ELECTRONIC STABILITY PROGRAM

4825-00/4850-01/4890-01/4890-10/4892-01/8510-23/8530-09

GENERAL INFORMATION

OVERVIEW AND OPERATING PROCESS

CONFIGURATION

REMOVAL AND INSTALLATION

GENERAL INFORMATION

1. SPECIFICATION

Unit	Description	
	ABS	ESP
HECU	Clock frequency: 32 MHz	Clock frequency: 50 MHz
	Memory: 128 KB	Memory: 512 KB
	Switch orifice	Switch orifice
Wheel speed sensor	Active type	Active type
Steering wheel angle sensor	None	Max. detection angle speed: 1500 °/Sec
		Operating voltage: 9 to 12 V
Sensor cluster	None	Yaw rate sensor + lateral G sensor + longitudinal G sensor (4WD)
Longitudinal G sensor	4WD only	None
Pressure sensor	None	HECU integrated

1) Specification of Active Wheel Sensor

Description	Specification
Supplying voltage	DC 12 V
Output current (at 2.75 km/h of vehicle speed)	7 mA (Lo) ~ 14 mA (Hi) +20%/-16%
Tightening torque	Front: 7.8 to 11.8 Nm
	Rear: 7.8 to 11.8 Nm
Operating temperature	−40 ~ 150 ℃
Operating frequency	1 ~ 2,500 Hz

Modification basis	
Application basis	
Affected VIN	

2) Specification of Steering Wheel Angle Sensor

Description	Specification
Operating voltage	9 to 16 V
Maximum output current	10 mA
Maximum detection angle speed	±100°/Sec
Operating temperature	−30 to 75 ℃
Supplying voltage	9 to 16 V (battery voltage)
Output voltage (HI)	approx. 3.50 V (3.0 to 4.1 V)
Output voltage (LO)	approx. 1.50 V (1.3 to 2.0 V)
Pulses/rev	45 pulses/rev

3) Specification of Sensor Cluster

Description	Specification	
Supplying voltage	approx. 12 V (8 to 16 V)	
Current consumption	below 250 mA	-
Operating range	Yaw rate sensor	± 75 °/Sec
	Lateral/longitudinal sensor	± 14.7m/Sec²

2. FUNCTIONS AND COMPONENT PARTS

1) Term Definition

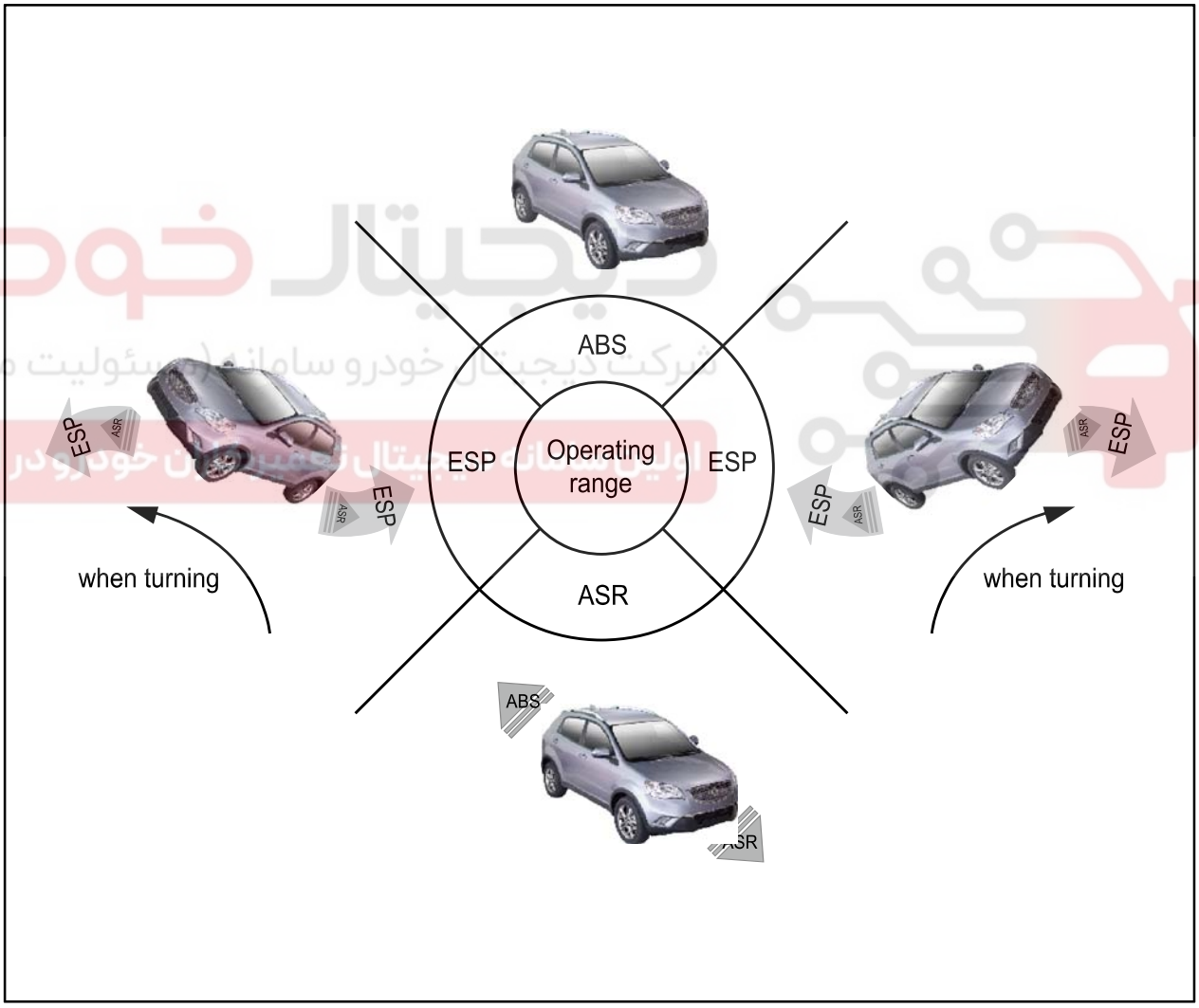
CBS: Conventional Brake System
ABS: Anti-Lock Brake System
EBD: Electronic brake-Force Distribution
ESP: Electronic Stability Program
ABD: Automatic Braking Differential
ASR: Acceleration Slip Regulation
AYC: Active Yaw Control (Understeer and Oversteer Control)
HBA: Hydraulic Brake Assistant
ARP: Active Rollover Protection
HSA: Hill Start Assistant

Modification basis	
Application basis	
Affected VIN	

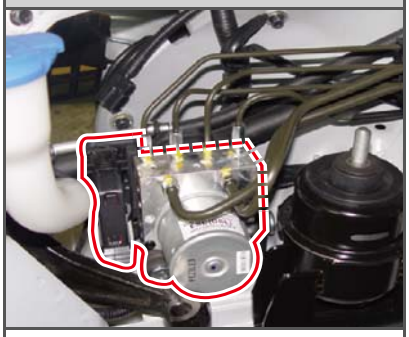
OVERVIEW AND OPERATING PROCESS

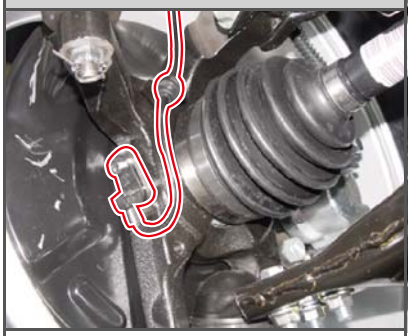
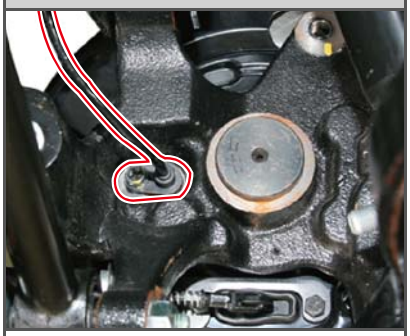
1. OVERVIEW

The ESP (Electronic Stability Program) has been developed to help a driver avoid danger of losing control of the vehicle stability due to understeer or oversteer during cornering. The yaw rate sensor, lateral sensor and longitudinal sensor in the sensor cluster and the steering wheel angle sensor under the steering column detect the vehicle conditions when the inner or outer wheels are spinning during oversteer, understeer or cornering. The ESP ECU controls against oversteer or understeer during cornering by controlling the vehicle stability using input values from these sensors and applying the braking force to the corresponding wheels independently. The system also controls the engine power right before the wheel spin synchronized to decelerate the vehicle automatically in order to maintain the vehicle stable during cornering.



2. COMPONENTS

1. HECU assembly	2. Steering wheel angle sensor	3. ESP OFF switch
		
Located under the power steering fluid reservoir and contains the pressure sensor.	Located on column shaft with contact coil.	Located on the left side of instrument panel.

4. Sensor cluster	5. Wheel speed sensor (4WD/2WD-front)	6. Rear wheel speed sensor (2WD)
		
Located on the floor under front passenger seat.	Located on knuckle. the appearance of front sensor is same with rear sensor.	Located on knuckle. The appearance is different from that for 4WD.

Modification basis	
Application basis	
Affected VIN	

3. PRECAUTIONS

CAUTION

The warning lamp flashes and warning beep sounds when the ESP is operating

When the ESP operates during vehicle movement, the ESP warning lamp on the instrument panel flashes and beep comes on every 0.1 second. The ESP system is only a supplementary device for comfortable driving. When the vehicle exceeds its physical limits, it cannot be controlled.
Do not rely on the system. Keep on the safe driving.

Feeling when ESP is working

When the ESP system activates, the feeling can be different depending on vehicle driving conditions. For example, you will feel differently when the ESP system is activated during the ABS is operating with the brakes applied and when the brakes are not applied on a curve.
If the ESP system operates when the brake is applied, the brake pressure will be increased on the corresponding wheel which already has braking pressure for the ESP controls.

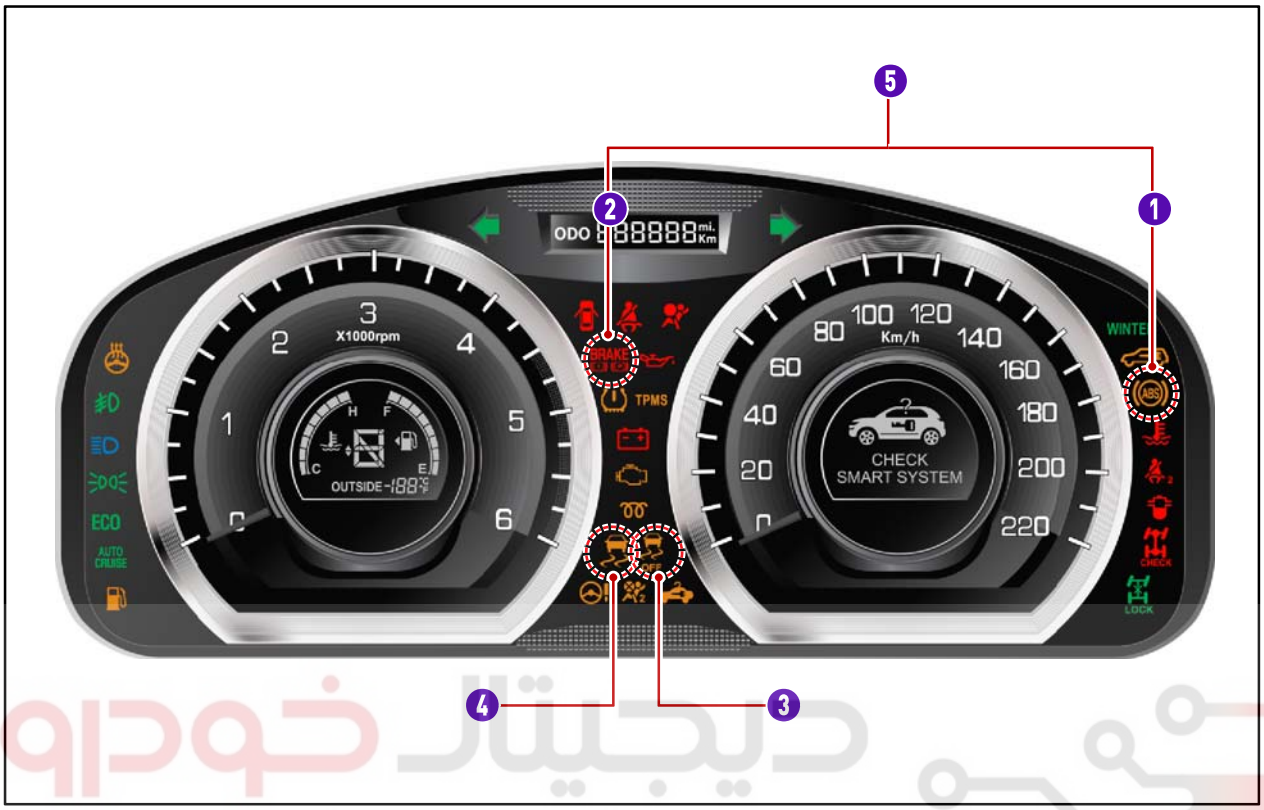
ARP Operation

During the ARP operation, vehicle safety (rollover prevention) takes the first priority and thus, stronger engine control is in effect. Consequently, the vehicle speed decreases rapidly, so the driver must take caution for the vehicle may drift away from the lane.

Noise and vibration that driver feels when ESP system is operating

The ESP system may transfer noise and vibration to the driver due to the pressure changes caused by the motor and valve operations in a very short period of time. And, keep in mind that the output and vehicle speed could be decreased without rpm increase due to the ASR function that controls the engine power.

4. WARNING LAMPS



1. ABS warning lamp
2. Brake warning lamp
3. ESP OFF indicator
4. ESP warning lamp/indicator
5. EBD warning lamp

1) ABS

ABS warning lamp module indicates the self-diagnosis and malfunction.
ABS warning lamp ON: Warning Lamp

1. When turning the ignition switch to ON position, ABS warning lamp comes on for 3 seconds for self-diagnosis and goes off if the system is OK (initialization mode).
2. When the system is defective, the warning lamp comes on.
3. When the self-diagnosis is performing, the warning lamp comes on.
4. When the HECU connector is disconnected, the warning lamp comes on.
5. ABS is not available during lamp ON. In this condition, Only normal brake system without ABS function is available.
6. When the communication between warning lamp CAN module in meter cluster, the warning lamp comes on.

Modification basis	
Application basis	
Affected VIN	

2) EBD (Electronic Brake-force Distribution) Warning Lamp (Brake Warning Lamp)

EBD warning lamp when the system perform the self diagnosis and when it detects the malfunction of EBD system. However, the brake warning lamp comes on regardless of EBD when the parking brake is applied.

EBD warning lamp ON:

1. When turning the ignition switch to ON position, ABS warning lamp and the brake warning lamp comes on for 3 seconds for self diagnosis and goes off if the system is OK (initialization mode). When applying the parking brake, the brake warning lamp comes on.
2. When the brake fluid is not sufficient, the brake warning lamp comes on.
3. When the self-diagnosis is performing, the warning lamp comes on.
4. When the HECU connector is disconnected, the warning lamp comes on.
5. When the system is defective, ABS warning lamp and the brake warning lamp come on
6. simultaneously.

   a. When the solenoid valve is defective
   b. When one or more wheel sensors are defective
   c. When ABS HECU is defective
   d. When the voltage is abnormal
   e. When valve relay is defective

7. When the communication between warning lamp CAN module in meter cluster, the warning lamp comes on.

3) ESP OFF Indicator

ESP OFF indicator ON:

1. When turning the ignition switch to ON position, ESP warning lamp comes on for 3 seconds for self diagnosis and goes off if the system is OK (initialization mode).
2. When the ESP OFF switch is pressed to turn off ESP function, ESP OFF indicator comes on.

4) ESP Warning Lamp

1. ESP warning lamp ON:
2. When turning the ignition switch to ON position, ESP warning lamp comes on for 3 seconds for self diagnosis and goes off if the system is OK (initialization mode).
3. When the system is defective, the warning lamp comes on.
4. When the ESP function is activated, ESP warning lamp blinks with the interval of 2 Hz.
5. When the communication between warning lamp CAN module in meter cluster, the warning lamp comes on.

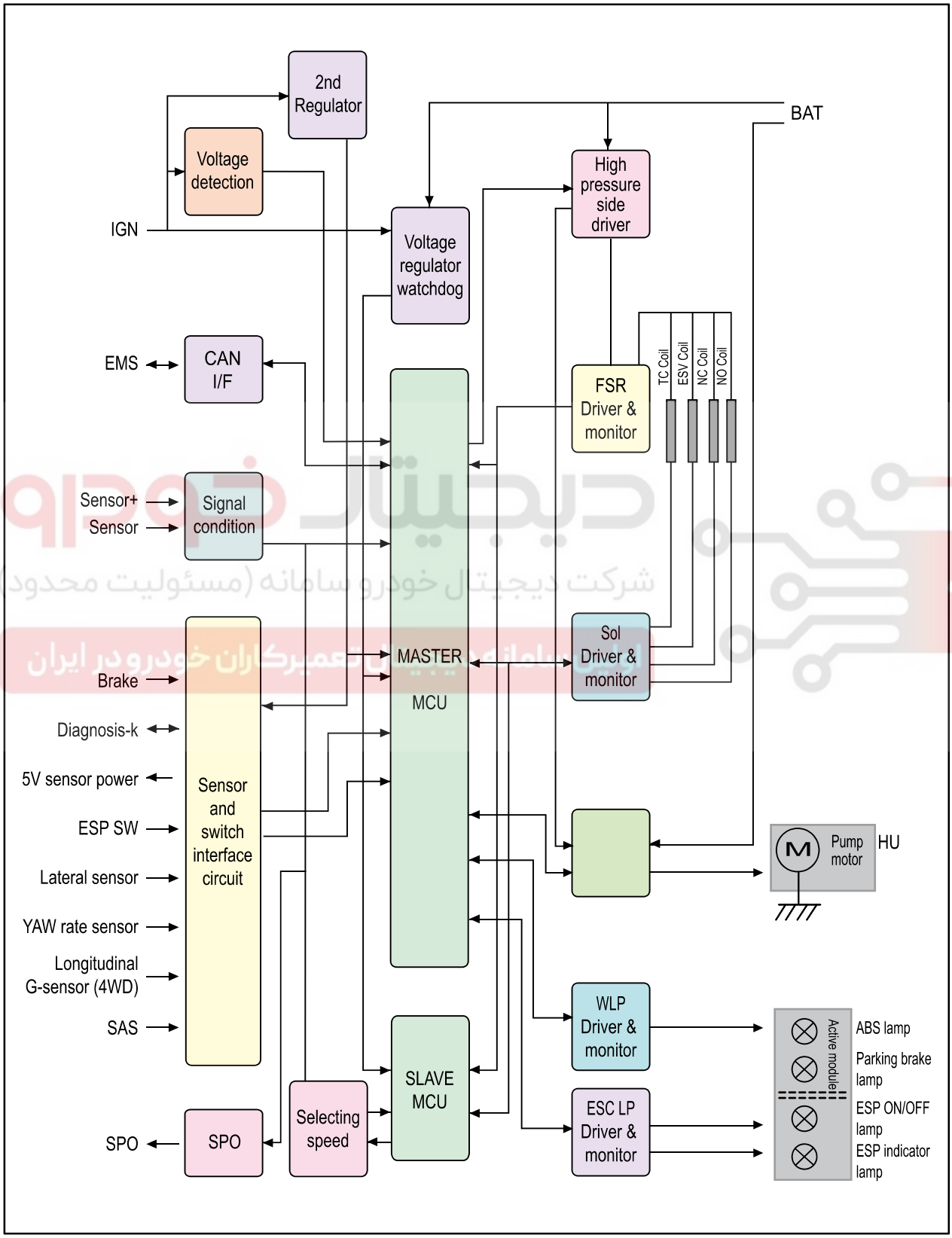
5) ESP OFF Switch

If ESP OFF switch is pressed, ESP function is deactivated and the ESP OFF indicator in the instrument cluster comes on.

To resume the ESP function, press the switch again. At this time, ESP OFF indicator goes out.

5. SYSTEM DESCRIPTION

1) Block Diagram of ESP HECU

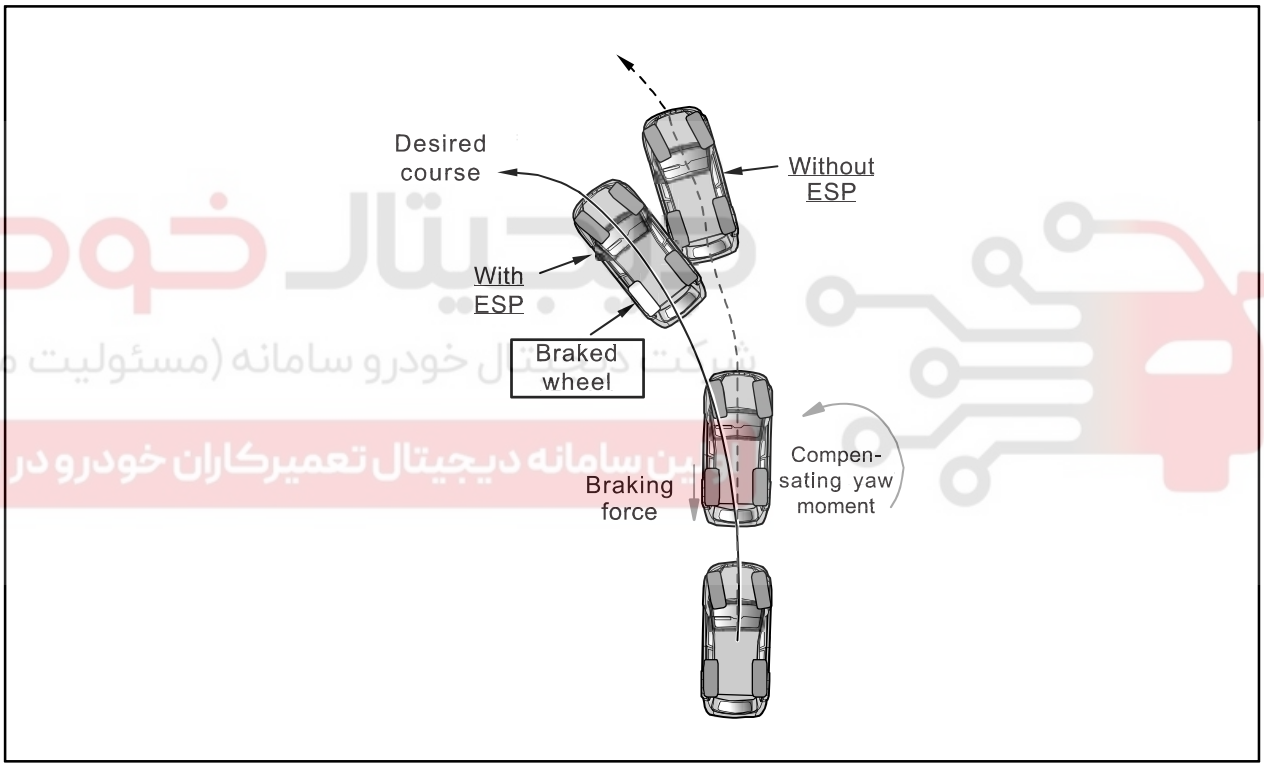


Modification basis	
Application basis	
Affected VIN	

2) Operation of ESP System

The ESP (Electronic Stability Program) has been developed to help a driver avoid danger of losing control of the vehicle stability due to understeer or oversteer during cornering. The yaw rate sensor, lateral sensor and longitudinal sensor in the sensor cluster and the steering wheel angle sensor under the steering column detect the vehicle conditions when the inner or outer wheels are spinning during oversteer, understeer or cornering. The ESP ECU controls against oversteer or understeer during cornering by controlling the vehicle stability using input values from these sensors and applying the braking force to the corresponding wheels independently. The system also controls the engine power right before the wheel spin synchronized with the ASR function to decelerate the vehicle automatically in order to maintain the vehicle stable during cornering.

(1) Under steering



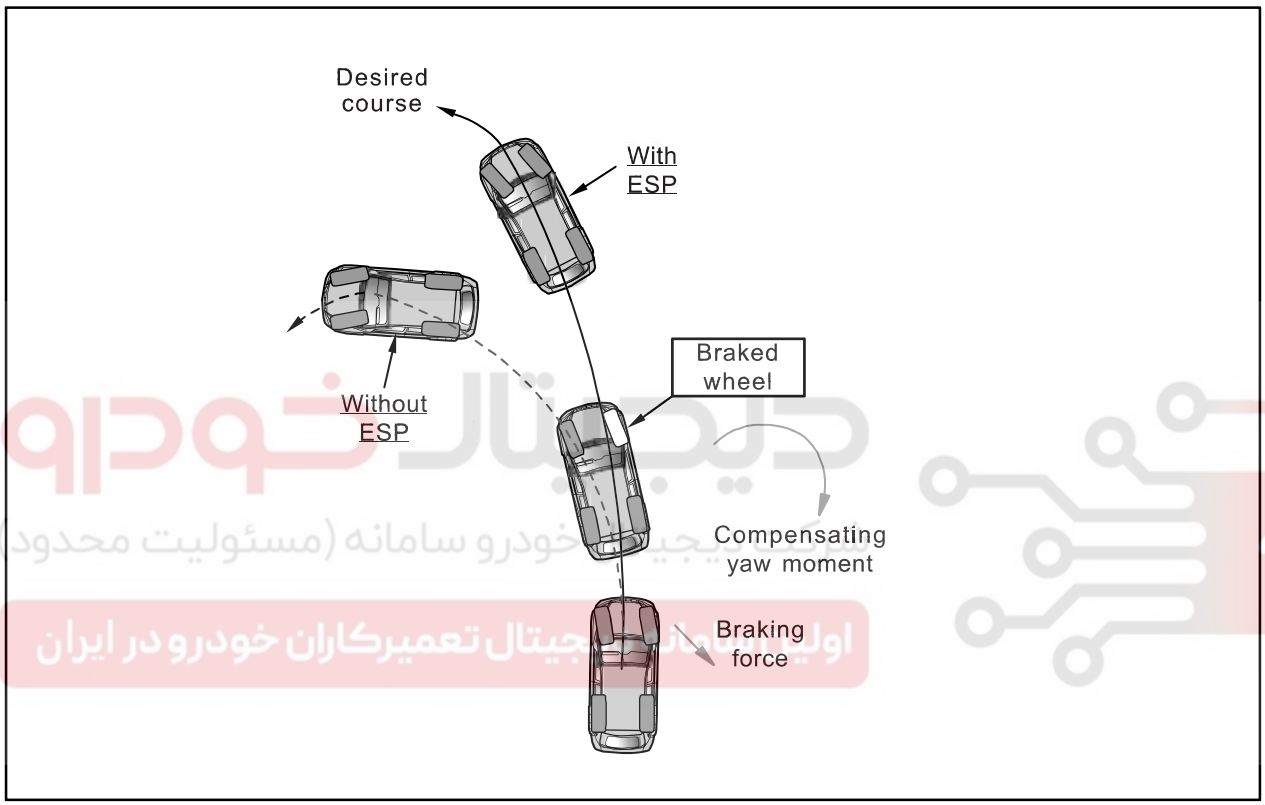
▶ **What is understeering?**

Understeer is a term for a condition in which the steering wheel is steered to a certain angle during driving and the front tires slip toward the reverse direction of the desired direction. Generally, vehicles are designed to have understeer. It is because that the vehicle can return back to inside of cornering line when the steering wheel is steered toward the inside 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.

▶ **ESP controls during understeer**

The ESP system recognizes the directional angle with the steering wheel angle sensor and senses the slipping route that occurs reversely against the vehicle cornering direction during understeer with the yaw rate sensor and 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 does not lose its driving direction and the driver can steer the vehicle as intended.

(2) Over steering



▶ **What is oversteering?**

Oversteer is a term of a condition in which the steering wheel is steered to a certain angle during driving and the rear tires slip outward losing traction.
Compared to understeering vehicles, it is hard to control the vehicle during cornering and the vehicle can spin due to rear wheel moment when the rear tires lose traction and the vehicle speed increases.

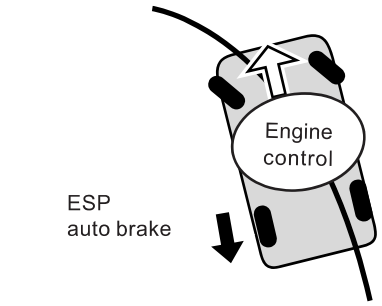
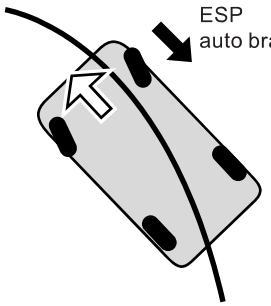
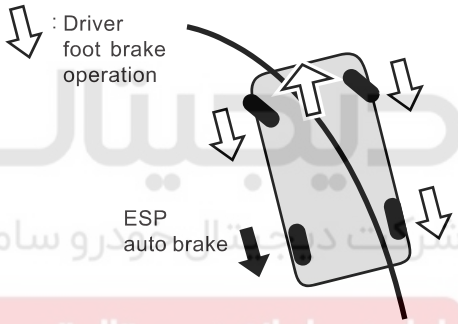
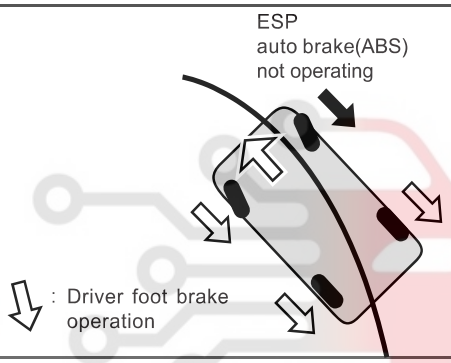
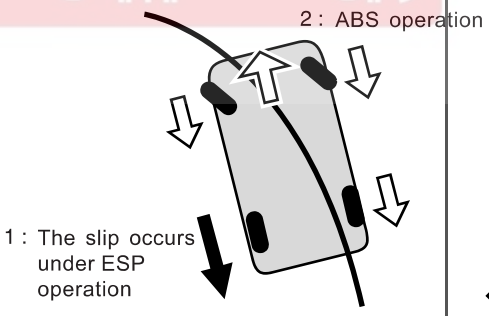
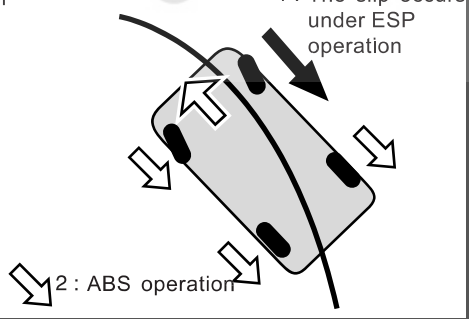
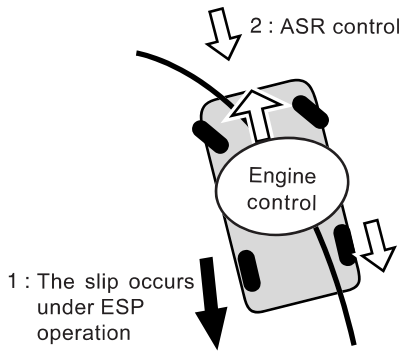
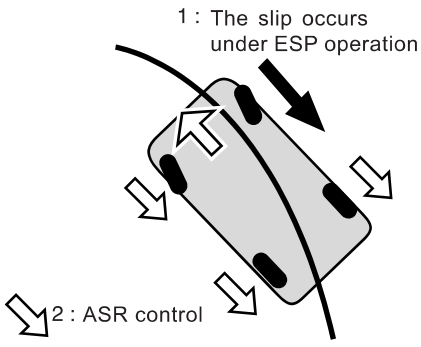
▶ **ESP controls during oversteer**

The ESP system recognizes the directional angle with the steering wheel angle sensor and senses the slipping route that occurs towards the vehicle cornering direction during oversteer with the yaw rate sensor and 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 does not lose its driving direction and the driver can steer the vehicle as intended.

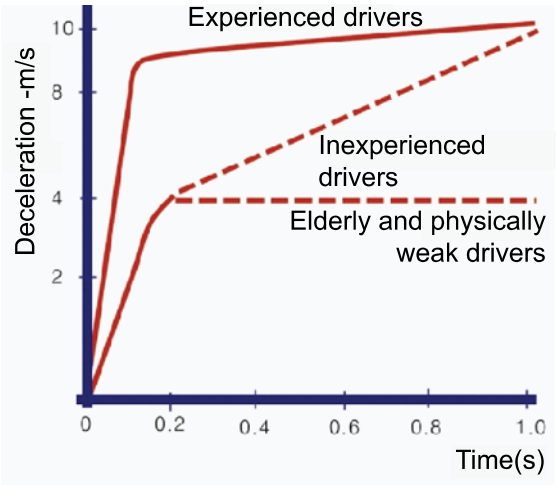
Modification basis	
Application basis	
Affected VIN	

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 depressed during cornering, when the ABS is operating and when braking without the ABS. It also includes the vehicle conditions when the TCS, a part of the ESP system, is operating.

Condition	Understeer control	Oversteer control
Only ESP in operation No braking by driver		
ESP + Normal braking (no ABS operation)		
ESP + ABS brake		
ESP + ASR		

4) HBA (Hydraulic Brake Assist System)



(1) Purpose

HBA (Hydraulic Brake Assist) system helps in an emergency braking situation when the driver applies the brake fast, but not with sufficient pressure, which leads to dangerously long braking distance. ECU recognizes the attempt at full braking and transmits the signal calling for full brake pressure from the hydraulic booster. An inexperienced, elderly or physically weak driver may suffer from the accident by not fully pressing the brake pedal when hard braking is required under emergency. The HBA System increases the braking force under urgent situations to enhance the inputted braking force from the driver. Based on the fact that some drivers depress the brake pedal too soft even under when hard braking is necessary, the HECU system is a safety supplementary system that builds high braking force during initial braking according to pressure value of the brake pressure sensor and the pressure changes of the pressure sensor intervals. When the system is designed to apply high braking force when brake pedal is depressed softly by an elderly or physically weak driver, the vehicle will make abrupt stopping under normal braking situation due to high braking pressure at each wheels.

(2) Operation

The brake pressure value and the changed value of the pressure sensor are the conditions in which the HBA System operates. There are 2 pressure sensors under the master cylinder. When the ESP ECU system determines that emergency braking is present, the pump operates, the brake fluid in the master cylinder is sent to the pump and the braking pressure is delivered to the wheels via the inlet valves . If the drive depress the brake pedal slowly, the pressure change is not high. In this case, only the conventional brake system with booster is activated.

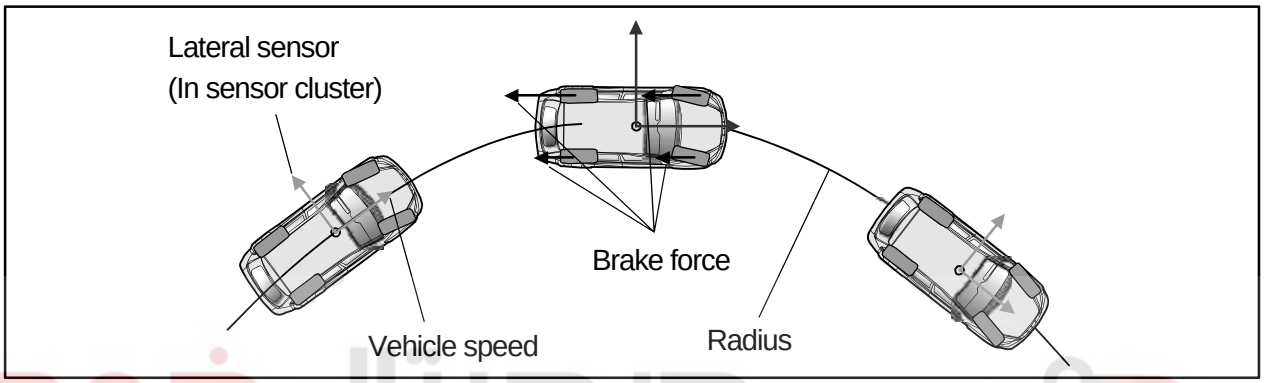
(3) Operating conditions

- Sensor pressure: over 40 bar
- Pressure changes: over 850 bar/sec
- Vehicle speed: over 30 km/h

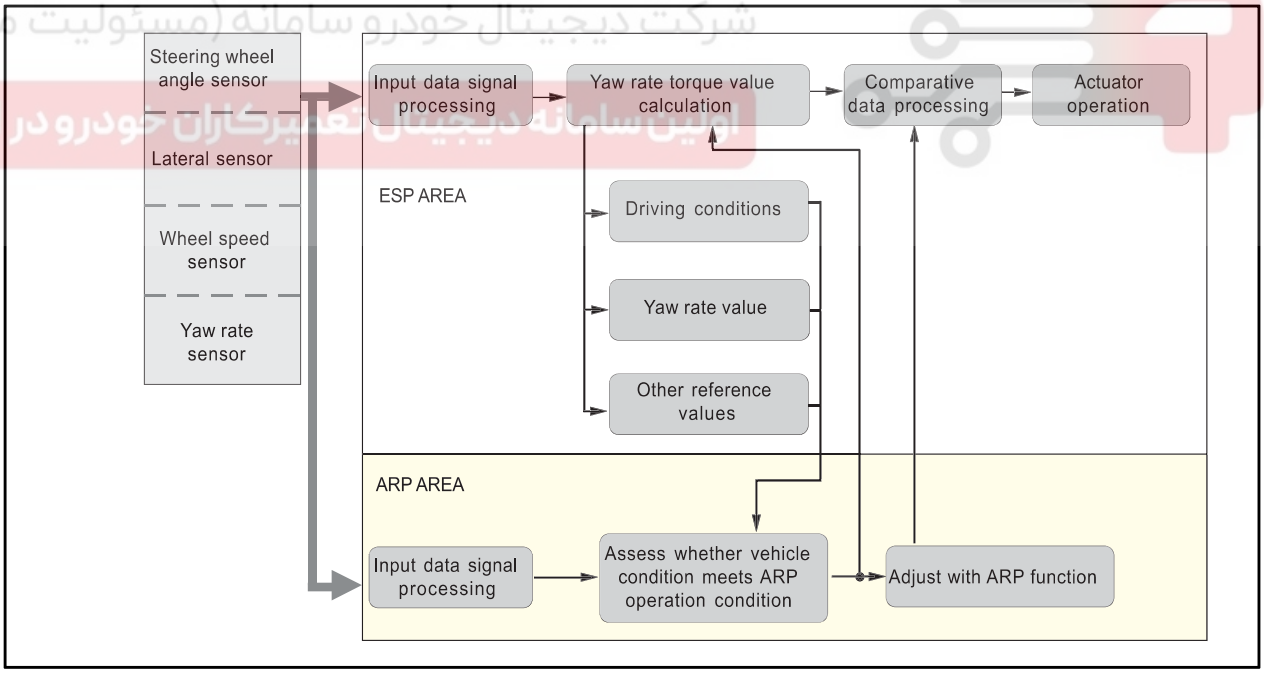
Modification basis	
Application basis	
Affected VIN	

5) ARP (Active Roll-Over Protection)

The ARP (Active Roll-over Protection) system is a safety assistant device that minimizes, by controlling brakes and the engine, the physical tendency of the vehicle rollover during sharp lane changes or U-turns. For the system, software is added to the existing ESP system and no additional device or switch is needed. One must note that the ARP system, just as general assistant devices including the ABS, is only a safety assistant device using the ESP system and its function is useless when the situation overcomes the physical power. Following picture shows how the ARP compensates the vehicle position by varying each wheel's braking power to overcome the physical tendency of the vehicle rollover during sharp turns.



The vehicle driving condition is controlled by the internally programmed logic according to the input signals from wheel speed sensor, steering angle sensor and lateral sensor.



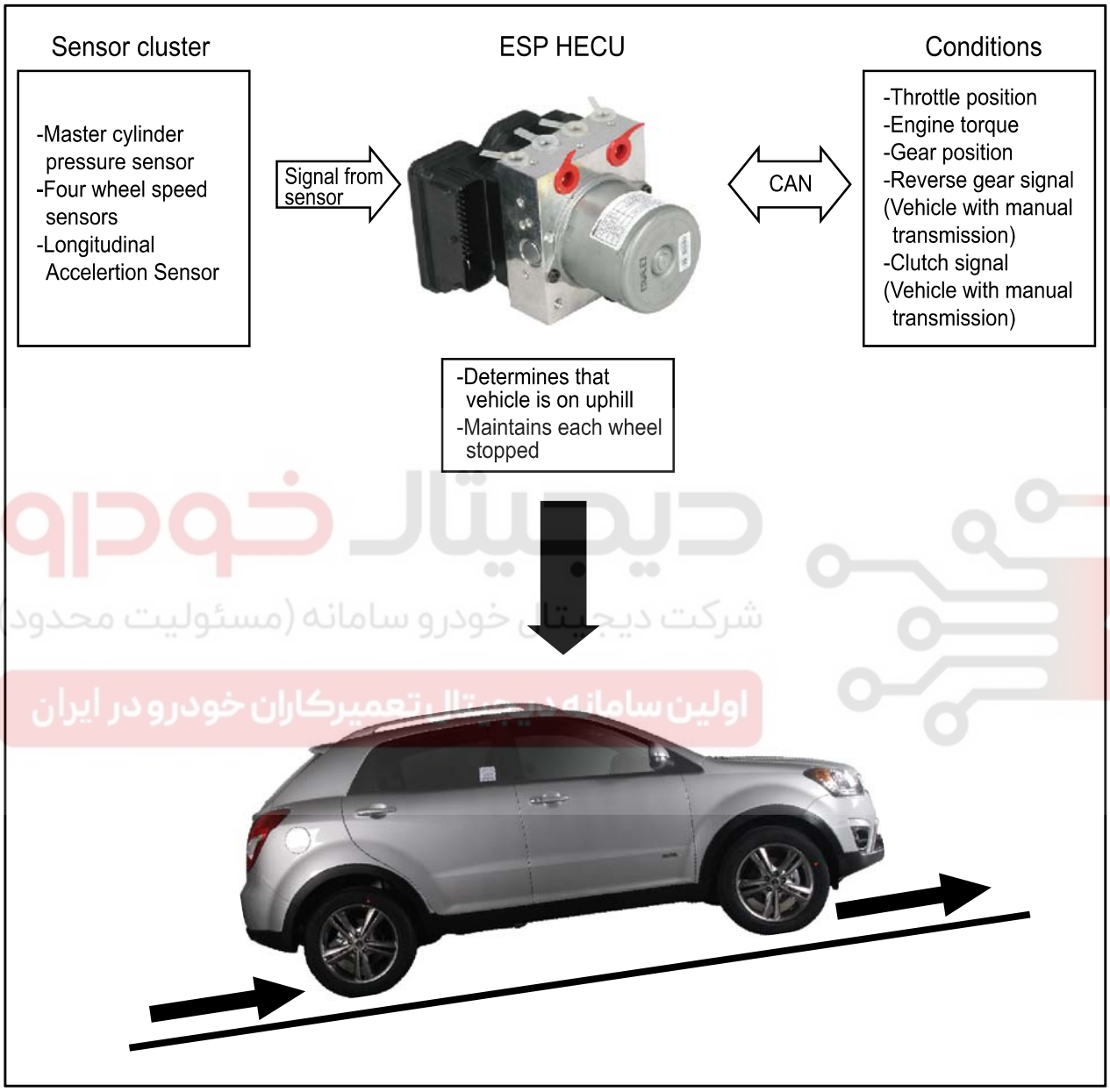
CAUTION

During the ARP operation, vehicle safety (rollover prevention) takes the first priority and thus, stronger engine control is in effect. Consequently, the vehicle speed decreases rapidly, so the driver must take caution for the vehicle may drift away from the lane.

Modification basis	
Application basis	
Affected VIN	

6) HSA (Hill Start Assist)

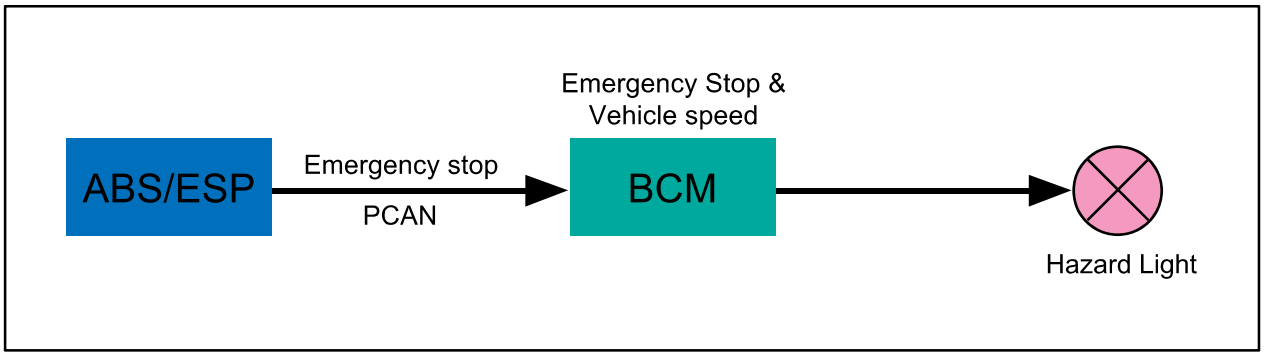
The HSA (Hill Start Assist) prevents the vehicle from rolling backward by supplying the hydraulic pressure to the wheels by the HECU after the brake pedal is released when starting off on uphill.



Modification basis	
Application basis	
Affected VIN	

7) Emergency Hazard Flasher Control (Coupled with ABS)

(1) System layout



(2) Emergency stop signal function

When ABS system is operating (or sudden braking), the hazard warning flashers will blink for 10 seconds to inform the emergency situation to the vehicles behind.

(3) Operating process

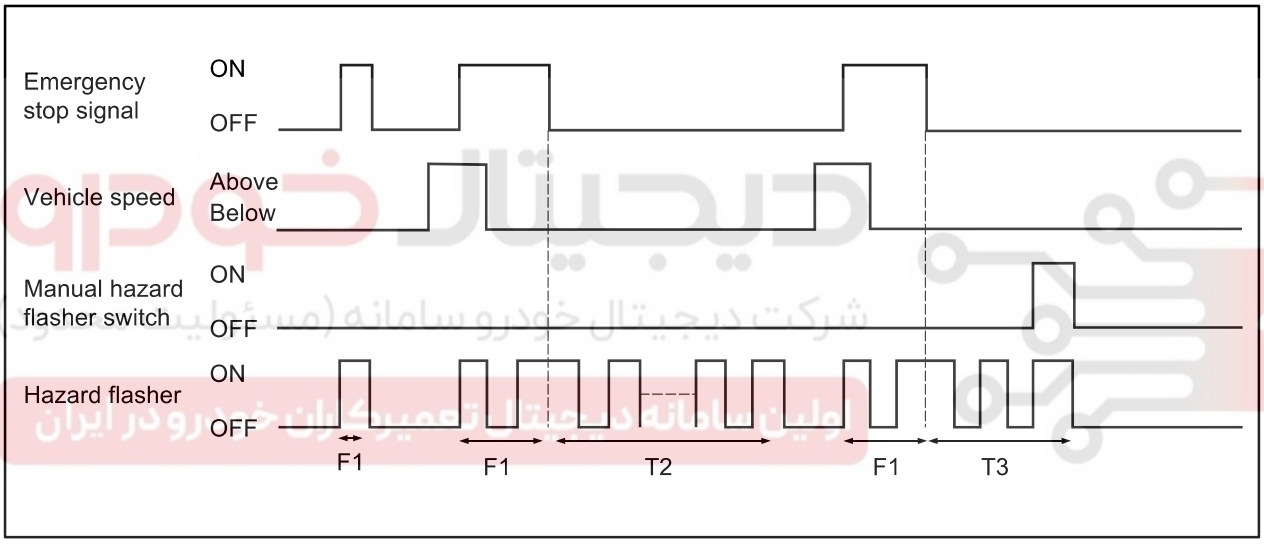
When receiving the emergency stop signal through PCAN communication it blinks with the interval of 4 Hz and when receiving the emergency stop OFF signal through PCAN communication it blinks with the interval of 1.25 Hz, normal operating speed.
However, the manual operation of the switch has a priority over this function.

NOTE

Priority: Manual operation > Emergency stop signal > Emergency hazard flasher > Auto hazard flasher

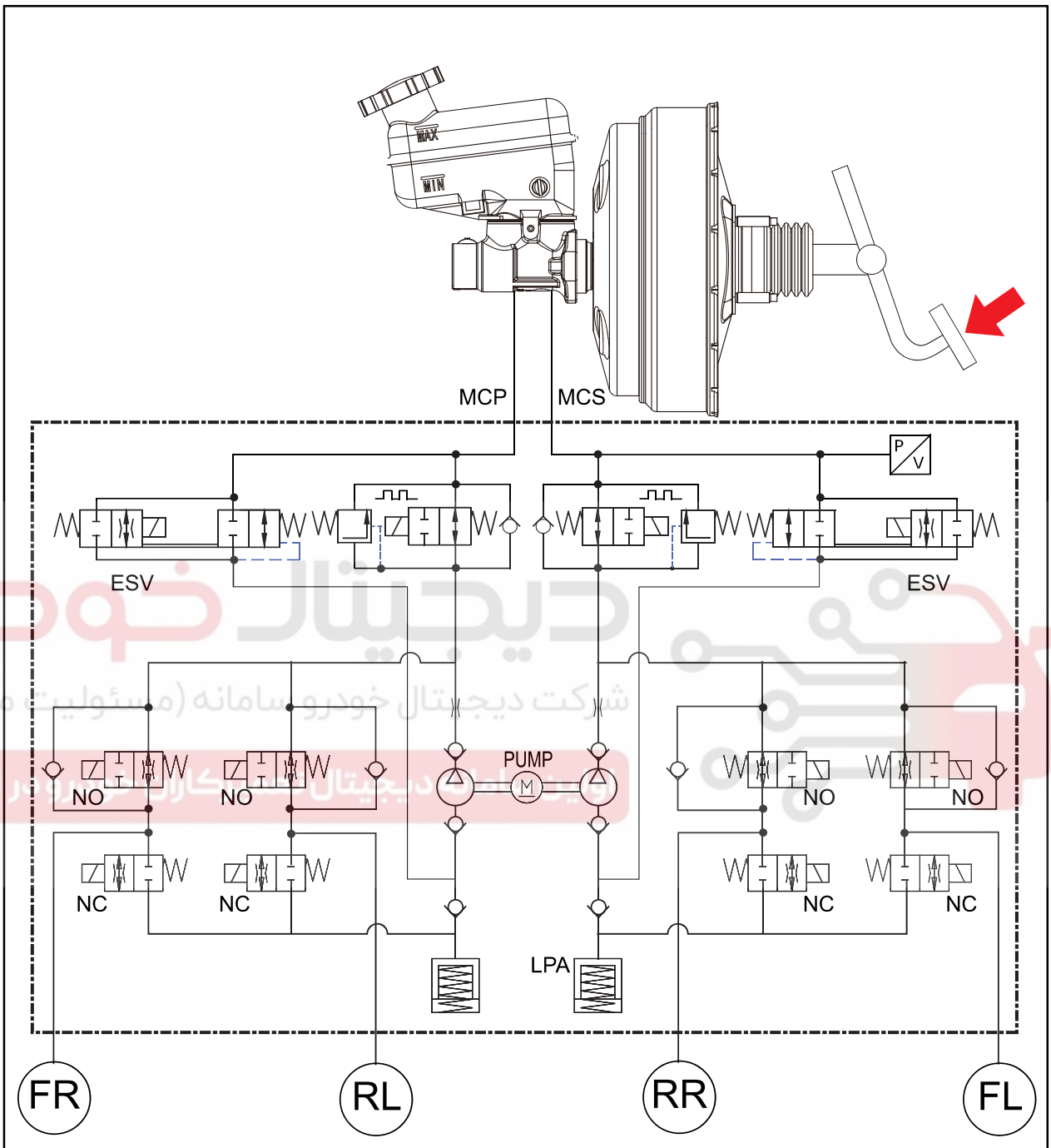
The BCM flashes the emergency auto hazard flasher with interval of 1.25 times/sec.:

- The emergency hazard flasher does not operate if the vehicle speed is over 50 km/h when the emergency stop signal is received.
- The emergency hazard flasher operates if the vehicle speed is 50 km/h or lower when the emergency stop signal is received.
- When vehicle speed increases more than 10 km/h above the speed when the signal is received during operation by emergency braking signal, the emergency hazard flasher stops operation.
  When turning emergency hazard flasher switch OFF during operation by emergency braking signal,
- it stops operation.
  It is deactivated automatically 10 seconds after if items 2) and 3) above are not met during operation
- by emergency braking signal.
  If multi-function automatic hazard flasher signal is received during operation by emergency braking
- signal, it will be overridden.



Modification basis	
Application basis	
Affected VIN	

6. HYDRAULIC CIRCUIT OF ESP



MCP: Master Cylinder Primary
MSP: Master Cylinder Secondary
ESV: Electric Shuttle Valve
NO: Normal Open
NC: Normal Close
LPA: Low Pressure Accumulator

Modification basis	
Application basis	
Affected VIN	

▶ Circuit description

When compared to the vehicle equipped with ABS/EBD only, the internal hydraulic circuit has a normally-open separation valve and a shuttle valve in primary circuit and in secondary circuit.
When the vehicle brakes are not applied during engine running or when applying the non-ABS operating brakes, the normally-open separation valve and the inlet valve are open, whereas the normally-closed shuttle valve and the outlet valve are closed.
When the ESP system is operating, the normally-open separation valve will be closed by the solenoid valve operation and the hydraulic circuit will be established by the shuttle valve. Then, the inlet and outlet valves will be closed or open depending on the braking pressure RISE, HOLD or DUMP conditions.

▶ Flashing warning lamp and warning sound during ESP operation

When the ESP operates while the vehicle is moving, the ESP warning lamp on the instrument panel flickers and the buzzer sounds at every 0.1 second. The ESP lamp operation is to inform a driver that the vehicle is extremely unstable.
The ESP system is just a supplementary system for the vehicle and it cannot control the vehicle over the physical limit. Do not solely rely on the system but be advised to drive the vehicle safely.

▶ Drive feeling during ESP operation

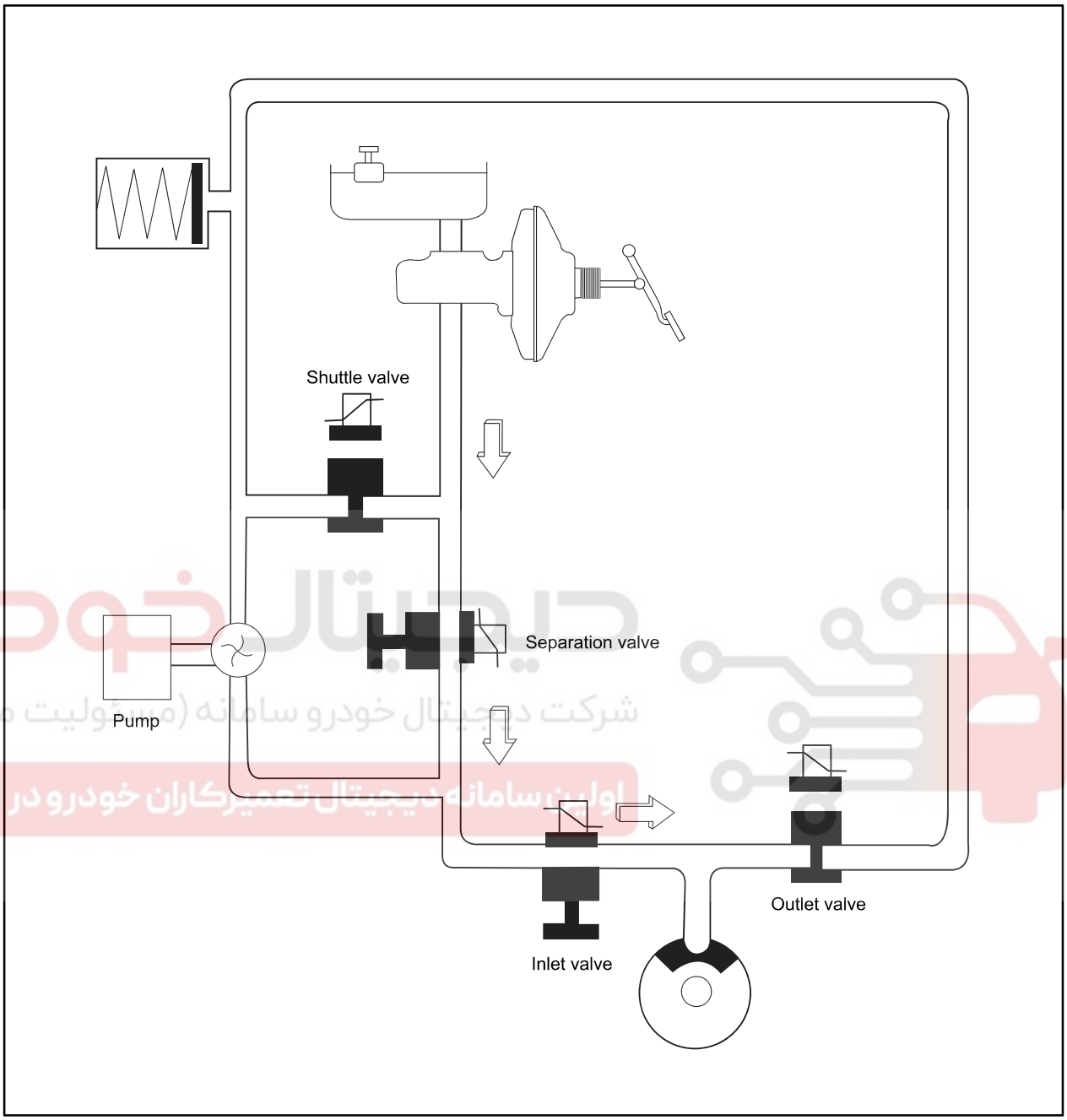
When the ESP system activates, the driving feeling can be different depending on vehicle driving conditions. For example, it will feel different when the ESP system is activated while the ABS is operated by depressing the brake pedal and when the ESP system is in control without the brake pedal depressed on the same curve.
If the ESP system operates with the brake applied, the brake pressure will be increased on the corresponding wheel which already has braking pressure for the ESP controls. In other words, the ESP system would make the driver feel more abruptly braked compared to the situation that the braking pressure is applied to wheel which had no braking force.

▶ Noise and vibration that driver senses during ESP operation

The ESP system may transfer noise and vibration to a driver due to the pressure changes caused by the motor and valve operations in a very short period of time.
Extreme cornering will trigger the ESP operation and this will make the driver sense noise and vibration due to sudden brake application.
Also, the ESP system controls the engine power. Therefore, the driver may notice the engine power decreases even when the accelerator pedal is depressed.

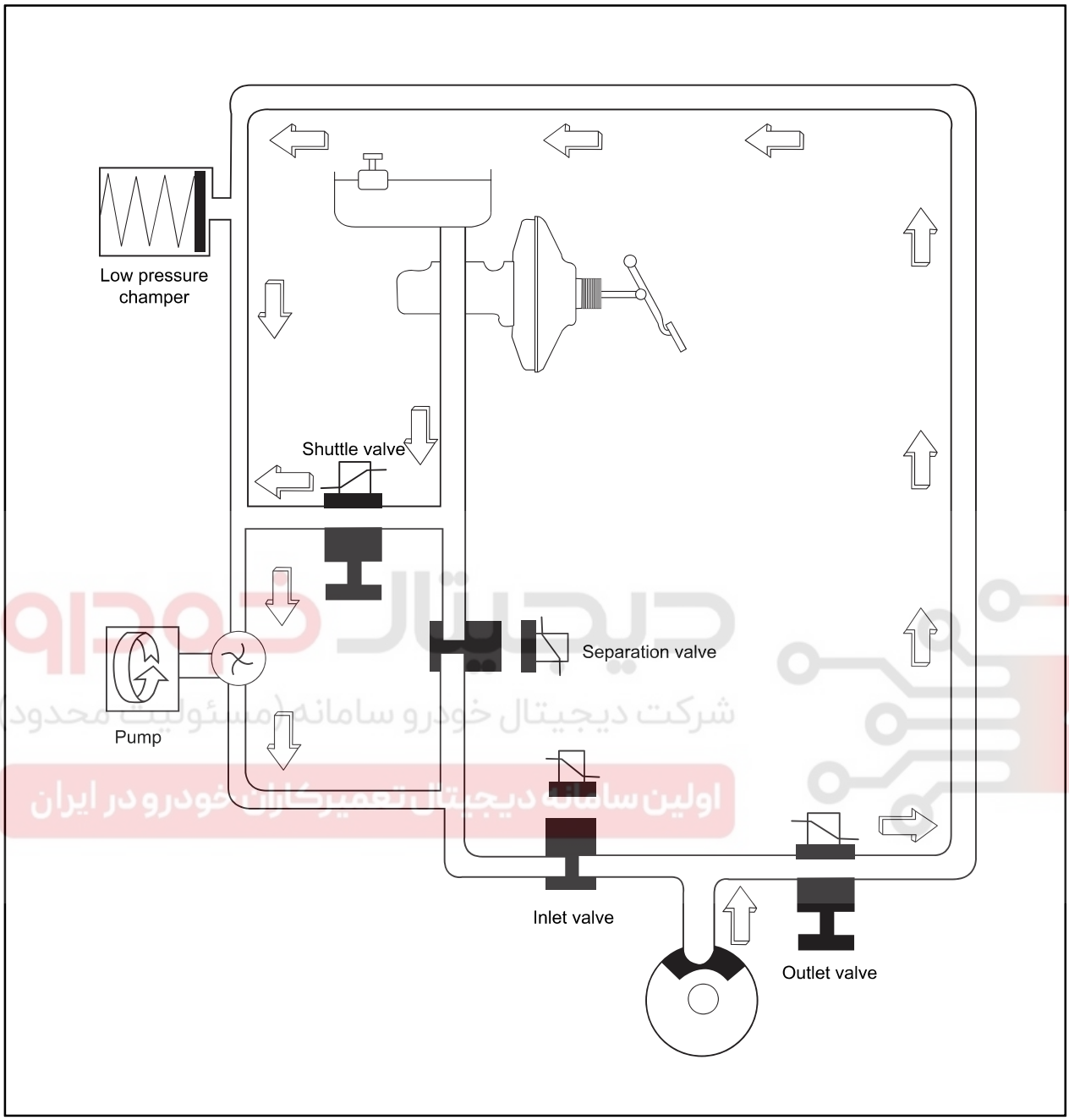
Modification basis	
Application basis	
Affected VIN	

1) Idling and Normal Braking Condition



In this position, the separation valve and the inlet valve are open (normal open), the electrically operated shuttle valve and the outlet valve are closed.
When the brake is applied under these conditions, the brake fluid will be sent to each wheel via the separation valve and inlet valve.

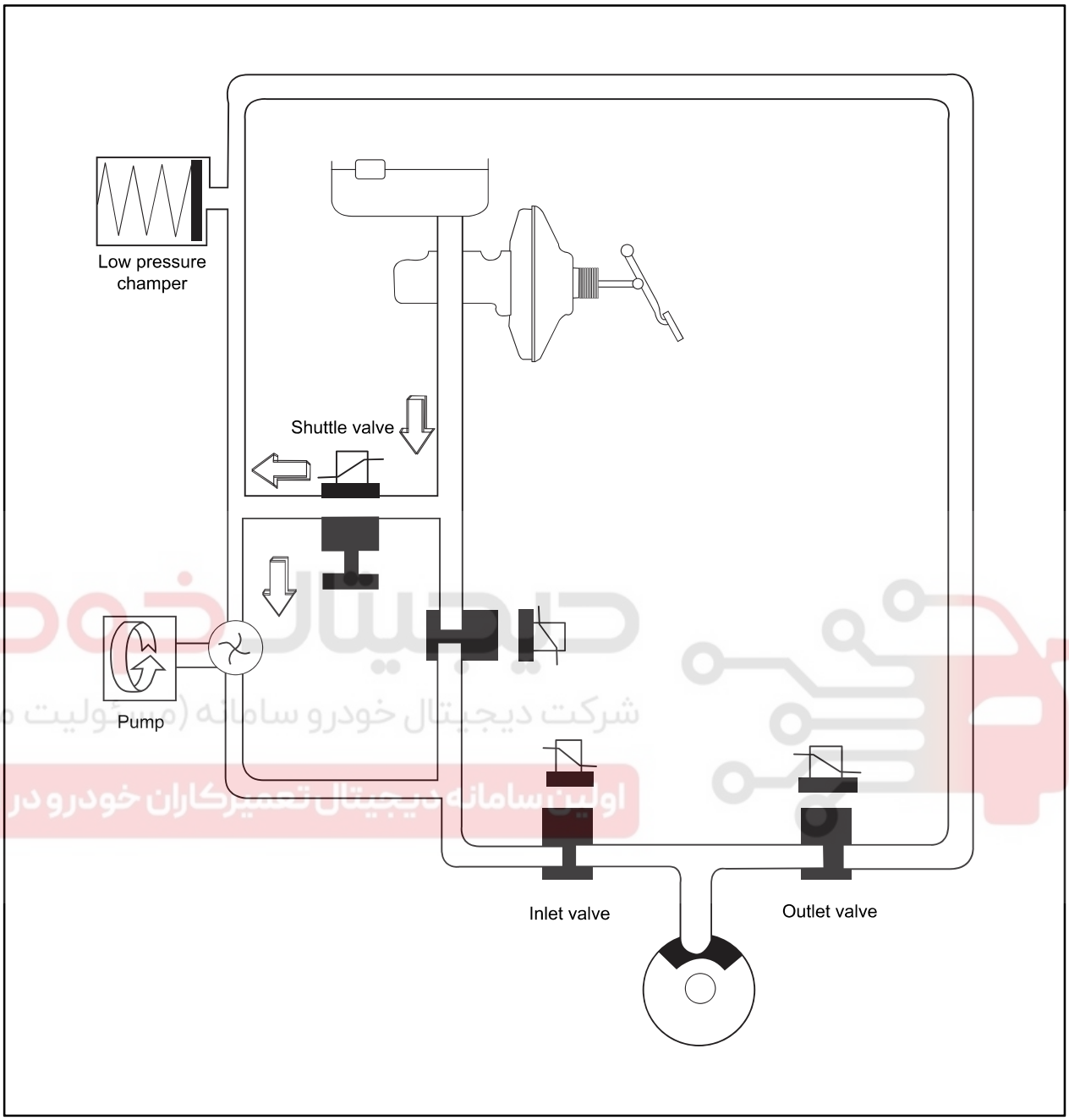
2) DUMP (ESP is working) Mode



The pressure decreases just before the wheel speed drops and the wheels are locked.
The inlet valve closes and the outlet valve opens as in the ABS HECU and the oil is gathered at the low pressure chamber while no additional oil is being supplied. Then the pump operates to allow fast oil drainage. The shuttle valve and the separation valve do not operate while decompression.

Modification basis	
Application basis	
Affected VIN	

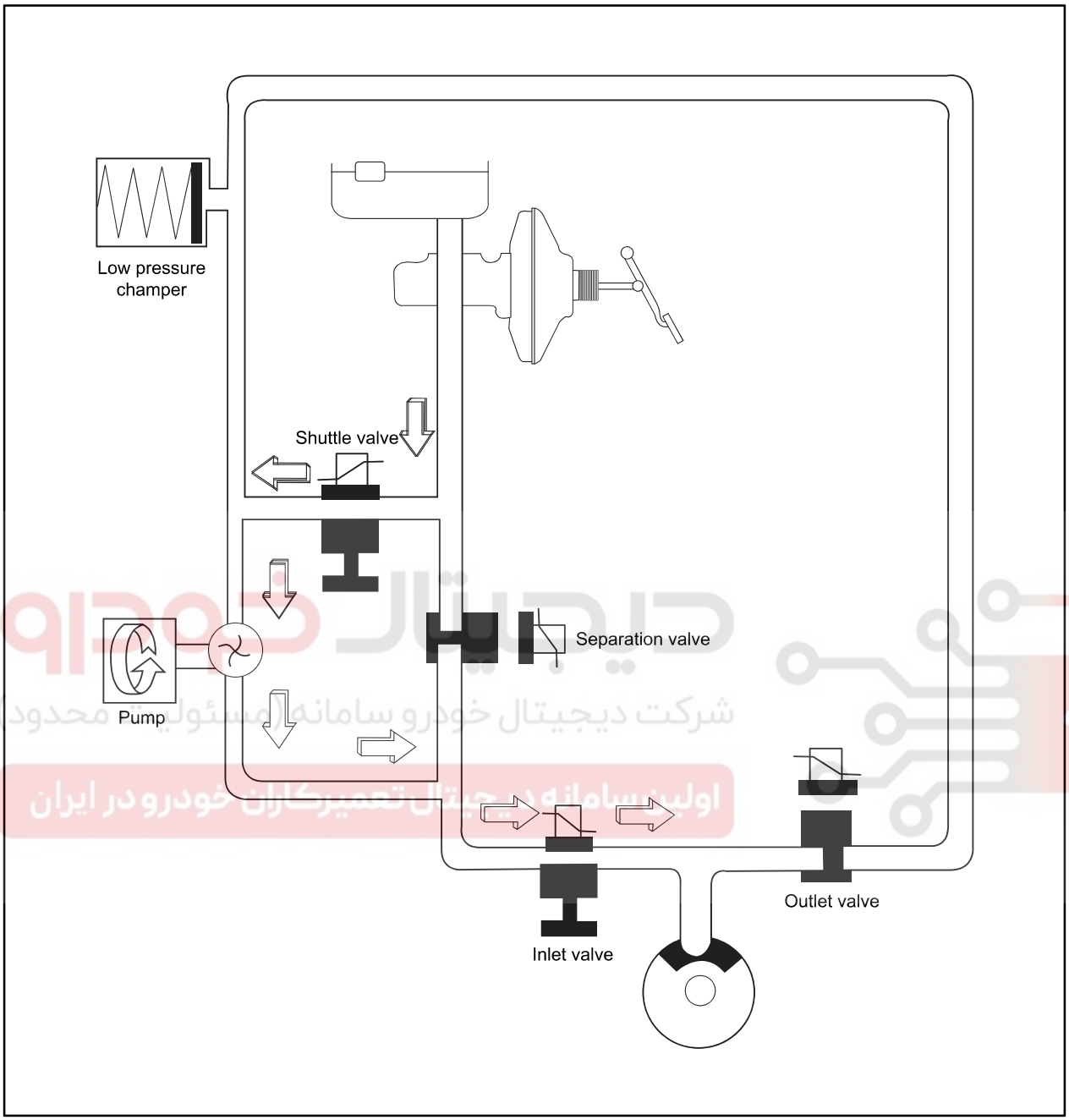
3) HOLD (ESP is working) Mode



The Inlet valve and outlet valve will be closed to maintain the pressure in the hydraulic circuit applied at the wheels. By closing the valves, the hydraulic pressure at the wheels will not be lost or supplied any more. During ESP operation, the separation valve closes and only the shuttle valve at the pump opens.

Modification basis	
Application basis	
Affected VIN	

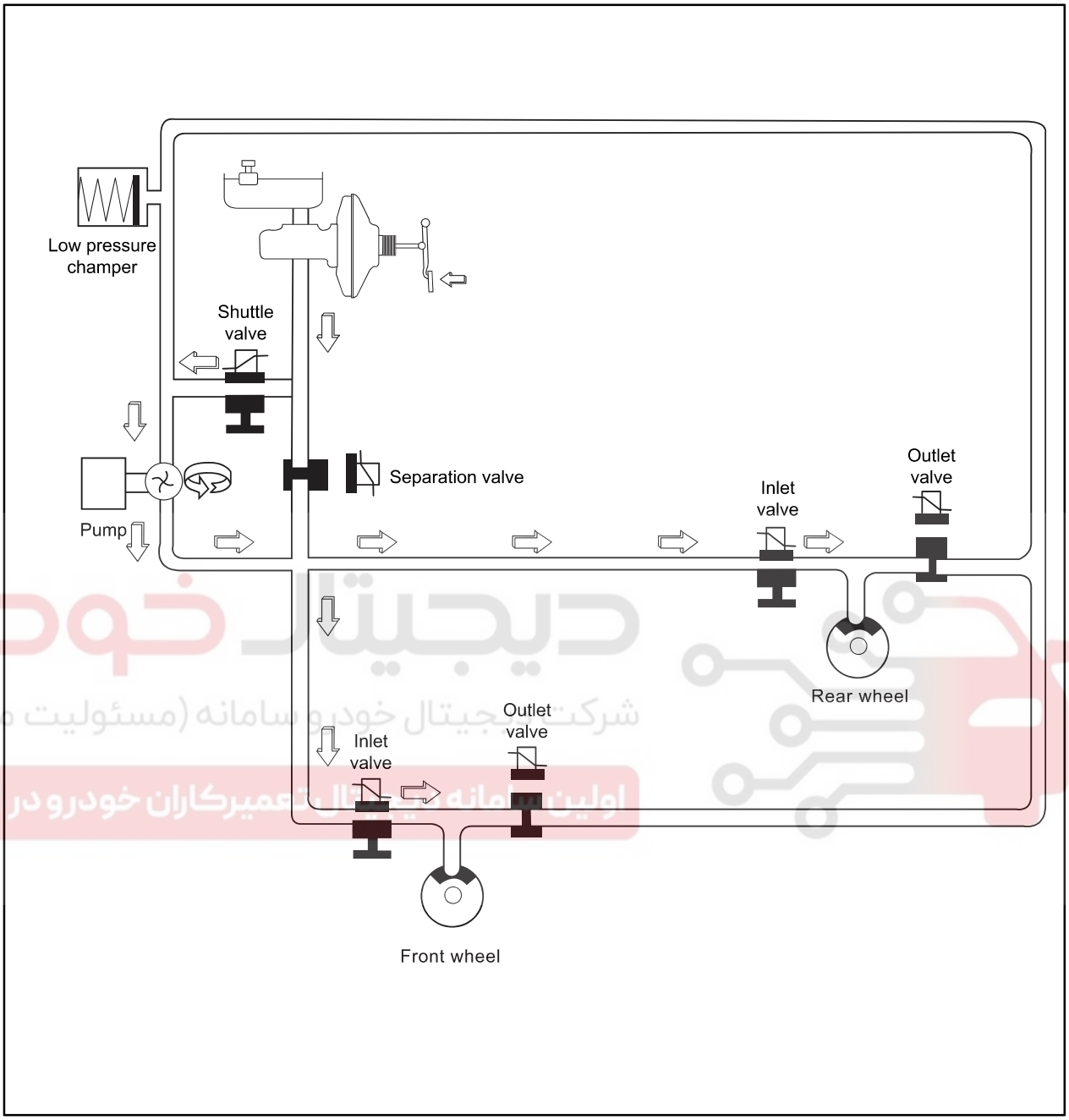
4) RISE (ESP is working) Mode



The shuttle valve and inlet valve will be open and the separation valve and outlet valve will be closed. Then, the pump is operated. When ESP operates while the ABS is operating, the pressure will be increased continuously until just before the corresponding wheel gets locked.

Modification basis	
Application basis	
Affected VIN	

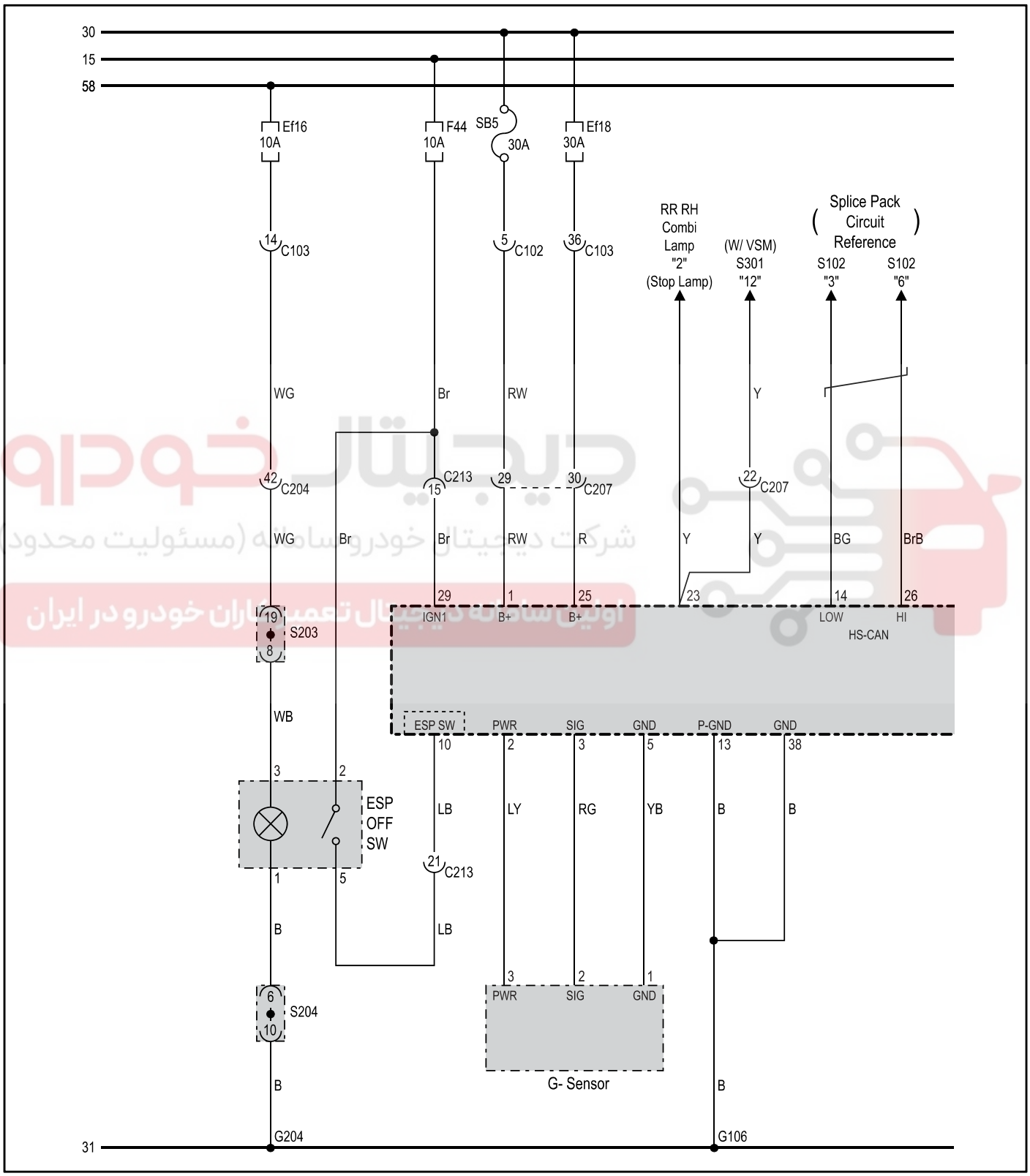
5) Hydraulic Circuit of HBA



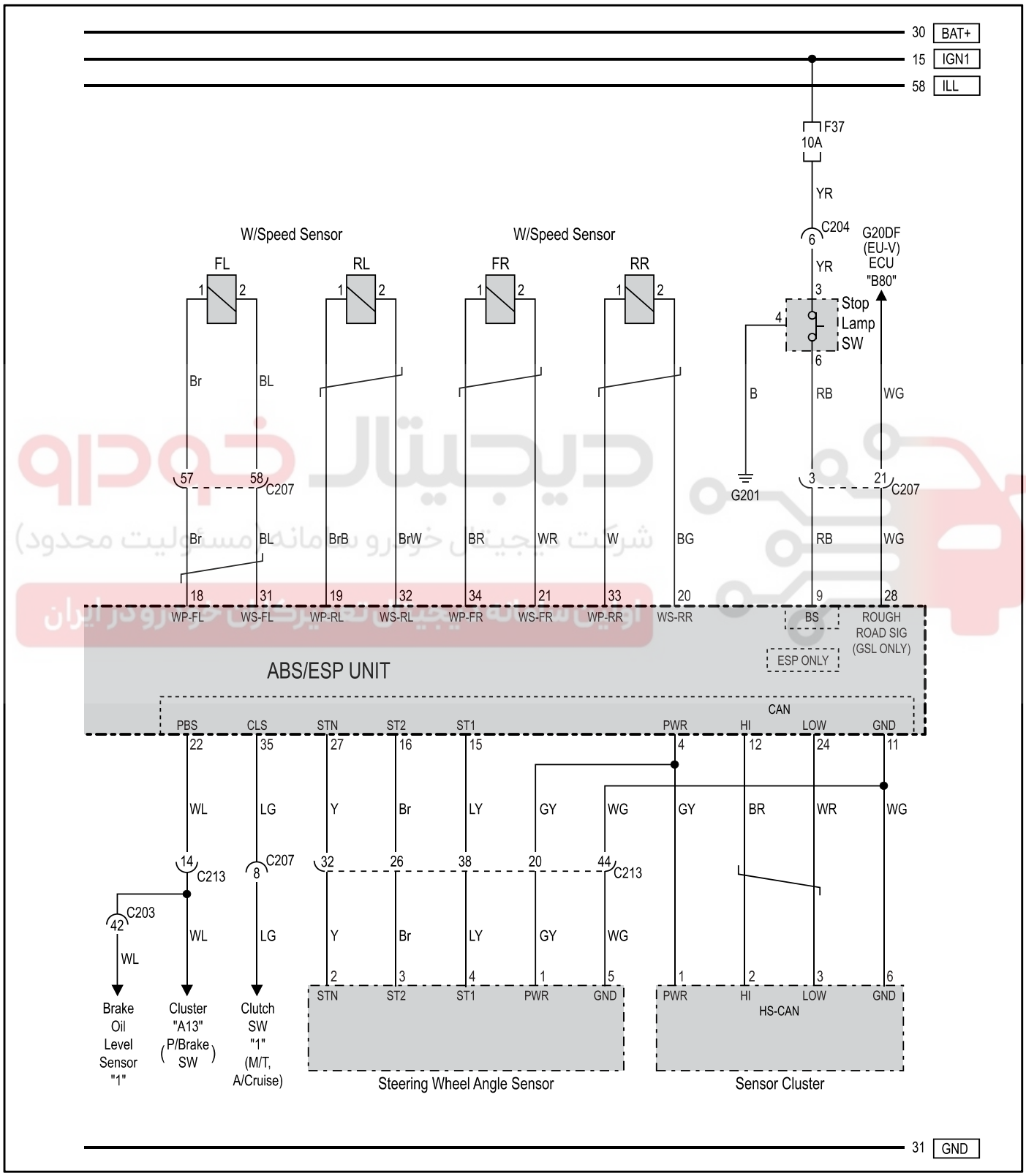
The above figure shows one front and one rear wheel and the same hydraulic circuit forms as in the ESP operation. When HECU recognizes that it is an emergency and it is required for hard braking, depending on the pressure value of the brake pressure sensor and pressure changes caused by the pressure sensor timing, it operates the pump immediately to apply the brake pressure at the wheels. Then, the pressure in the pump increases until just before the corresponding wheel gets locked. The motor still keeps rotating and the outlet valve and the separation valve will stay closed. When the wheel starts to lock, the HBA function cancels and switches to ABS operation.

7. CIRCUIT DIAGRAM

▶ **Wheel speed sensor, Stop lamp switch, Self diagnostic connector, Warning lamp (ABS/ESP)**



Modification basis	
Application basis	
Affected VIN	



Modification basis	
Application basis	
Affected VIN	

ELECTRONIC STABILITY PROGRAM

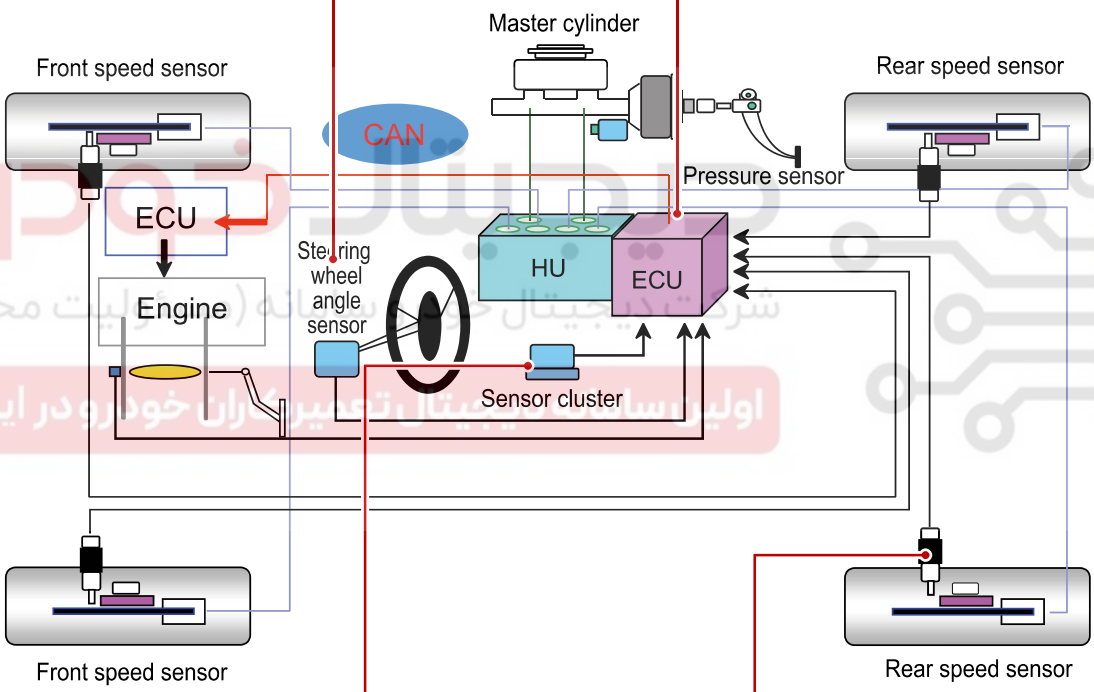
KORANDO 2015.01

CONFIGURATION

1. Components: ESP HCU (Hydraulic Control Unit), ESP ECU (Electronic Control Unit), Sensors (wheel speed sensor, steering wheel angle sensor, sensor cluster), ESP OFF switch

Steering wheel angle sensor

HECU



Sensor cluster

Wheel speed sensor

[4WD/2WD-Front]

[2WD-Rear]

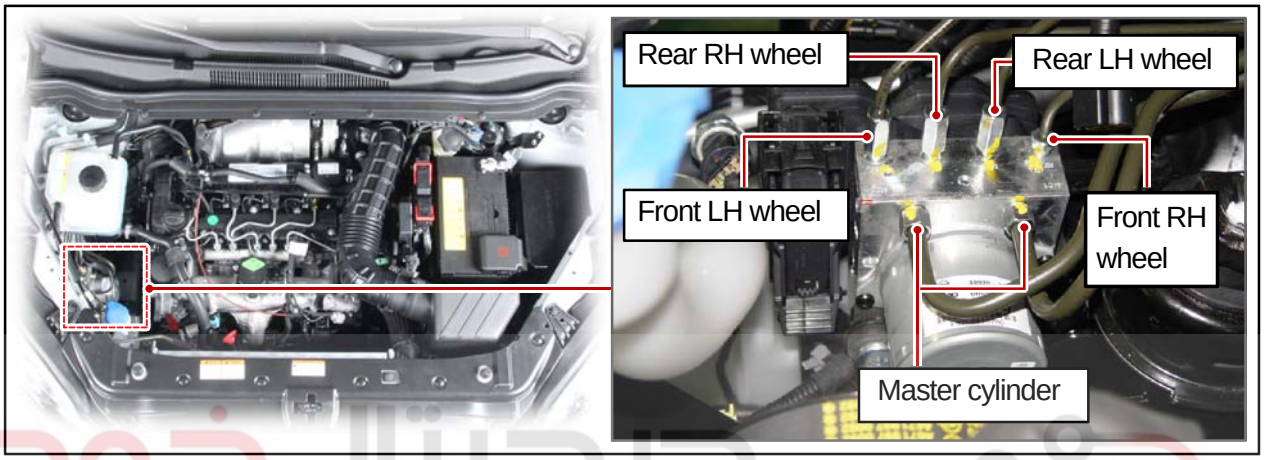
Modification basis	
Application basis	
Affected VIN	

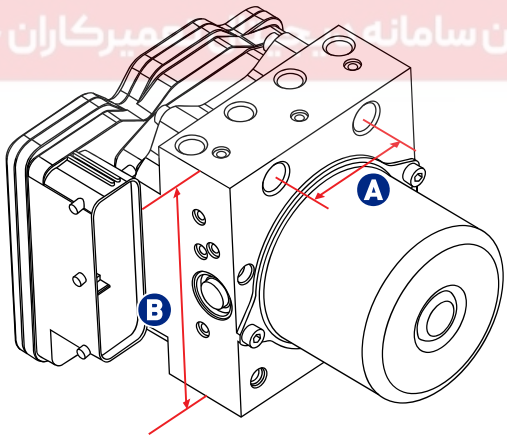
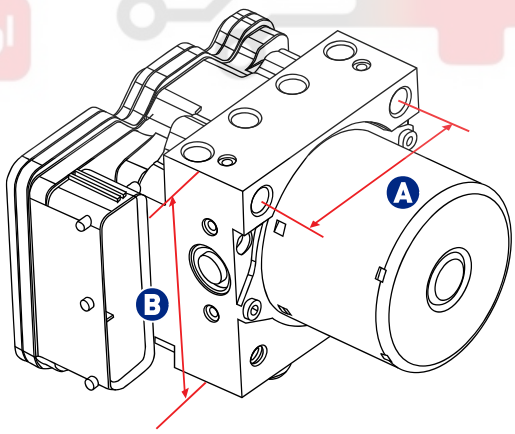
S.G.N. 4892-01

HECU (HYDRAULIC & ELECTRONIC CONTROL UNIT)

1) Mounting Location

HECU (Hydraulic Electronic Control Unit) is located under power steering fluid reservoir.
HECU consists of motor pump, valve body and ECU with solenoid valves and pressure sensor, and ECU connector has 38 pins.



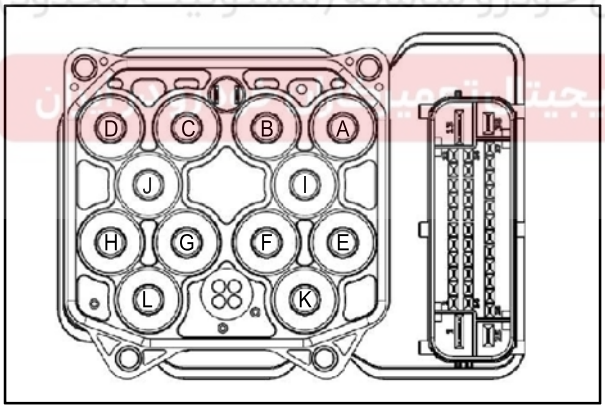
	Comparison between ESP HECU and ABS HECU	
	ESP HECU	ABS HECU
		
A	44.0mm	70.0mm
B	107.5mm	92.5mm

2) Components Description of HECU

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

▶ HCU (Hydraulic Control Unit)

The hydraulic circuit contains the primary circuit and secondary circuit for ABS operation. This unit controls the hydraulic pressure to each wheel. If the system needs ABS operation, the valves in the unit operate to control HOLD, RISE and DUMP according to ECU control logic.



▶ ECU (Electronic Control Unit)

HECU controls the hydraulic valves by supplying or cutting off the voltage to solenoid valves depending on the wheel speed and other information from wheel speed sensors.
The ABS ECU has 8 solenoid valves.
It has four channels; 2 channels for front wheels and 2 channels for rear wheels.
Each channel has one inlet and one outlet valve, therefore, there are eight solenoid valves.

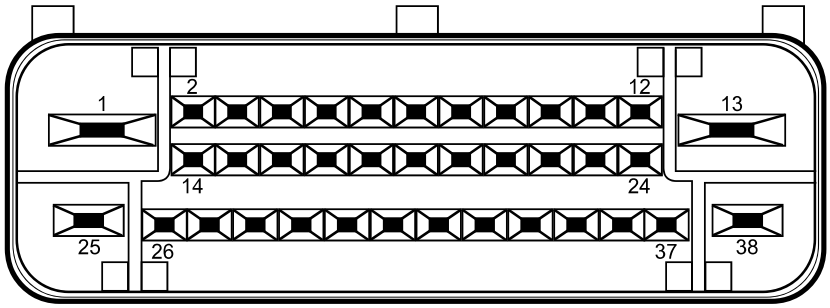
A. Outlet valve (FL)
B. Outlet valve (RR)
C. Outlet valve (RL)
D. Outlet valve (FR)
E. Inlet valve (FL)
F. Inlet valve (RR)
G. Inlet valve (RL)
H. Inlet valve (FR)
I. Electronic shuttle valve (ESV-S)
J. Electronic shuttle valve (ESV-P)
K. Traction valve (STC)
L. Traction valve (PTC)
M. Motor connector

*** ECU Lower cover**

The electrical components are weak to moisture. To protect ECU, Gore Tex-based plate is used at ECU lower cover. The vent hall allows air to ventilate but does not allow moisture to penetrate.

Modification basis	
Application basis	
Affected VIN	

3. **ESP HECU Connector**



Pin No.	Function	Remark
1	BAT2	Motor
2	-	
3	-	
4	Power - sensor cluster/Steering wheel angle sensor/ Heating steering wheel	
5	Ground - G sensor	
6	-	
7	-	
8	-	
9	Brake switch	
10	ESP OFF switch	
11	Ground - sensor cluster/Steering wheel angle sensor/ Heating steering wheel	
12	Sensor cluster CAN High	
13	Ground	
14	CAN Low	
15	Steering wheel angle sensor ST1/Heating steering wheel	
16	Steering wheel angle sensor ST2/Heating steering wheel	
17	Rear RH sensor output (RR OUT)	
18	Power - wheel speed sensor (FL)	
19	Power - wheel speed sensor (RL)	
20	Signal - wheel speed sensor (RR)	
21	Signal - wheel speed sensor (FR)	
22	Parking brake switch (Wire Type)	only for ESP
23	Stop lamp switch	

Modification basis	
Application basis	
Affected VIN	

Pin No.	Function	Remark
24	Sensor cluster CAN Low	
25	BAT1	Solenoid
26	CAN High	
27	Steering wheel angle sensor STN/Heating steering wheel	
28	Rear RH sensor output (FR OUT)	
29	IGN1	CE
30	-	
31	Signal - wheel speed sensor (FL)	
32	Signal - wheel speed sensor (RL)	
33	Power - wheel speed sensor (RR)	
34	Power - wheel speed sensor (FR)	
35	Clutch switch	
36	-	
37	-	
38	Ground	

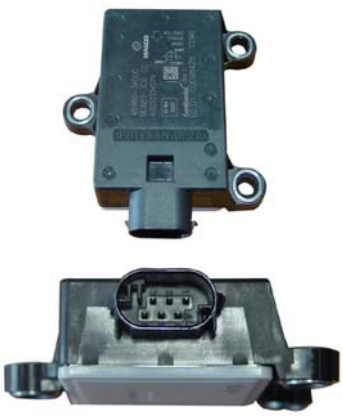
S.G.N. 4890-10

SENSOR CLUSTER

The lateral sensor, longitudinal sensor and the yaw rate sensor are integrated into the sensor cluster. There is an additional electronic circuit to send and receive the internal data to/from the CAN communication.

1) Location

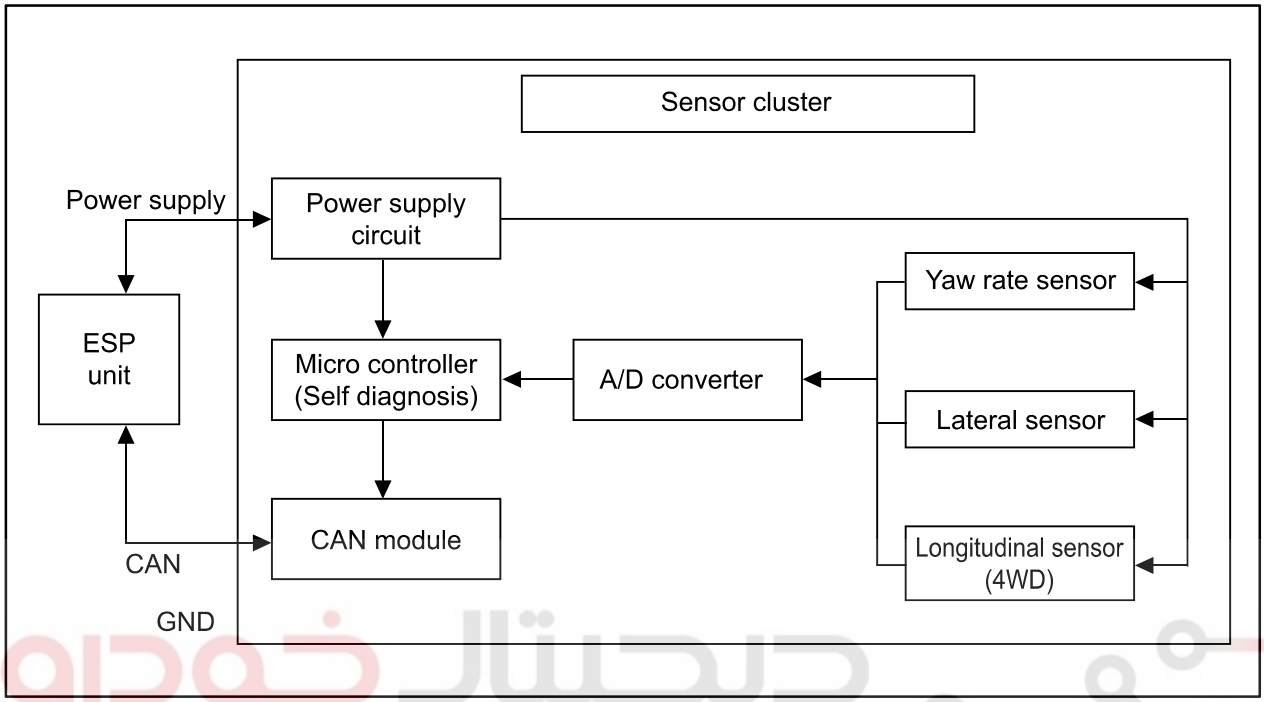
The sensor cluster is located on the floor under front passenger's seat.

Installation	Appearance
	

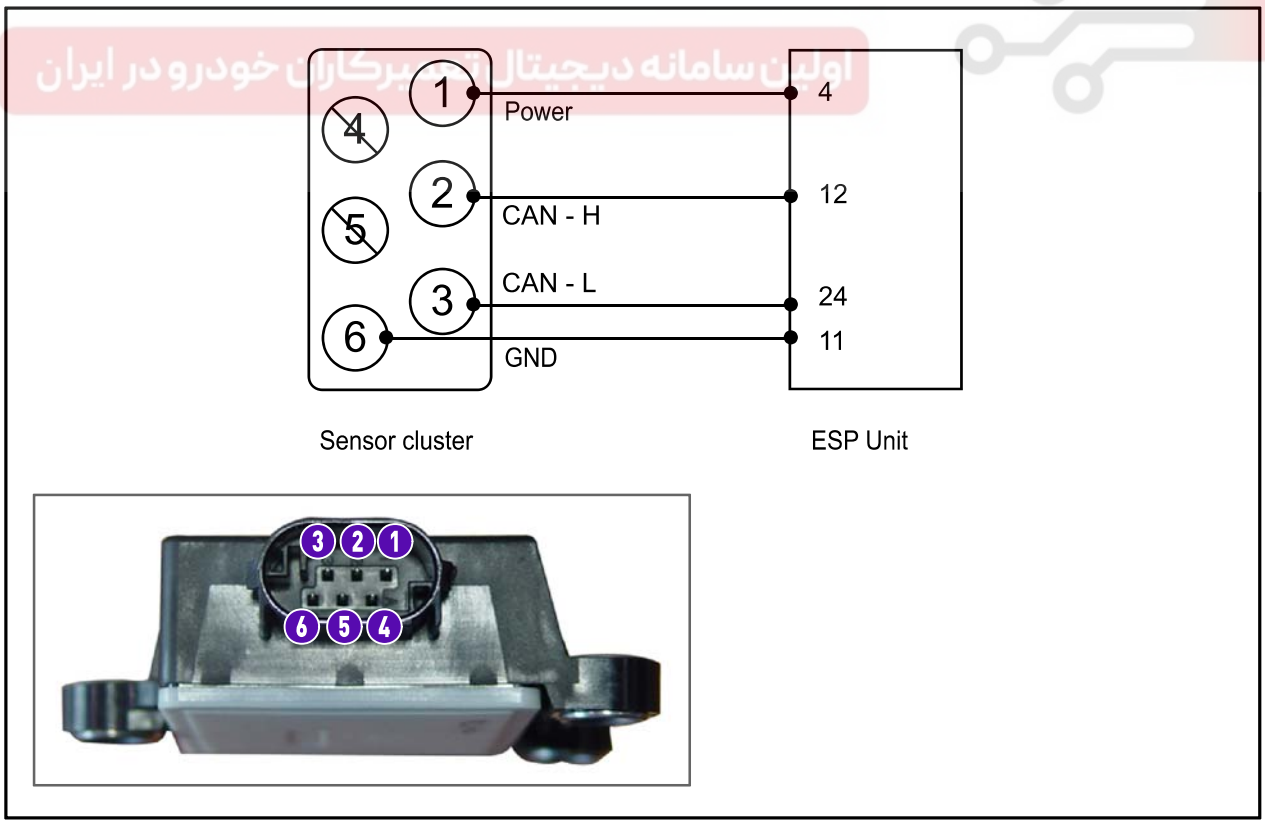
Modification basis	
Application basis	
Affected VIN	

2) Circuit Diagram

(1) Internal circuit



(2) Connector circuit



Modification basis	
Application basis	
Affected VIN	

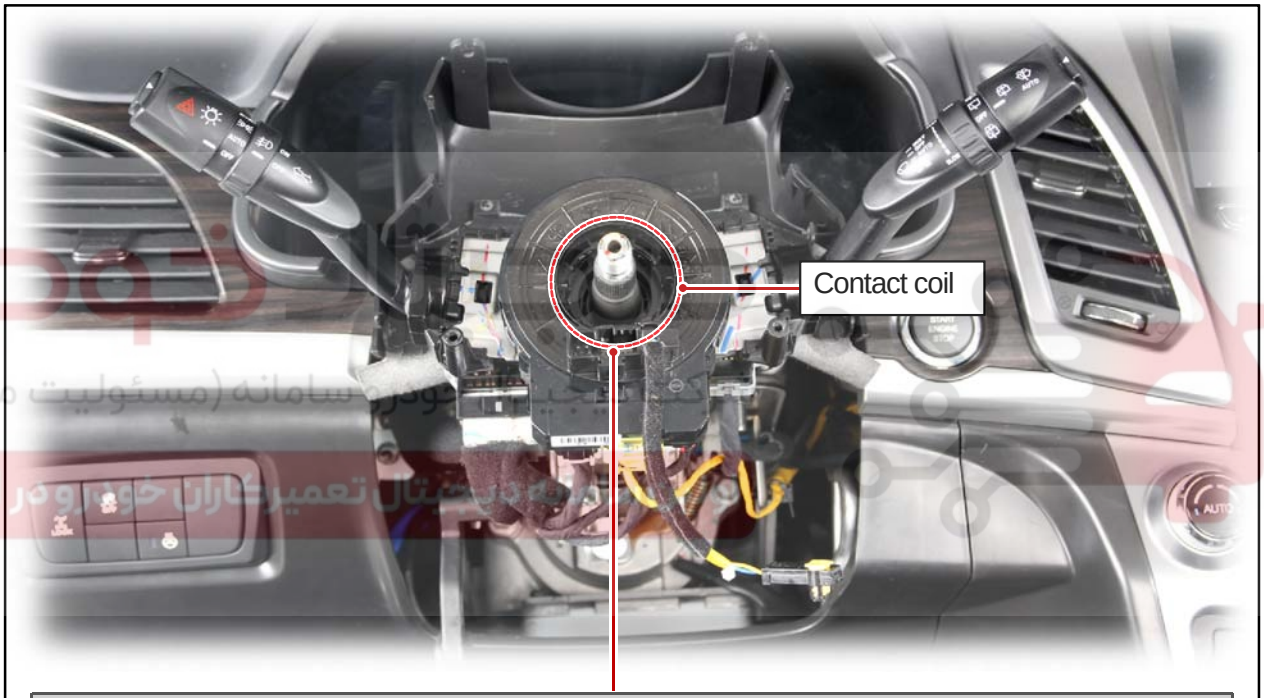
S.G.N. 8530-09

STEERING WHEEL ANGLE SENSOR (SWAS)

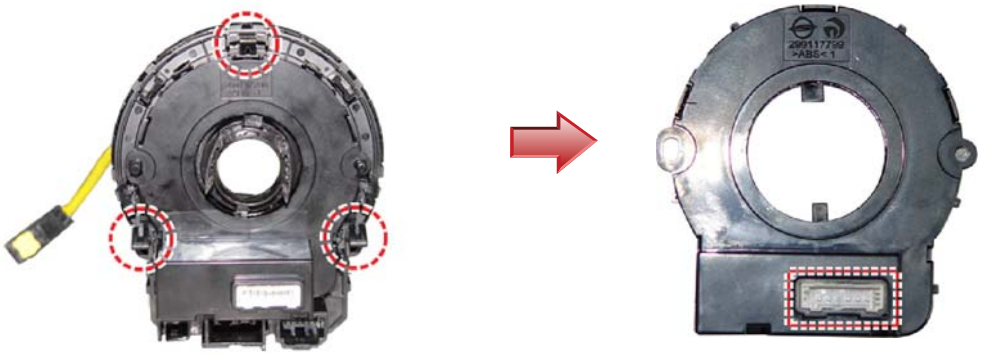
1) Overview

The steering wheel angle sensor is mounted between the steering column and the steering column shaft. Therefore it can be removed after removing the steering column assembly. It is commonly used by the ESP (Electronic Stability Program) system. And it receives signals of the steering wheel angle sensor from the ESP HECU (Hydraulic & Electronic Control Unit).
This signal is major information to control the damping force in accordance with the left/right movement of the vehicle caused by the operation of the steering wheel while driving.

(1) Mounting Location



Steering wheel angle sensor



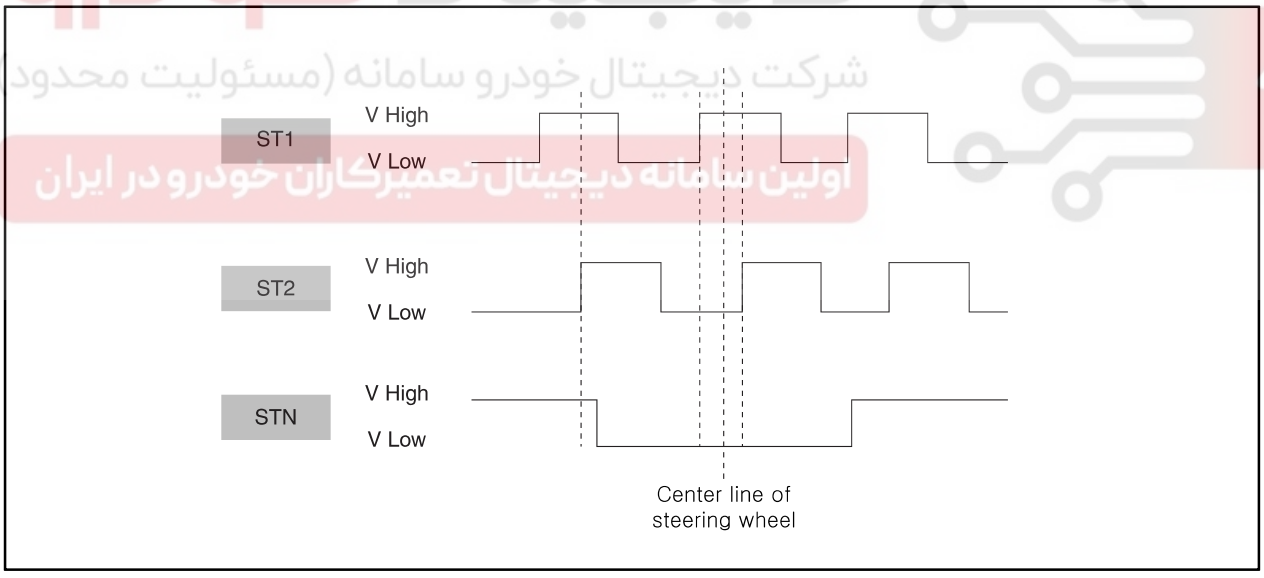
Sensor

Modification basis	
Application basis	
Affected VIN	

2) Operation

The steering wheel angle sensor is integrated with the phototransistor and the LED and there is a slotted plate between them. When the inner slotted plate rotates with the steering column shaft when the steering wheel is turned, the voltage occurs through the holes. The detected voltage will be transmitted to the HECU as a pulse from the 3 terminals. Then, the two voltage pulses are used to get the average value for detecting the steering wheel position and its angle speed. And the other pulse is used for checking the alignment of the steering wheel.

Description	Specification
Supplying voltage	9 to 16 V
Pulse/revolution	45 Pulses/rev
Duty	approx. 50 %
High - V	3.0 to 4.1 V
Low - V	1.3 to 2.0 V
ST1 & ST2	Average value of steering wheel angle and angular speed
STN	Center value of steering wheel angle



Modification basis	
Application basis	
Affected VIN	

S.G.N. 8510-23

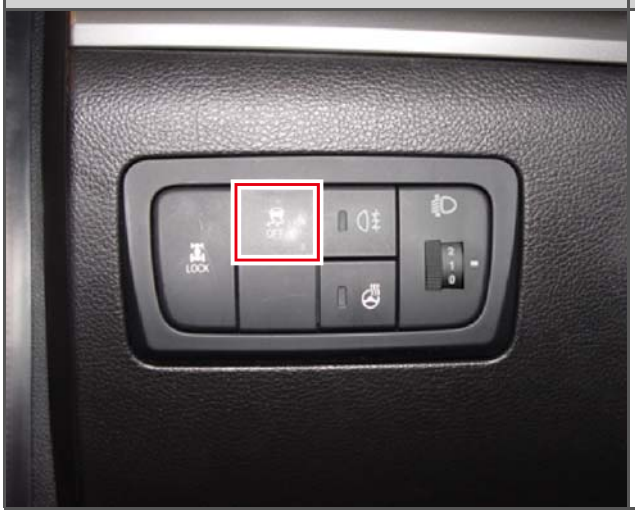
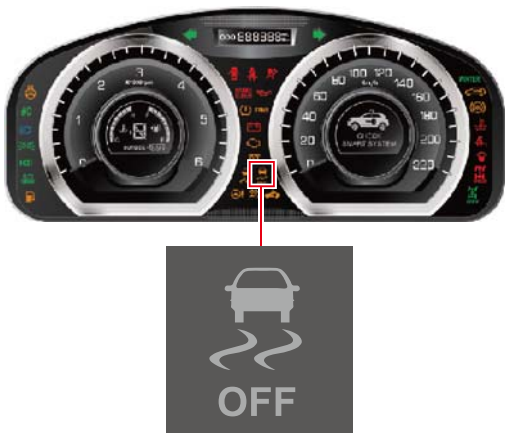
ESP OFF SWITCH

1) Overview

ESP OFF switch is located on the left side of the instrument panel. When pushing ESP OFF switch, ESP function is deactivated and ESP OFF indicator comes on. However, ABS function is still available.

2) Location

ESP OFF switch is located on the left side of the instrument panel.

ESP OFF switch	Indicator
	

Modification basis	
Application basis	
Affected VIN	

3) Operation

(1) ESP ON/OFF switch

The ESP ON/OFF switch is used to turn the ESP function ON or OFF. This switch is instantaneous contact switch of normal-open type and contacted to the IGN1. The initial condition is normal operating condition and it is toggled ON and OFF each time the switch is pressed.

(2) ESP OFF indicator module

▶ **CAN Cluster Type**

ESP OFF lamp indicates the operating conditions of ESP function.
ESP OFF lamp ON:

- When pushing ESP OFF switch to deactivate ESP function

(3) ESP warning lamp module

ESP warning lamp indicates the self-diagnosis and defective conditions.
ESP warning lamp ON:

- When turning the ignition switch to ON position, ESP warning lamp comes on for self diagnosis and goes off if the system is OK (initialization mode).
- When the system is defective, the warning lamp comes on.
- When ESP is operating, the warning lamp blinks.
- When the communication between warning lamp CAN module in meter cluster, the warning lamp comes on.

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

Modification basis	
Application basis	
Affected VIN	

S.G.N. 4890-01

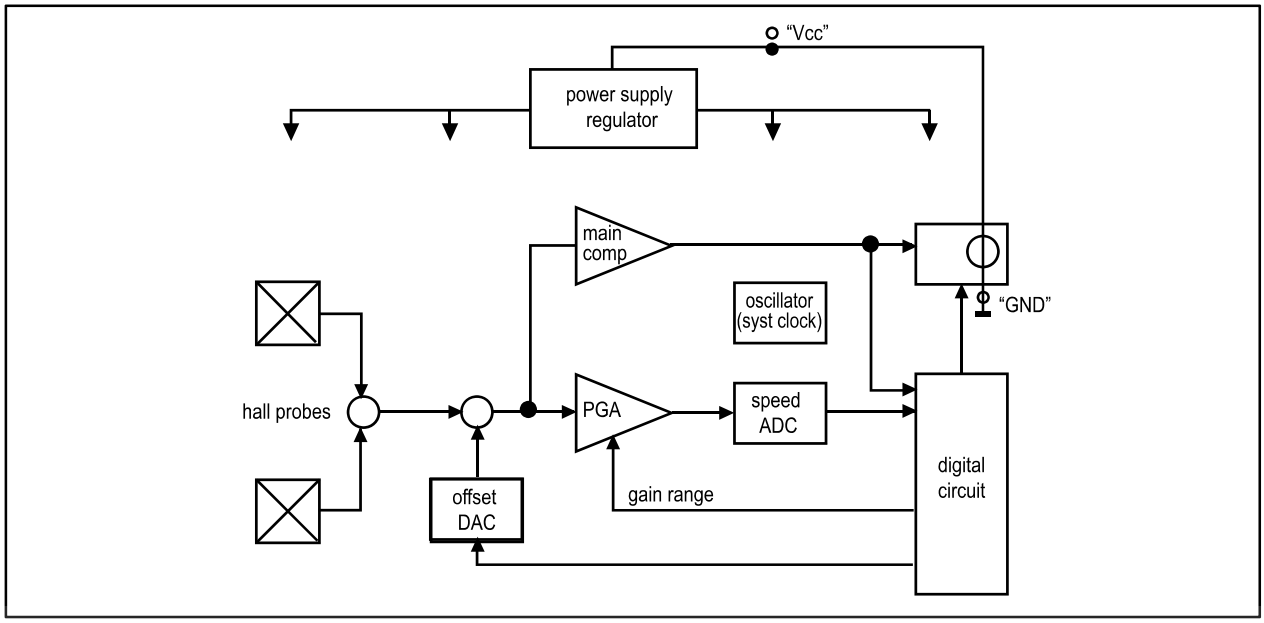
ACTIVE WHEEL SPEED SENSOR

1) Mounting Location

The wheel speed sensors are mounted to wheel knuckles and all of the sensors have the same appearance. But the rear wheel speed sensor for 2WD is little bit different.
For 4WD, the tone wheels are mounted to the drive shafts, while the tone wheels for 2WD are mounted to the rear side hub.

Modification basis	
Application basis	
Affected VIN	

2) Block Diagram



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

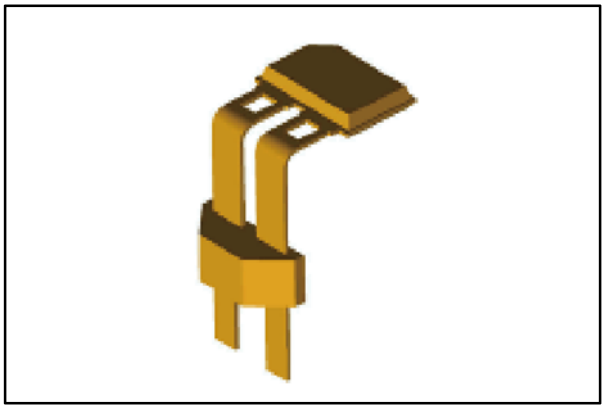
3) Function of Active Wheel Speed Sensor System

Tone Wheel
Tone wheel in drive shaft (4WD/2WD-front) 
Tone wheel in hub (2WD-rear) 

- 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.

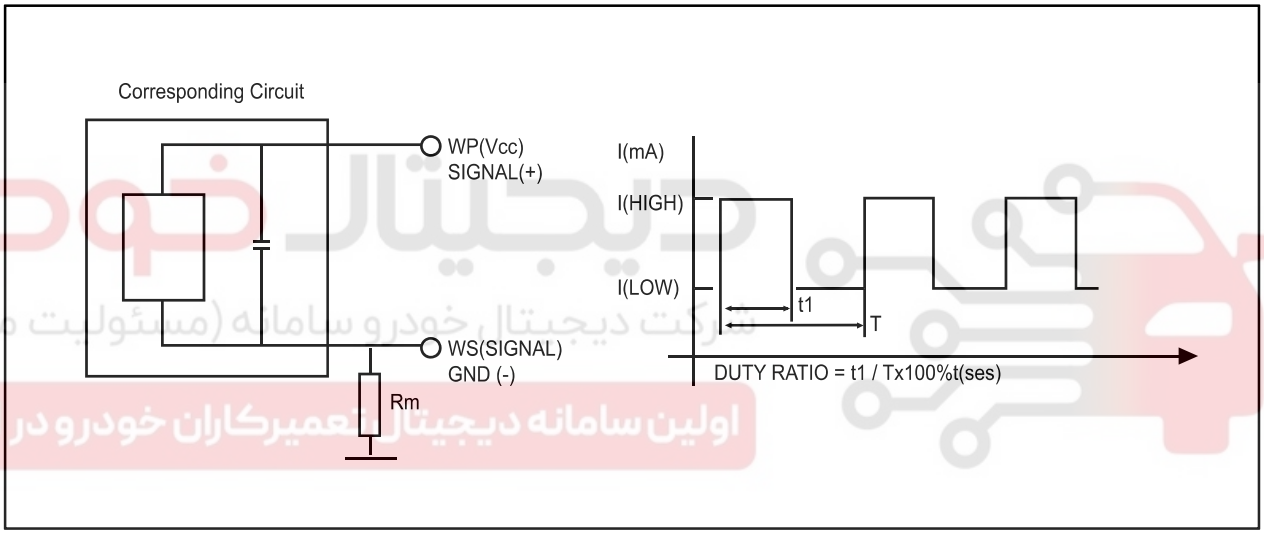
Modification basis	
Application basis	
Affected VIN	

4) Hall Type Active Wheel Speed Sensor



The IC consists of 2 hall elements and a plastic housing with peripheral circuits integrated, and there is a capacitor for EMI performance improvement in the center of the lead frame. The 2 lead frames are for signal output and voltage supply.

5) Circuit Diagram of Wheel Sensor



Modification basis	
Application basis	
Affected VIN	

REMOVAL AND INSTALLATION

S.G.N. 4825-00 AIR BLEEDING

1) Air Bleeding Should be Done When

- After removal and installation of the brake master cylinder.
- After removal and installation of the ABS HECU.
- After removal and installation of the brake oil pipes and hoses.
- After replacing the brake fluid.

2) Precautions

- Wipe off any brake fluid on the paintwork immediately.
- The HECU for after sale service is filled with brake fluid, so below air bleeding processes should be carried out to bleed the internal circuit.
- The air bleeding should be repeated until bubbles come out and the break operating status should be checked at the final step.

3) Air Bleeding Procedure (With Diagnostic Tool)

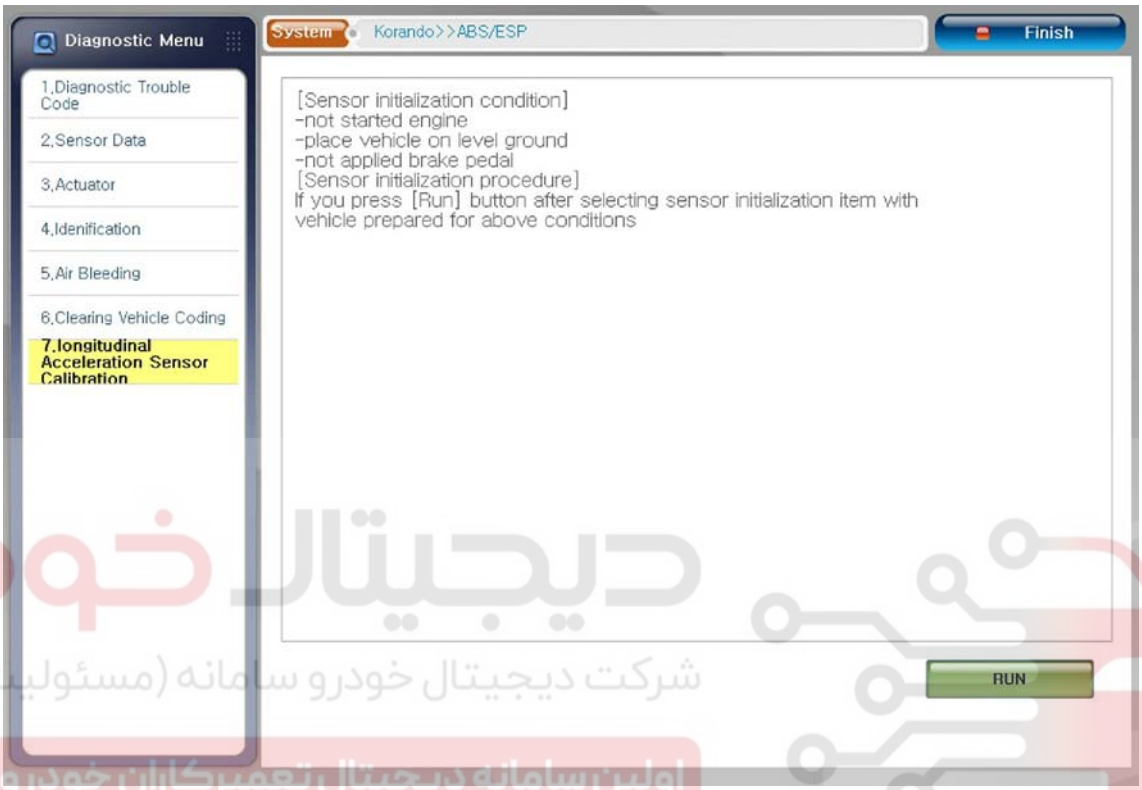
1. Apply the parking brake and start the engine when the shift lever is at “N(M/T)” or "P(A/T)" position.
2. Connect the oil supply device (air bleeding device) with air compressor to the brake fluid reservoir. The oil supply device should be filled with sufficient oil.
3. Loosen the air bleed screw in caliper and place an empty container under the screw.
4. Bleed the air in each wheel by using diagnostic device's air bleeding menu. At this time, the modulator motor runs for 180 seconds.
5. Simultaneously, run the oil supply device to supply oil and depress the brake pedal repeatedly. This procedure needs at least 3 persons for doing below jobs:
6. a. Collect the bleeding oil from the air bleed screw into the container.
   b. Depress the brake pedal repeatedly.
   c. Check the conditions of oil supply device.
   The air bleeding procedure should be started from the rear right wheel.
   Repeat the step 4 through 5 until clear brake fluid comes out of air bleed screw. Perform the same
7. procedures at each wheel.

Modification basis	
Application basis	
Affected VIN	

4) Air Bleeding by using Diagnostic Tool

(1) Sensor calibration (Initialization)

Performing a sensor initialization in the ESP diagnosis menu which enables the initialization of the sensor (only for ESP).



After confirming the vehicle conditions are met, click the "Run" button to start the initialization.

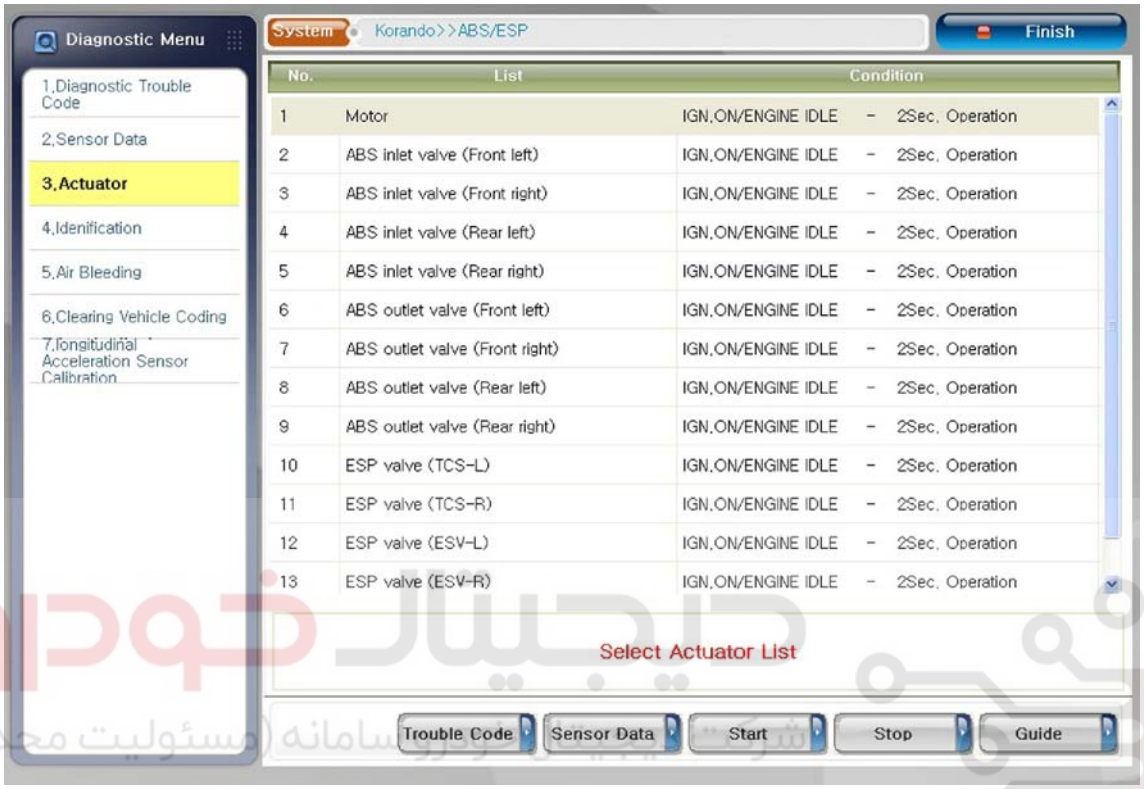
▶ **Steering wheel angle sensor**

- The steering wheel angle sensor automatically searches for a center position when the vehicle is driving straight forward with 20 km/h of driving speed (no additional diagnostic menu).

Modification basis	
Application basis	
Affected VIN	

(2) Operation Check

Select the "Actuator" in the diagnosis menu.



Pressing the "Start" button after selecting the desired device from the forced operation list enables the forced operation for 10 seconds.

NOTE

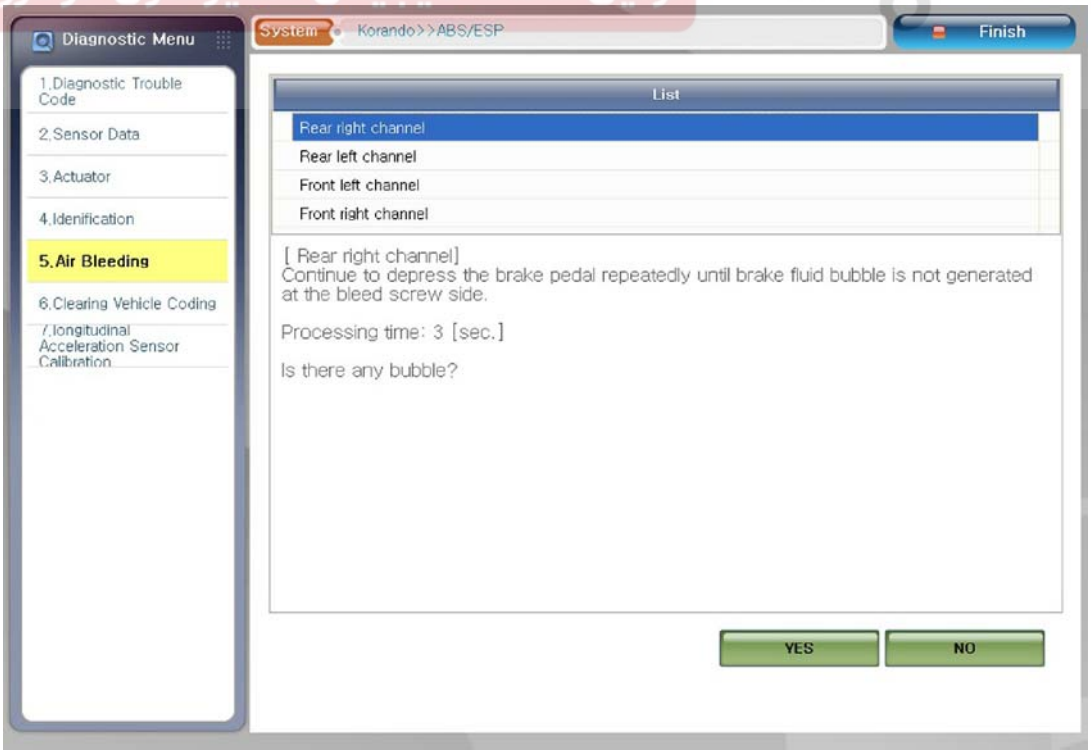
All components except the pump motor require brake pedal operation and can be checked by the forced operation.
Input/primary valve -> The brake pedal gets heavy and is not depressed completely.
Output/secondary valve -> The brake pedal is light and is depressed fully.

Modification basis	
Application basis	
Affected VIN	

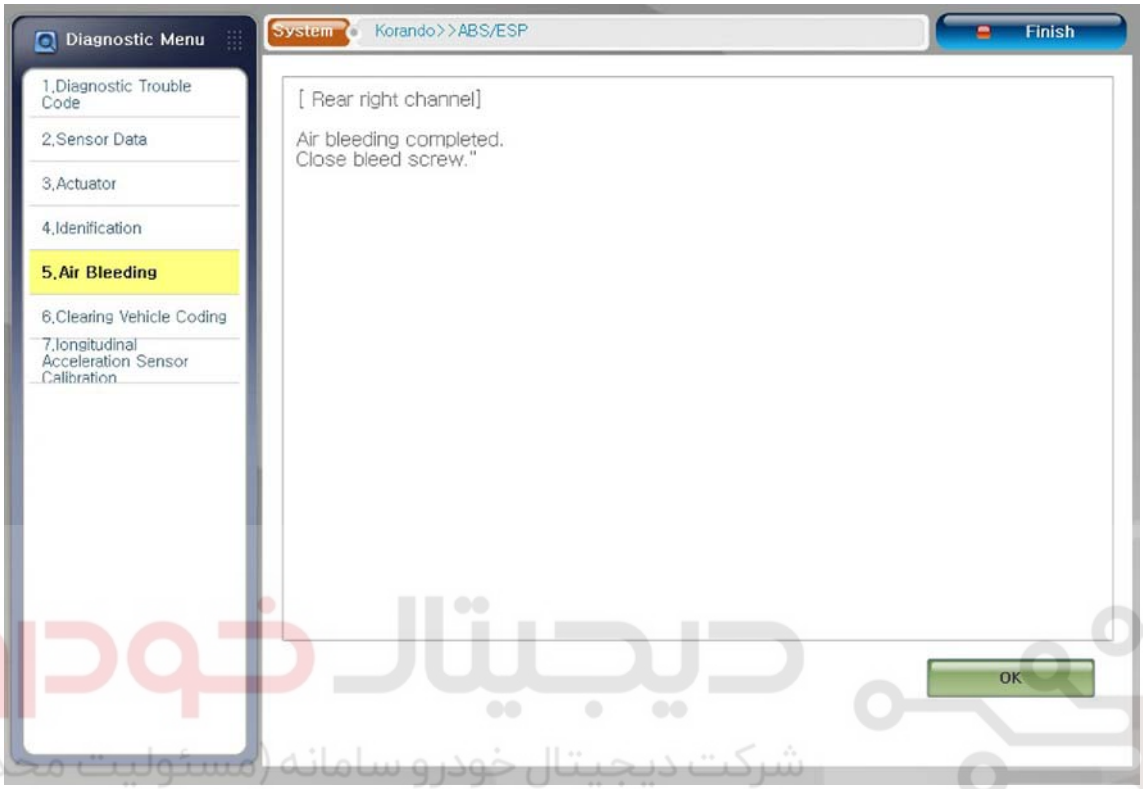
(3) Air bleeding

Select the "Air Bleeding" in the diagnosis menu. After confirming the vehicle conditions are met, click the "YES" button to start the initialization.

If no bubbles come out from the bleed screw, then click "YES".



The pump motor stops operating with the message "Air Bleeding Completed".



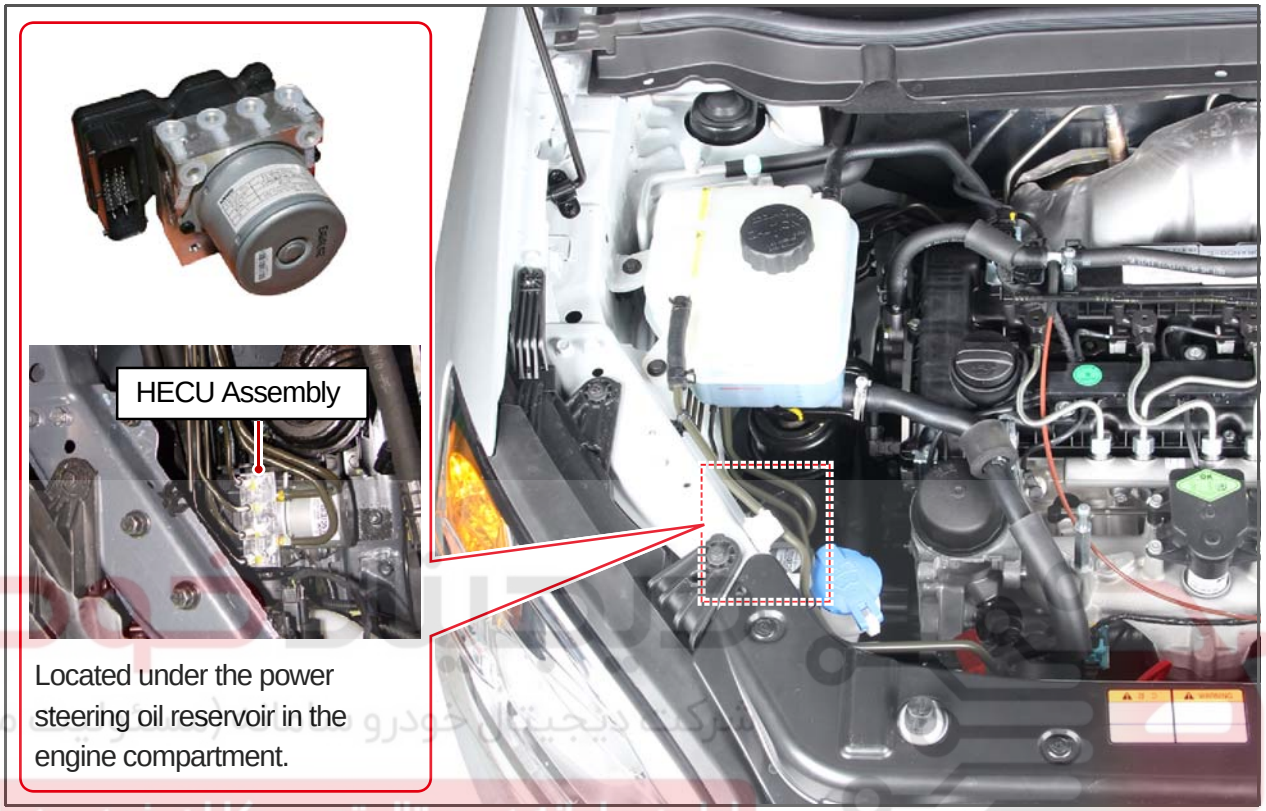
Perform the same procedures for the other brake lines.

Modification basis	
Application basis	
Affected VIN	

S.G.N. 4892-01

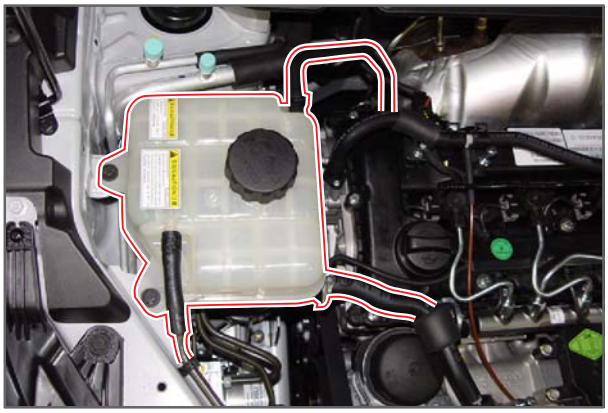
HECU (HYDRAULIC ELECTRONIC CONTROL UNIT) REMOVAL AND INSTALLATION

▶ Mounting location

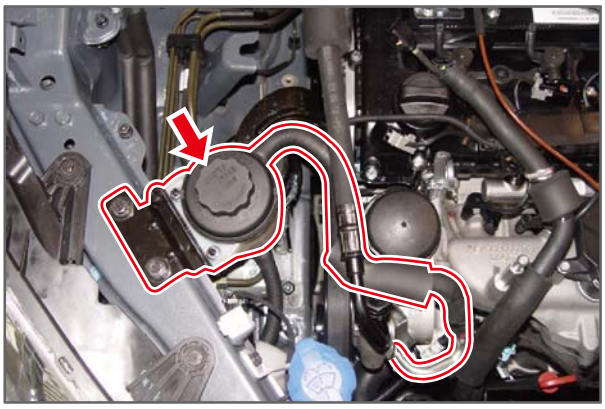


Preceding work

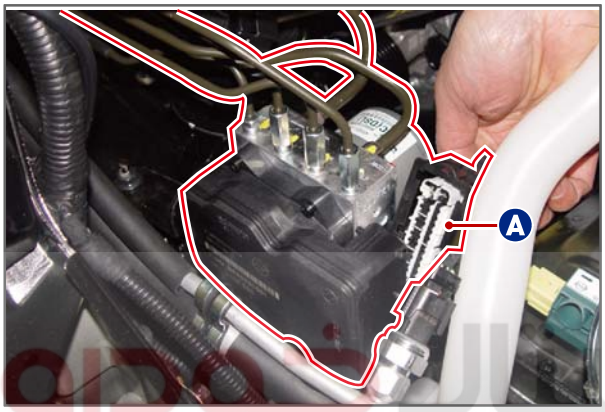
- Disconnect the negative cable from the battery.
- Collect the brake fluid from the brake fluid reservoir completely using an oil suction.
- Collect the coolant from the coolant reservoir completely using a suction device.



1. Remove the coolant reservoir. For further information, refer to the section "Cooling System" of Chapter "Engine".



2. Remove the power steering oil reservoir. For further information, refer to the section "Steering".



3. Disconnect the ABS wiring harness connector (A) from the HECU socket and cover the openings of the connector and the socket with a piece of cloth to keep the brake oil entering.

CAUTION

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 ABS system.

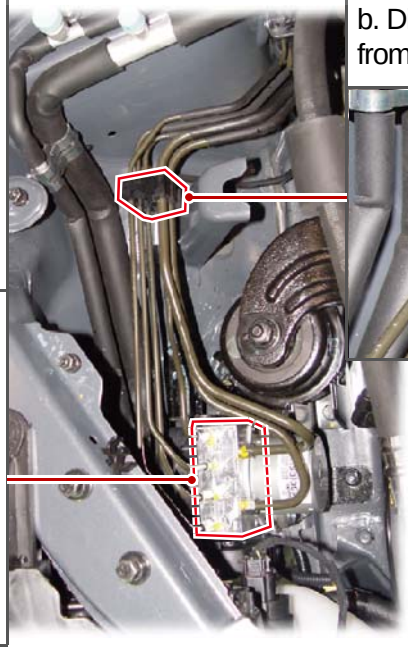
4. Remove the hydraulic modulator assembly.

CAUTION

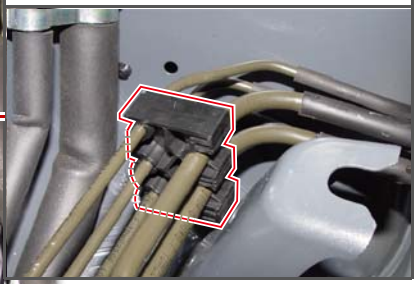
The openings of the pipes and the hydraulic modulator should be sealed with the sealing caps.

a. Disconnect all brake pipes connected to the hydraulic modulator.

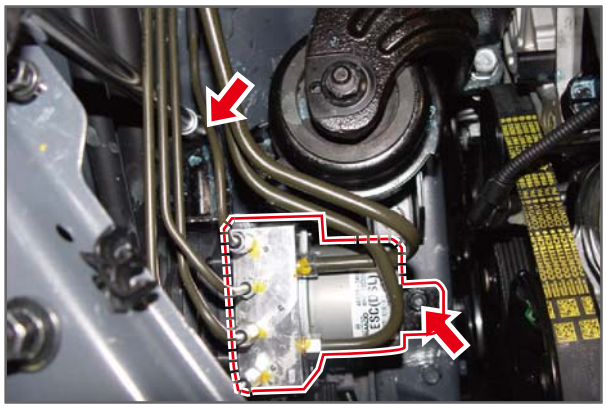
- **Tightening torque for 4 brake caliper pipes (10 mm) 12.0 to 16.0 Nm**
- **Tightening torque for 2 master cylinder pipes (12 mm) 19.0 to 23.0 Nm**



b. Disconnect each brake pipe from the pipe clip.



Modification basis	
Application basis	
Affected VIN	



5. Unscrew the 2 bracket mounting nuts (12 mm) on the hydraulic modulator and remove the hydraulic modulator assembly.

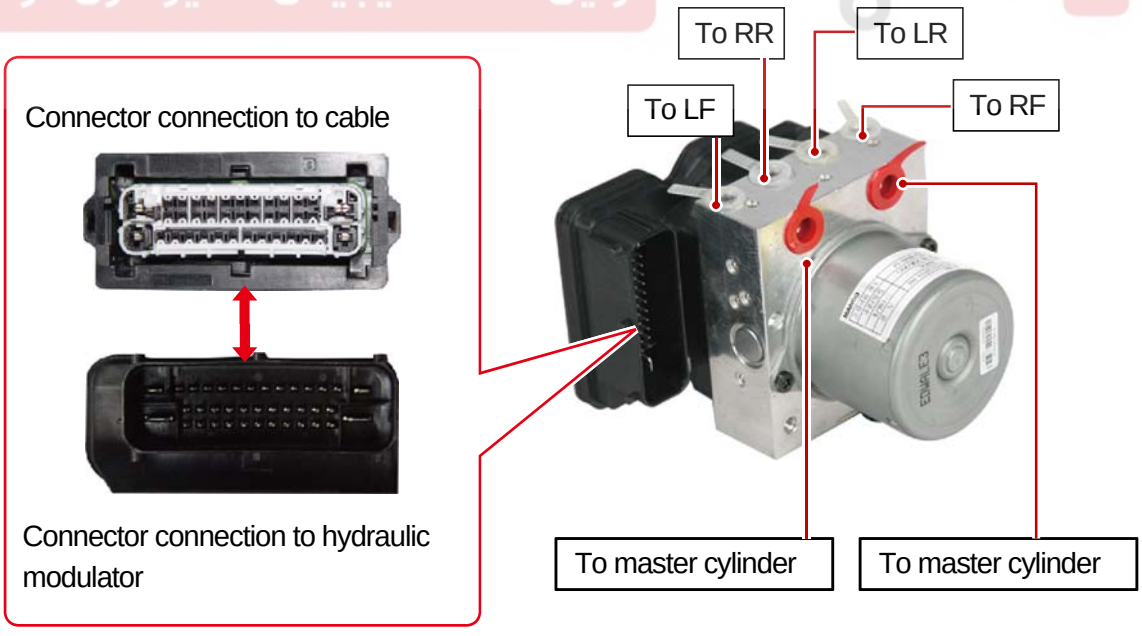
NOTE

Remove the hydraulic modulator by sliding aside the disconnected pipes. Do not apply excessive force to remove it. Otherwise, the pipes could be damaged.

Tightening torque 10.0 to 14.0 Nm

6. Install in the reverse order of removal.

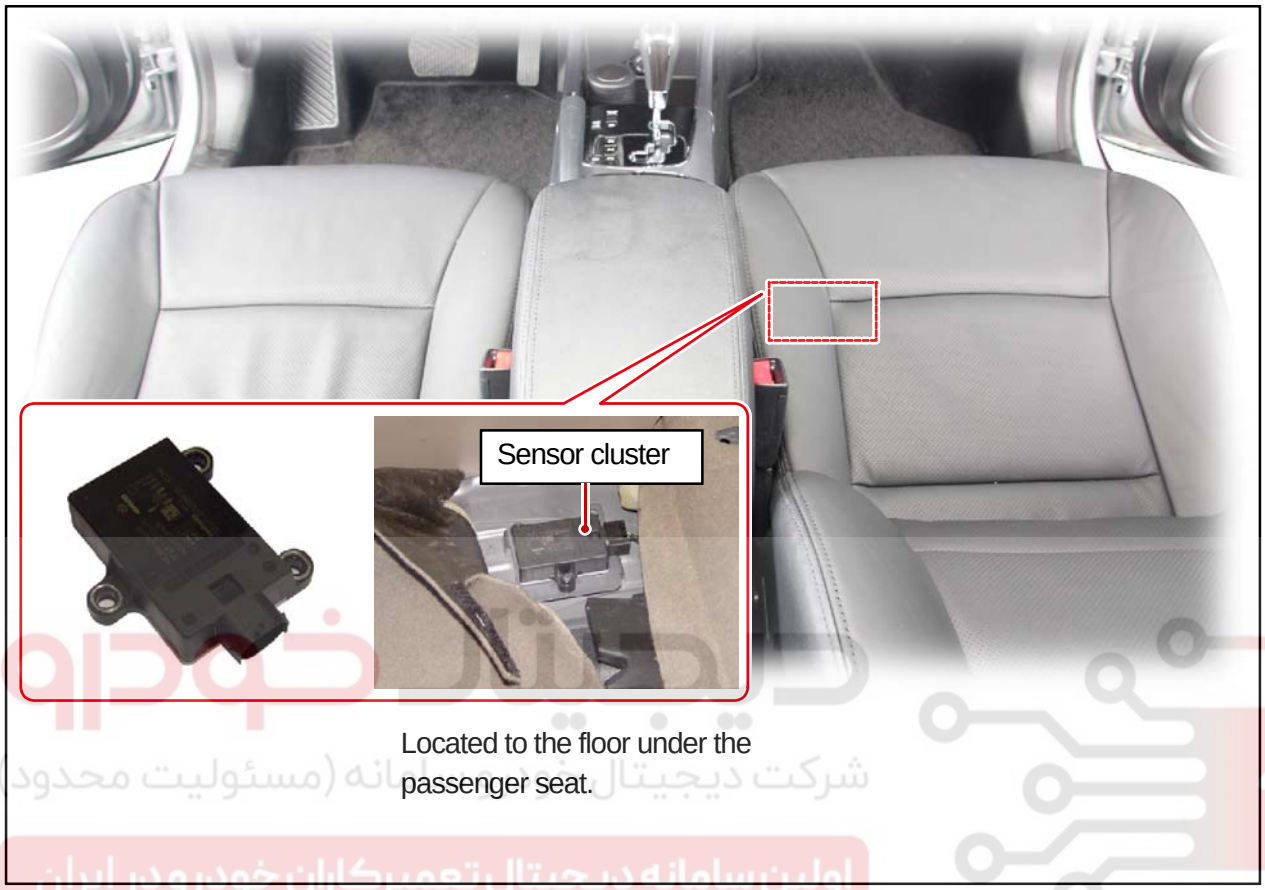
Configuration of HECU



Modification basis	
Application basis	
Affected VIN	

S.G.N.
4890-10 SENSOR CLUSTER

▶ **Mounting location**



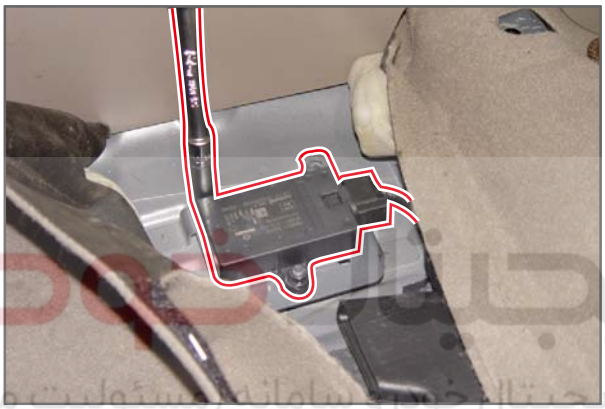
Located to the floor under the passenger seat.

Preceding work Disconnect the negative cable from the battery.

1. Remove the passenger seat. For further information, refer to the section "Seat" of Chapter "Body".

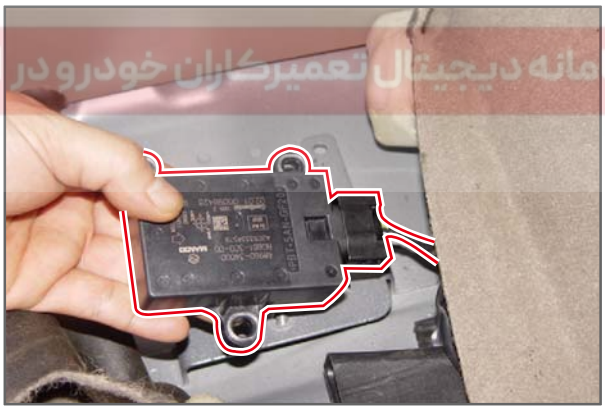
Modification basis	
Application basis	
Affected VIN	

2. Turn back the floor panel carpet.



3. Unscrew the 3 mounting bolts (10 mm) for center cluster.

Tightening torque 7.8 to 10.8 Nm



4. Disconnect the connector and remove the sensor cluster.

5. Install in the reverse order of removal.

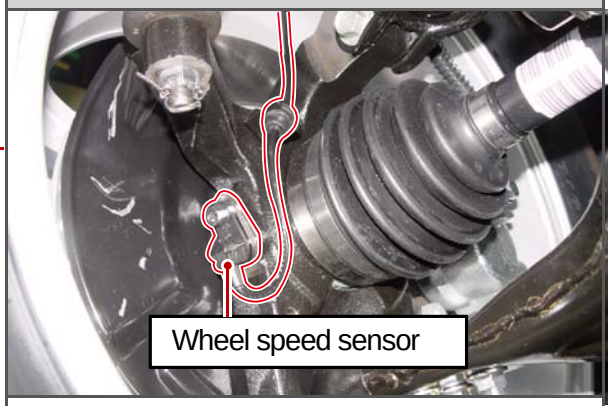
Modification basis	
Application basis	
Affected VIN	

S.G.N. 4890-01

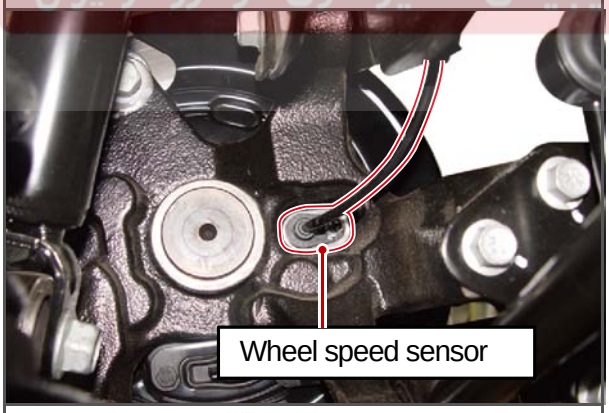
ACTIVE WHEEL SPEED SENSOR

▶ **Mounting location**

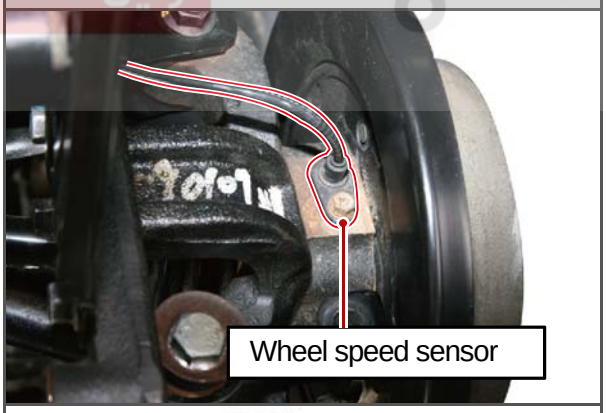
Front wheel speed sensor



Rear wheel speed sensor for 2WD



Rear wheel speed sensor for 4WD

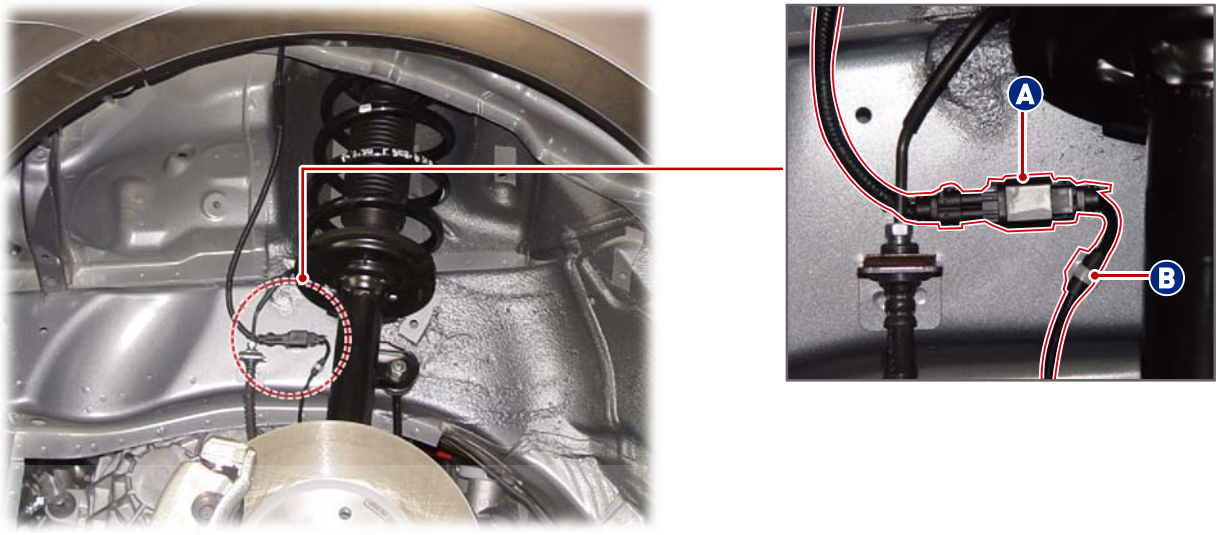


Modification basis	
Application basis	
Affected VIN	

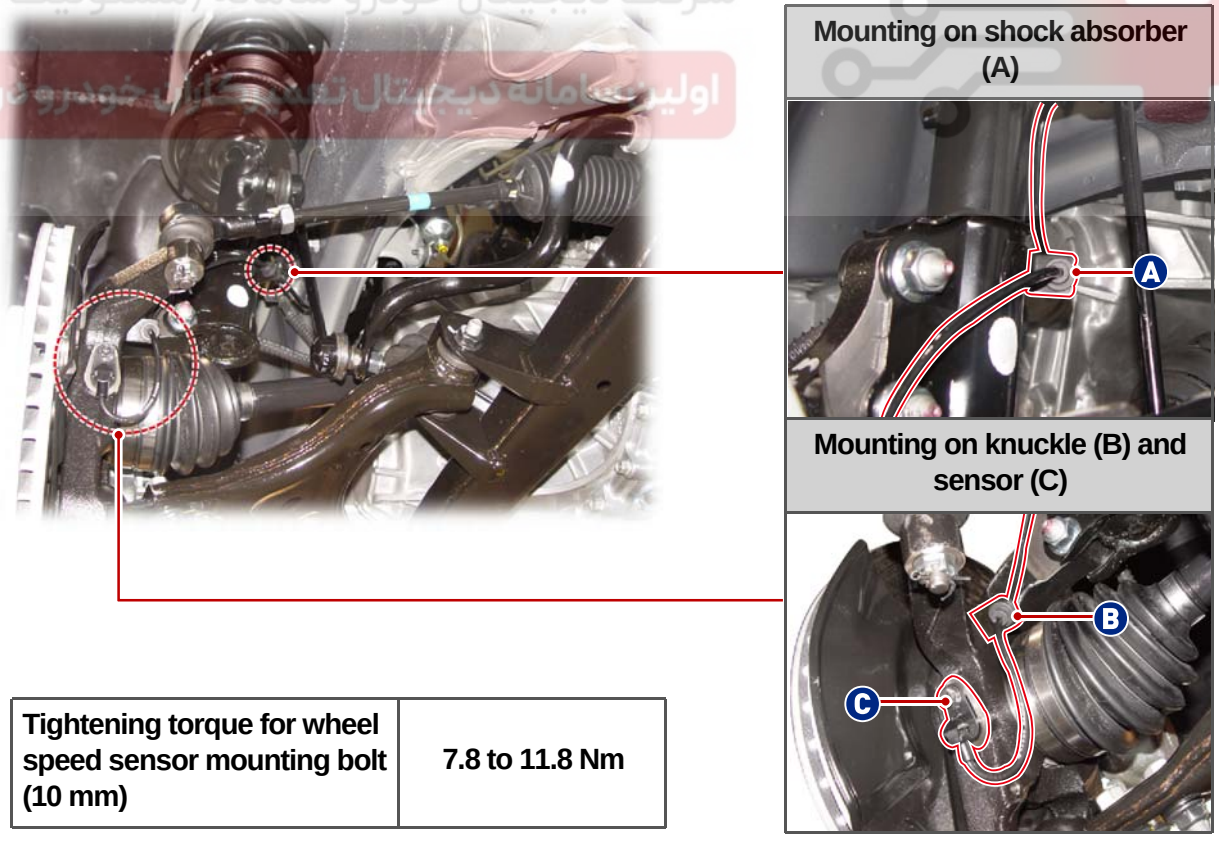
▶ Front wheel speed sensor

Preceding work Disconnect the negative cable from the battery.

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



2. Disconnect the cable (A) connected to the shock absorber and the cable (B) connected to the knuckle, and unscrew the mounting bolt (10 mm) to remove the wheel speed sensor (C).



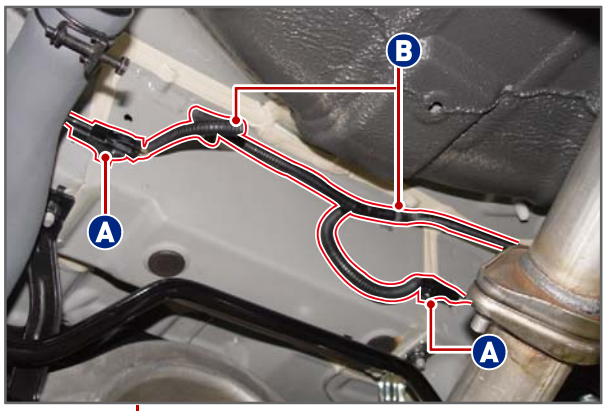
Tightening torque for wheel speed sensor mounting bolt (10 mm)	**7.8 to 11.8 Nm**

3. Install in the reverse order of removal. Connect the connector firmly.

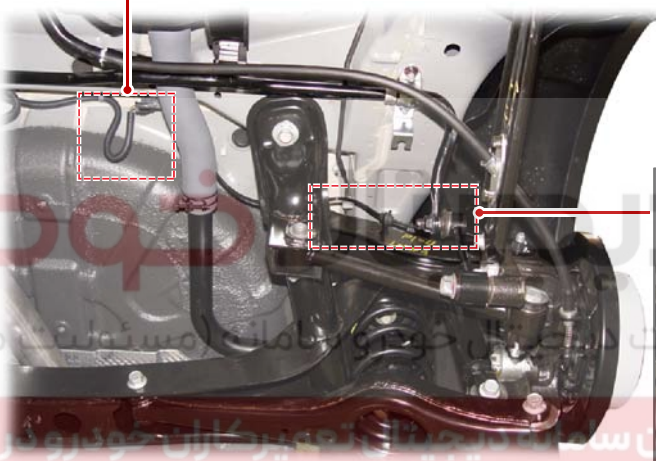
Modification basis	
Application basis	
Affected VIN	

▶ Rear wheel speed sensor

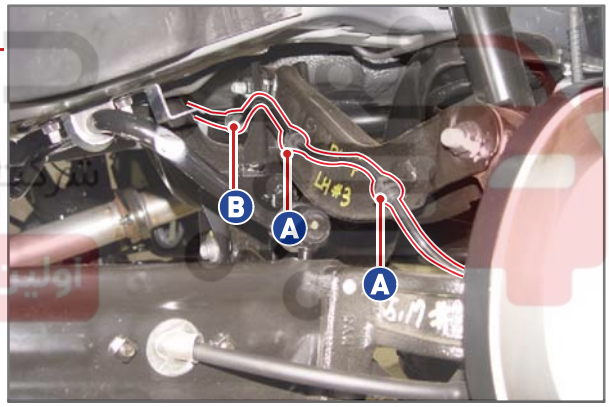
Preceding work Disconnect the negative cable from the battery.

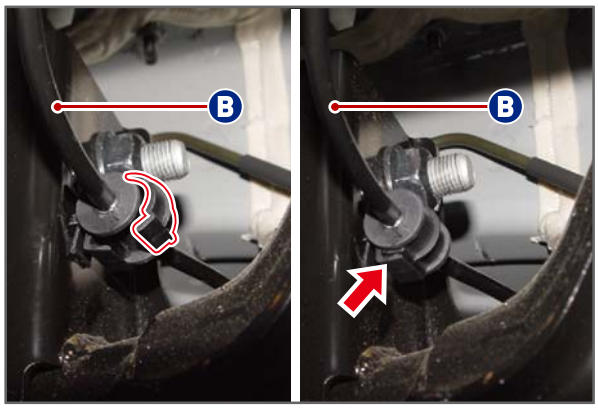


1. Remove the connector (A) and cable mounting (B) for the rear wheel speed sensor.



2. Disconnect the cable (A) connected to the upper arm and cable (B) connected to the sub frame.



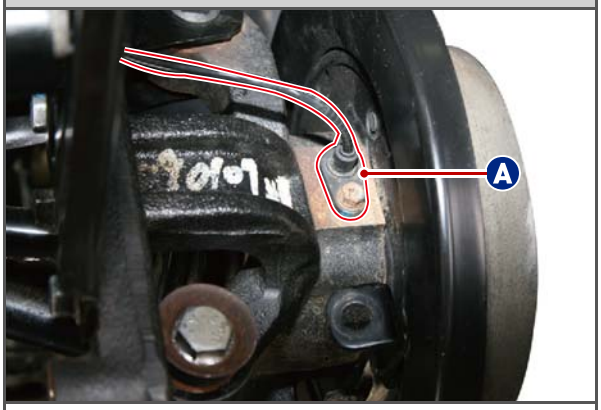


- Disengage the cable holder clip to disconnect the cable (B) installed to the frame as shown in the figure.

Modification basis	
Application basis	
Affected VIN	

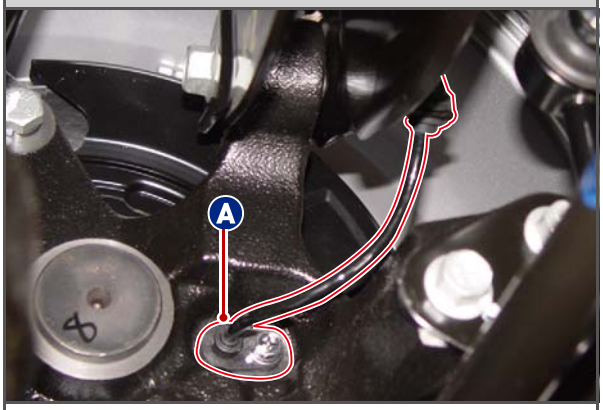
3. Unscrew the mounting bolt (10 mm) on the rear knuckle to remove the wheel speed sensor.

Rear wheel speed sensor for 4WD Mounting location



Tightening torque 7.8 to 11.8 Nm

Rear wheel speed sensor for 2WD Mounting location



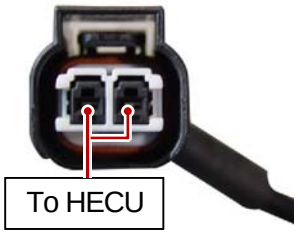
Tightening torque 7.8 to 11.8 Nm

4. Install in the reverse order of removal. Connect the connector firmly.

Front wheel speed sensor for 4WD/2WD

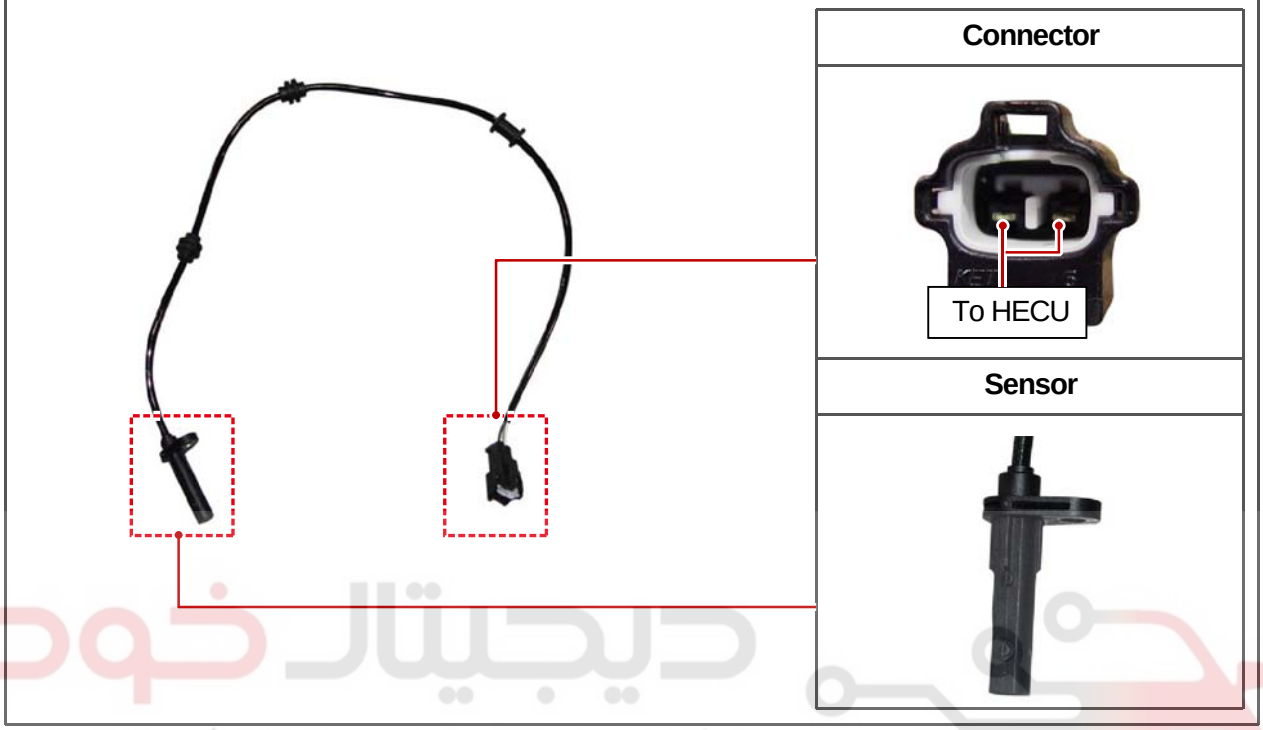
Sensor

Connector



Modification basis	
Application basis	
Affected VIN	

Wheel speed sensor for 2WD



Modification basis	
Application basis	
Affected VIN	

S.G.N. 8530-09

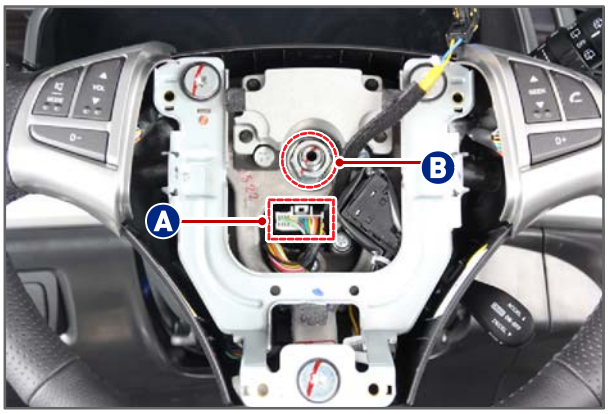
STEERING WHEEL ANGLE SENSOR

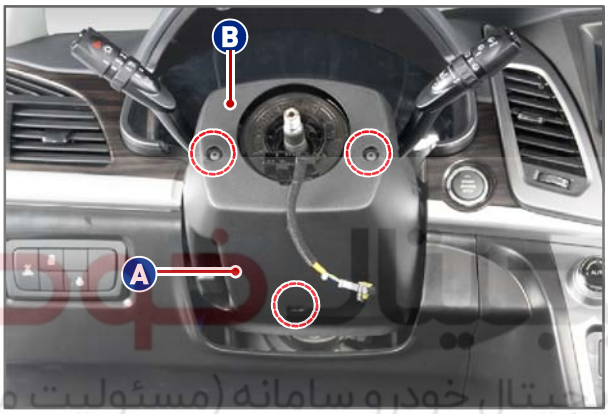
▶ Mounting location

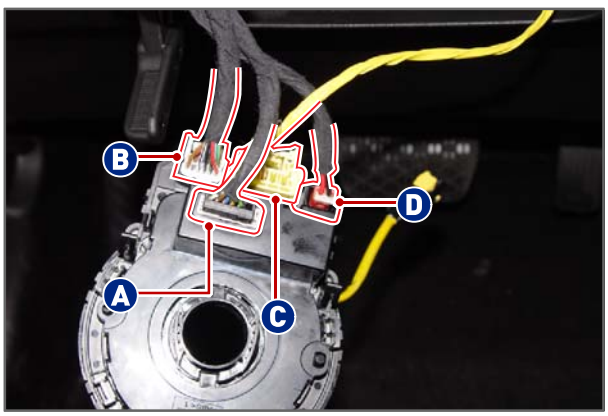
Preceding work Disconnect the negative cable from the battery.

1. Remove the air bag module assembly from the steering wheel. For further information, refer to the section "Air Bag".

Modification basis	
Application basis	
Affected VIN	







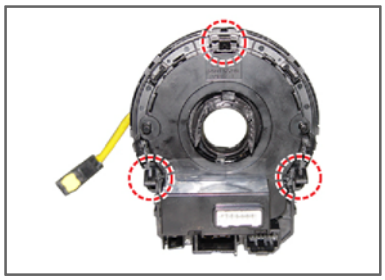
2. Disconnect the connector (A) and unscrew the mounting nut (B, 22 mm) to remove the steering wheel body complete.

3. Unscrew the 3 mounting screws for the lower cover of the column shaft to remove the lower cover (A) and the upper cover (B). The upper cover is connected to the IP cover. So it should be separated from the lower cover.

4. Pull up the contact coil on the column shaft.

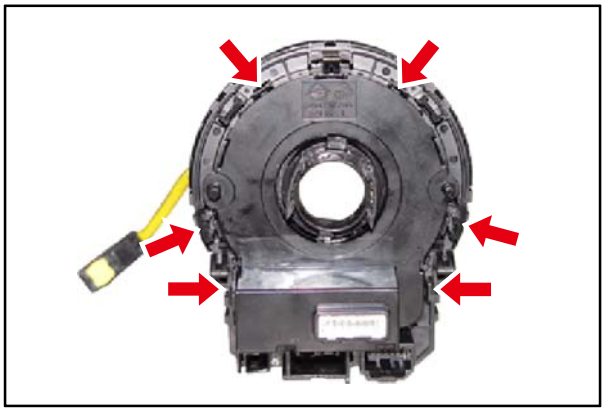
CAUTION

Be careful not to damage the three locks behind the contact coil.

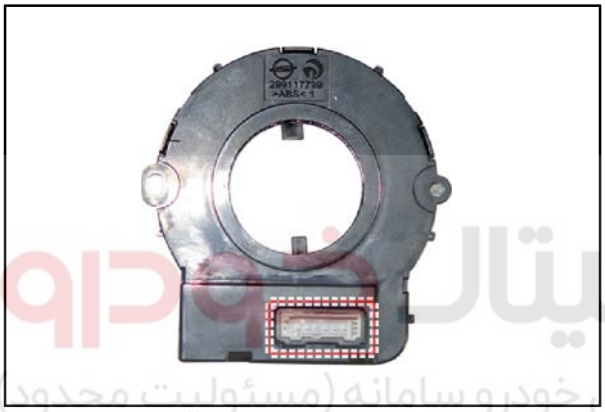


5. Disconnect the sensor connector (A) and contact coil connectors (B, C and D) and remove the contact coil.

Modification basis	
Application basis	
Affected VIN	



6. Remove the steering wheel angle sensor from the removed contact coil by expanding the 6 mountings of the sensor.



7. Install in the reverse order of removal. For more information, refer to the sections "Steering" and "Air Bag".

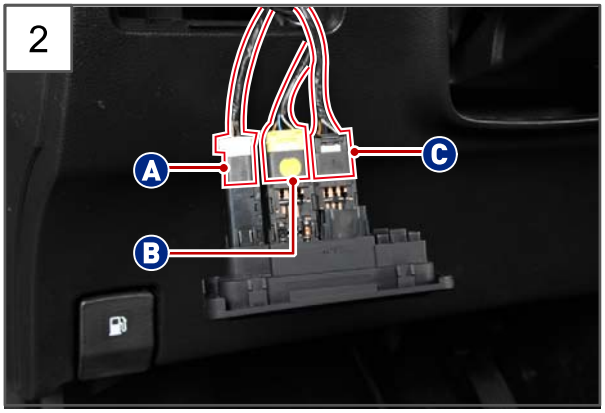
Modification basis	
Application basis	
Affected VIN	

S.G.N. 8510-23

ESP OFF SWITCH

▶ **Mounting location**

1. Pry off the lower switch cluster with a remover.



2. Disconnect the connectors (A, B and C) and remove the lower switch cluster.
   - (A) 4WD LOCK switch connector
   - (B) ESP OFF switch connector
   - (C) Steering wheel heating switch connector

Modification basis	
Application basis	
Affected VIN	

3

3. Separate the ESP OFF switch from the remove the switch cluster.

4

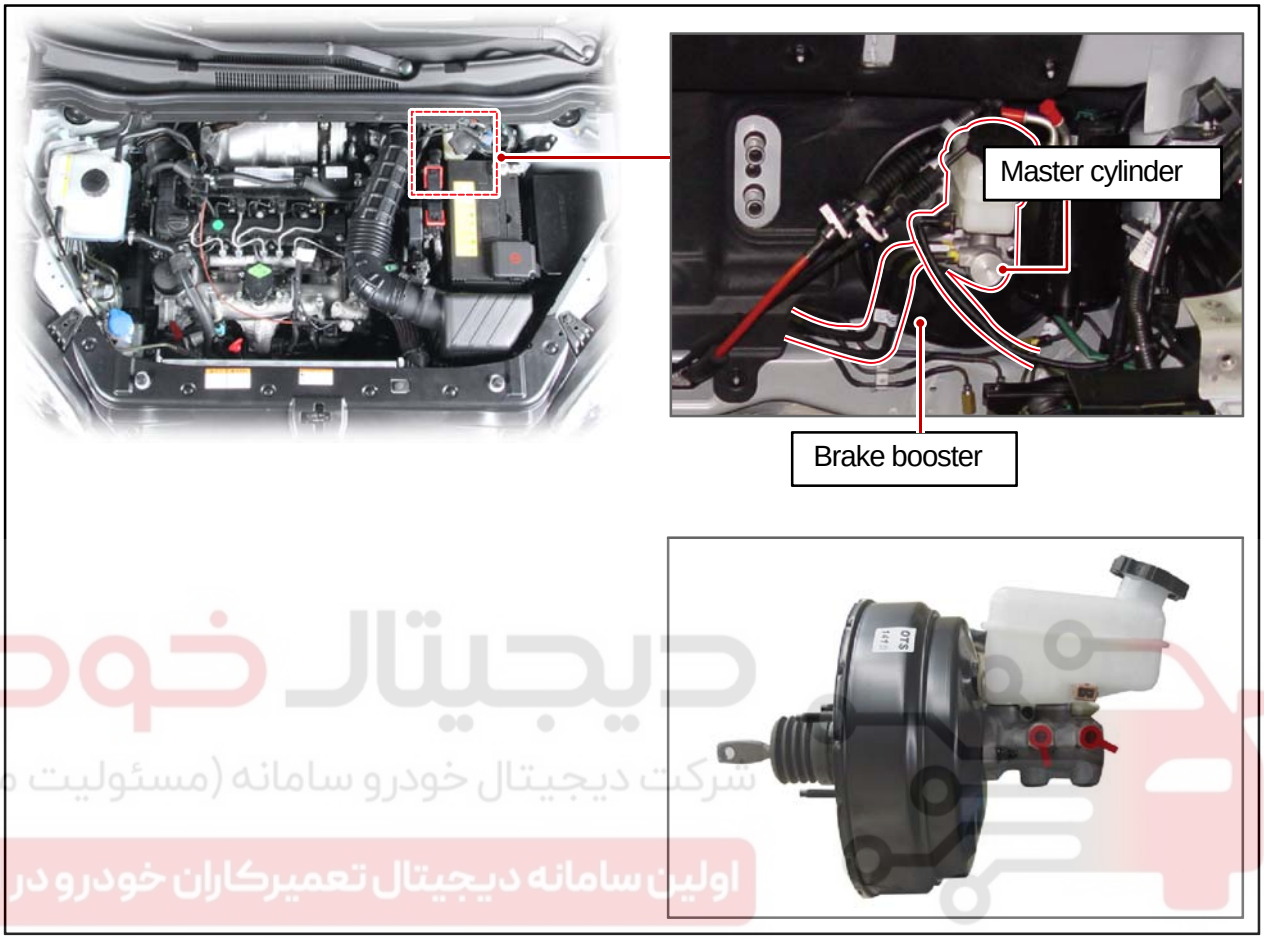
4. Install in the reverse order of removal.

Modification basis	
Application basis	
Affected VIN	

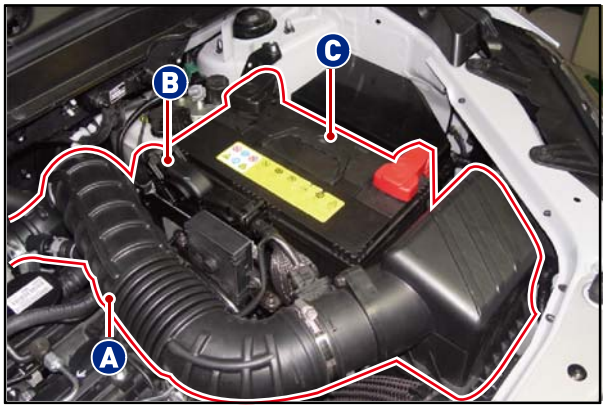
S.G.N. 4850-01

MASTER CYLINDER AND BOOSTER

▶ **Mounting location**



Preceding work Disconnect the negative cable from the battery.



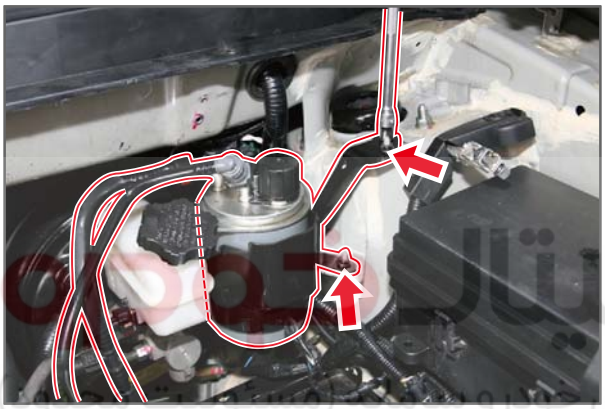
1. Remove the air cleaner duct (A), engine ECU assembly (B) and battery assembly (C) from the engine compartment. For further information, refer to the Chapter "Engine".

Modification basis	
Application basis	
Affected VIN	

2. Open the brake fluid reservoir cap and drain the brake fluid in the fluid reservoir using a suction device.

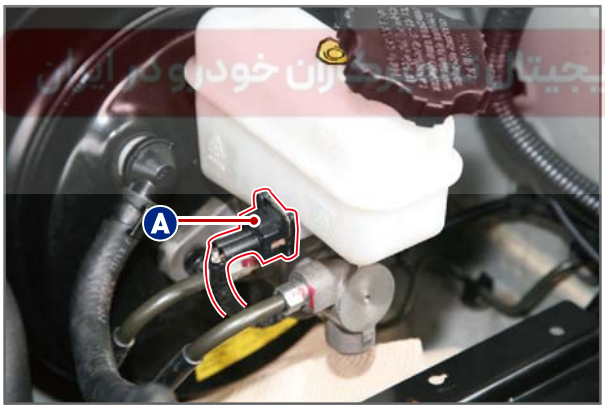
CAUTION

Make sure that the brake fluid does not get on other parts when draining it.



3. Unscrew the two bracket mounting nuts (10 mm) and remove the fuel filter assembly.

Tightening torque 7.8 to 11.8 Nm



4. Disconnect the level switch connector (A) of the brake fluid reservoir.

5. Unscrew the brake pipe nuts (14 mm) on the HECU of the brake master cylinder.

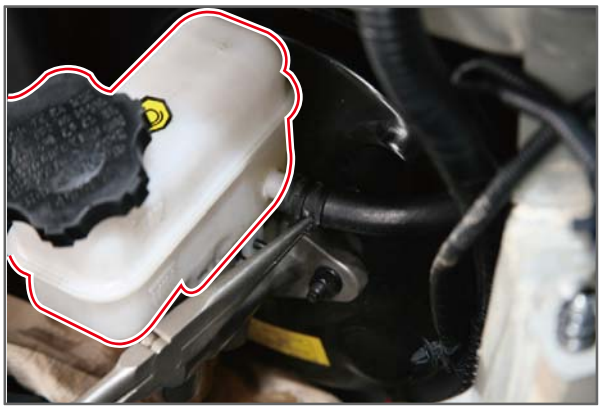
CAUTION

Place a piece of cloth or shop rag under the pipe in order to prevent the brake fluid from getting on other parts as the fluid remaining in the pipe may flow out. The opening of the removed pipe should be sealed with plastic bag, etc.

Tightening torque ABS HECU: 14.7 to 18.6 Nm

Tightening torque ESP HECU: 20.0 to 24.0 Nm

Modification basis	
Application basis	
Affected VIN	



6. Disengage the clamp for the hose connected to the clutch master cylinder from the brake fluid reservoir and disconnect the hose from the reservoir.

CAUTION

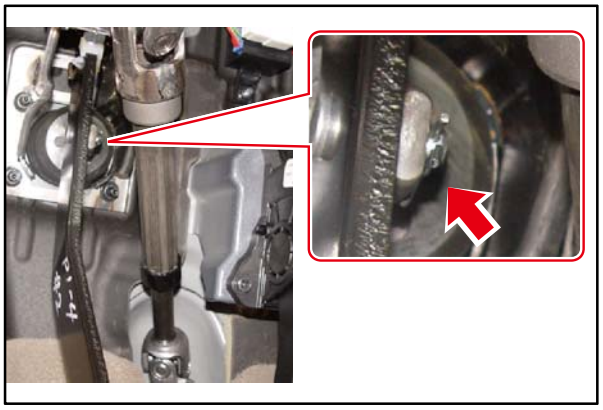
Place a piece of cloth or shop rag under the hose in order to prevent the brake fluid from getting on other parts as the fluid remaining in the hose may flow out. The opening of the removed hose should be covered with plastic bag, etc.

7. Unscrew the two brake master cylinder mounting nuts (12 mm).

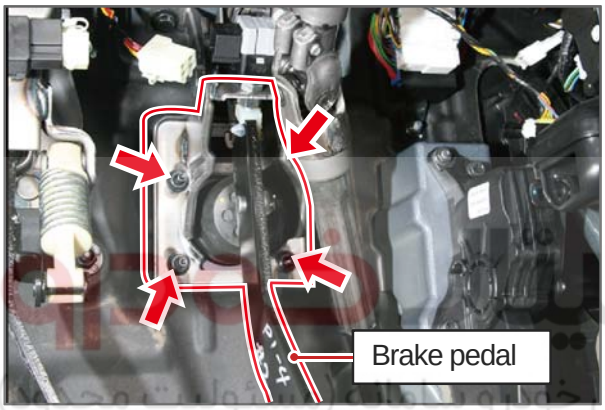
Tightening torque 12.8 to 16.7 Nm

8. Remove the brake master cylinder from the brake booster.

9. Disconnect the vacuum hose from the brake booster.



10.Remove the split pin (A) which connects the brake pedal and booster push rod. For further information, refer to Chapter “Brake”.



11.Unscrew four nuts 92 mm) from the brake booster.

Tightening torque 17.6 ~ 21.6Nm

12.Remove the brake booster.

13.Install in the reverse order of removal.

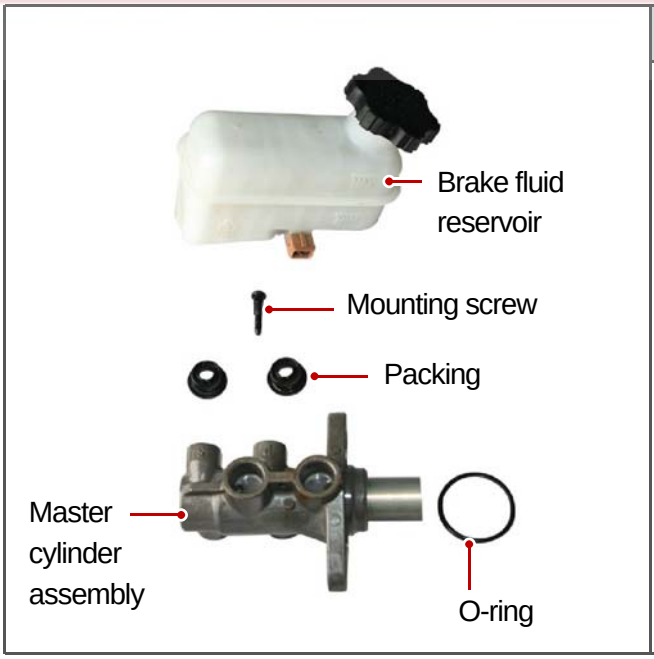
Modification basis	
Application basis	
Affected VIN	

▶ Disassembling and assembling of break fluid reservoir

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

2. Remove the fluid reservoir from the master cylinder.

3. Install in the reverse order of removal. Replace the O-ring and the packing.



Master cylinder assembly

Modification basis	
Application basis	
Affected VIN	

S.G.N. 4892-01

TROUBLE DIAGNOSIS CODE

1. DTC LIST

DTC	Description
C1101	Battery voltage high
C1102	Battery voltage low
C1112	Sensor power voltage error
C1200	WSS Front-LH open/short
C1201	WSS Front-LH range / performance / intermittent
C1202	WSS Front-LH invalid/no signal
C1203	WSS Front-RH open/short
C1204	WSS Front-RH range / performance / intermittent
C1205	WSS Front-RH invalid/no signal
C1206	WSS Rear-LH open/short
C1207	WSS Rear-LH range / performance / intermittent
C1208	WSS Rear-LH invalid/no signal
C1209	WSS Rear-RH open/short
C1210	WSS Rear-RH range / performance / intermittent
C1211	WSS Rear-RH invalid/no signal
C1235	Primary pressure sensor - electrical error
C1237	Primary pressure sensor - signal error
C1259	Steering sensor - electrical error
C1260	Steering sensor circuit - signal error
C1274	G sensor open/short
C1275	G Sensor Range/Performance error installed system
C1285	G sensor calibration error
C1282	Yaw rate & lateral G sensor - electrical error
C1283	Yaw rate & lateral G sensor - signal error
C1503	ESP off switch error
C1513	Brake switch error
C1604	ECU hardware error
C2112	Valve relay error

Modification basis	
Application basis	
Affected VIN	

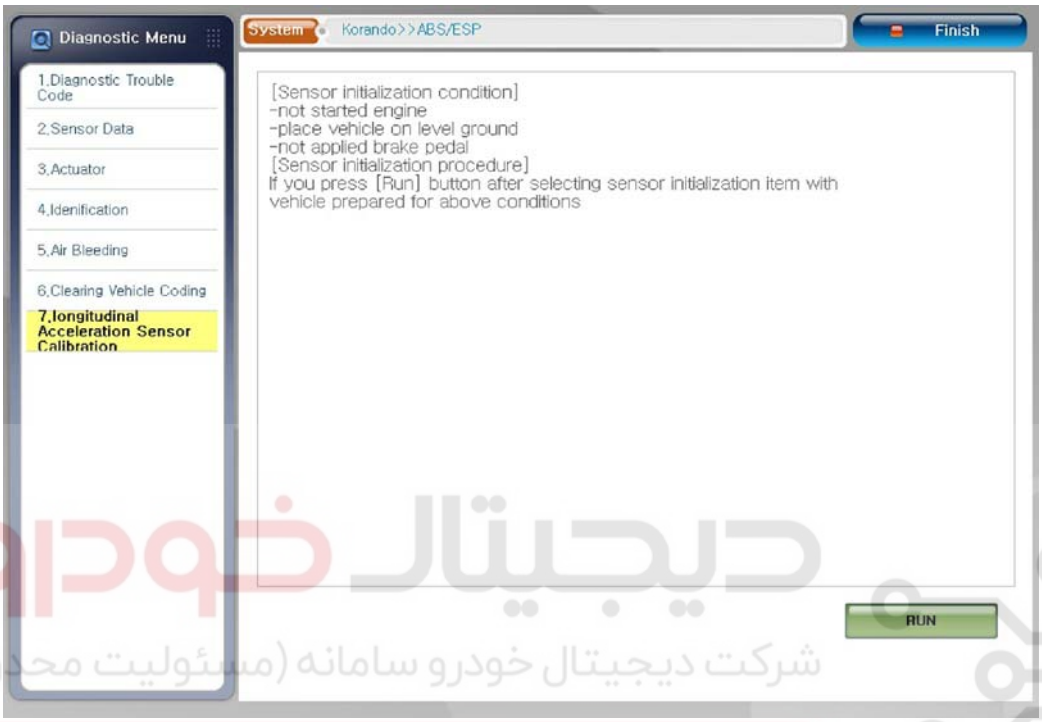
DTC	Description
C2227	Excessive temperature of brake disc
C2380	ABS/ESP valve error
C2402	Motor electrical error
C1605	CAN: hardware error
C1647	CAN: hardware error(Sensor Cluster)
C1611	CAN: EMS Message not Received (Time Out)
C1612	CAN: TCU Message not Received (Time Out)
C1616	CAN: Communication Interruption(Bus Off)
C1627	CAN: 4WD Message not Received (Time Out)
C1613	CAN: wrong message
C1702	Variant coding error
C1520	Clutch switch open/short

Modification basis	
Application basis	
Affected VIN	

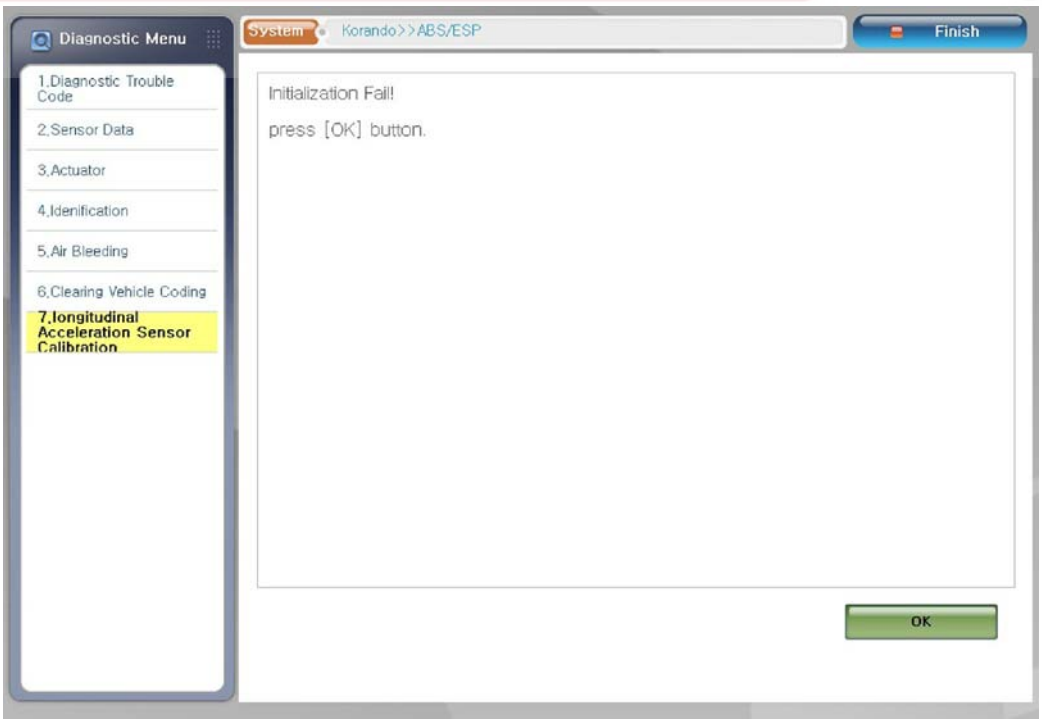
2. HOW TO USE DIAGNOSTIC TOOL

1) Initialization

1. Performing a sensor initialization in the ABS/ESP diagnosis menu which enables the initialization of the sensor.



2. The screen below appears after completed the initialization process. Press “OK”.



Modification basis	
Application basis	
Affected VIN	