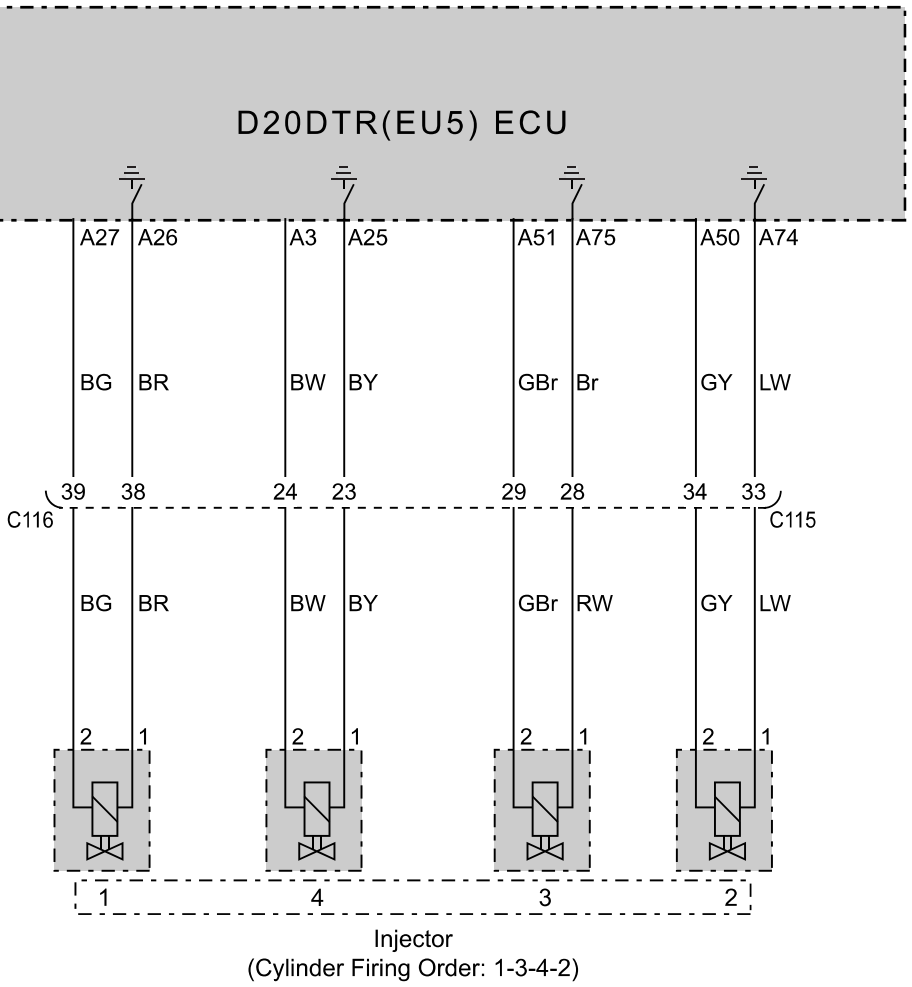


- Small injection separation: minimum interval of 200ms (duration between the end of pilot injection and start of main injection)



- Opening Delay:
  Delayed time from applying operating voltage to start of injection

5) Circuit Diagram

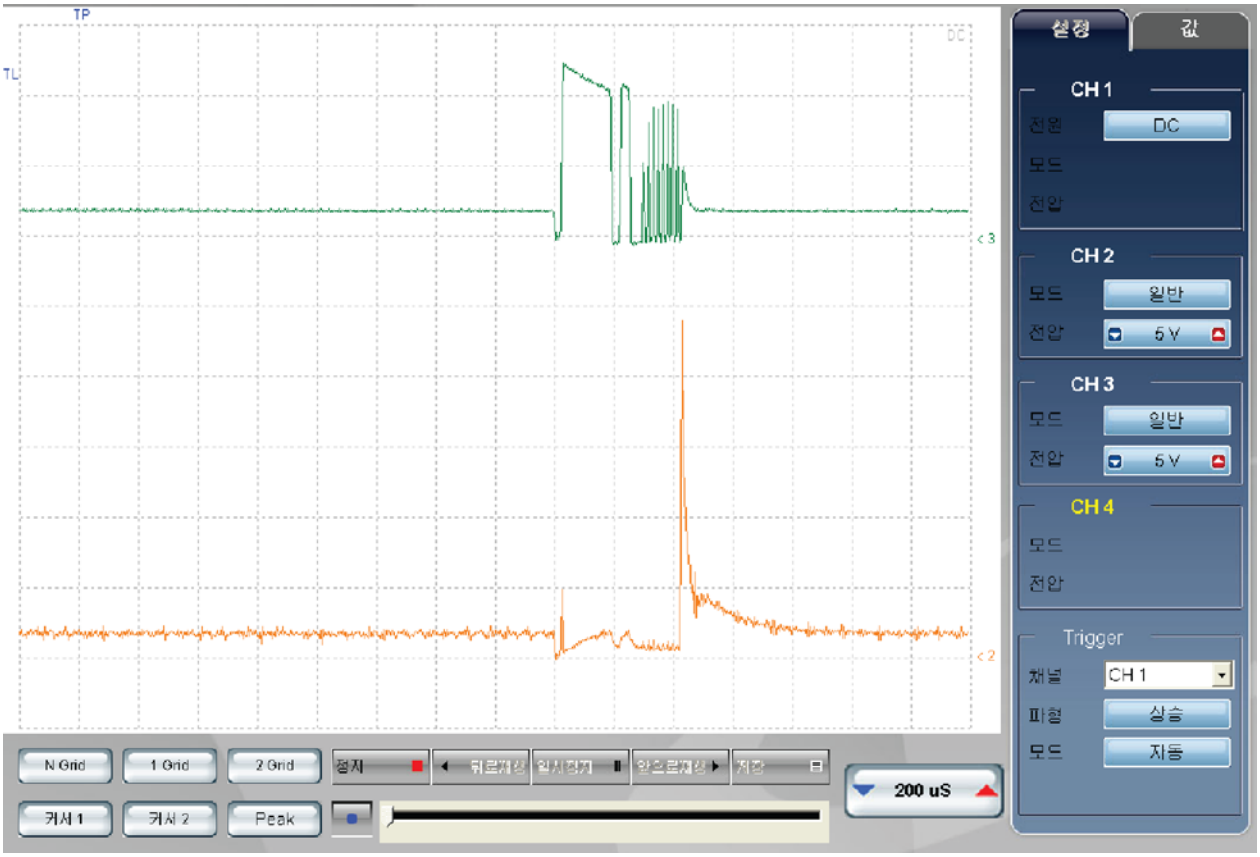


Injector
(Cylinder Firing Order: 1-3-4-2)

Modification basis	
Application basis	
Affected VIN	

6) Operating wave

#1 injector	#1 channel	#3 channel
Measuring	Measuring probe (+) A27 Measuring probe (-) body ground	Measuring probe (+) A26 Measuring probe (-) body ground



The injector operation needs high current (26A). During idle range, 2.2V of power is supplied to check the wiring conditions and charge the injector operating power into bank. The charged power from each bank is supplied to injector at operating point. At this moment, #1 and #4 injectors use one bank, and #2 and #3 injectors use another bank. (+) side of injector uses 12V power and (-) side is grounded at injector operating point.

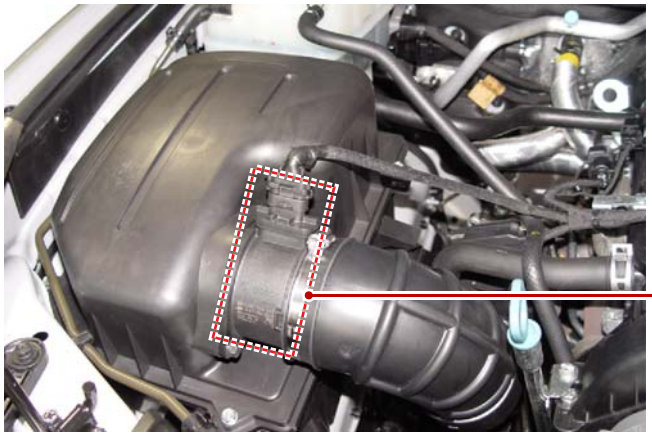
S.G.N.
2330-08 HFM (HOT FILM AIR MASS SENSOR)

1) Overview

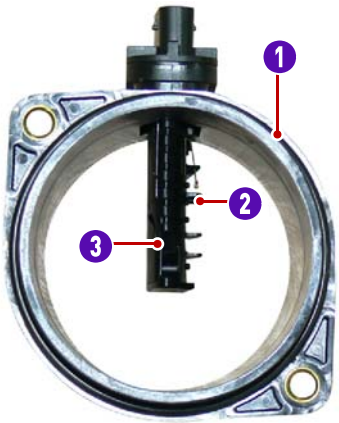
HFM (Hot Film Air-Mass) sensor is installed between air cleaner and turbocharger, and consists of intake air mass sensor and intake air temperature sensor.
HFM sensor determines the fuel injection volume and injection timing by measuring the intake air mass and intake air temperature. And, the intake air mass is used as a basic control signal for EGR control.

- Measure the inflow air mass and temperature into engine.
- This is used as an important information for determining the fuel injection volume to get ideal air-fuel ratio.
- This is used as a feedback signal for E-EGR valve control.

2) Location



HFM



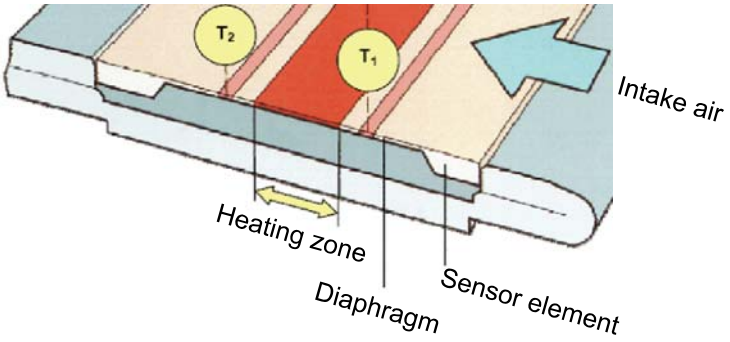
1. Housing
2. ntake air temperature sensor
3. Air inlet port

Modification basis	
Application basis	
Affected VIN	

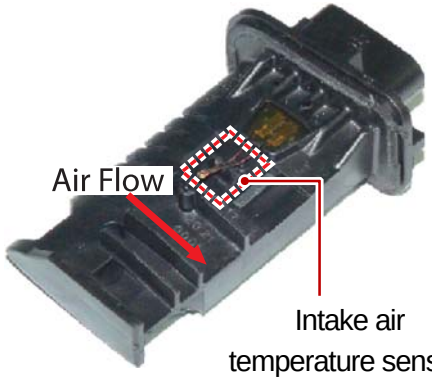
3) Operating Principle

HFM sensor (Hot Film Air-Mass Sensor)

Intake air mass sensor



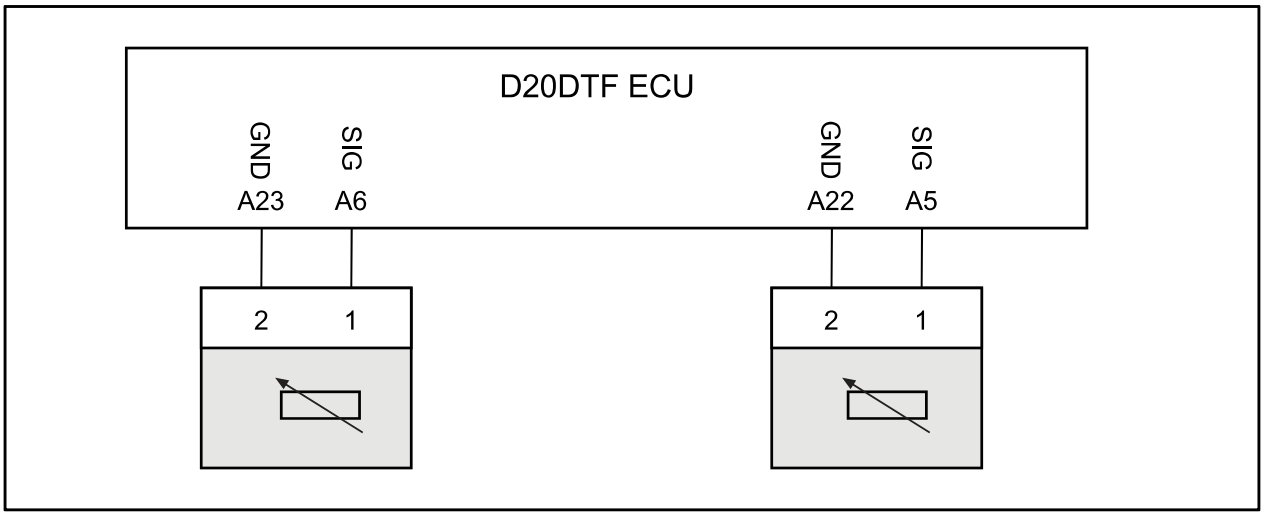
Intake air temperature sensor



The HFM sensor detects the intake air volume, and calculates the air flow by measuring the current consumption of the heater cooled by the air passes through bypass channel. The diaphragm is positioned in the sensor element, and has a heating zone. The heating zone is continuously cooled by the intake air temperature. The ECU calculates the volume of the intake air by measuring the current which is supplied to the heating zone to keep the temperature constantly. There intake air temperature sensor, which measures the intake air temperature to calculate the exact air density, is also mounted in this sensor.

For HFM7, the intake air volume is converted to a digital signal and the intake air temperature is output in the form of both digital and analog signals, like HFM6.

4) Input/Output

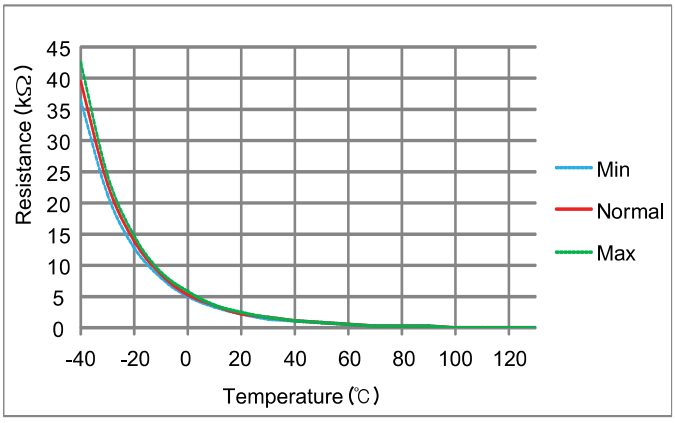


5) Signal

▶ **Features for intake air mass sensor**

Intake air mass	Feature (μs)
10kg/h	504.27
75kg/h	365.46
160kg/h	295.19
310kg/h	223.01
640kg/h	127.68
800kg/h	94.07

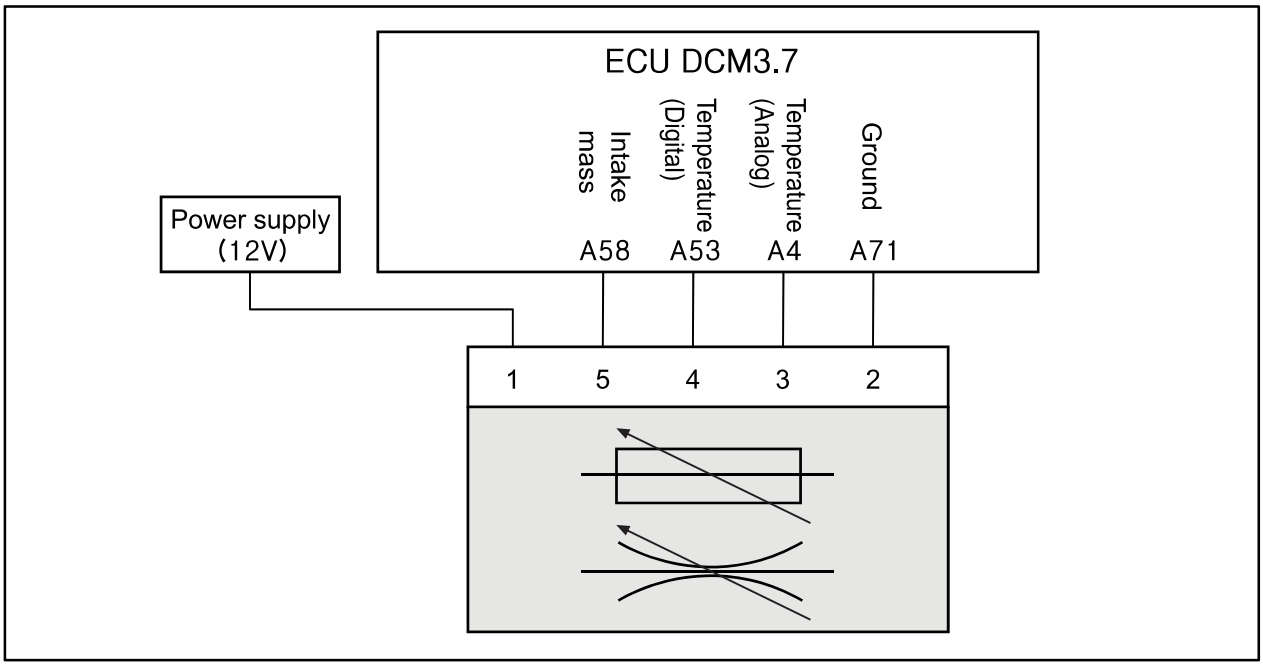
▶ **Features for intake air temperature sensor**



Intake air temperature	Resistance (Ω)
-40	39650
0	5489
20	2419
80	336.1
100	197.3
130	97.11

Modification basis	
Application basis	
Affected VIN	

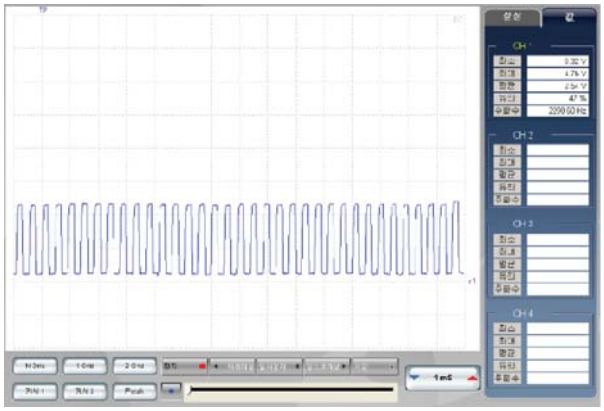
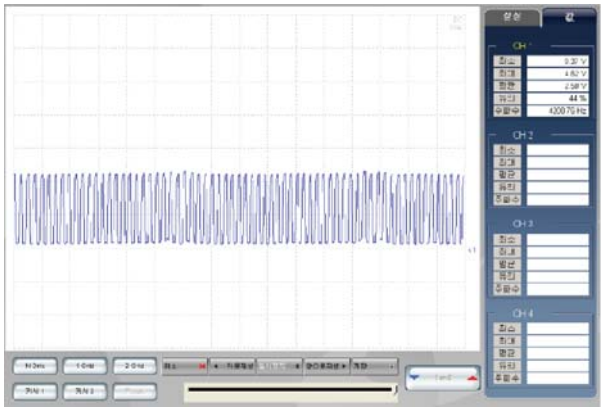
6) Circuit Diagram



7) Operating Wave

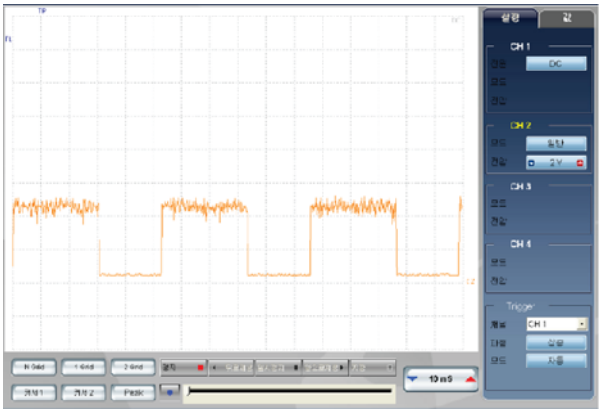
(1) Intake air mass sensor

Measuring	Measuring probe (+) A58 Measuring probe (-) A71

Idling	Abrupt acceleration (4000 rpm)
	
The signal form intake air mass sensor is digital type (0 V, 5 V). And, the output is frequency type and the duty ratio is fixed at 50%.	The intake air mass is increased by 1,000 mg/stk during sharp acceleration. If it continues to go up, the sensor output frequency is increased nut the duty ratio is fixed at 50%.

(2) Intake air temperature (digital)

Measuring	Measuring probe (+) - A53
	Measuring probe (-) - A71



There are two types, analog and digital, of signal for intake air temperature. Digital signal sends the temperature value with duty ratio. As the temperature goes up (-), duty ratio also goes up.

Modification basis	
Application basis	
Affected VIN	

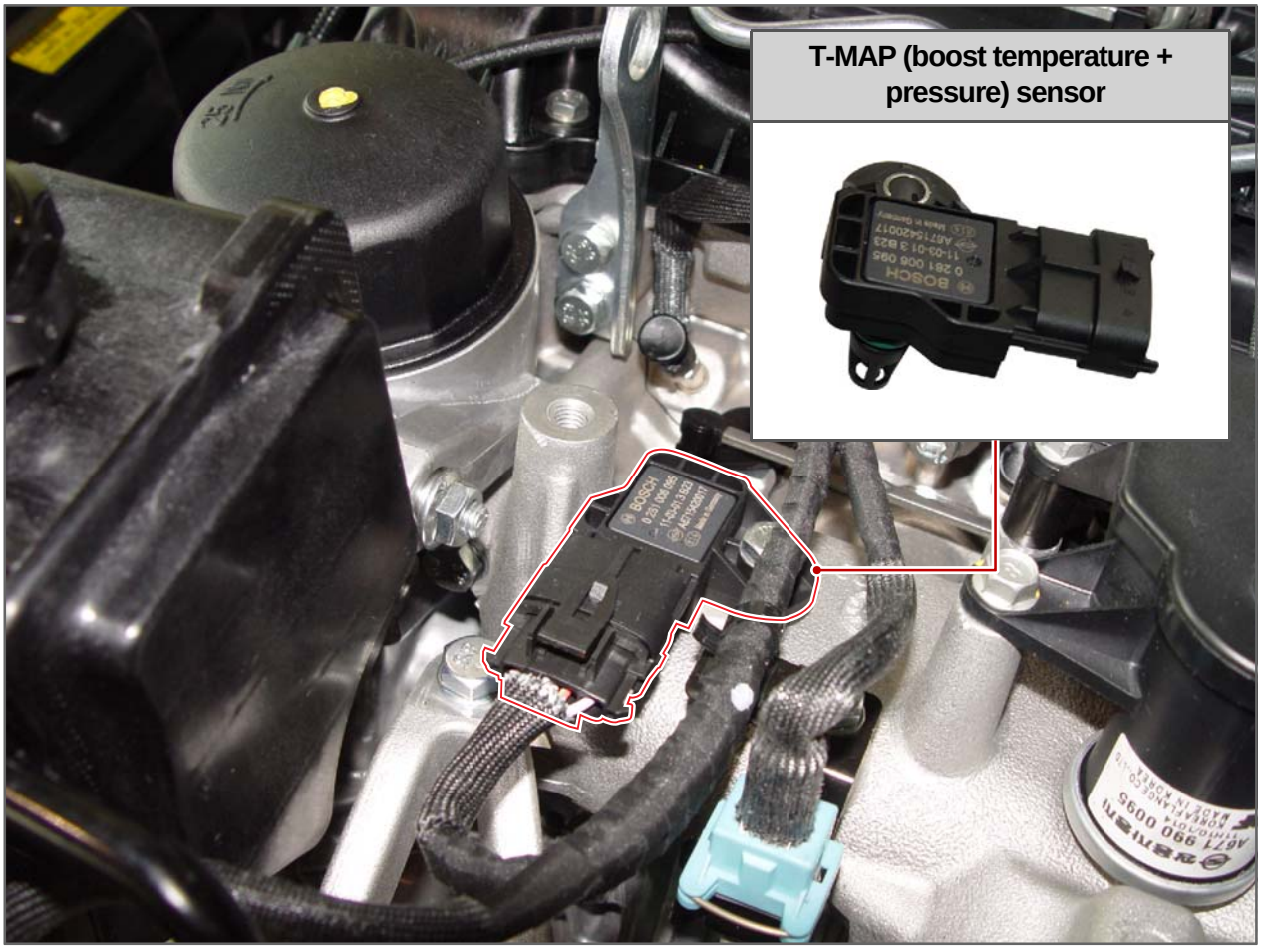
S.G.N.
1432-01

T-MAP (TEMPERATURE-MANIFOLD AIR **PRESSURE) SENSOR**

1) Overview

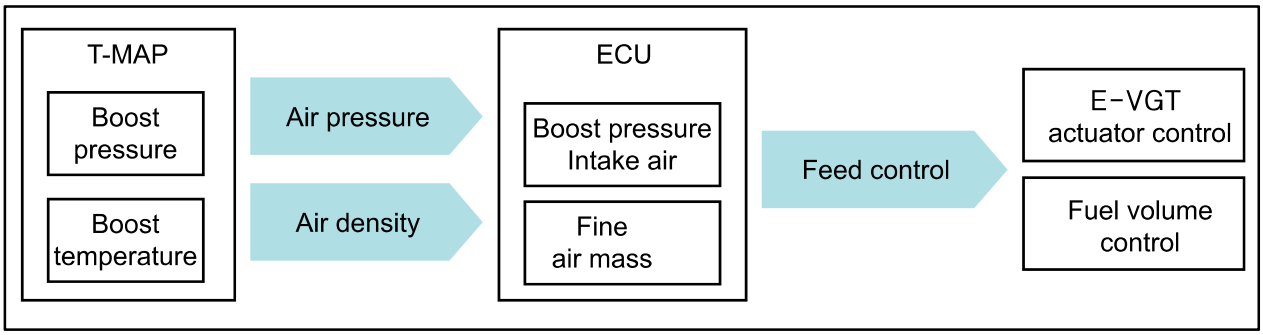
T-MAP sensor is installed in the intake duct between electronic throttle body and intake manifold.
T-MAP sensor contains the pressure sensor and the temperature sensor. It measures the boost pressure in turbocharger and the boost temperature passed intercooler.
T-MAP sensor uses NTC thermister to measure the air density into turbocharger. This allows the sensor to control the system precisely according to the intake air volume. Boost pressure sensor corrects the fuel injection timing and volume according to the turbocharger operating conditions, and supports HFM sensor.

2) Location



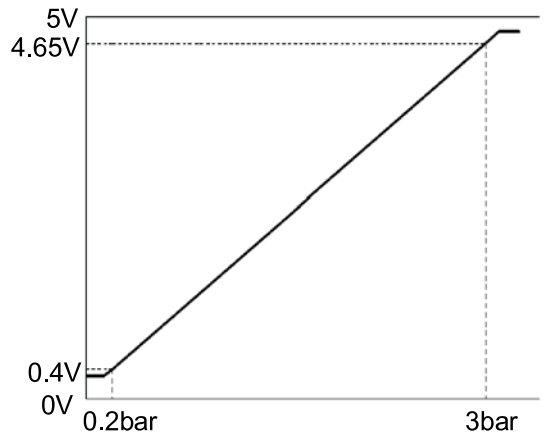
Modification basis	
Application basis	
Affected VIN	

3) Input/Output for T-MAP sensor



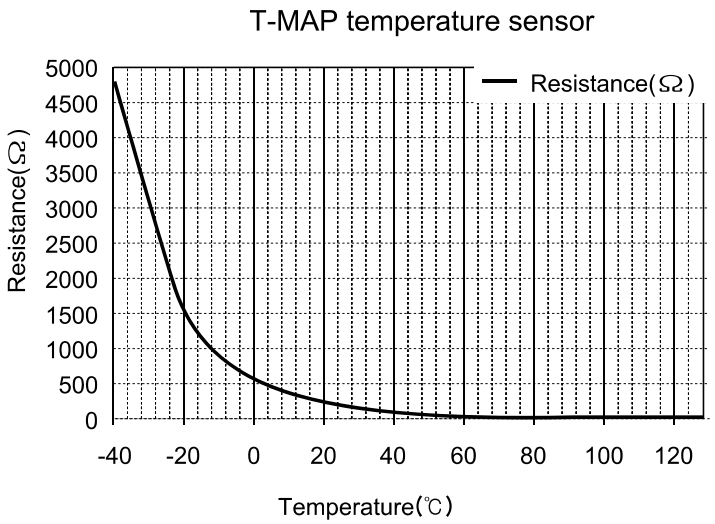
4) Features

▶ Boost pressure sensor



- Check boost pressure sensor data
  Check data at sharp acceleration: over 1.6 bar

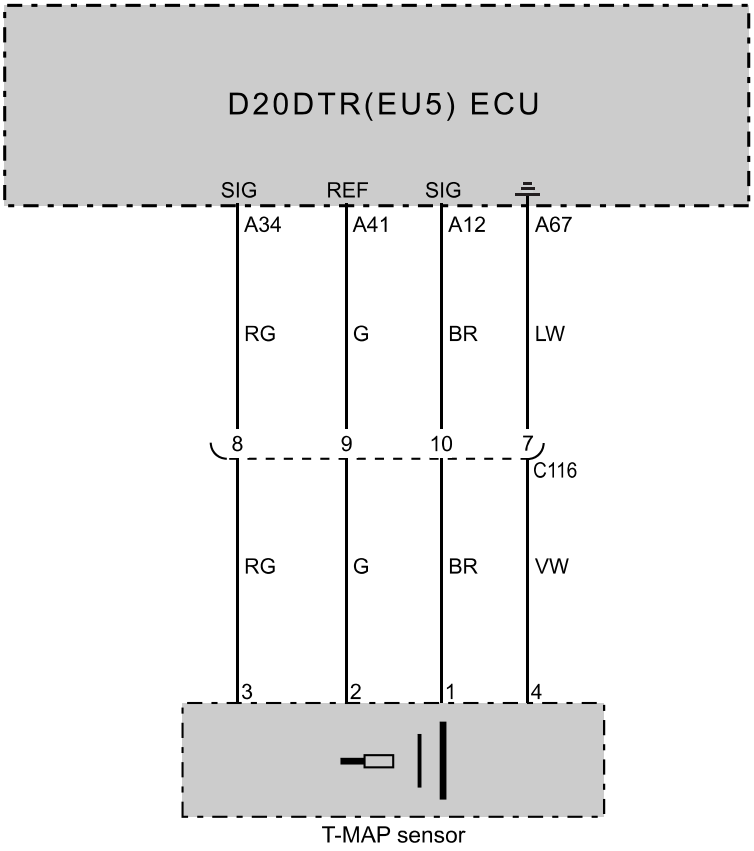
▶ Intake air temperature sensor



Intake air temperature	Resistance (Ω)
-40	48153
-20	15614
0	5887
20	2510
40	1199.6
60	612.3
80	329.48
100	186
130	84.45

Modification basis	
Application basis	
Affected VIN	

5) Circuit Diagram

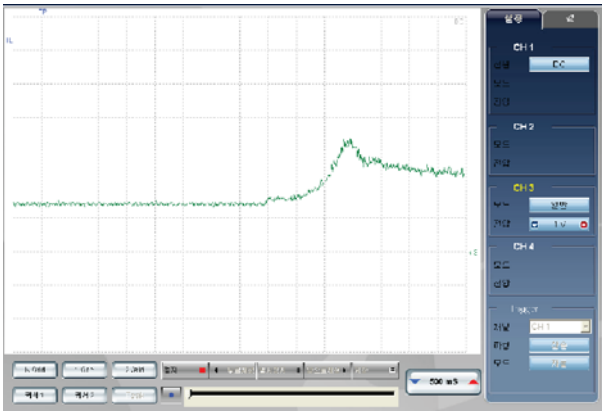


Modification basis	
Application basis	
Affected VIN	

6) Operating Wave

(1) Boost pressure

Measuring condition	Maintain 4,000 rpm for 3 seconds with vehicle stopped
Measuring	Measuring probe (+) A12 Measuring probe (-) A67



When idling, the output value is 1.2 to 1.3 V at 1 bar (atmospheric pressure). When accelerating the engine sharply, the boost pressure is increased over 1.6 bar instantly.

Modification basis	
Application basis	
Affected VIN	

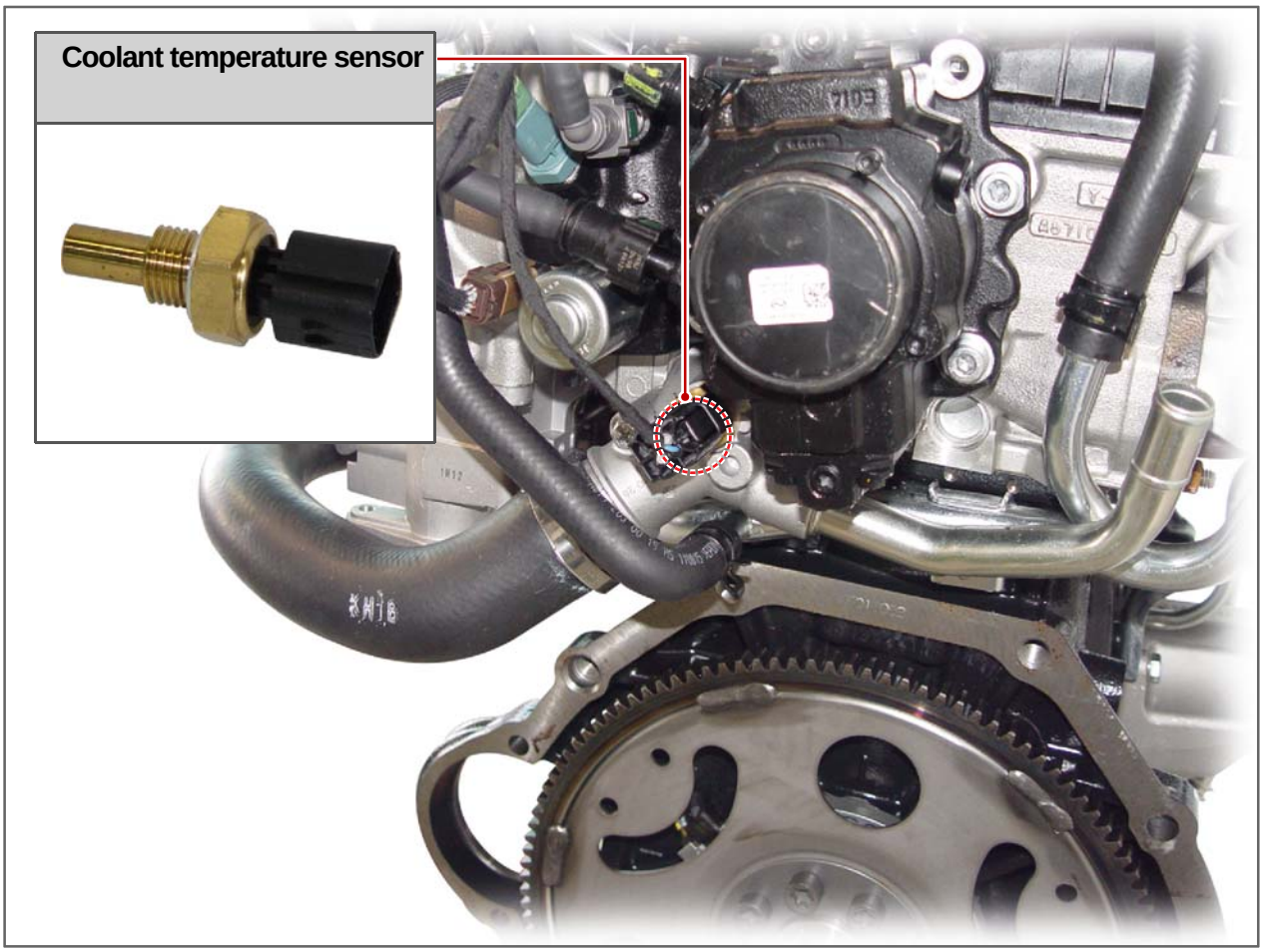
S.G.N.
1432-07 COOLANT TEMPERATURE SENSOR

1) Overview

Coolant temperature sensor uses NTC thermister that the resistance goes down as the temperature goes up. Coolant temperature sensor corrects the fuel injection volume according to the coolant temperature. When the engine is cold, the engine output could be insufficient. This may cause the increase of exhaust gas volume, and accordingly, the fuel injection volume is also increased.
This sensor has the functions as below (through CAN communication):

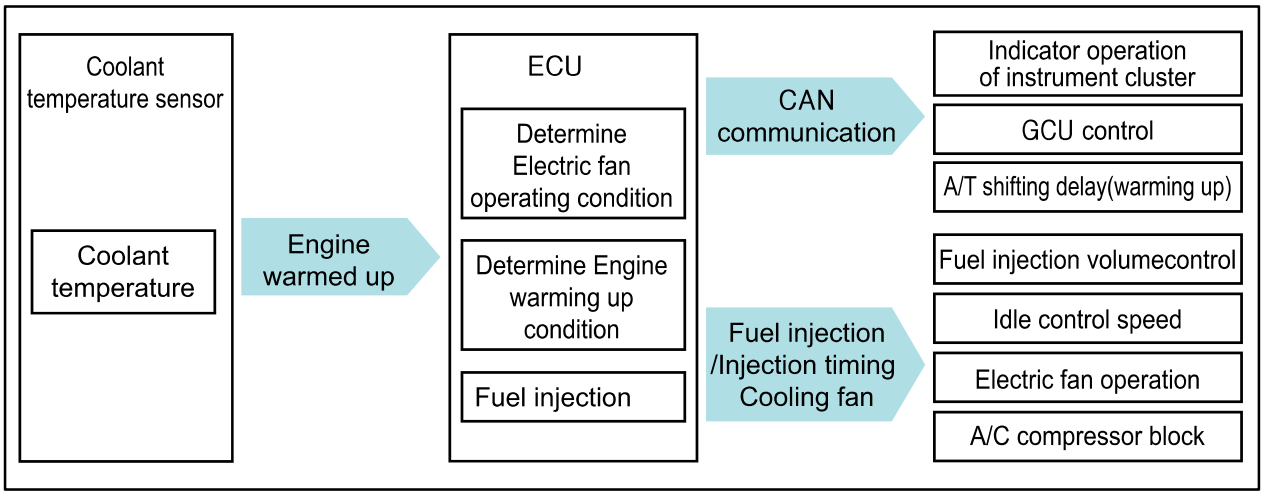
- Shows the coolant temperature on meter cluster
- Stops cooling fan and A/C compressor operation when the engine is overheated
- Determines the pre-glow time by sending coolant temperature signal to GCU at initial engine starting

2) Location



Modification basis	
Application basis	
Affected VIN	

3) Input/Output for Water Temperature Sensor

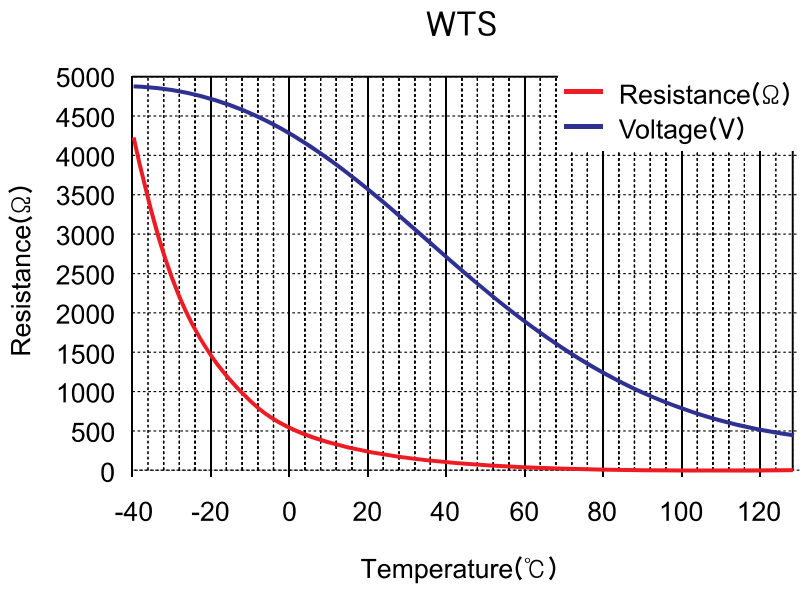


4) Control Elements according to Coolant Temperature

- Injection period
  Idle speed is increased to 1,500 rpm from 1,140 rpm according to the coolant temperature.
- Fuel injection volume control
  Helps engine warming up by controlling the fuel injection volume according to the coolant temperature.
- Shifting delay (A/T)
  Delays the transaxle shiting to help engine warming up when the coolant temperature is low.
- Cooling fan operation
  Cools down the engine by operating the cooling fan according to the coolant temperature.
- A/C operation
  Stops the A/C compressor according to the coolant temperature.

Modification basis	
Application basis	
Affected VIN	

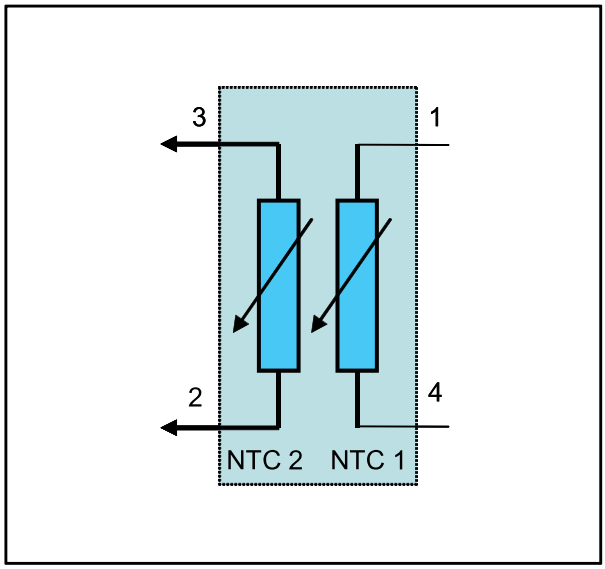
5) Characteristic Curve



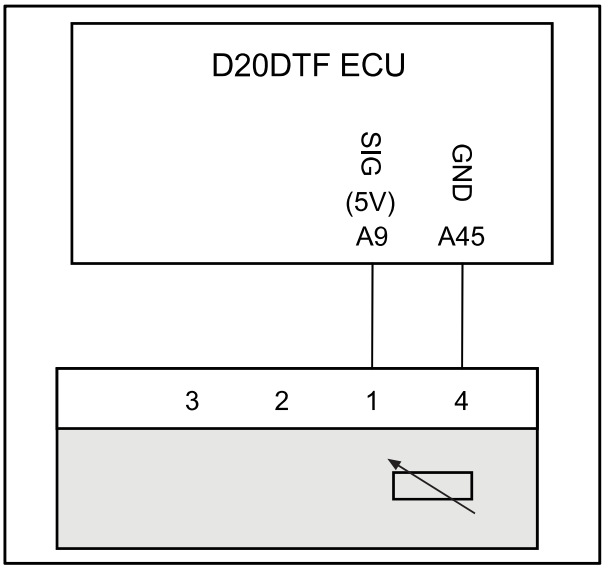
Temperature (℃)	Resistance (Ω)	**Voltage (V)**
-40	42695.5	4.896
-20	14641.6	4.705
0	5681.8	4.298
20	2449.9	3.615
40	1155.9	2.747
60	589.4	1.910
80	321.4	1.259
100	185.7	0.819
120	112.9	0.536
130	89.52	0.436

6) Circuit Diagram of Water Temperature Sensor

▶ **Internal circuit of sensor**

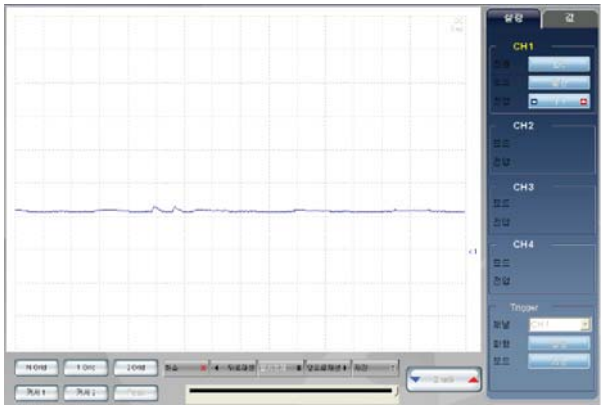


▶ **Connected circuit to ECU**



7) Operating Wave

Measuring condition	After engine warmed up (80℃ of coolant temperature)
Measuring	Measuring probe (+) A09 Measuring probe (-) A45



Water temperature sensor uses NTC thermister that the resistance goes down as the temperature goes up. It uses 5 V of reference voltage. When the coolant temperature is 80℃, the output voltage is approx. 1.2 V.

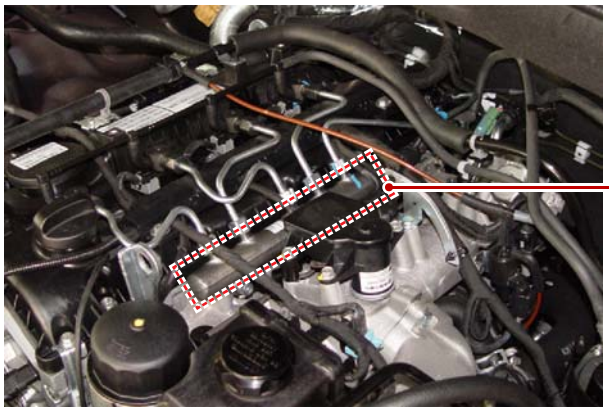
Modification basis	
Application basis	
Affected VIN	

S.G.N.
1882-23 FUEL RAIL PRESSURE SENSOR

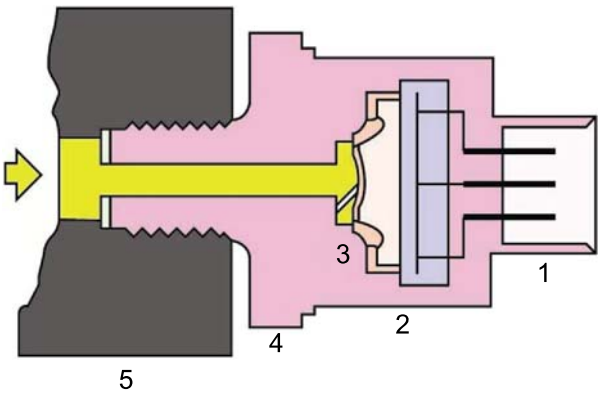
1) Overview

The fuel rail sensor in fuel rail assembly converts the fuel pressure signal to electric signal, and sends it to ECU after amplifying. To replace the fuel rail sensor, replace the fuel rail assembly as a unit. The pressure in fuel rail is determined by engine rpm, engine torque, atmospheric pressure, coolant temperature and intake air temperature. The fuel rail pressure sensor determines the opening of IMV to control the fuel rail pressure.
The measurable rage of fuel rail pressure is 0 to 2,200 bar.

2) Location



Fuel rail assembly

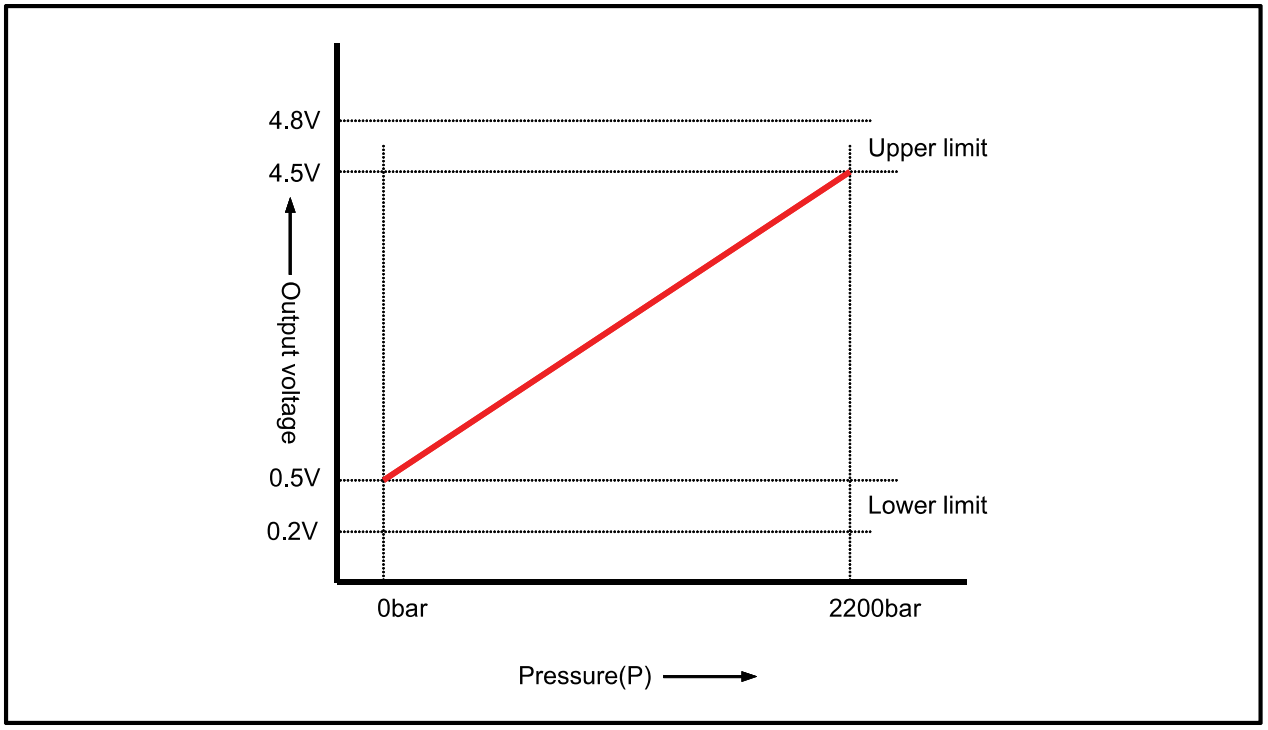


1. Connector
2. Measuring circuit
3. Sensor element (diaphragm)
4. Fuel rail pressure sensor assembly
5. Fuel rail

Modification basis	
Application basis	
Affected VIN	

3) Features

▶ **Output voltage**

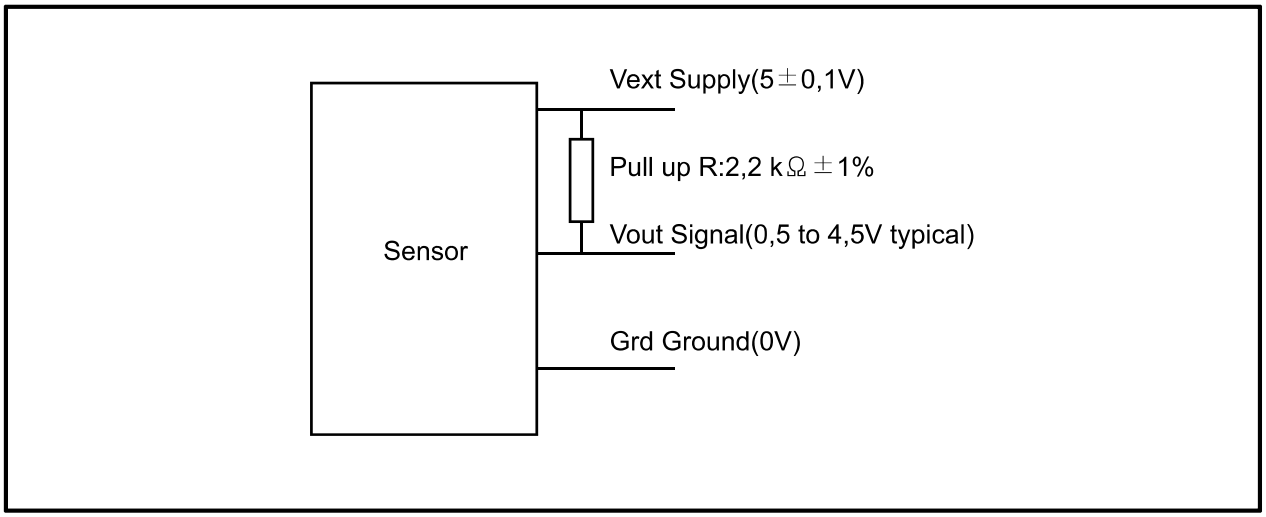


Supply voltage		5 ± 0.1 V
Output voltage	at 2,200 bar	4.5± 0.125V
	at 0 bar	0.5 ± 0.04 V
Operating range	0 to 1,000 bar	over ± 1.0 %
	1,000 to 1,800 bar	over ± 1.6 %

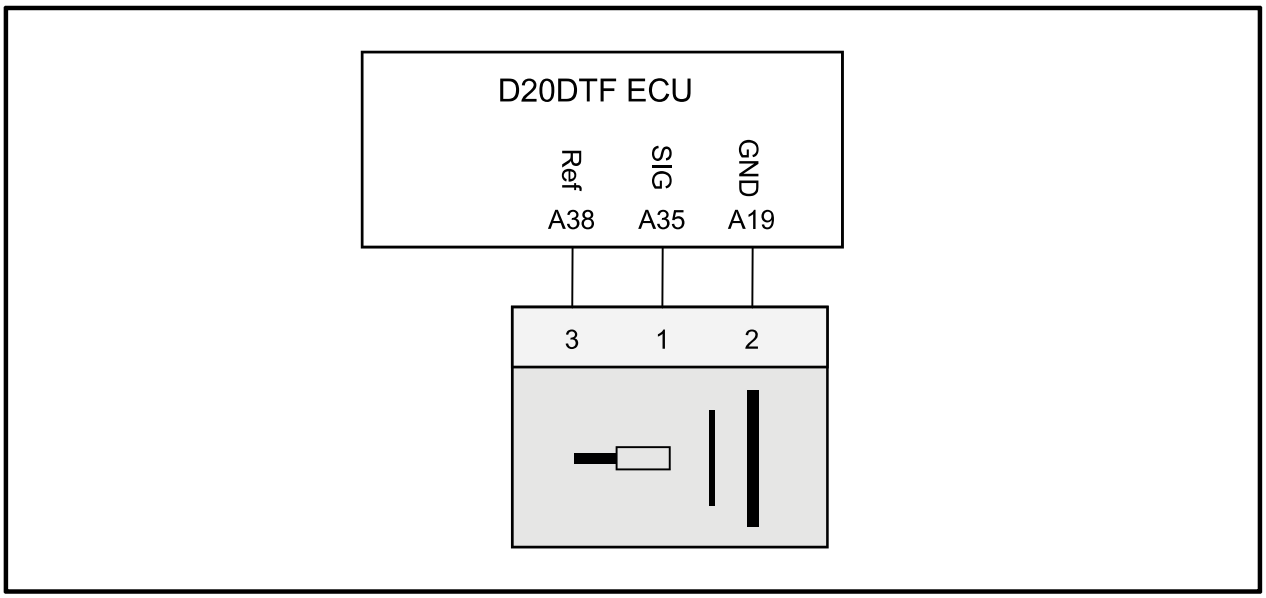
Modification basis	
Application basis	
Affected VIN	

4) Circuit Diagram

▶ **Internal circuit**



▶ **Connected circuit**

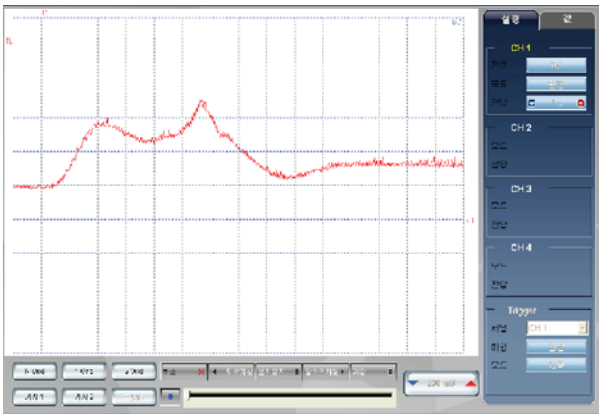


The fuel rail pressure sensor with Piezo element is installed on silicone chip. The Piezo element changes its resistance according to the changes of external pressure. The fuel rail pressure sensor uses this characteristic to measure the pressure.

Modification basis	
Application basis	
Affected VIN	

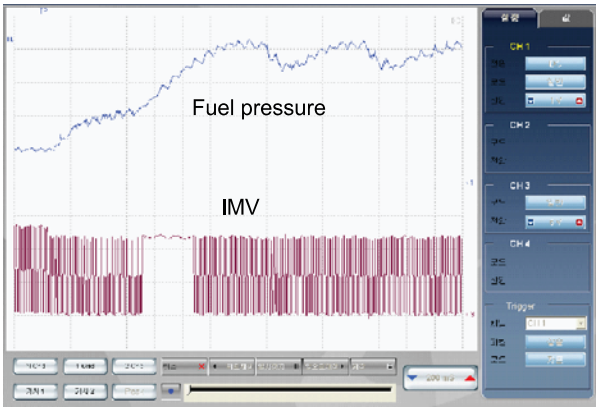
5) Operating wave

Measuring condition	Sharp acceleration with vehicle stopped
Measuring	Measuring probe (+) A35 Measuring probe (-) A19



The fuel pressure is increased by 700 bar when accelerating the engine sharply with the vehicle stopped. Accordingly, the fuel pressure signal is also increased.

Measuring condition	Disconnect IMV connector with vehicle stopped



IMV is NO (Normally Open) type valve. This controls the fuel pressure. Thus, when cutting off the power, the fuel pressure is increased by maximum value.

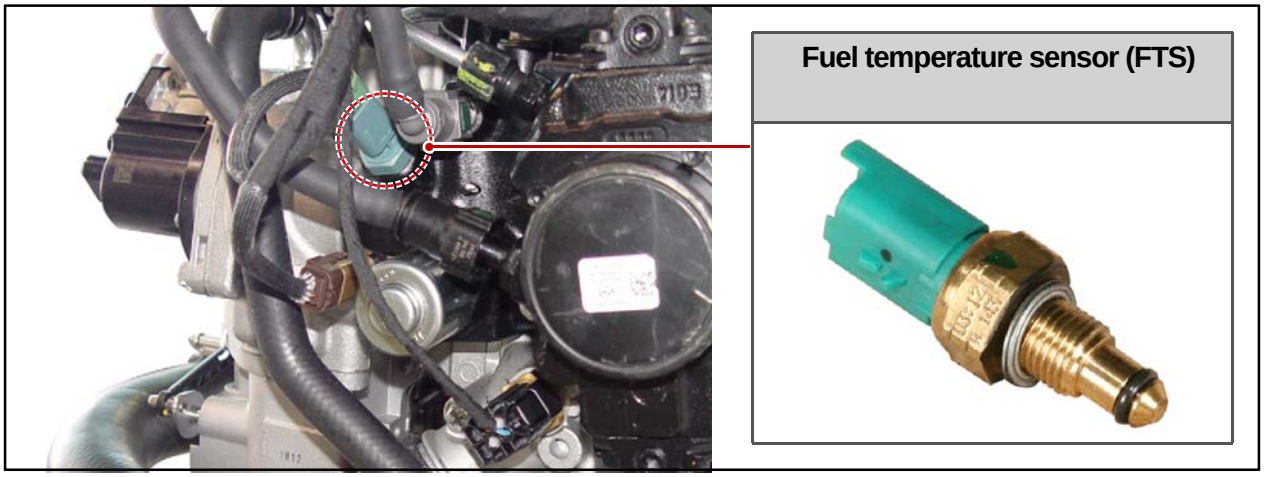
Modification basis	
Application basis	
Affected VIN	

S.G.N.
1882-01 FUEL TEMPERATURE SENSOR

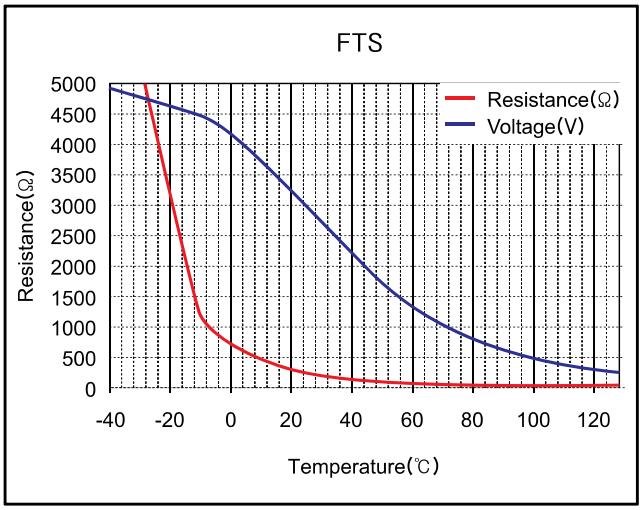
1) Overview

The fuel temperature sensor is NTC type resistor to detect the fuel temperature and to send it to ECU. If the fuel temperature is too high, ECU reduces the opening of IMV to decrease the fuel volume. The fuel temperature sensor is installed between low pressure line and high pressure line. It uses 5 V to generate the output voltage.

2) Location



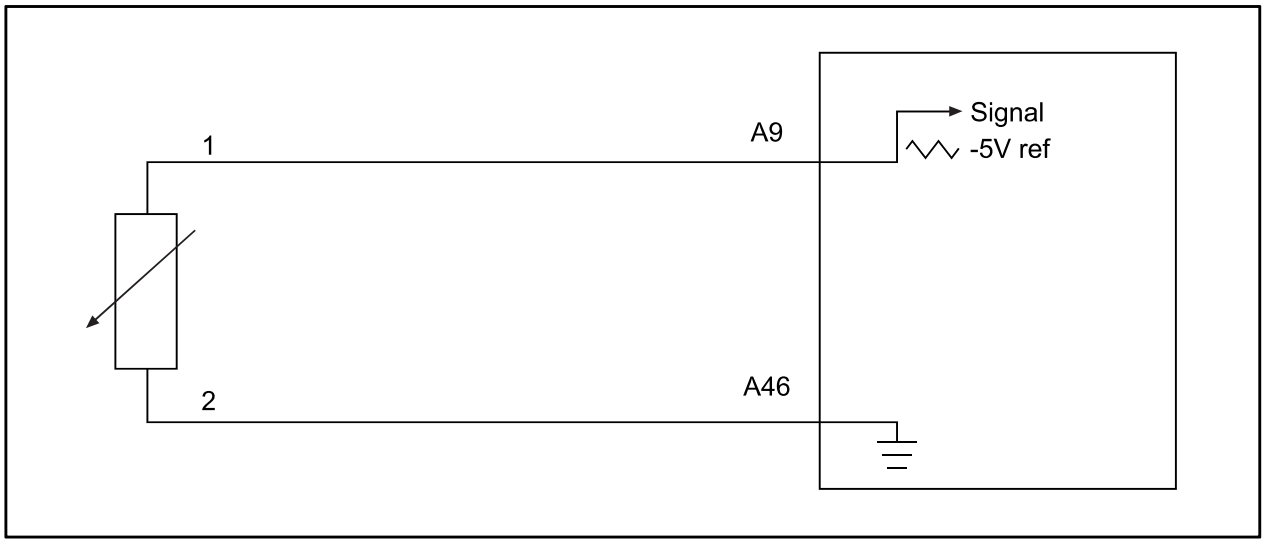
3) Features



Temp. (℃)	Resistance (Ω)	Voltage (V)
-40	75789	4.903
-10	12462	4.463
0	7355	4.153
10	4481	3.746
20	2812	3.261
40	1199	2.221
70	394	1.040
90	206	0.604
120	87	0.276
140	52	0.171

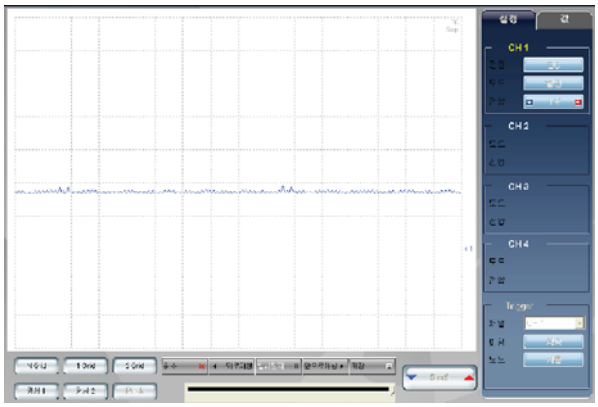
Modification basis	
Application basis	
Affected VIN	

4) Circuit Diagram



5) Operating wave

Measuring condition	Fuel temperature: 40 ℃
Measuring	Measuring probe (+) A10 Measuring probe (-) A46



The fuel temperature sensor measures the fuel temperature to check the lubrication performance. If the fuel temperature is too high, ECU reduces the opening of IMV to lower the fuel temperature.
Therefore, if there is a failure related fuel temperature, the engine could be stopped due to insufficient fuel.

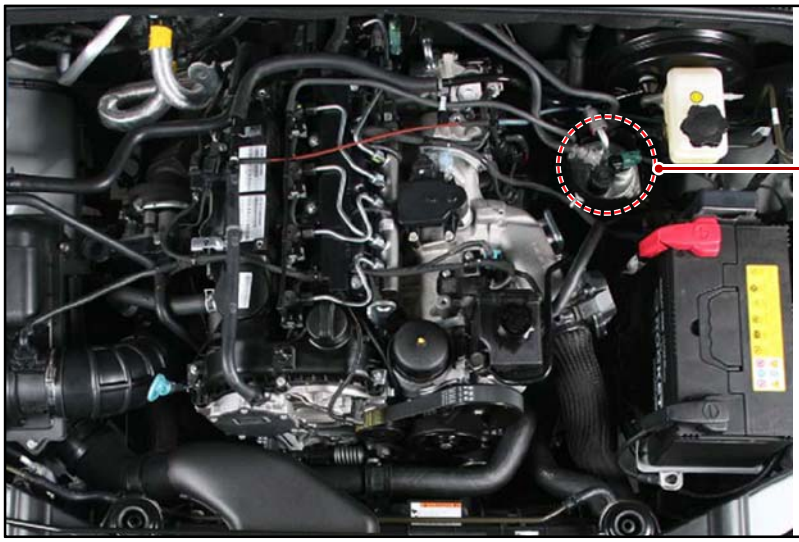
Modification basis	
Application basis	
Affected VIN	

S.G.N.
2231-01 WATER SENSOR IN FUEL FILTER

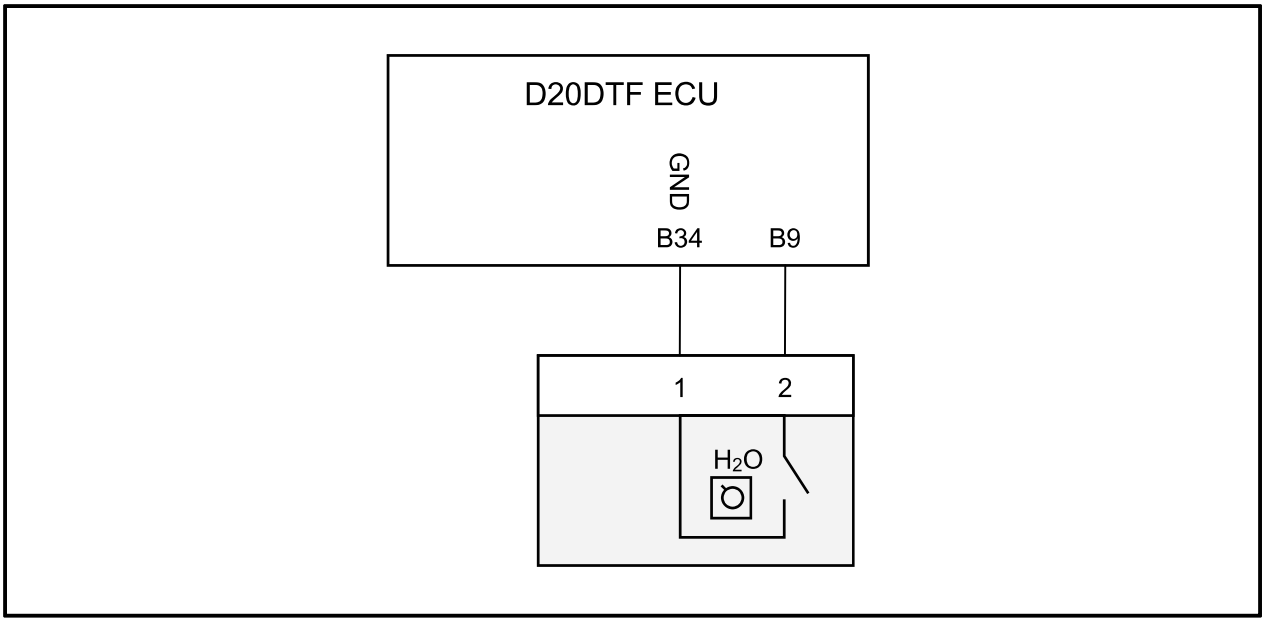
1) Overview

Water sensor is installed at bottom of fuel filter. If water accumulated in fuel filter exceeds a certain level (approx. 45 cc), the sensor sends the signal to ECU to turn on the warning lamp.

2) Location



3) Circuit Diagram



Modification basis	
Application basis	
Affected VIN	

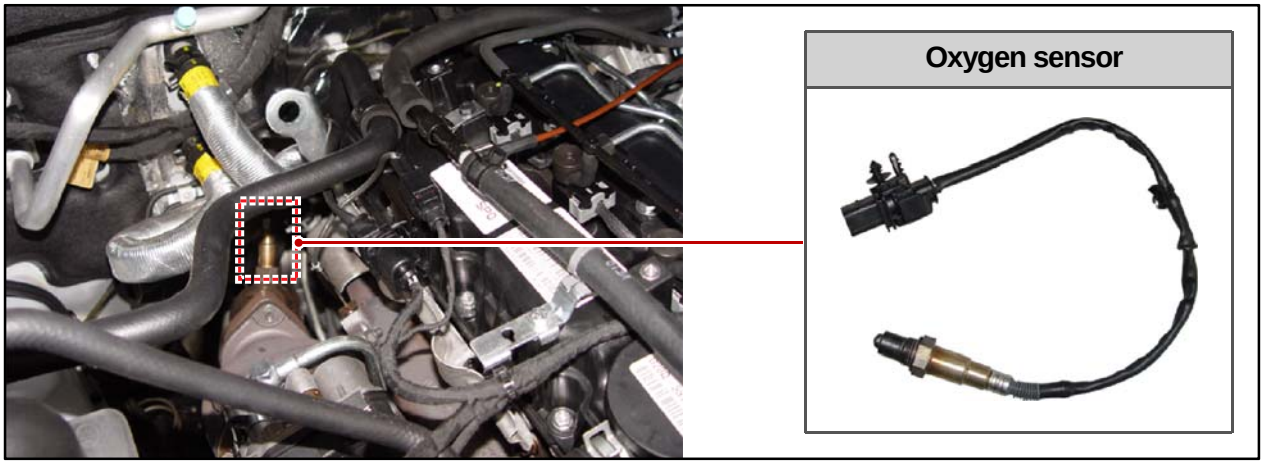
S.G.N.
1432-08 WIDE BAND OXYGEN SENSOR

1) Overview

For diesel engine, combustion is not performed at the optimum (theoretically correct) air-fuel ratio and the oxygen concentration is lean in most cases. So the wide-band oxygen sensor is used for this kind of engine, and this sensor is a little different from the one that used for gasoline engine. This sensor is located at front end of CDPF. It measures the concentration of oxygen (ideal air-fuel ratio) in exhaust gas to check if the combustion is in proper condition. It sends this signal to ECU for recycling CDPF, operating EGR, reducing smoke and correcting air-fuel ratio due to old engine.

- Heating oxygen sensor: Increase the oxygen sensor temperature to active level (approx. 300 to 600℃) at initial start stage of engine.

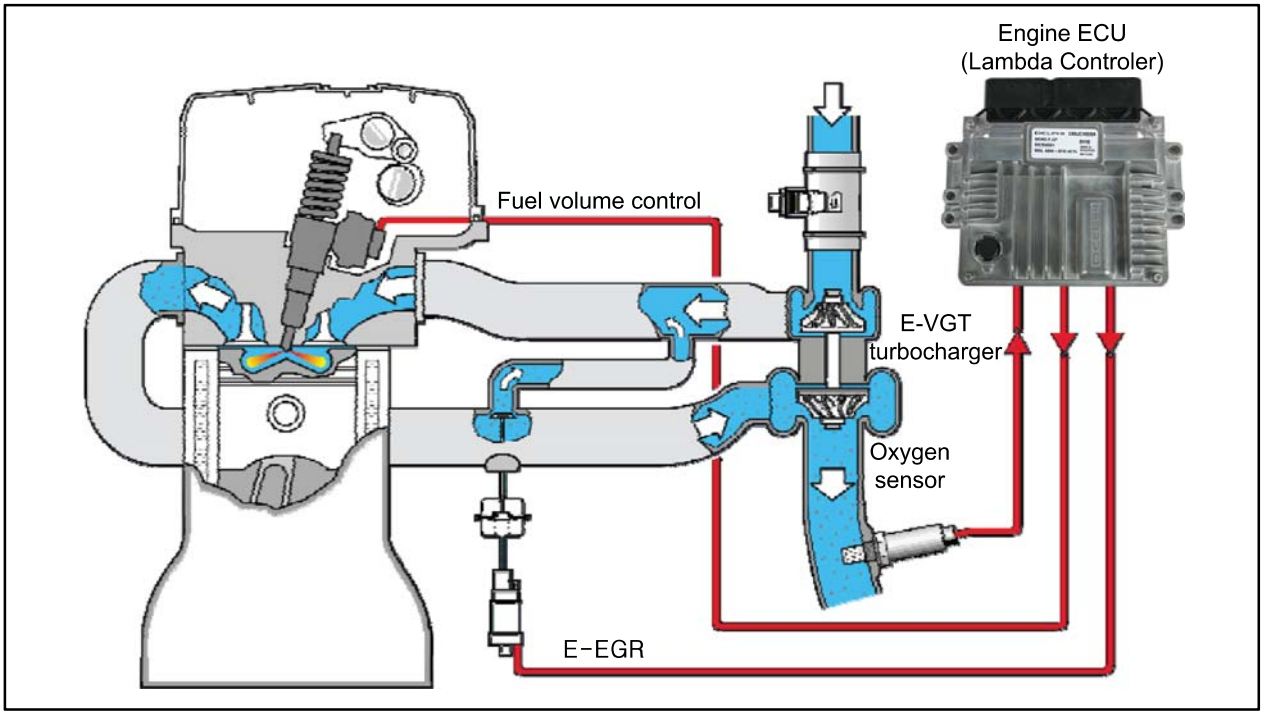
2) Location



Modification basis	
Application basis	
Affected VIN	

3) Features

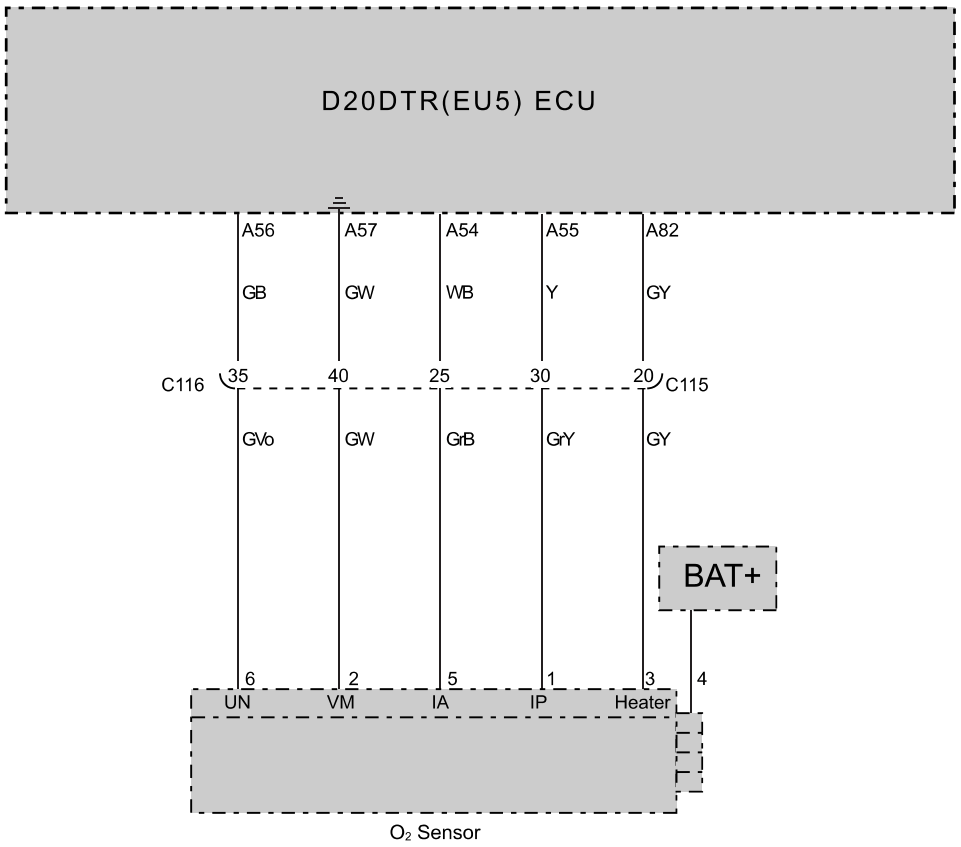
The oxygen sensor used in gasoline engine produces voltage by movement of oxygen ions when there is oxygen concentration difference between the exhaust gas and atmosphere. The wide-band oxygen sensor also uses similar principle. If a certain voltage is applied to the sensor, the movement of oxygen ions occurs regardless of the oxygen density. The current generated through this flow of ions, is called pumping current (IP), and the oxygen sensor measures this value.



The wide-band oxygen sensor contains 2 platinum electrodes with a electrolyte (ZrO_2) between them. The exhaust gas penetrates the space between these 2 electrodes, then the oxygen sensor compares the oxygen concentration in this reference space (oxygen in the exhaust gas) against the one in the atmosphere. The oxygen sensor performs the current feedback control based on the reference voltage (452 mV) at the point of optimum air-fuel-ratio. When the mixture is lean, the difference between oxygen levels is smaller than normal. Thus the sensor controls the pumping current until the voltage reaches 450 mV while the oxygen is moving because of the difference in oxygen concentration. The pumping current more increased, as the air-fuel ratio gets leaner. The air-fuel ratio of exhaust gas can be calculated by using this value.

Functions:
- Reduce Nox and PM by controlling E-EGR
- Reduce smoke at full load
- Detect irregular combustion
- Adjust Nox volume in CDPF

4) Circuit Diagram

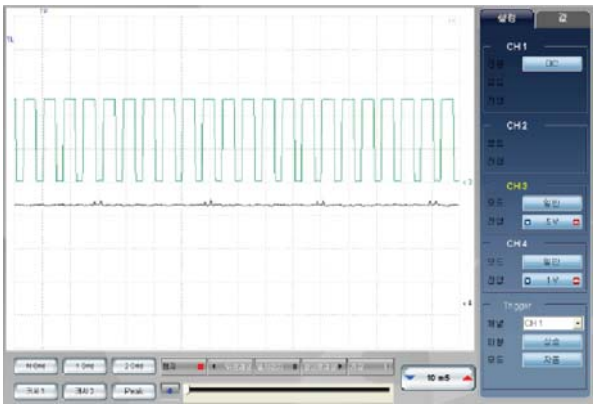


Modification basis	
Application basis	
Affected VIN	

5) Operating wave

(1) Oxygen sensor heater

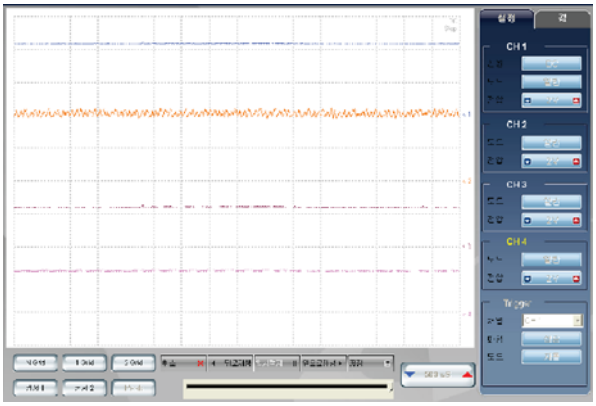
Measuring	Measuring probe (+) A82, Measuring probe (-) body ground



The oxygen sensor is optimized at approx. 700℃.

(2) IP, IA, VM, UN

Measuring	#1 channel	#2 channel
	Measuring probe (+) A10 Measuring probe (-) A46	Measuring probe (+) A Measuring probe (-) body ground
	#3 channel	#4 channel
	Measuring probe (+) A Measuring probe (-) body ground	Measuring probe (+) A Measuring probe (-) body ground

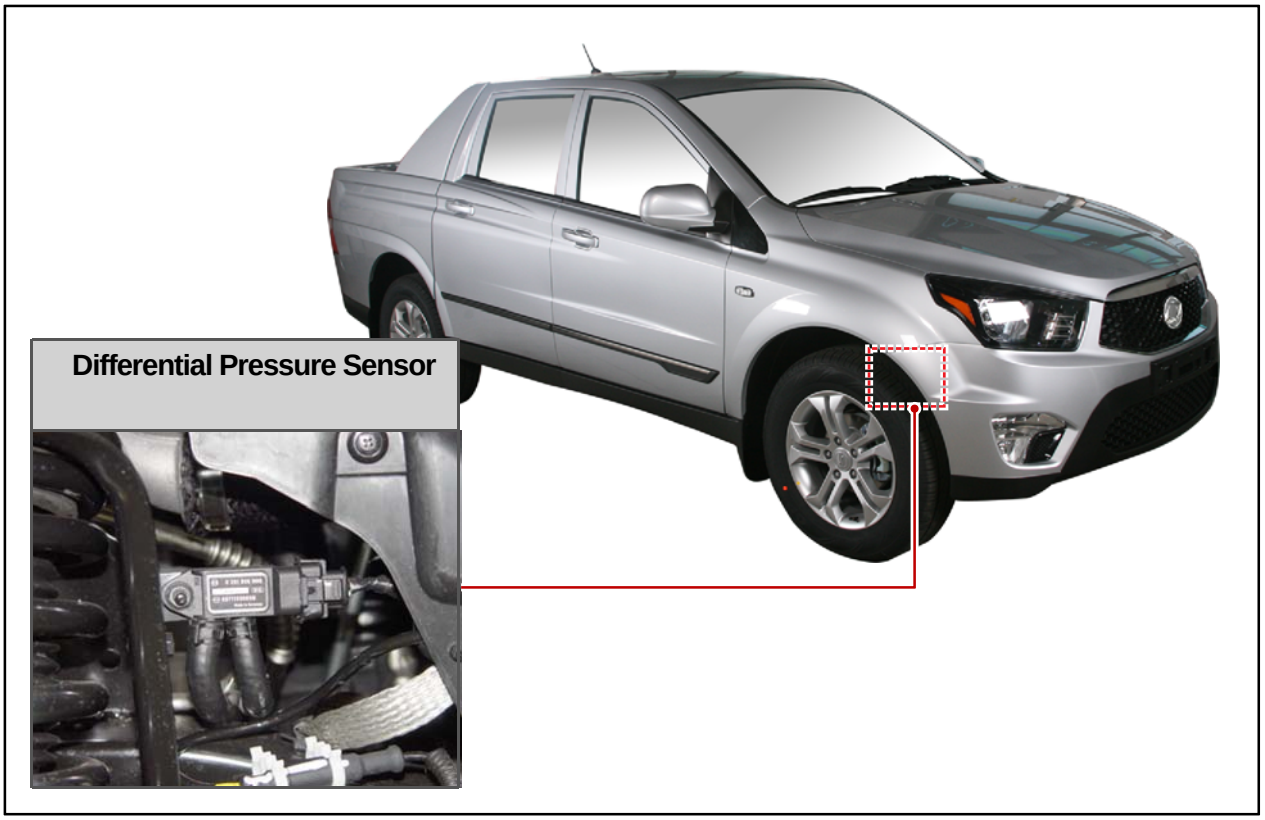


S.G.N.
1432-04 DIFFERENTIAL PRESSURE SENSOR

1) Overview

The differential pressure sensor detects the pressure difference between the front end and rear end of CDPF, and has a integrated piezoelectric resistor. As the PM is accumulated in CDPF, the pressure of exhaust gas increases. Therefore, the signal from the differential pressure sensor is used as a basic operation signal for CDPF regeneration. This signal is sent to ECU.
The actual amount of PM in CDPF is calculated not only by differential pressure sensor but also by exhaust gas temperature (volume expansion), intake air mass and boost pressure.
If the amount of PM in CDPF exceeds a certain level, post injection is performed to increase DOC temperature by 450℃ to 500℃ for recycling PM.

2) Location

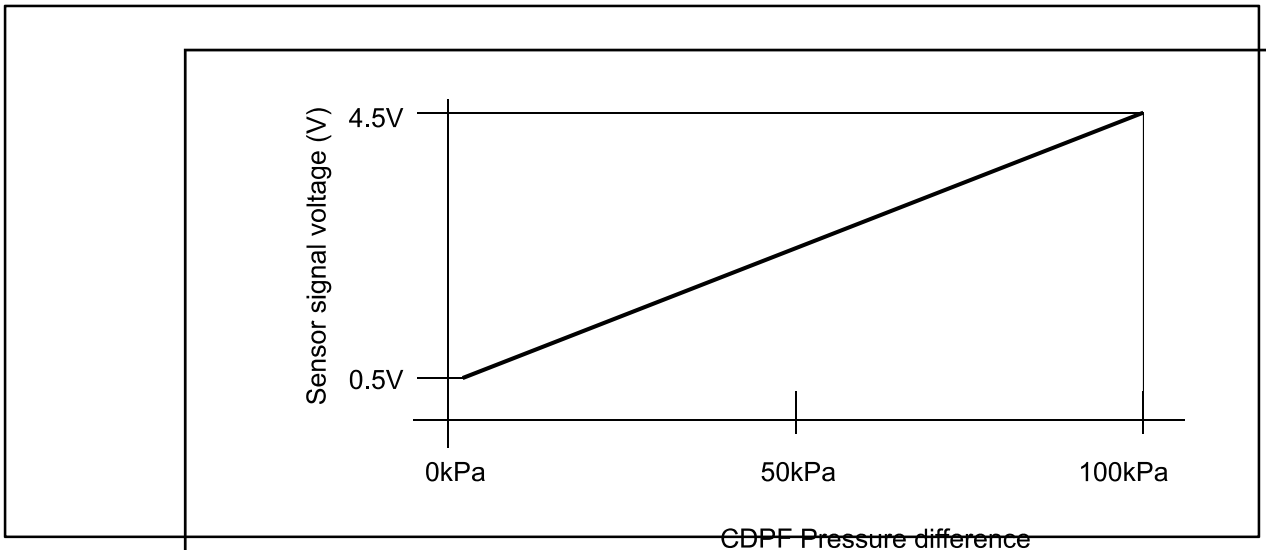


Modification basis	
Application basis	
Affected VIN	

3) Specification

	Unit	Measured value		
		Min.	Typ.	Max.
Operating pressure	kPa	0		100
Permissible temperature	℃	-40		130
Supply voltage	V	4.75	5.0	5.25
Supply current	mA	10	14	17.5
Output current	mA	-1.0		0.5
Response time	ms		1.0	

4) Features



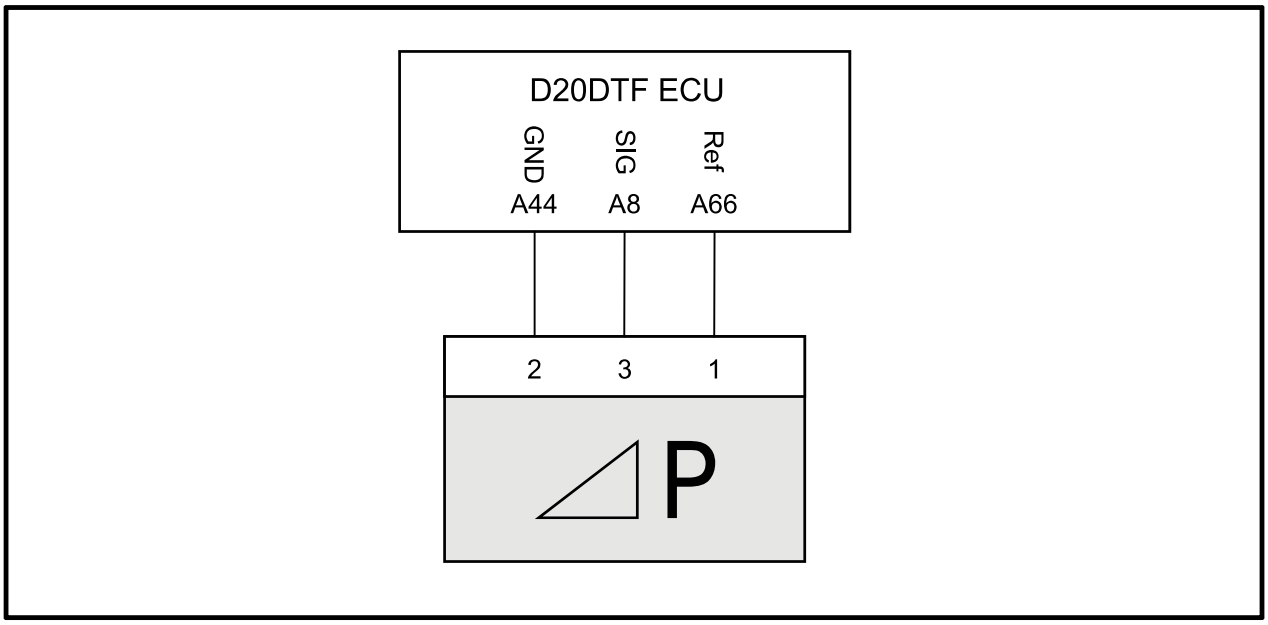
The differential pressure sensor detects the difference between front and rear end of CDPF, and sends the signal value (0.5 to 4.5 V) to ECU. If the difference goes bigger, the signal value approaches to 4.5 V. And, if it goes smaller, the signal value approaches to 0.5 V.

▶ **Function**

1. Used as a signal for calculating the amount of PM in CDPF
2. Measure the pressure of recycled exhaust gas to check if CDPF is working properly

5) Circuit Diagram

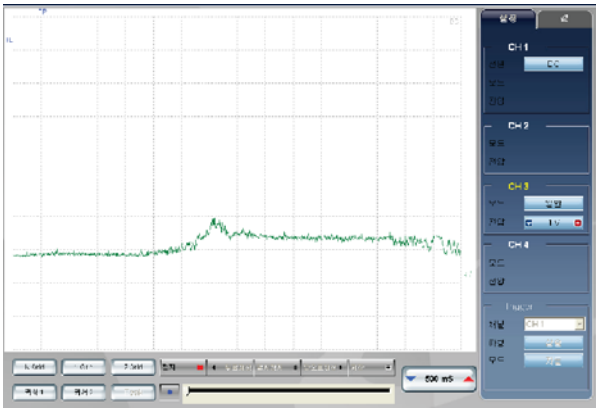
(1) Sensor data check



- Check sensor data with Scan Tool
- Key ON: 0 kPa
- Idling: approx. 1 kPa
- At sharp accelerating: approx. 20 kPa

6) Operating Wave

Measuring condition	Sharp acceleration with vehicle stopped
Measuring	Measuring probe (+) A08 Measuring probe (-) A44



In general, the output of difference is below 1 kPa in idling condition because the exhaust gas is not much. During sharp acceleration, the output of difference is highly increased, but it is not over 20 kPa.

Modification basis	
Application basis	
Affected VIN	

S.G.N.
1432-17 EGT (EXHAUST GAS TEMPERATURE) SENSOR

1) Overview

The front temperature sensor is installed in the exhaust manifold and the rear temperature sensor is installed in CDPF assembly. The sensing area of rear exhaust gas temperature sensor is longer than that of front exhaust gas temperature sensor.

2) Location

Front EGT sensor	Rear EGT sensor
	
To prevent the turbocharger from damaging due to POST injection, the fuel injection volume is limited when the exhaust gas temperature goes very high.	This sensor determines the POST injection volume.

Modification basis	
Application basis	
Affected VIN	

3) Features

CDPF temperature (°C)	Resistance (Ω)
-40	169.18
-20	184.64
0	200.0
25	219.07
50	237.99
100	275.40
150	312.22
200	348.46
250	384.11
300	419.18

CDPF temperature (°C)	Resistance (Ω)
350	453.66
400	487.56
450	520.87
500	553.60
600	617.30
700	678.66
800	737.68
830	754.93
850	766.31

▶ **Front EGT sensor**

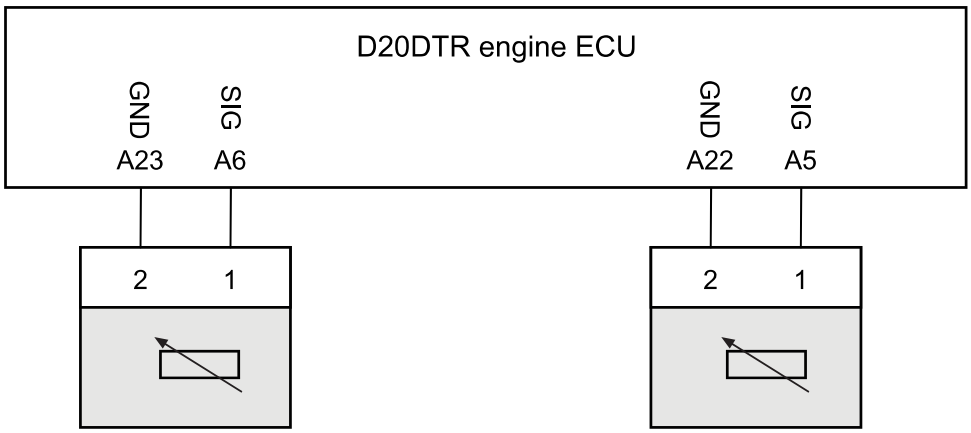
The front EGT sensor is installed between the turbocharger and exhaust manifold, and monitors the exhaust gas temperature to protect the turbocharger from damage due to overheating. If the temperature of exhaust gas exceeds approx. 800˚C, internal bearing could be stuck by burnt out. ECU monitors the signals from front temperature sensor so that the exhaust gas is not overheated. If necessary, ECU reduces the fuel injection volume or increases the EGR gas volume to lower the temperature.

▶ **Rear EGT sensor**

The rear EGT sensor is installed between the DOC and CDPF, and determines whether the exhaust gas temperature is suitable for performing regeneration or not, during postinjection. The exhaust gas temperature after DOC is increased to approx. 600˚C. If the temperature exceeds this limit, the sensor reduces the post-injection volume; if the temperature drops under this limit the sensor increases the temperature by increasing the injection volume.

Modification basis	
Application basis	
Affected VIN	

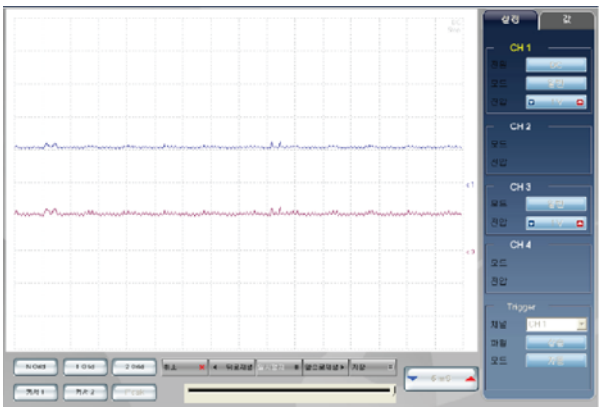
4) Circuit Diagram



Front temperature sensor	Rear temperature sensor
The front exhaust gas temperature sensor sends the voltage value as a signal to ECU.	The rear exhaust gas temperature sensor measures the temperature pass through DPF. If the temperature is low (below 600℃), engine ECU reduces the intake air volume and extends post injection period to raise the exhaust gas temperature.

5) Operating wave

Measuring condition	After warmed up	
Measuring	Exhaust gas temperature sensor #1	Exhaust gas temperature sensor #2
	Measuring probe (+) A06 Measuring probe (-) A23	Measuring probe (+) A05 Measuring probe (-) A22



The front exhaust temperature is nearly same with the rear exhaust gas temperature before post injection.

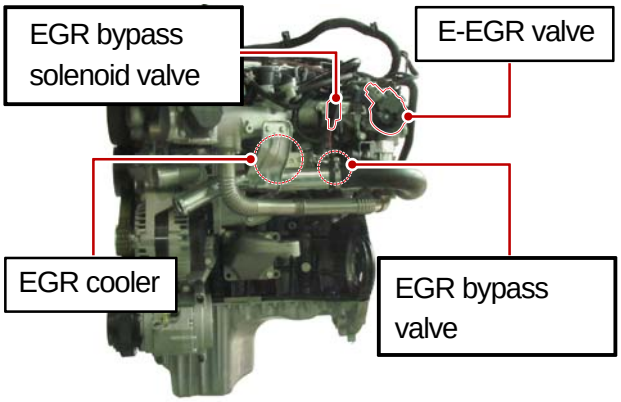
S.G.N. 1793-01

E-EGR (ELECTRIC-EXHAUST GAS RECIRCULATION) VALVE

1) Overview

The DC motor type EGR valve for the D20DTR engine is the E-EGR (Electric-Exhaust Gas Recirculation) valve that is directly controlled by the ECU with electric signal. The E-EGR valve is directly controlled by the ECU through the duty control and the valve location signal is sent to ECU as feedback. This signal is also used as feedback signal for ECU to control the EGR rate. Also it is used to check whether the E-EGR valve is properly controlled by ECU.

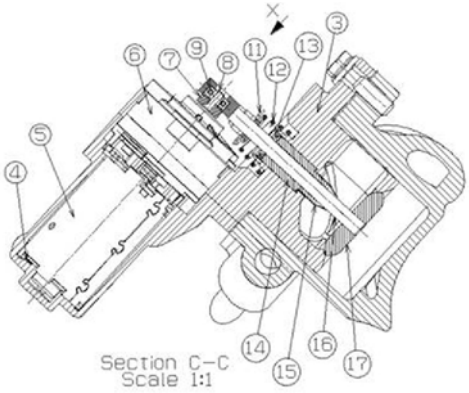
2) Location and Components



	Name
3	Socket
4	Valve spring
5	Motor assembly
6	Gear box assembly
7	Cam
8	Shaft
9	Bearing
11	Disc spring
12	Spring
13	Oil seal
14	Stem guide
15	Case
16	Stem
17	Valve disc

E-EGR valve

E-EGR valve assembly	E-EGR valve connector
	



Modification basis	
Application basis	
Affected VIN	

3) Features

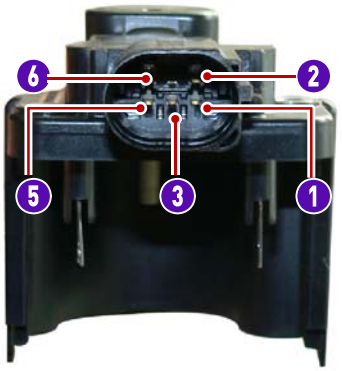
(1) Features

A. Improved response and accuracy by ECU control

E-EGR valve directly controls the integrated solenoid valve by receiving the signals from ECU. With this, there are improvement in vacuum leak and response delay. And, E-EGR could be controlled more precisely by electric signals.

B. Introduction of feed-back function in E-EGR valve

Engine ECU directly controls E-EGR valve, and E-EGR valve feedbacks the exact position to ECU.

E-EGR body	E-EGR connector
	

The resistance of solenoid in E-EGR valve is approx. 8Ω ± 0.5Ω at terminal #1 and #5, and approx. 4 kΩ ± 40% at terminal #4 and #2 (at normal temperature).
The resistance value is changed by EGR valve opening according to the electric signals from ECU (terminal #4 and #3). This is the feedback signal for E-EGR valve opening to ECU. The intake air volume of HFM sensor is the basic feedback signal for controlling E-EGR valve opening.

C. Anti-chattering and improvement of durability

There are two valve seats in E-EGR valve. This reduces the valve chattering due to back pressure during vale operation compared to conventional EGR valve. Accordingly, it improves the durability of valve stem.

D. Introduction of EGR valve cleaning function

E-EGR is chattered when turning off the engine and decelerating in mid/high speed by operating the solenoid. During this period, the carbon and foreign materials on E-EGR valve are cleaned.

E. Correcting EGR valve position (change due to accumulated carbon)

E-EGR valve is able to correct the change of valve position by monitoring and analyzing the open and closed positions when turning off the engine.

4) E-EGR Valve Operating Range

The operating range of E-EGR valve is controlled by precise control logic (MAP).

1. Moderate intake air temperature:approx. -10˚C to 50˚C
2. Proper atmospheric pressure: over 0.92 bar
3. Proper engine coolant temperature: 0˚C to 100˚C
4. Sharp acceleration (over 2,600 rpm): stop EGR valve operation
5. Long idling over 1 minute: stop EGR valve operation
6. High vehicle speed over 100 km/h: stop EGR valve operation
7. High engine torque over 380 Nm: stop EGR valve operation
8. No DTC related EGR system: normal EGR valve operation

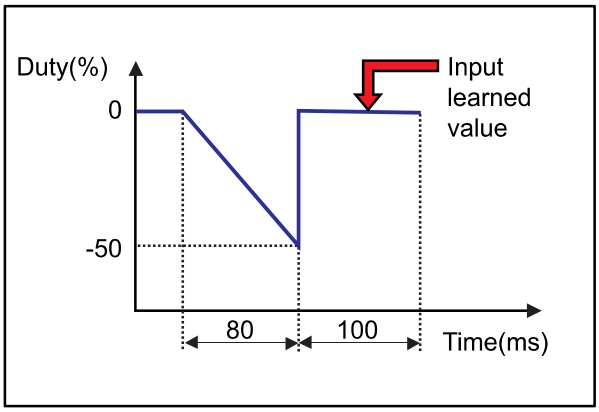
Modification basis	
Application basis	
Affected VIN	

5) Control Logic of EGR Valve

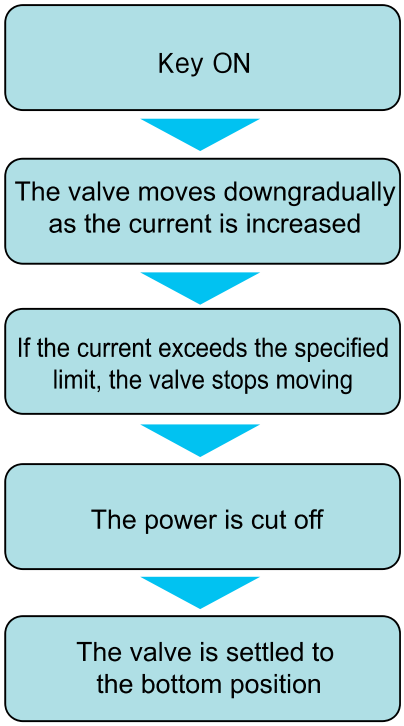
(1) Initial learning mode

If there is no position data for EGR valve, the initial learning should be performed.

Learning period	key on



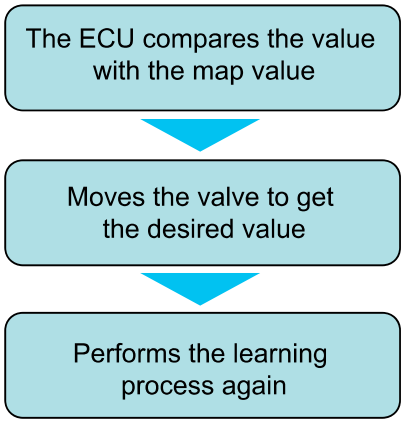
If there is no learning value memorized, the learning begins when the key is turned ON. The current is increased gradually to position the valve at the bottom position If the valve contacts the seating surface the current will rise again. The bottom (initial) position of the valve is determined by this process.



(2) Learning mode with engine ON/OFF

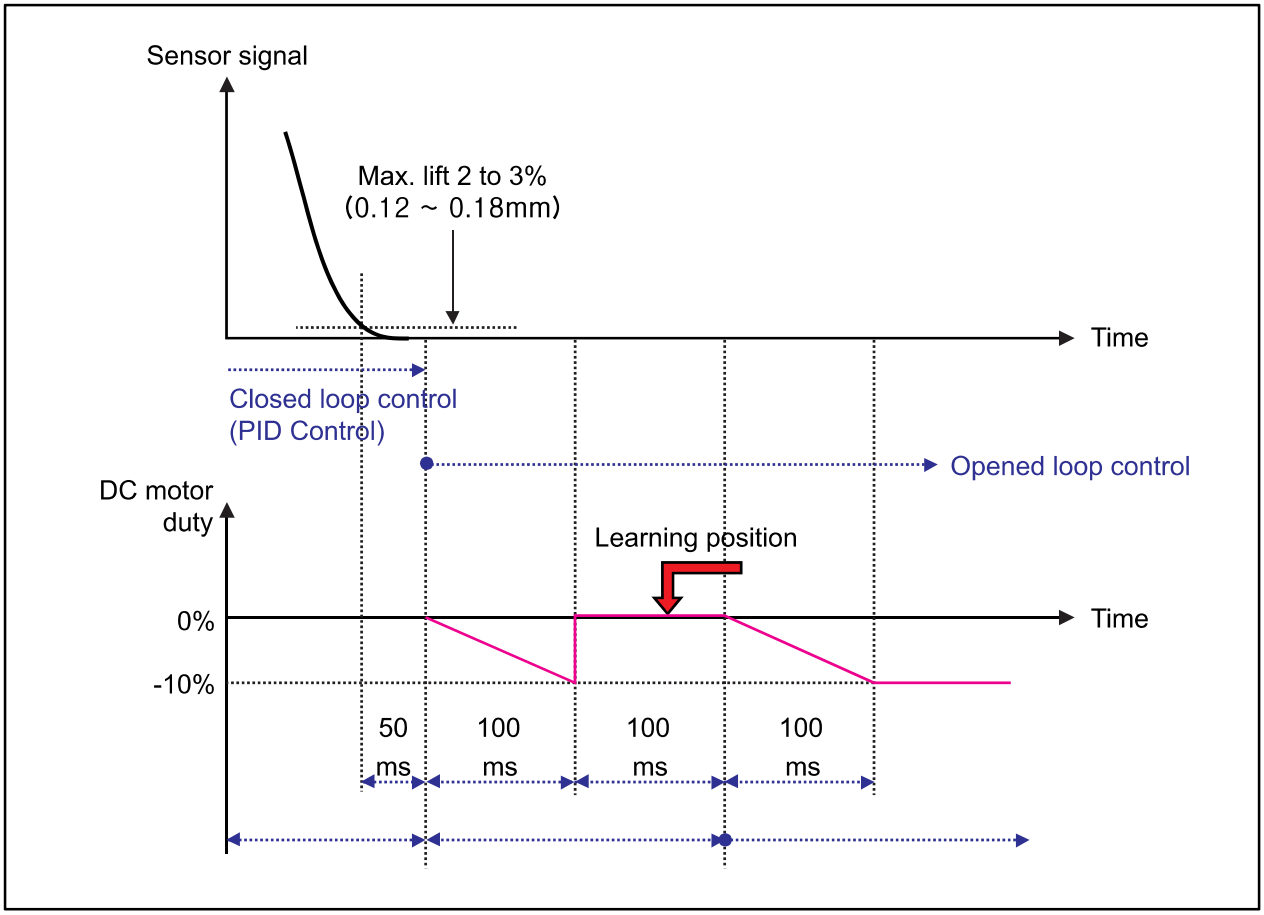
Learning period	Key ON or Key OFF

The learning of EGR valve is performed when the key is turned ON and OFF. At each time, the ECU compares the current value and the map value and performs the learning process again if those values are different from each other. The process for relearning is the same with the initial learning.



(3) Learning during driving & removing soot mode

Learning period	During closing EGR valve



When the learning is performed during the vehicle is running, the valve slowly moves to the closing position. After initial learning with the valve is closed, the EGR valve is controlled by duty of 10% when the valve is closed, so as not to be open by the exhaust gas pressure.

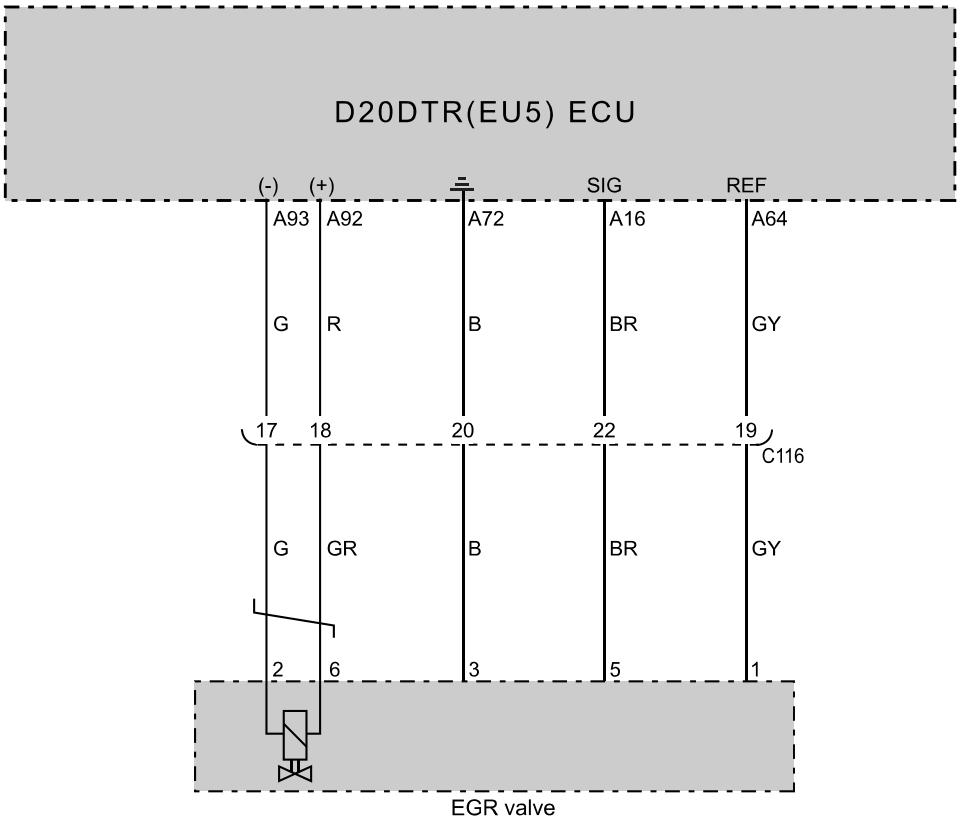
Performs the learning process again

Initial learning

To prevent the valve from being open by exhaust gas pressure

Modification basis	
Application basis	
Affected VIN	

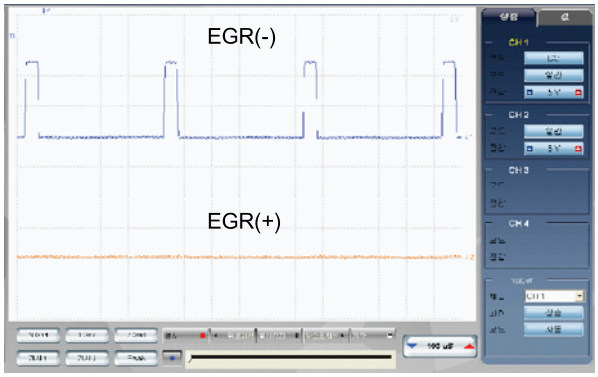
6) Circuit Diagram

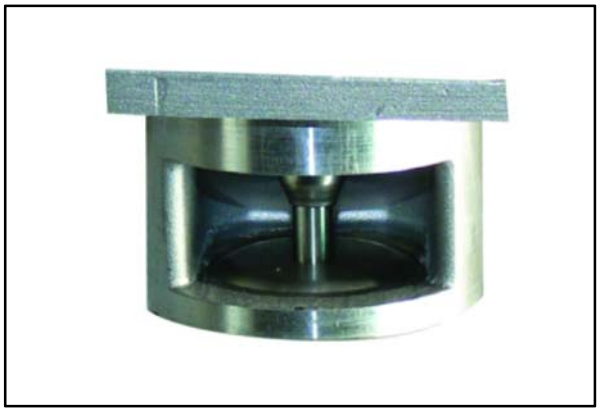


7) Operating Wave

Measuring condition	After warmed up
Measuring	Measuring probe (+) A92 Measuring probe (-) A93

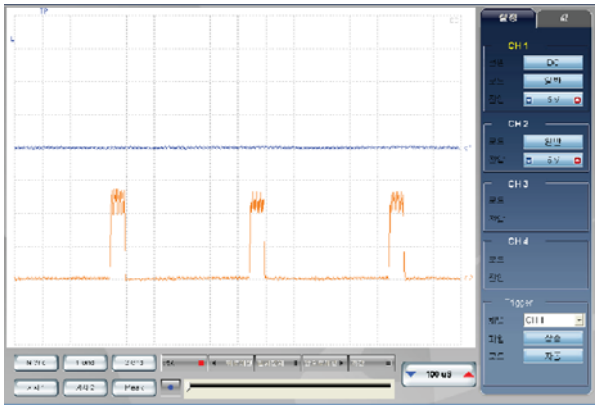
▶ **When EGR valve is not operating**





E-EGR uses DC motor. It is controlled by duty ratio at (-) side when not in use.

▶ **When EGR valve is operating**



E-EGR valve is operated by supply power from PWM at (+) side when in use

Modification basis	
Application basis	
Affected VIN	

S.G.N.
1719-16 ELECTRONIC THROTTLE BODY

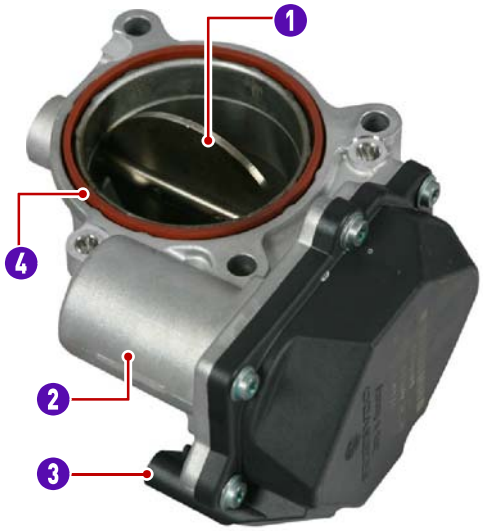
1) Overview

Electronic throttle body control system contains electronic throttle body, accelerator pedal sensor and ECU as basic elements. Throttle body consists of actuator, throttle plate and throttle position sensor. The actuator is driven by motor. ECU receives the signals from throttle position sensor to control the engine as below:

- event the dieseling and vibration by cutting off the intake air when stopping the engine
- Control the intake air volume while working with CDPF system
- Control EGR volume effectively while working with EGR system

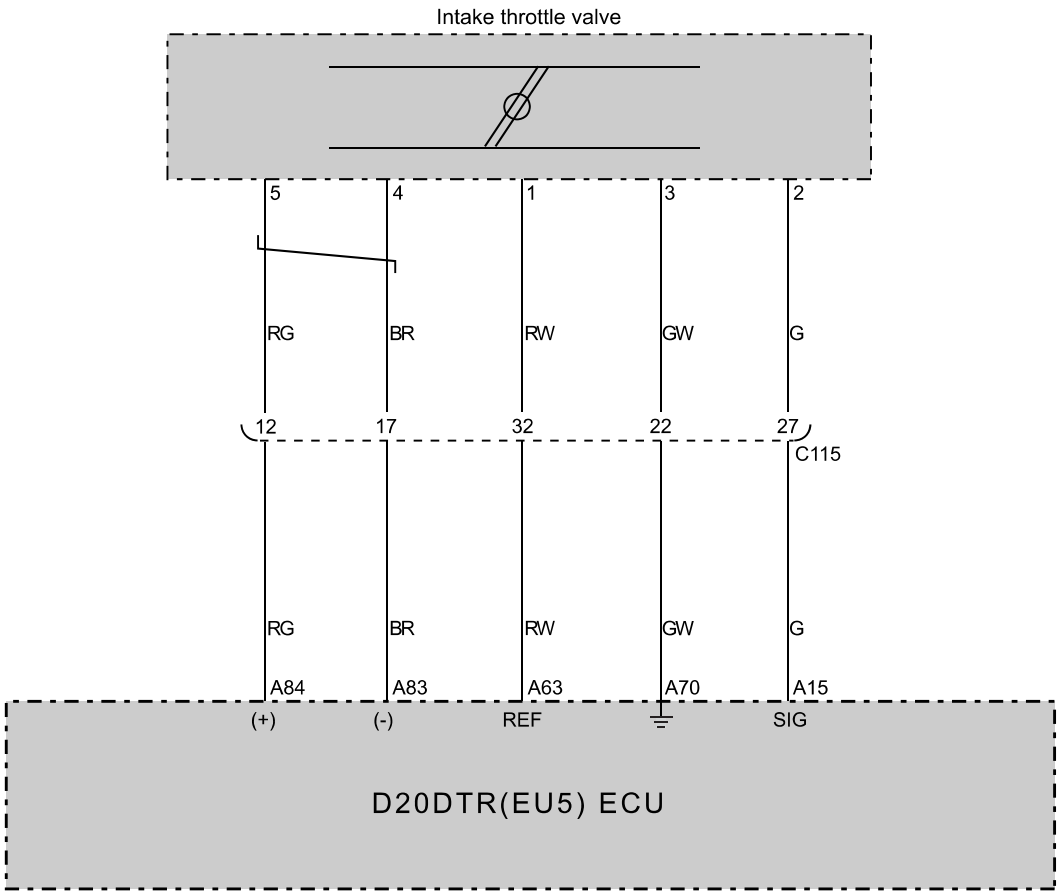
2) Location and Components

Electronic throttle body



	Name
1	Throttle plate
2	Housing
3	Connector
4	Sealing

3) Circuit Diagram



NOTE

The throttle valve is completely closed when turning the ignition switch to OFF position. At this moment, 5V of voltage is output for approx. 1.2 seconds.

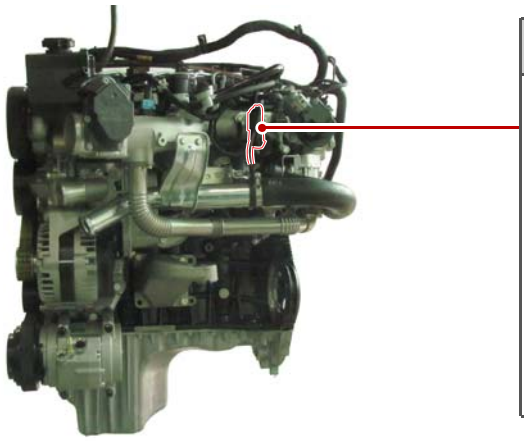
Modification basis	
Application basis	
Affected VIN	

S.G.N.
1432-14 EGR BYPASS SOLENOID VALVE

1) Overview

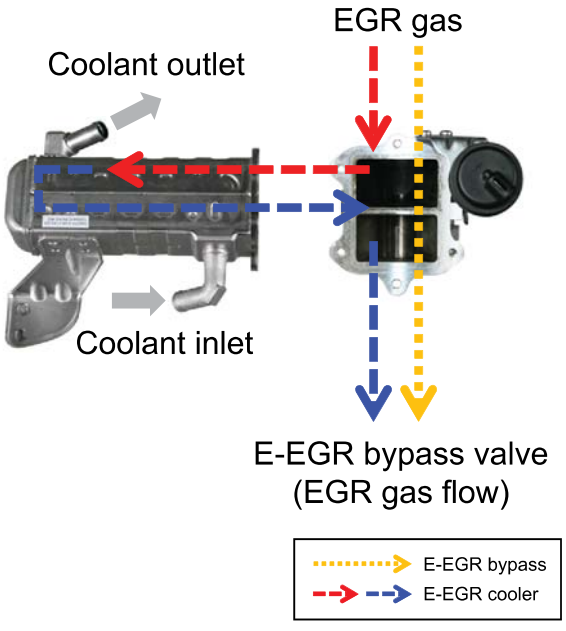
ECU controls E-EGR bypass valve to reduce NOx in exhaust gas when the engine is cold.
The vacuum modulator valve is operated by the signals from ECU to bypass the exhaust gas into the intake manifold. The vacuum modulator is ON/OFF type operated by ECU.

2) Location



E-EGR bypass solenoid valve

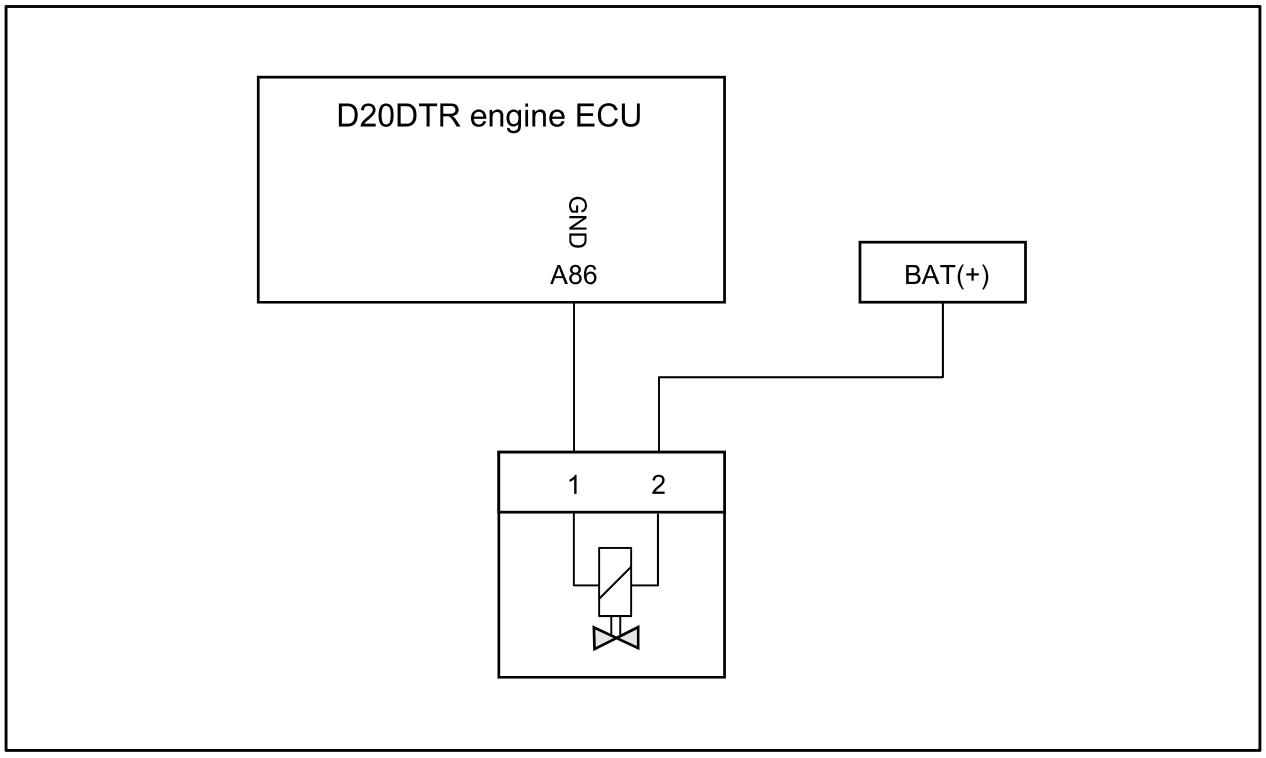
3) Operation



The solenoid valve is turned ON/OFF by the signals from ECU. The vacuum pressure generated by vacuum pump is transferred to E-EGR bypass valve. The cooling operation in EGR cooler is not needed before engine is warmed up. Therefore, in this period, the EGR gas goes to the intake manifold through bypass line without passing through EGR cooler.

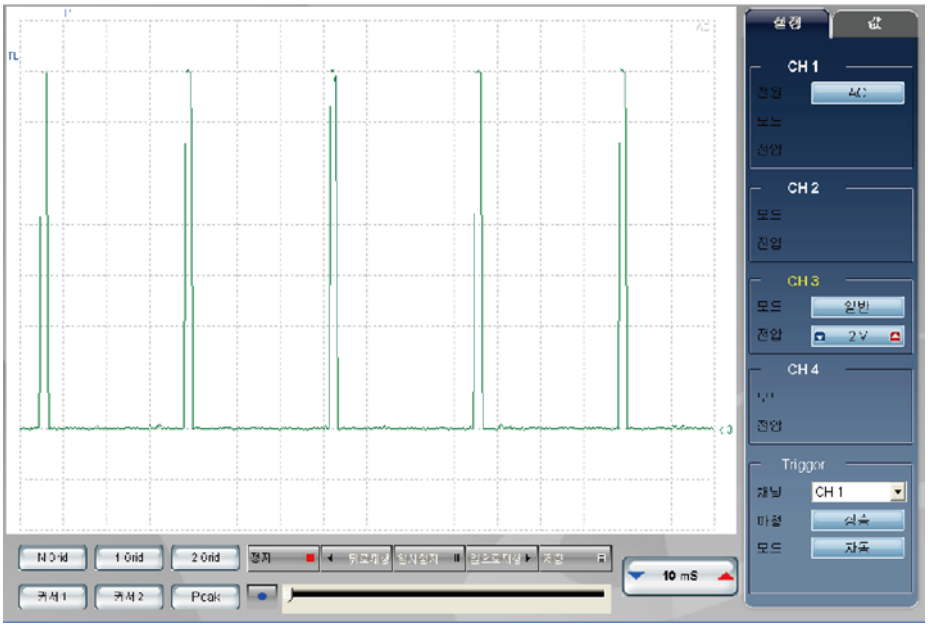
Modification basis	
Application basis	
Affected VIN	

4) Circuit Diagram



5) Operating Wave

Measuring condition	After engine warmed up
Measuring	Measuring probe (+) A86 Measuring probe (-) body ground



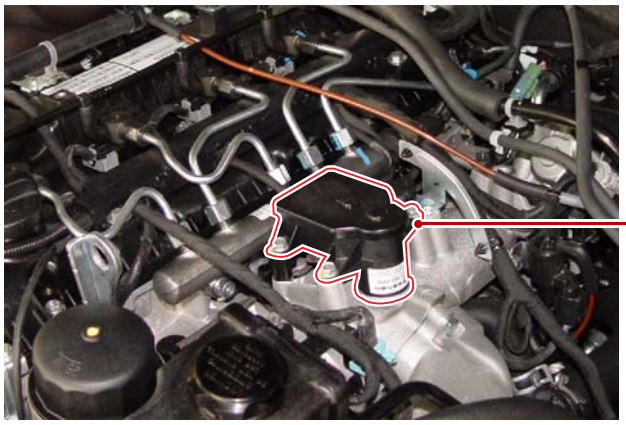
Modification basis	
Application basis	
Affected VIN	

S.G.N.
1719-02 VARIABLE SWIRL ACTUATOR

1) Overview

The swirl control valve is installed on the intake manifold and generates the swirl by blocking the vertical port of intake valves. The swirl improves the combustion efficiency and increases the EGR ratio by accelerating the air-fuel mixture. The swirl valve is controlled by DC motor.

2) Location



Variable swirl actuator

3) Specification

Description		Specification
Operating voltage		10V ~ 16V
Operating temperature		-30℃ ~ 130℃
DC motor	Idle speed	6010 ~ 7510rpm
	Resistance	3.9Ω ± 12%
	Operating frequency	1000Hz
	Holding current	below 0.7 A
Position sensor	Sensing type	Potentiometer
	Supply voltage	5V
	Signal range	0.17V ~ 4.83V
	Permissible maximum current	< 15㎂

4) Operation

▶ **Mid- and low speed range**

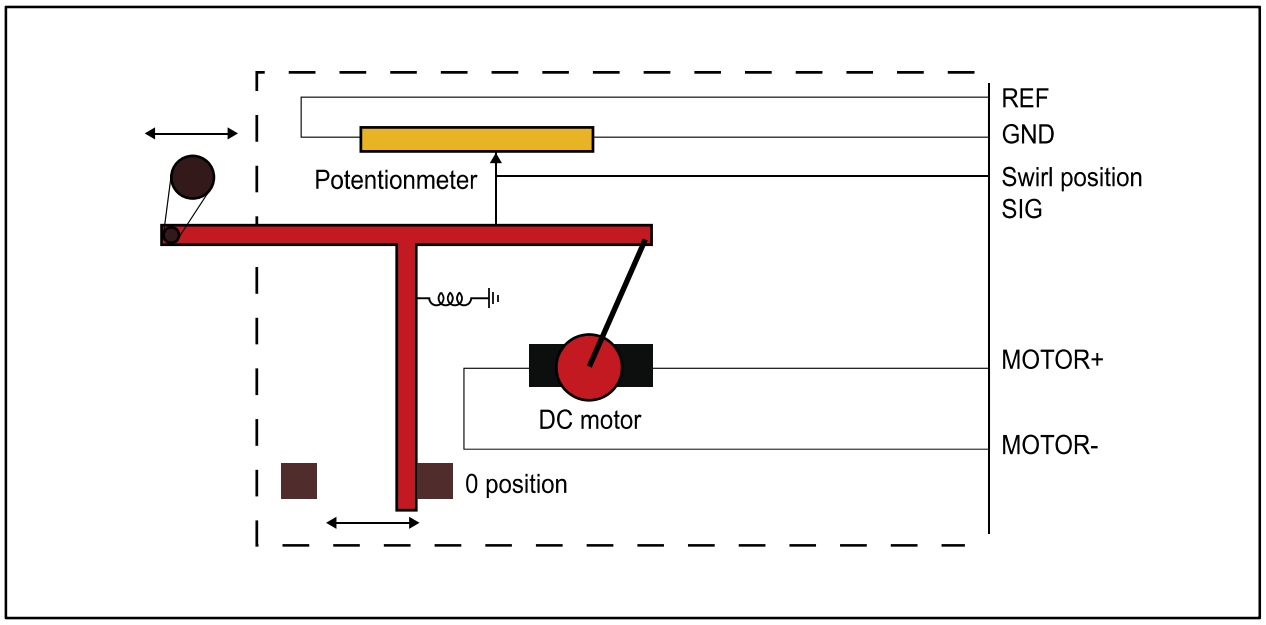
The moving speed of piston is slow in mid- and low speed range. Accordingly, the intake air flowing speed could be also slow. It may cause slow air flow and poor air-fuel efficiency in cylinder. To improve this, the system closes the intake port partially.

▶ **High speed range (approx. 3,000 rpm)**

If the intake port is partially closed in high speed range, the air intake efficiency could be decreased due to high friction resistance. Therefore, in high speed range, both intake ports are open to maximize the air intake efficiency.

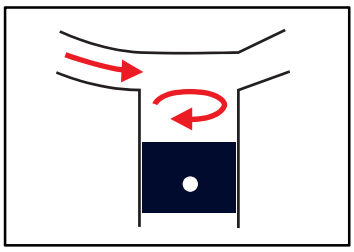
5) Features

- The swirl valve is controlled by DC motor.
- The internal position sensor is the potentiometer type.

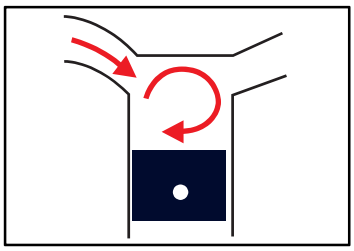


Modification basis	
Application basis	
Affected VIN	

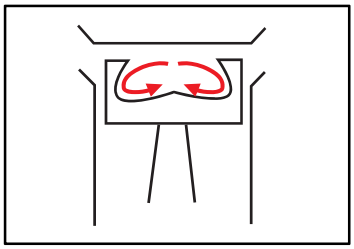
▶ Types of swirl



Swirl: One cylinder has two intake air ports, one is set horizontally and the other one is set vertically. Swirl is the horizontal air flows in cylinder due to the horizontal intake air ports.



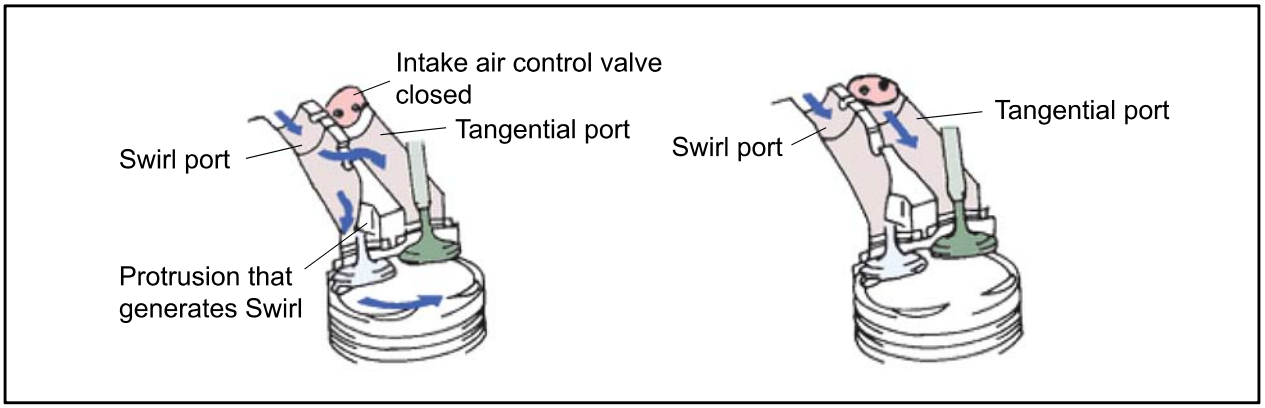
Tumble: Tumble is the vertical air flows in cylinder due to the vertical intake air port



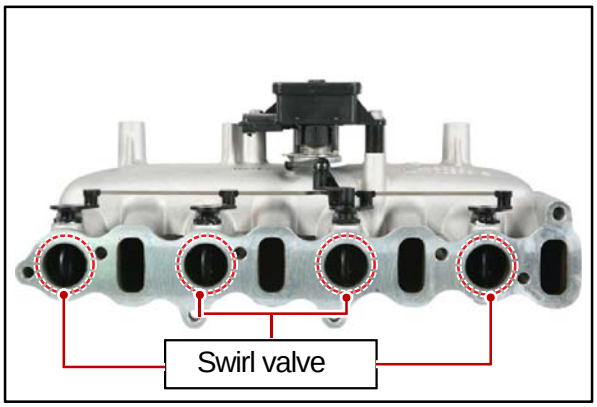
Squish: Squish is the air flows due to the piston head. Normally, this is appears at the final process of compression. In CRDi engine, the piston head creates the bowl type squish.

▶ Swirl control

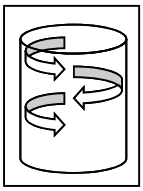
In DI type diesel engine, the liquefied fuel is injected into the cylinder directly. If the fuel is evenly distributed in short period, the combustion efficiency could be improved. To get this, there should be good air flow in cylinder. In general, there are two intake ports, swirl port and tangential port, in each cylinder. The swirl port generates the horizontal flow and the tangential port generates the longitudinal flow. In low/mid load range, the tabgential port is closed to increase the horizontal flow. Fast flow decreases the PM during combustion and increases the EGR ratio by better combustion efficiency.



Load	Engine speed	Swirl valve	Amount of swirl	Remarks
Low speed, Low load	below 3,000 rpm	Closed	Heavy	Increased EGR ratio, better air-fuel mixture (reduce exhaust gas)
High speed, High load	over 3,000 rpm	Open	Light	Increase charge efficiency, higher engine power



The variable swirl valve actuator operates when turning the ignition switch ON/OFF position to open/close the swirl valve. In this period, the soot will be removed and the learning for swirl valve position is performed.



NOTE

Swirl: This is the twisted (radial) air flow along the cylinder wall during the intake stroke.
This stabilizes the combustion even in lean air-fuel mixture condition.

▶ Features

- Swirl and air intake efficiency
  To generate the swirl, the intake port should be serpentine design. This makes the resistance in air flow. The resistance in air flow in engine high speed decreases the intake efficiency. Eventually, the engine power is also decreased, Thus, the swirl operation is deactivated in high speed range to increase the intake efficiency.
- Relationship between swirl and EGR
  To reduce Nox, it is essential to increase EGR ratio. However, if EGR ratio is too high, the PM also could be very higher. And, the exhaust gas should be evenly mixed with newly aspired air. Otherwise, PM and CO are dramatically increased in highly concentrated exhaust gas range and EGR ratio could not be increased beyond a certain limit. If the swirl valve operates in this moment, the limit of EGR ratio will be higher.

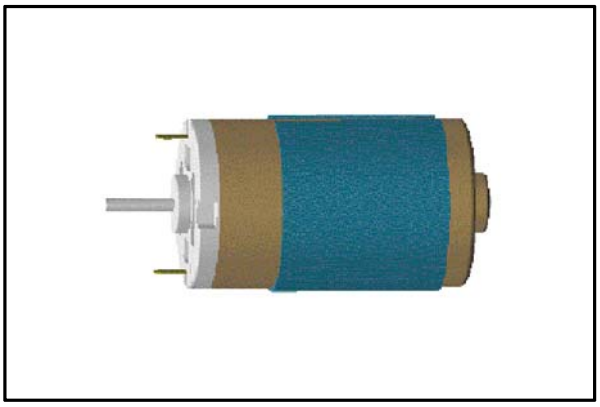
▶ Relationship between swirl and fuel injection pressure

The injector for DI engine uses the multi hole design. For this vehicle, there are 8 holes in injector. If the swirl is too strong, the injection angles might be overlapped and may cause the increased PM and insufficient engine power. Also, if the injection pressure is too high during strong swirl, the injection angles might be overlapped. Therefore, the system may decreases the fuel injection pressure when the swirl is too strong.

Modification basis	
Application basis	
Affected VIN	

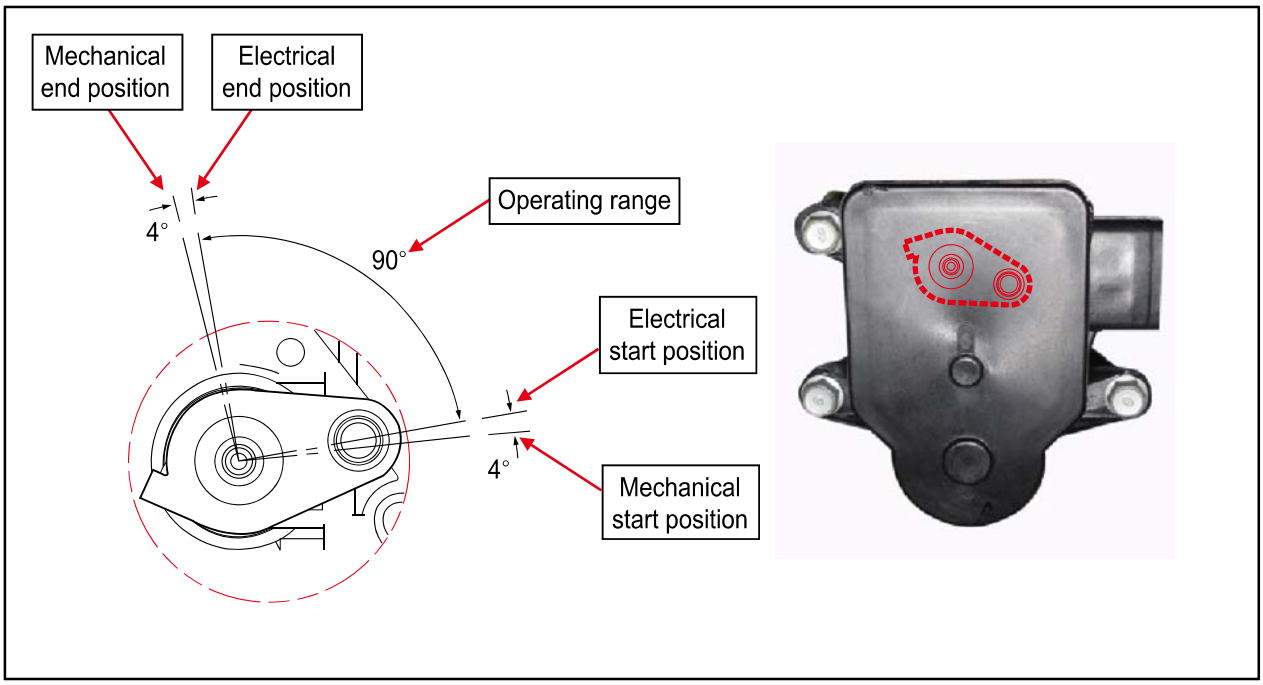
6) Swirl Valve Actuator

(1) DC motor



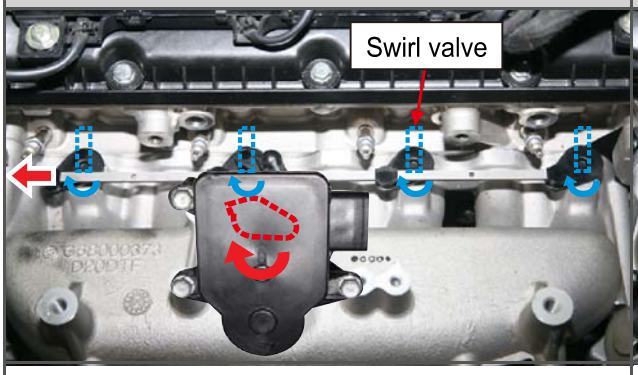
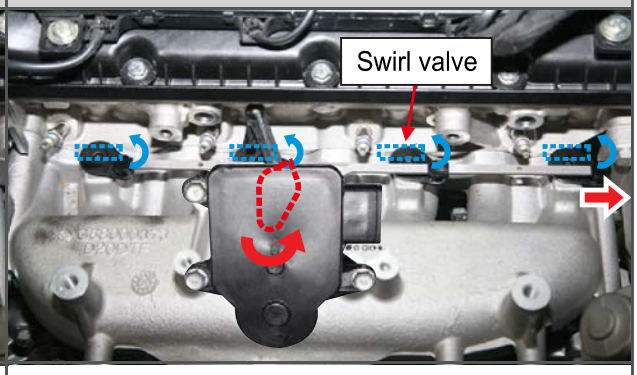
DC motor is used for operating the actuator. PWM uses H-bridge circuit and signal range is 1~10000 Hz. The maximum current is 4 A and the normal operating current is 0.7 A.

(2) Actuator



1. Mechanical start position: initial position without power, −4˚
2. Electric start position: Fully opened swirl flap, 0˚
3. Electric end position: Fully closed swirl flap by electric signal, 90˚
4. Mechanical end position: Fully closed swirl flap by mechanical device, 94˚

The maximum rotating angle is 98˚ but the actual operating angle is 90˚.
The reason why there are different operating ranges in electrical and mechanical types is to prevent damage due to external impact and signal by physical or electrical elements.

Opened swirl valve	Closed swirl valve
	
	

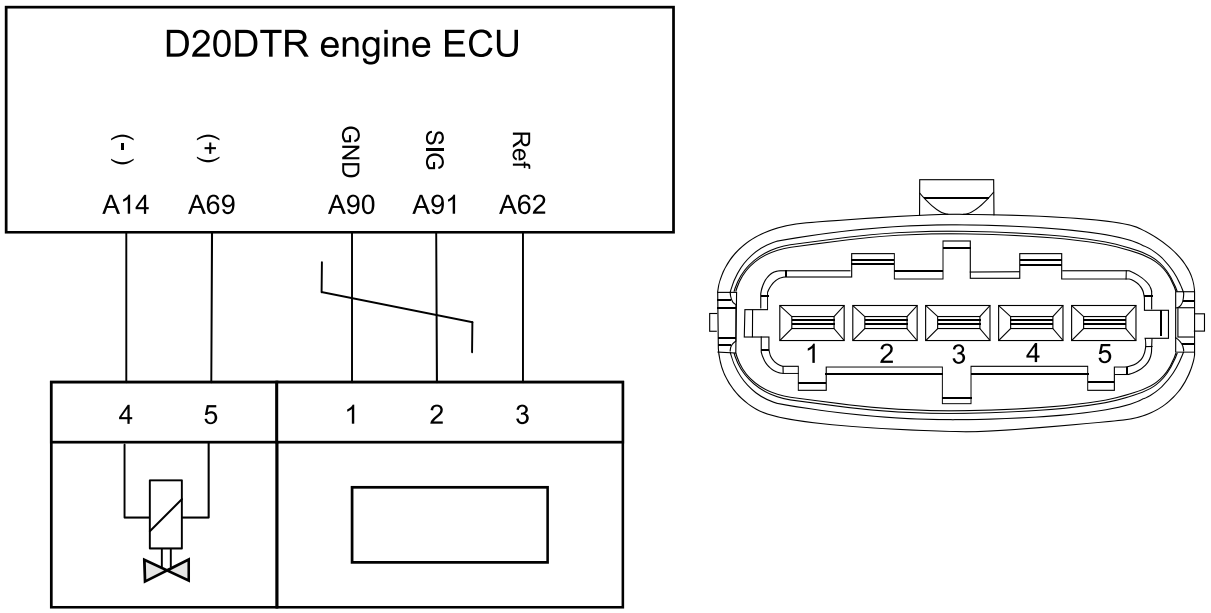
7) Swirl Valve Actuator Learning

(1) Difference Learning

The actuator moves to the mechanical start/end position after moved to the electrical start/end position first. The learning is performed by using signal values at both mechanical positions. This difference learning is performed whenever stopping the engine.

Modification basis	
Application basis	
Affected VIN	

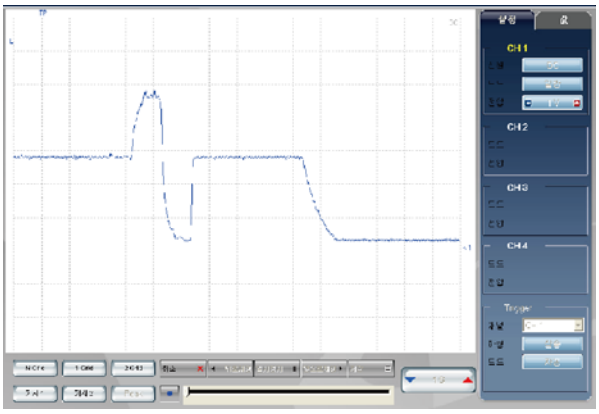
8) Circuit Diagram



Connect the measuring probe at terminal A90 and A91	
At fully open	0.17V
At fully close	4.83V

9) Operating Wave

Measuring condition	Ignition OFF
Measuring	Measuring probe (+) A14 Measuring probe (-) A69

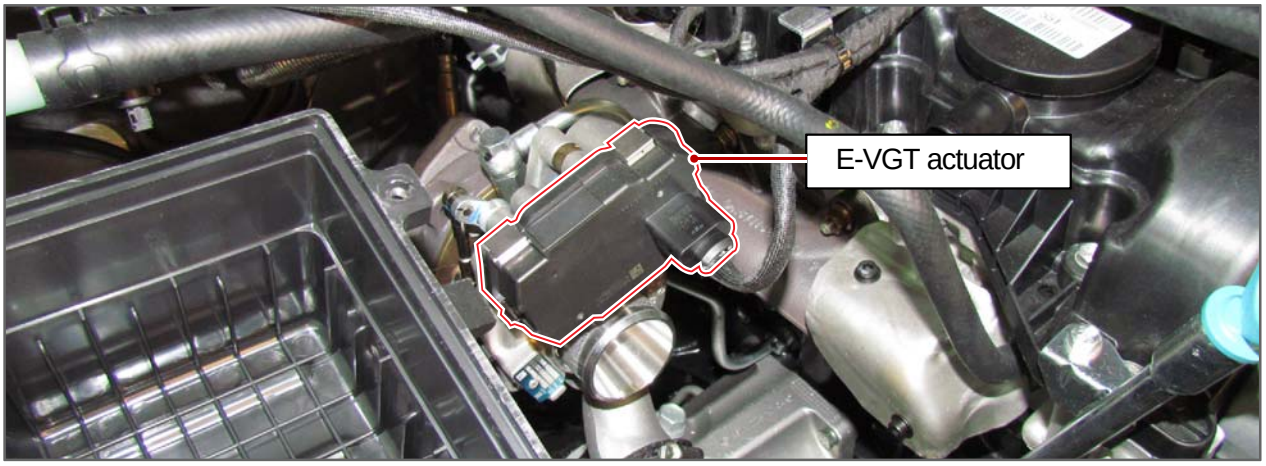


S.G.N.
1914-01 E-VGT CONTROL ACTUATOR

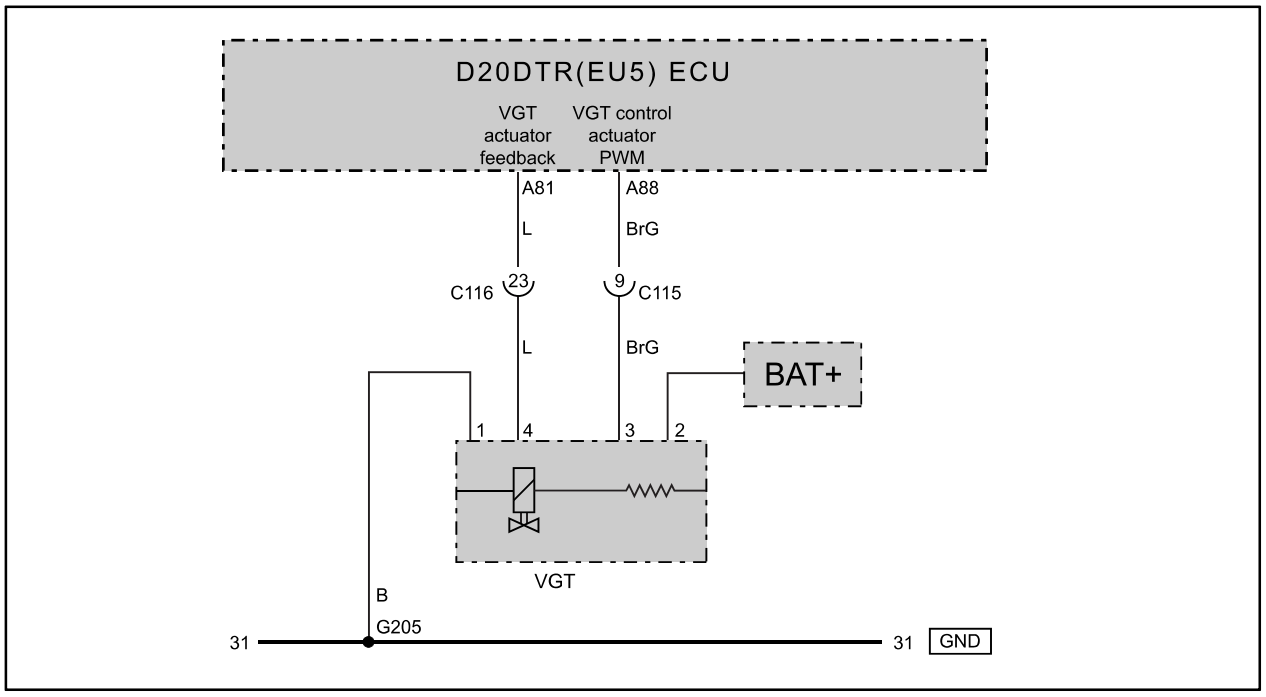
1) Overview

E-VGT (Electric-Variable Geometry Turbine) turbocharger system in D20DTF engine uses the venturi effect that controls the flow rate of exhaust gas by adjusting the passage in turbine housing. The newly adopted DC motor actuator (E-actuator) controls the E-VGT system more precisely and faster. To get the high operating power from turbine, the ECU reduces the exhaust gas passage In low speed range and increases it in high speed range.

2) Location



3) Circuit Diagram



Modification basis	
Application basis	
Affected VIN	

S.G.N.

1432-03 CAMSHAFT POSITION SENSOR

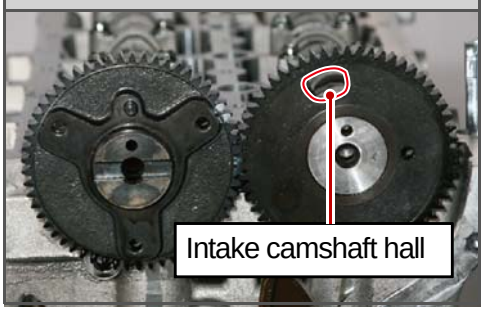
1) Overview

The camshaft position sensor uses hall-effect to set the camshaft position and metallic-agnetic-material sensor end is attached on the camshaft and then rotates with it. If sensor protrusion passes camshaft position sensor's semi-conductor wafer, magnetic field changes direction of electron on the semi-conductor wafer to the current flow direction that passes through wafer from the right angle. When operation power is supplied from camshaft position sensor, camshaft hall sensor generates signal voltage. The signal voltage will be 0 V if protrusion and camshaft position sensor are near and 4.5 V if apart.
ECU can recognize that the No. 1 cylinder is under compression stroke by using this voltage signal (hall voltage). The rotating speed of camshaft is half of the crankshaft and controls engine's intake and exhaust valves. By installing sensor on the camshaft, can recognize specific cylinder's status, compression stroke or exhaust stroke, by using camshaft position when the piston is moving toward TDC (OT). Especially when started first, it is difficult to calculate the stroke of a specific cylinder with only crankshaft position sensor.
Accordingly, camshaft position sensor is necessary to identify the cylinders correctly during initial starting. However, when engine is started, ECU learns every cylinder of the engine with crankshaft position sensor signals so can run the engine even though the camshaft position sensor is defective during engine running.

2) Location

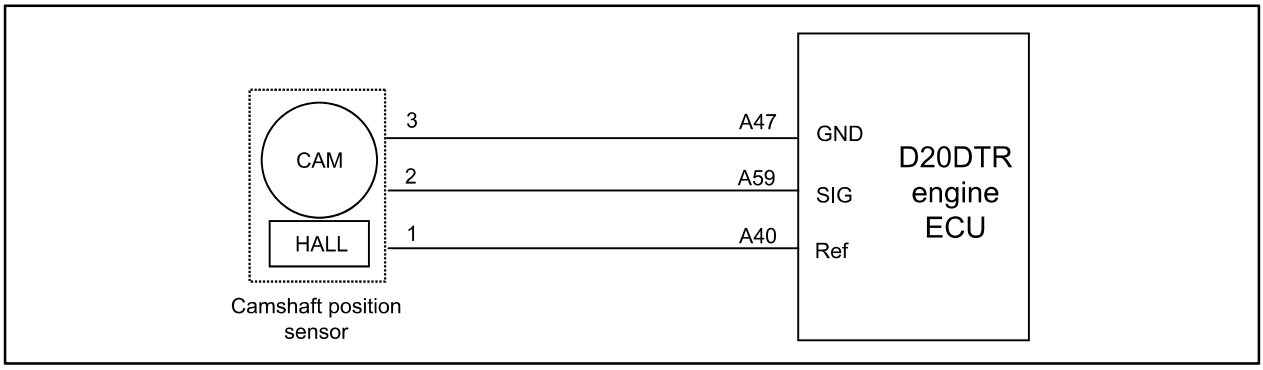
Camshaft position sensor

Intake camshaft sprocket



Modification basis	
Application basis	
Affected VIN	

3) Circuit Diagram

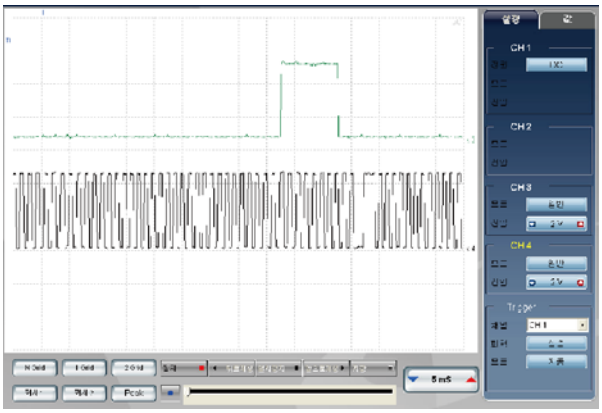


Cam clearance	0.2mm~1.8mm
Voltage	0V or 12V~14V
Current	10mA

Differently from magnetic pickup type, the hall sensor type must use the reference voltage. The internal hall voltage changes the signal voltage according to external electro-magnetic field.

4) Operating Wave

Measuring condition	At idle	
Measuring	Channel #3 (camshaft position sensor)	Channel #4 (crankshaft position sensor)
	Measuring probe (+) A59 Measuring probe (-) A47	Measuring probe (+) A60 Measuring probe (-) A20



The synchronization point of crankshaft position sensor and camshaft position sensor is at two teeth before the missing tooth. MR type sensor outputs the signal in the rectangular wave form.

(1) Analyzing the synchronization

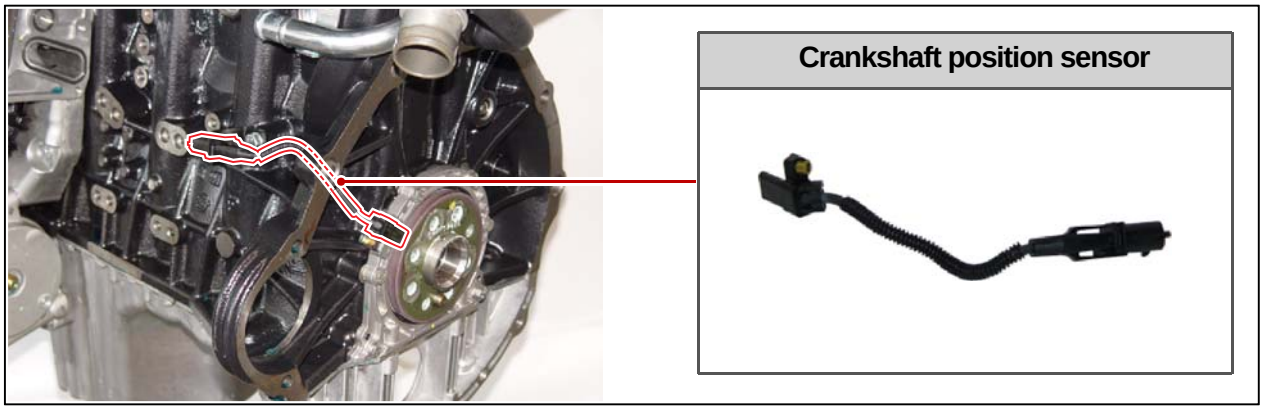
- There are signal gap of two teeth between the end position of camshaft signal and the missing tooth.
- Determines whether the width of each tooth is constant when checking the crankshaft position sensor signal.

S.G.N.
1127-35 CRANKSHAFT POSITION SENSOR

1) Overview

The crankshaft position sensor consists of the active type MR sensor and the magnetic trigger ring. The sensor is supplied 5 V of power. When the crankshaft rotates, the magnetic field is changed. Four internal resistors (MR element) in MR sensor detect the changes of resistance and converts it to the current value to determine the position/speed of the crankshaft.
The crankshaft position sensor is important signal and used to determine the injection timing and injection volume by detecting the piston position. The magnetic trigger ring sends total 58 signals. Each piston position is determined based on long tooth.

2) Location

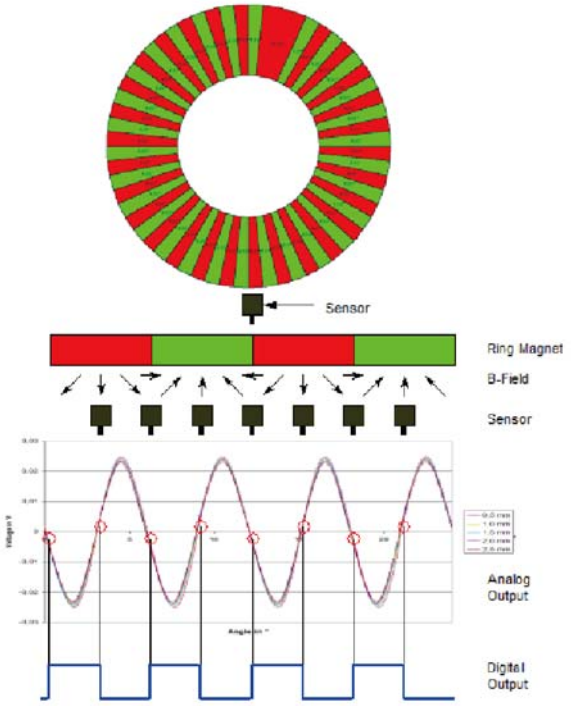


NOTE
Magneto Resistance Sensor Element
When a magnetic field is applied to the metal or semi-conductor, the resistance will be raised. This is called the magnetoresistance effect, and depends on the electron mobility of the material.

Modification basis	
Application basis	
Affected VIN	

3) Features

1. Wave for MR sensor: Rectangular type wave
2. The magnetic trigger ring has the magnetic field.
3. There is the angle difference of 114˚ in #1 cylinder at long tooth.



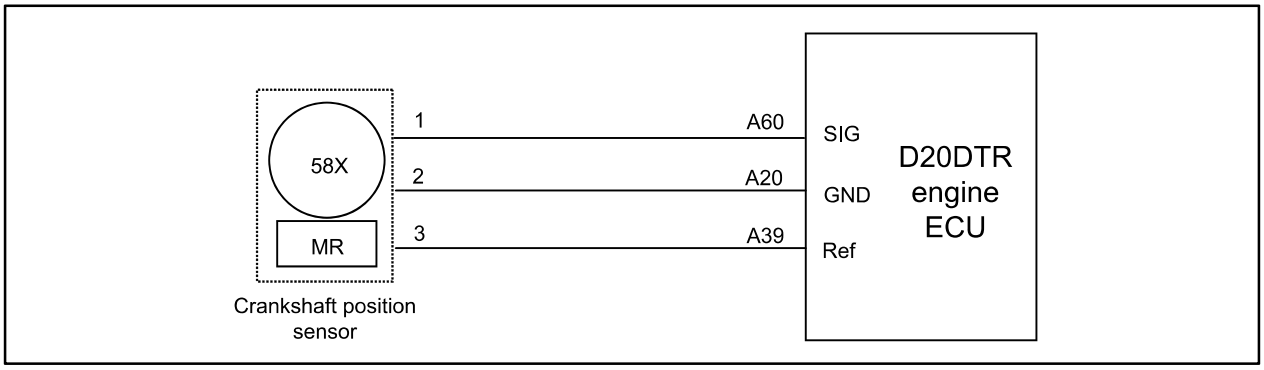
Description	Specification
Supply voltage	5V
Output voltage	4.48V
Air gap	0.6 ~ 1.4mm

CAUTION

Do not work near the tool or equipment with magnetic field to prevent the magnetic trigger ring from losing the magnetic field.

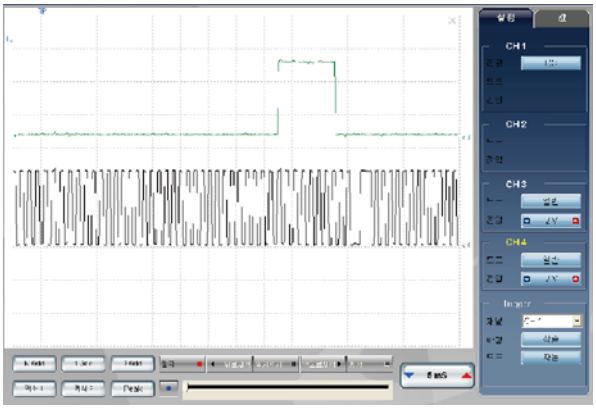
Modification basis	
Application basis	
Affected VIN	

4) Circuit Diagram



5) Operating Wave

Measuring condition	At idle	
Measuring	Channel #3 (Camshaft position sensor)	Channel #4 (Crankshaft position sensor)
	Measuring probe (+) A59 Measuring probe (-) A47	Measuring probe (+) A60 Measuring probe (-) A20



The synchronization point of crankshaft position sensor and camshaft position sensor is at two teeth before the missing tooth. MR type sensor outputs the signal in the rectangular wave form.

(1) Analyzing the synchronization

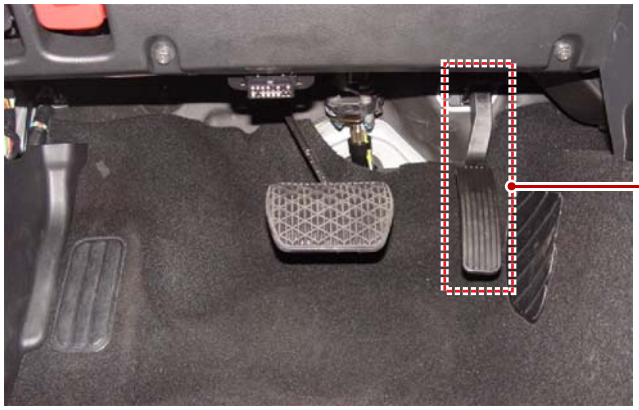
- There are signal gap of two teeth between the end position of camshaft signal and the missing tooth.
- Determines whether the width of each tooth is constant when checking the crankshaft position sensor signal.

S.G.N.
2010-01 ACCELERATOR PEDAL POSITION SENSOR

1) Overview

The accelerator pedal sensor converts the position of the accelerator pedal into an electric signal and sends this information to the ECU. There are 2 sensors in each accelerator pedal sensor. The signal from the No. 1 accelerator pedal sensor (ACC 1) is an element used to determine the fuel injection volume and timing while the signal from the No. 2 accelerator pedal sensor (ACC 2) is used to check the validity of the signal value from the No. 1 sensor.
When the No. 1 and 2 accelerator pedal sensors are all defective, the ECU stores the output DTCS, the acceleration response becomes poor, and it becomes hard to increase the engine rpm.

2) Location



Accelerator pedal position sensor

Modification basis	
Application basis	
Affected VIN	

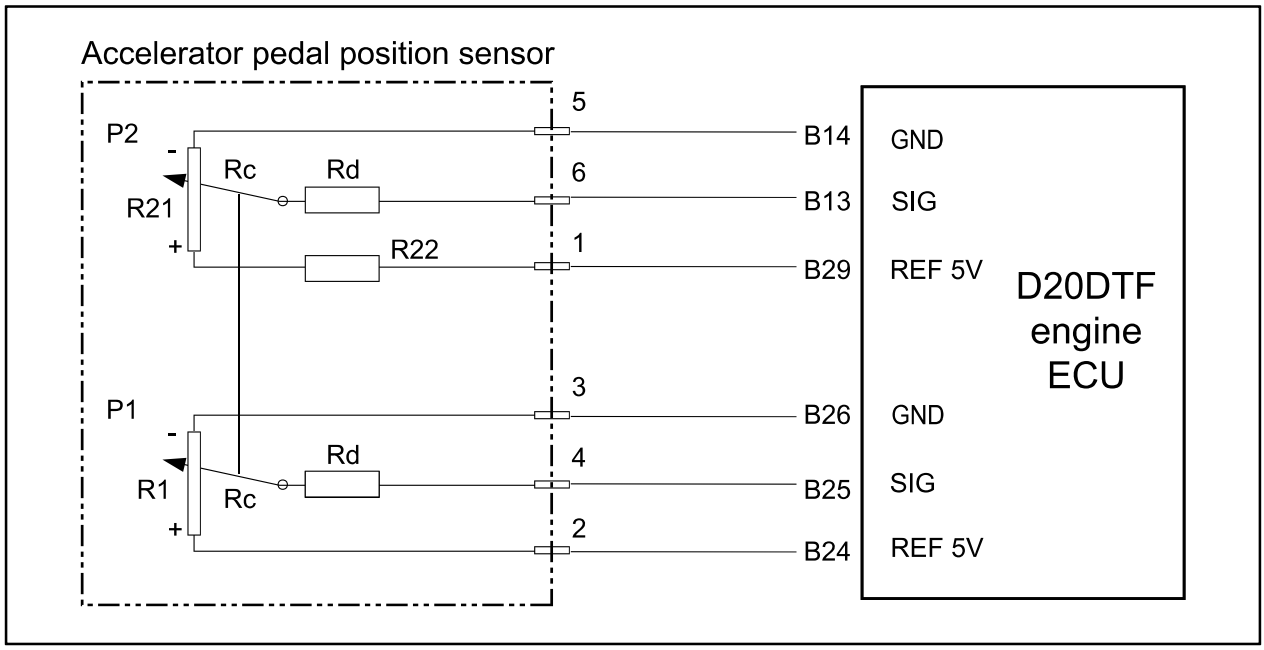
3) Features

1. Determines the injection timing and fuel injection volume
   ACC1 : Main sensor, determines injection timing and fuel injection volume (5.0 V)
   ACC2 : Checks if ACC1 is OK (2.5 V)
2. Failure in ACC1 or ACC2
   Controls the torque reduction by 50%
3. Failure in ACC1 and ACC2
   Changes to limp home mode (1,300 to 1,400 rpm)

	Accelerator pedal 1	Accelerator pedal 2
Full resistance of potentiomete	1.2kΩ	1.7kΩ
Maintenance	+ Check the resistance of individual component. + Check the resistance changes in individual component while operating the pedal.	

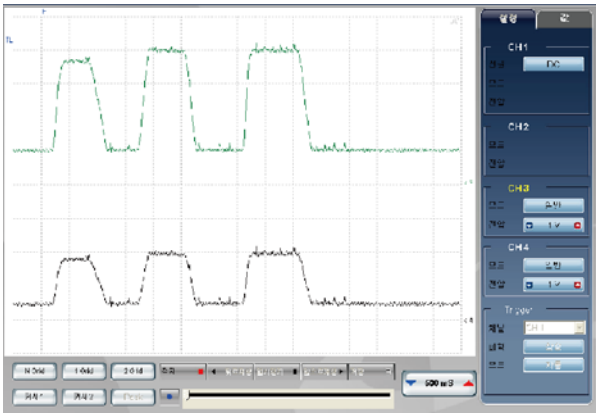
	Pedal position	Specified value
Accelerator pedal 1	Idle	1V ± 10%
	When fully depress the pedal	4V ± 10%
Accelerator pedal 2	Idle	0.5V ± 10%
	When fully depress the pedal	2V ± 10%

4) Circuit Diagram



5) Operating Wave

Measuring condition	Accelerating 3 times	
Measuring	Channel #3 (P1)	Channel #4 (P2)
	Measuring probe (+) A25 Measuring probe (-) A26	Measuring probe (+) A13 Measuring probe (-) A14



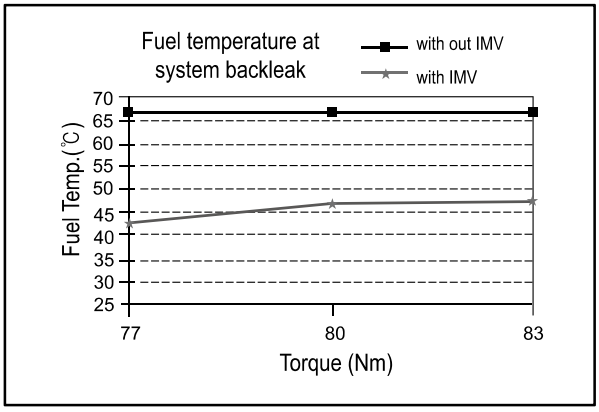
No.1 uses 5 V Ref, and No.2 uses 2.5 V Ref.

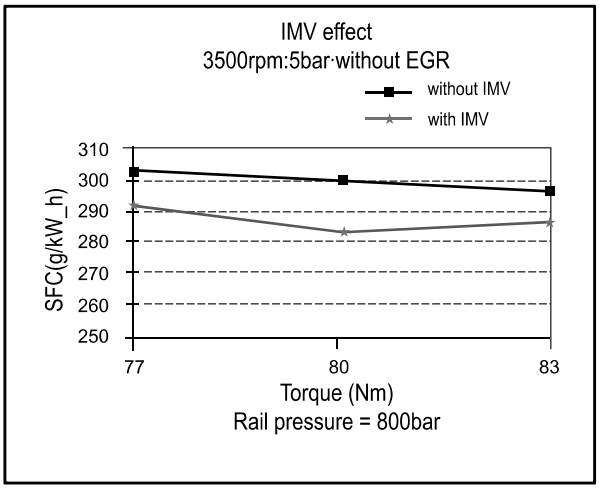
Modification basis	
Application basis	
Affected VIN	

S.G.N.
1882-21 INLET METERING VALVE (IMV)

1) Overview

The LP actuator, also called the inlet metering valve, is used to control the rail pressure by regulating the amount of fuel which is sent to the pumping element of the HP pump.
The actuator has two functions as below:

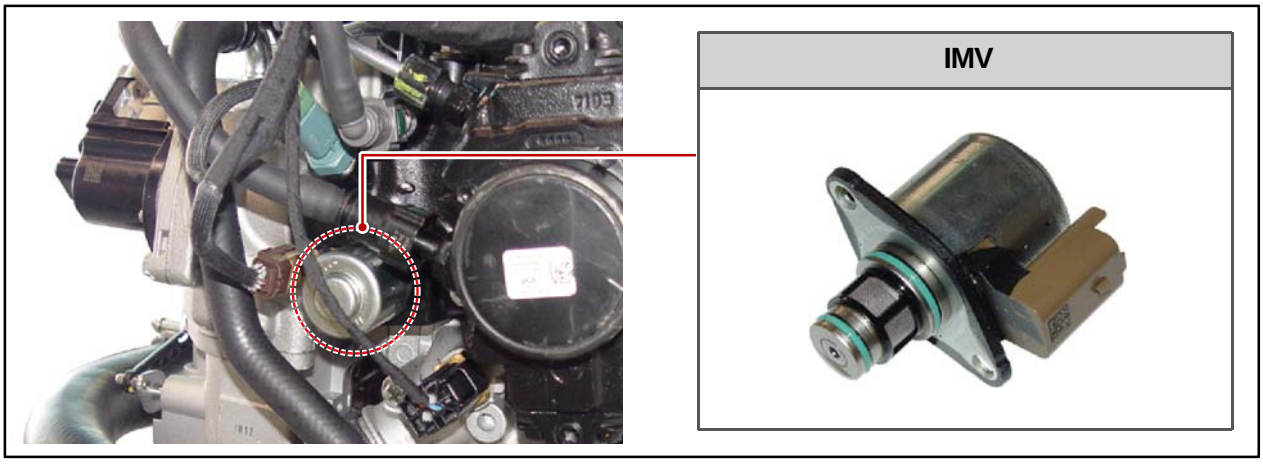




1. It allows the efficiency of the injection system to be improved, since the HP pump only compresses the amount of fuel necessary to maintain in the rail the level of pressure required by the system as a function of the engine's operating conditions.

2. It allows the temperature to be reduced in the fuel tank. When the excess fuel is discharged into the back leak circuit, the pressure reduction in the fluid (from rail pressure down to atmospheric pressure) gives off a large amount of heat. This leads to a temperature rise in the fuel entering the tank. In order to prevent too high a temperature being reached, it is necessary to limit the amount of heat generated by the fuel pressure reduction, by reducing the back leak flow. To reduce the back leak flow, it is sufficient to adapt the flow of the HP pump to the engine's requirements throughout its operating range.

2) Location

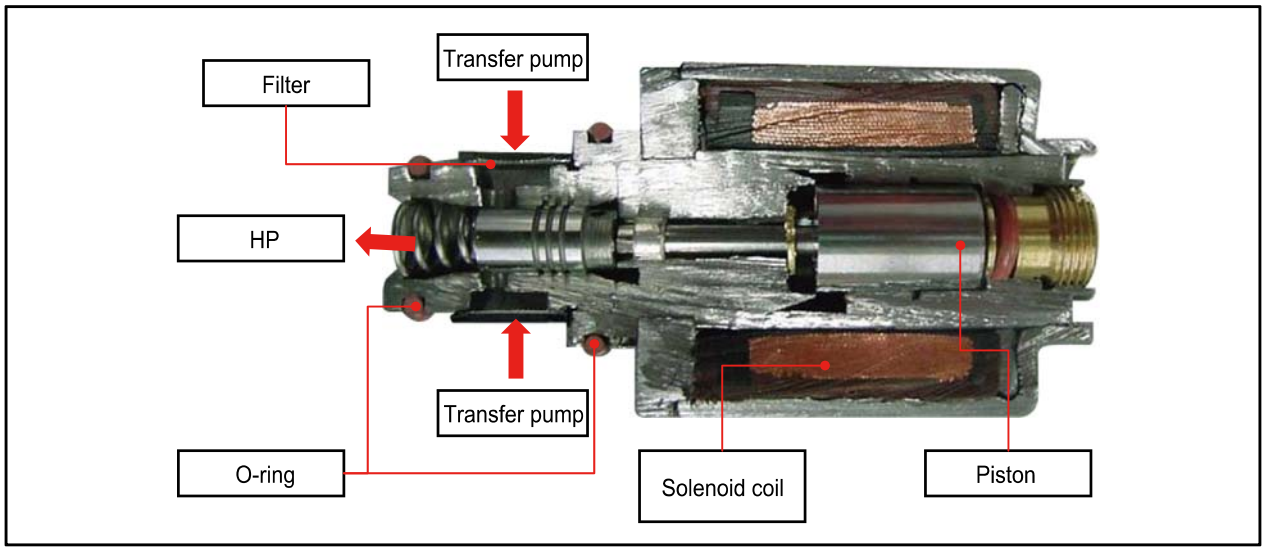


Modification basis	
Application basis	
Affected VIN	

3) Composition of IMV

IMV is located on the front plate of HP pump. It is fed with fuel by the transfer pump via two radial holes. A cylindrical filter is fitted over the feed orifices of the IMV. This makes it possible to protect not only the LP actuator, but also all the components of the injection system located downstream of the IMV.
The IMV consists of the following components:

- A piston held in the fully open position by a spring
- A piston filter located at inlet
- Two O-rings ensuring pressure tightness between the hydraulic head and the body of IMV
- A body provided with two radial inlet holes and an axial outlet hole
- Coil



(1) Function

Controls the fuel pressure by regulating the fuel volume to HP pump.

(2) Advantage

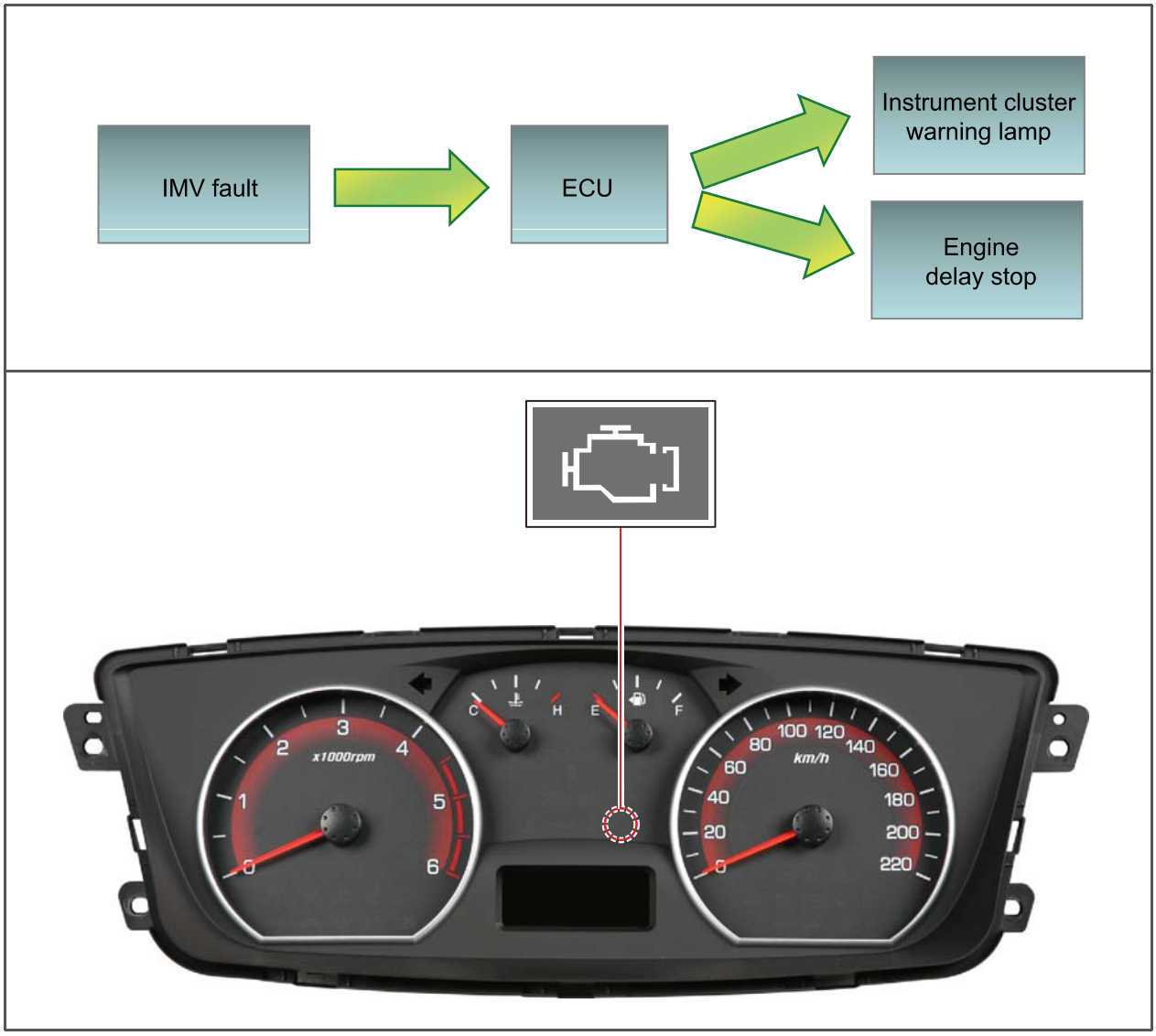
Lowers the fuel temperature in return line and improves the injection efficiency.

(3) Not usable as a safety device

If the power is not supplied, the fuel volume decreases when the current for valve opening increases.

Modification basis	
Application basis	
Affected VIN	

(4) Engine delay stop

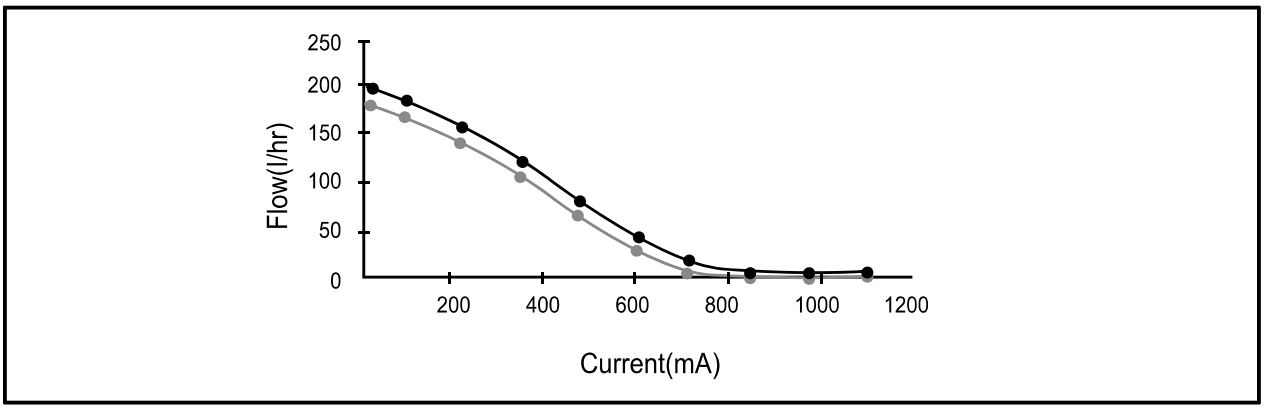


- If IMV drive is defective during driving (IMV circuit is open)
- Engine CHECK warning lamp ON and changed to limp home mode
  (Limp home mode: Driving with minimum torque, engine rpm is restricted by 1,300 to 1,400 rpm)
- Emergency engine stop after 50 seconds

※ The engine can be started in 3 seconds after emergency stop, but running in limp home mode

4) Operating Principle

The LP actuator is used to proportion the amount of fuel sent to the pumping element of the HP pump in such a way that the pressure measured by the HP sensor is equal to the pressure demand sent out by the ECU. At each point of operation, it is necessary to have:
Flow introduced into the HP pump = Injected flow + Injector backleak flow + injector control flow.
The IMV is normally open when it is not being supplied with fuel. It cannot therefore be used as a safety device to shut down the engine if required.
The IMV is controlled by current.
The flow/current law is represented below.



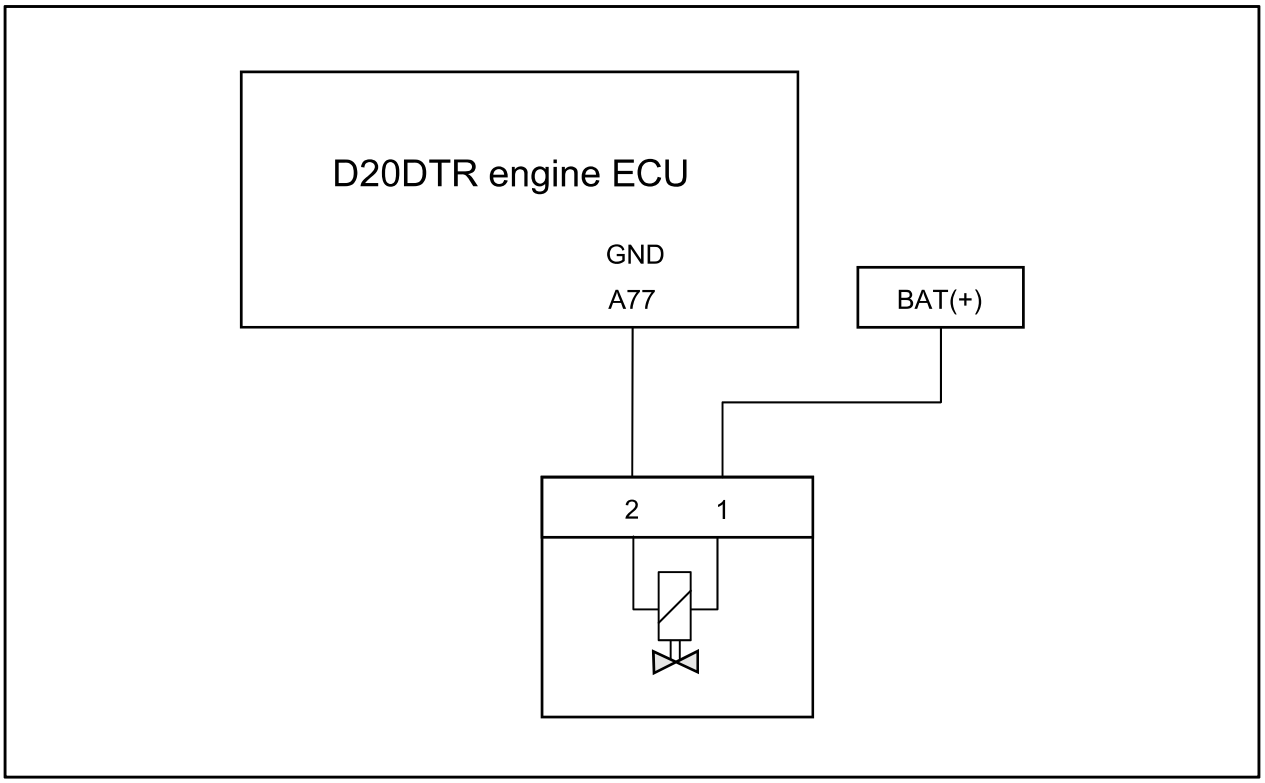
Engine condition	Fuel pressure	IMV opening
at Idle	approx. 250 bar	33 ~ 34%
at full load	approx. 1600 bar	16.8%

5) Specifications

Piston stroke	1.4mm
Hole diameter	3.4mm
Coil resistance	5.4 Ω (at 25℃)
Supply power	Battery voltage (It is prohibited to supply directly from battery during diagnostic test)
Maximum current	1A
Weight	260g
Operating temperature	40℃<T<125℃
Control logic	If no power supply, normal opening status

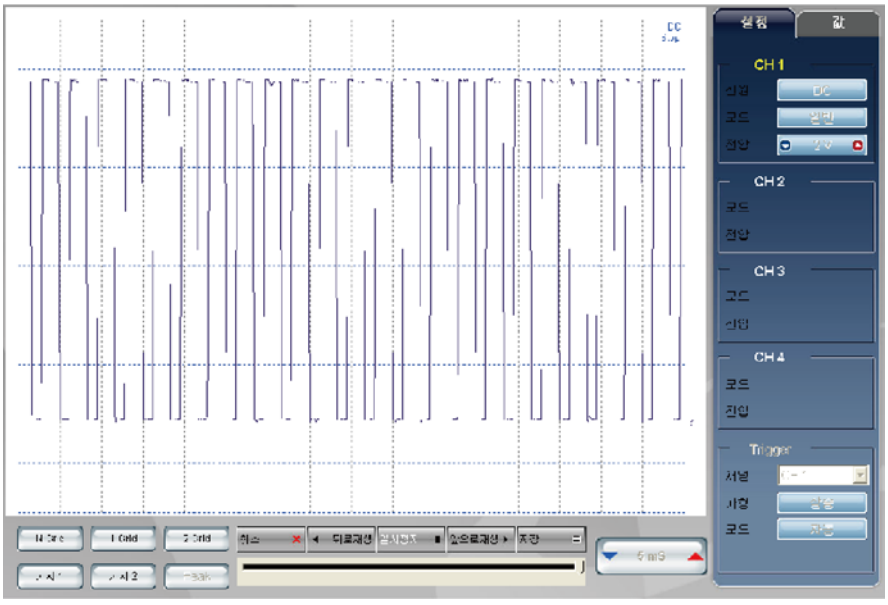
Modification basis	
Application basis	
Affected VIN	

6) Circuit Diagram



7) Operating Wave

Measuring condition	Accelerating 3 times
Measuring	Measuring probe (+) A77 Measuring probe (-) body ground



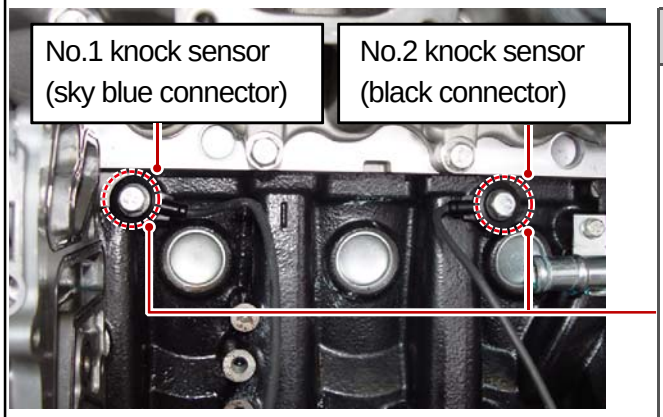
Modification basis	
Application basis	
Affected VIN	

S.G.N.
1432-05 KNOCK SENSOR

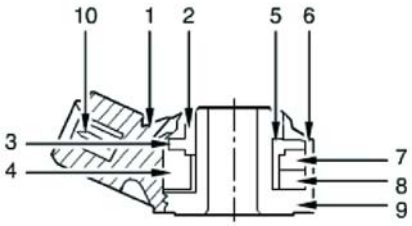
1) Overview

There are 2 knock sensors on the cylinder block (at intake manifold side).
The knock sensor has a piezoelectric element which detects the engine vibration generated from abnormal combustion and is fixed on the diaphragm; the diaphragm is fixed on the base section of the knock sensor. This sensor a) controls stable idle, b) checks the injector for any damage, and c) turns on the engine warning lamp if any fault is found. Also, it d) adjusts the pilot injection volume precisely during MDP learning process. The engine ECU corrects the injection timing according to the MAP values, such as engine rpm, intake air volume and coolant temperature in the event of failure in the knock sensor.

2) Location



Knock sensor



1. Sensor housing
2. Nut
3. Dish spring
4. Weight
5. Insulation pipe
6. Upper contact plate
7. Piezoelectric element
8. Lower contact plate
9. Body
10. Terminal
11. Resistor

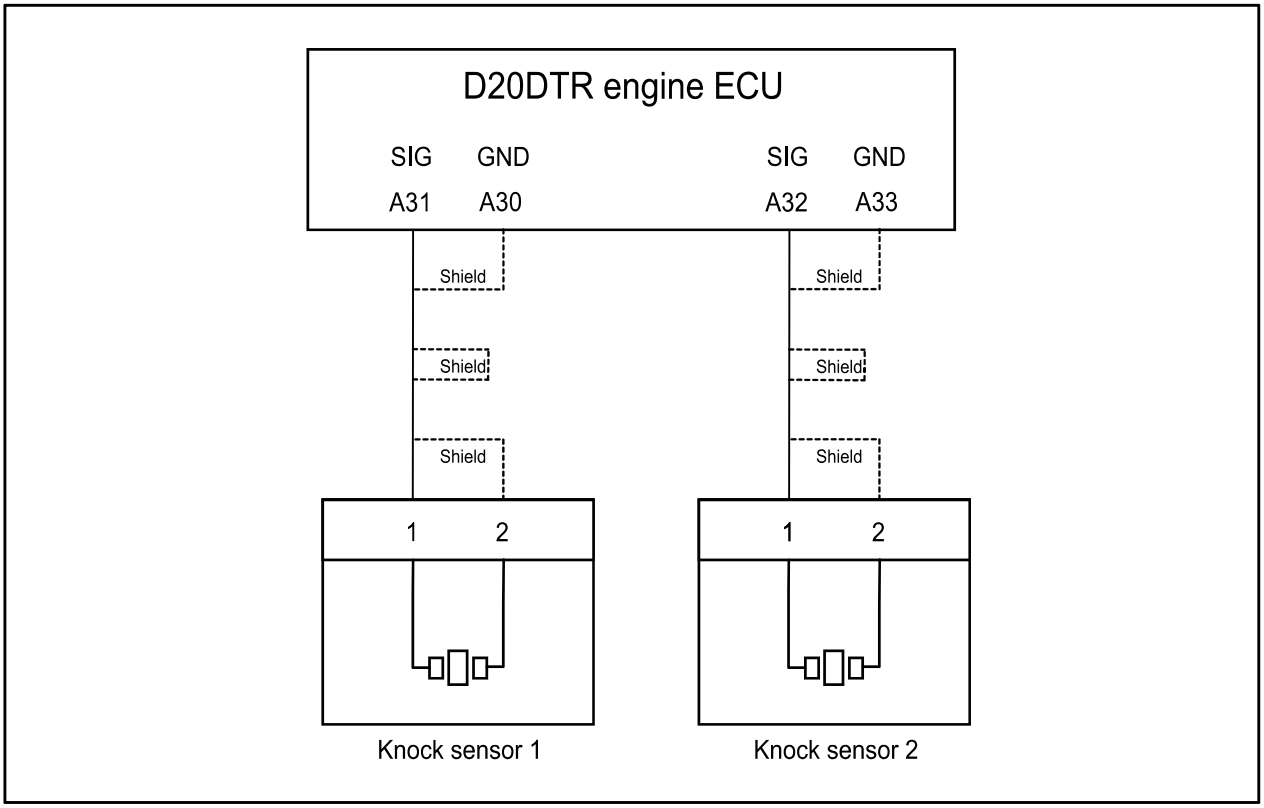
Modification basis	
Application basis	
Affected VIN	

3) Specifications

Insulation resistance	at least 1 MΩ
Idle frequency	25 kHz
Operating temperature	−40 to 150°C
Output voltage	26 ± 8 mV/g (at 5kHz)
	22 to 37 mV/g (3 to 10 kHz)
	22 to 57 mV/g (10 to 20 kHz)

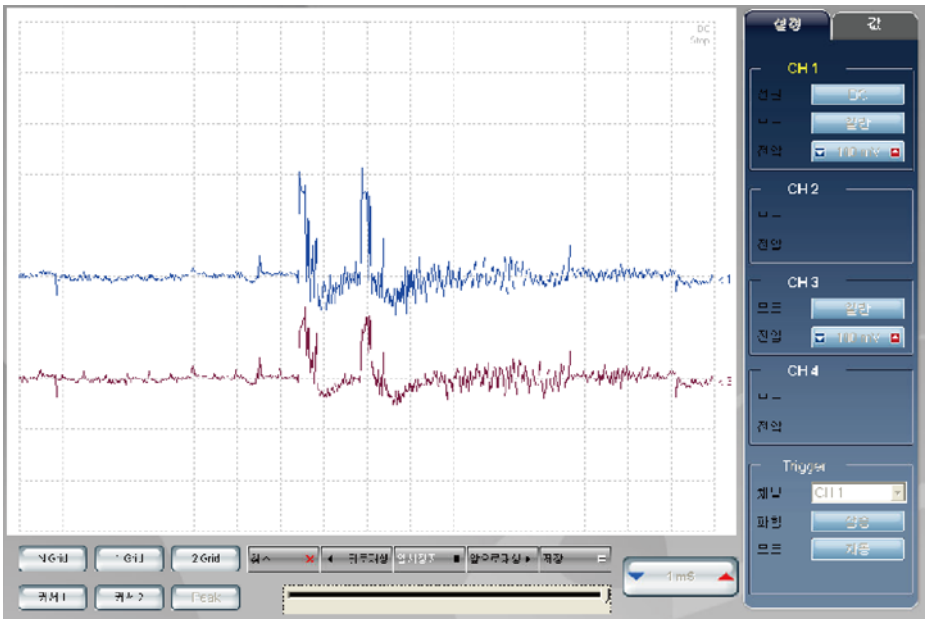
- Stabilizes the idling
- Turns ON warning lamp when the injector is defective
- Determines the fuel injection volume for pilot injection during MDP learning
- Adjusts the balance for each cylinder
- When the knock sensor is defective:
  ECU determines the injection timing according to MAP value such as engine rpm, intake air mass and coolant temperature

4) Circuit Diagram



5) Operating Wave

Measuring condition	at idle	
Measuring	Channel #3	Channel #4
	Measuring probe (+) A31 Measuring probe (-) A30	Measuring probe (+) A32 Measuring probe (-) A33



The knock sensor has a piezoelectric element. It generates very low voltage when there is an external vibration.

Modification basis	
Application basis	
Affected VIN	

REMOVAL AND INSTALLATION

S.G.N. 1491-01 ECU (D20DTR)

1) Overview

NOTE

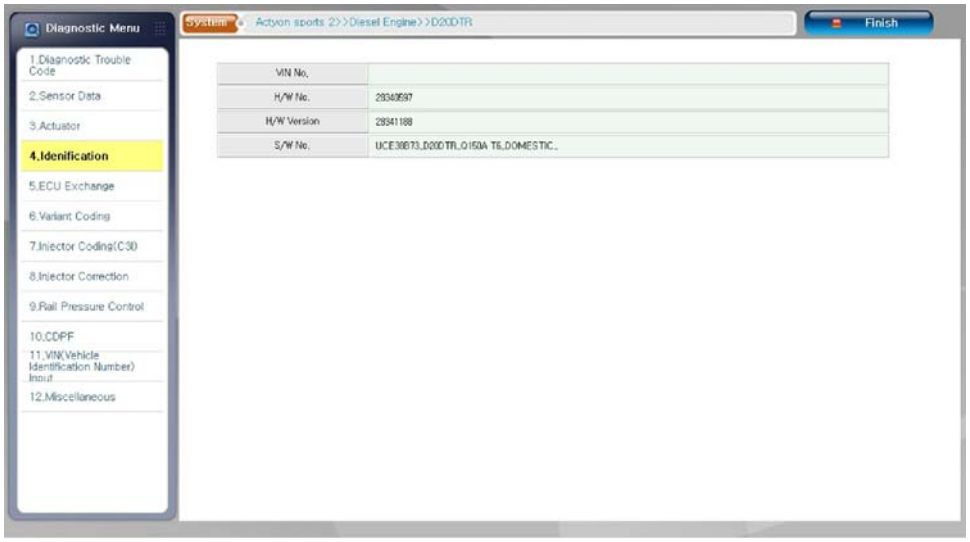
For a simple removal and installation, skip the coding procedures.

1. Enter into diagnosis menu on diagnostic program
2. Check and record variant coding item
3. Replace ECU
4. Check new ECU variant coding item
5. Perform EMS coding
6. Clear the DTC(s) for relevant units including engine ECU and check for any abnormality

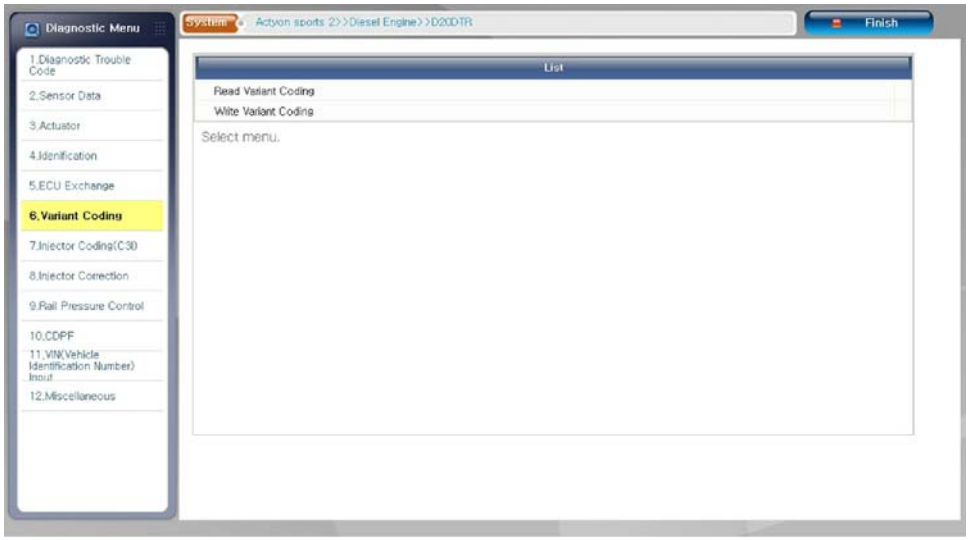
Modification basis	
Application basis	
Affected VIN	

2) Engine ECU

1. Connect the diagnostic device to the diagnostic connector. Choose "Vehicle Type" and "Engine Type" on the main screen, then press the "Diagnosis" button.
2. Choose "Device Check" on the diagnosis menu and check the ECU part number and software version shown to the right of the screen.



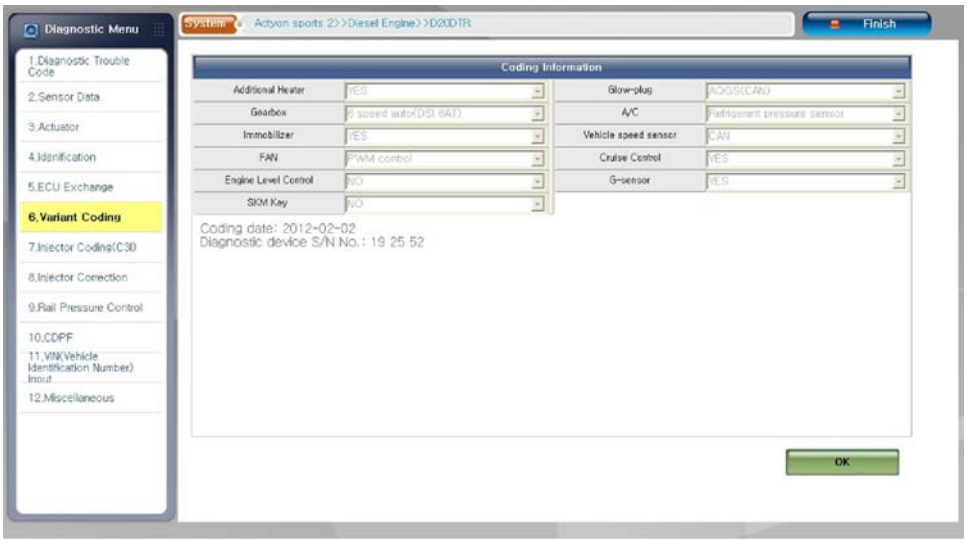
3. Choose "Variant Coding Check" of the items shown to the right of the diagnosis menu, then choose "Engine Variant Coding Check" and "Chassis Variant Coding Check" on the screen which follows.



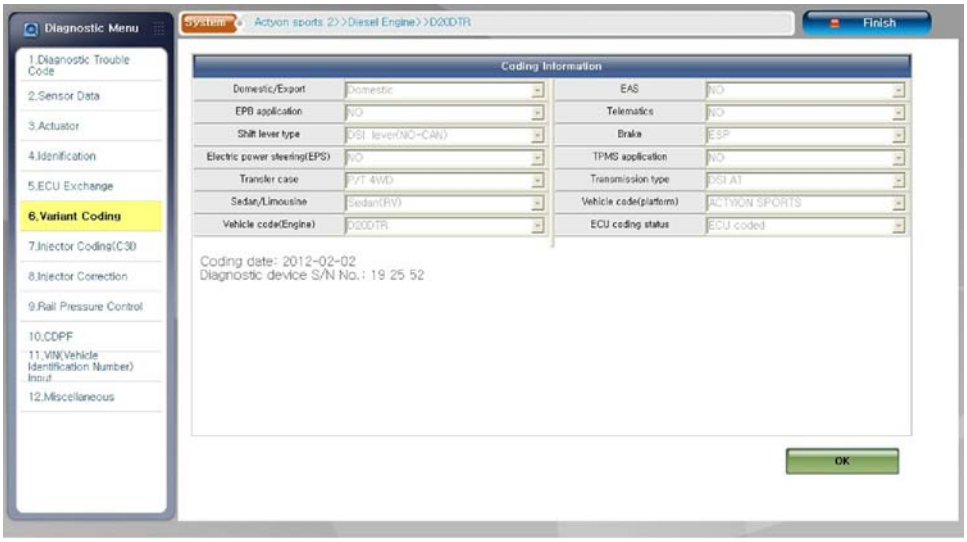
Modification basis	
Application basis	
Affected VIN	

4. Record the displayed variant coding information.

▶ **Variant coding for engine**

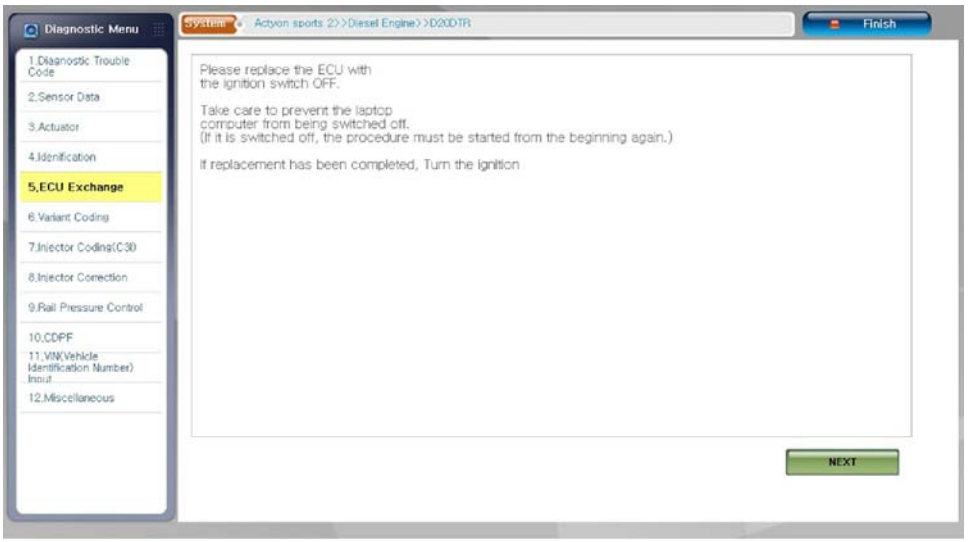


▶ **Variant coding for chassis**



5. Choose the item "Replace ECU" on the diagnosis menu.

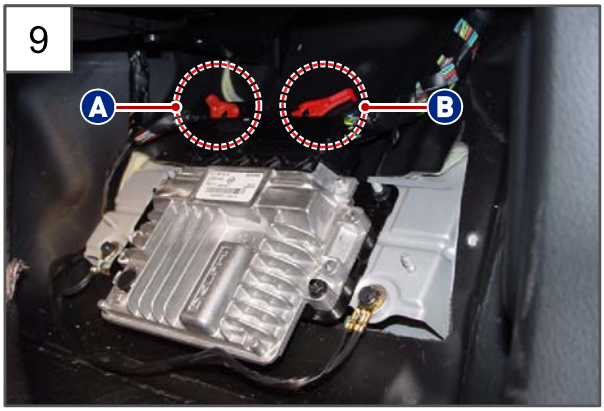
6. Follow the instructions on the screen to remove the ECU.



Modification basis	
Application basis	
Affected VIN	

7. Disconnect the negative cable from the battery. Fold up the floor mat in front passenger side and unscrew two nuts (10 mm) from the protect cover.

8. Remove the protect cover.

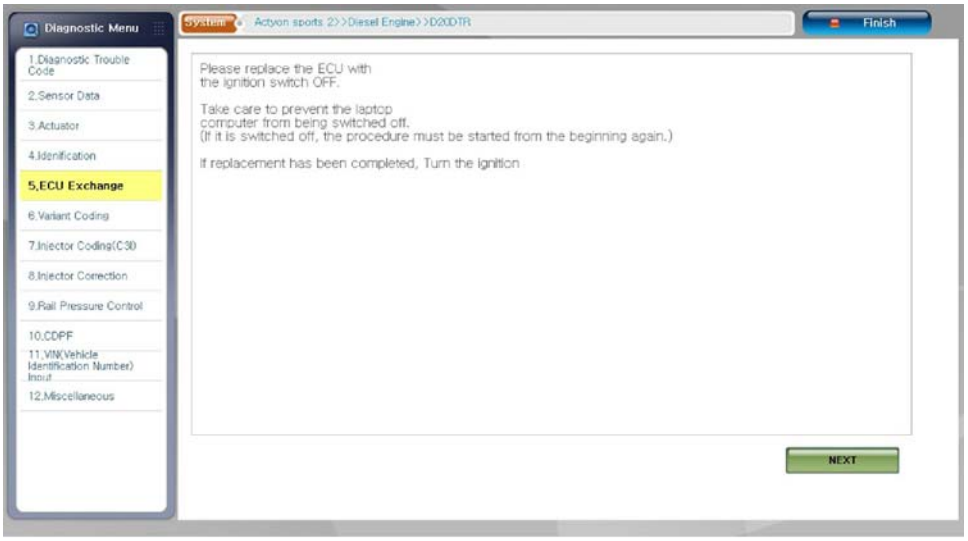


9. Disconnect the ECU connector A and B.

10. Unscrew two nuts (10 mm) from the ECU.

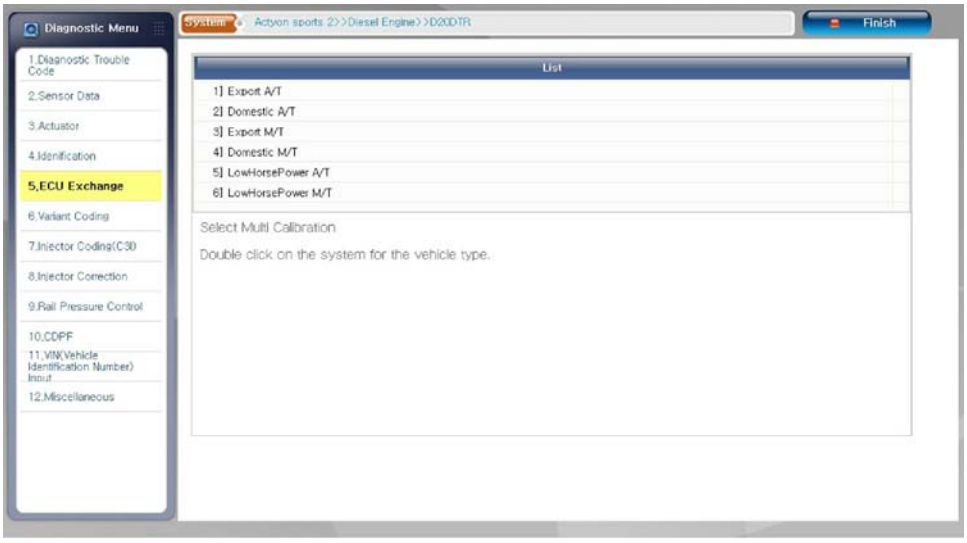
11. Remove the ECU.
12. Install the ECU in the reverse ordr of removal.

13. Replace the engine ECU and press the "Next" button on the bottom of the screen below.

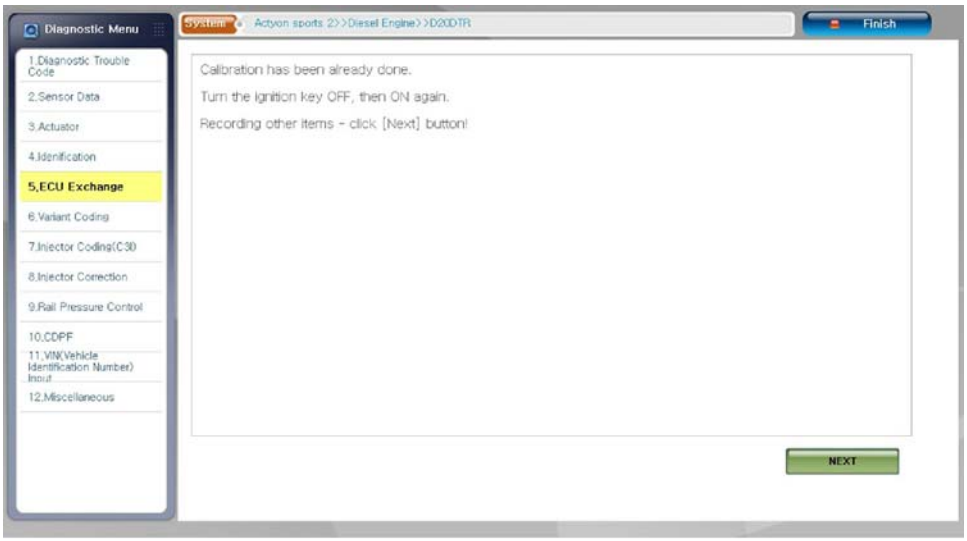


Modification basis	
Application basis	
Affected VIN	

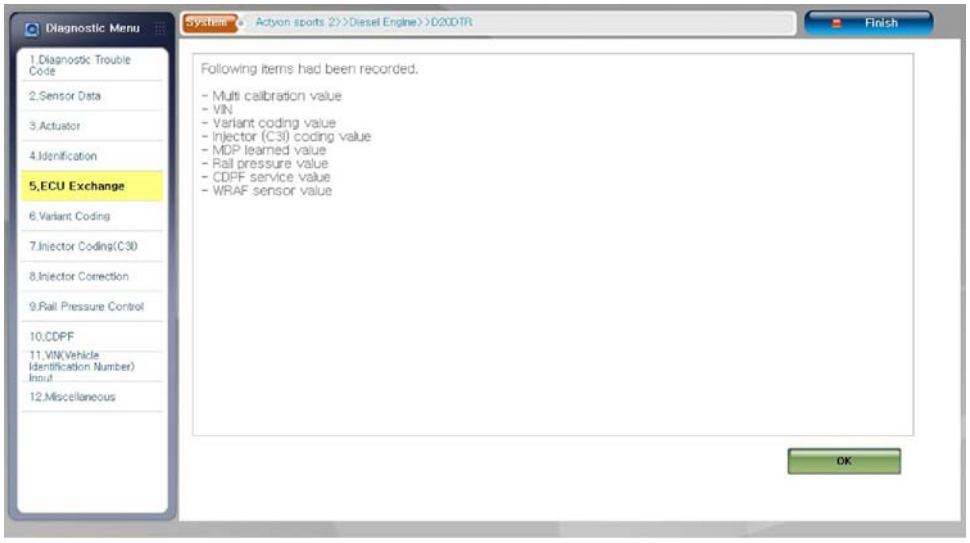
14. Select the multi-calibration for the vehicle to be operated.



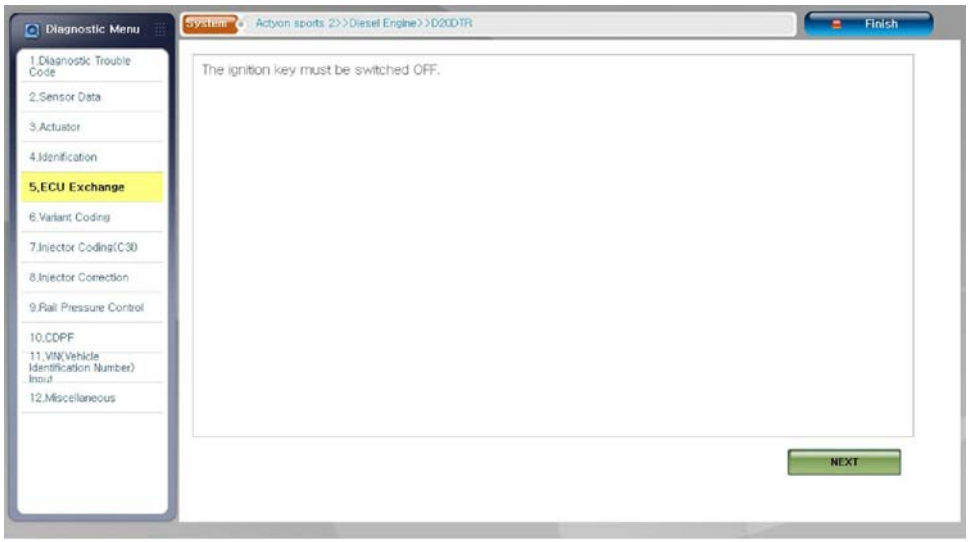
15. Turn the ignition switch to the "OFF" and "ON" positions, then press "Next" as instructed on the screen.



16.If the following screen is displayed, press the "OK" button.

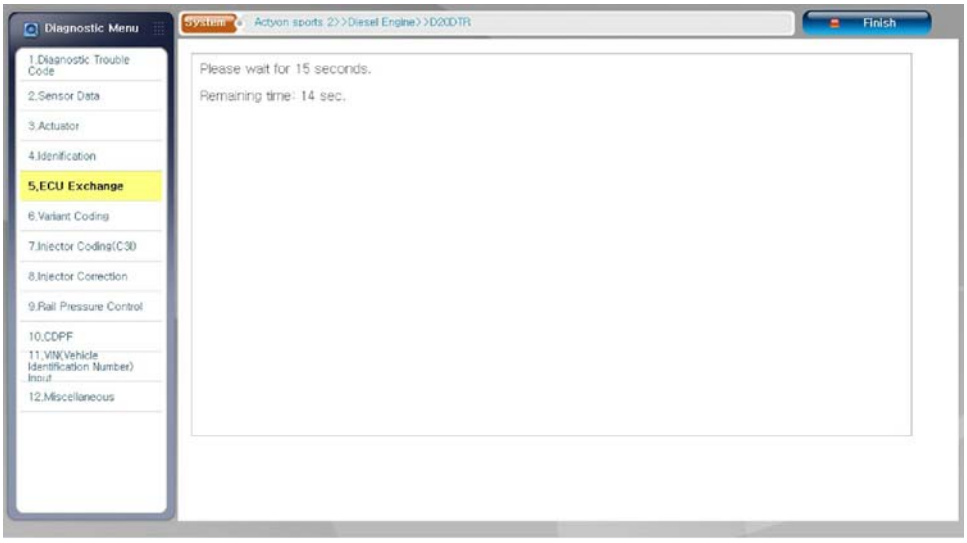


17.Turn the ignition switch to the "OFF" position, then press "Next" as instructed on the screen.

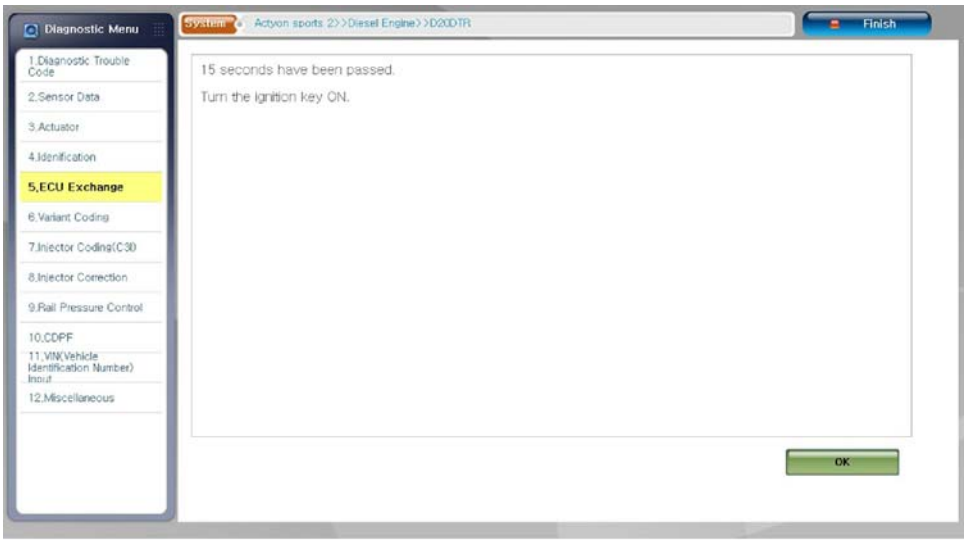


Modification basis	
Application basis	
Affected VIN	

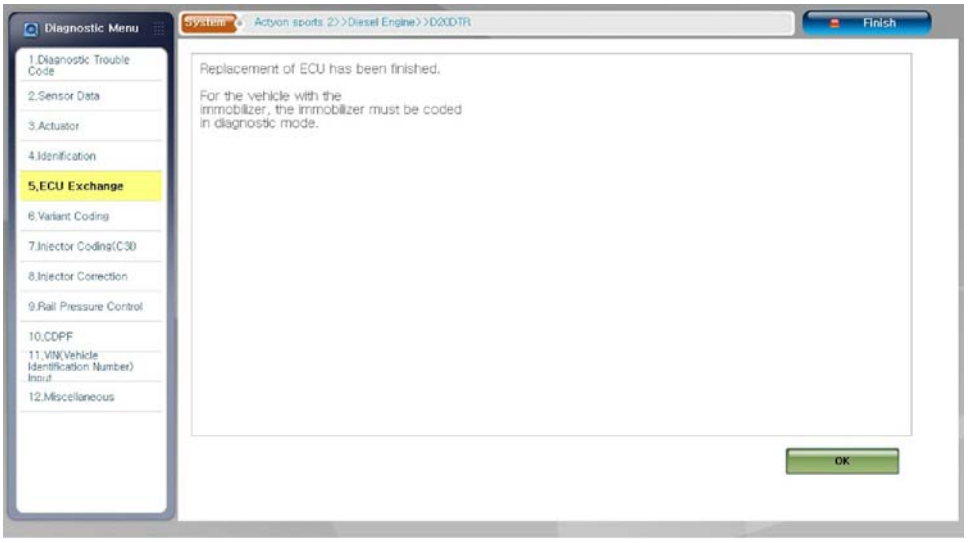
18. Wait for 15 seconds as instructed on the screen.



19. Turn the ignition switch to the "ON" position, then press "Next" as instructed on the screen.

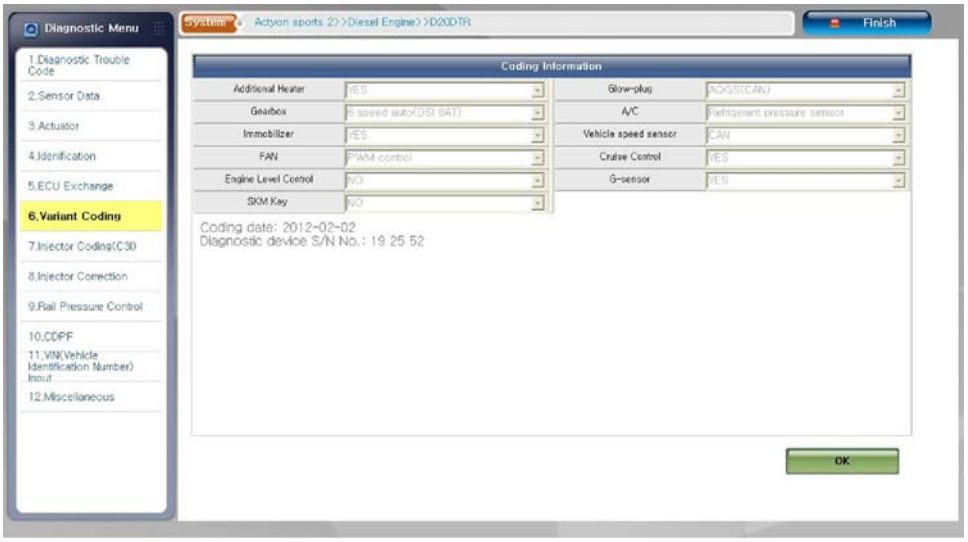


20. If the following screen is displayed, press the "Next" button.



21. Go to the screen "Variant Coding" and check what is shown in the display to check if the replaced ECU is coded successfully.
(Check that it is identical with the variant coding, which is recorded before replacing the engine ECU.)

▶ **Variant coding for engine**

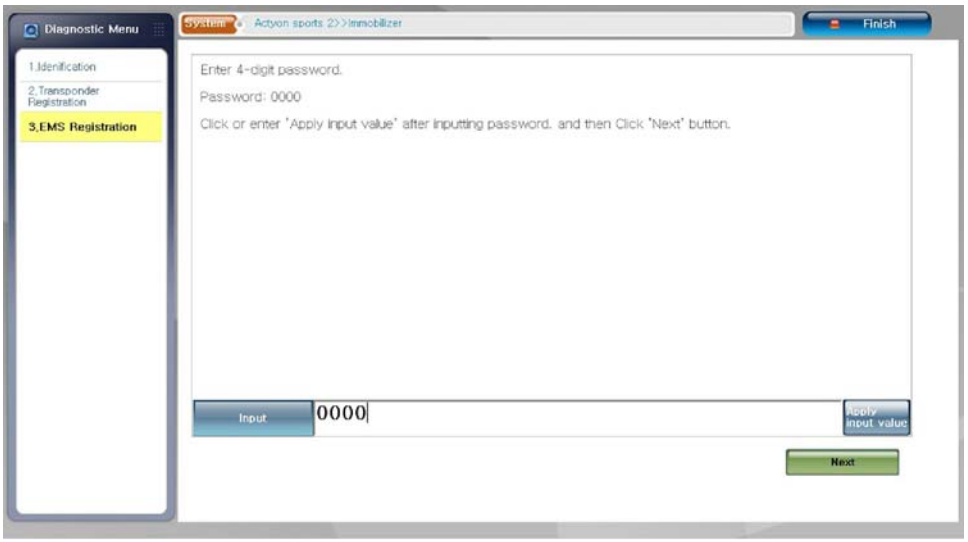


Modification basis	
Application basis	
Affected VIN	

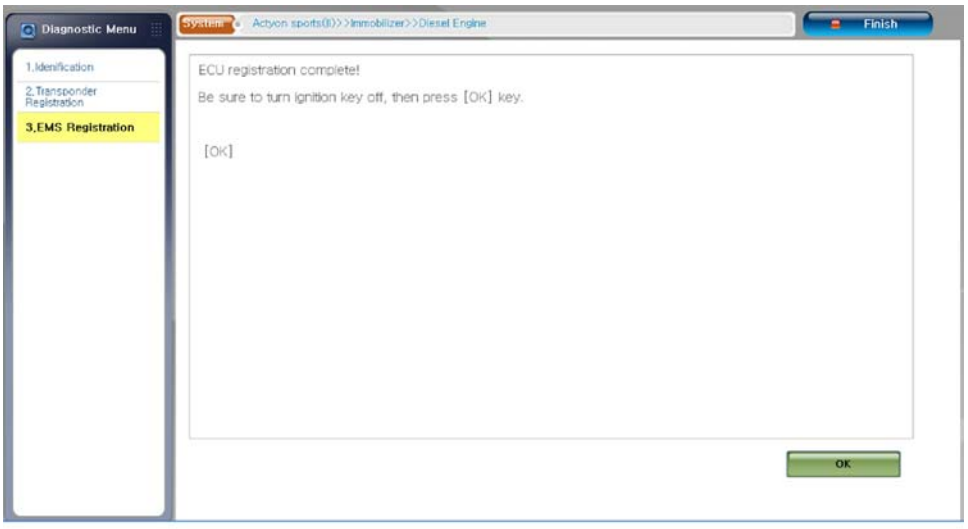
▶ Variant coding for chassis

22. Return to the main screen and enter into the item "Immobilizer" under "System".

23. Go into "EMS Registration" on the right of the diagnosis menu, enter the password - default value "0000" - and press the "Next" button.

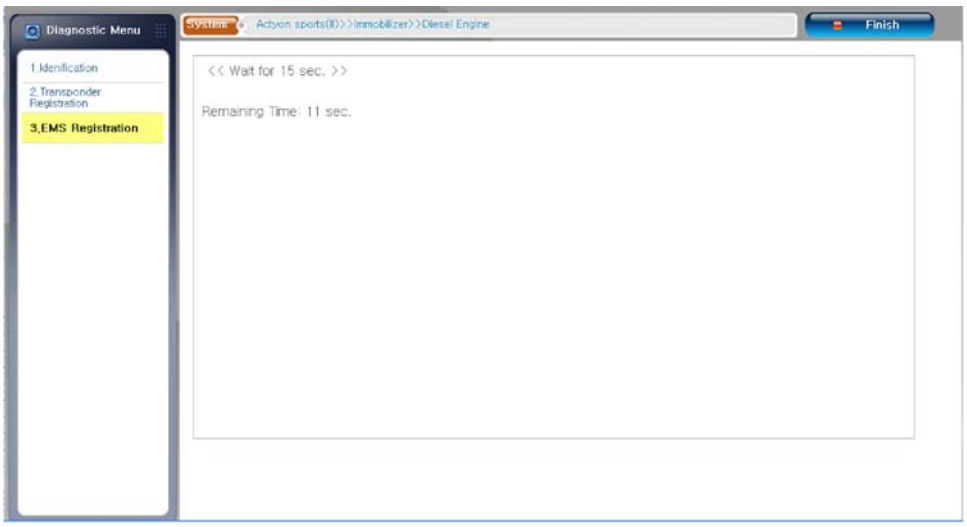


24. Turn the ignition switch to the "OFF" position as instructed on the screen.

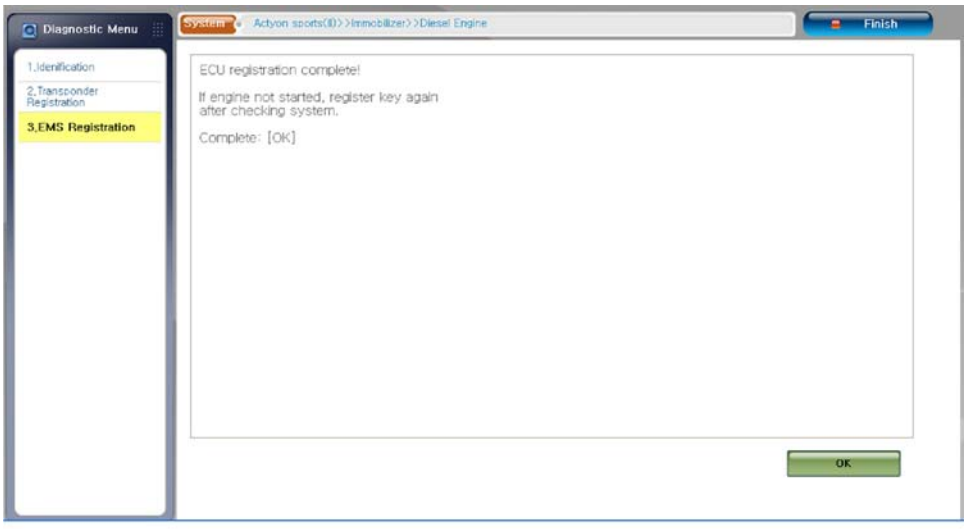


Modification basis	
Application basis	
Affected VIN	

25. Wait for 15 seconds as instructed on the screen.



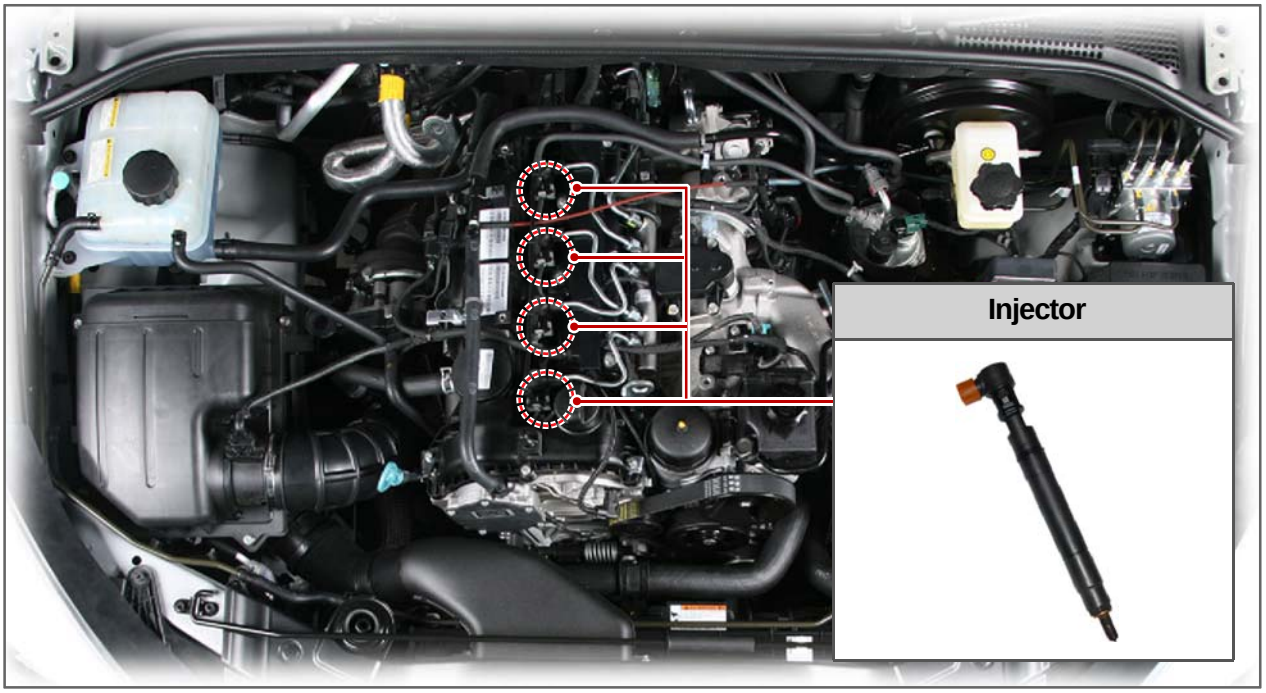
26. Once the EMS registration is completed, press the "OK" button to exit the program.

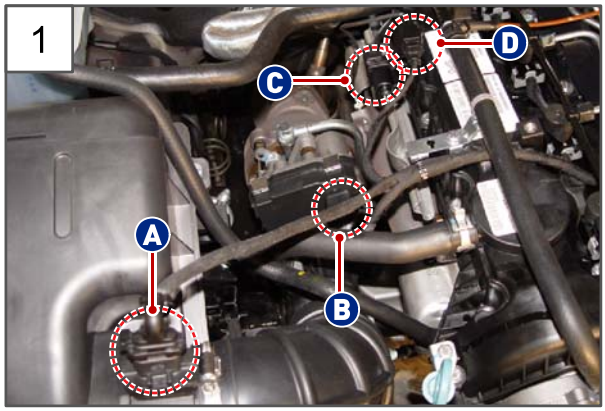


27. Clear the DTC(s) for relevant units including engine ECU and check for any abnormality.

S.G.N.
1882-09 INJECTOR

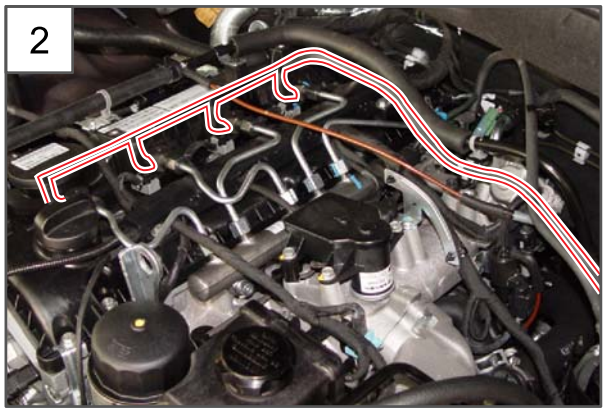
Preceding work
- Disconnect the negative cable from the battery.
- Remove the engine acoustic cover.





1. Disconnect the connectors (A, B, C, D) and set the wiring aside.

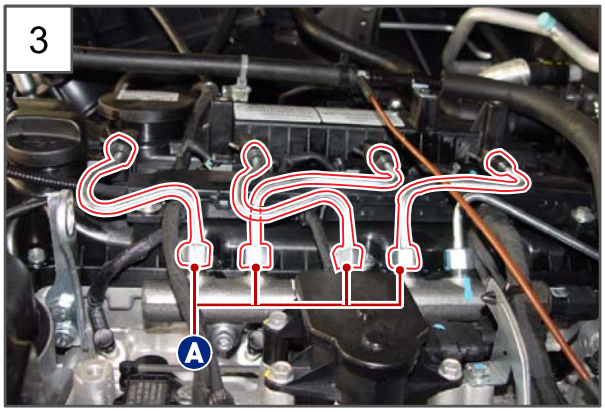
   (A) HFM sensor connector
   (B) VGT connector
   (C) Oxygen sensor connector
   (D) Front temperature sensor connector



2. Remove the fuel return tube assembly.

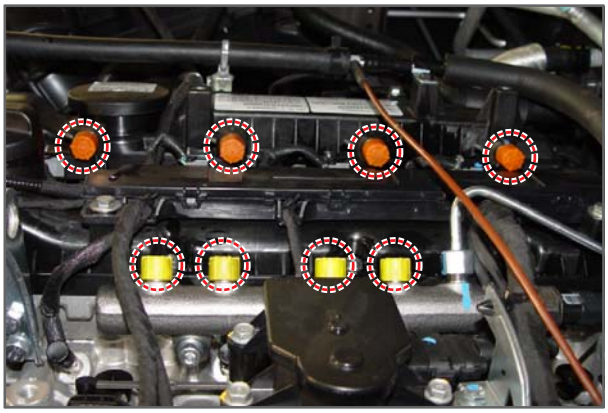
Modification basis	
Application basis	
Affected VIN	

3



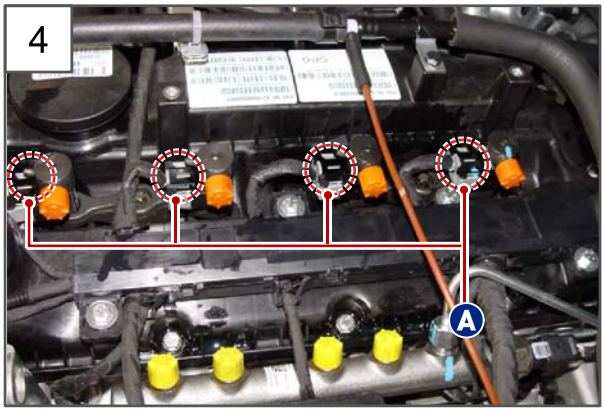
3. Remove the fuel pipe assembly (A).

Tightening torque 30Nm



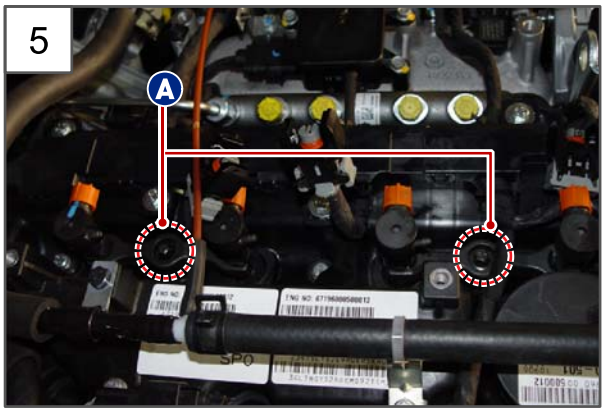
CAUTION
- Replace the fuel pipe assembly with new one.
- Seal the inlets of fuel rail and injector with the sealing caps.

4



4. nnect four connectors (A) from the injector assembly.

5

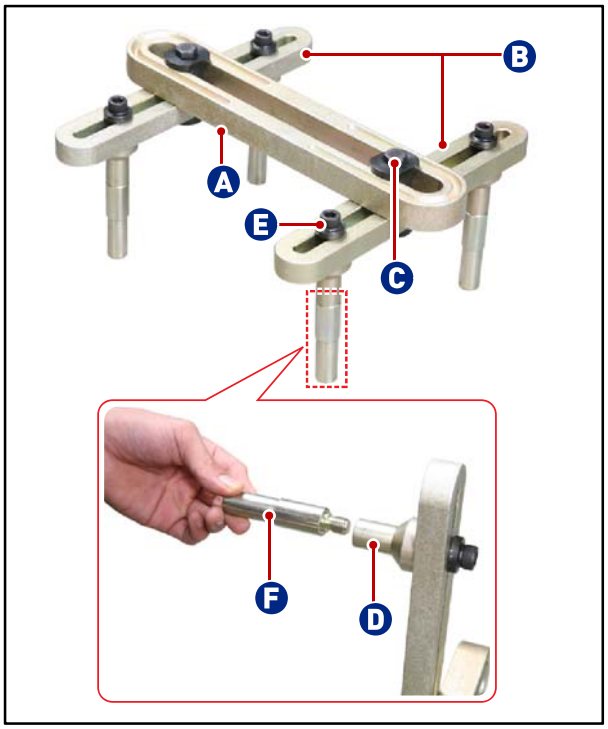


5. Unscrew two bolts (A, E12) from the injector clamp.

Tightening torque 9 ± 1.0Nm(130° ±10°)

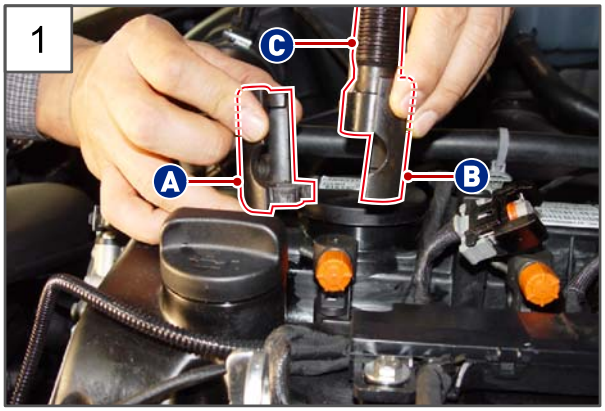
Modification basis	
Application basis	
Affected VIN	

▶ How to assemble the injector remover for Euro-V



1. Temporarily assemble the main bars (A) and cross bar (B) with the bar holders (C).
2. Assemble the main supports (D) and cross bar (B) and temporarily tighten the bolts (E)
3. Install the sub supports (F) at the main supports.

▶ How to set up the injector remover to the vehicle

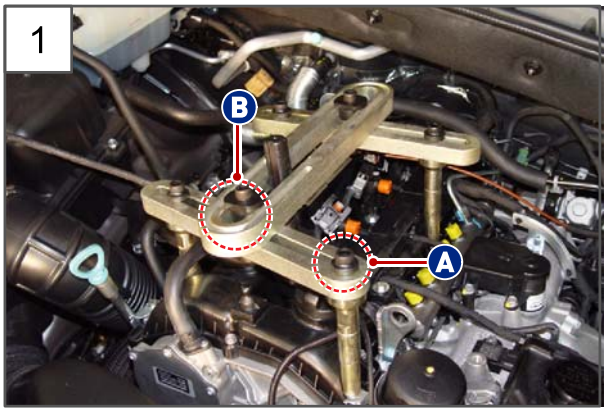


1. Set up the injector holder (A, B) and main bolt (C).
2. Secure the injector holder by inserting the injector holder cover on the main bolt.

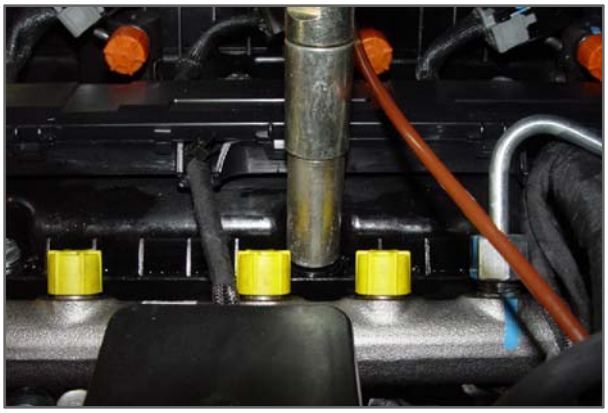
Modification basis	
Application basis	
Affected VIN	

▶ How to remove the injector for Euro-V

1



1. Set up the injector remover assembly on four cylinder head bolts and completely tighten the support mounting bolts (A) and the bar holder bolts (B).



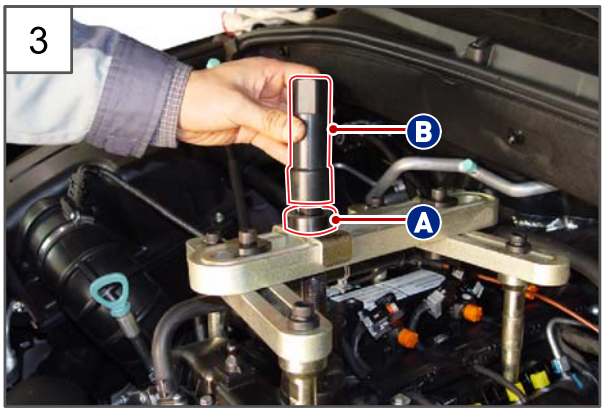
CAUTION

- Pay attention not to damage the other components when installing the main bar assembly.
- The sub supports should be positioned on the cylinder head cover bolts.

2

2. Install the main bolt holder.

3



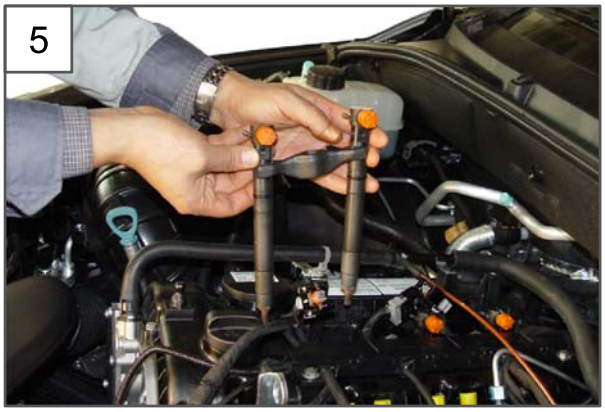
3. Install the ball bearing (A) and the main nut (B) on the main bolt.

4. Slowly release the injector by turning it clockwise with a torque wrench and socket (32 mm).

Tightening torque 98Nm

CAUTION

To avoid any damage to cylinder head and head cover, keep the specified tightening torque.



5. Release the other injector on same clamp with same manner, and remove two injectors with the clamp.

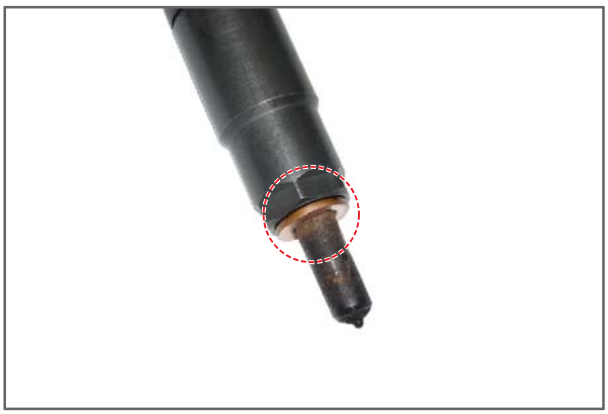
CAUTION

To avoid the damage to injector and engine, the maximum lift should be below 15 mm.

6. Install the injector in the reverse order of removal.

NOTE

Replace the O-ring and washer with new ones.

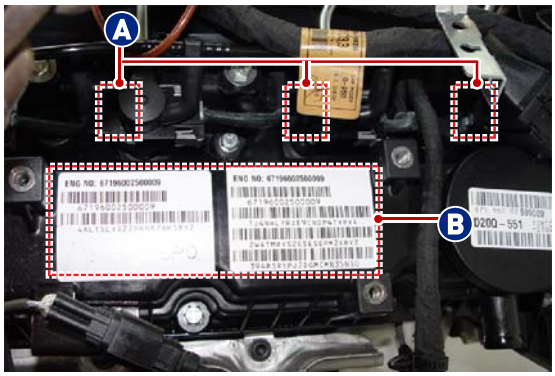


Modification basis	
Application basis	
Affected VIN	

Checking C3I code when installing the injector

C3I [Improved Individual Injector Calibration]	
C3I code	Totally 20 digits (use Arabian numbers (1~9) and Alphabet except I, O, Q, V)
MDP learning	When idling and driving
Numbers of nozzle	Eight

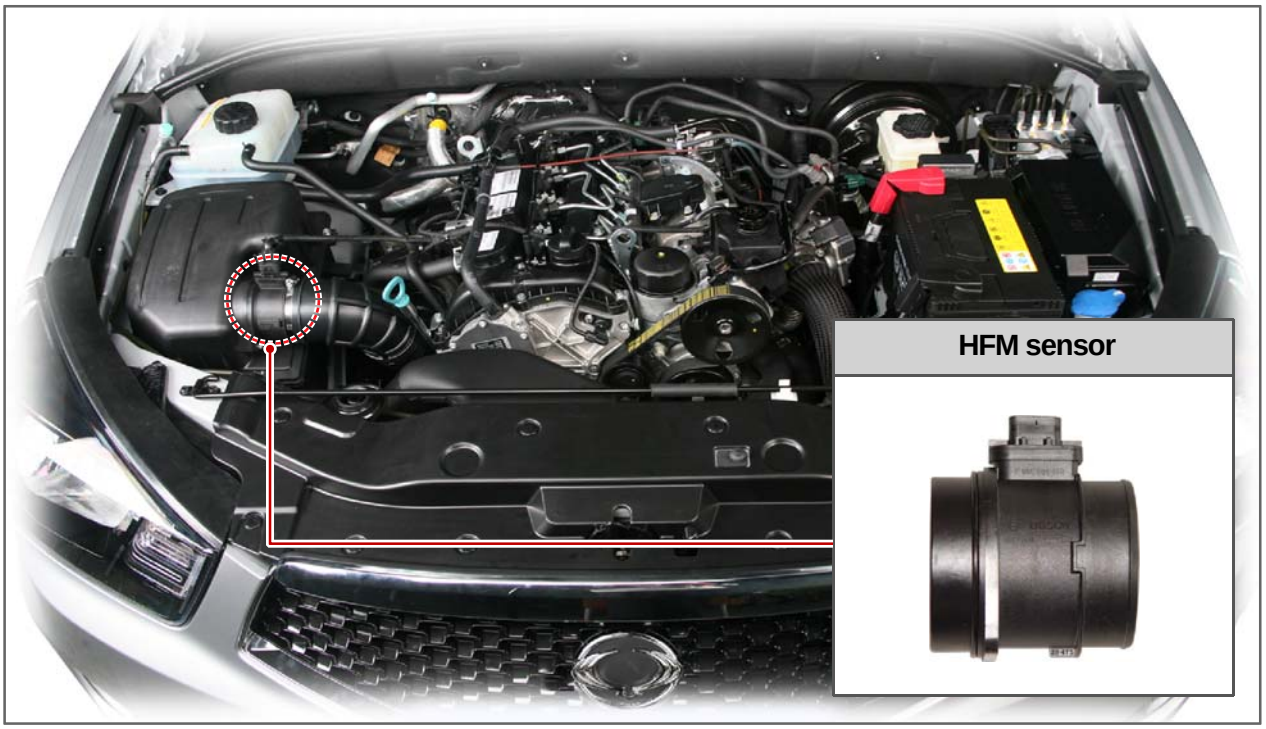
C3I code on injector



(A) on injector	(B) on cylinder head cover
	ENG NO:00000000000000 1. 12345678901234567890 2. 12345678901234567890 3. 12345678901234567890 ENG NO:00000000000000 4. 12345678901234567890
C3I code marked on the upper side of injector	Engine serial number and C3I code for each injector on two labels in cylinder head cover

S.G.N.
2330-08 HFM (HOT FILM AIR-MASS) SENSOR

Preceding work - Disconnect the negative cable from the battery.



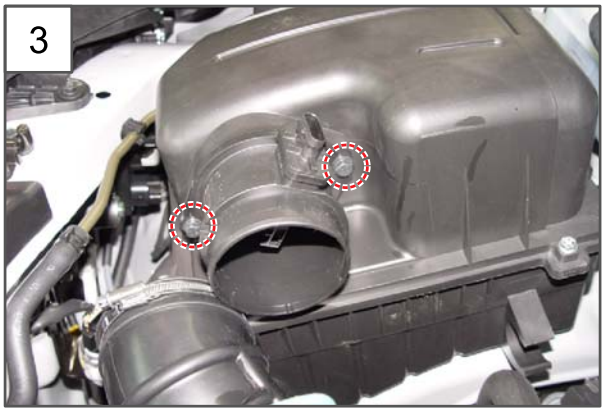
1. Disconnect the HFM sensor connector.

2. Release the spring clamp (7 mm) on the air cleaner hose and set it aside.

Tightening torque 4.9 ~ 5.9Nm

Modification basis	
Application basis	
Affected VIN	

3



3. Unscrew two bolts 910 mm) from the HFM sensor.

Tightening torque 7.8 ~ 11.8Nm

4

4. Remove the HFM sensor.

CAUTION

Replace the O-ring with new one.

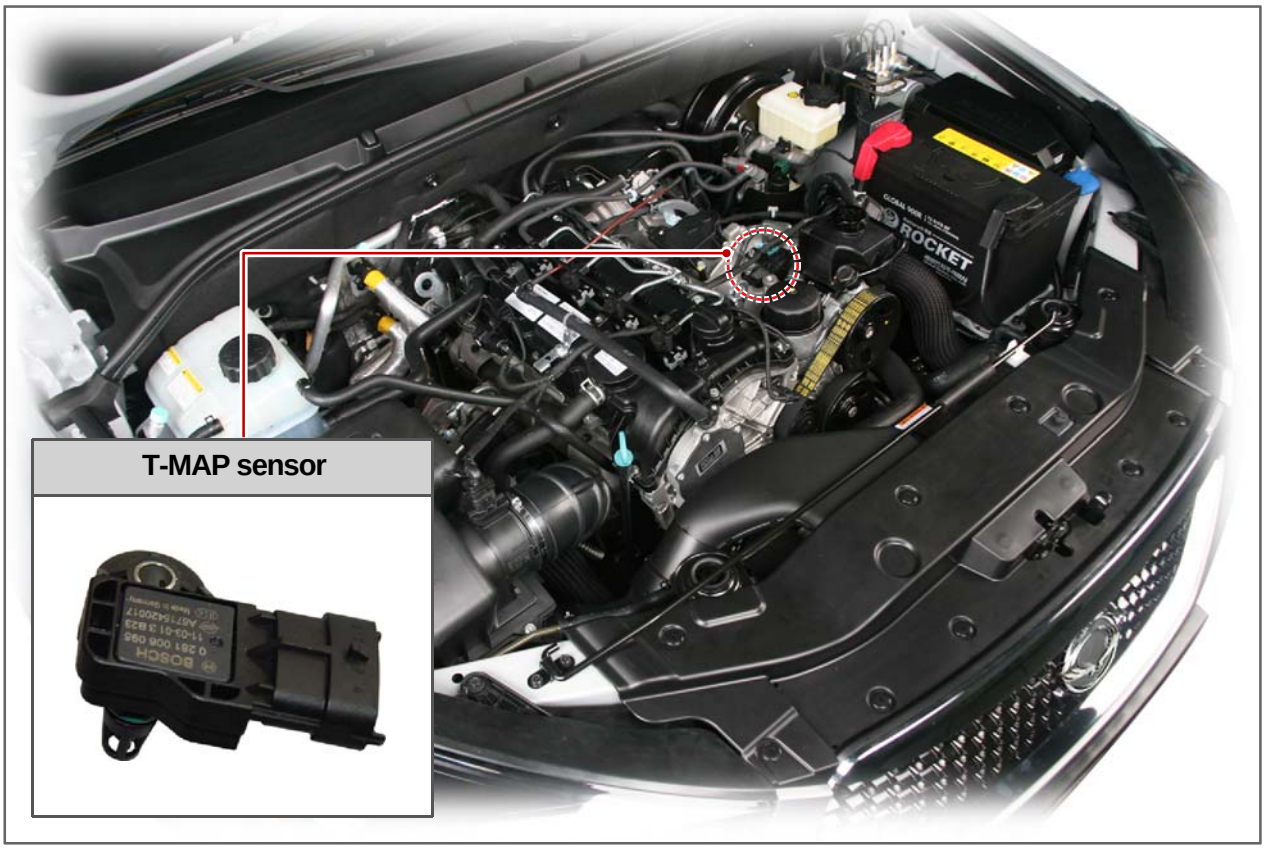
5

5. Install the HFM sensor in the reverse order of removal.

Modification basis	
Application basis	
Affected VIN	

S.G.N.
1432-01 T-MAP (TEMPERATURE-MANIFOLD AIR PRESSURE) SENSOR

Preceding work
- Disconnect the negative cable from the battery.
- Remove the engine acoustic cover.



1. Disconnect the T-MAP sensor connector.

Modification basis	
Application basis	
Affected VIN	

2

2. Unscrew the bolt (10 mm) from the T-MAP sensor.

Tightening torque 10 ± 1.0Nm

3

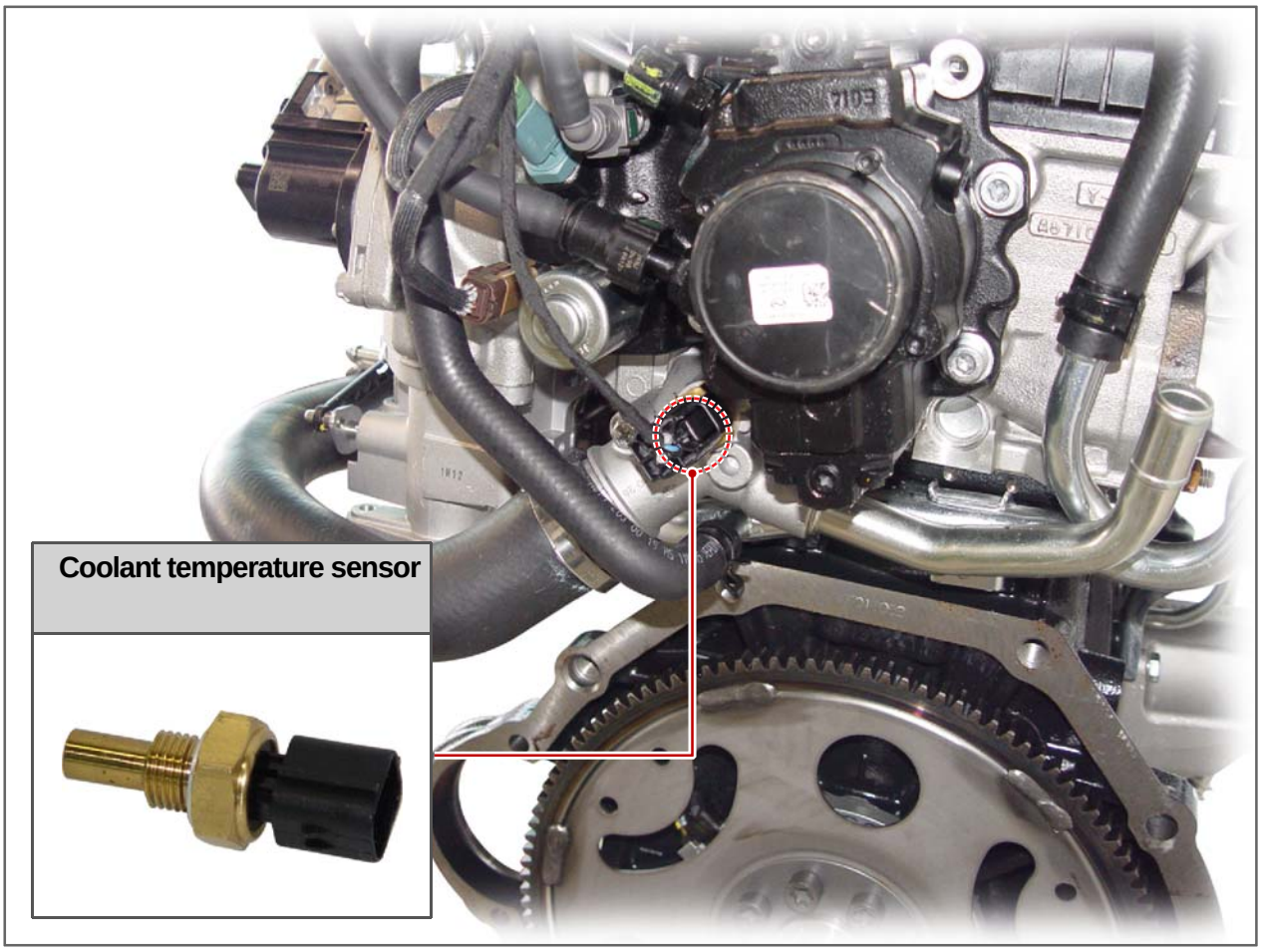
3. Remove the T-MAP sensor.

4

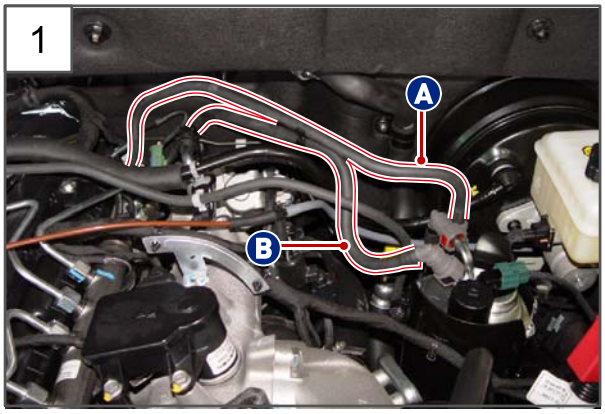
4. Install the T-MAP sensor in the reverse order of removal.

S.G.N.
1432-07 COOLANT TEMPERATURE SENSOR

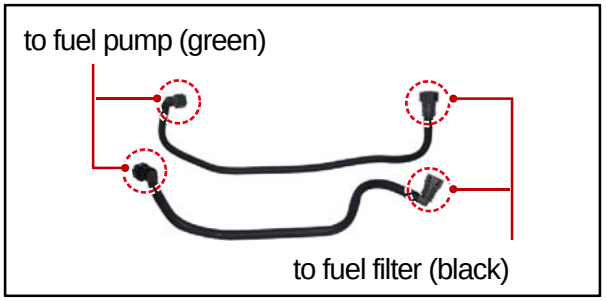
Preceding work
- Disconnect the negative cable from the battery.
- Remove the engine acoustic cover.
- Draing the coolant.



1



1. Disconnect the fuel return tube (A) and the fuel supply tube (B).



Modification basis	
Application basis	
Affected VIN	

2

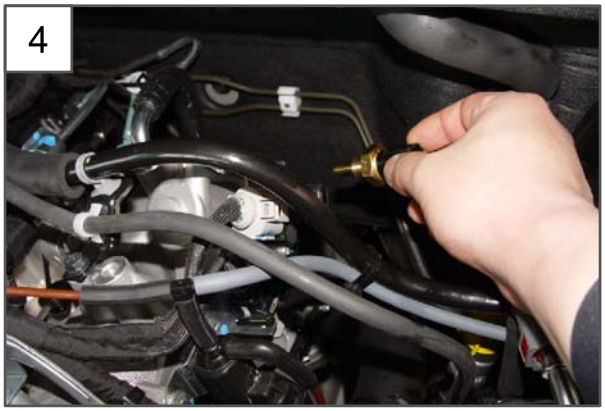
2. Disconnect the coolant temperature sensor connector.

3

3. Turn the coolant temperature sensor to arrow direction with a spanner (32 mm).

Tightening torque **30Nm**

4



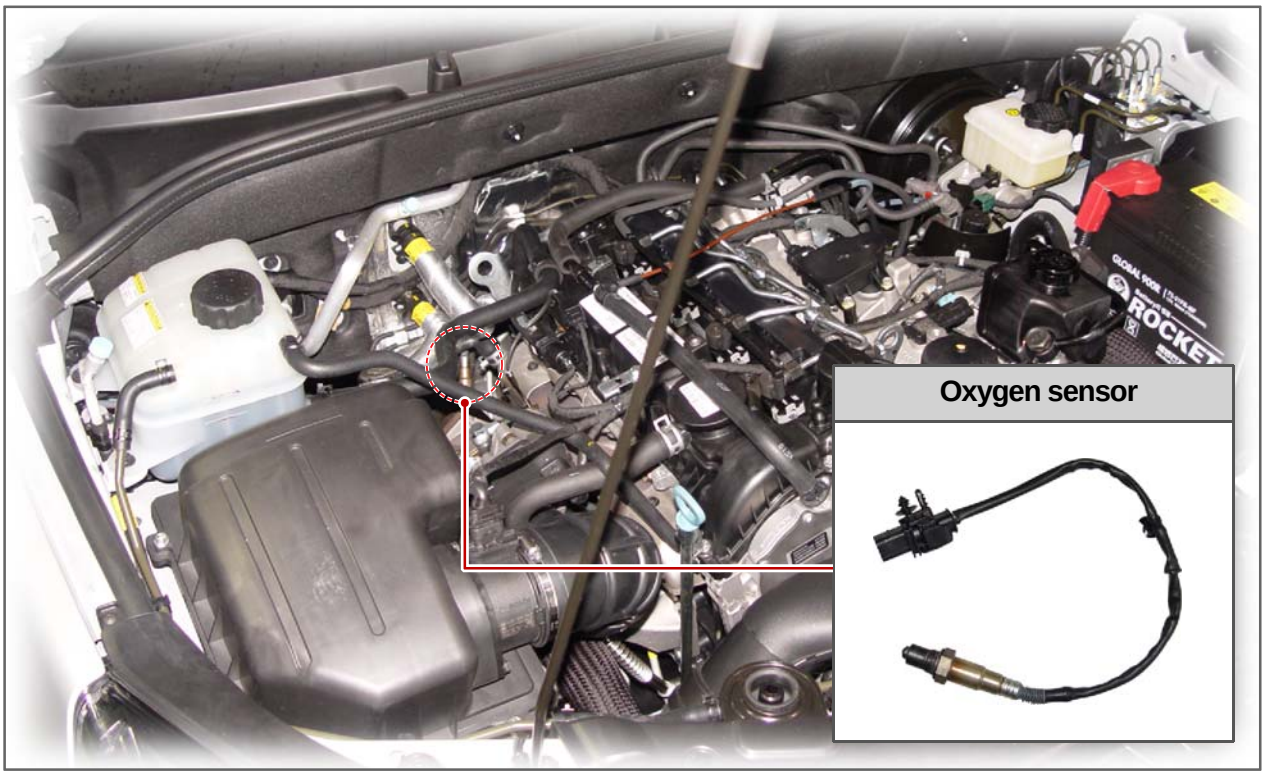
4. Remove the coolant temperature sensor.

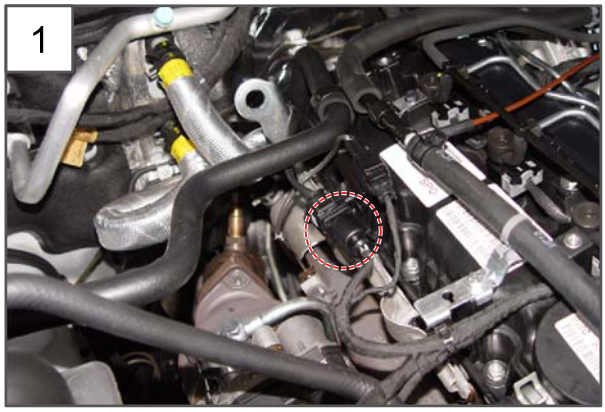
5

5. Install the coolant temperature sensor in the reverse order of removal.

S.G.N.
1432-08 WIDE BAND OXYGEN SENSOR

Preceding work
- Disconnect the negative cable from the battery.
- Remove the engine acoustic cover.

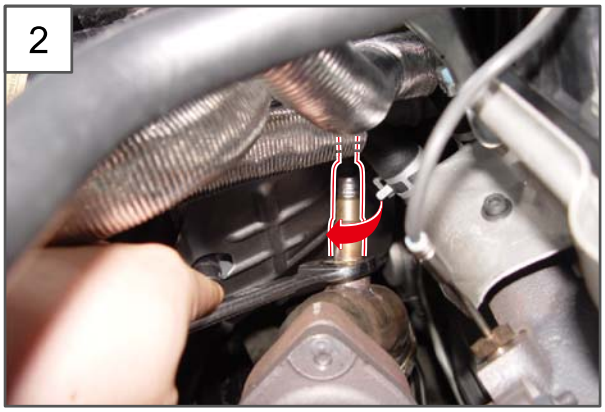




1. Disconnect the oxygen sensor connector.

Modification basis	
Application basis	
Affected VIN	

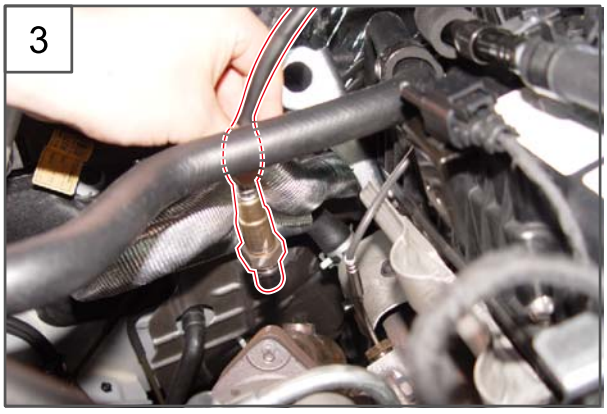
2



2. Turn the oxygen sensor to arrow direction with a spanner (19 mm).

Tightening torque **50 ~ 60Nm**

3



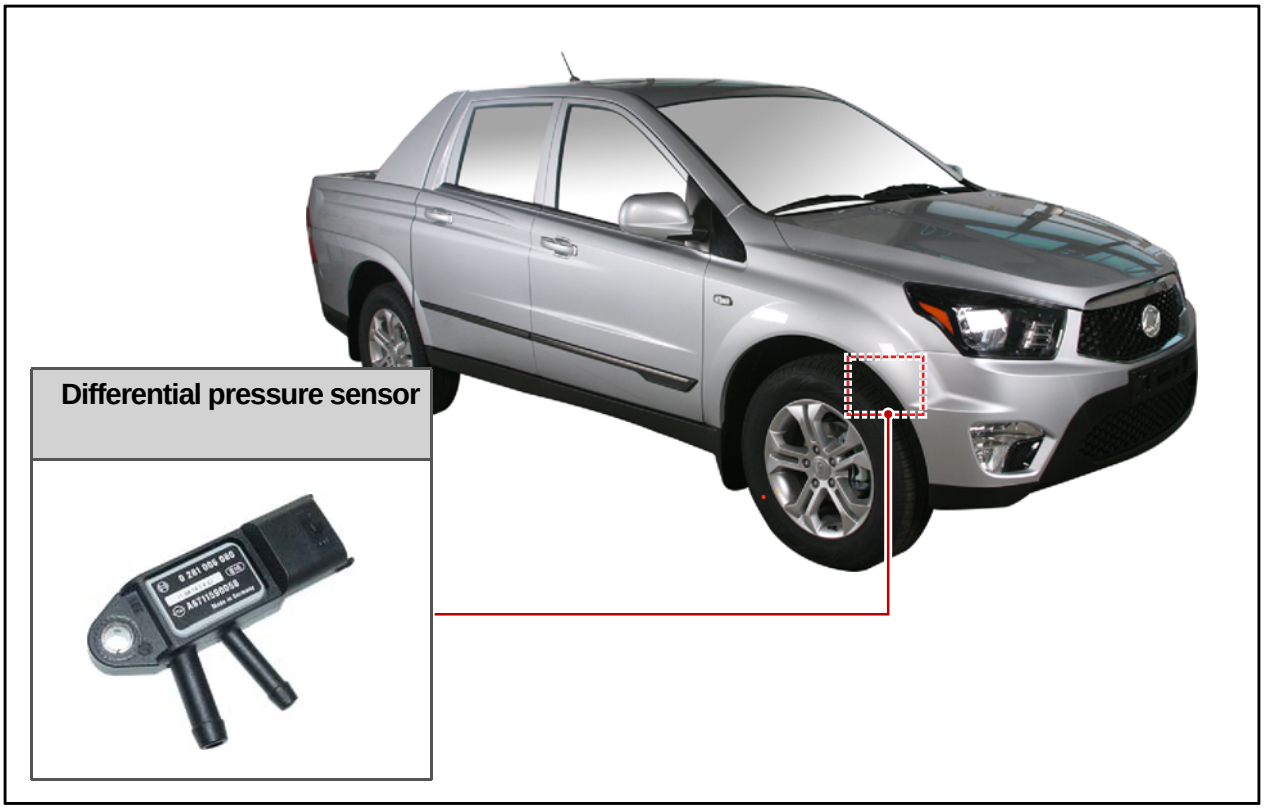
3. Remove the oxygen sensor.

4

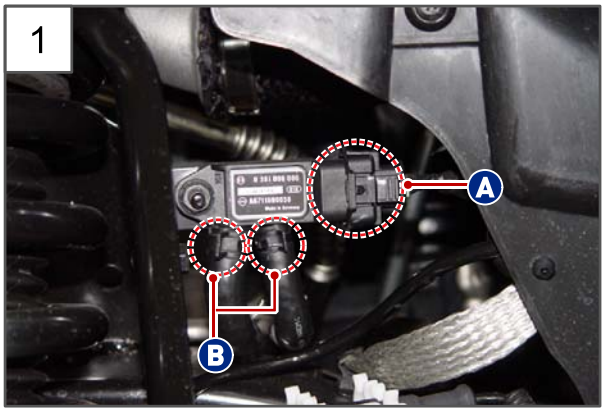
4. Install the oxygen sensor in the reverse order of removal.

S.G.N.
1432-04 DIFFERENTIAL PRESSURE SENSOR

Preceding work - Disconnect the negative cable from the battery.



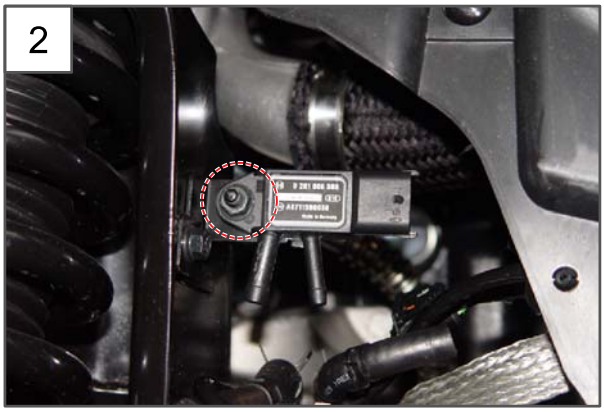
1



1. Disconnect the connector (A) and the inlet/outlet hoses (B) from the differential pressure sensor.

Modification basis	
Application basis	
Affected VIN	

2



2. Unscrew the nut (10 mm) from the differential pressure sensor.

Tightening torque 10 ± 1.0Nm

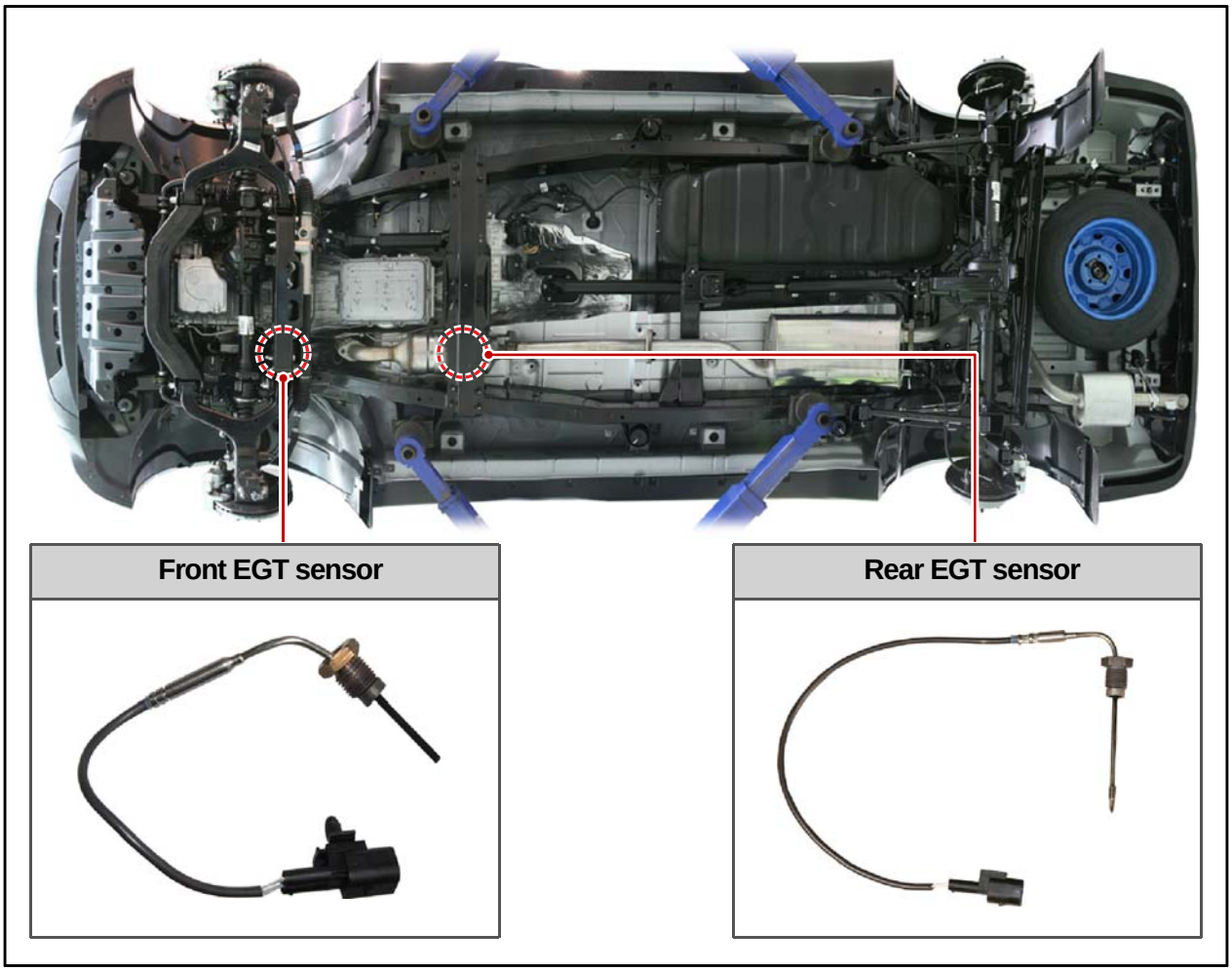
3

3. Install the differential pressure sensor in the reverse order of removal.

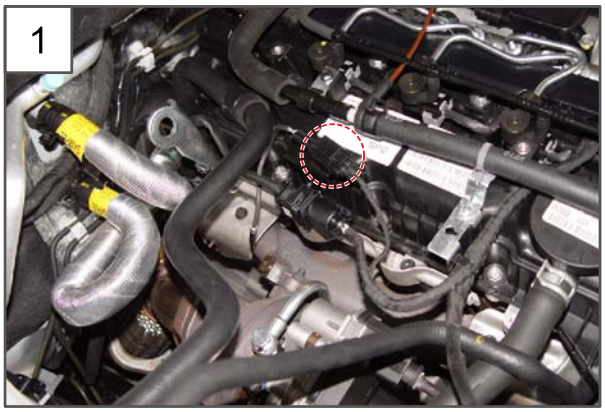
Modification basis	
Application basis	
Affected VIN	

S.G.N.
1432-17 EGT (EXHAUST GAS TEMPERATURE) SENSOR

Preceding work
- Disconnect the negative cable from the battery.
- Remove the engine acoustic cover.



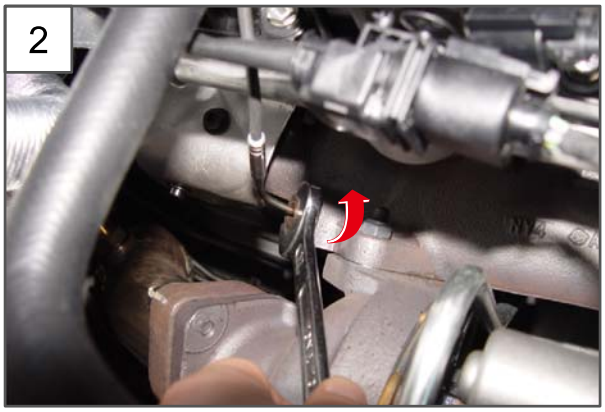
1) Front EGT sensor



1. Disconnect the front EGT sensor connector.

Modification basis	
Application basis	
Affected VIN	

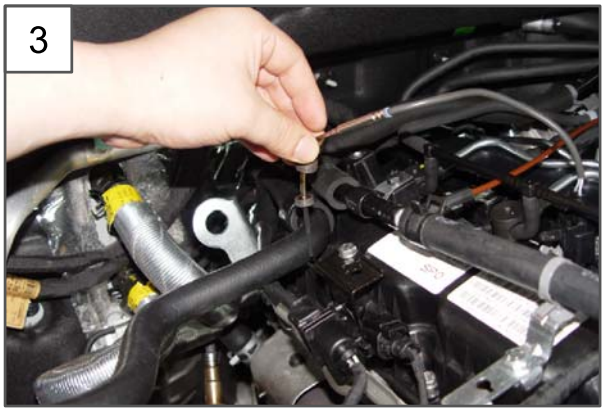
2



2. Turn the front EGT sensor to arrow direction with a spanner (17 mm).

Tightening torque 40 ± 5.0Nm

3



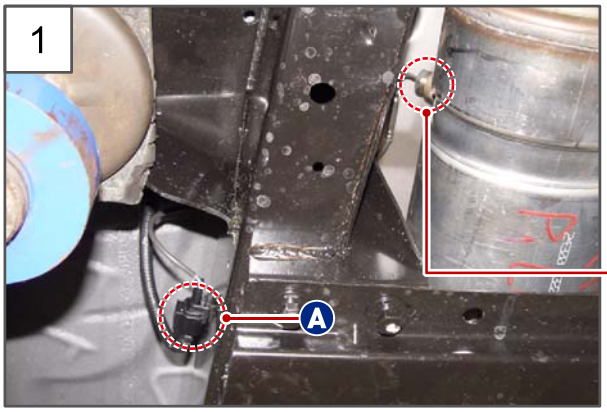
3. Remove the front EGT sensor.

4

4. Install the front EGT sensor in the reverse order of removal.

2) Rear EGT sensor

1



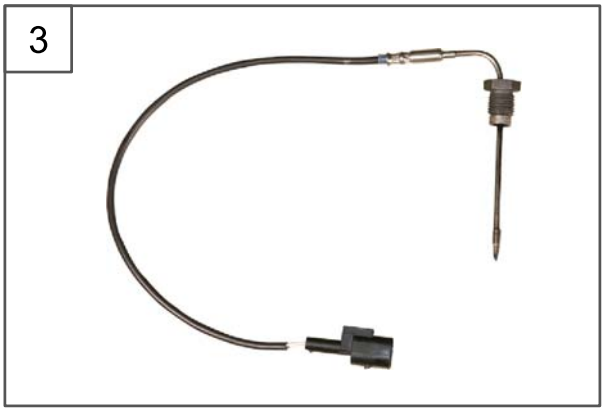
1. Disconnect the rear EGT sensor connector (B) and turn the rear EGT sensor to arrow direction with a spanner (17 mm).

Tightening torque 40 ± 5.0Nm

2

2. Remove the rear EGT sensor.

3



3. Install the rear EGT sensor in the reverse order of removal.

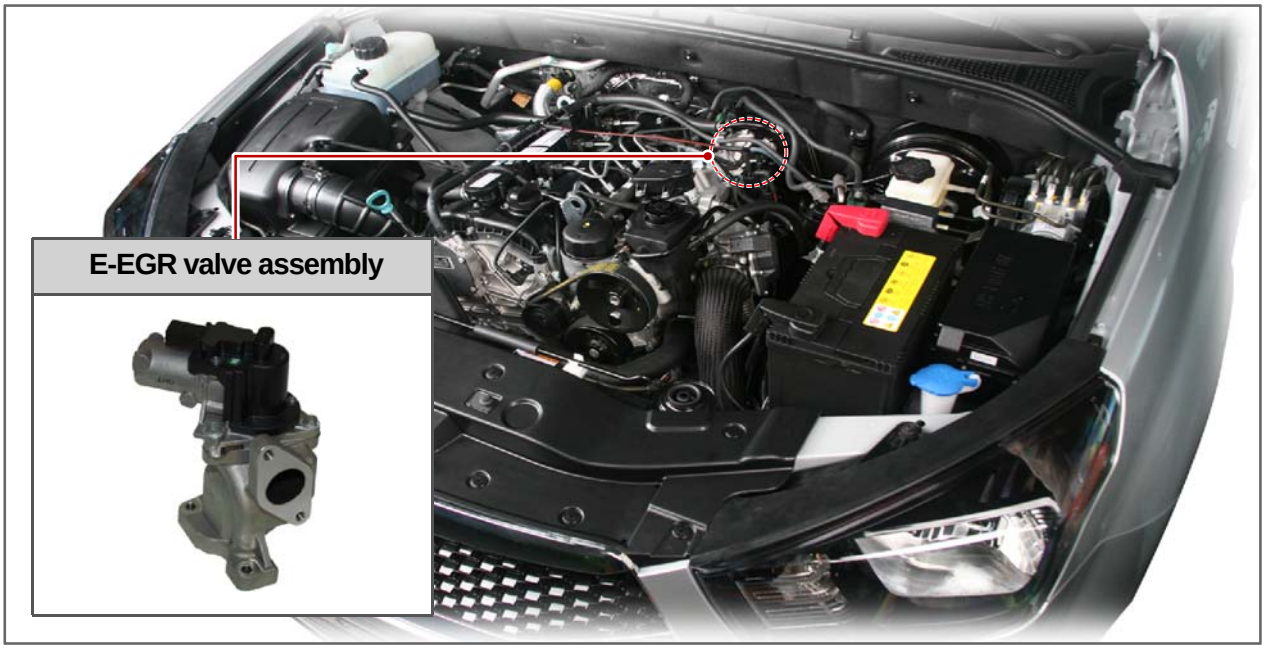
Modification basis	
Application basis	
Affected VIN	

S.G.N.
1793-01

E-EGR (ELECTRIC-EXHAUST GAS RECIRCULATION) VALVE ASSEMBLY

Preceding work

- Disconnect the negative cable from the battery.
- Remove the engine acoustic cover.
- Drain the coolant.

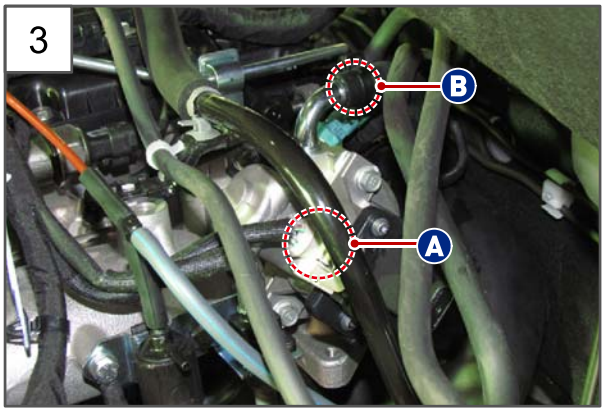


1. Remove the fuel filter assembly.
   (Refer to Chapter "Fuel System".)

2. Remove the EGR cooler assembly.
   (Refer to Chapter "E-EGR Assembly".)

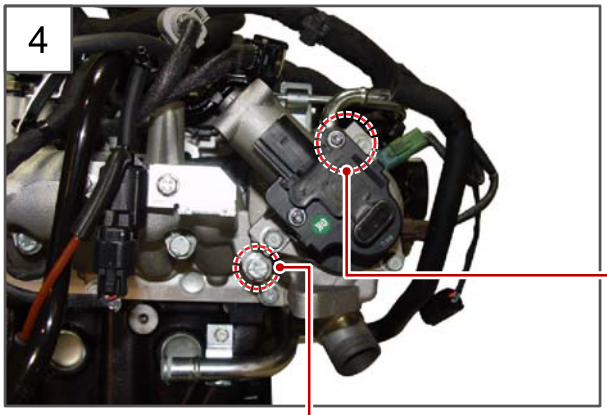
Modification basis	
Application basis	
Affected VIN	

3



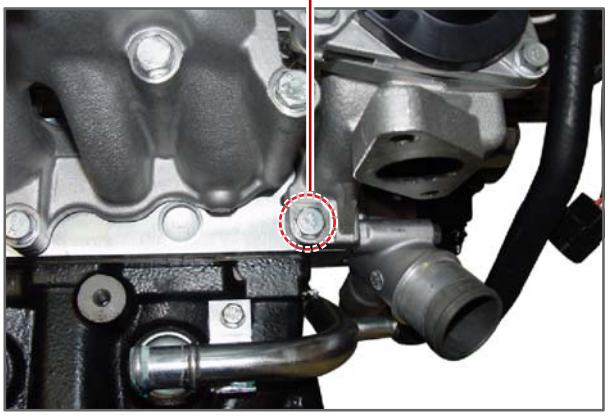
3. Disconnect the E-EGR valve connector (A) and hose (B).

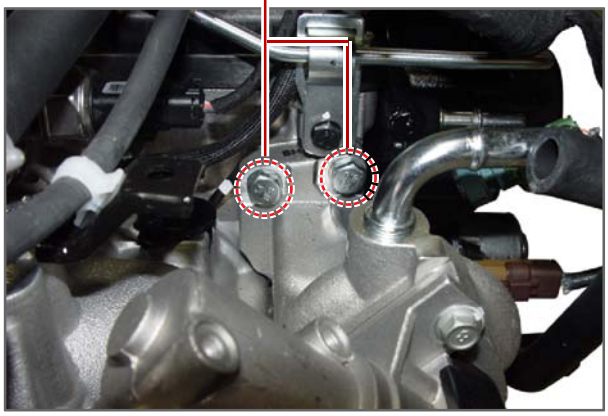
4



4. Unscrew three bolts (13 mm) from the E-EGR valve assembly.

Tightening torque 25 ± 2.5Nm





5

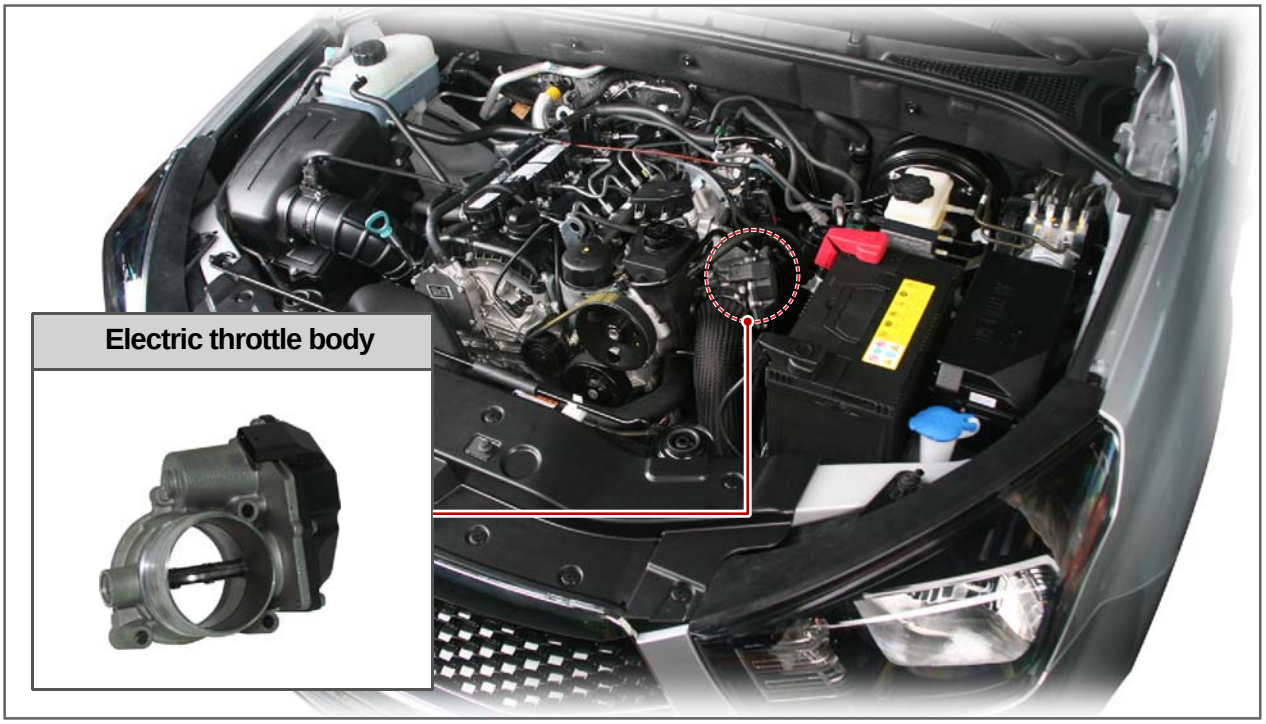
5. Remove the E-EGR valve assembly.

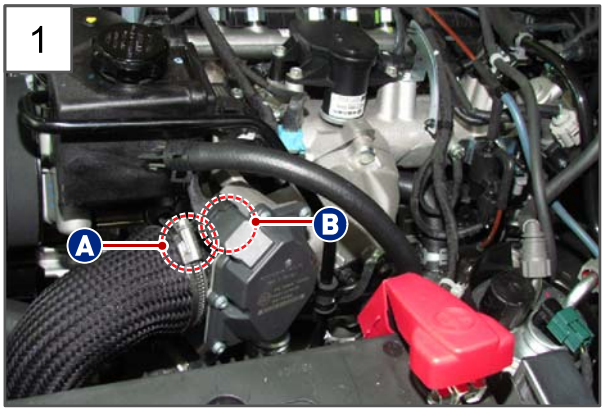
6. Install the E-EGR valve assembly in the reverse order of removal.

Modification basis	
Application basis	
Affected VIN	

S.G.N.
1719-16 ELECTRIC THROTTLE BODY

Preceding work
- Disconnect the negative cable from the battery.
- Remove the engine acoustic cover.

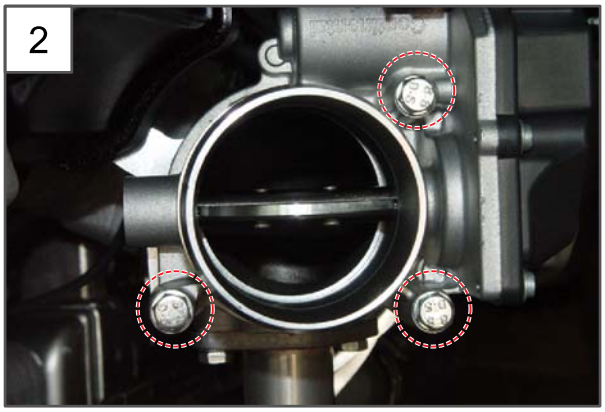




1. Release the spring clamp (A, 7mm) on the intercooler hose and disconnect the connector from the electric throttle body.

Tightening torque (A) 6.0 ~ 7.0Nm

Modification basis	
Application basis	
Affected VIN	



2. Unscrew three bolts (10 mm) from the electric throttle body.

Tightening torque 10 ± 1.0Nm

3. Remove the electric throttle body.

4. Install the electric throttle body in the reverse order of removal

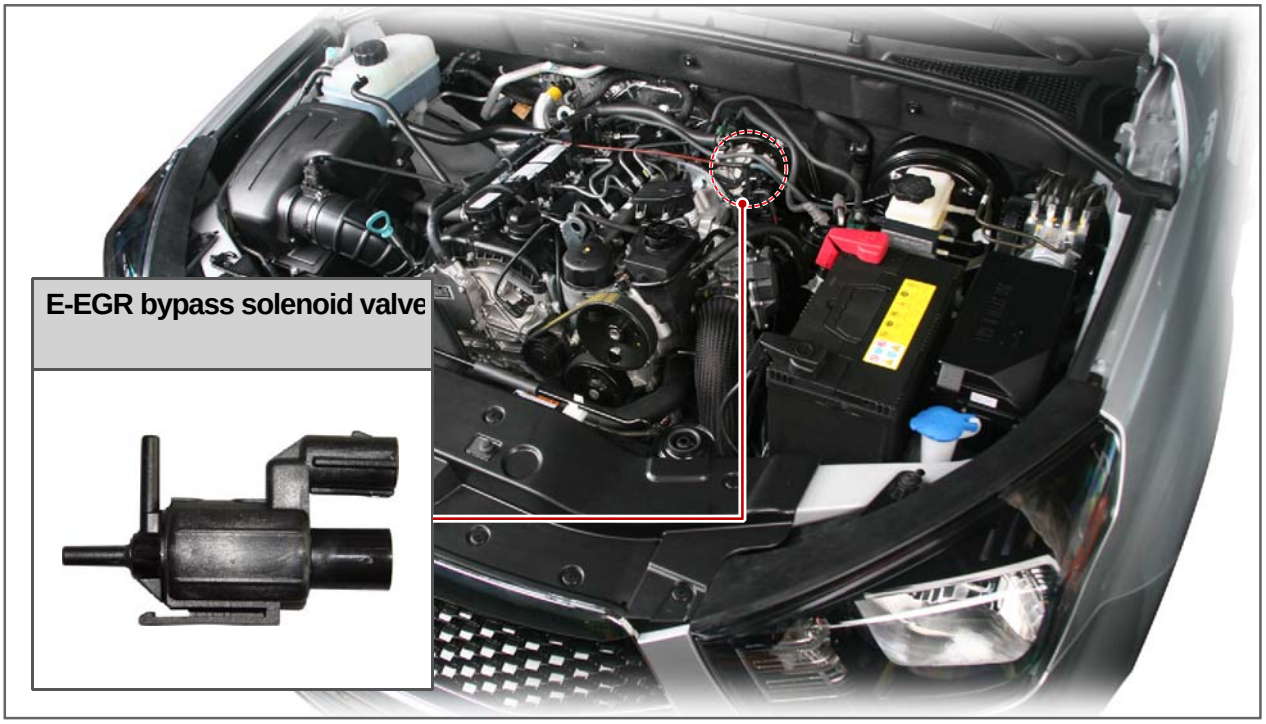
NOTE

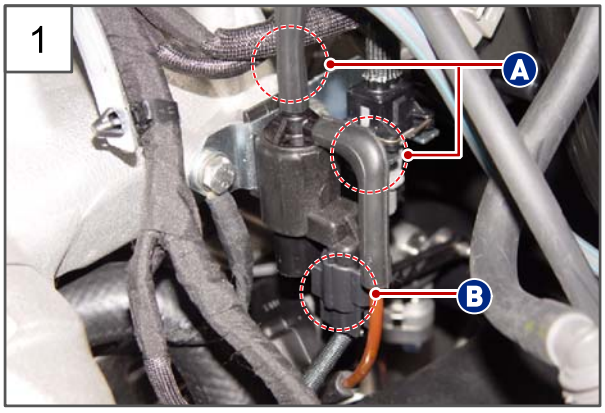
Replace the O-ring with new one.

Modification basis	
Application basis	
Affected VIN	

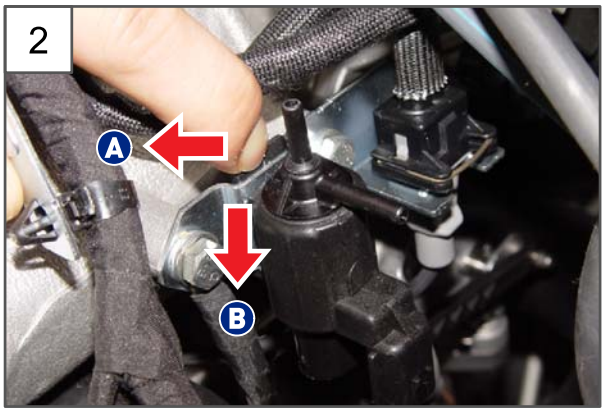
S.G.N.
1432-14 E-EGR BYPASS SOLENOID VALVE

Preceding work
- Disconnect the negative cable from the battery.
- Remove the engine acoustic cover.





1. Disconnect two vacuum hoses (A) and the connector (B) from the E-EGR bypass solenoid valve.



2. Pull the lock key to direction (A), push it direction (B).

Modification basis	
Application basis	
Affected VIN	

3

3. Remove the E-EGR bypass solenoid valve.

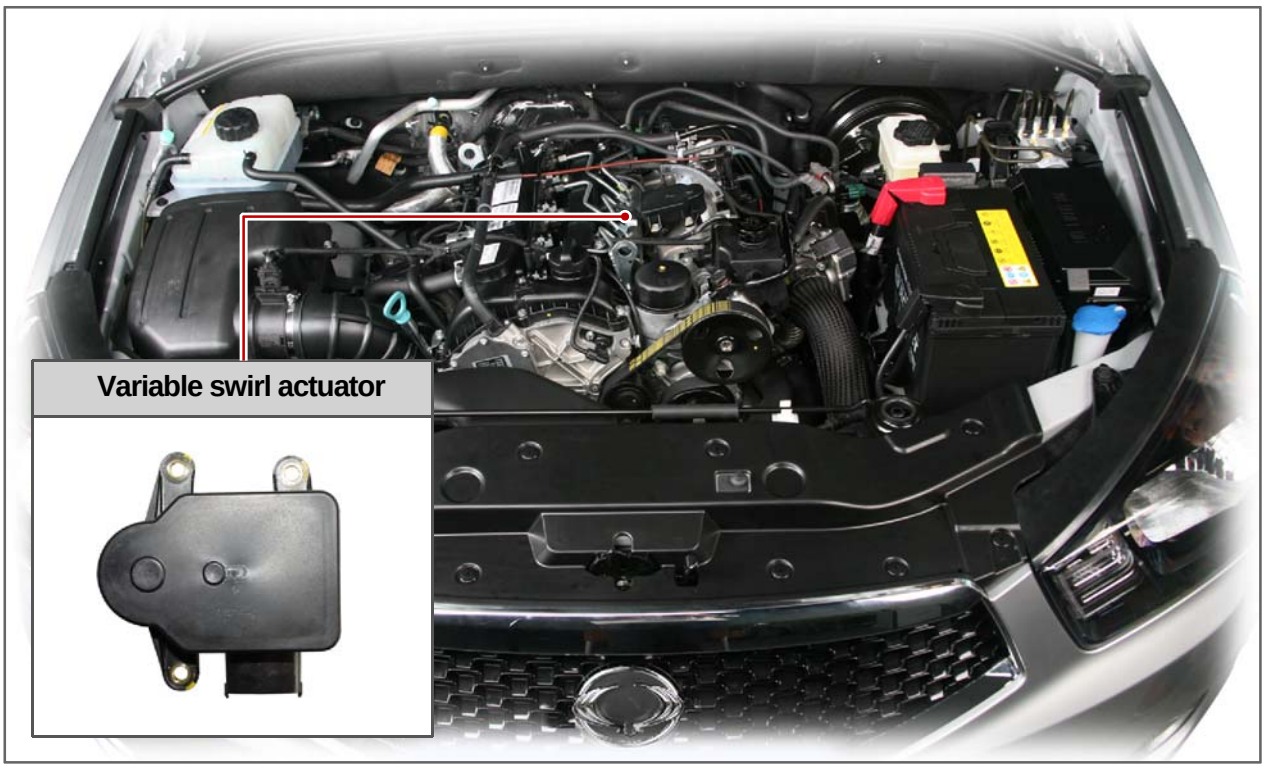
4

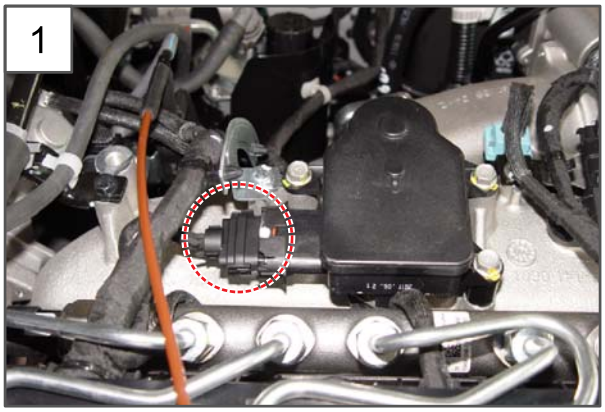
4. Install the E-EGR bypass solenoid valve in the reverse order of removal.

Modification basis	
Application basis	
Affected VIN	

S.G.N.
1729-02 VARIABLE SWIRL ACTUATOR

Preceding work
- Disconnect the negative cable from the battery.
- Remove the engine acoustic cover.

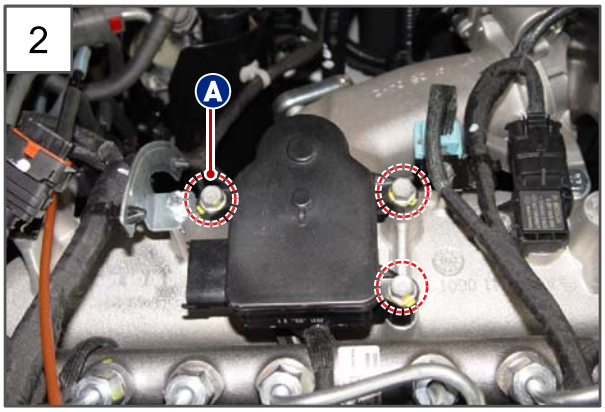




1. Disconnect the variable swirl actuator connector.

Modification basis	
Application basis	
Affected VIN	

2



2. Unscrew three bolts (10 mm) from the variable swirl actuator.

Tightening torque 10 ± 1.0Nm

CAUTION

Make sure keep the spacer (A) in a safe place.

3

3. Separate the link to arrow direction.

4

4. Remove the variable swirl actuator.

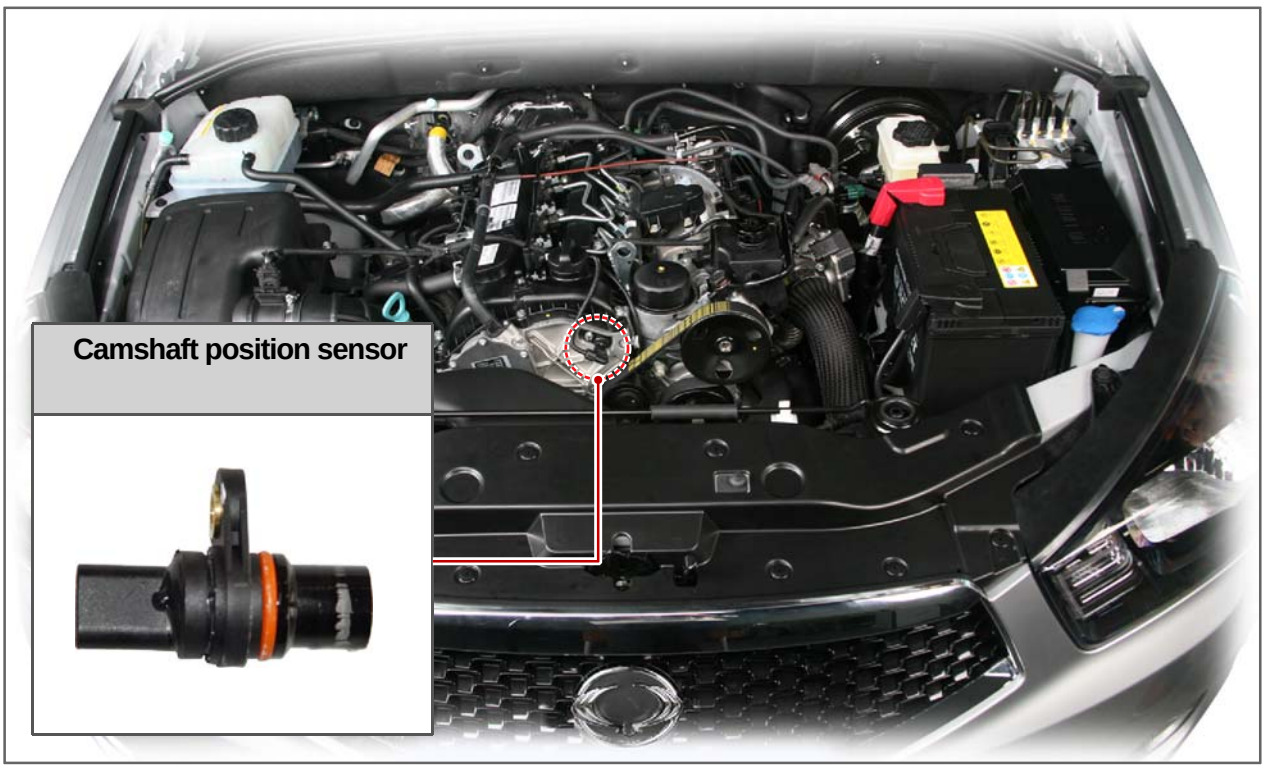
5

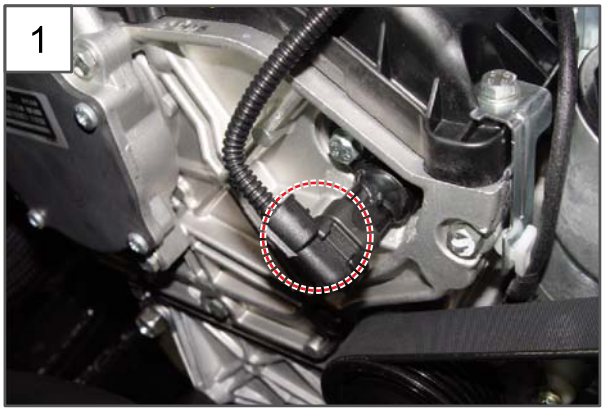
5. Install the variable swirl actuator in the reverse order of removal.

Modification basis	
Application basis	
Affected VIN	

S.G.N.
1432-03 CAMSHAFT POSITION SENSOR

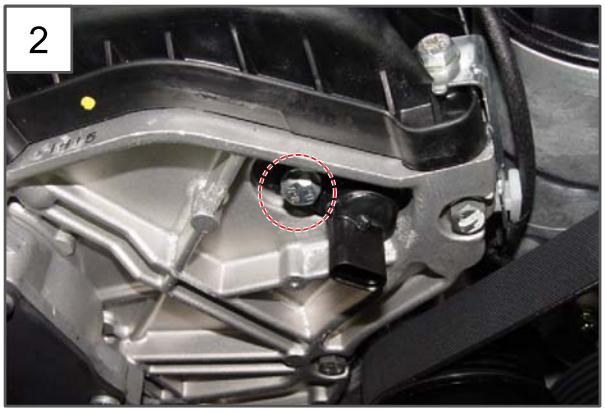
Preceding work
- Disconnect the negative cable from the battery.
- Remove the engine acoustic cover.





1. Disconnect the camshaft position sensor.

Modification basis	
Application basis	
Affected VIN	



2. Unscrew the bolt (10 mm) from the camshaft position sensor.

Tightening torque 12 ± 2Nm

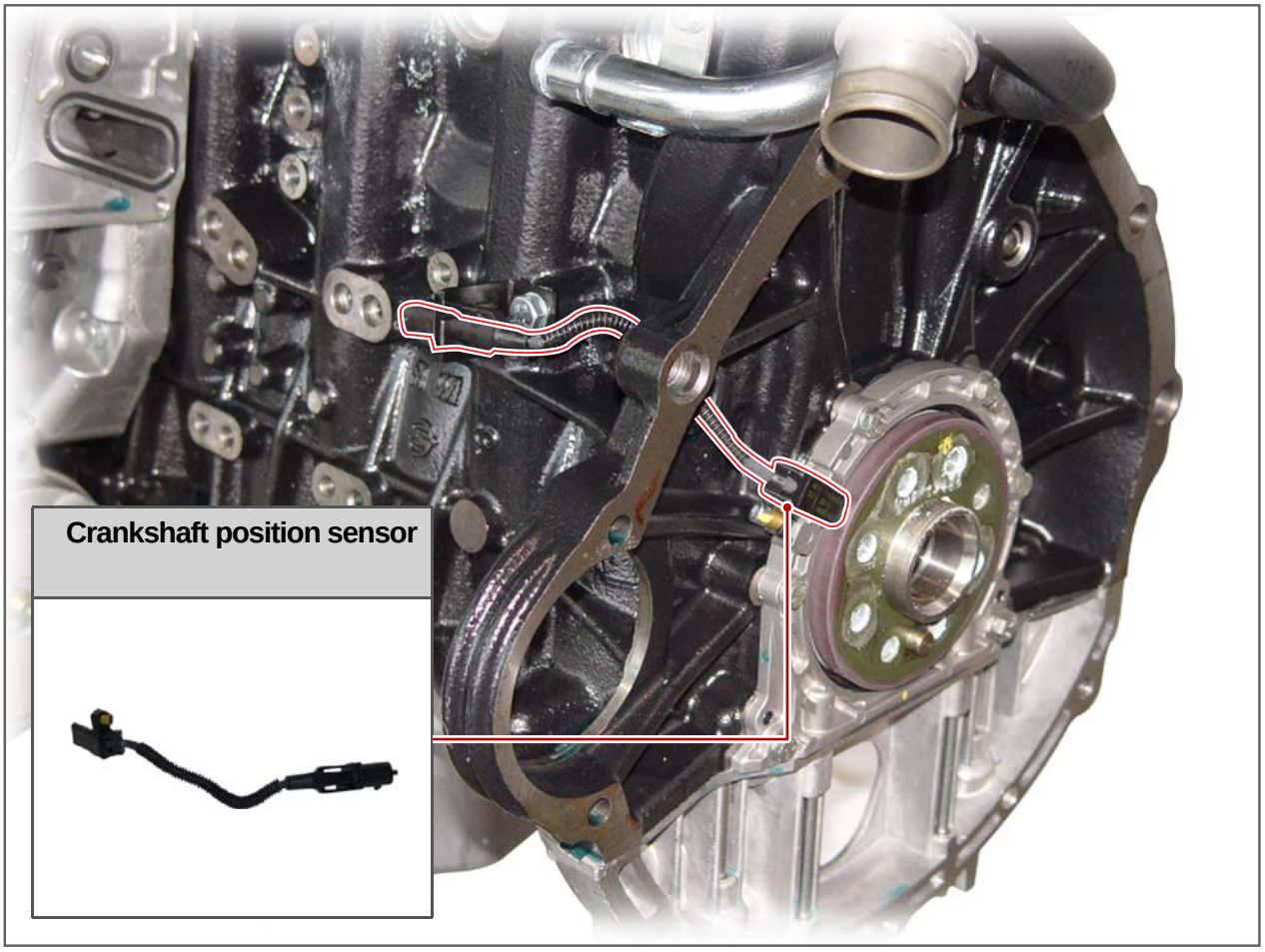
3. Remove the camshaft position sensor.

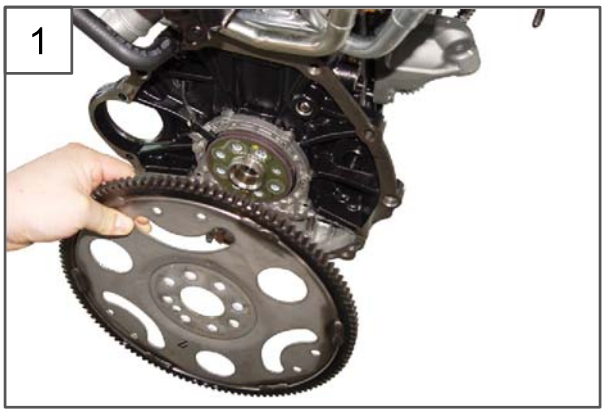
4. Install the camshaft position sensor in the reverse order of removal.

Modification basis	
Application basis	
Affected VIN	

S.G.N.
1127-35 CRANKSHAFT POSITION SENSOR

Preceding work
- Disconnect the negative cable from the battery.
- - Remove the transmission.



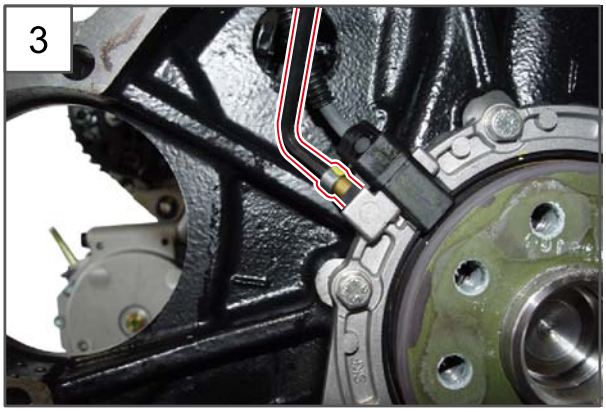


1. Remove the drive plate assembly.

NOTE
In this section, the working procedures are based on the automatic transmission. In the vehicle with the manual transmission, remove the DMF assembly.

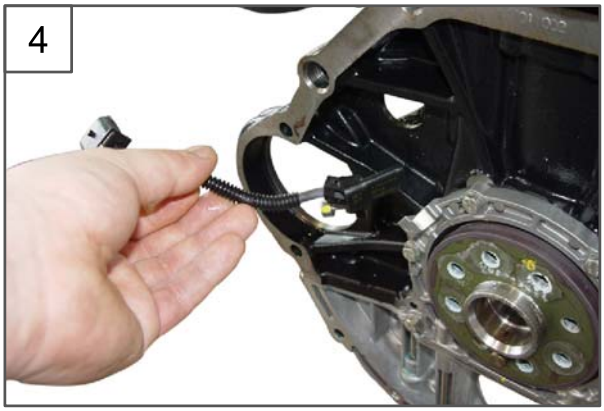
Modification basis	
Application basis	
Affected VIN	

2. Disconnect the crankshaft position sensor connector.



3. Unscrew the hexagon bolt (4 mm) from the crankshaft position sensor.

Tightening torque **10 ± 1.0Nm**



4. Remove the crankshaft position sensor.

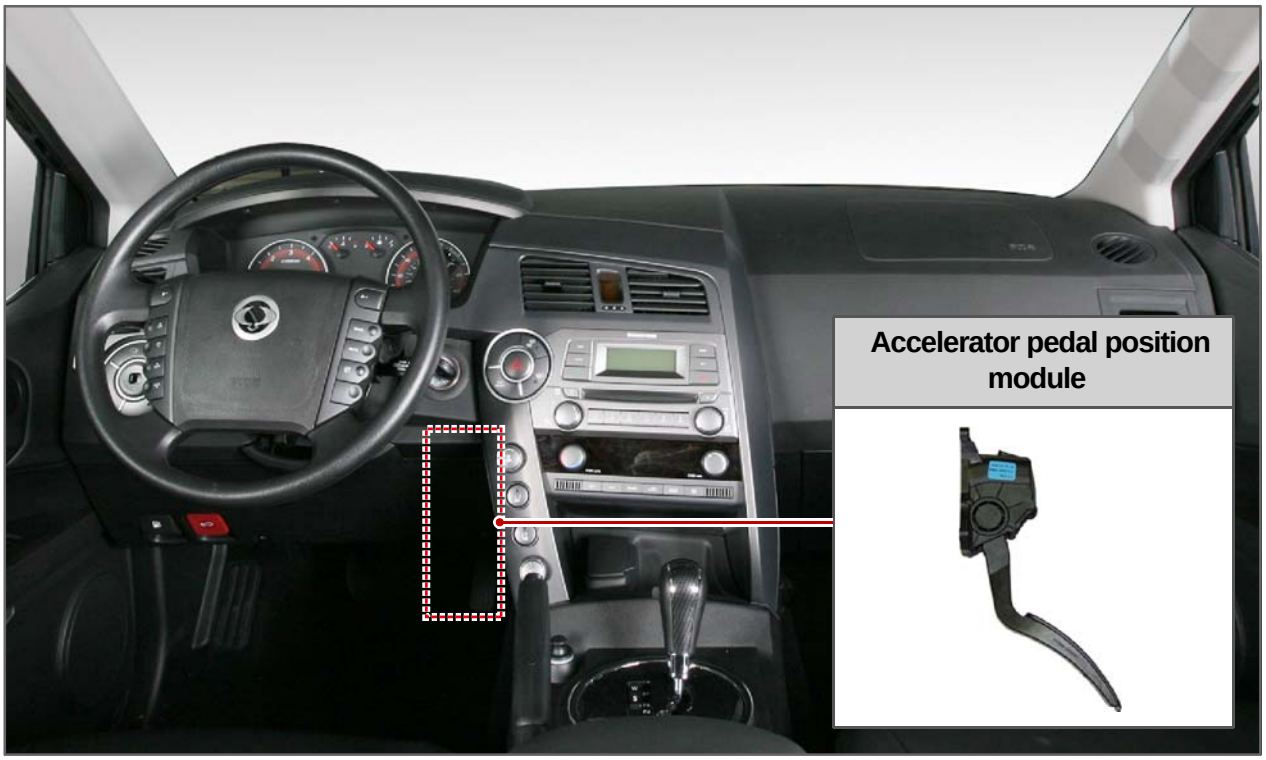
5. Install the crankshaft position sensor in the reverse order of removal.

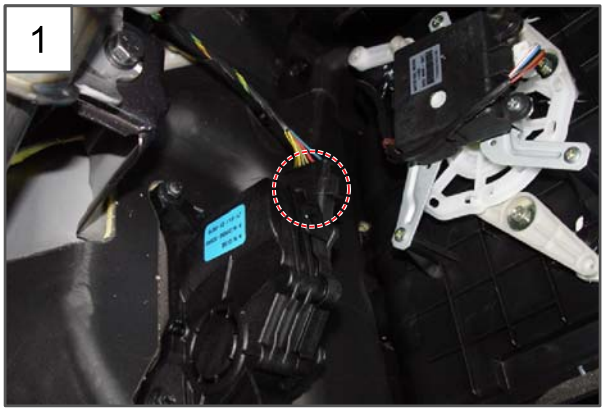
Modification basis	
Application basis	
Affected VIN	

S.G.N.
2010-01

ACCELERATOR PEDAL POSITION MODULE

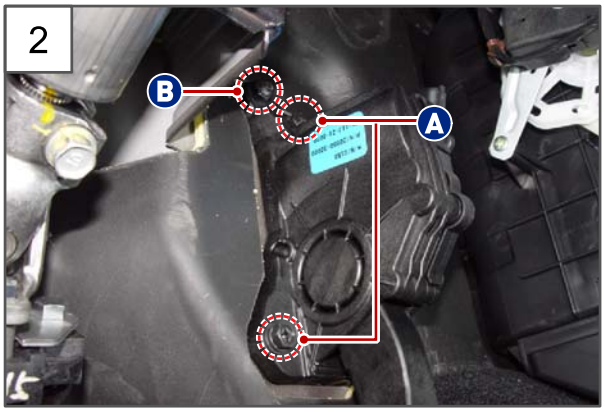
Preceding work - Disconnect the negative cable from the battery.





1. Disconnect the accelerator pedal position module connector.

Modification basis	
Application basis	
Affected VIN	



2. Unscrew two bolts (A, 10 mm) and the nut (B, 10 mm) from the accelerator pedal position module.

Tightening torque (A), (B) 10 ± 1.0Nm

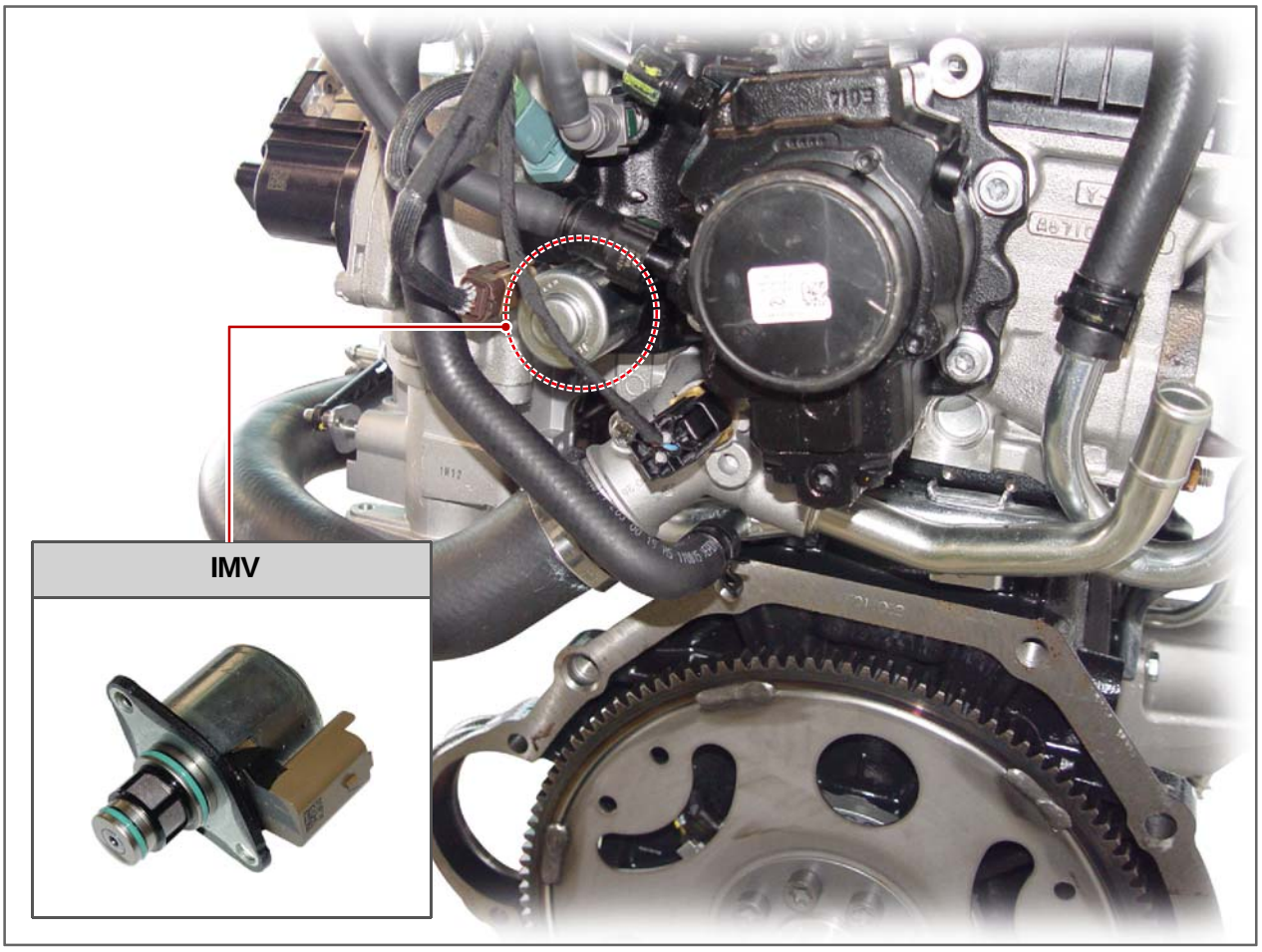
3. Remove the accelerator pedal position module.

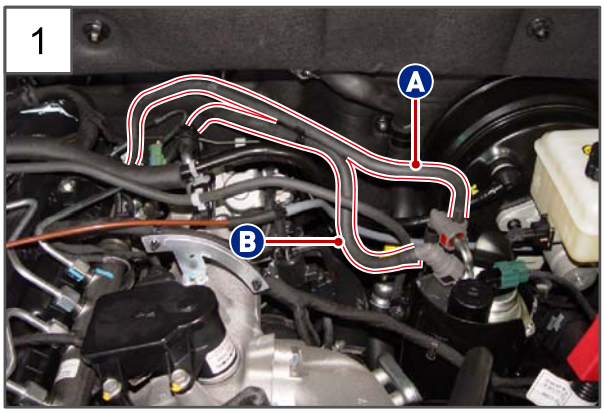
4. Install the accelerator pedal position module in the reverse order of removal.

Modification basis	
Application basis	
Affected VIN	

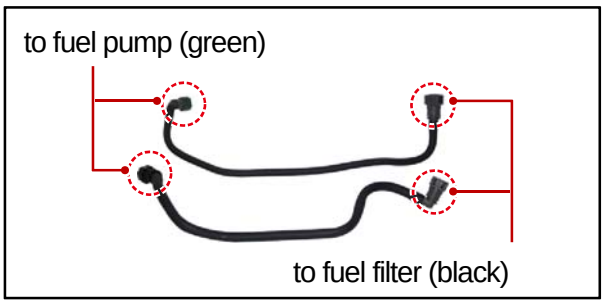
S.G.N.
1882-01 IMV (INLET METERING VALVE)

Preceding work
- Disconnect the negative cable from the battery.
- Remove the engine acoustic cover.

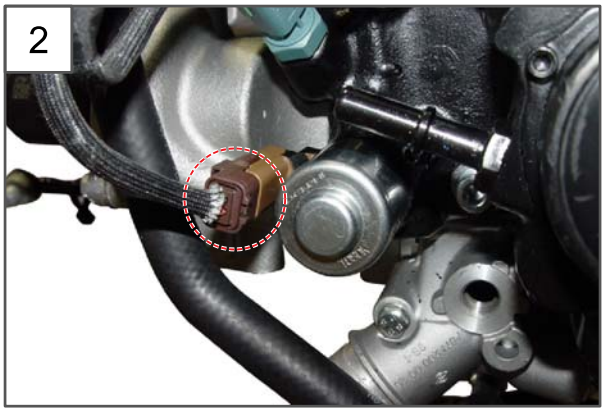




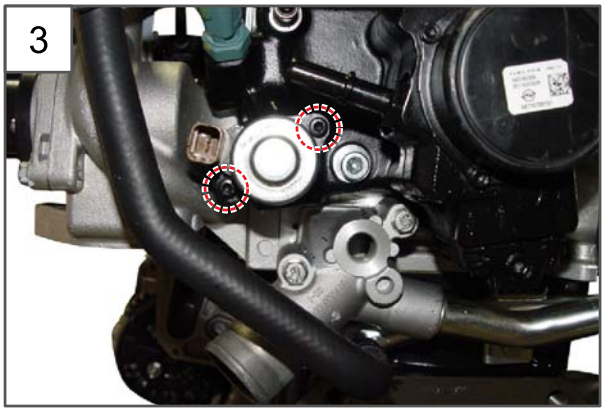
1. Disconnect the fuel return tube (A) and the fuel supply tube (B).



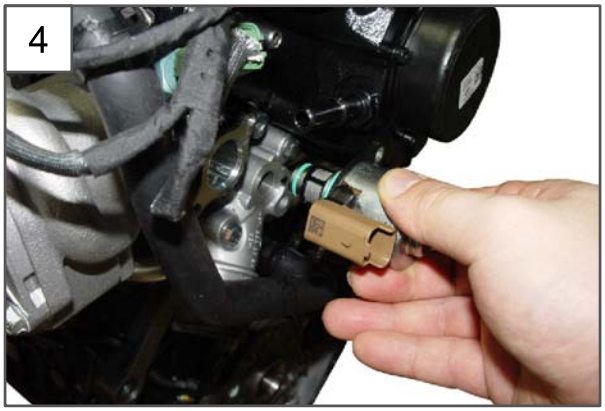
Modification basis	
Application basis	
Affected VIN	



2. Disconnect the IMV connector.



3. Unscrew two bolts (T25) from the IMV.



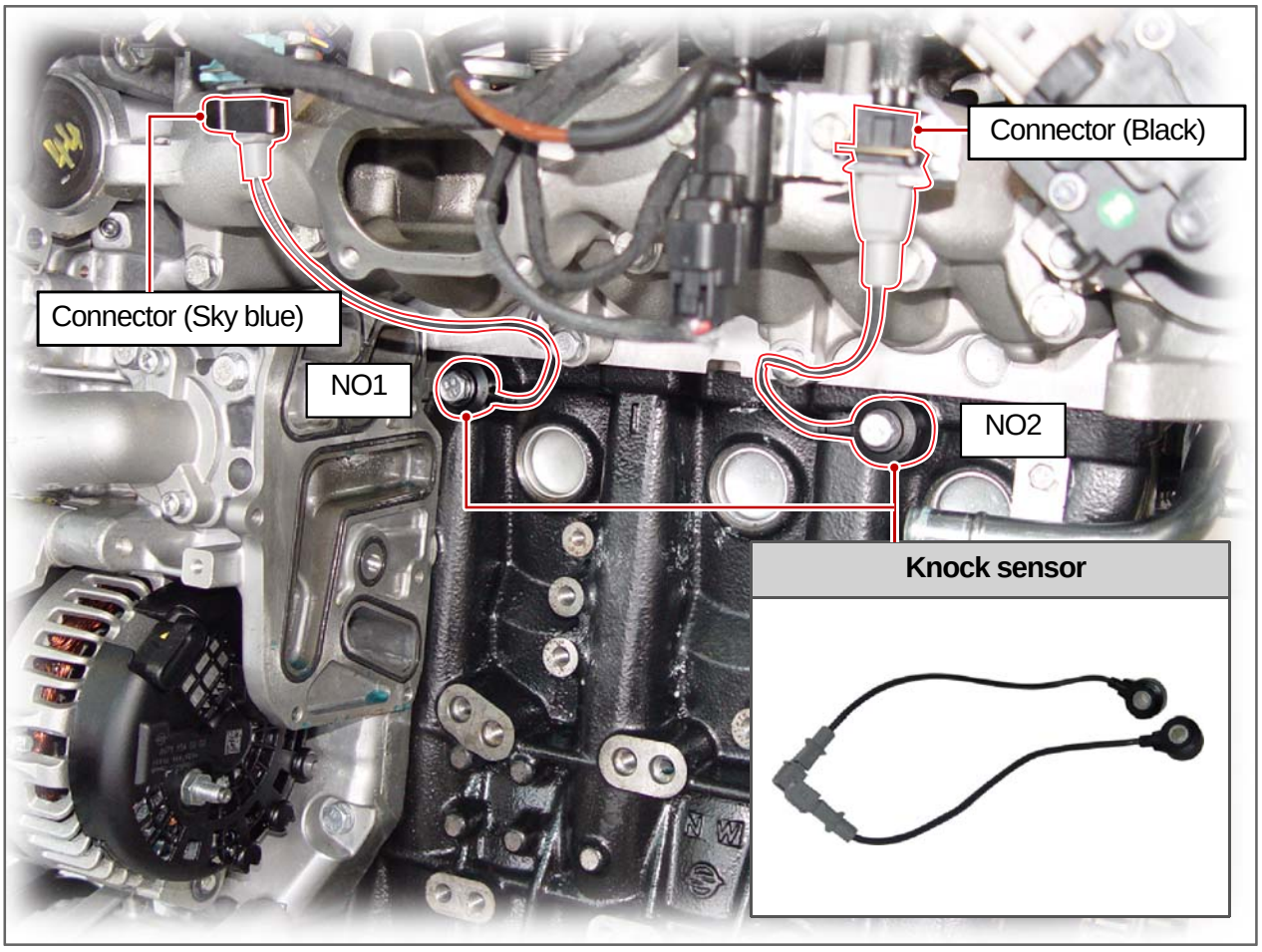
4. Remove the IMV.

5. Install the IMV in the reverse order of removal.

Modification basis	
Application basis	
Affected VIN	

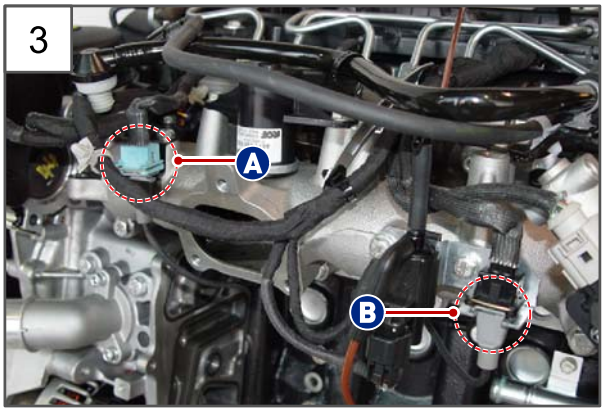
S.G.N.
1432-05 KNOCK SENSOR

Preceding work
- Disconnect the negative cable from the battery.
- Remove the engine acoustic cover.
- Drain the coolant.

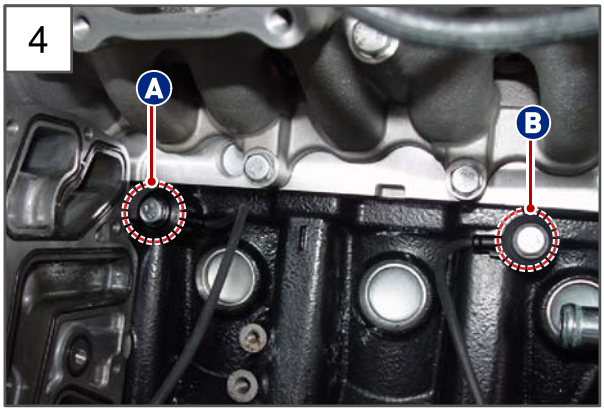


1. Remove the EGR cooler assembly. (Refer to Chapter "E-EGR System".)

2. Remove the oil cooler assembly.
   (Refer to Chapter "Lubrication System".)

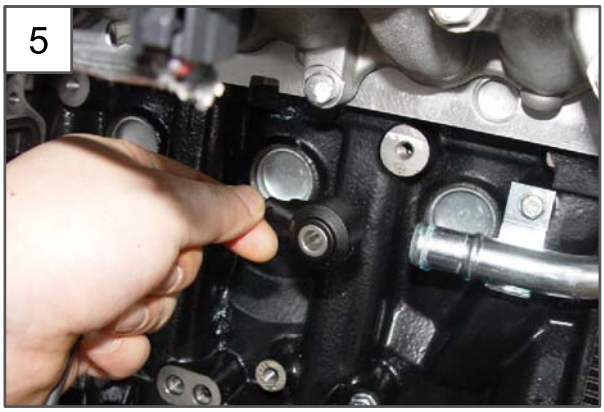


3. Disconnect the No.1 connector (A) and the No.2 connector (B) from the knock sensors.



4. Unscrew the bolts (13 mm) from each knock sensor.

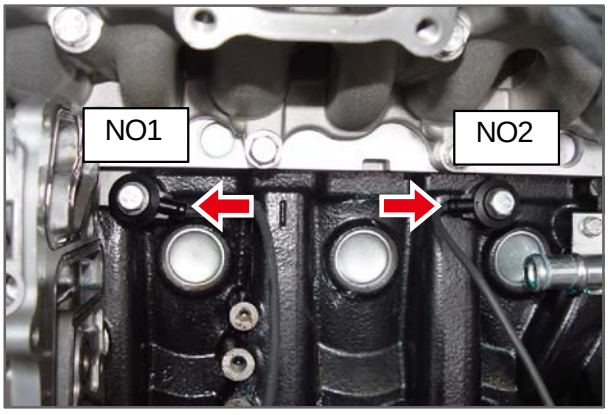
Tightening torque 20 ± 5.0Nm



5. Remove the knock sensors.

Modification basis	
Application basis	
Affected VIN	

6. Install the knock sensors in the reverse order of removal.



NOTE

Place the wirings to the dedicated location for the knock sensors when installing.

Memo