ESP

4850-02/4850-03/4890-01/4890-02/4892-00/4892-01/ 8510-07/

GENERAL INFORMATION

OVERVIEW AND OPERATING PROCESS

CONFIGURATION AND FUNCTIONS

REMOVAL AND INSTALLATION

CODING PROCESS

ESP 4892-01

GENERAL INFORMATION

1. SPECIFICATIONS

Item			Specifications
HECU	Operating voltage		10.0 ± 0.5 V to 16.0 ± 0.5 V
	Operating temperature		−40°C to 125°C
	Max. allowed current		40 A
	Dark current		0.1 mA
	Pressure sensor		Built-in
	Motor power		270 W
	Oil piping type		X-Shape
	Channel		4 channels
Wheel speed sensor	Air gap	Front	0.3 to 1.3 mm
		Rear	0.5 to 1.5 mm
	Operation frequency		1 to 2500 Hz
	Sensor operating temperature		−40°C to 150°C
	Tightening torque	Front	8 ± 2 Nm
		Rear	9.0 ± 1.5 Nm
Steering wheel angle sensor	None (EPS signal)		
Sensor cluster	None (SDM signal)		
Longitudinal acceleration sensor (G-sensor)	Incorporated in HECU		

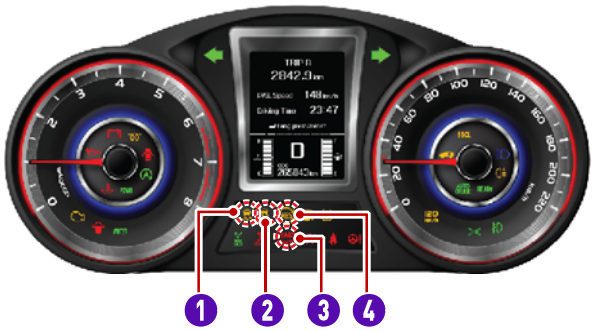
Modification basis	
Application basis	
Affected VIN	

2. MAJOR FUNCTIONS

1) Term Definition

- ESP: Electronic Stability Program
- ABS: Anti-lock Brake System
- EBD: Electronic Brake-Force Distribution
- TCS: Traction Control System
- HBA: Hydraulic Brake Assist
- ARP: Active Rollover Protection
- HSA: Hill Start Assist
- ESS: Emergency Stop Signal
- CBC: Cornering Brake Control
- DST: Dynamic Steering Torque Assist
- FBC: Fading Brake Compensation

3. ESP SYSTEM WARNING LAMPS

Supervision instrument cluster	Standard instrument cluster
	

1. ESP ON indicator/warning lamp
2. ESP OFF indicator
3. Parking brake operating indicator (EBD warning lamp: both parking brake operating indicator and ABS warning lamp come on at the same time)
4. ABS warning lamp

Warning lamps	Color	Indicator	Operating conditions
ESP ON indicator/warning lamp	Amber		ON: Failure of ESP system Flashing: ESP activated
ESP OFF indicator	Amber		ON: ESP deactivated
Parking brake indicator	Red		ON: Parking brake applied
ABS warning lamp	Amber		ON: Faulty ABS function
EBD warning lamp	Amber + Red		ON: Faulty EBD function

Modification basis	
Application basis	
Affected VIN	

1) ABS Warning Lamp

The ABS warning lamp module performs self diagnosis for ABS function and displays the fault status.
The ABS warning lamp is turned ON when:

A. the ignition switch is turned ON (for 4 seconds). If the ABS is normal, the lamp will go off. (Initialization mode)
B. there is a fault in the ABS.
C. the self-diagnosis function is activated.
D. the HECU connector is disconnected.
E. If the ABS warning lamp is turned on, the ABS function is deactivated and only normal braking is available.
F. the communication with the warning lamp drive CAN module is not available.

2) EBD Warning Lamp

If the EBD system is malfunctioning, the ABS warning lamp ( ) and parking brake operating indicator (BRAKE) are turned on at the same time.

The EBD warning lamp is turned ON when:

A. the ignition switch is turned ON (for 4 seconds). If the EBD is normal, the lamp will go off. (Initialization mode)
B. the parking brake switch is turned ON.
C. the brake fluid level is low.
D. the self-diagnosis function is activated.
E. the HECU connector is disconnected.
F. the EBD system is uncontrollable (EBD not operated). - In this case, the ABS warning lamp is also turned on.
   - faulty solenoid valve
   - two or more sensors are malfunctioning
   - faulty HECU
   - overvoltage
   - faulty valve relay
G. the communication with the warning lamp drive CAN module is not available.

3) ESP OFF Switch

The ESP function is turned ON and OFF each time the driver presses the ESP OFF switch.
This switch is a normal-open momentary contact switch. It is connected to the IGN.

Modification basis	
Application basis	
Affected VIN	

4) ESP OFF Indicator

The ESP OFF indicator is turned ON when:

A. the ignition switch is turned ON (for 4 seconds).
B. the driver operates the ESP OFF switch.

5) ESP Warning Lamp

The ESP warning lamp is turned ON when:

A. the ignition switch is turned ON (for 4 seconds).
B. the ESP function is inhibited because of system fault.
C. The warning lamp flashes during ESP control. (buzzer sounds)
D. the self-diagnosis function is activated.
E. the communication with the warning lamp drive CAN module is not available.

Modification basis	
Application basis	
Affected VIN	

4. PRECAUTIONS

CAUTION

- **Warning lamp flashing and warning sound during ESP operation**
  When the ESP is activated while the vehicle is driven, the ESP warning lamp on the instrument panel flashes and a beep sounds. The ESP lamp operation is to inform the driver that the vehicle is extremely unstable. The ESP system is just a supplementary system for the vehicle motion and it cannot control the vehicle when it exceeds the physical limits. Do not solely rely on the system. Driven in an unsafe manner, all vehicles can go out of control.
  When the ESP is activated, a beep sounds to inform the driver of the danger.

- **Drive feeling during ESP operation**
  When the ESP system is activated, the driving feeling can be different depending on vehicle driving conditions.
  For example, the feeling when the ESP system is activated with the ABS is activated and the brake pedal depressed and the feeling when the ESP system is in control without the brake pedal depressed can be different on the same curve.
  If the ESP system is operated with the brake pedal depressed, additional brake pressure will be applied to the wheels on which the braking pressure is already applied, for the ESP control. In other words, the driver can feel more braking force when the ESP system is activated.

Noise and vibration that driver senses during ESP operation

- The ESP system may transfer noise and vibration, due to the pressure changes because of the motor and valve operations in a very short period of time, to the driver. Extreme cornering will trigger the ESP operation and this will make the driver feel a sudden brake application with noises and vibrations. Also, the ESP system controls the engine output (same function with conventional ASR system). So, the driver may notice decreased engine rpm and output even when the accelerator pedal is depressed.

CAUTION

- **When the ARP is activated**
  The ARP system prioritizes the vehicle safety (preventing roll-over). Therefore, ARP system performs more enhanced engine control than ESP system does. This may result in the decreased vehicle speed and lane departure.

Modification basis	
Application basis	
Affected VIN	

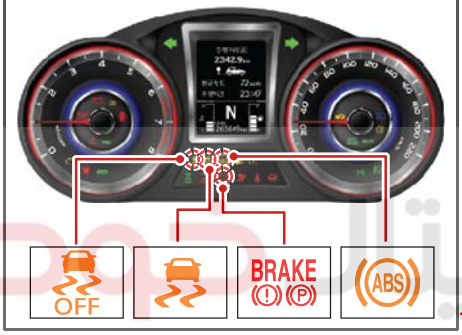
OVERVIEW AND OPERATING PROCESS

1. OVERVIEW

The Electronic Stability Program (ESP) is used to make the vehicle stabilized by recognizing the dangerous driving conditions. This system controls the brake for each wheel and the engine power when the brake system or acceleration does not work in dangerous circumstances.

2. COMPONENTS

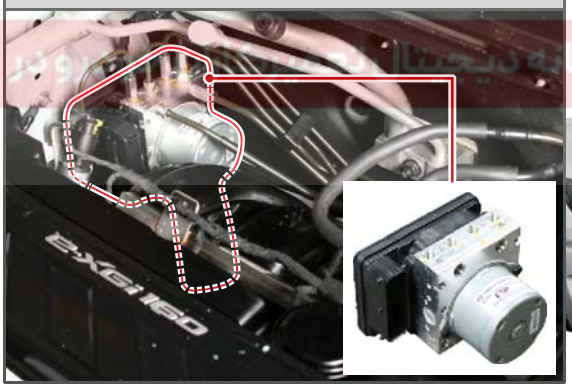
Indicator lamp on instrument cluster

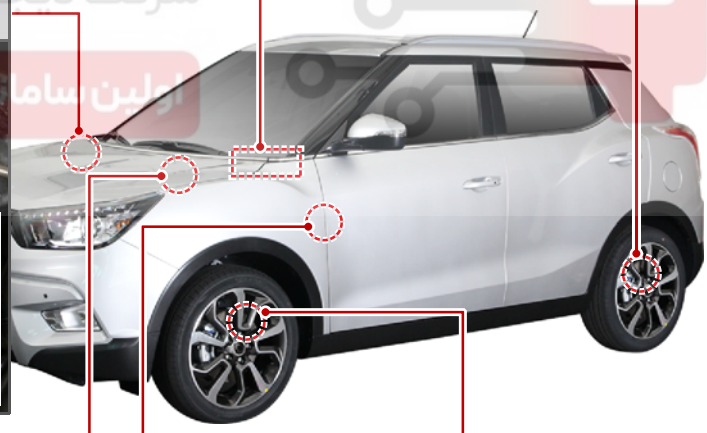


Rear wheel speed sensor

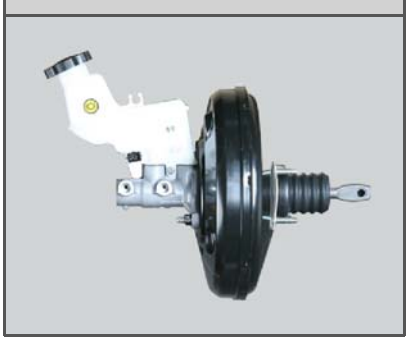
2WD	AWD

HECU





Master cylinder with booster



ESP OFF switch

Front wheel speed sensor

Modification basis	
Application basis	
Affected VIN	

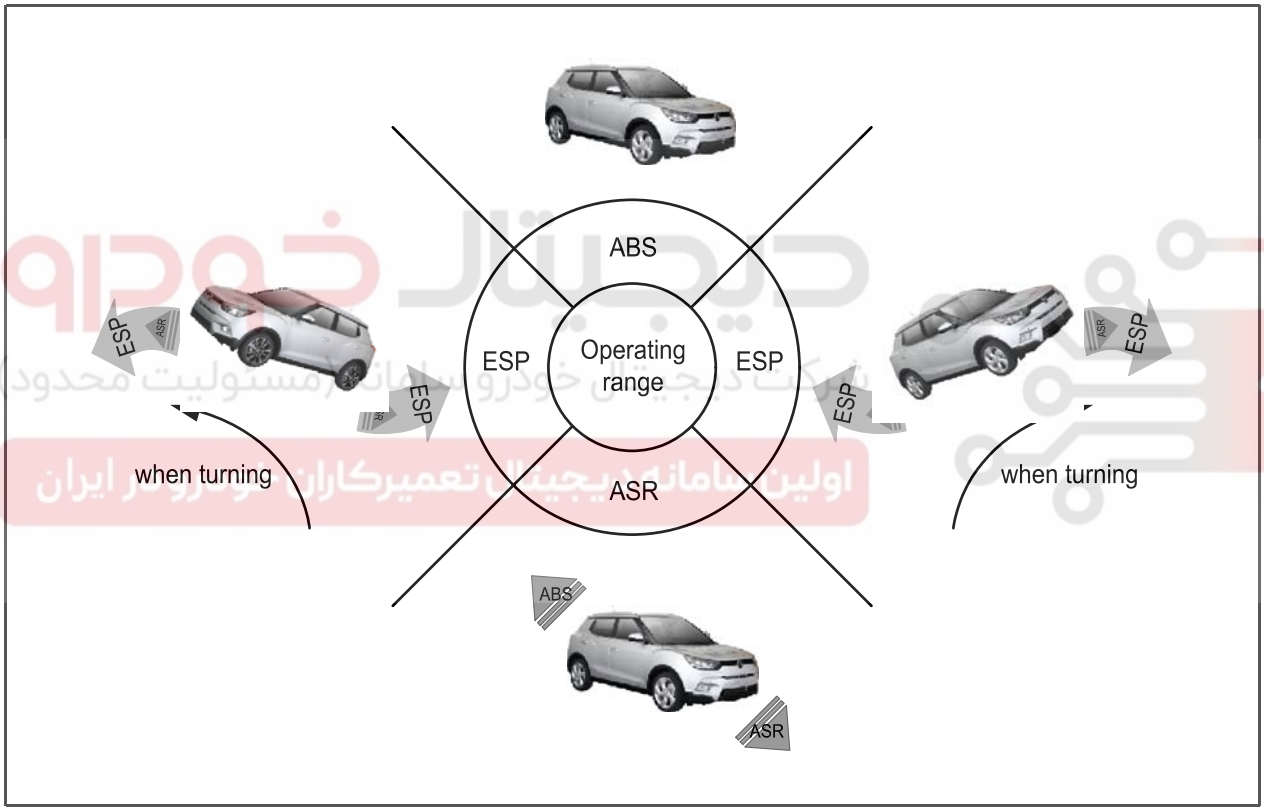
3. OPERATING PROCESS

ESP system consists of functions like ABS, EBD, and TCS. Each function is activated depending on the driving situations. For example, when the brake pedal is depressed during cornering at 100 km/h, the ABS system is activated instantly and the TCS system may be activated to reduce the driving force of the slipping wheel. And when the yaw rate sensor detects the yaw rate exceeding 4°/sec, the ESP system is activated to apply the brake force to the corresponding wheel to compensate the yaw moment with the vehicle stability control function

When various systems operate simultaneously under a certain situation, there may be vehicle control problems due to internal malfunctions of a system or simultaneous operations. In order to prevent such problems, the ESP system sets the priority among the systems.

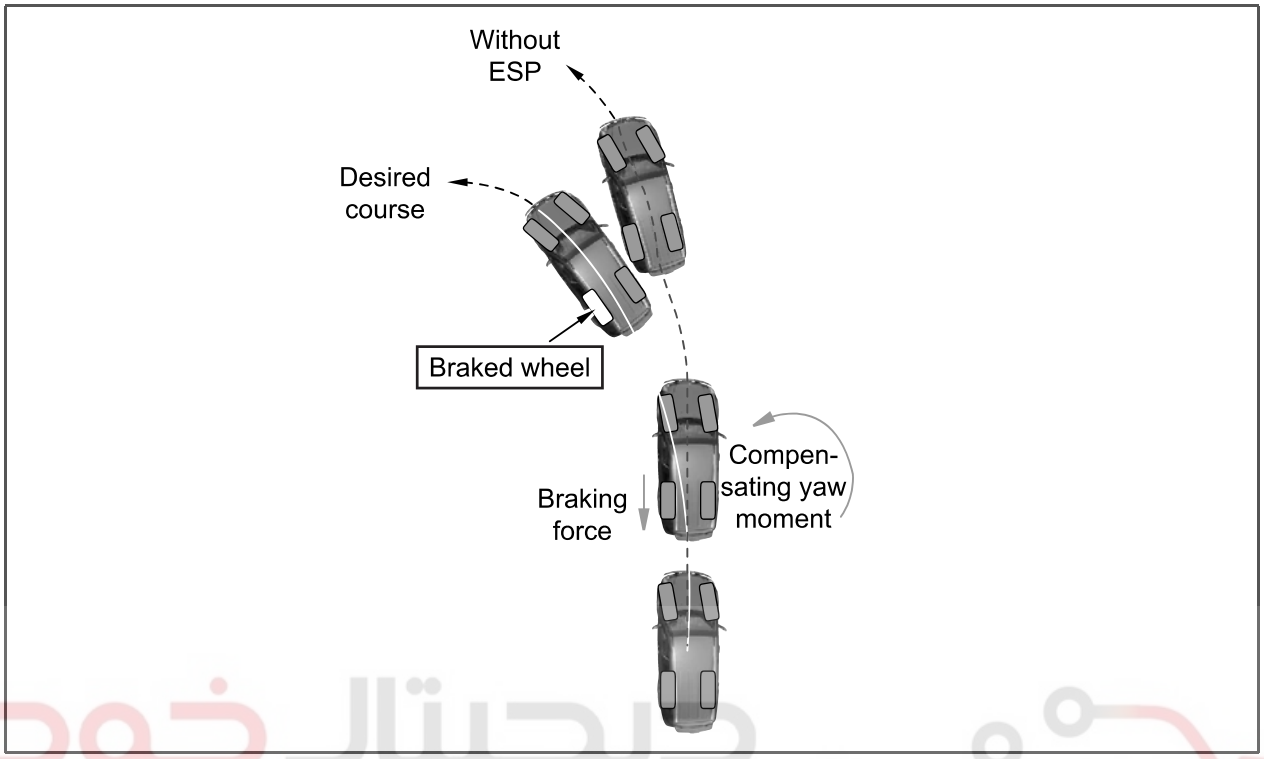
Priority: TCS > ESP > ABS

The ESP system is only operated when the vehicle moves forward.



Modification basis	
Application basis	
Affected VIN	

1) Understeer



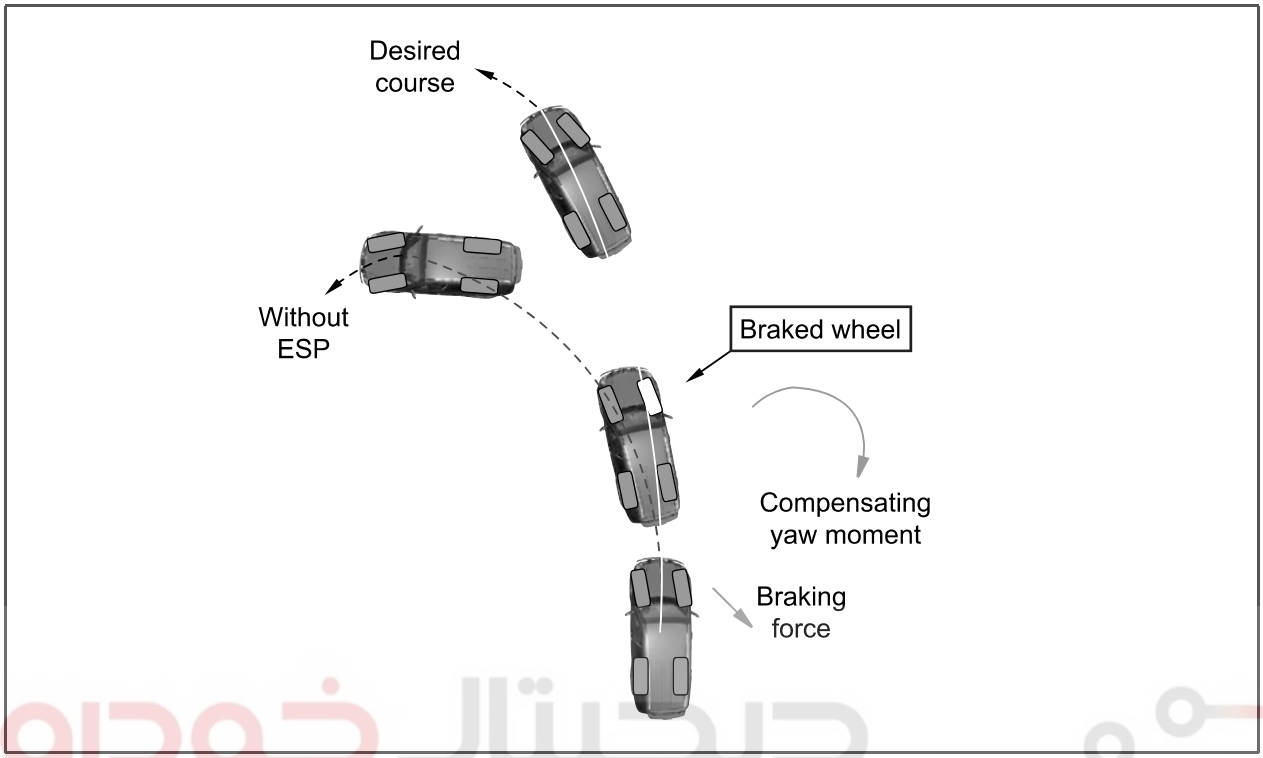
(1) What is understeer?

Understeer is a vehicle dynamics term used to describe the situation when the traction is lost at the front wheels during cornering with constant turn angle of the steering wheel.
Generally, vehicles are designed to have understeer for safety reasons. Because of this design, the vehicle can get back in line with a small corrective input to the steering wheel even when the front wheels are slipped outward.
As the centrifugal force increases, the tires can easily lose the traction and the vehicle tends to slip outward when the curve angle gets bigger and the speed increases.

(2) ESP control during understeer

The ESP system recognizes the direction with the steering wheel angle sensor and senses the vehicle tracking during understeer with the yaw rate sensor and the lateral sensor. Then the ESP system applies the braking force to the rear inner wheel to compensate the yaw moment value. In this way, the vehicle is steered for the amount commanded by the driver.

2) Oversteer



(1) What is oversteer?

Oversteer means that the rear wheels of a vehicle are slipping outwards with a greater angle than the front wheels do with a constant input by the driver.
An oversteer vehicle is hard to control during cornering and can spin due to the moment of the rear wheels. Therefore, the rear tires lose traction and the vehicle speed increases.

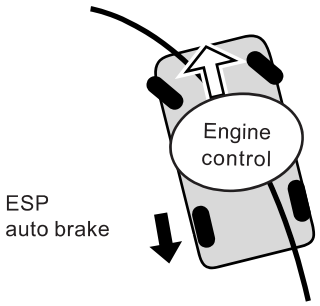
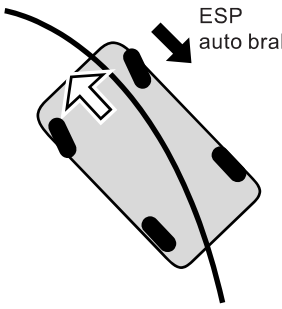
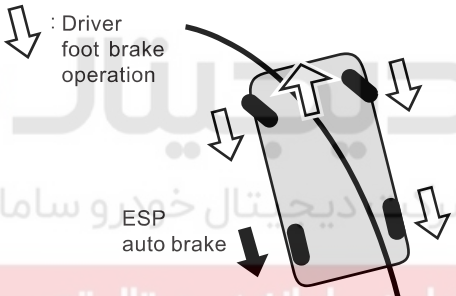
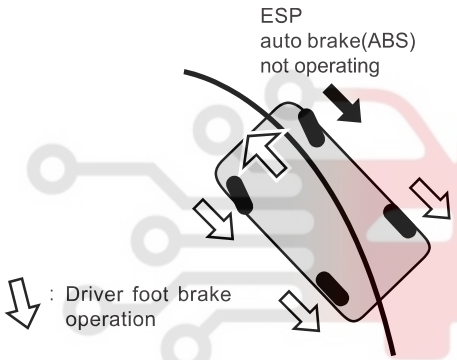
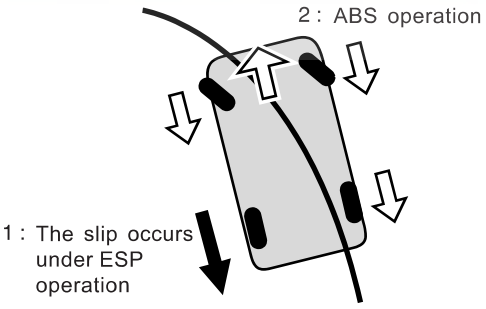
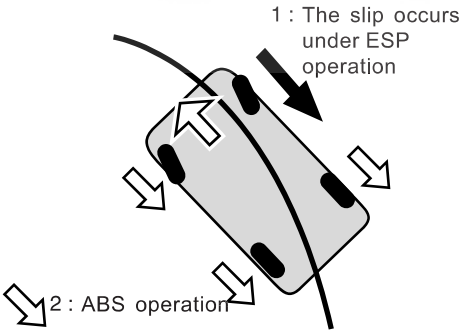
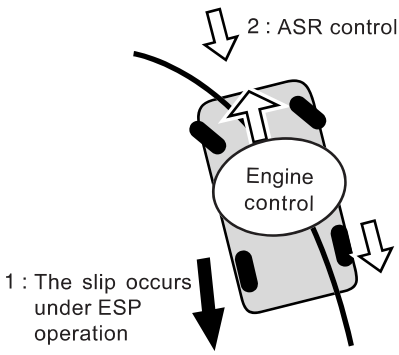
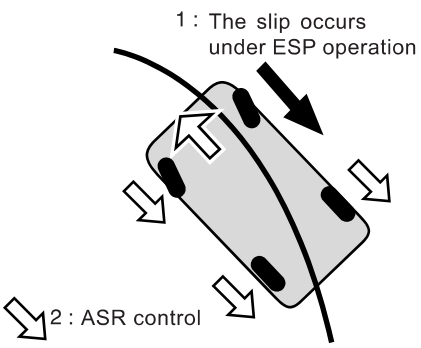
(2) ESP control during oversteer

The ESP system recognizes the direction with the steering wheel angle sensor and senses the vehicle tracking during oversteer with the yaw rate sensor and the lateral sensor. Then the ESP system applies the braking force to the front outer wheel to compensate the yaw moment value. In this way, the vehicle is steered for the amount commanded by the driver.

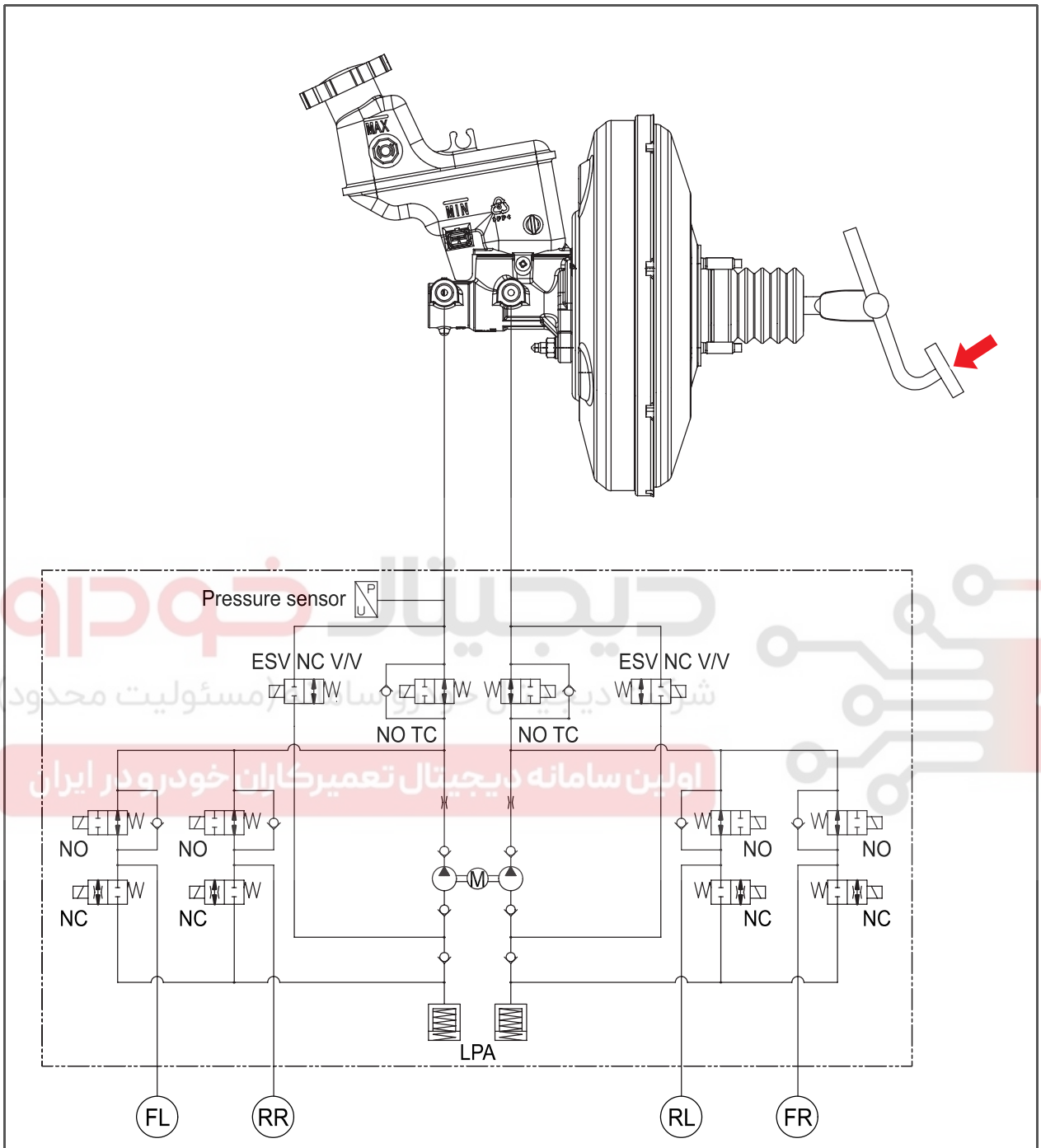
Modification basis	
Application basis	
Affected VIN	

3) Vehicle Control During Cornering

The figure below shows the vehicle controls by the ESP system under various situations such as when the brake pedal is depressed or not during cornering, when the ABS is activated or not and with the braking force applied.
It also includes the vehicle conditions when the TCS, a part of the ESP system, is operating.

Operating conditions	Understeer control	Oversteer control
Only ESP in operation Brake pedal not depressed		
ESP + Normal braking (no ABS operation)		
ESP + ABS brake		
ESP + ASR		

4. HYDRAULIC CIRCUIT



MC2: Primary master cylinder
MC1: Secondary master cylinder
ESV: Electric shuttle valve
LPA: Low pressure accumulator
NO: Normal open
NC: Normal close

Modification basis	
Application basis	
Affected VIN	

▶ Warning lamp flashing and warning sound during ESP operation

When the ESP is activated while the vehicle is moving, the ESP warning lamp on the instrument panel flashes and a buzzer sounds every 0.1 sec. The ESP lamp operation is to inform the driver that the vehicle is extremely unstable.
The ESP system is just a supplementary system for the vehicle motion and it cannot control the vehicle when it exceeds the physical limits.
If only the TCS function works, the ESP warning lamp will flash without buzzer sound.

▶ Drive feeling during ESP operation

When the ESP system is activated, the driving feeling can be different depending on vehicle driving conditions.
For example, the feeling when the ESP system is activated with the ABS is activated and the brake pedal depressed and the feeling when the ESP system is in control without the brake pedal depressed can be different on the same curve If the ESP system is operated with the brake pedal depressed, additional brake pressure will be applied to the wheels on which the braking pressure is already applied, for the ESP control. In other words, the driver can feel more braking force when the ESP system is activated.

▶ Noise and vibration that driver senses during ESP operation

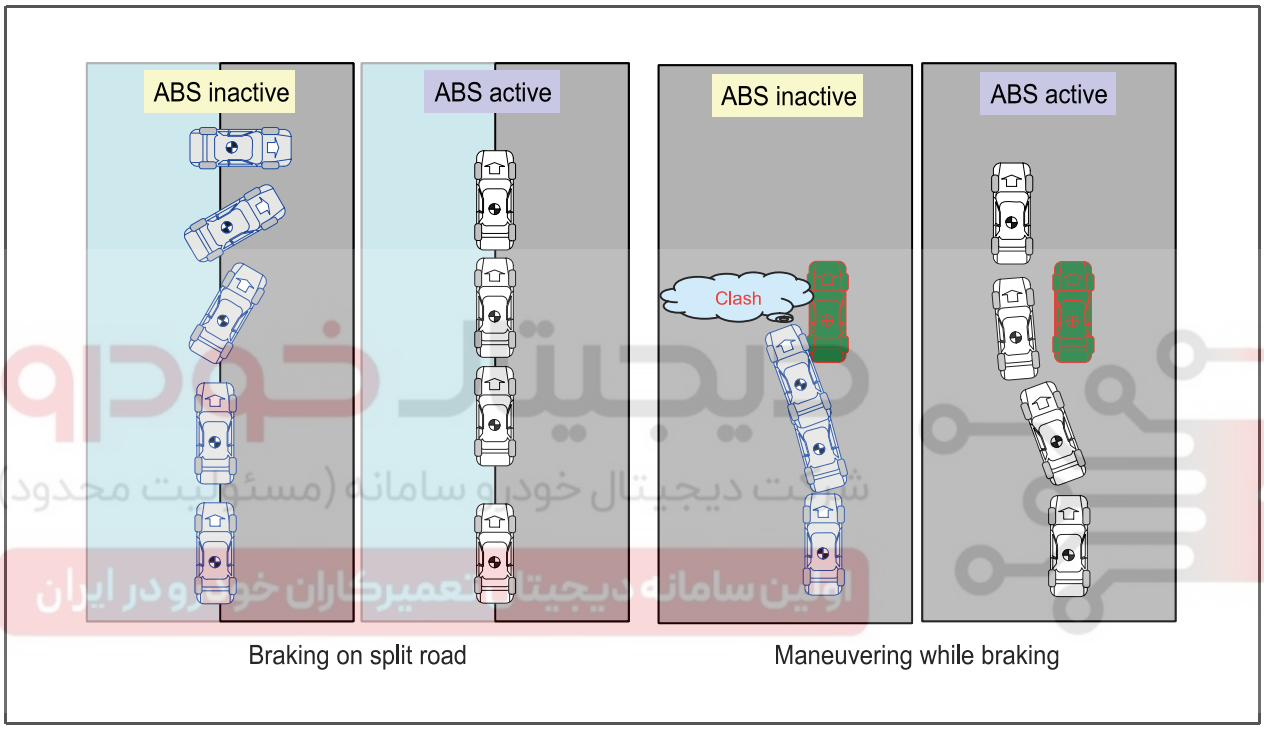
The ESP system may transfer noise and vibration, due to the pressure changes because of the motor and valve operations in a very short period of time, to the driver.
Extreme cornering will trigger the ESP operation and this will make the driver feel a sudden brake application with noises and vibrations.
Also, the ESP system controls the engine output. So, the driver may notice decreased engine rpm and output even when the accelerator pedal is depressed.

Modification basis	
Application basis	
Affected VIN	

5. ANTI-LOCK BRAKE SYSTEM(ABS)

When you brake abruptly or brake on a slippery road, the vehicle tries to move forward but the wheels are locked and unable to rotate. If this is the case, the vehicle will loose its steering or turn, resulting in an accident. ABS controls the wheels properly so that they are not locked to stabilize the vehicle.
Do not solely rely on the ABS system. The ABS system cannot assure safety when certain physical limits are reached. Driven in an unsafe manner, all vehicles can go out of control.

▶ Normal braking vs ABS operation

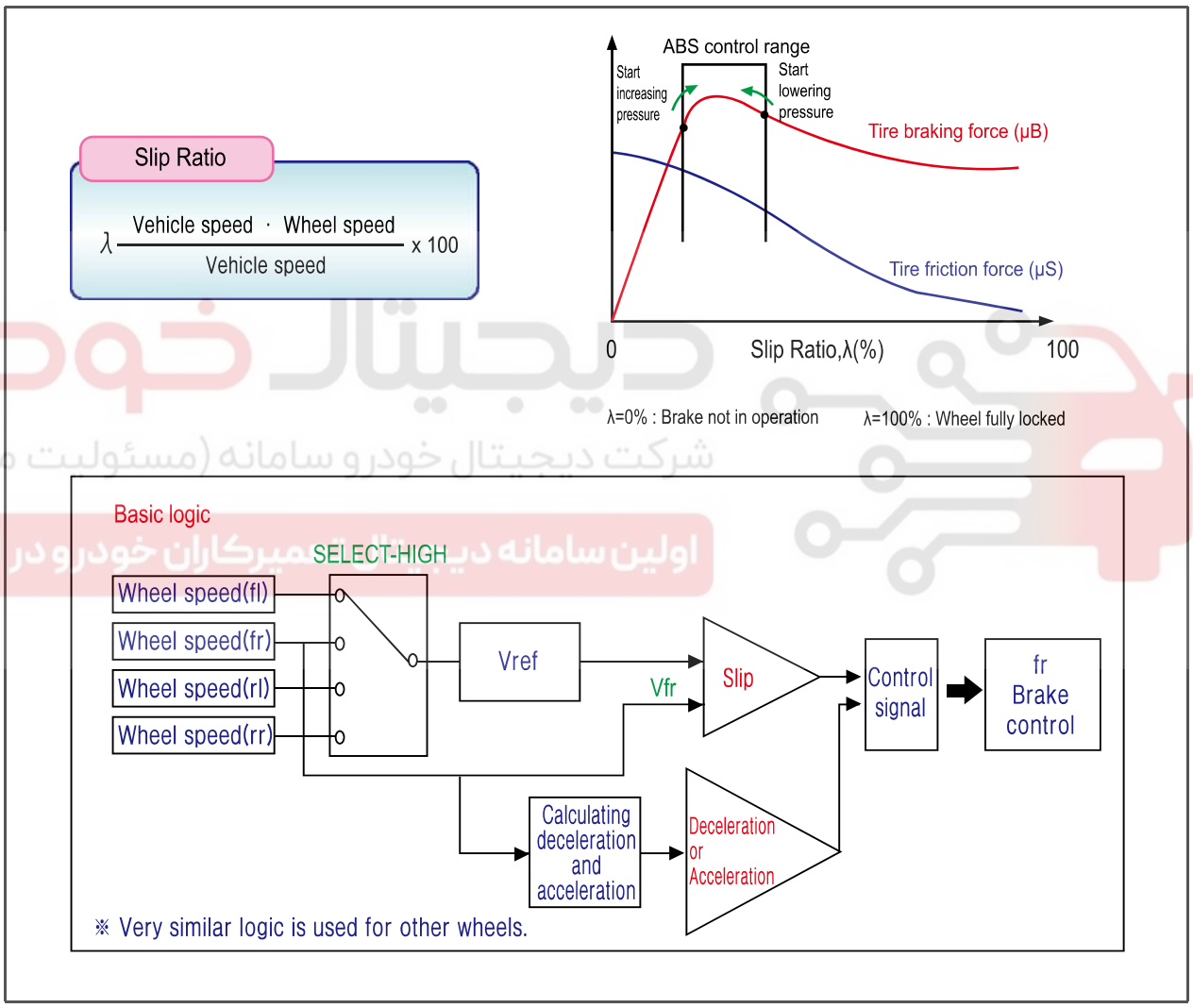


Modification basis	
Application basis	
Affected VIN	

1) System Description

(1) ABS Control Logic

The principal ABS control logic is the determination of the reference speed by choosing one wheel meeting a certain condition, while receiving the speed information from the 4 wheel speed sensors when the vehicle is being driven.
For example, when the comparison of the reference speed with the front right wheel speed results in a slip, the control signal is determined based on deceleration or acceleration of the vehicle. If the control conditions are met, the braking of the front right wheel will be controlled by the system.



Modification basis	
Application basis	
Affected VIN	

2) Basic Information

To understand the ABS, you need to get information about braking force, slip, and cornering force.

(1) Braking distance

▶ Braking distance and stopping distance

Stopping distance = Thinking distance + Braking distance

▶ Stopping distance

A certain distance (thinking distance + braking distance) is needed from the moment an obstacle appears ahead until you bring your vehicle to a complete stop. This is called as stopping distance.

▶ Braking distance

Tire slip occurs when the brake is applied and continues until the vehicle stops completely.
The distance that tire slipped is called "braking distance".

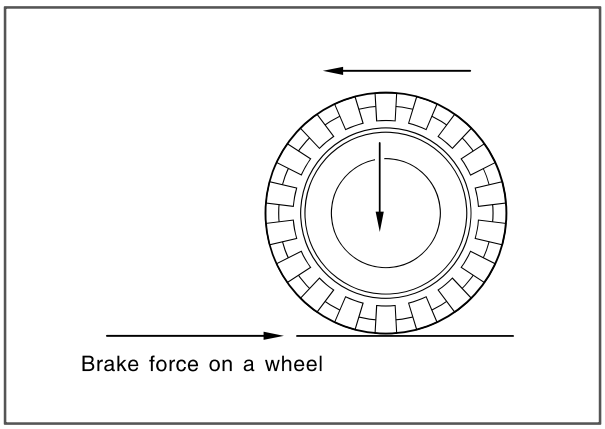
▶ Thinking distance

The thinking distance is the distance traveled for a certain period of time from the moment when the driver sees the obstacles and prepares to depress the brake pedal to the moment when the brake pedal is depressed.

(2) Braking force applied on a wheel

The maximum possible braking force on a wheel depends on the wheel weight and the coefficient of friction between the tire and road surface. When the coefficient of friction is low, the braking force obtained is very low. Think about driving on the roads in winter.

▶ Maximum braking force



Brake force on a wheel

Max. braking force =
Wheel weight FR x Friction coefficient Mh

The braking process cannot be described accurately with the braking force calculated. The value calculated from the above formula is based on the wheels unlocked.
If the wheels are locked, the static friction force is converted into the dynamic friction force, resulting in increased braking distance. This loss of friction is called "slip".

Modification basis	
Application basis	
Affected VIN	

▶ Slip

The brake slip varies with the vehicle speed and the circumferential speed of the wheel. If the wheels are stuck, the brake slip is 100%. If the wheels rotates freely without braking force applied, the slip is 0%. The slip is calculated based on the vehicle speed (Vveh) and wheel speed (Vw).

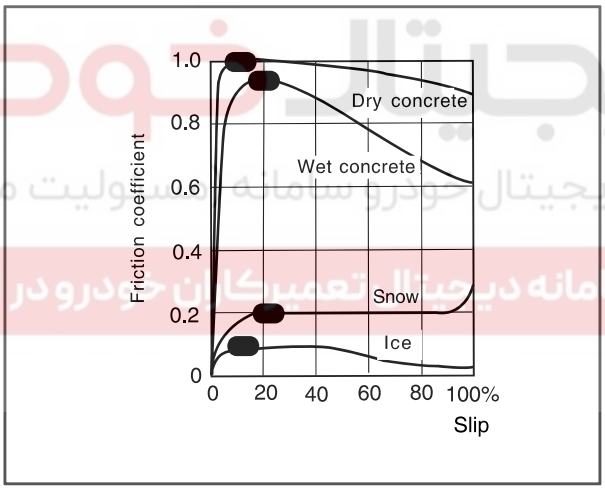
$$S = \frac{Vveh - Vw}{Vveh} \times 100\%$$

Vveh = 100km/h, Vw = 70km/h

$$S = \frac{Vveh - Vw}{Vveh} \times 100\%$$

S = 30%

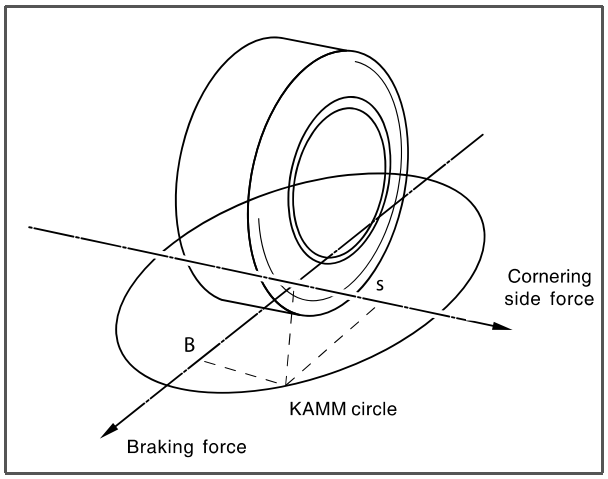
▶ Typical Slip Curves



For the various road conditions, the friction coefficients were plotted. The typical course of the curves is always the same. The only special feature is shown by the curve for freshly fallen snow, for this curve increases at 100 % slip. In a vehicle without ABS, the wheel locks on braking and therefore pushes a wedge before it. This wedge of loose surface or freshly fallen snow means and increased resistance and as a result the stopping distance is shorter. This reduction in stopping distance is not possible with a vehicle with ABS, as the wheel does not lock. On these surfaces the stopping distance with ABS is longer than without ABS. The reason for this is based in physics and not in the Anti-Lock System.

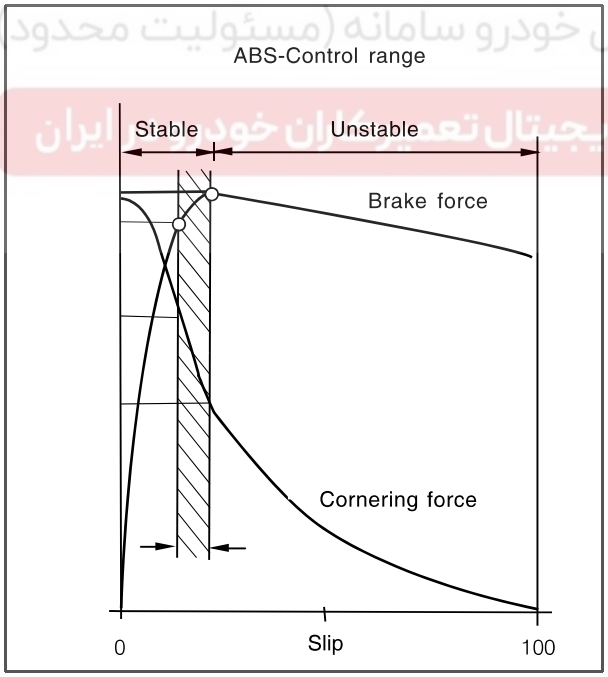
However, as mentioned before, ABS is not about the stopping distance, but maneuverability and driving stability, for the vehicle with locking wheels without ABS cannot be steered.

▶ KAMM circle



The maximum tire force transmissibility is 100%. It is all the same for the tire whether we require 100 % in the direction of braking or in the direction of the acting lateral force, e.g. when driving round curves. However, if the vehicle is driven on a road with sharp bends, the tires cannot transmit the 100% braking force required. Therefore, the vehicle moves out of the corner even if the vehicle is equipped with ABS. The relationship between braking force B and cornering force S is shown very clearly in the Kamm circle. If we put a vehicle wheel in this circle, the relationship becomes even clearer. As long as the acting forces and the resultant force stay within the circle, the vehicle is stable to drive. If one force exceeds the circle, the vehicle moves out of the lane.

▶ Braking force and cornering force

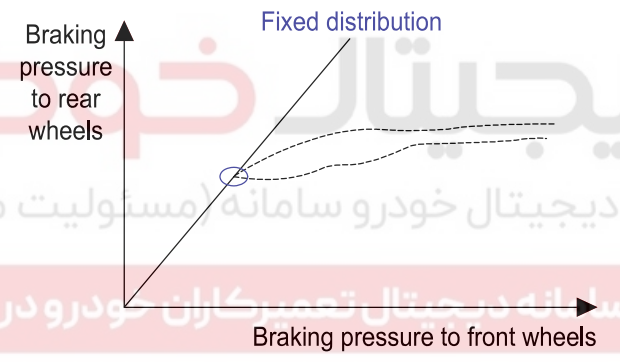
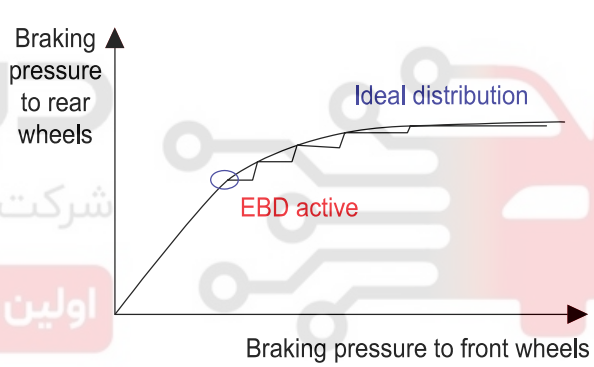


- **Braking force**
  When depressing the brake pedal the braking force increases to the maximum, then the braking force decreases until the wheel locks.
  Cornering force
- The maximum cornering force is applied to the vehicle when the wheel is turning freely with zero slip. When braking, the cornering force will fall to zero if the wheels are locked (slip 100 %).
  ABS operating range
  The operating range starts just before applying
- the maximum braking force and ends when the maximum braking force has been applied. After that, the vehicle enters into the unstable range. In this range, no further modulation is possible. The ABS controls the regulation of the brake pressure so that the braking force only becomes great enough for a sufficient proportion of cornering force to remain.

Modification basis	
Application basis	
Affected VIN	

6. ELECTRONIC BRAKE FORCE DISTRIBUTION(EBD)

Sudden braking while the vehicle is driven causes nose down in which the load of the vehicle is pulled to the front axle. In this case, the friction on the rear wheels is larger than the friction on the front wheels. Therefore the rear wheels are locked before the front wheels are locked, resulting in poor straight ahead run. To resolve this problem, the vehicle is equipped with electronic brake force distribution (EBD) system which is an advanced form of proportioning valve.
The proportioning valve can control the pressure but cannot control according to the vehicle loading, number of occupants, cornering, and road conditions. But the EBD can control the braking force applied on each wheel independently by receiving the wheel speed from the wheel speed sensor.
For a vehicle with EBD system, the HECU measures the wheel retardation continuously and the separate program of the ABS controls the rear brake pressure to ensure good straight ahead run. The EBD system works before the ABS is activated.

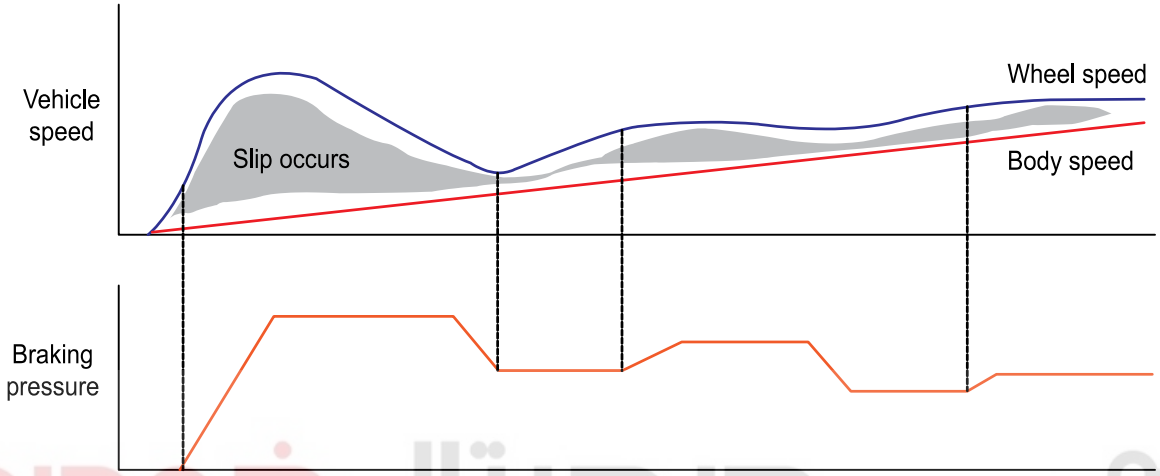
<table>
<tr><th colspan="2">Braking force</th></tr>
<tr><th>Proportioning valve</th><th>EBD</th></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td colspan="2">1) EBD control
The EBD control function detects the wheel speed, vehicle speed, slip, and vehicle retardation to compare the sips of the front wheels and rear wheels. The brake pressure for the rear wheels is determined by the slip comparison value. The rear braking is controlled depending on the cornering control as follows:
- Braking while cornering: rear braking, independently
- Braking while cornering: rear braking, simultaneously

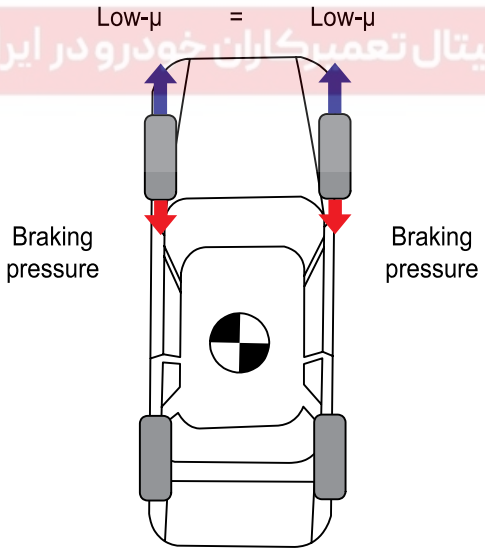
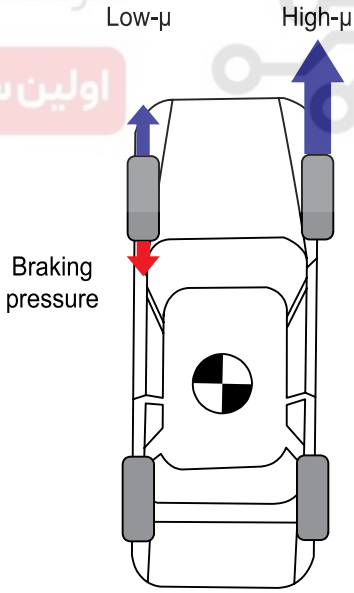
2) Advantage
- Implemented by the ABS system
- Effective response according to the driving conditions.
- Different pressure controls between the inside and outside of corner during cornering control
- Constant braking force distribution over the life of the vehicle.
- Controls the brake pressure close to ideal distribution</td></tr>
</table>

7. TRACTION CONTROL SYSTEM (TCS)

The traction control system prevents excessive slip (abrupt acceleration and rapid start) by controlling the brake pressure applied on the drive wheel to ensure stability of the vehicle when starting rapidly, accelerating abruptly, or turning at high speed.

TCS control pattern



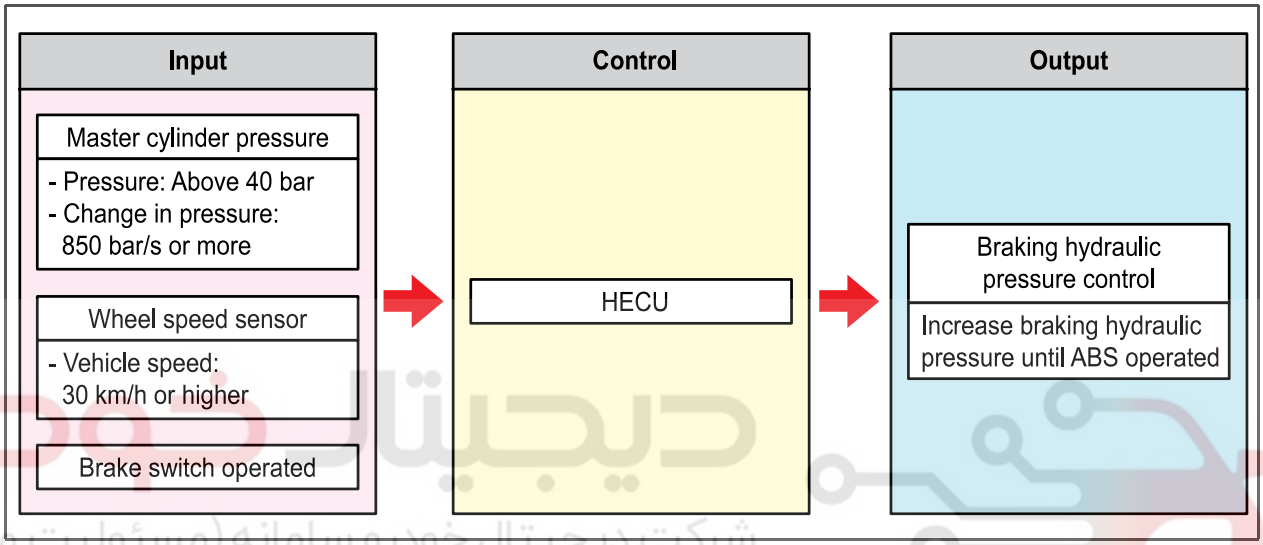
Simultaneous drive wheel slip control	Separate slip control according to road conditions
	

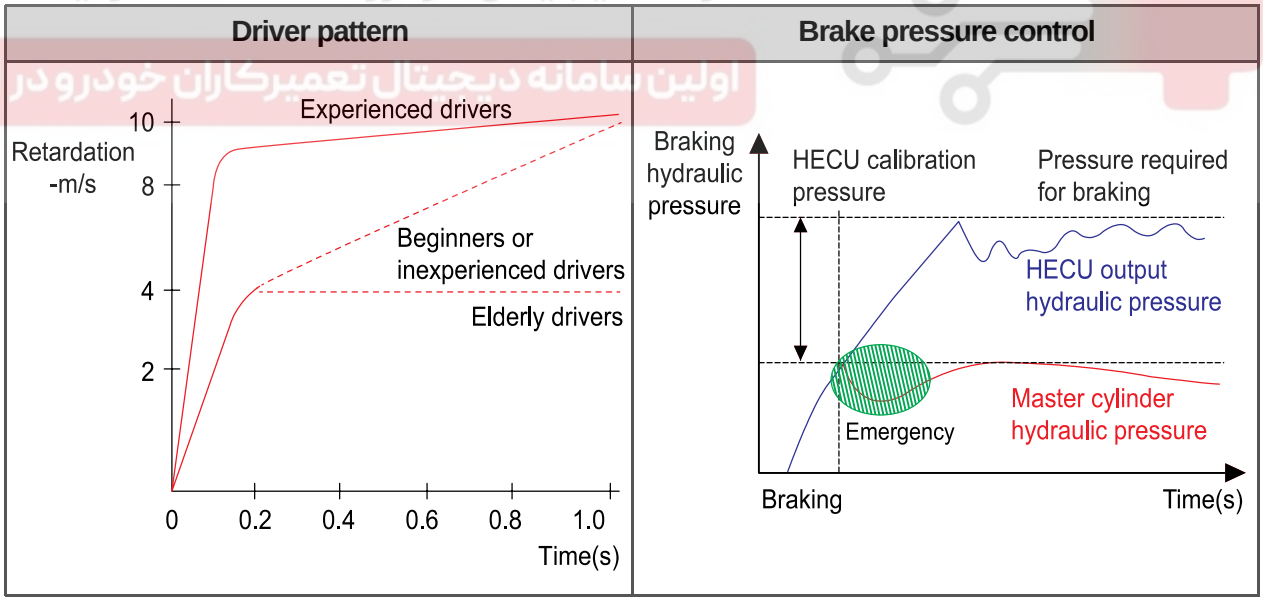
Applies braking force to the corresponding wheel to reduce the excessive slip occurred.

Modification basis	
Application basis	
Affected VIN	

8. HYDRAULIC BRAKE ASSIST (HBA) SYSTEM

The hydraulic brake assist (HBA) system increases the initial braking force to improve the ABS performance when braking abruptly. For example, if the system determines that the driver applies the brake pedal slowly in an emergency state, the ESP HECU controls the solenoid valve in the hydraulic modulator to provide maximum brake pressure on each wheel. Because of this process, the initial braking force is maximized by the booster, and the vehicle will stop abruptly with the brake pedal depressed slightly. The HBA system prevents this by regulating the brake hydraulic pressure.

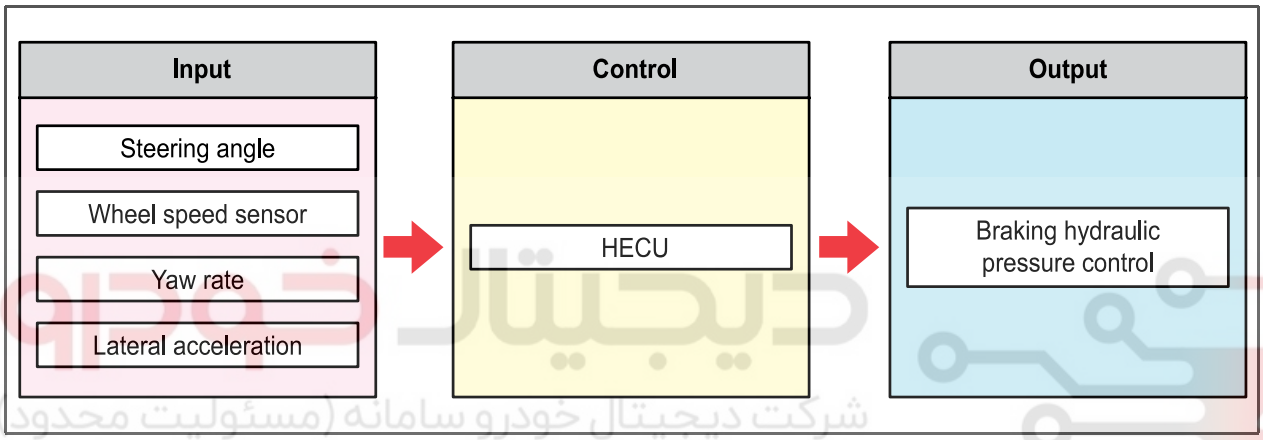


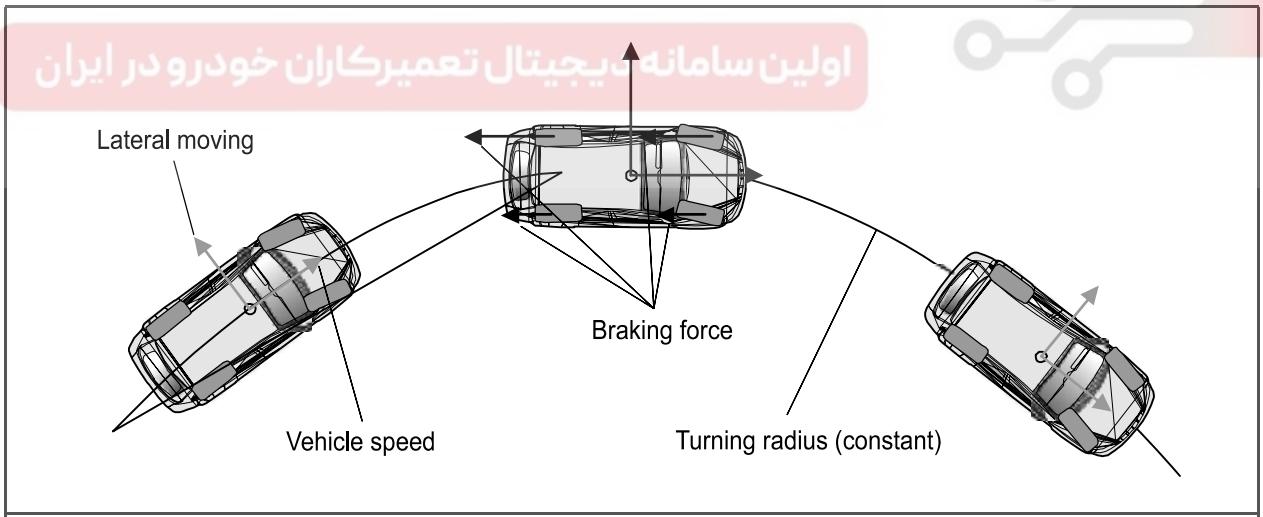


Modification basis	
Application basis	
Affected VIN	

9. ACTIVE ROLLOVER PROTECTION (ARP)

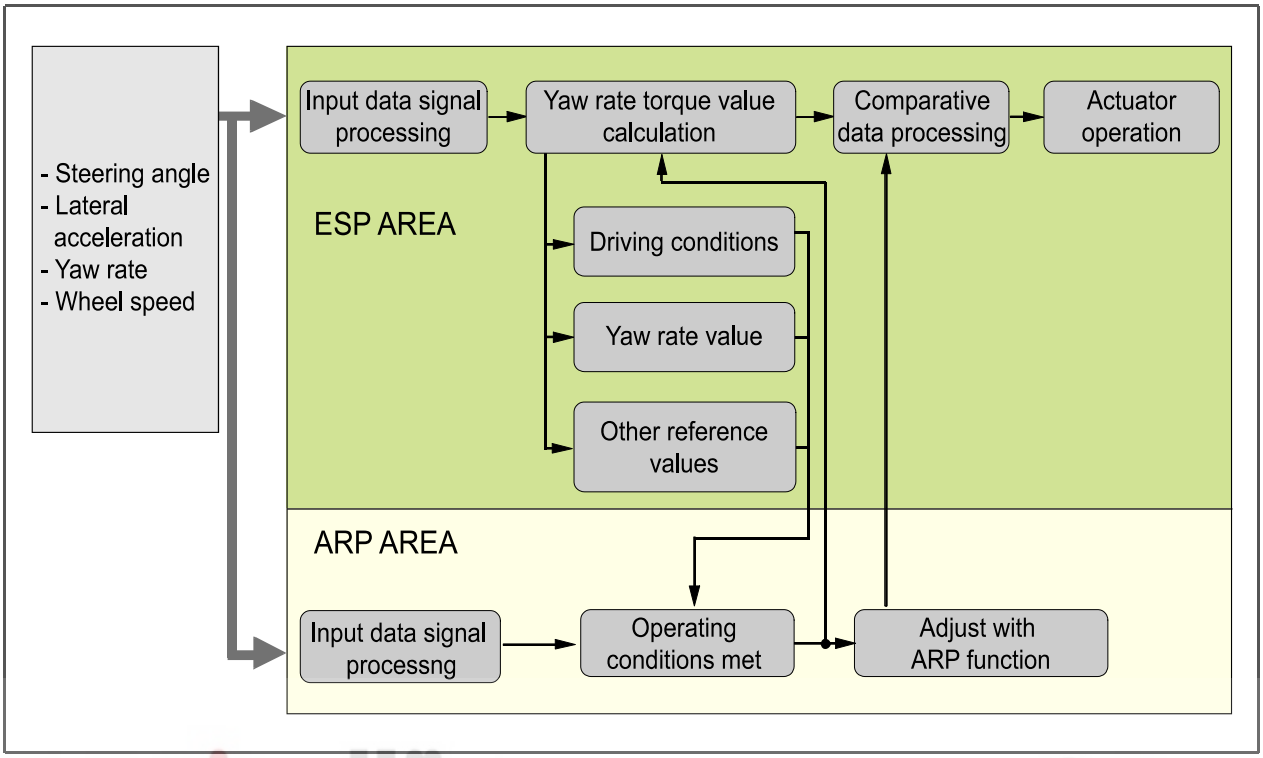
The active rollover protection (ARP) system is a supplementary device for safety in ESP system and can help minimize the rollover accidents by detecting a potential rollover situation through the brake and engine controls when the vehicle suddenly changes the lane or turns too sharply. The ARP system performs this function only by using a software, without any extra devices or switches.
Keep in mind that the ARP is also only an aid using the ESP system like ABS. The system is unable to surpass the physical limits of the brake system.
The following figure shows the operation of the ARP system to prevent rollover of the vehicle. The ARP system reduces the speed of the turning vehicle and then makes the vehicle understeer.





The operation of ARP system when the vehicle increases its speed while running at a constant turning radius is the same with the ARP operation when the vehicle runs at a constant speed while the turning radius is being decreased.

Modification basis	
Application basis	
Affected VIN	



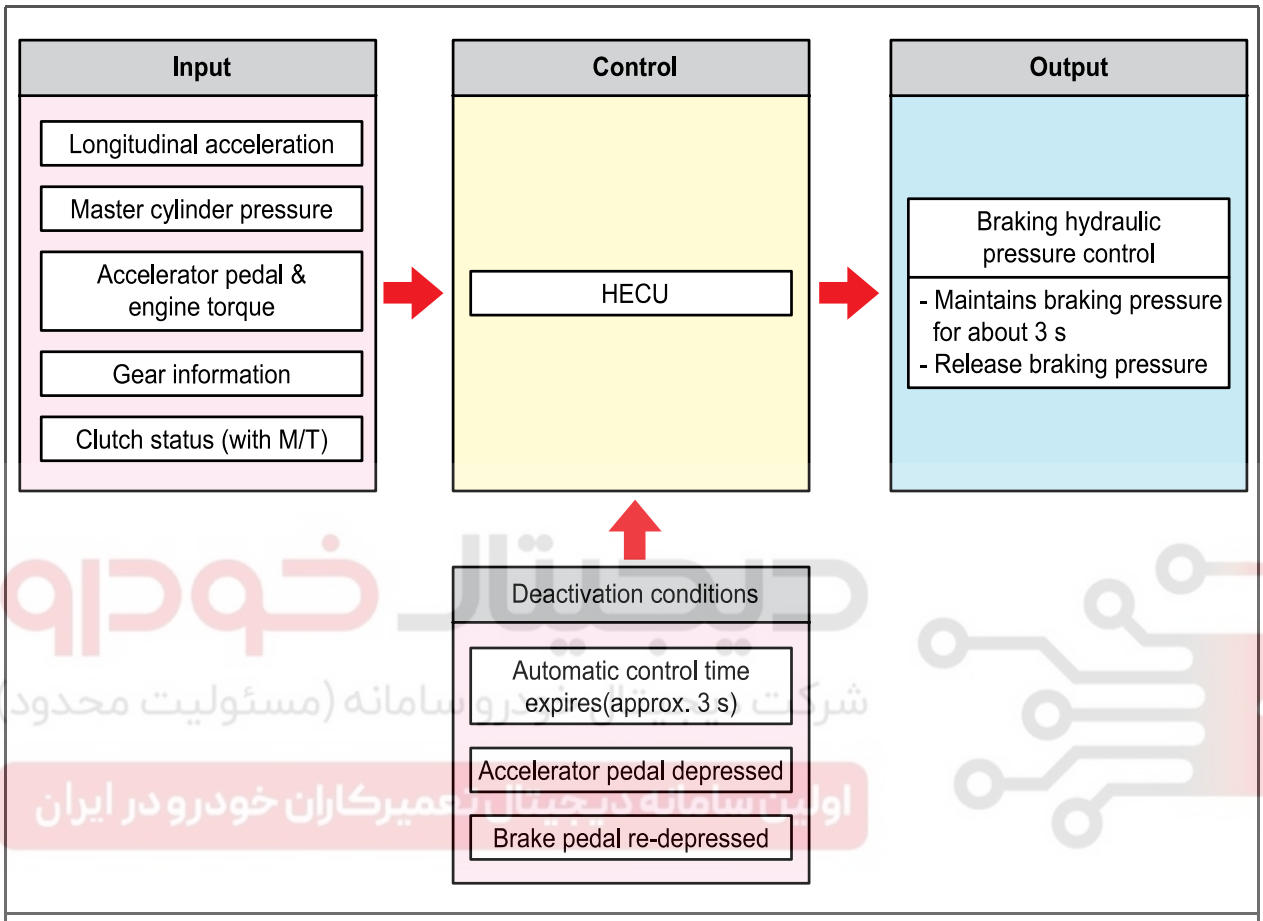
CAUTION

The ARP system prioritizes the vehicle safety (preventing roll-over). Therefore, the ARP system performs more enhanced engine control than the ESP system does. This may result in the decreased vehicle speed and lane departure.

Modification basis	
Application basis	
Affected VIN	

10. HILL START ASSIST (HSA)

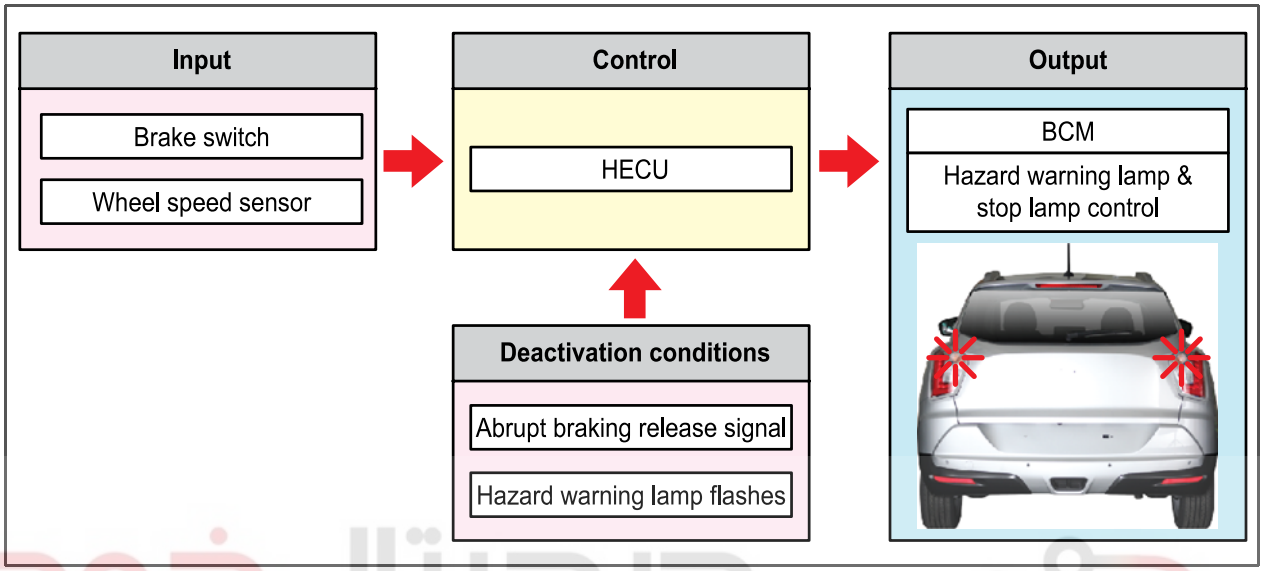
The hill start assist (HSA) prevents the vehicle from rolling backward by supplying the hydraulic pressure to the wheels by the HECU for approx. 3 seconds after the brake pedal has been released when starting off on uphill gradients.



Modification basis	
Application basis	
Affected VIN	

11. EMERGENCY STOP SIGNAL (ESS)

The emergency stop signal (ESS) informs other drivers of emergency situation. When the moving vehicle is braked abruptly or the ESP system is activated, the HECU sends the emergency braking signal to the BCM to turn on the hazard warning lamp.



The BCM turns ON or OFF the emergency braking as follows:

Operation 1

A. The hazard warning lamp does not operate when the vehicle speed is over 50 km/h upon the emergency braking signal input.
B. If this is the case, the stop light flashes at 4 Hz (every 0.25 sec.).

Operation 2

C. If the vehicle speed is 50 km/h or lower upon the emergency braking signal input, the hazard warning lamp will illuminate for 10 seconds (T1).
D. The stop lamp flashes at 4 Hz (every 0.25 sec.) upon the emergency braking signal input even if the vehicle speed drops below 50 km/h after the operation B.

Operation 3

E. If the hazard warning lamp switch is turned off during the operation C, the emergency braking signal output will be stopped.
F. If the hazard warning lamp switch is operated during the operation B or D, the stop light will stop flashing and the hazard warning lamp will operate.
G. The stop light will not flash even if the condition for the operation B is met during the hazard warning lamp operation.

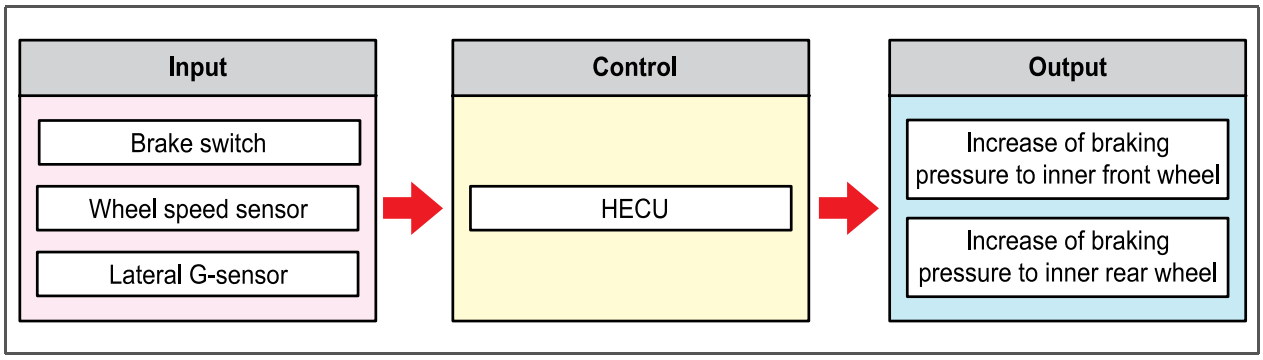
NOTE

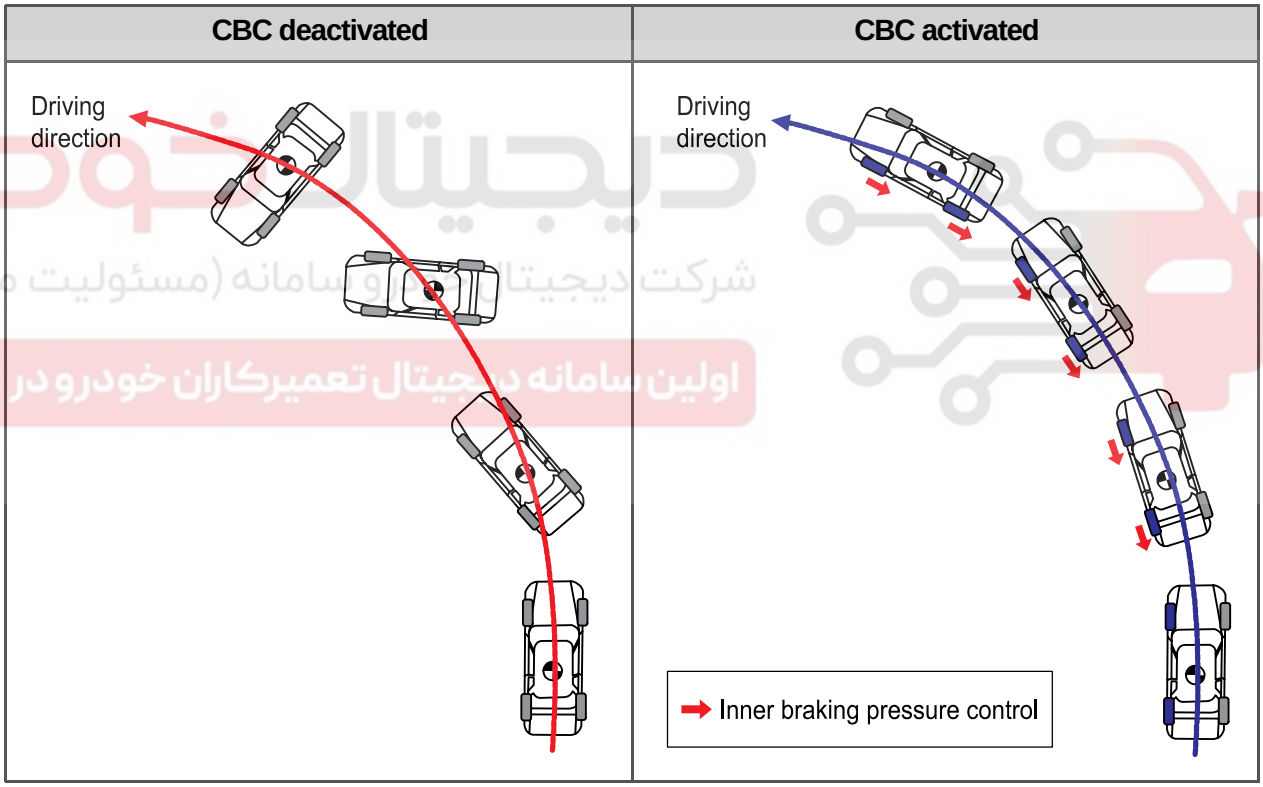
- Priority: Manual operation of hazard warning lamp > Emergency braking signal > AUTO hazard warning lamp
- The BCM operate the stop light upon the brake pedal switch ON signal input, regardless of the IGN status.
- The emergency braking signal is switched off when the vehicle speed exceeds 10 km/h (if emergency braking signal is input).

Modification basis	
Application basis	
Affected VIN	

12. CORNERING BRAKE CONTROL (CBC)

When applying the brake to the vehicle driving on winding road at high speed, a slip occurs with the vehicle load pulled toward the outside of the corner.
The cornering brake control (CBC) system minimizes the vehicle slip when the vehicle is turning by applying more brake hydraulic pressure to the inner wheels.

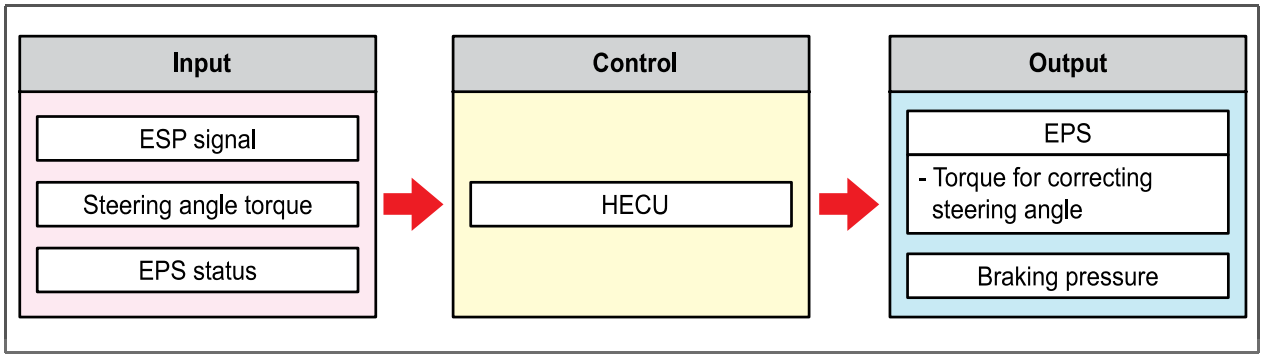


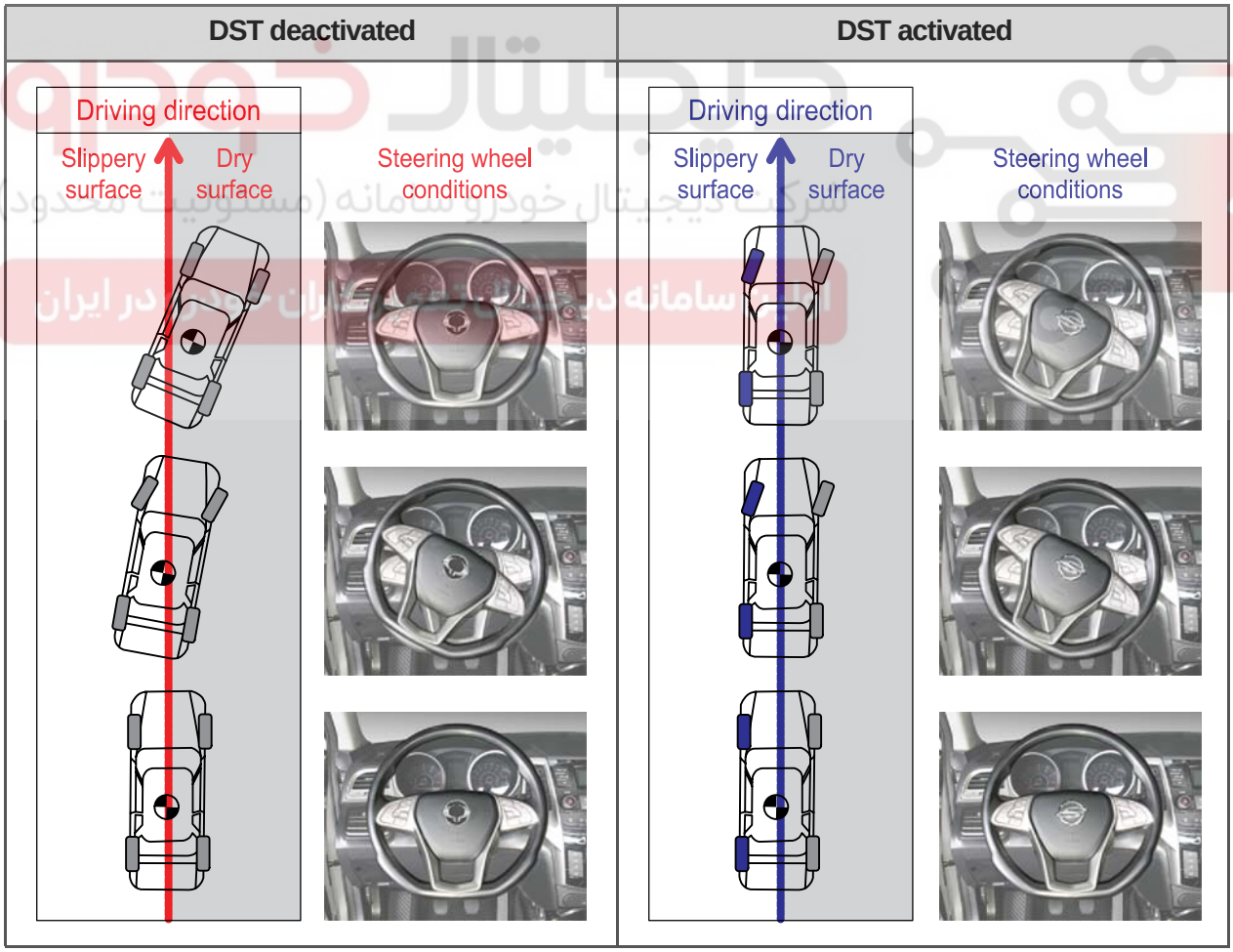


Modification basis	
Application basis	
Affected VIN	

13. DYNAMIC STEERING TORQUE ASSIST(DST)

The dynamic steering torque assist system compensate the braking force and additional torque for steering on a slippery road.
When the brake pedal is depressed on a road where the surfaces contacting with the left and right wheels are different from each other, the steering is turned toward the surface side with high friction, resulting in veering off the carriageway. At this time, the DST system controls the ESP with EPS together (generating torque required for correcting the steering angle).

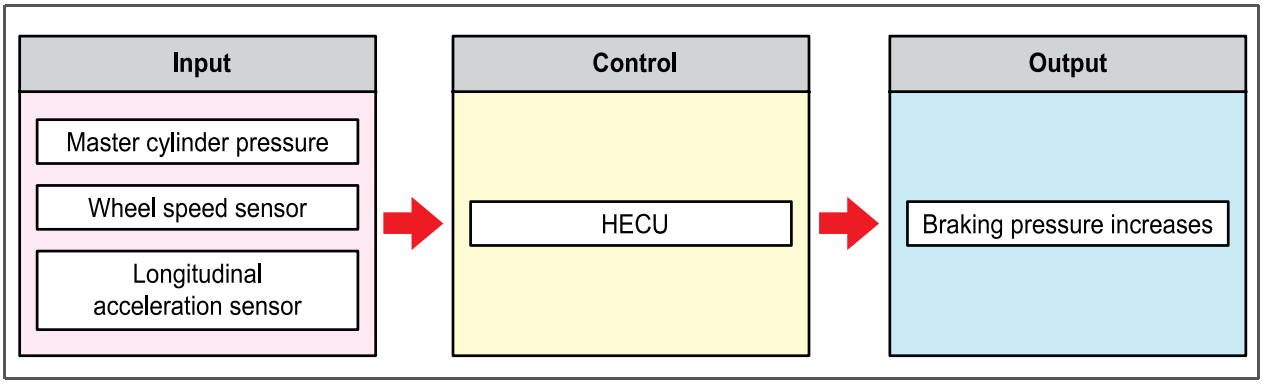




Modification basis	
Application basis	
Affected VIN	

14. FADING BRAKE COMPENSATION(FBC)

The fading brake compensation (FBC) system complements the reduced braking performance due to hot brake pad with excessive braking.



The braking distance is reduced with the FBC system activated.

Modification basis	
Application basis	
Affected VIN	

CONFIGURATION AND FUNCTIONS

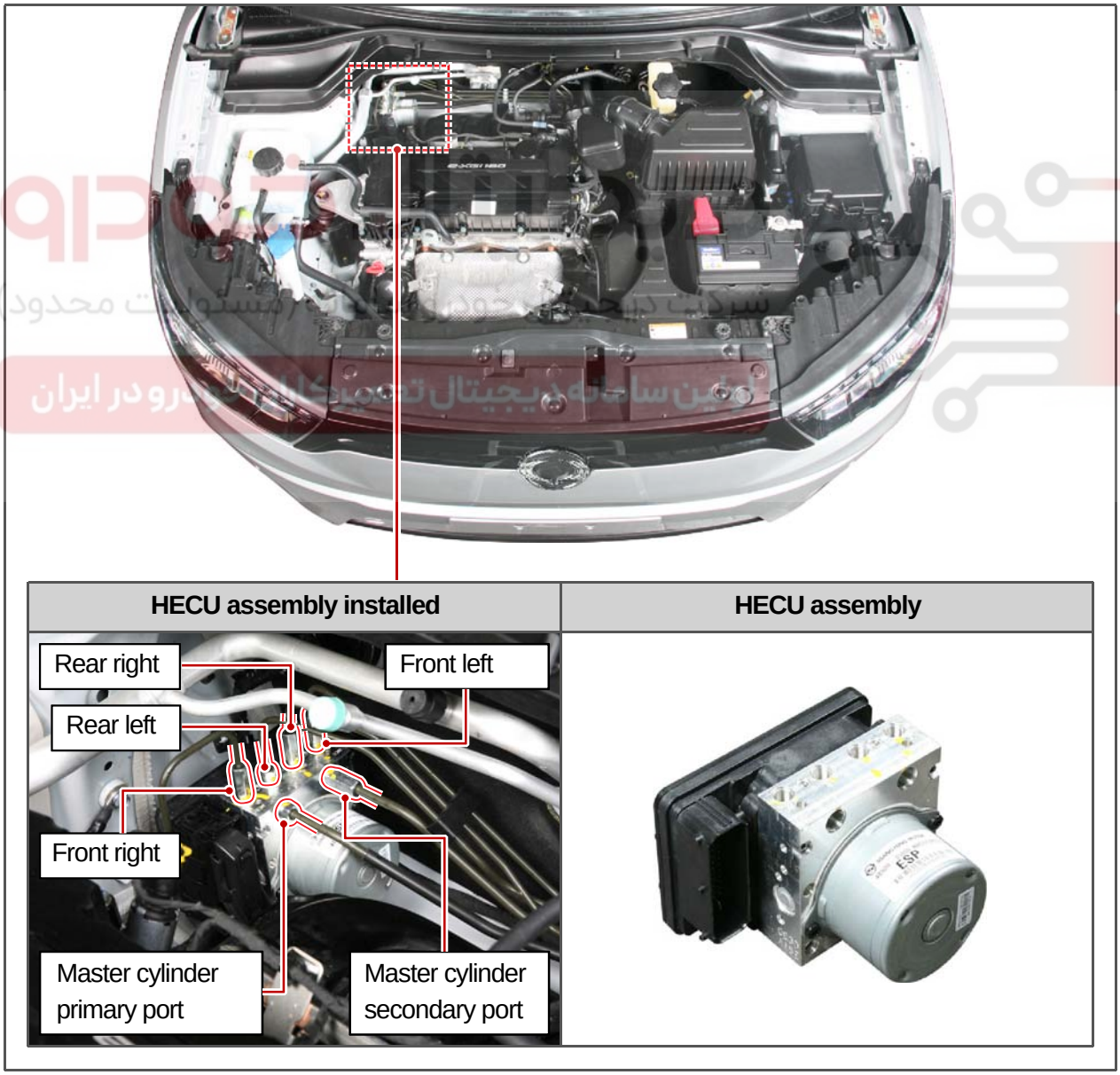
S.G.N. 4892-01

HYDRAULIC & ELECTRONIC CONTROL UNIT (HECU)

1) Overview

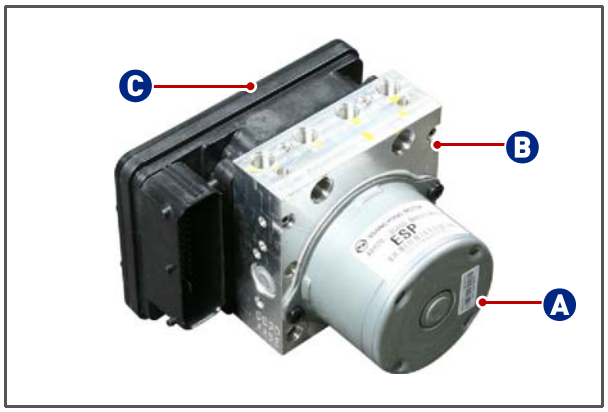
The hydraulic & electronic control unit (HECU) is installed to the dash panel side on the right side of the engine compartment.
The HECU consists of the motor pump section, solenoid valve body section, and ECU including pressure sensor. The ECU connector has 38 pins total.

2) Mounting Location



Modification basis	
Application basis	
Affected VIN	

3) Components



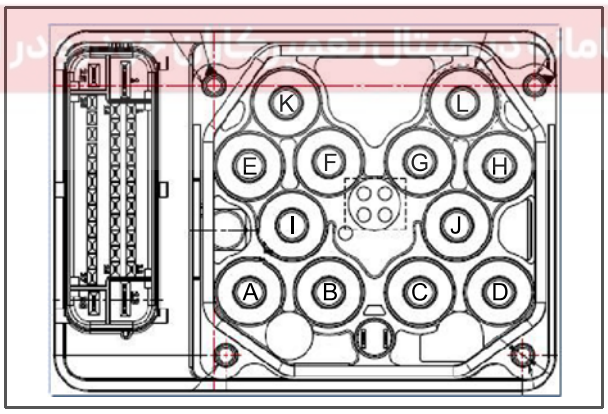
The HECU consists of the motor pump section (A), solenoid valve section (B), and ECU with pressure sensor (C).

▶ Electronic control unit (ECU)

The ECU controls the hydraulic valves by supplying or cutting off the voltage to each solenoid valve depending on the wheel speed and other information from the wheel speed sensors. The solenoid valve consists of 12 channels including: 4 channels for inlet, 4 channels for outlet, 2 channels for electronic shuttle valve, and 2 channels for traction valve.

*** ECU lower cover**

Since the electrical components are susceptible to moisture and water, GoreTex-based plate is used in the ECU lower cover to cut off water entry as well as the air flow.



A. Outlet valve (FL)
B. Outlet valve (RR)
C. Outlet valve (RL)
D. Outlet valve (FR)
E. Inlet valve (FL)
F. Inlet valve (RR)
G. Inlet valve (RL)
H. Inlet valve (FR)
I. Electronic shuttle valve (ESV-S)
J. Electronic shuttle valve (ESV-P)
K. Traction valve (STC)
L. Traction valve (PTC)
M. Motor connector

▶ Hydraulic control unit (HCU)

The HCU is a set of components which are used to control the hydraulic pressure transmitted to each wheel. It consists of the primary circuit and the secondary circuit. The primary circuit is used as a basic hydraulic circuit, and the secondary circuit is used when the ABS is activated. The HCU calculates using the signals sent from various sensors to determine the slip condition. When the ABS is activated, the valves and motors are operated by the control logic of the ECU to control the pumping and boosting/reducing/keeping pressure.

4) HECU Self-Diagnosis

The HECU performs the tests for solenoid and pump as follows:

Item	Operating conditions	
Solenoid valve	Non-operating test	- After IGN ON
	Operating test	- During initial check after IGN ON - When the vehicle speed is 40 km/h or higher
Pump motor	Operating test	When the vehicle speed reaches 15 km/h to 30 km/h after IGN ON

NOTE

The system check is performed before the completion of HECU self-diagnosis.

No.	Function
1	BAT + (motor power supply)
2	P-CAN Low
3	-
4	-
5	-
6	-
7	-
8	-
9	-
10	-
11	-
12	-
13	Ground
14	P-CAN High
15	-
16	Brake switch signal input
17	Vehicle speed "ECU B80"(G16DF)
18	Wheel speed sensor power supply (FR)
19	Wheel speed sensor power supply (RR)

No.	Function
20	Wheel speed sensor signal (RL)
21	Wheel speed sensor signal (FL)
22	Air bag unit A43 (CAN High)
23	ESP OFF switch signal
24	-
25	BAT + (solenoid power supply)
26	-
27	-
28	-
29	IGN 1
30	-
31	Wheel speed sensor signal (FR)
32	Wheel speed sensor signal (RR)
33	Wheel speed sensor power supply (RL)
34	Wheel speed sensor power supply (FL)
35	Air bag unit A44 (CAN Low)
36	-
37	-
38	Ground

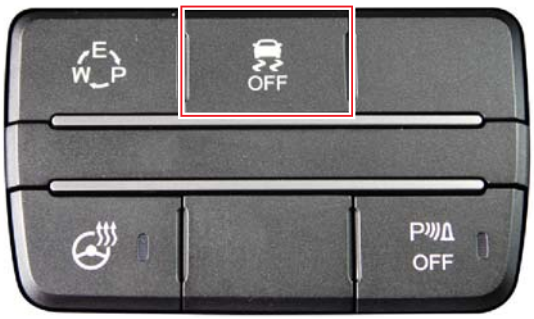
Modification basis	
Application basis	
Affected VIN	

S.G.N.
8510-07 ESP OFF SWITCH

1) Overview

If the driving wheels are slipping on the snowy or icy roads, the engine rpm may not be increased even when the accelerator pedal is depressed, and accordingly, the vehicle may not be started off.
When the ESP OFF switch is pressed, the ESP function is deactivated and the vehicle will be driven regardless of the output values from the corresponding sensors. However, the ABS function still operates.

2) Mounting Location

ESP OFF switch	ESP Indicator
	
	ESP operation indicator / ESP OFF indicator
	 

Modification basis	
Application basis	
Affected VIN	

3) Operating Process

(1) ESP ON/OFF switch

The ESP function turns ON and OFF each time the driver presses the ESP ON/OFF switch. This switch is a constant-open type instant contact switch and connected to IGN1 when the switch is operated. The default setting is ESP ON and it is turned off and on each time the switch is pressed.

(2) ESP OFF indicator module

▶ **CAN Cluster Type**

The ESP OFF indicator module shows the operating conditions of the ESP function.
The ESP OFF indicator comes on when:

- the ESP function is deactivated by switch input

(3) ESP warning lamp module

The ESP warning lamp shows the self-diagnosis result of ESP function and fault conditions of the system.
The ESP warning lamp comes on when:

- the initialization mode is processed after IGN1 ON
- the ESP function is inhibited because of fault
- the ESP is activated (flashing)
- the trouble diagnosis mode is processed
- the communication with the warning lamp drive CAN module is not available.

Mode	Warning Lamp			
	 EBD warning lamp	 ABS warning lamp	 ESP OFF Lamp	 ESP warning lamp
EBD Error	ON	ON	OFF	ON
ABS Error	OFF	ON	OFF	ON
ESP Error	OFF	OFF	OFF	ON

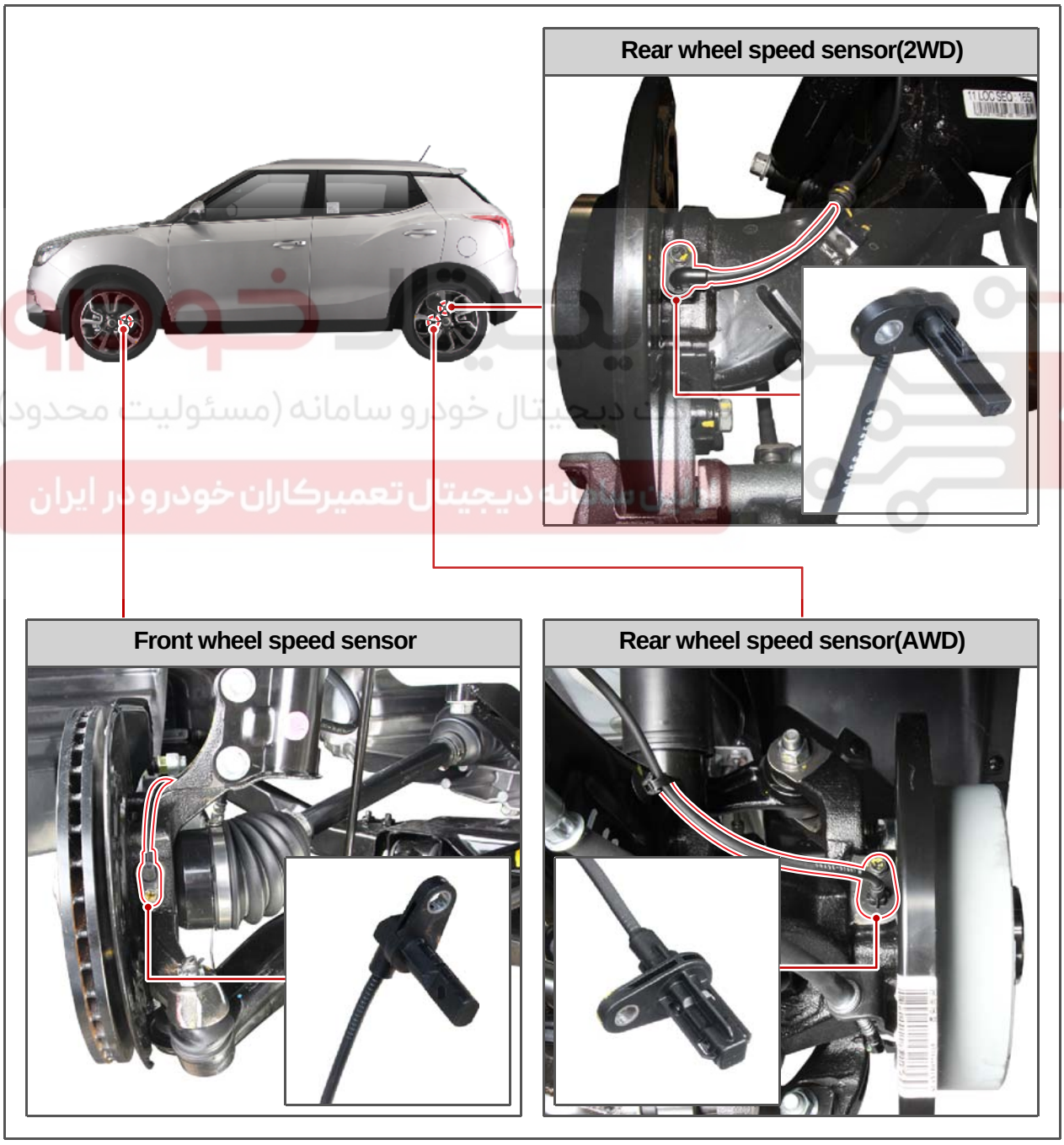
S.G.N. 4890-01

FRONT AND REAR WHEEL SPEED SENSORS

1) Overview

The wheel speed sensor is installed to the knuckle on each wheel. For the 2WD vehicle, the front sensor has the same shape as the rear sensor. The rear wheel speed sensor for the AWD vehicle differs slightly. While the sensor detects the wheel speed using a magnetic wheel of the hub for the 2WD vehicle, the rear wheel speed sensor detects the wheel speed using a tone wheel of the rear drive shaft for the AWD vehicle.

2) Mounting Location



Modification basis	
Application basis	
Affected VIN	

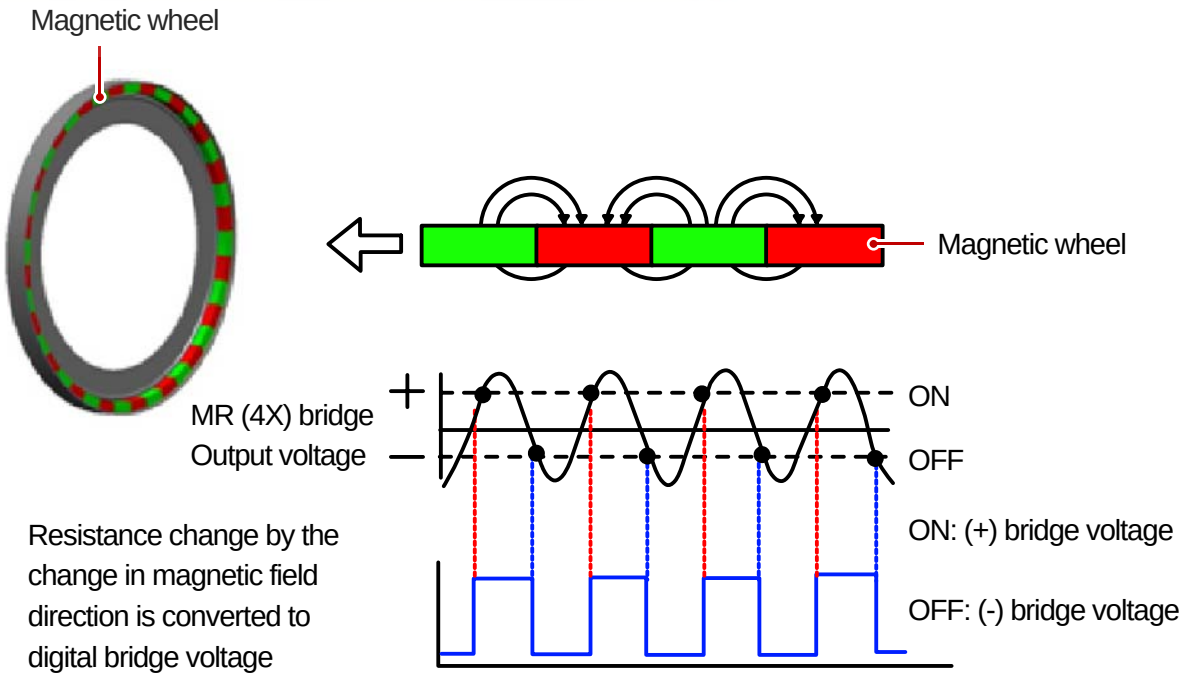
3) Operating Process

(1) 2WD (front/rear), AWD (front) wheel speed sensors

The wheel speed sensor consists of the permanent magnet (ring magnet) and magnetic resistance element and is used to record the wheel speed. When the magnetic resistance element is under the influence of the magnetic field, it is changed into a resistor. The ring magnet is seated on the plate of the hub and connected to the tire wheel through the hub. As the magnetic field is changed by the rotational movement of the internal gear magnet, the magnetic resistance element is changed to the resistor.
The HECU receives this information to control the ESP system. If it detects an open or short circuit of the wheel speed sensor, it will stop the ABS operation and turn on the warning lamp.

Front	Rear(2WD)
	

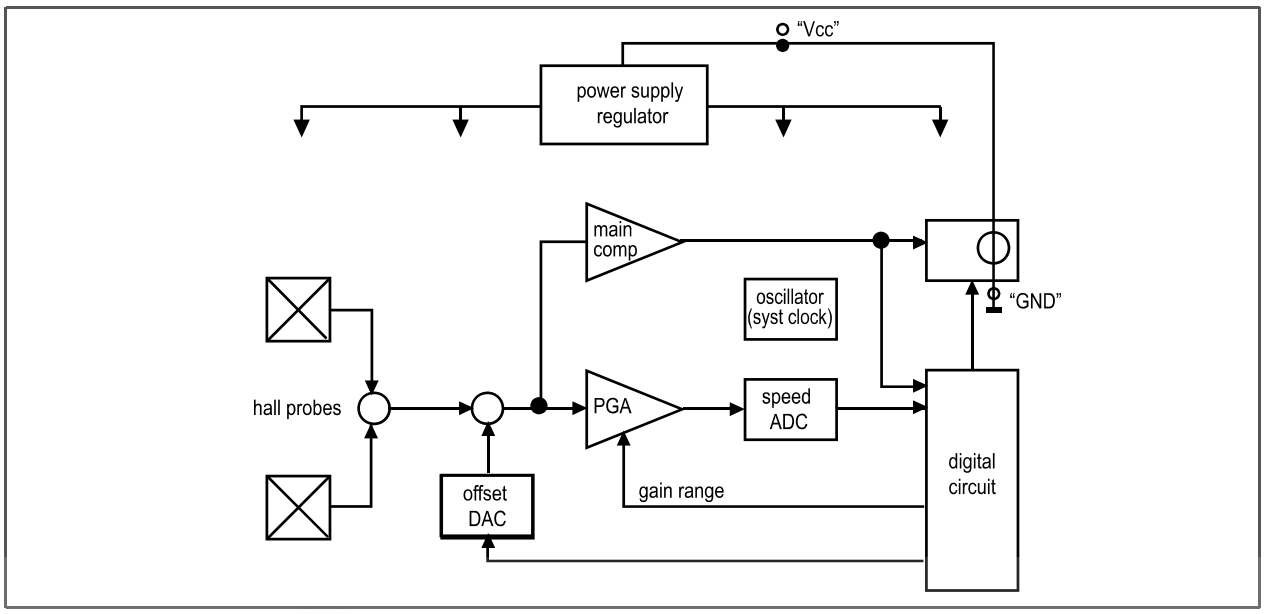
A. Wheel speed sensor
B. Magnetic wheel
C. Hub assembly



Modification basis	
Application basis	
Affected VIN	

(2) (Rear) Wheel Speed Sensor for AWD

▶ Block diagram



- Two hall elements with varying voltage according to magnetic field
- Power supply (12 V)
- Amplifier/Comparator
- Analog/digital converter

▶ Function of active wheel speed sensor system

Rear drive shaft tone wheel

- Basically, the tone wheel or the magnetized encoder wheel is required to activate the sensor. When the wheel rotates, the magnetic flux is changed as a sine wave form and this change is converted to voltage value by the hall elements. The voltage of sine wave form is amplified by the amplifier and finally converted to rectangular wave form by the comparator. This signal is transmitted to the
- ABS control unit to measure the speed. When the vehicle wheel rotates, the tone wheel rotates, and this rotation of the wheels changes the magnetic flux of the sensor and generates the induced electromotive force. The frequency of this duty waveform changes relative to the number of the rotation counts, and this frequency is controlled to detect the wheel speed.

Modification basis	
Application basis	
Affected VIN	

REMOVAL AND INSTALLATION

S.G.N. 4892-00 BLEEDING ABS/ESP SYSTEM

▶ **The ABS/ESP system needs to be bled when:**

- the brake caliper is replaced, removed/installed.
- the brake hydraulic pipe and hose are replaced, removed/installed.
- the brake master cylinder is replaced, removed/installed.
- the HECU is replaced, removed/installed.

NOTE

What is an air bleeding using a diagnostic device?

A program which drives the hydraulic pump of the HECU forcibly to facilitate the air bleeding from the ESP system.

CAUTION

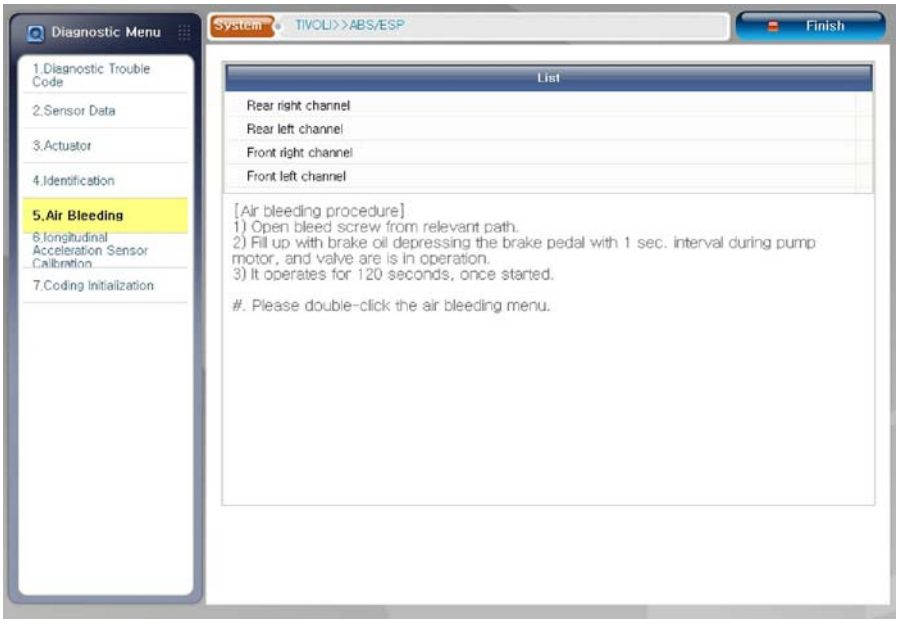
- Do not re-use the drained brake fluid.
- Avoid mixing different brake fluids and use only specified brake fluid (DOT4R). It may cause the brake system damage.
- After finishing the work, make sure the brake fluid level is between the MAX and MIN marks on the reservoir tank (0.7 to 0.8 liters).
- Make sure that no foreign materials get into the system when bleeding and working on the brake system.
- Avoid getting brake fluid on your body or other vehicle parts. In case of contact, wash with plenty of water.

1

1. Install the brake fluid supplier with pressurizer (equipment for brake fluid change).

Master cylinder reservoir tank location

2. Start the vehicle and install the diagnostic device.
3. Under the start-up screen, click on "Air Bleeding" in the "Vehicle Name" → "System" → "ESP Diagnosis".



Modification basis	
Application basis	
Affected VIN	

4. Operate the brake fluid supplier with pressurizer.

CAUTION

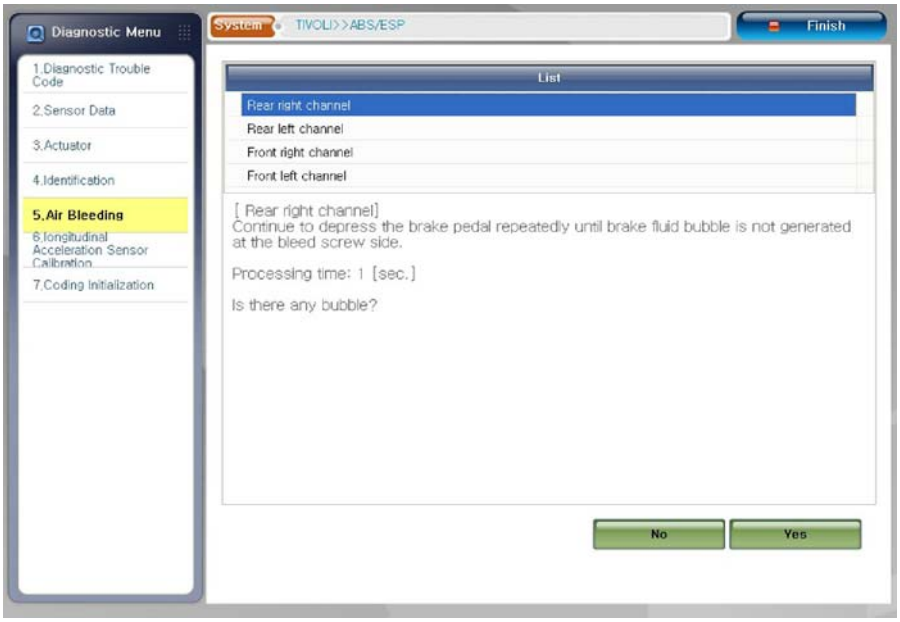
Check that the brake fluid level in the pressurizer is sufficient before performing the air bleeding.

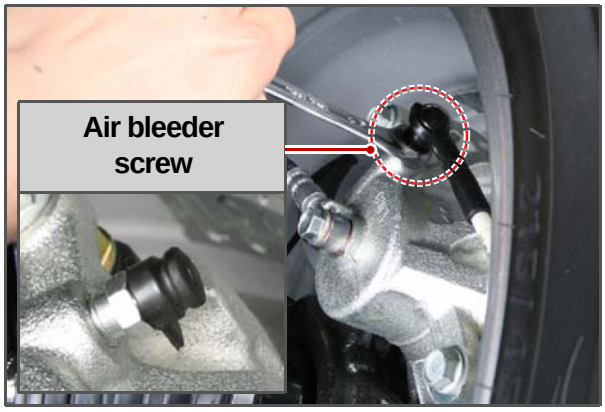
NOTE

Oil specification

DOT4

5. Select "Rear right path" in the Diagnostics menu, unscrew the caliper air bleeder screw at the rear right hand side, and connect the transparent hose. (When performing air bleeding, the hydraulic pump of the HECU is operated for 120 seconds. Depress the pedal until the air bubbles are invisible.)

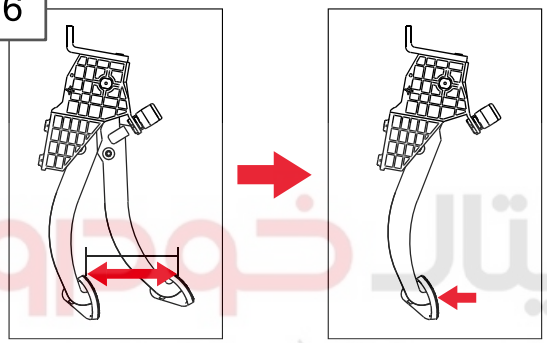




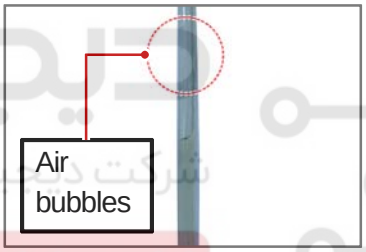
NOTE

Air bleeding order: 1. rear right → 2. front left → 3. rear left → 4. front right

6

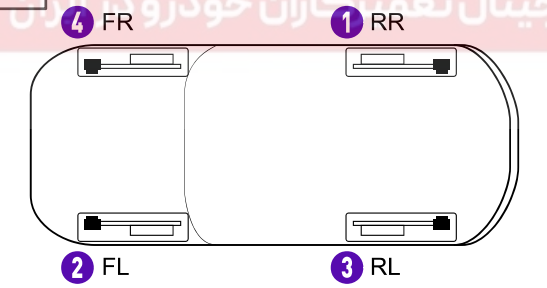


6. The mechanic A should depress the brake pedal repeatedly while the mechanic B drains the brake fluid by removing the brake air bleeder screw until the bubbles are invisible, and tighten the screw.



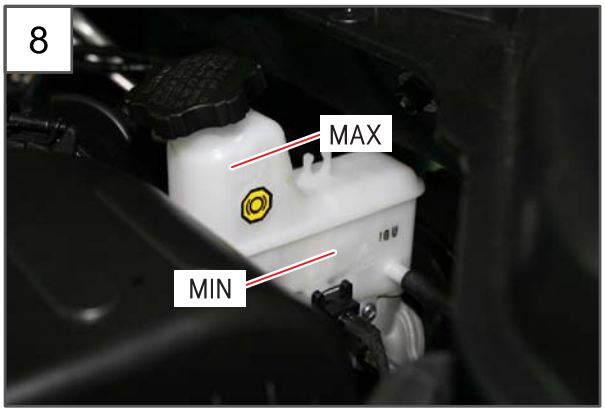
If no bubbles are visible, press "YES" under the corresponding diagnostic menu.

7



7. Carry out air bleeding for the rest of the wheels in the order shown in the figure (1. rear right → 2. front left → 3. rear left → 4. front right) using the method described above.

8



8. After finishing the service work, visually check the brake operation and oil leaks, and fill the brake reservoir tank with the brake fluid level between the MIN and MAX marks on the tank.

Modification basis	
Application basis	
Affected VIN	

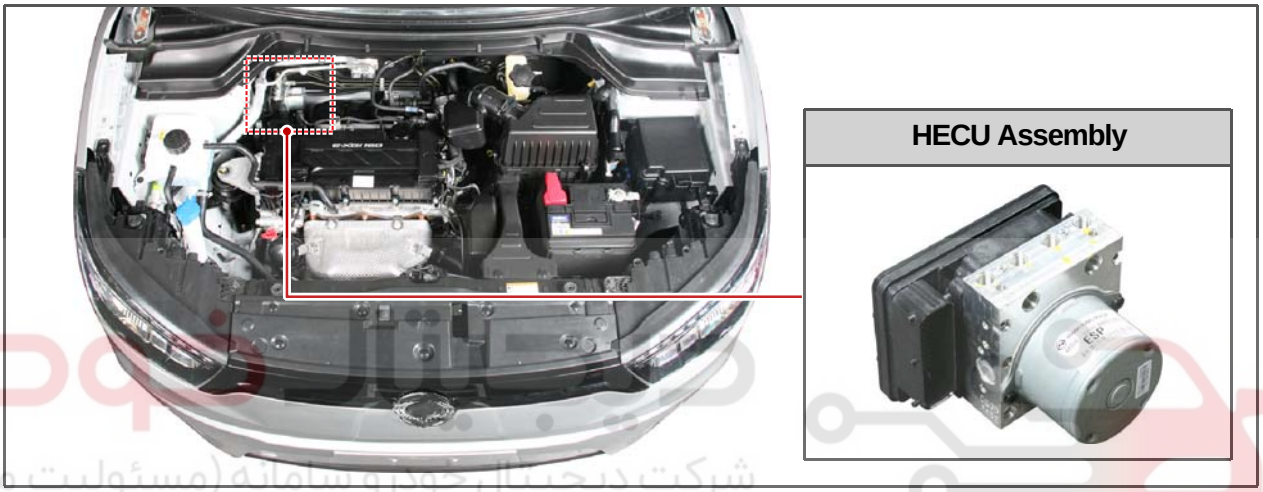
S.G.N. 4892-01

HECU

Preceding work - Disconnect the negative battery cable.

CAUTION

- Avoid getting brake fluid on the painted surface of the vehicle. In case of contact, rinse with plenty of water.
- Be careful not to allow any entry of air to the hydraulic modulator. If the air enters to the hydraulic system, perform bleeding using a diagnostic device which is programmed for ESP system.



HECU Assembly

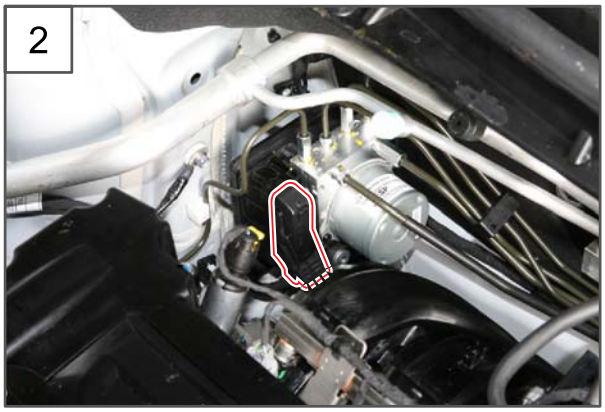
1

1. Collect the brake fluid from the brake fluid reservoir tank using an oil pump.

CAUTION

Make sure that the brake fluid does not come into contact with the vehicle body or skin.

2



2. Disconnect the HECU connector.

Modification basis	
Application basis	
Affected VIN	

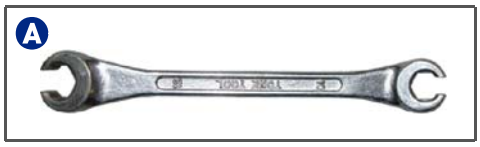
3

3. Remove the 2 mounting nuts (12 mm) securing the HECU brake pipes to the master cylinder.

Tightening torque 19.6 to 23.5 Nm

CAUTION

Use only the dedicated tool (A) when removing the brake pipe mounting nut.



4

4. Remove the 4 mounting nuts (10 mm) securing the caliper brake pipe to the HECU.

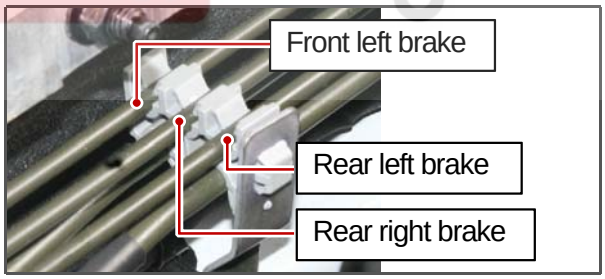
Tightening torque 14.7 to 18.6 Nm

CAUTION

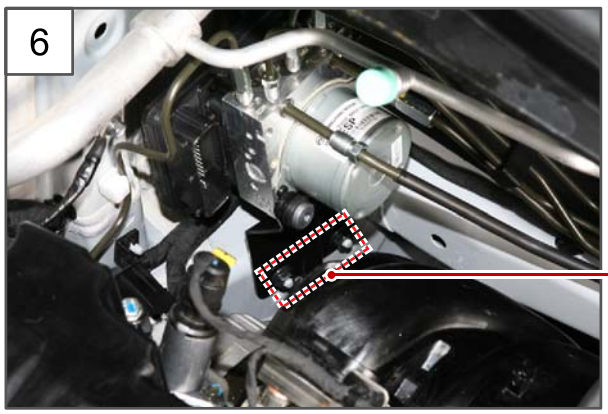
If the threads of the brake pipe and HECU are not fitted correctly, the pipe and HECU can be damaged and oil leaks can occur.

5

5. Free the following brake pipes from the 2 pipe mounting holders.

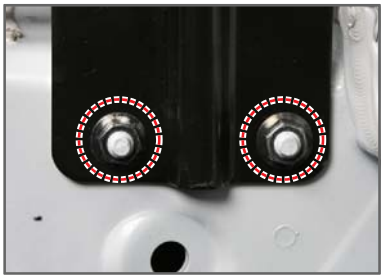


6



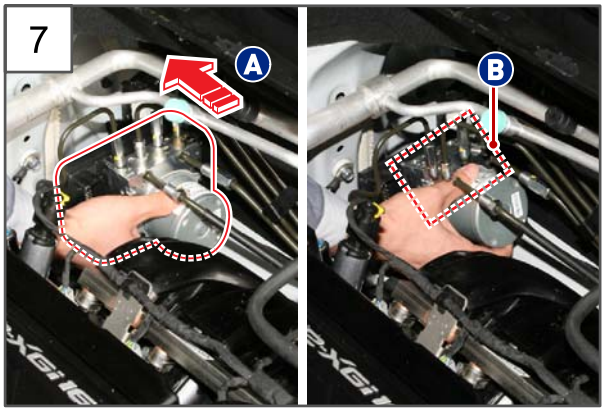
6. Remove the 2 mounting nuts (12 mm) for the HECU bracket.

Tightening torque 10.0 to 14.0 Nm



Modification basis	
Application basis	
Affected VIN	

7

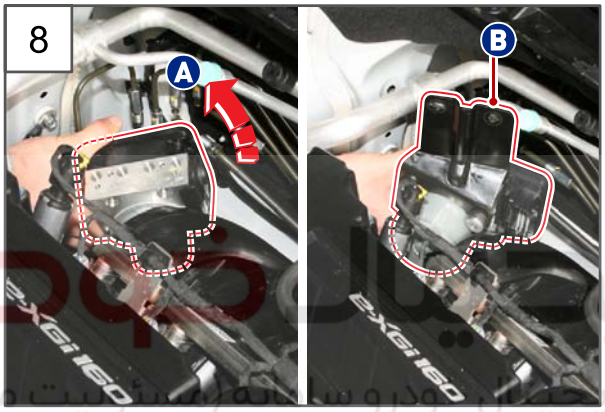


7. Swing the HECU assembly up in the direction of the arrow (A) to prise loose between the HECU assembly and brake pipe (B) as shown in the picture.

CAUTION

Make sure to avoid the pipe damage from contact with the brake pipes.

8

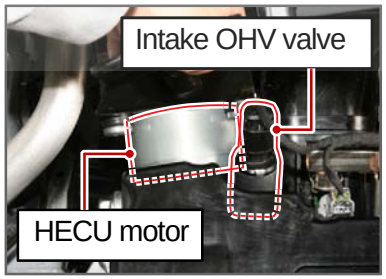


8. Turn the HECU assembly 180° in the direction of the arrow (A) from the right side of the intake manifold, so that the bracket (B) faces upward.

9

9. Remove the HECU assembly.

CAUTION



Be careful not to damage the intake OHV valve connector.

10

10. Unscrew 3 hexagon HECU bracket mounting bolts (6 mm) to remove the bracket.

Tightening torque 11.0 to 14.0 Nm

Modification basis	
Application basis	
Affected VIN	

11

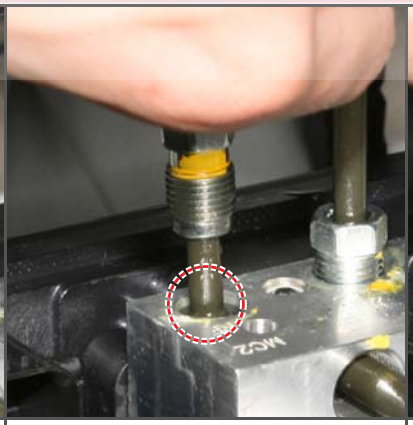
11.Install in the reverse order of removal.

CAUTION

- Always perform air bleeding after replacing. (Refer to "BLEEDING ABS/ESP SYSTEM" under this subsection)
  When you install a new HECU to the vehicle,
- coding is executed automatically.

Cautions for installation of HECU

Observe the following when installing the pipe and HECU to prevent damage to the components or oil leaks.

		
Pull up the brake pipe with the mounting nut in the direction of the arrow shown in the picture.	Insert the brake pipe into the hole of the HECU.	Tighten the mounting nut by hand and tighten the nut to the specified torque using a proper tool.

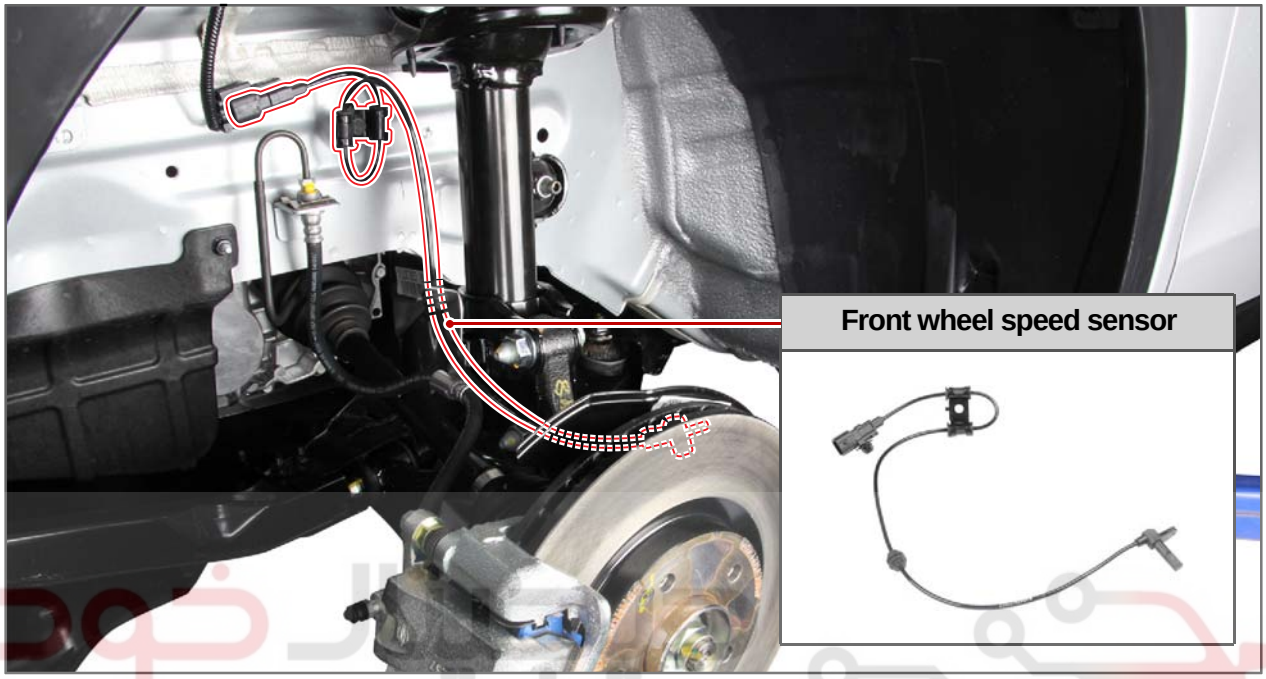
Modification basis	
Application basis	
Affected VIN	

S.G.N. 4890-01

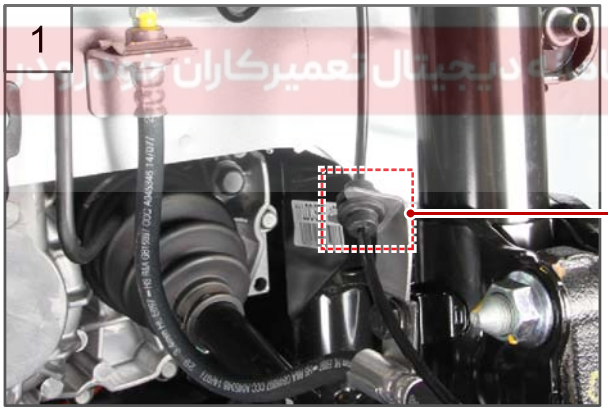
FRONT WHEEL SPEED SENSORS

Preceding work

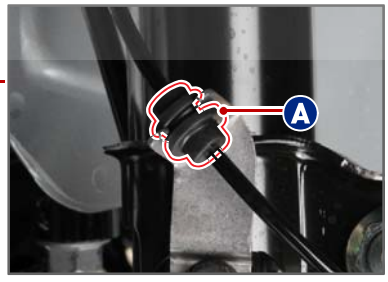
- Disconnect the negative battery cable.
  Remove the tire.



1



1. Free the mounting for the front wheel speed sensor (A).



2

2. Unscrew the mounting bolt (12 mm) for the front wheel speed sensor.

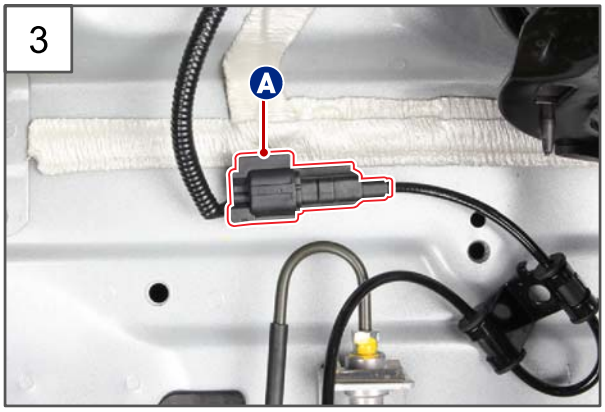
Tightening torque 9.8 to 12.7 Nm

CAUTION

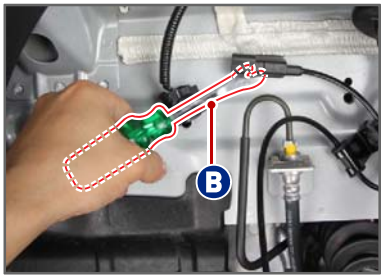
Check the left (L) and right (R) marks on the mounting bracket when installing the front wheel speed sensor.

Modification basis	
Application basis	
Affected VIN	

3



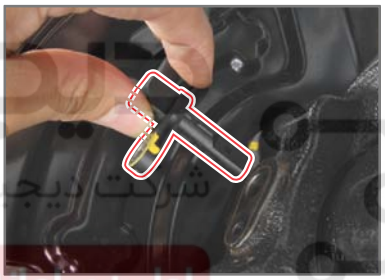
3. Disconnect the front wheel speed sensor connector (A) and remove it from the vehicle using a hand remover (B).



4

4. Unscrew the front wheel speed sensor mounting bolt (10 mm) and separate the wheel speed sensor from the knuckle.

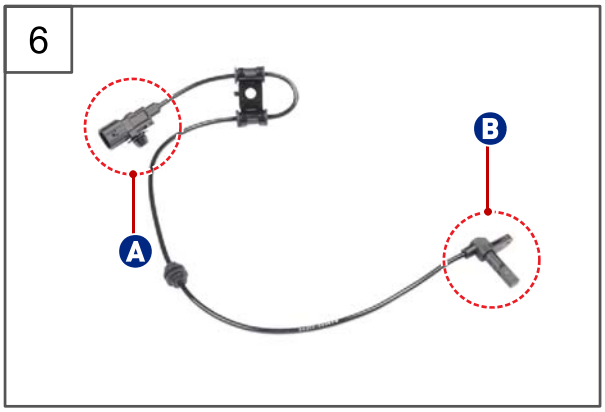
Tightening torque 8.0 ± 2.0 Nm



5

5. Remove the front wheel speed sensor.

6



6. Install in the reverse order of removal.

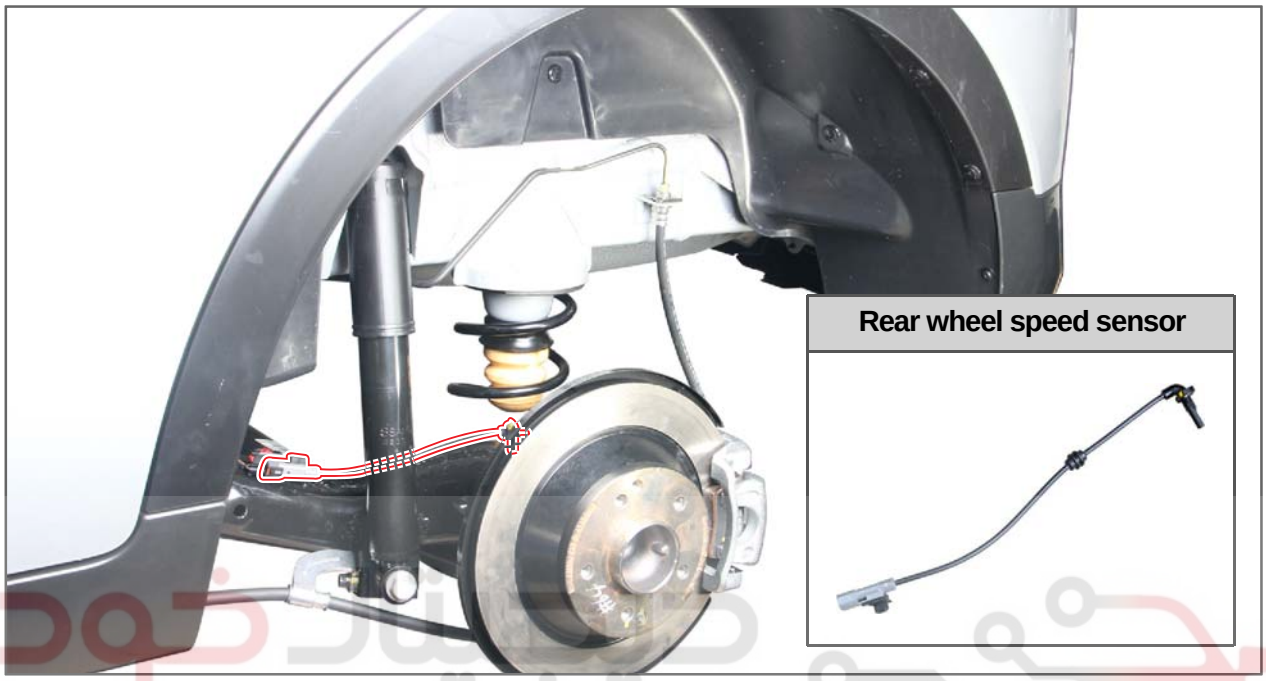
A Connector	B Sensor
	

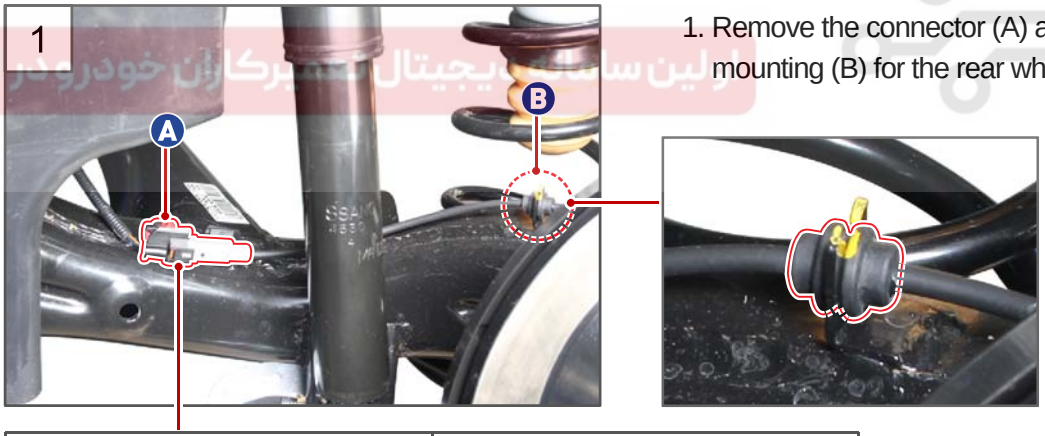
Modification basis	
Application basis	
Affected VIN	

S.G.N. 4890-02

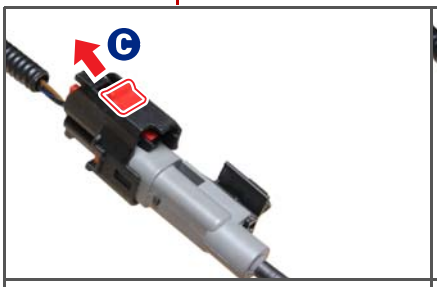
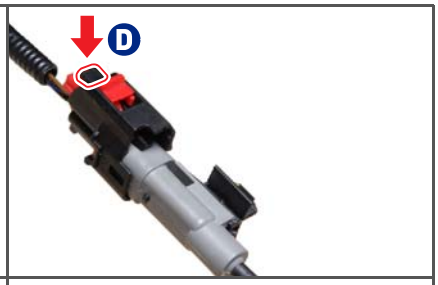
REAR WHEEL SPEED SENSOR (2WD)

Preceding work
- Disconnect the negative battery cable.
- Remove the rear wheel.





1. Remove the connector (A) and cable mounting (B) for the rear wheel speed sensor.

	
Move the connector locking part (red) in the direction of the arrow (C).	Press on the locking part in the direction of the arrow (D) to disconnect the connector.

Modification basis	
Application basis	
Affected VIN	

2

2. Unscrew the mounting bolt (10 mm) for the rear wheel speed sensor.

Tightening torque 9.0 ± 1.5 Nm

3

3. Remove rear wheel speed sensor.

4

4. Install in the reverse order of removal.

Connector	Sensor
	

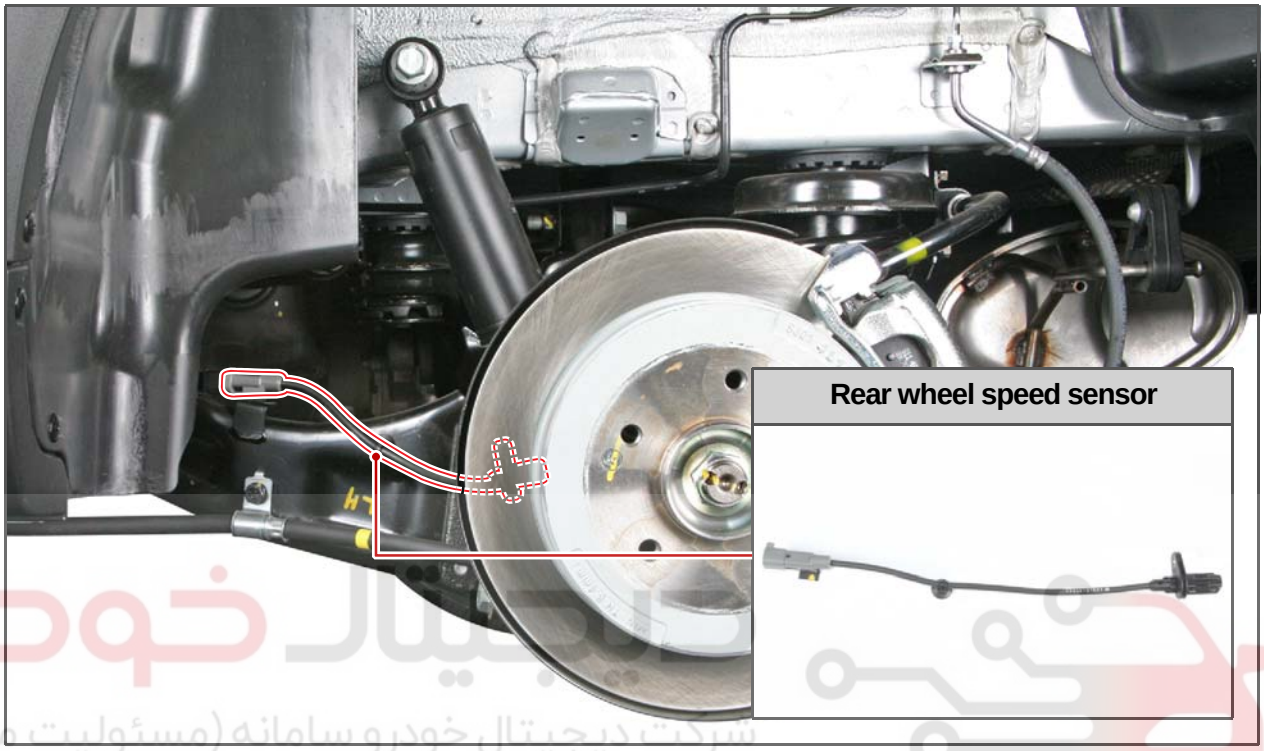
Modification basis	
Application basis	
Affected VIN	

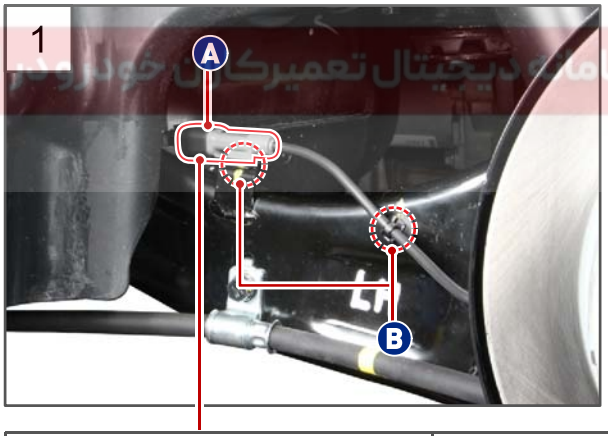
S.G.N. 4890-02

REAR WHEEL SPEED SENSOR (AWD)

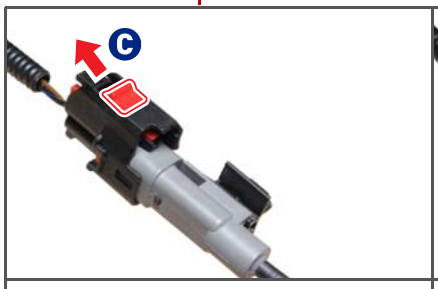
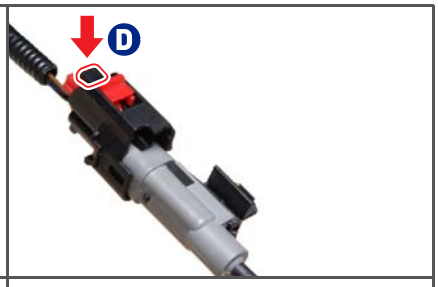
Preceding work

- Disconnect the negative battery cable.
- Remove the rear wheel.



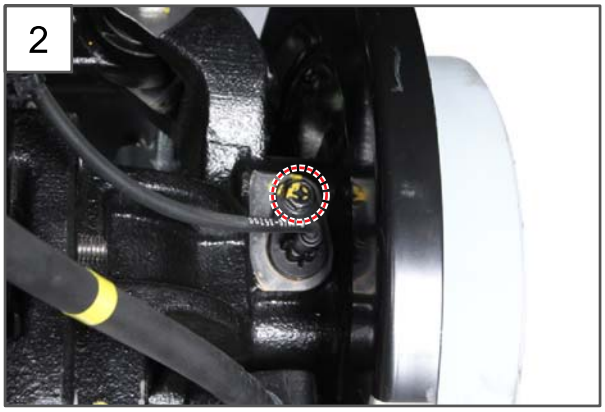


1. Remove the connector (A) and cable mounting (B) for the rear wheel speed sensor.

	
Move the connector locking part (red) in the direction of the arrow (C).	Press on the locking part in the direction of the arrow (D) to disconnect the connector.

Modification basis	
Application basis	
Affected VIN	

2



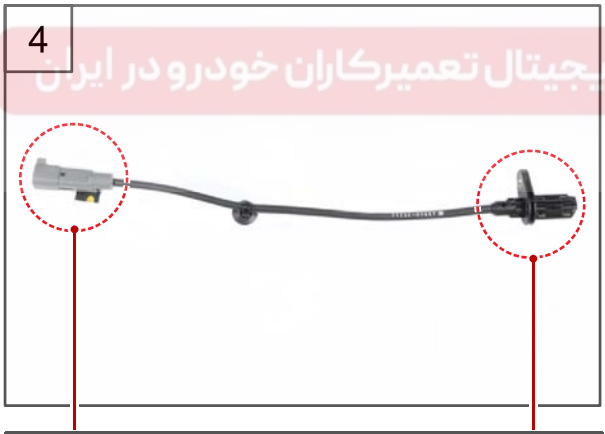
2. Unscrew the rear wheel speed sensor mounting bolt (10 mm).

Tightening torque 9.0 ± 1.5 Nm

3

3. Remove rear wheel speed sensor.

4



4. Install in the reverse order of removal.

Connector Appearance	Sensor
	

Modification basis	
Application basis	
Affected VIN	

S.G.N. 8510-07

ESP OFF SWITCH

Preceding work - Disconnect the negative battery cable.

1. Prize off the lower main panel using a hand remover.

2. Disconnect the connector from the rear side of the lower main panel.

Modification basis	
Application basis	
Affected VIN	

3

3. Remove the lower main panel switch assembly.

4

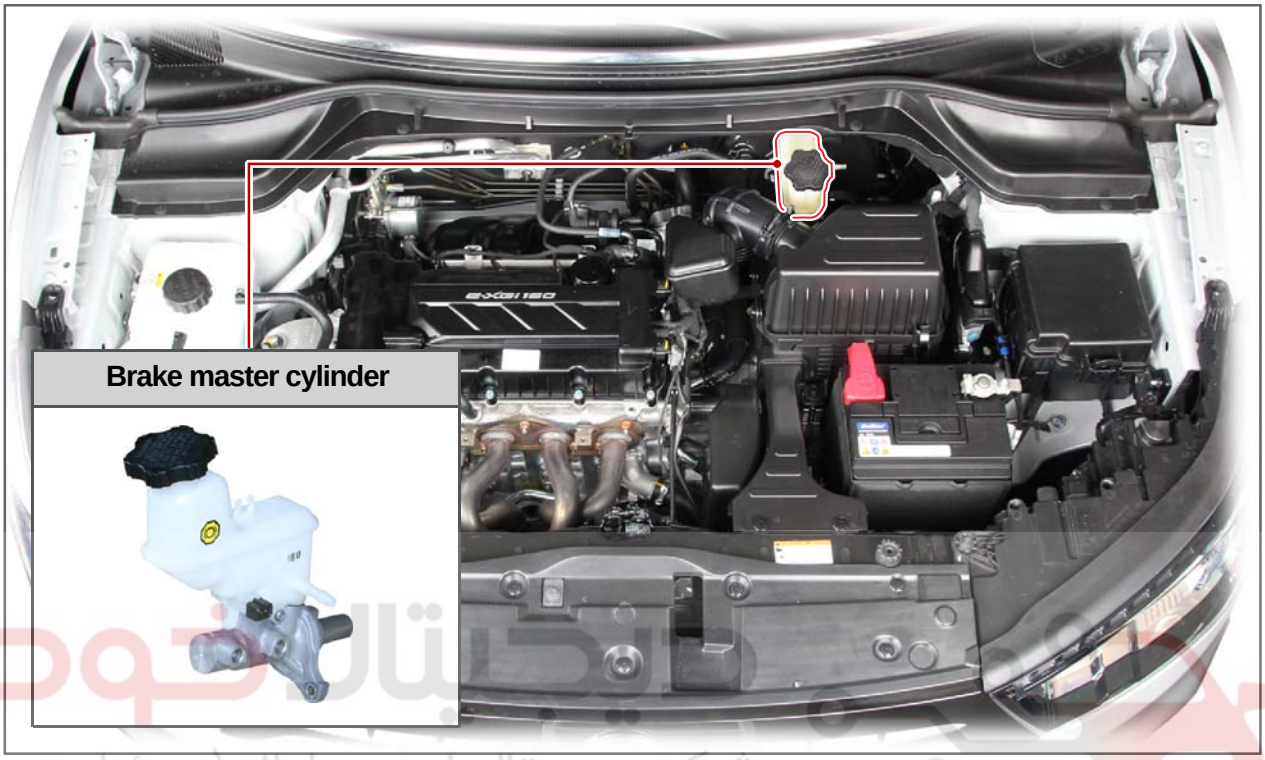
4. Install in the reverse order of removal.

Modification basis	
Application basis	
Affected VIN	

S.G.N. 4850-03

BRAKE MASTER CYLINDER

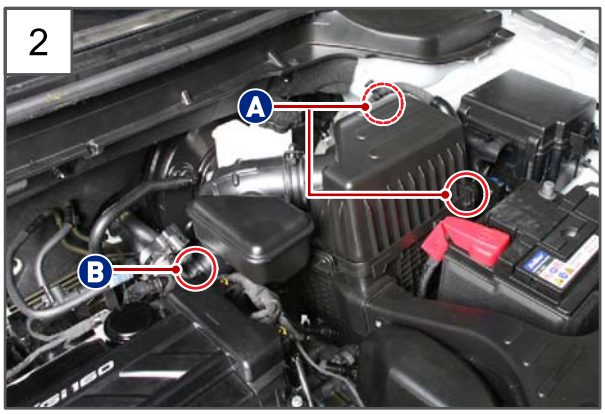
Preceding work - Disconnect the negative battery cable.



1. Collect the brake fluid from the brake fluid reservoir tank using an oil pump.

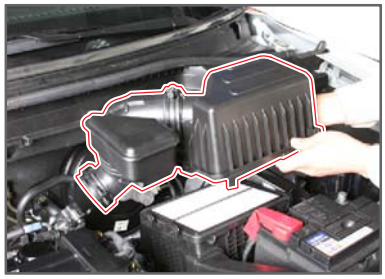
CAUTION

Make sure that the brake fluid does not come into contact with the vehicle body or skin.



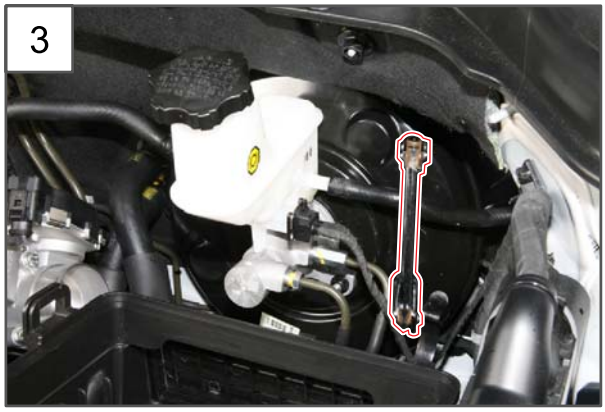
2. Remove the retaining clips (A) on the air cleaner upper cover and the spring clamp (B, 10 mm) of the air cleaner hose.

Tightening torque (B) 6 to 7 Nm



Modification basis	
Application basis	
Affected VIN	

3



3. For a vehicle with M/T, fit a special tool (hydraulic pressure shut-off clamp) to the hose connected from the brake fluid reservoir tank to the clutch master cylinder to block the flow of brake fluid.

4

4. Disconnect the brake fluid level switch connector.

5

5. Disconnect the 2 brake pipes (12 mm) to the master cylinder.

Tightening torque 18.7 to 22.6 Nm

CAUTION

Make sure that the remaining brake fluid does not come into contact with the vehicle body or your skin.

6

6. Unscrew the 2 mounting nuts (12 mm) for the brake master cylinder.

Tightening torque 12.8 to 16.7 Nm

Modification basis	
Application basis	
Affected VIN	

7

7. Remove the brake master cylinder.

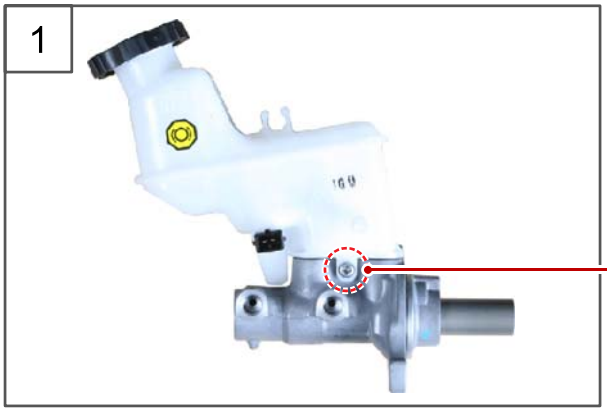
8

8. Install in the reverse order of removal.

Modification basis	
Application basis	
Affected VIN	

▶ Disassembling brake fluid reservoir tank

1



1. Unscrew the mounting screw for the brake fluid reservoir tank from the removed master cylinder.

2

2. Separate the brake fluid reservoir tank from the master cylinder.

3

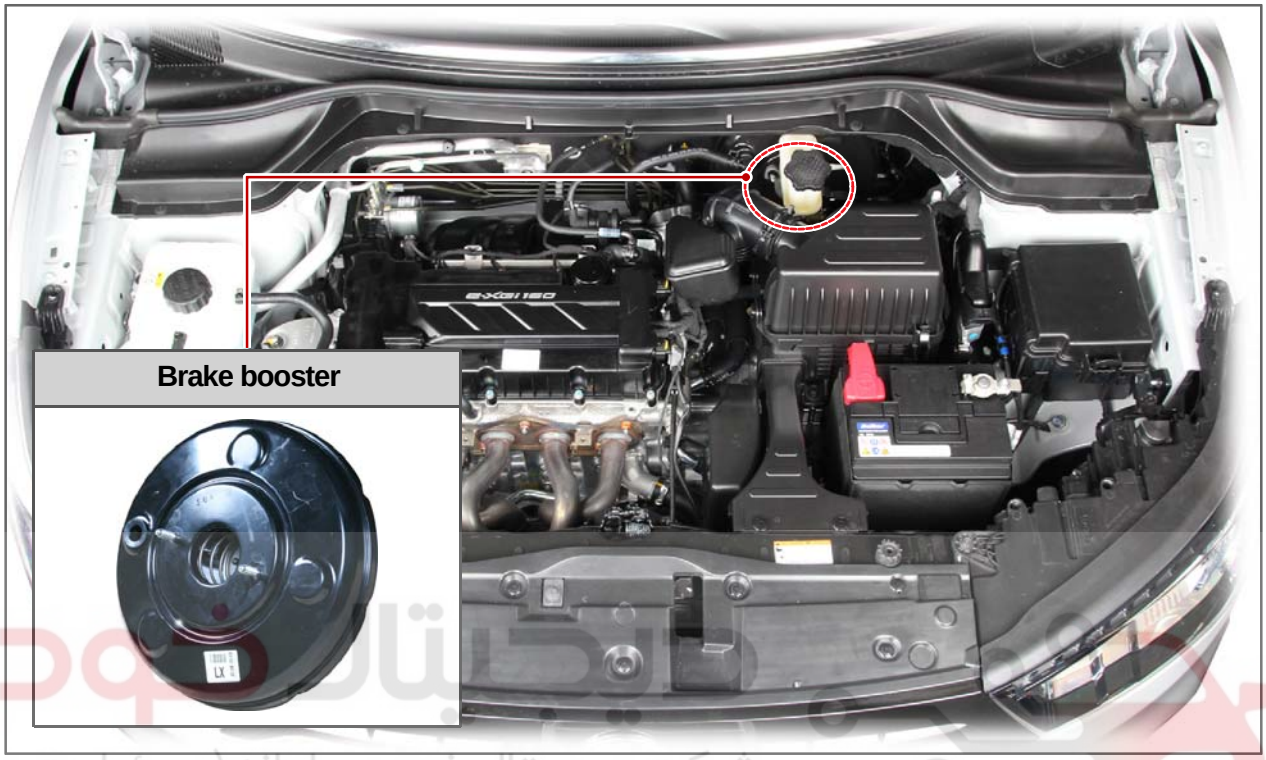
3. Install in the reverse order of removal.

Modification basis	
Application basis	
Affected VIN	

S.G.N. 4850-02

BRAKE BOOSTER

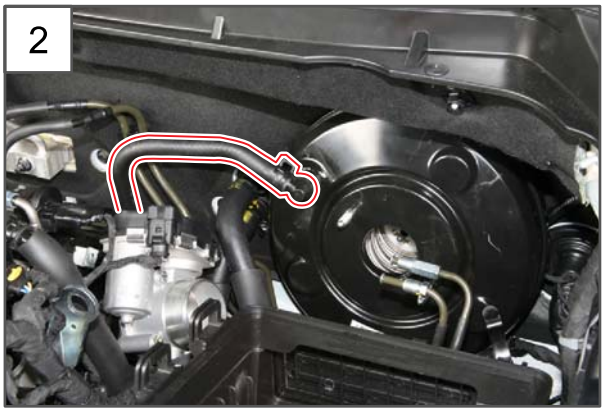
Preceding work - Disconnect the negative battery cable.



1. Remove the brake master cylinder.

NOTE

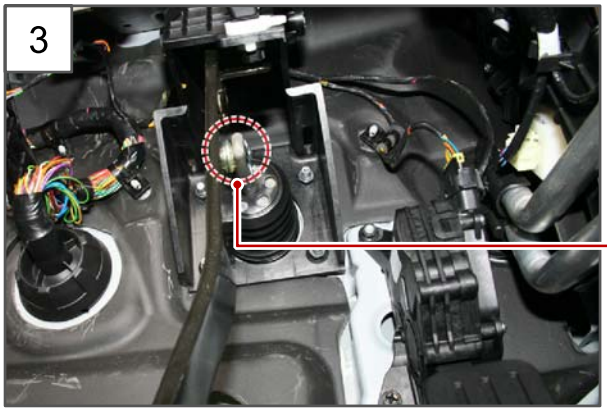
Refer to "BRAKE MASTER CYLINDER" under "REMOVAL AND INSTALLATION" subsection of "BRAKE SYSTEM" section in "CHASSIS" chapter.



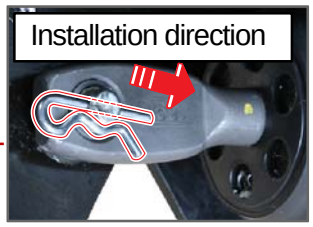
2. Disconnect the vacuum hose connected to the brake booster.

Modification basis	
Application basis	
Affected VIN	

3



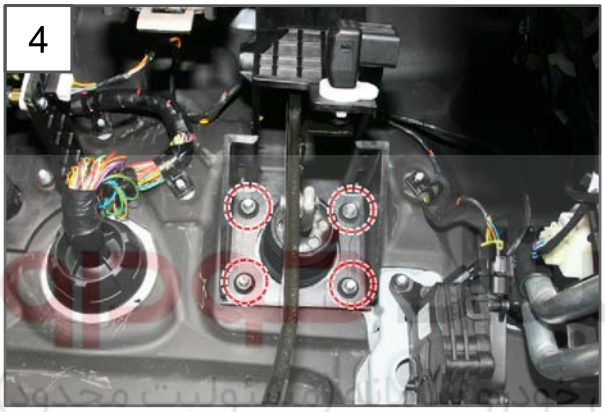
3. Remove the split pin which connects the brake pedal and booster push rod.



CAUTION

When installing the split pin, pay close attention to the installation direction.

4



4. Unscrew the 4 mounting nuts (12 mm) securing the booster on the brake pedal bracket.

Tightening torque 17.6 to 21.6 Nm

5

5. Remove the brake booster.

6

6. Install in the reverse order of removal.

Modification basis	
Application basis	
Affected VIN	

CODING PROCESS

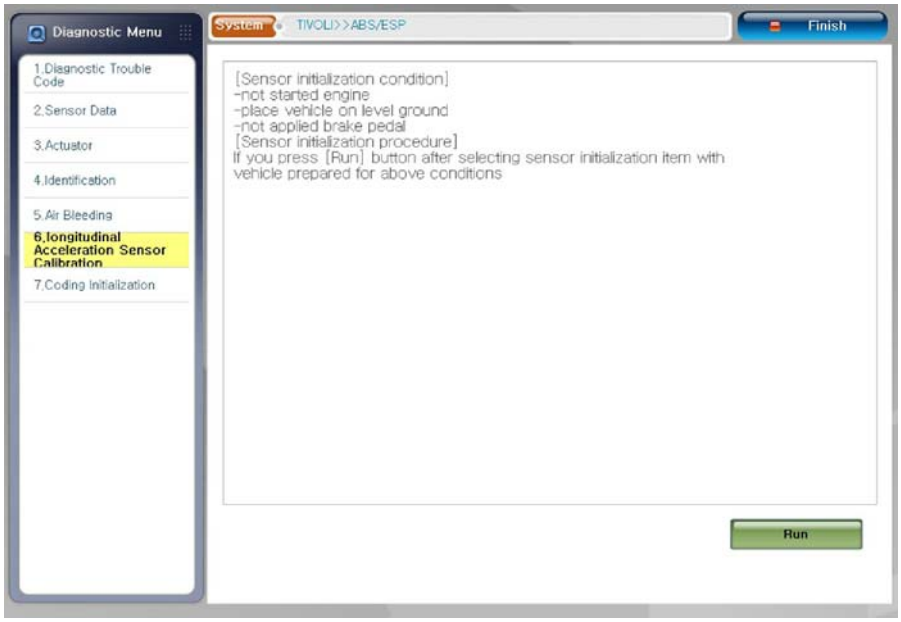
1. SENSOR CALIBRATION

▶ **Perform the sensor calibration when replacing the air bag unit (SDM).**

reference In this vehicle, the sensor cluster is built in the air bag unit (SDM).

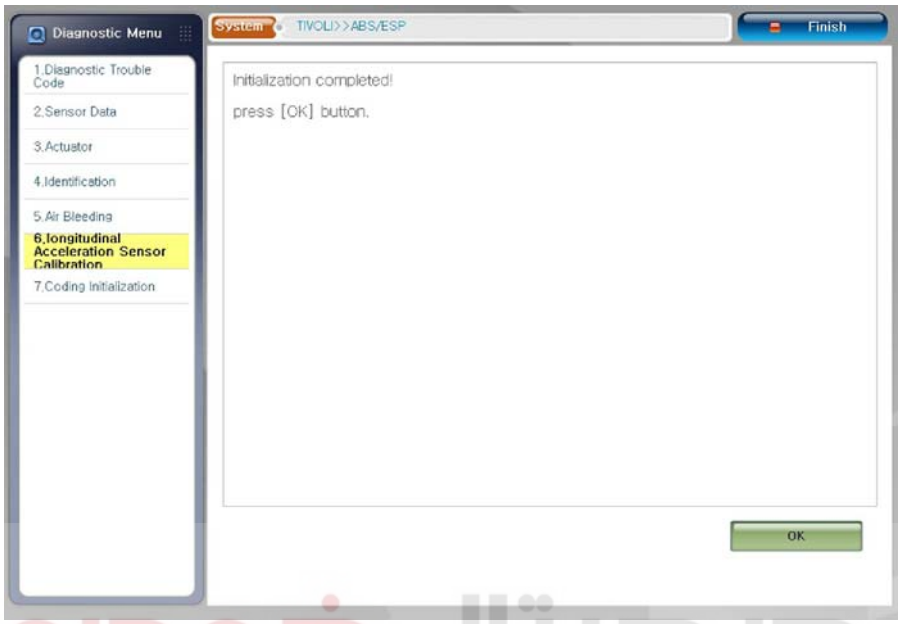
1. Turn the ignition ON and select vehicle type and system (ABS/ESP) on the diagnostic program for diagnosis.

2. Select the menu "Longitudinal acceleration sensor calibration" and follow the instructions on the screen to prepare the vehicle. Press the [Next] button.



Modification basis	
Application basis	
Affected VIN	

3. Press the [OK] button after the initialization has been completed.



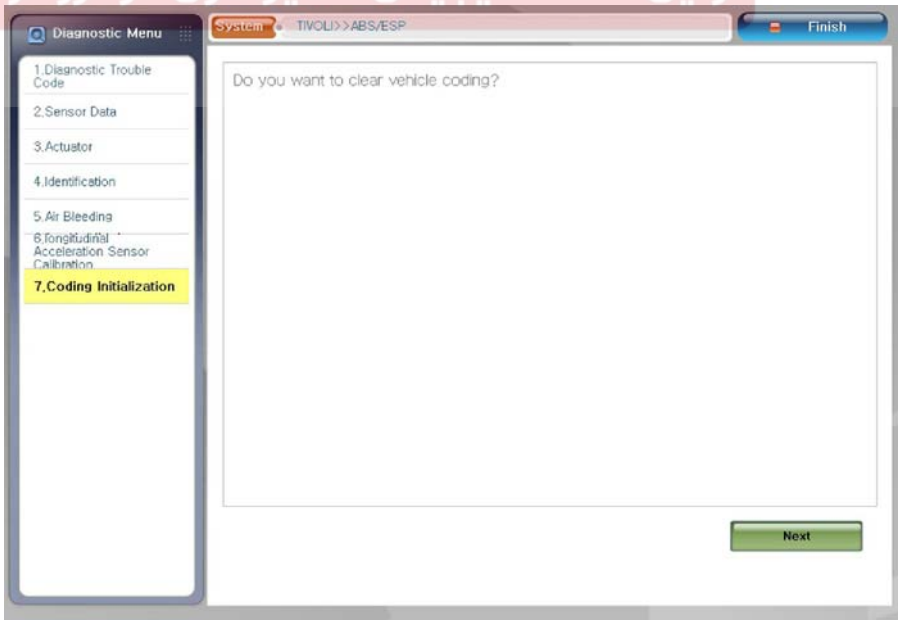
Modification basis	
Application basis	
Affected VIN	

2. CLEARING CODING

▶ **Perform the clearing vehicle coding when HECU.**

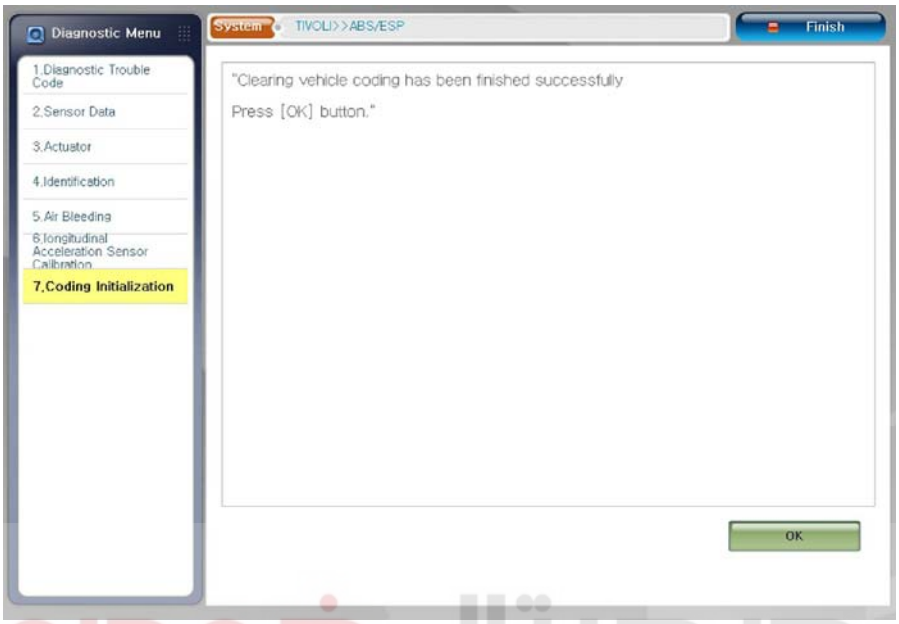
1. Turn the ignition ON and select vehicle type and system (ABS/ESP) on the diagnostic program for diagnosis.

2. Select the menu "Clearing vehicle coding" and press the [Next] button.



Modification basis	
Application basis	
Affected VIN	

3. Press the [OK] button after the clearing has been completed.



Modification basis	
Application basis	
Affected VIN	