ESP & ABS

4850-01/4890-01/4892-00/4892-01/8510-21/8510-56/

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ESP AND ABS

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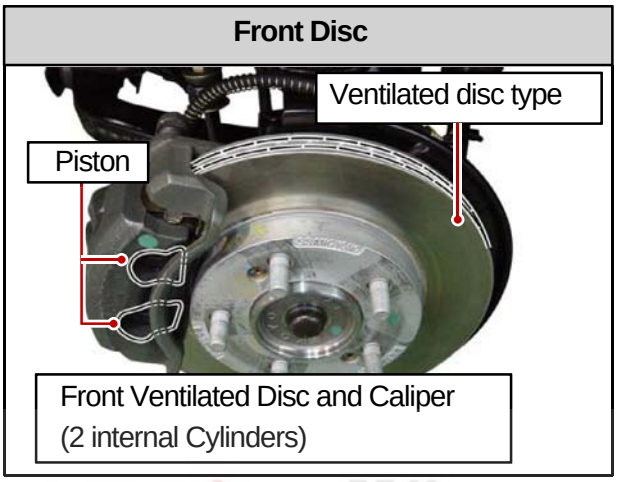
Modification basis	
Application basis	
Affected VIN	

ESP 4892-01

GENERAL

1. SYSTEM GENERAL

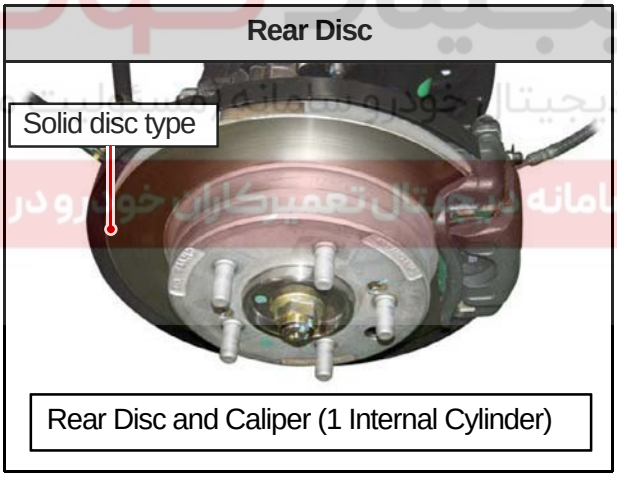
1)Front Disc Brake



For the front brake system, the ventilated disc type is applied regardless of the ABS/ESP system installation.
Two cylinders are installed in each caliper.

Description	Caliper diameter
Without ABS or ESP	43mm
With ABS or ESP	45mm

2) Rear Disc Brake



For the rear brake system, it differ between ABS/ESP system equipped vehicle and non-ABS/ESP equipped vehicle.
The drum type brake is installed on non-ABS equipped vehicle while the solid disc (thickness: approx.
10.4 mm) is installed on ABS/ESP equipped vehicle.

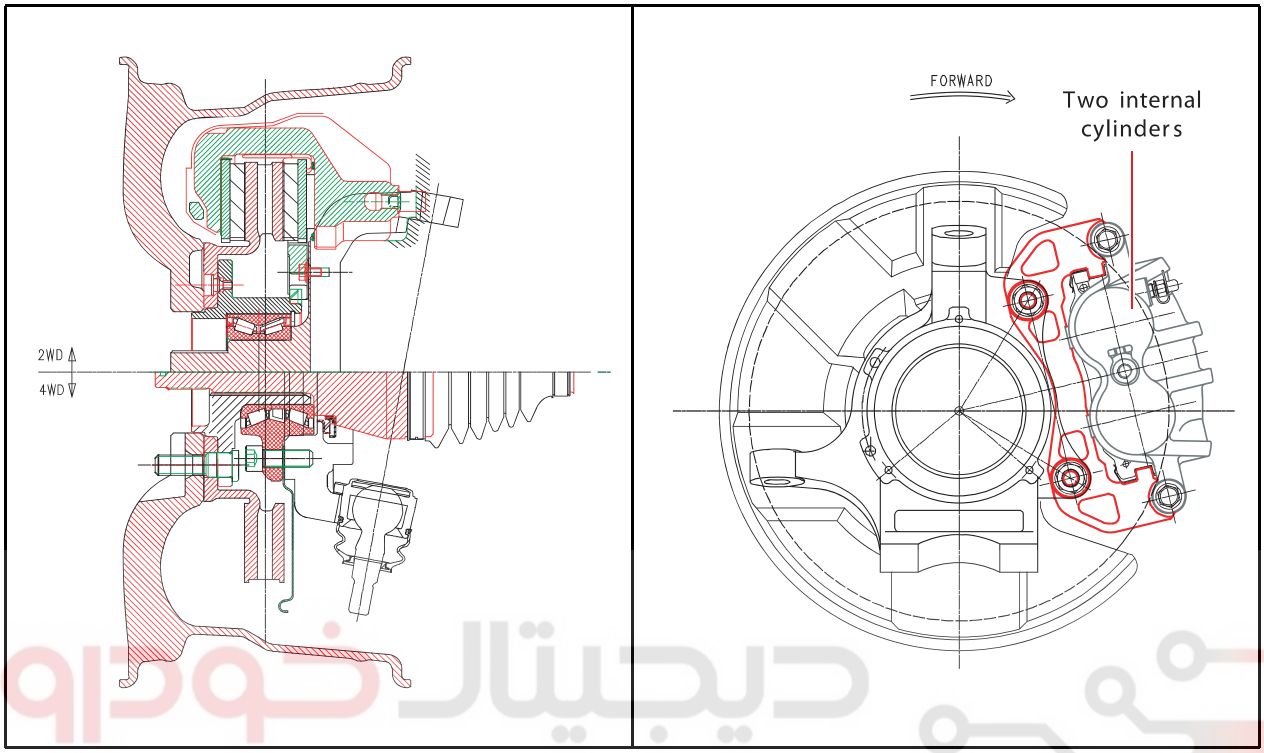
Description	Brake type
Without ABS	Drum brake
With ABS or ESP	Solid disc

3) Parking Brake

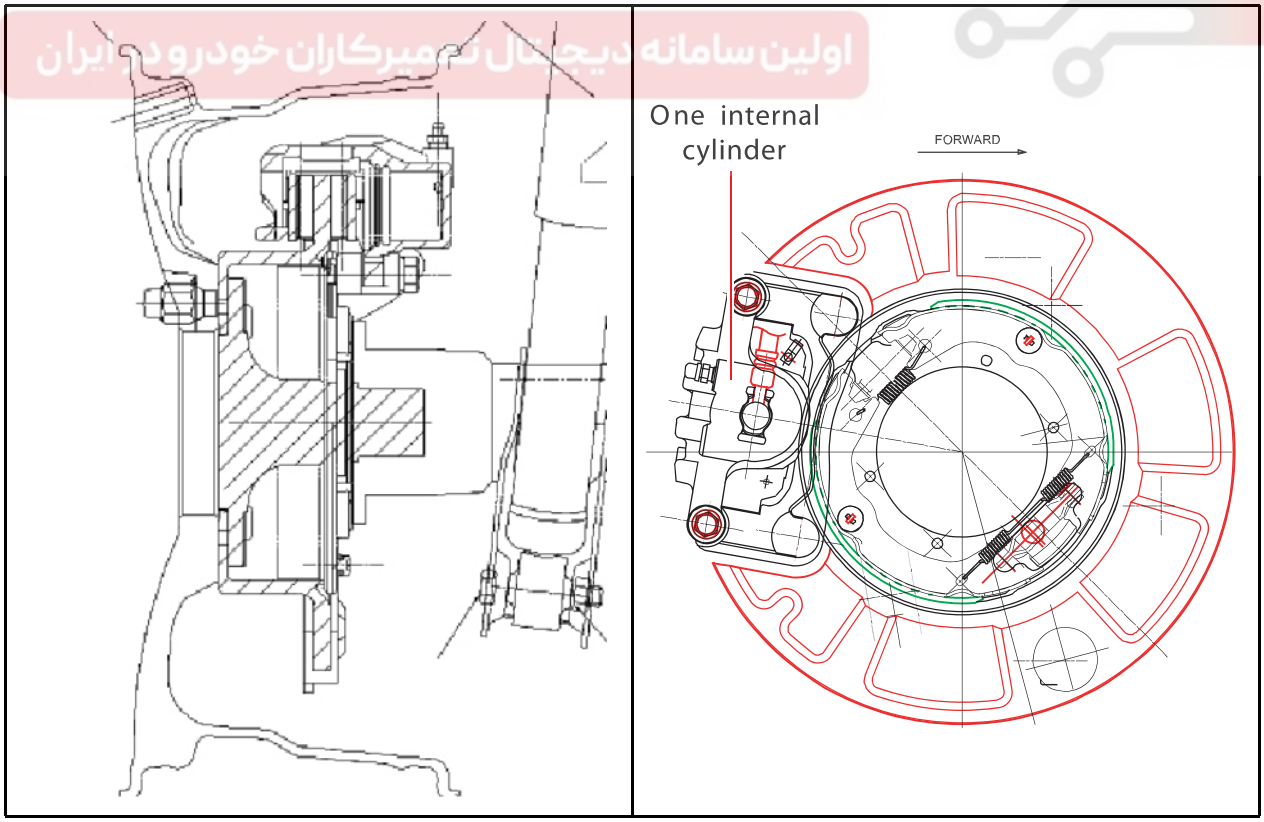
For the parking brake system, the hand operated type parking brake is installed regardless of the models.

2. SECTIONAL DRAWING

1) Front Disc Brake



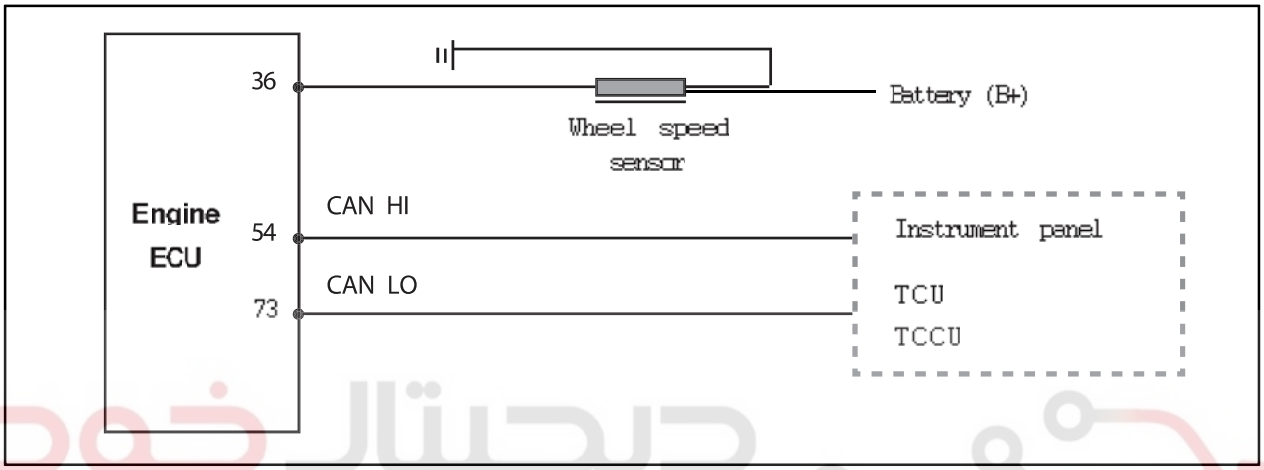
2) Rear Disc Brake



Modification basis	
Application basis	
Affected VIN	

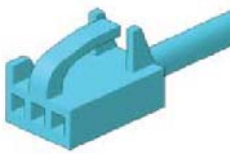
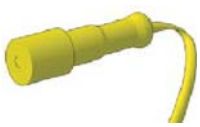
3) Non-ABS Equipped Vehicle - With One Wheel Speed Sensor

The wheel speed sensor is installed on the rear right wheel regardless of the ABS/ESP installation. This sensor is to signal the vehicle speed to the engine ECU, TCCU, transmission and instrument panel. There is no separate unit to process the wheel speed sensor signal. The wheel speed sensor is connected to the engine ECU (terminal 36), where its signal is processed, and is connected to other related systems through CAN communication.



(1) Location of the wheel speed sensor (rear right wheel)

Location of the Sensor Connector


Connector Appearance	
In vehicle without ABS	In vehicle with ABS/ESP
	

Modification basis	
Application basis	
Affected VIN	

3. SPECIFICATIONS

Description	Item	NON-ABS	ABS/ESP
Brake pedal	Pedal ratio	4.0 : 1	
	Max. operating stroke	150 mm	
	Free play	1 ~ 4 mm	
Brake master cylinder	Type	Tandem type (with level sensor)	
	I.D. of cylinder	ϕ 25.4 mm	
Brake booster	Type	Vacuum assisted type	
	Booster pressure ratio	9 : 1	
Front brake	Type	Ventilated disc type	
	I.D. of caliper cylinder	2 x ϕ 43 mm	2 x ϕ 45 mm
	Brake pad thickness	10.5 mm	
	Brake pad wear limit	2 mm	
	Disc plate thickness	26 mm	
	Disc plate wear limit	24 mm	
	I.D./O.D. of disc plate	ϕ 294 / ϕ 184 mm	
Rear brake	Type	Drum type	Solid disc type
	I.D. of drum	ϕ 254 mm	-
	W x L x T	55 x 243 x 5	-
	I.D. of wheel cylinder	ϕ 23.81 mm	-
	I.D. of caliper cylinder	-	ϕ 42.9 mm
	Brake pad thickness	-	10 mm
	Brake pad wear limit	-	2 mm
	Disc plate thickness	-	10.4 mm
	Disc plate wear limit	-	8.5 mm
	I.D./O.D. of disc plate	-	ϕ 299 / ϕ 220 mm
Parking brake	Type	Cable type (internal expansion)	
	Operation type	Hand Operated	
	I.D. of drum	ϕ 254 mm	ϕ 190 mm
Brake fluid	Capacity	0.7 ~ 0.8	
	Specification	DOT4	

Modification basis	
Application basis	
Affected VIN	

4. BRAKE OPERATION AND NOISE

This section describes the noise phenomena occured possibly in the brake system operation.
Distinguish between the information given below and the actual problems and then, inspect the vehicle and take appropriate measures.

1) Noise Phenomena and Causes

Phenomenon 1. If depressing the brake pedal when the engine is cold, "screeching" sound always occurs and, after driving for a while, the sound disappears.

This usually occurs in the morning. When the temperature goes down, the dew condensation phenomenon sets moisture on the brake disc as the window frost forms.
Due to this moisture, the iron within the brake disc and pad oxidizes, forming undetectable micro-rusts on the disc surface.
When starting the engine under this condition, noise may sound due to the friction of micro-rusts. When operating the brake several times, the disc temperature goes up and the micro-rusts come off and the noise goes away.
Depending on the driving conditions, noise gets louder when
slightly depressing the brake pedal and oppositely, noise is smaller when deeply depressing the brake pedal.
This is simply a physical phenomenon, called "morning effect" in professional terms, and does not imply any problems with the brake system.

Phenomenon 2. Slip or screech after the brake pad replacement.

This usually occurs when the bed-in is not made between the disc and the pad's friction material.
The bed-in is a state that the brake system normally works and gives no noise out, when, after about 300 km city driving, the contact area of the pad friction material is enlarged and the disk is in complete contact with the pad's friction material.
Therefore, for some time after the brake disk/pad replacement, the brake system poorly operates or noise (abnormal sound) occurs due to the partial contact.

Phenomenon 3. "Groaning" sound occurs in the automatic transmission vehicle when slightly taking the foot off the brake pedal to slowly start after waiting for the signal, or slightly depressing the brake pedal.

This is the noise "Creep groan" that occurs when, in both the automatic and manual transmission, slightly releasing the brake pedal in the neutral gear at downhill roads.
It frequently occurs at the low braking power and low speed, through the following process. When operating the brake system at low speed and low pressure, adhesion and slip
repeatedly take place between the brake disk and the friction material, and this makes the braking power inconstant, instantly increasing or decreasing, and gives out the brake noise.
It is also a physical phenomenon and has no relation with the brake performance.

5. ESP SYSTEM RELATED PRECAUTIONS

1. The HDC system is intended for use only on off-roads with a slope level exceeding 10%. Thus, do not use it on public road.
2. Too frequent use of HDC system may weaken the durability of the ESP HECU and related systems. Driver must turn the HDC switch to OFF position when driving on public and level roads.
3. As mentioned previously, when a driver make sharp turns or drive on rough roads, the HDC may suddenly operate for these sudden shocks influencing the G sensor values. When such occurs, the driver may panic because the vehicle speed drops sharply and the driver will experience difficulty in controlling the vehicle.
4. During the HDC operation, a loud noise and the vehicle vibration may occur from the HECU and the brake system, but this is a normal condition during the HDC operation.
   The warning lamp flashes and warning beep sounds when the ESP is operating
5. When the ESP operates during vehicle movement, the ESP warning lamp on the instrument panel flashes and beep comes on every 0.1 seconds. 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.
6. 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.
   Noise and vibration that driver feels when ESP system is operating
7. 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.
   ARP Operation
8. 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	

OVERVIEW AND OPERATION PROCESS

1. OVERVIEW OF ESP(ELECTRONIC STABILITY PROGRAM) SYSTEM

The ESP system consists of basic ABS functions, the vehicle position control depending on the driving conditions and the road conditions, the HBA (Hydraulic Brake Assist System) that improves the braking power in an emergency,
and the ARP (Active Rollover Protection) that obstructs the physical tendency to rollover during sharp turns and prevents the vehicle rollover by quickly and firmly controlling the engine output and the brake.

The HDC (Hill Descent Control) is newly introduced function that helps drivers maintain their speed automatically by switch operation when driving slowly on steep hills (over 10°).

ESP HECU	HDC Switch / Indicator
	

▶ **Functions applied on ESP system are as follows.**

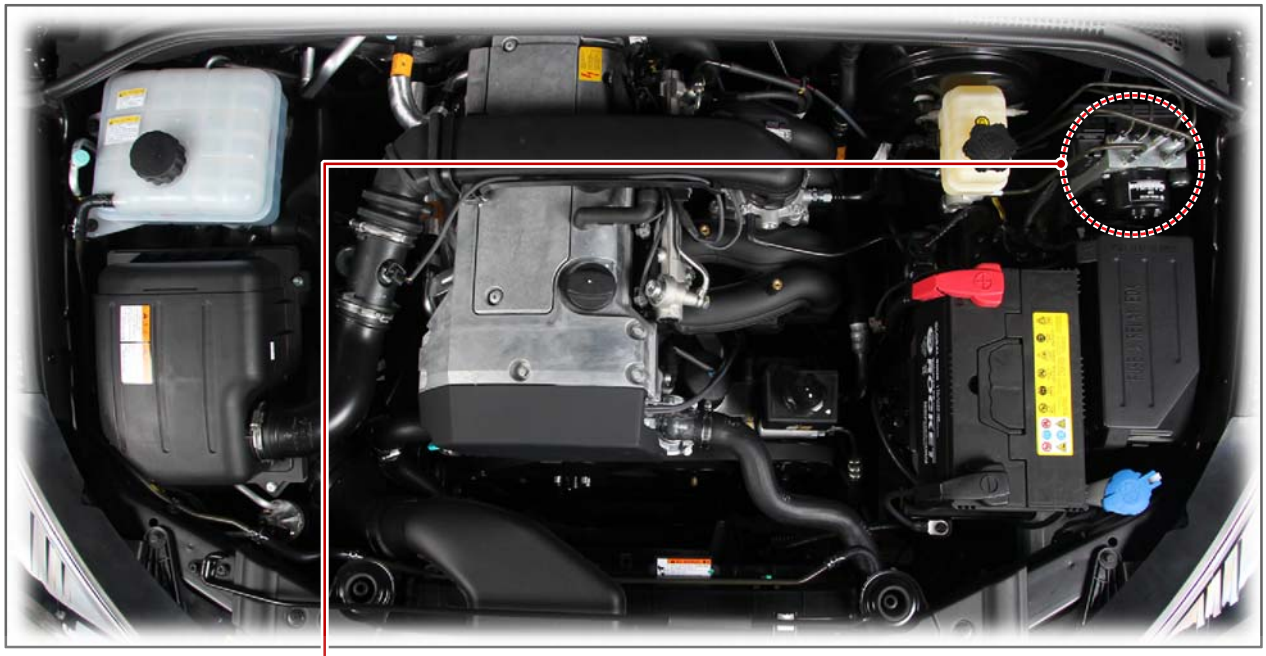
1. ABS (Anti-Lock Brake System)
2. EBD (Electronic Brake-Force Distribution)
3. ABD (Automatic Braking Differential)
4. ASR (Acceleration Slip Regulation)
5. AYC (Active Yaw Control, Understeer Oversteer control)
6. HBA (Hydraulic Brake Assist System)
7. ARP (Active Rollover Protection)
8. HDC (Hill Descent Control)

2. COMPONENTS OF ESP

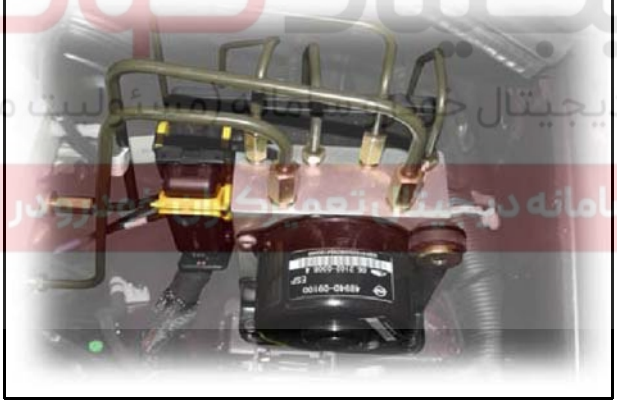
ESP OFF Switch	HDC Switch
	
ESP is deactivated by pressing the switch (ESP warning lamp comes on) ESP is activated by pressing the switch again (ESP warning lamp goes off)	HDC is activated by pressing the switch (Green HDC indicator comes on) HDC is deactivated by pressing the switch again (Green HDC indicator goes off)

Steering Angle Sensor (Steering Wheel)	Sensor cluster Detects
	
Detects the angle of the steering wheel and sends it to HECU.	Detects lateral acceleration, longitudinal acceleration and yaw rate.

Modification basis	
Application basis	
Affected VIN	



HECU



Receives the signals from wheel speed sensor, steering wheel angle sensor, sensor cluster and pressure sensor and perform the vehicle stability control function.

Rear Wheel Speed Sensor (LH/RH)

Wheel Speed Sensor(FOR 4WD)

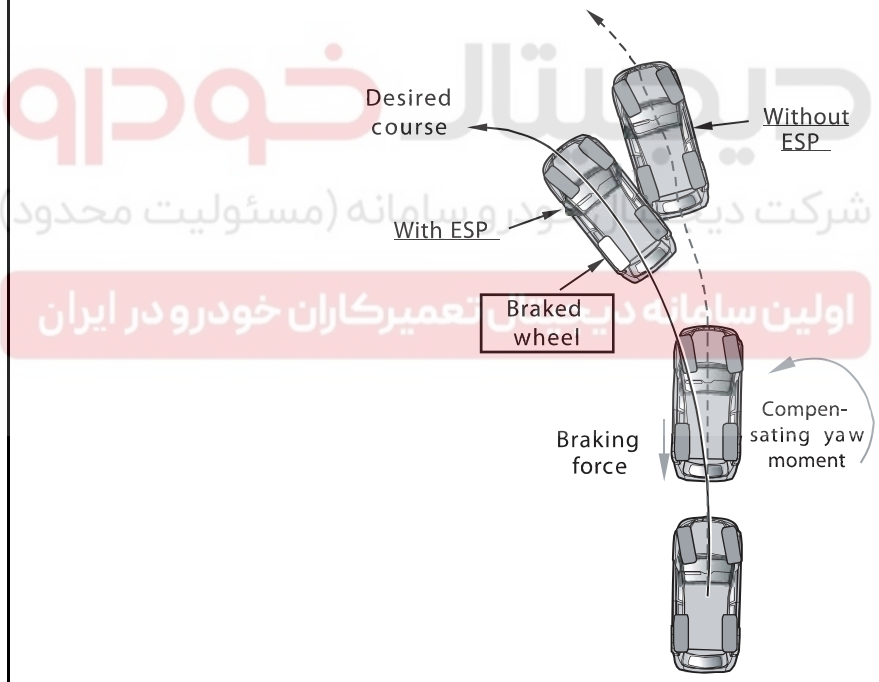
Modification basis	
Application basis	
Affected VIN	

3. PRINCIPLE OF ESP

1) Understeer & Oversteer Control

situations, and stabilizes the vehicle by wheel-individual braking and engine control intervention with no need for actuating the brake.
This system is developed to help the driver avoid the danger of losing the control of the vehicle stability due to under-steering or over-steering during cornering.
The yaw rate sensor, lateral sensor and longitudinal sensor in the sensor cluster and the steering angle sensor under the steering column detect the spin present at any wheels during over-steering, under-steering or cornering.
The ESP ECU controls against over-steering or under-steering during cornering by controlling the vehicle stability using the input values from the sensors and applying the brakes independently to the corresponding wheels.
The system also controls during cornering by detecting the moment right before the spin and automatically limiting the engine output (coupled with the ASR system).

Under Steering

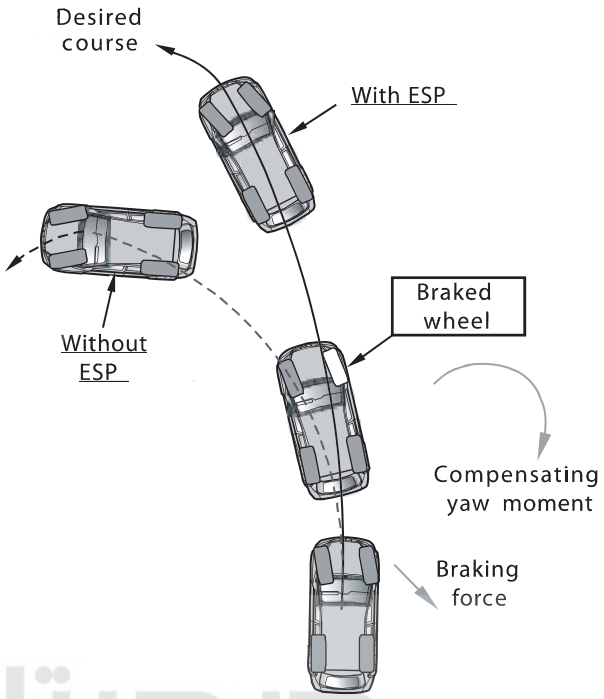


(1) Under steering

Understeering is when 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 under steering.
The vehicle can return back to inside of cornering line when the steering wheel is steered toward the inside even when the vehicle front is 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.

Modification basis	
Application basis	
Affected VIN	

Over steering



(2) Over steering

Oversteering is when the steering wheel is steered to a certain angle during driving and the rear tires slip outward losing traction.

When compared with under steering vehicles, the controlling of the vehicle is difficult during cornering and the vehicle can spin due to rear wheel moment when the rear tires lose traction and the vehicle speed increases.

(3) ESP Controls During Under Steering

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 understeering with the yaw rate sensor and the lateral sensor.
Then the ESP system applies the brake at 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 driver intends.

(4) ESP Controls During Oversteering

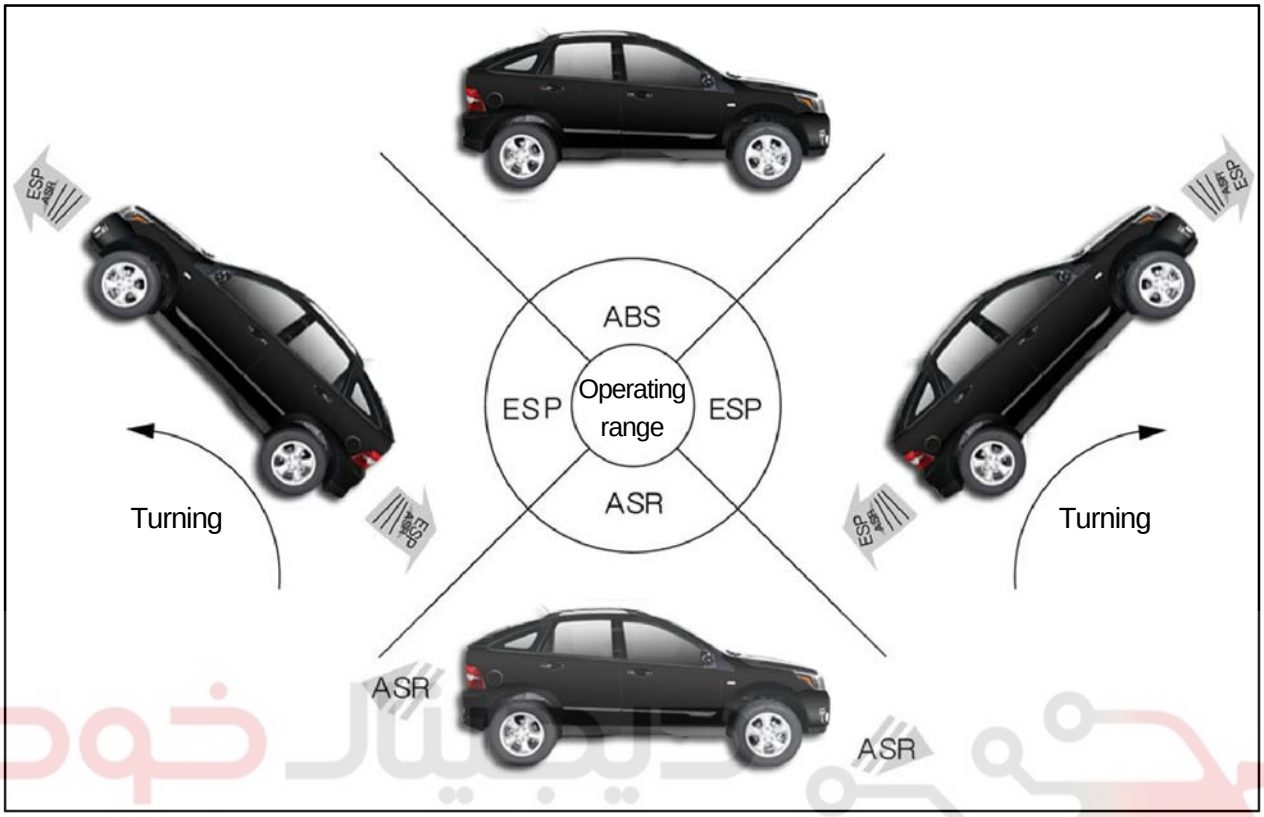
The ESP system recognizes the directional angle with the steering wheel angle sensor and senses the slipping route that occurs towards the vehicle cornering direction during oversteering with the yaw rate sensor and the lateral sensor. Then the ESP system applies the
brake at the front outer wheel to compensate the yaw moment value. In this way, the vehicle does not lose its driving direction and the driver can steer the vehicle as he or she intends.

2) ESP Control

As the single-track vehicle model used for the calculations is only valid for a vehicle moving forward, ESP intervention never takes place during backup.
The ESP system includes the ABS/EBD and ASR systems allowing the system to be able to operate depending to the vehicle driving conditions.
For example, when the brakes are applied during cornering at the speed of 100 km/h, the ABS system will operate at the same time the ASR or ABD systems operate to reduce the power from the slipping wheel. And when yaw rate sensor detects the rate exceeding 4 degree/seconds, 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 malfunction of a system or simultaneous operations.
In order to compensate to this problem, the ESP system sets the priority among systems.
The system operates in the order of TCS (ASR or ABD), ESP and ABS.
The order may be changed depending on the vehicle driving situations and driving conditions.

Modification basis	
Application basis	
Affected VIN	

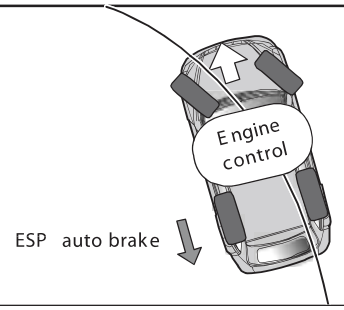
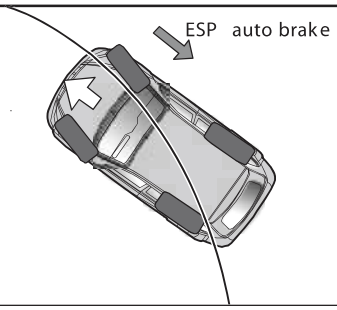
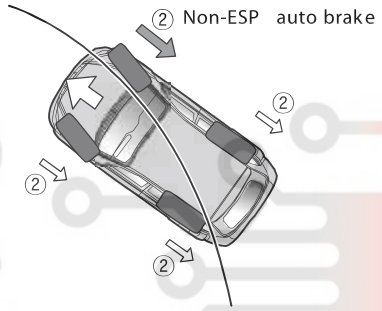
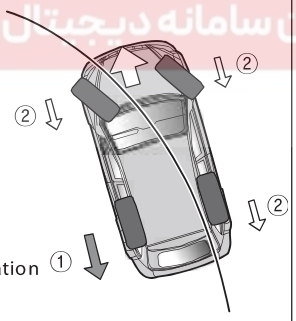
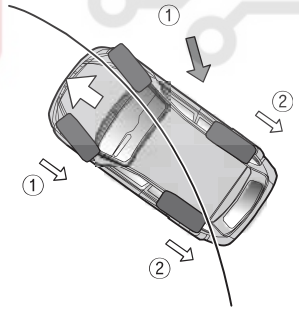
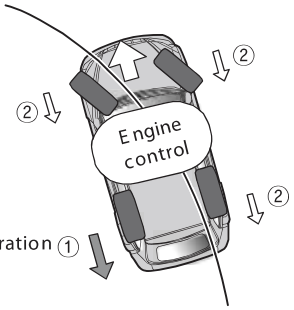
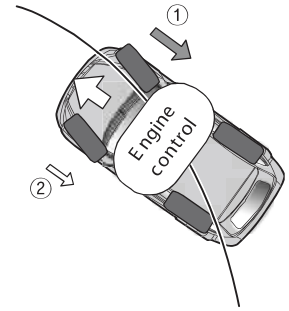
The following figure shows the operating range according to driving conditions.



Modification basis	
Application basis	
Affected VIN	

3) Vehicle Control During Cornering

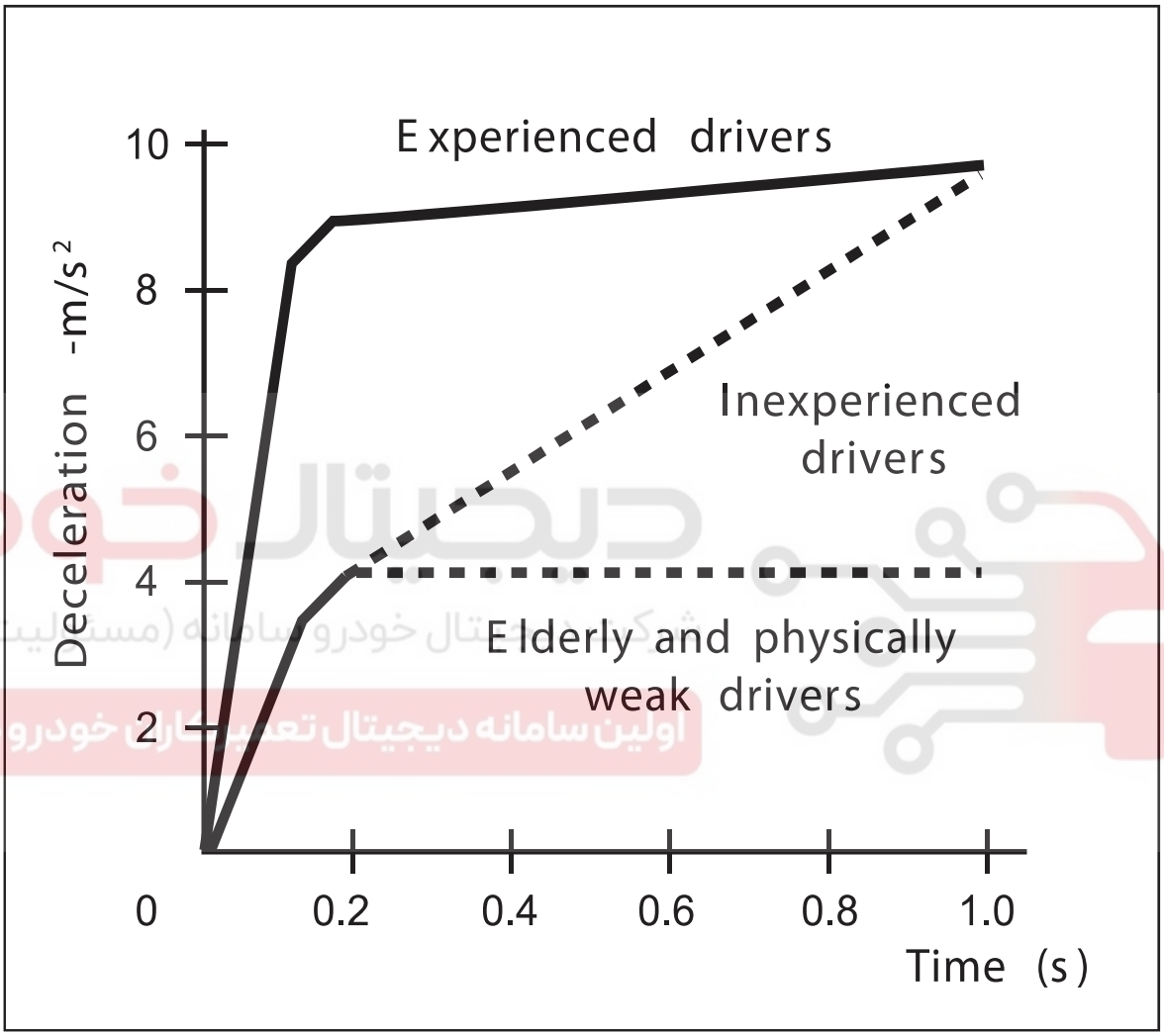
The figure below shows the vehicle controls by ESP system under various situations such as when the brake pedal is pressed (or not pressed) during cornering and when the ABS is operating or when just the conventional brake is operating during braking.
It also includes the vehicle conditions when the TCS that is included in the ESP system is operating.

Operations	Understeering Contro l	Oversteering Contro l
Only ESP operating No braking by driver		
ESP + Conventional brake (ABS not operating)		
ESP + ABS brake		
ESP + TCS (Engine control)		

Modification basis	
Application basis	
Affected VIN	

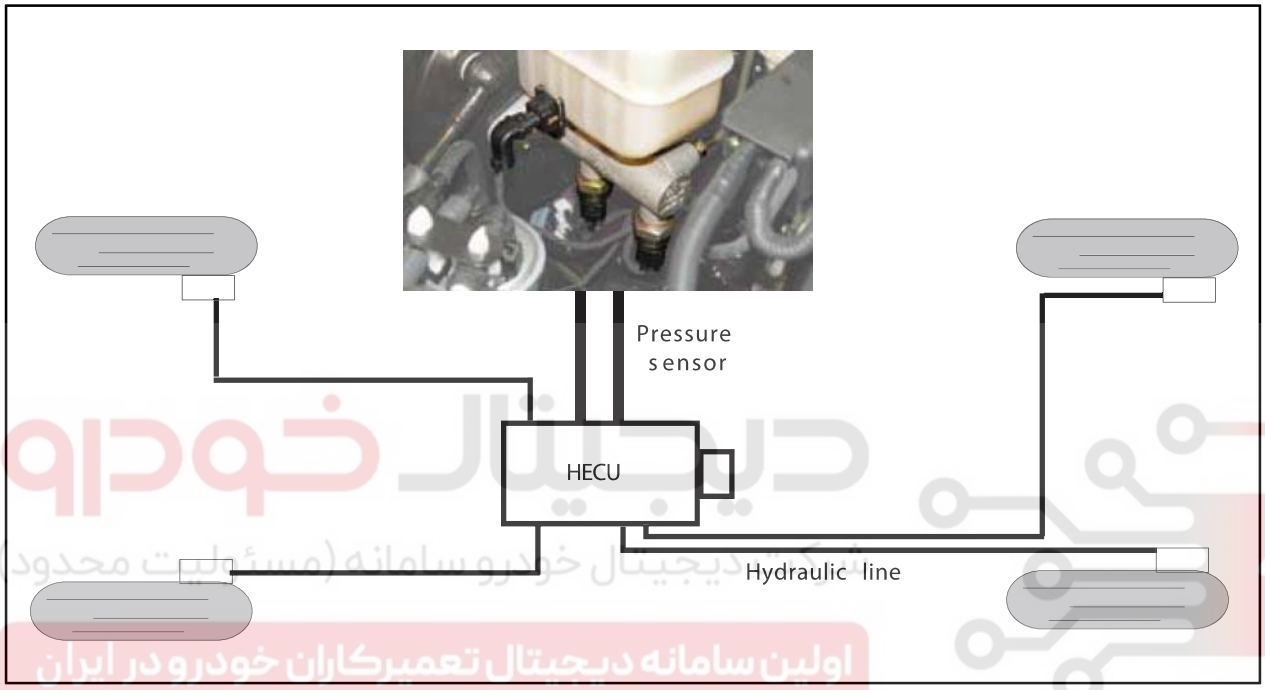
4. PRINCIPLE OF BAS(BRAKE ASSIST SYSTEM)

BAS (Brake Assist System) 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 BAS 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.

The brake pressure value and the changed value of the pressure sensor are the conditions in which the BAS 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 depresses the brake pedal slowly, the pressure change is not high. In this case, only the conventional brake system with booster is activated.



Operating conditions:

1. Pressure: over 20 bar
2. Pressure changes: over 1500 bar/sec
3. Vehicle speed: over 7 Km/h

Modification basis	
Application basis	
Affected VIN	

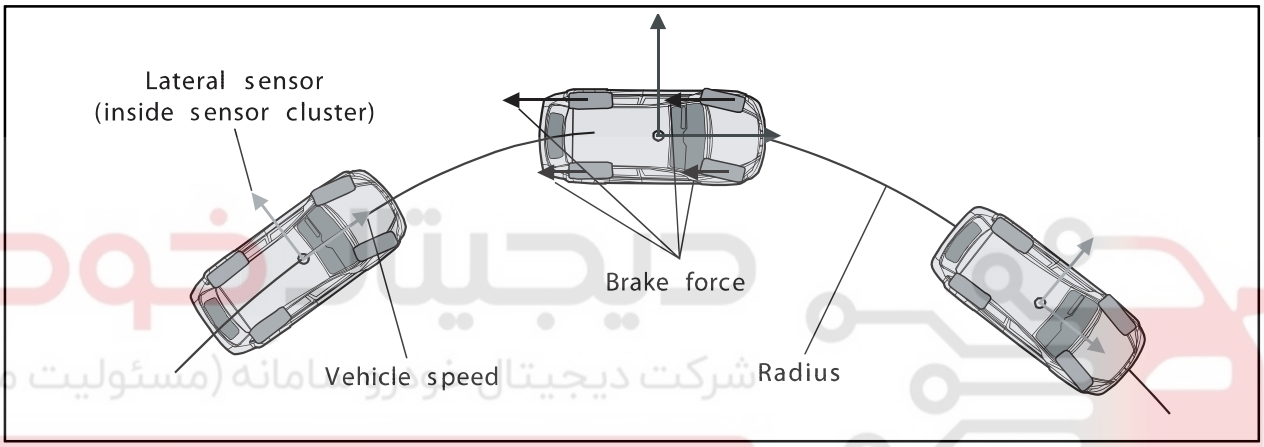
5. PRINCIPLE ARP(ACTIVE ROLL-OVER PROTECTION)

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.

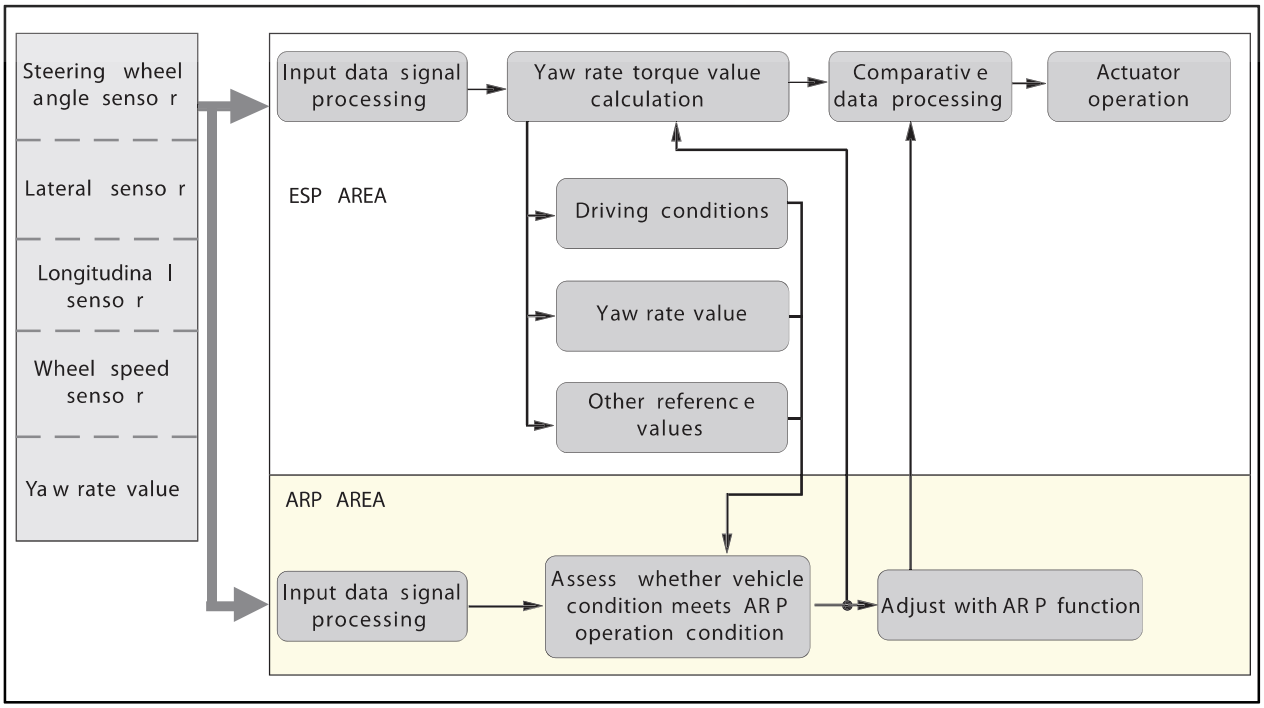
For the system, software is added to the existing ESP system and no additional device or switch is needed.

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.
- The ARP function is activated when the vehicle is subject to turning over due to sharp cornering even when the ESP function is turned off (however, the ARP function is also deactivated when the ESP function is not operatable due to system malfunction).

Modification basis	
Application basis	
Affected VIN	

6. PRINCIPLE OF HDC(HILL DESCENT CONTROL)

1) System Overview

The HDC system is an automatic descent control device that allows the vehicle to automatically decelerate to about 7 km/h by 0.1G, on steep roads (slope level exceeding 10%) through a separately installed switch operation.
When the vehicle speed reaches below 7 km/h (refer to the information below), the HDC automatically terminates the operation.

When you see a steep downhill ahead, press the HDC switch and the green HDC indicator comes on. When the G sensor within the sensor cluster detects a slope level exceeding 10%, the ESP's HDC function operates.
When this occurs, the green HDC indicator flashes along with a loud operation sound.

HDC Switch

HDC Indicator (Instrument Panel)	Sensor Cluster (G Sensor)
	
When you press the HDC switch, the green HDC indicator comes on, and when the HDC operates, the green HDC indictor flashes at 0.5 second of interval.	The G Sensor within the sensor cluster detects the steepness of driving roads. When the HDC switch is in operation, if the G sensor detects a downhill steepness exceeding 10%, it transmits the HDC operation signal to the ESP HECU.

HDC Red letters

HDC Green letters

CAUTION

The G sensor in sensor cluster measures the actual road steepness. However, it may recognize a sharp turn or rough road as a downhill road with a slope level exceeding 10%, and the HDC may operate.

2) HDC (Hill Descent Control) System Operating Conditions

1. When HDC switch is turned ON **and**
2. Gearshift lever position (Forward/Reverse) **and**

Manual transmission: operates in the 1st gear or reverse gear position (does not operate in neutral position).
Automatic transmission: operates in any position except for P (parking) or N (neutral) positions.

CAUTION

- The vehicles with manual transmission do not have a separate device or switch that detects the 1st gear.
  It only detects the forward/reverse driving direction of the vehicle through backup lamp switch and neutral switch, and cannot solely detect the 1st gear position. The reason why, though the HDC also operates in 2nd gear position, that is because the engine may turn off during the HDC operation process.
  You may face a very dangerous situation if the engine turns off at a steep hill.
- The HDC is the device to improve the engine brake effect during downhill driving on a steep hill.
  For manual transmission equipped vehicle, HDC system should operated only in 1st gear.

3. When not depressing the accelerator pedal or brake pedal. **and**
4. The vehicle speed is above 7 km/h (in Automatic transmission/4H mode). **and**

CAUTION

The vehicle speed given in step (4) varies according to the vehicle driving mode, and the speed ranges by the vehicle driving mode and condition are as follows.

1) Speed available in HDC mode (slope)

Forward driving 2H/4H mode: vehicle speed below 50 km/h (operation slope level: 10%, termination slope level: when it reaches 8%)

Reverse driving 2H/4H mode: vehicle speed below 50 km/h (operation slope level: 8%, termination slope level: when it reaches 5%)

2) HDC target speed in 2H/4H mode

(The HDC target speed is the speed that the HDC is not terminated even after the vehicle speed reaches 7 km/ h, but is converted to the stand-by mode.
When the vehicle speed increases again as a result of the increase of the road steepness, etc., the HDC goes into operation.)

Forward driving: 7 km/h
Reverse driving: 7 km/h (automatic transmission), 8.5 km/h (manual transmission)

Modification basis	
Application basis	
Affected VIN	

5. Vehicle position control function in ESP and HBA function are not in operation: and
The HDC is the device to improve the engine brake effect during downhill driving on a steep hill. If the ESP function is in operation, HDC operation is overridden.

6. Slope level exceeds 10%.
When the slope level exceeds 10%, the HDC operates until the vehicle reaches the speed value given in step (4).

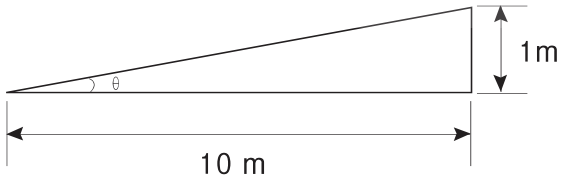
When the slope level is between 10% and 20% during the HDC operation
When depressing the accelerator pedal or brake pedal, HDC system is changed to stand-by mode.
When releasing the pedal, HDC starts its operation again.
Therefore, drivers can control the vehicle speed to a desired level by depressing and releasing the pedal.

When the slope level exceeds 20% during the HDC operation
When depressing the accelerator pedal, HDC system is changed to stand-by mode.
When depressing the brake pedal, HDC continues its operation and the braking power is increased.
In this case, HECU sounds an abnormal noise and brake pedal may be very rigid, but this is a normal condition due to HDC operation.

CAUTION

- **The percentage of the slope level:**
  tan θ X 100 = slope level (%)

ex)



$$\tan\theta \times 100 = \frac{1}{100} \times 100 = 10\ (\%)$$

For example, 10% of slope level indicates that the heigh is 1 m when the transverse length is 10 m.

l 1G = 9.8 m/s^2: Acceleration

3) HDC (Hill Descent Control) System Non-Operation Conditions

1. When HDC switch is turned OFF **or**
2. Gearshift lever has passed neutral (N) position. **or**

CAUTION
- Vehicle with manual transmission: Sensing at the neutral switch
- Vehicle with automatic transmission: Sensing at the selector lever unit

3. When the vehicle speed is out of the specified values (under 7 km/h). **or**
4. When the ESP related functions, e.g. vehicle position control, BAS, ARP is activated during HDC operation. **or**

The HDC is the device to improve the engine brake effect during downhill driving on a steep hill. If the ESP function is in operation, HDC operation is overridden

5. When the internal temperature of HDC system goes over 450°C due to long downhill driving on a steep hill with HDC operated. **or**

There is no specific temperature sensor in the system, but a programmed logic inside the HECU predicts the temperature based on the operating times and conditions of HDC.

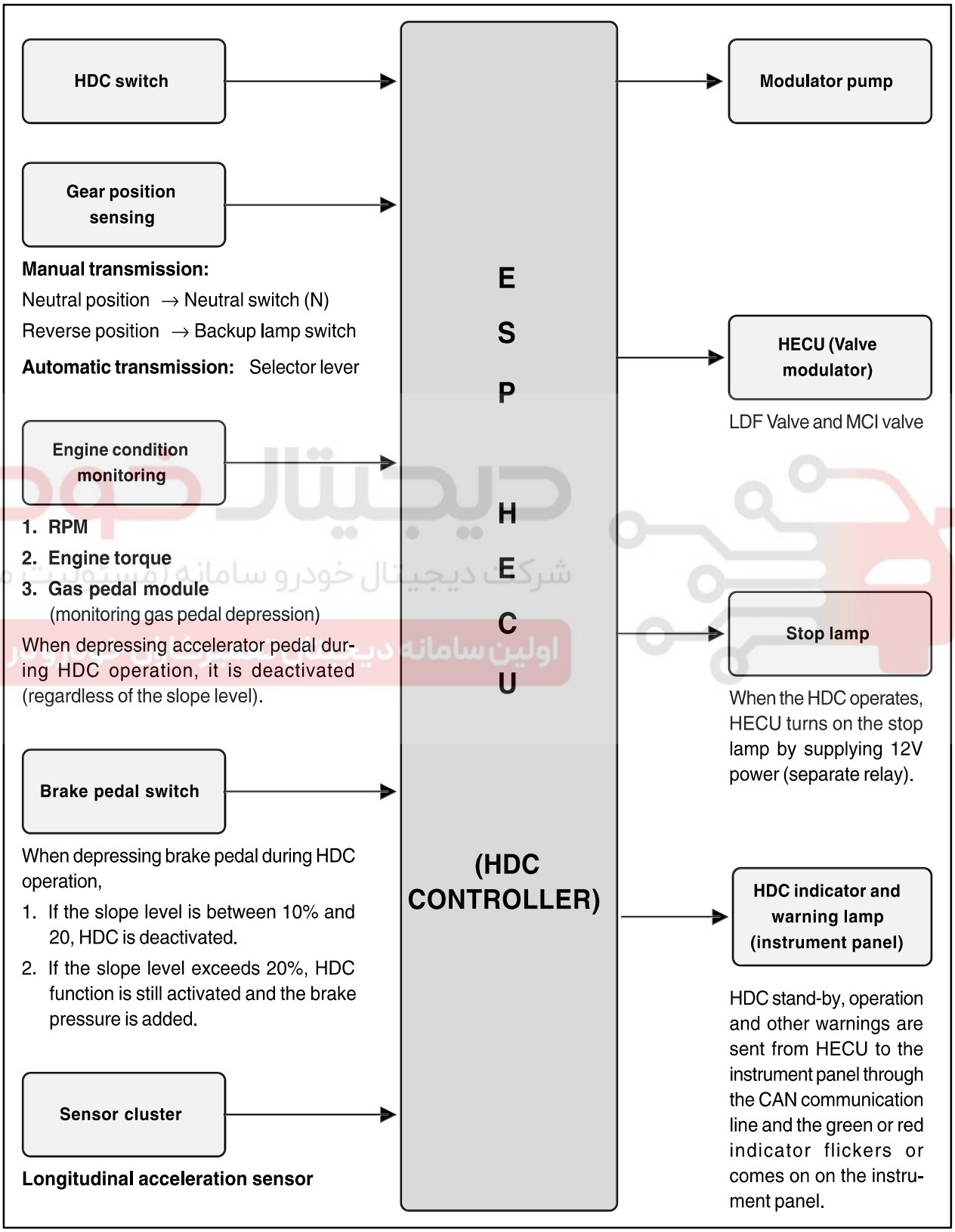
CAUTION
The red HDC warning lamp blinks when the internal temperature goes over 350C. When it reaches 450C, the HDC warning lamp stays on. The HDC can be operated in this range even where the HDC warning lamp blinks.

6. When the slope level is below 10%

Modification basis	
Application basis	
Affected VIN	

4) Input/Output Signals for HDC Operation

The HDC controller operates its function in the HECU inside the ESP unit and receives the following signals to perform the hill descent control function.



5) Operation of HDC Indicator Controller

This table describes the coming-on and blinking mode of HDC indicator according to the HDC switch operation (ON/OFF) and operation conditions.
The HDC indicator on the instrument panel has two modes; green (function lamp) and red (warning lamp).
The HDC switch is a push & self return type switch - when you press it once, it starts to operate and when you press it again, it stops the operation.

<table>
<tr><th colspan="4" rowspan="3">HDC Operation Mode</th><th>HDC Indicator</th><th>HDC Warning Lamp</th></tr>
<tr><th>Green</th><th>Red</th></tr>
<tr><th> 
</th><th> 
</th></tr>
<tr><td colspan="4">Initial ignition ON (From hence, this signifies operation mode after the engine starts. Even when HDC switch is ON, if the ignition is OFF, HDC operation stops automatically.)</td><td>OFF</td><td>ON
(goes off after 1.8 seconds)</td></tr>
<tr><td rowspan="2">Not available</td><td colspan="3">HDC switch OFF</td><td>OFF</td><td>OFF</td></tr>
<tr><td colspan="3">HDC system error</td><td>OFF</td><td>ON</td></tr>
<tr><td>Stand-by</td><td colspan="3">HDC switch ON</td><td>ON</td><td>OFF</td></tr>
<tr><td rowspan="3">In operation</td><td colspan="5">The HDC switch is turned ON, but HDC system is in stand-by mode because the operating requirements are not met.</td></tr>
<tr><td colspan="3">HDC system is operating.</td><td>Blinking (0.5 seconds of interval)</td><td>OFF</td></tr>
<tr><td colspan="5">The HDC switch is turned ON, and the operating requirements are met. HDC is operating with operating sound.</td></tr>
<tr><td rowspan="4">System overheat</td><td rowspan="2">High brake system temperature (over 350°C)</td><td>HDC stand-by mode</td><td>OFF</td><td>Blinking</td></tr>
<tr><td>HDC is operating</td><td colspan="2">Alternate blinking of green and red lamp (0.5 seconds of interval)</td></tr>
<tr><td colspan="2">Too high brake system temperature (over 450°C)</td><td>OFF</td><td>ON</td></tr>
<tr><td colspan="4">There is no specific temperature sensor in the system, but a programmed logic inside the HECU predicts the temperature based on the operating numbers and conditions of HDC (HDC cannot be operated).</td></tr>
</table>

CAUTION

Basically, the brake system's basic functions can work even when there are problems with the HDC system.
As given in the table above, the HDC warning lamp comes on when:

- Initial ignition ON
- HDC system error occurs
- Brake system overheat

Modification basis	
Application basis	
Affected VIN	

6) Cautions When Using HDC System

Customers must first acquaint themselves with the HDC operation related information, e.g. operation conditions and non-operation conditions, because they may feel unfamiliar with its function and operation process.
The noise during the HDC operation is very different from that during the ABS/ESP operation. This noise may be irritating and accompany some vibration, because, on steep hills, it attempts to control the physical properties of the vehicle weight with the braking power.

Below is the summary of precautions to remember in HDC operation.

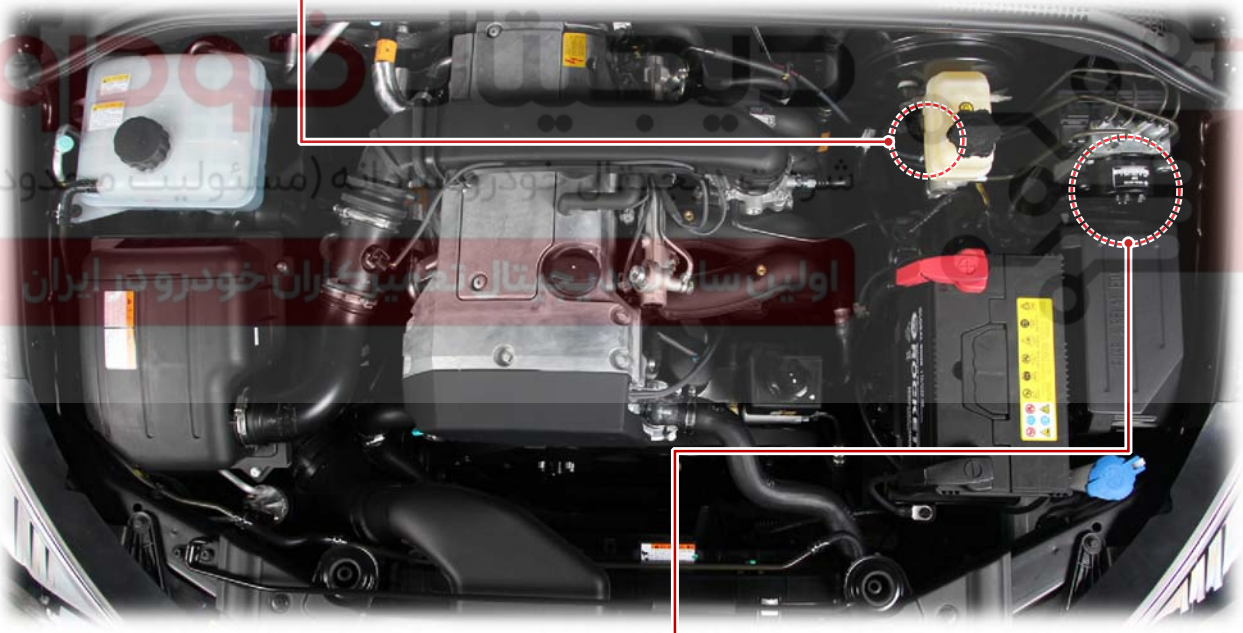
CAUTION

- The HDC system is intended for use only on off-roads with a slope level exceeding 10%. Thus, do not use it on public road.
- Too frequent use of HDC system may weaken the durability of the ESP HECU and related systems.
- Driver must turn the HDC switch to OFF position when driving on public and level roads.
  As mentioned previously, when a driver make sharp turns or drive on rough roads, the HDC may suddenly operate for these sudden shocks influencing the G sensor values.
  When such occurs, the driver may panic because the vehicle speed drops sharply and the driver will experience difficulty in controlling the vehicle.
- During the HDC operation, a loud noise and the vehicle vibration may occur from the HECU and the brake system, but this is a normal condition during the HDC operation.

7) Components and Locations

There are no major changes in the ESP system of ACTYON comparing to the conventional ESP system.
However, the HDC switch and the HDC indicator has been added to the system as the HDC system has been applied.

Master cylinder pressure sensor	Active Wheel Speed Sensor
	



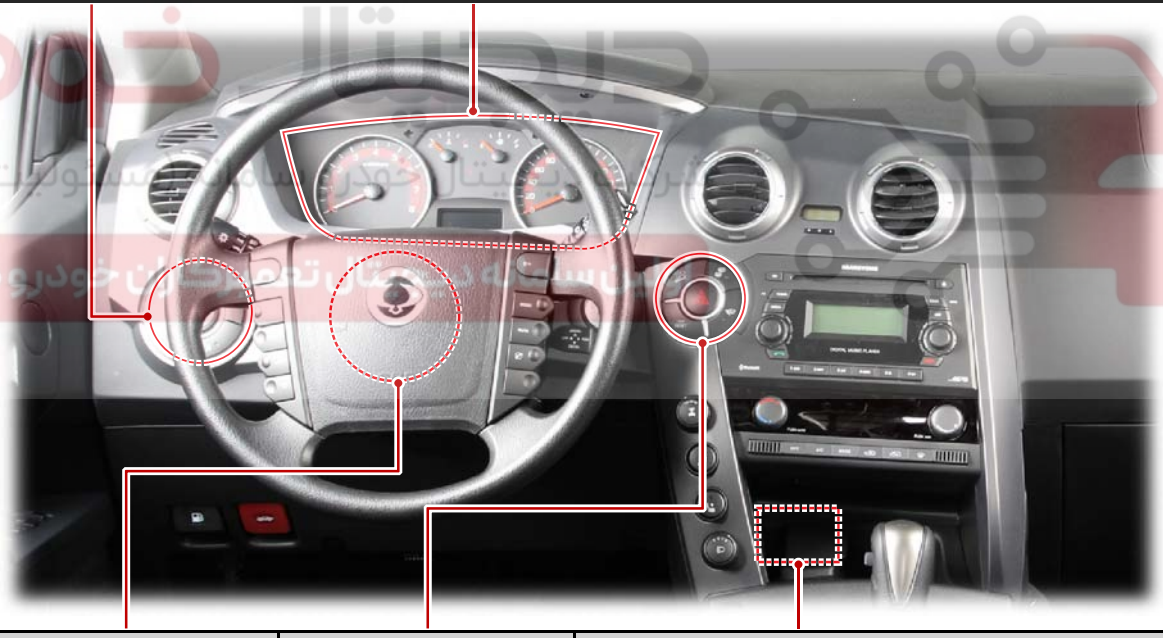
Valve body	Motor pump
	

Modification basis	
Application basis	
Affected VIN	

(1) Comparison with ABS System

No	Name	ESP Component	ABS Component s	Remark
1	HECU	0	0	ESP system contains ESP OFF switch and HDC switch.
2	Pressure sensor	0	N/A	
3	Wheel speed sensor	0	0	
4	Sensor cluster	0	N/A	
5	Steering wheel angle sensor	0	N/A	

ESP OFF Switch	ABS, ESP, HDC Indicator
	

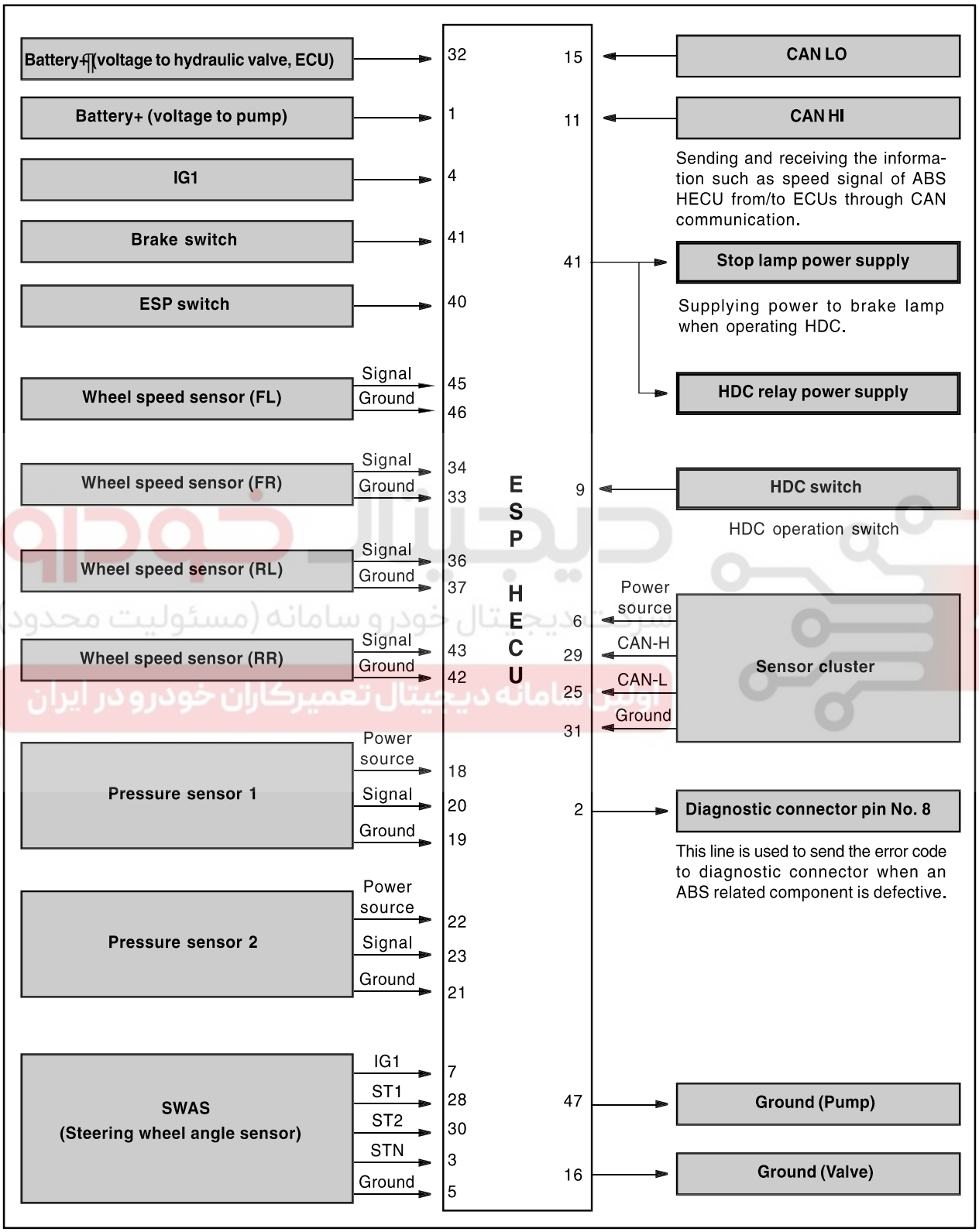


Steering Wheel Angle Sensor	HDC Switch	Sensor Cluster (Yaw Rate + Lateral Sensor + Longitudinal Sensor)
		

Modification basis	
Application basis	
Affected VIN	

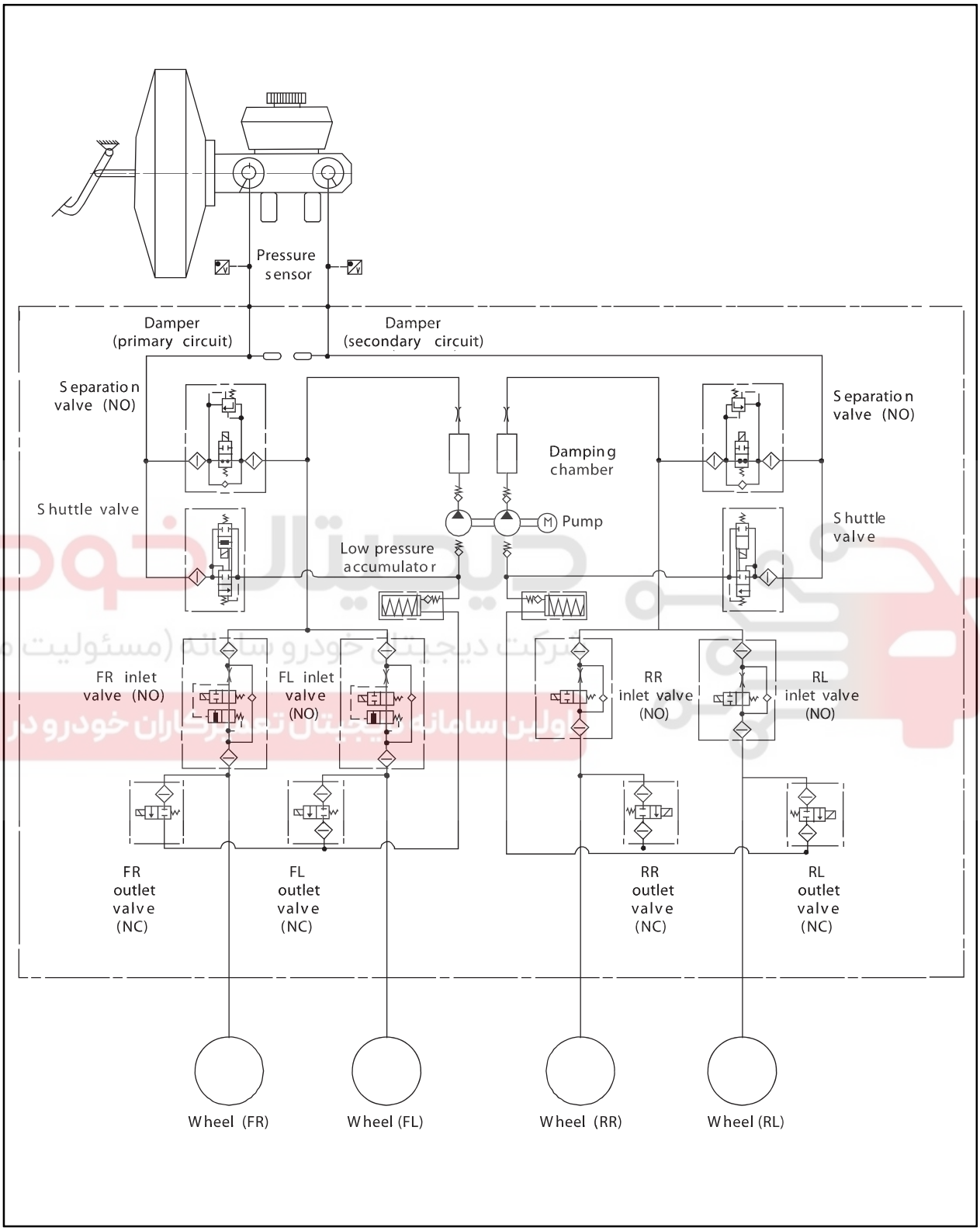
7. INPUT AND OUTPUT DIAGRAM OF ESP SYSTEM

▶ **Input/Output of ESP System**



Modification basis	
Application basis	
Affected VIN	

8. HYDRAULIC CIRCUIT DIAGRAM OF ESP SYSTEM



Modification basis	
Application basis	
Affected VIN	

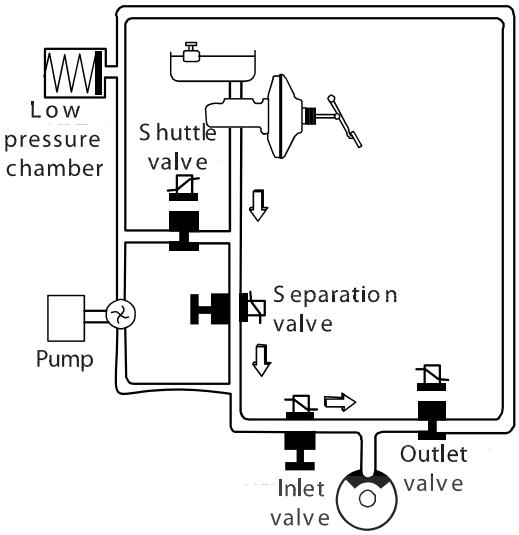
If the vehicle is equipped with ABS, the braking force at each wheel will be controlled with 3-channel 4-sensor method. Also, if the vehicle is equipped with ESP, 4 wheels will be controlled independently with 4-channel method.
(When controlling ABS system only, it will be operated with 3-channel method.) When compared to the vehicle equipped with ABS 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 increase, decrease or unchanged conditions.
For details, refer to "Hydraulic Pressure for each ESP Operating Range".

Modification basis	
Application basis	
Affected VIN	

9. HYDRAULIC PRESSURE FOR EACH ESP OPERATING RANGE

ESP Hydraulic unit in idling and normal braking position

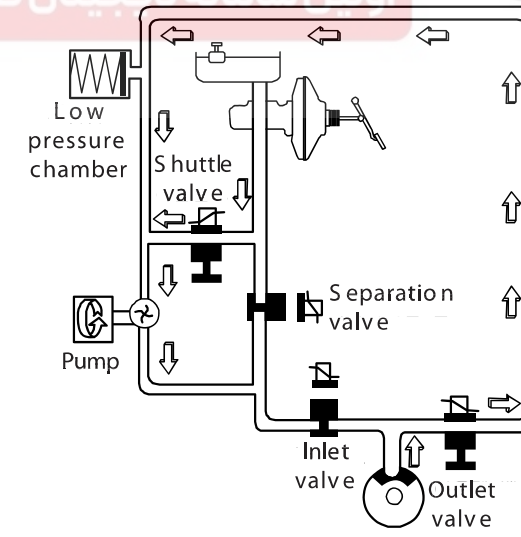
1



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.

ESP Hydraulic unit (decreased pressure)

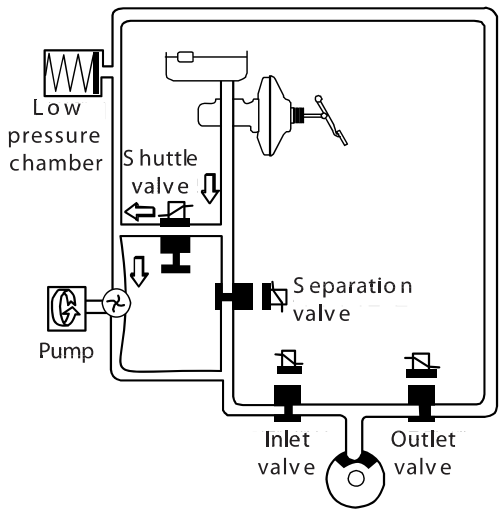
2



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.

ESP unit circuit (when the pressure is maintained)

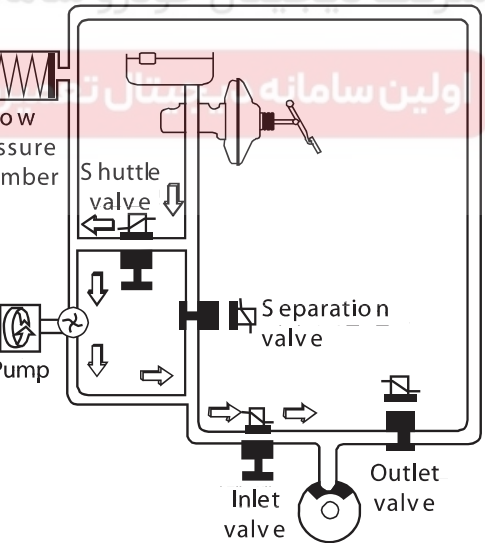
3



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.

ESP unit circuit (when the pressure is increased)

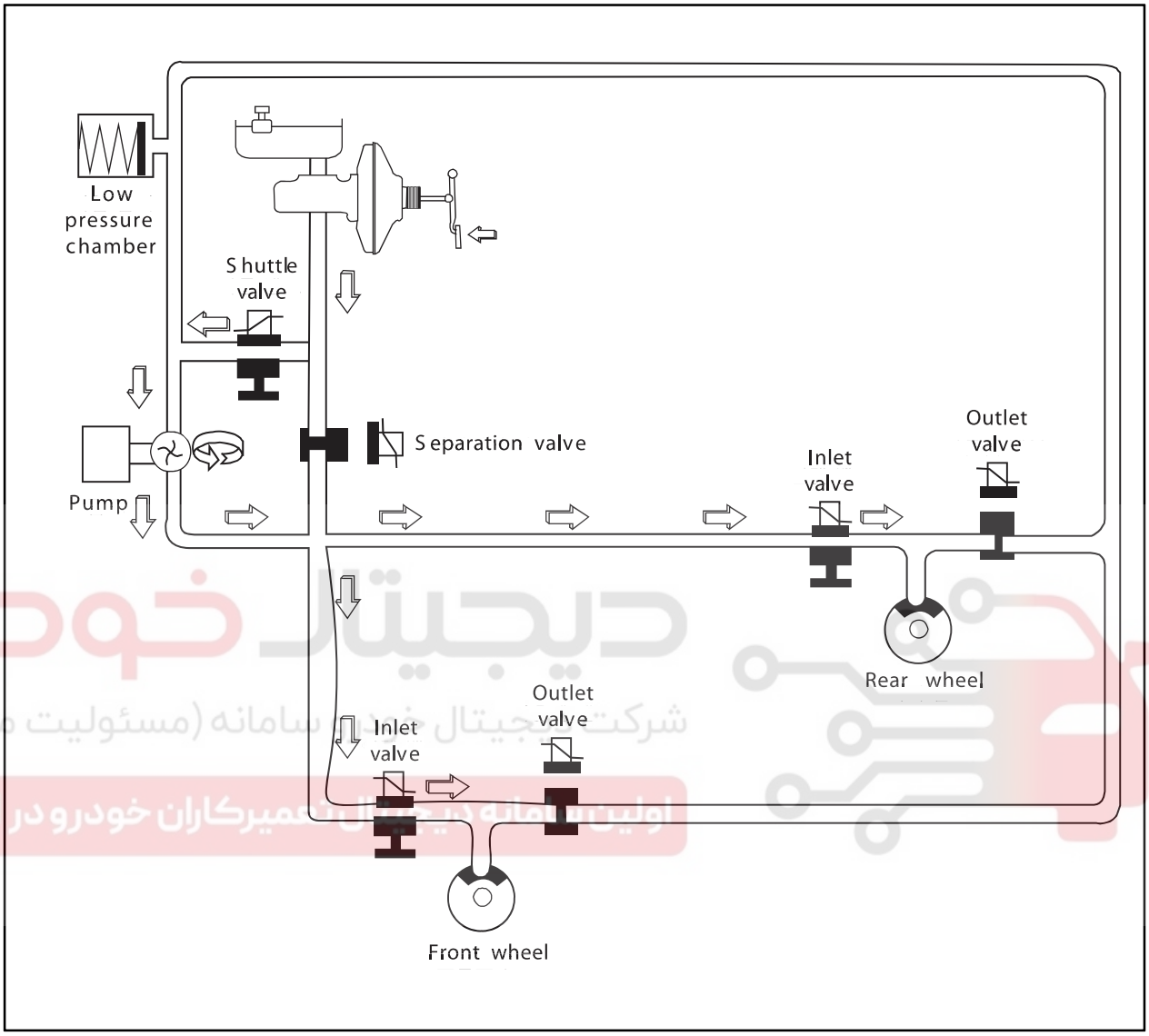
4



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	

10. HYDRAULIC CIRCUIT OF BAS (BRAKE ASSIST SYSTEM)



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 BAS function cancels and switches to ABS operation.

11. COMPONENTS OF ABS SYSTEM

The following figure shows the basic system components of the ABS. This system consists of HECU (valve body and ECU integrated type), front wheel speed sensor and rear wheel speed sensor.

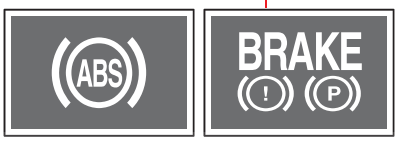
HECU (Valve Body and ECU Integrated Type)

Valve body

B: Plunger C: Cam bushing

Motor pump

ABS warning lamp



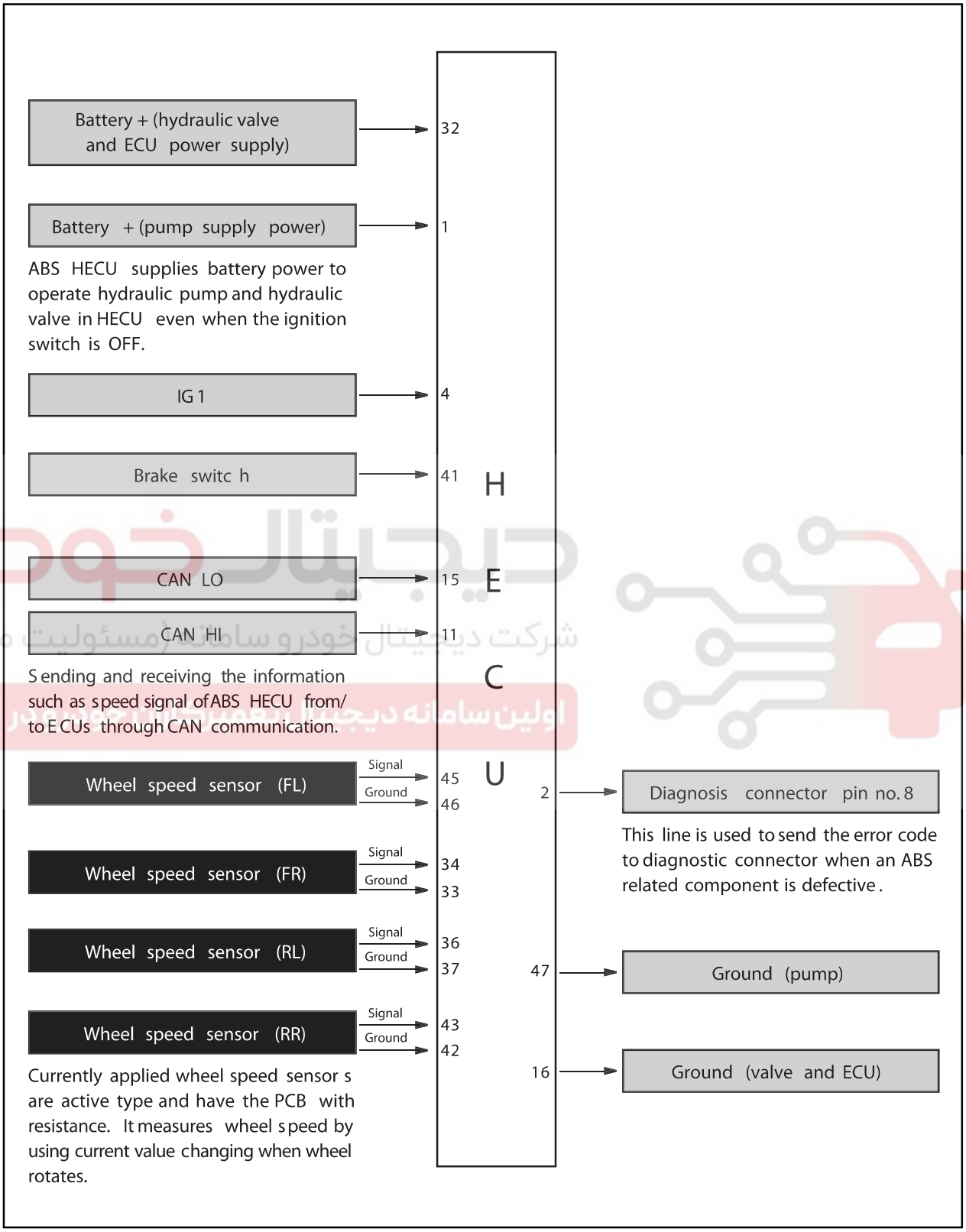
EBD warning lamp
(two indicators come on)

Front Wheel Speed Sensor (for 4WD)

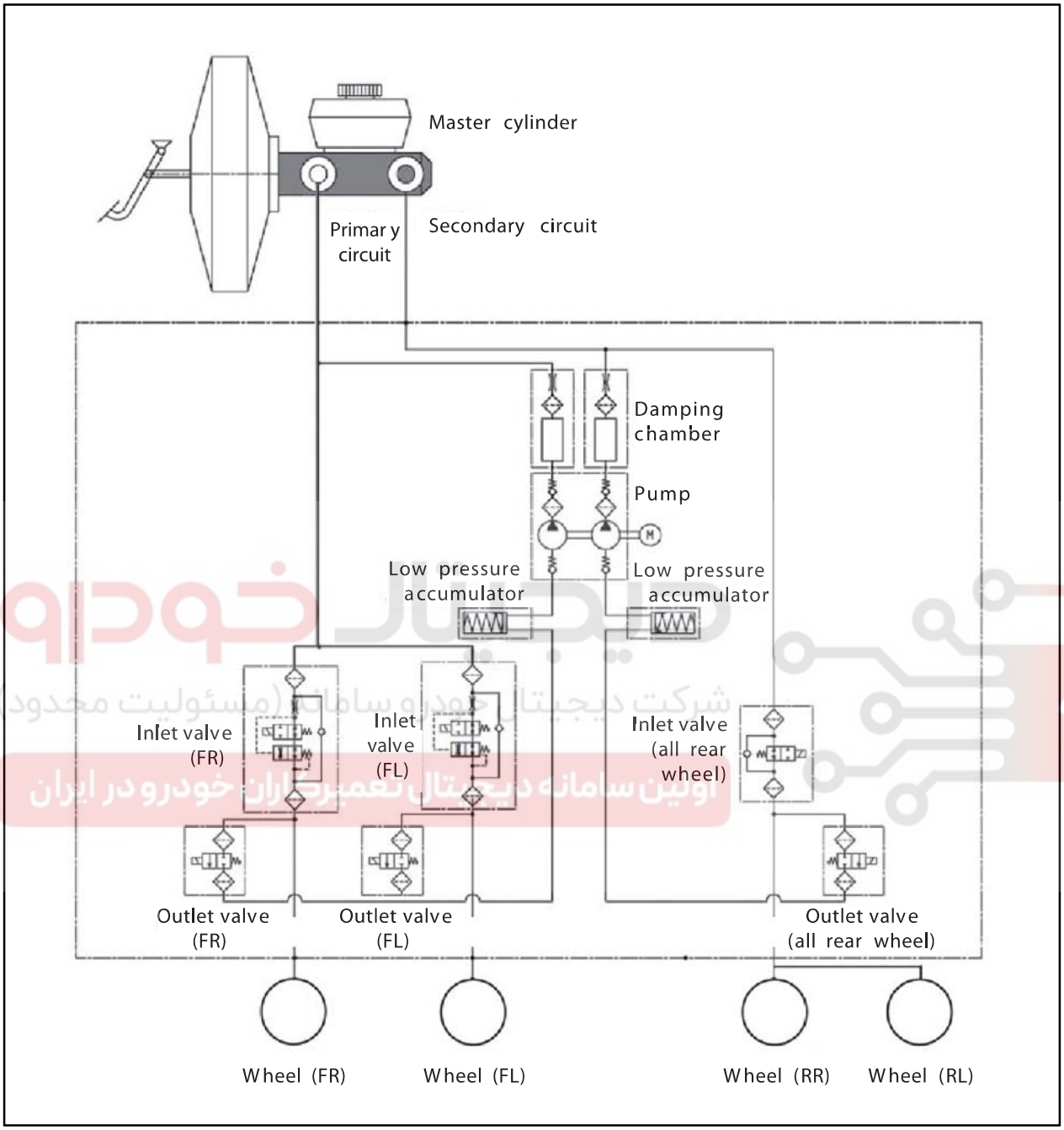
Rear Wheel Speed Sensor

Modification basis	
Application basis	
Affected VIN	

1) Input and Output Diagram Of ABS System



2) Hydraulic Circuit Of ABS



The vehicle equipped only with the ABS controls the wheel's braking force using 3-channel 4-sensor method.

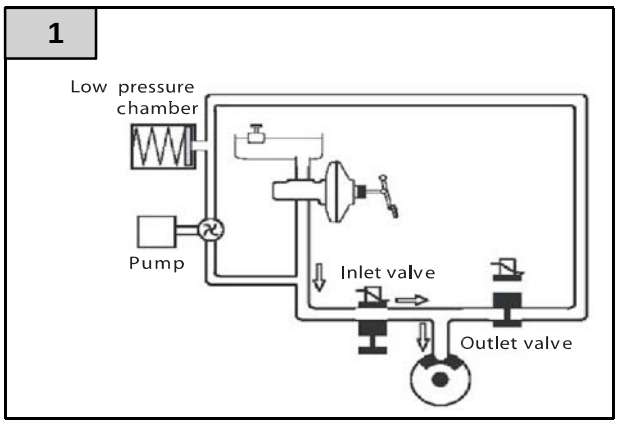
The front wheels that are the primary circuit of the brake system is composed of two wheel speed sensors and two channel valves system with two inlet valves and two outlet valves. The rear wheels that are the secondary circuit of the brake system is composed of two wheel speed sensors, one inlet valve and one outlet valve.

This system is similar to the one from the previous model.

Modification basis	
Application basis	
Affected VIN	

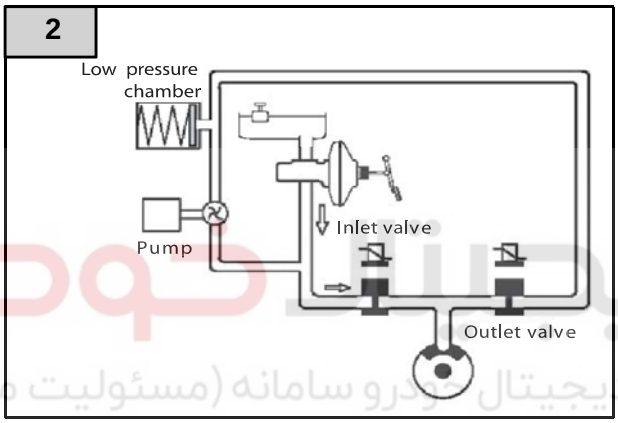
3) ABS Circuit in Each Operation Range

1



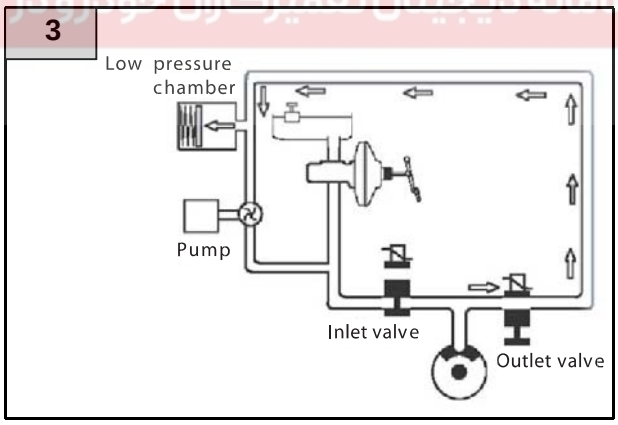
Hydraulic Pressure Circuit when ABS is Not Operating The hydraulic pressure in the master cylinder increases through the vacuum booster and it is delivered to the wheel via the normal open inlet valve. At this moment, the normally-closed outlet valve is closed.
The speed of the wheel that hydraulic pressure is delivered reduces gradually.

2

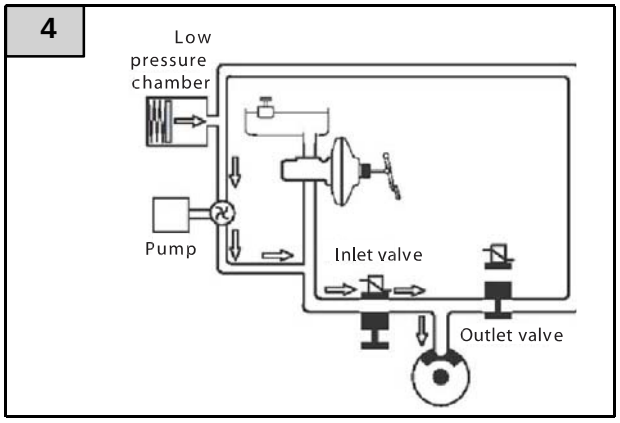


Hydraulic Pressure Locked in Circuit when ABS is Operating As hydraulic pressure on each wheel increases, the wheel tends to lock.
In order to prevent the wheel from locking, the hydraulic valve modulator operates the inlet valve control solenoid to close the inlet valve and stop the hydraulic pressure increases.
At this moment, the outlet valve is closed.
This procedure helps the wheel to maintain a stable hydraulic pressure.

3



Pressure Decreases in the Circuit when ABS is Operating Even when the hydraulic pressure on each circuit is stable, the wheel can be locked as the wheel speed decreases.
This is when the ABS ECU detects the wheel speed and the vehicle speed and gives the optimized braking without locking the wheels. In order to prevent from hydraulic pressure increases, the inlet valve is closed and the outlet valve is opened.
Also, the oil is sent to the low pressure chamber and the wheel speed increases again.
The ABS ECU operates the pump to circulate the oil in the low pressure chamber to the master cylinder.
This may make the driver to feel the brake pedal vibration and some noise.



Pressure Increases in the Circuit when ABS is Operating As the wheel speed increases, the inlet valve opens and the wheel's pressure increases due to the master cylinder pressure.
The oil in the low pressure chamber circulates to the wheel by the pump (no pressure increase in wheel).
Therefore, when depressing the brake pedal, the pressure generated in the master cylinder is transferred to the disc and then the outlet valve decreases this pressure
intermittently.
This operation continues repetitively until there are no signs that the ABS ECU is locking the wheels.
When the ABS hydraulic pressure control takes place, there may be some vibration and noises at the brake pedal.

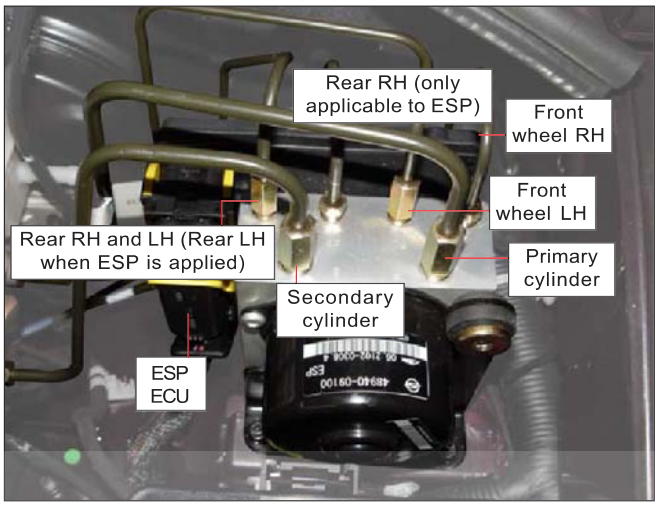
Modification basis	
Application basis	
Affected VIN	

CONFIGURATION AND FUNCTION

S.G.N. 4892-01

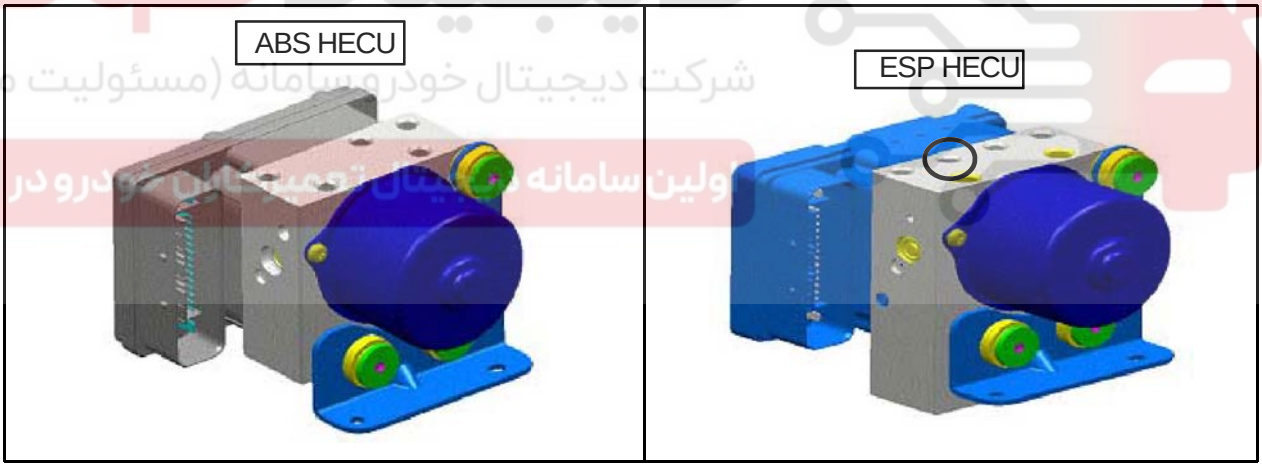
HECU OF ESP

1) HECU Installed in a Vehicle



HECU consists of motor pump, solenoid valve and ECU including solenoid valve. ECU connector has 47 pins and the number of valves in valve body is 12 (with ESP) or 6 (only with ABS).

2) Comparison of ESP HECU and ABS/EBD HECU



3) Other Components

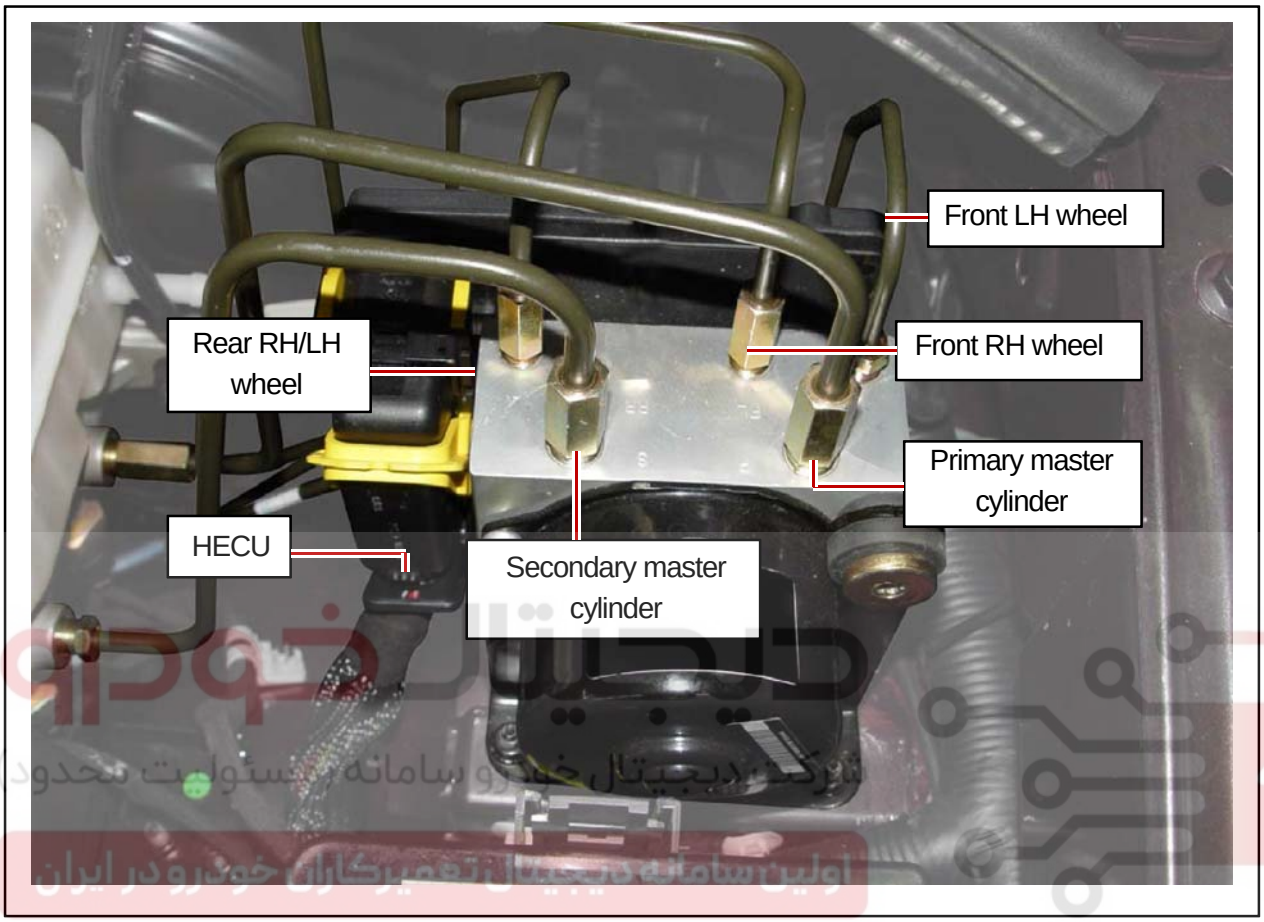
HECU internal valve	Pump Motor	Valve Body
		b: plunger, c: cam bushing 

Modification basis	
Application basis	
Affected VIN	

S.G.N. 4892-01

HECU OF ABS

1) Components and Location

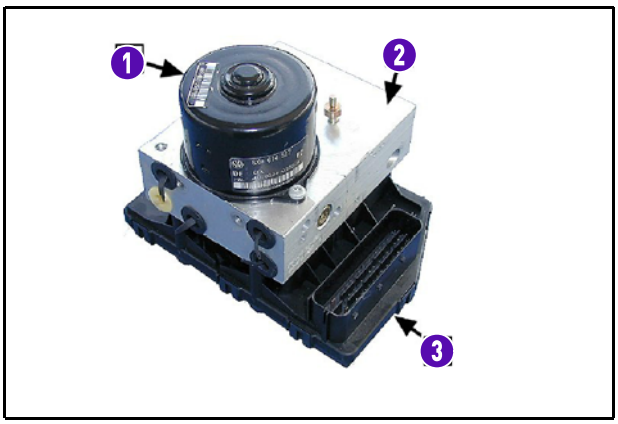


Wheel Speed Sensor - Front (for 4WD)

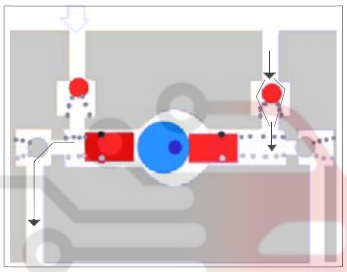
Wheel Speed Sensor - Rear

Modification basis	
Application basis	
Affected VIN	

2) Components Description of HECU(Hydraulic & Electronic Control Unit)



This section is provided only for the understanding of HECU.
Note that this component cannot be disassembled for repair and maintenance. HECU consists of motor pump, valve body and ECU including solenoid valve.
ECU connector has 47 pins and the number of valves in valve body is 6 when equipped with only ABS and 12 when equipped with ESP system.

Motor pump	Valve body	<Pumping>
1  The motor is operated when ABS is activated. The cam-shaped output shaft of the motor (a) enables the brake system to receive and supply the brake fluid during the motor operation.	2  The cam bushing (c) is installed between plungers (b) and it draws and discharges the brake fluid according to the rotation of motor output shaft.	 When the cam pushes the left plunger during motor operation, the system pressure is generated in the left cylinder. At this time, the right plunger is expanded by spring force and the expanded volume of the right cylinder draws the brake fluid.

3 ECU (Including Solenoid Valves)

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 6 solenoid valves.
It has three channels; 2 channels for front wheels and 1 channel for rear wheels.
Each channel has one inlet and one outlet valve, therefore, there are six solenoid valves.

Main functions are

a. Overall control of ABS functions
b. Monitoring of ABS electric components
c. Diagnosis function support

<ECU lower cover>

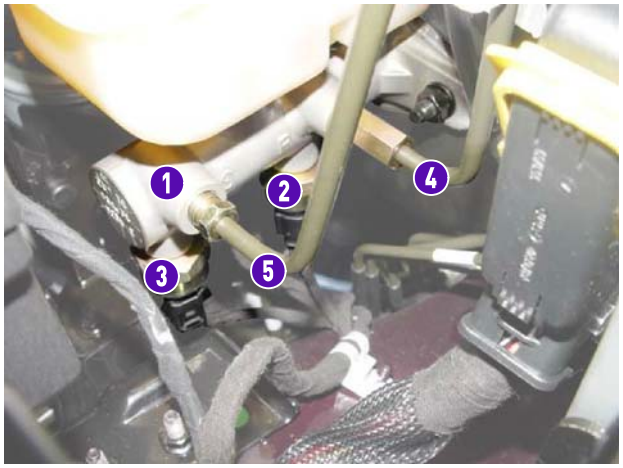
The electrical components are weak to moisture.
To protect ECU, Gore Tex-based plate is used at ECU lower cover. The vent hall (arrow) allows air to ventilate but does not allow moisture to penetrate.

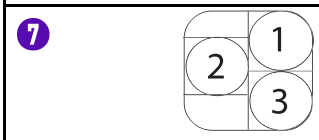
Modification basis	
Application basis	
Affected VIN	

S.G.N. 4850-01

PRESSURE SENSOR

1) Location



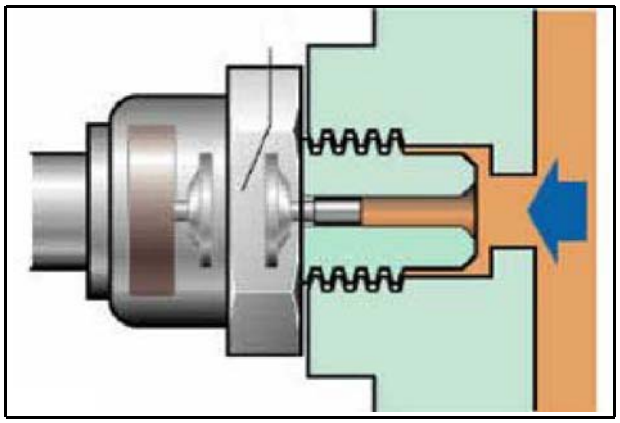


1. Master cylinder
2. Primary pressure sensor
3. Second pressure sensor
4. Hydraulic pipe in primary circuit
5. Hydraulic pipe in secondary circuit
6. Inside of pressure sensor
7. Connector

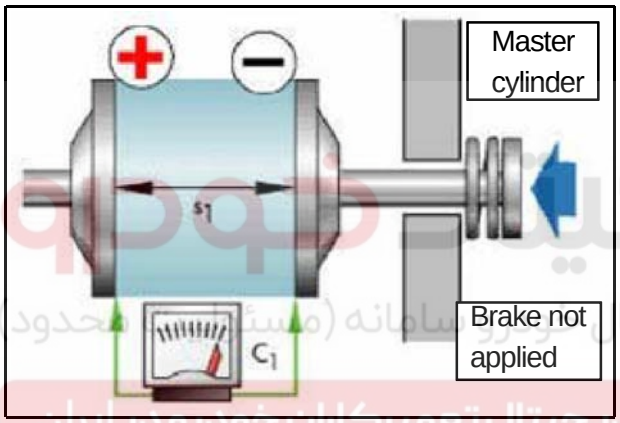
2) Specifications

Supplying voltage	4.75 ~ 5.25 V
Output voltage	0.25 ~ 4.75 V (This is linearly changed from 0.5 V (brake not applied) to 4.75 V (brake applied))
Operating pressure range	0 ~ 170 bar

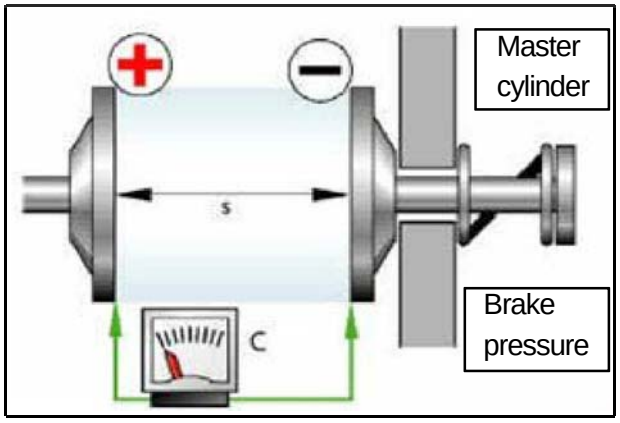
3) Description



Two sensors installed in the lower side of the master cylinder consist of two ceramic discs, one disc is stationary and the other is moved according to the brake pressure.
The pressure value of the brake and the change value of the pressure sensor are operating conditions for BAS operation.



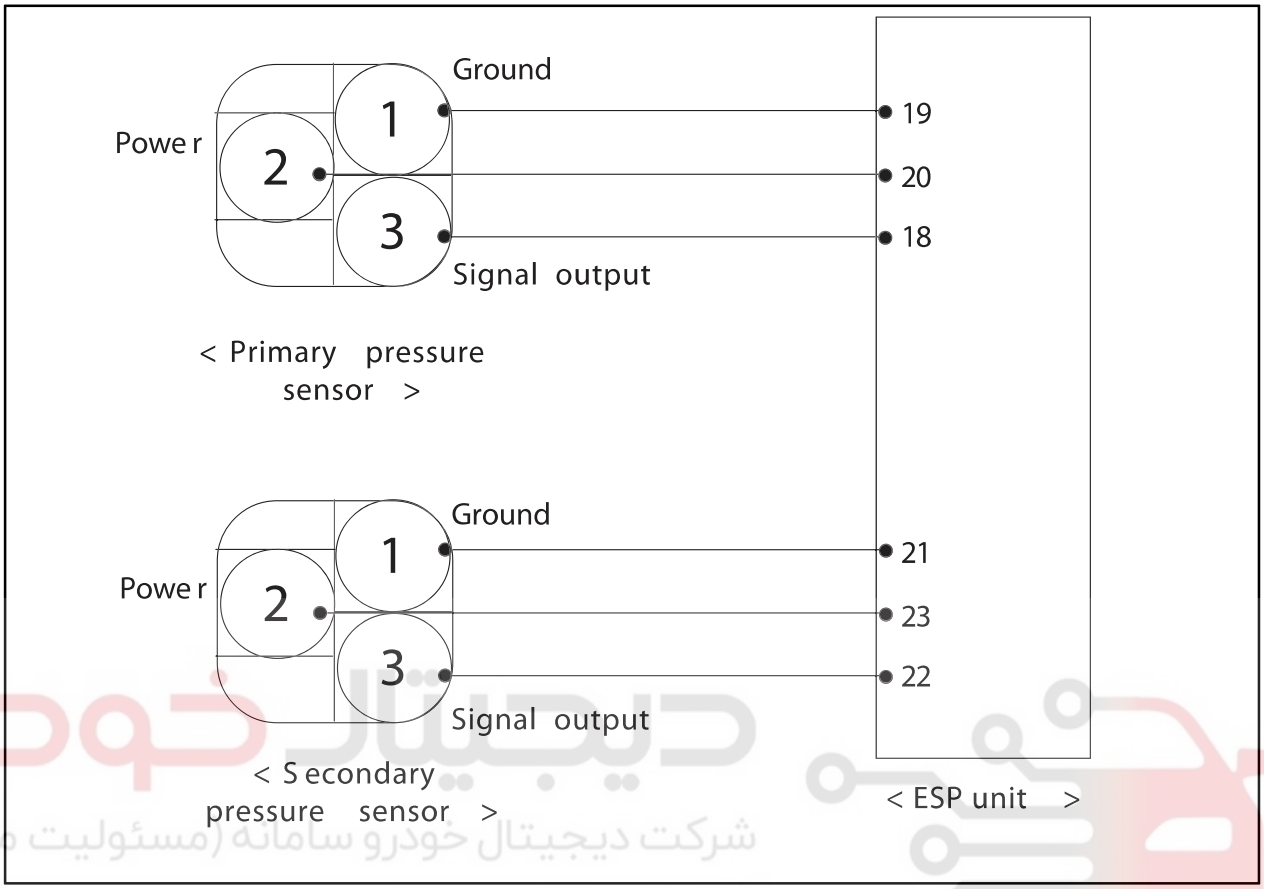
The distance (S) between the two ceramic discs with different polarity changes as the pressure changes of the brake.
Due to this change the capacitance changes and it is measured in the voltage value.
The voltage value is approx. 0.5 V when the brake is not operated.



When brake pressure is applied from the master cylinder, the ceramic disk moves towards the fixed ceramic disk and the electric charge volume changes accordingly.
The voltage value is linearly changed from 0.5 V (brake not applied) to 4.75 V (brake applied).

Modification basis	
Application basis	
Affected VIN	

4) Pressure Sensor Circuit



The ESP unit supplies around 5V power to two pressure sensors installed on the ESP system when the ignition switch is ON.
Each sensor's pin no. 1 is its ground and pin no. 3 outputs the sensor output voltage to the ESP unit. When the brake is not in operation, this voltage is about 0.5V and, during the brake operation it increases linearly to about 0.5 ~ 4.75V.

BAS operating conditions:

1. Pressure: 20 bar
2. Pressure changes: over 1500 bar/sec
3. Vehicle speed: over 7 km/h

S.G.N. 4890-01

SENSOR CLUSTER

1) Location

Installed sensor cluster


1. Center fascia panel
2. Sensor cluster

2) Specification (Sensor cluster: Yaw rate sensor + Lateral acceleration sensor + Longitudinal acceleration sensor)

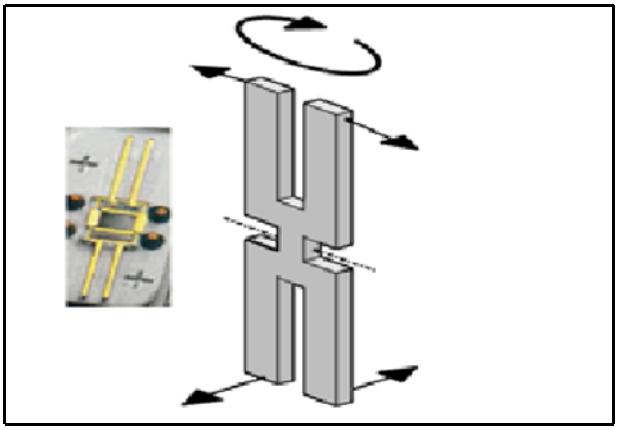
S upplying voltage	Approx. 5V (4.75 ~ 5.25V)
Output voltage during stopping	Approx. 2.5V (Ignition switch "ON")
Ya w rate sensor operating range	-75°/S ~ +75°/S
Lateral acceleration sensor operating range	-1.7 ~ +1.7g (16.7m/s ^{2})
Longitudinal acceleration sensor operating range	-1.7 ~ +1.7g (16.7m/s ^{2})

3) Sensor Cluster Operation and Principles

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.

During the vehicle cornering, the microscopic tuning forks installed in the yaw rate sensor detects the yaw rate (acceleration around the vertical axis of the vehicle) and transmits it through the CAN communication line to the ESP unit, using the electronic signal. Especially, the longitudinal acceleration sensor detects the slope level of the driving road and provides important information for the HDC operation.

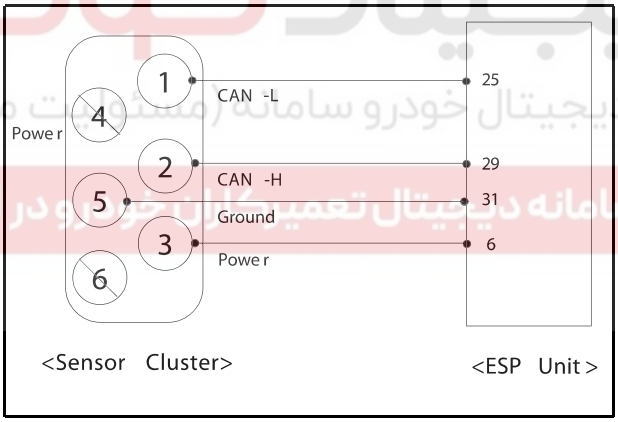
Modification basis	
Application basis	
Affected VIN	



The Microscopic tuning forks in the yaw rate sensor measures the acceleration on the vertical axis of the vehicle.
When the angular acceleration occurs on the vertical axis of the vehicle (Z axis) and this acceleration occurs more than 4° (4 degree) per second, vibration occurs at the top and bottom as shown in the figure.
This vibration is transmitted through the CAN communication line by the form of voltage value. In other words, it detects the yawing of the vehicle.

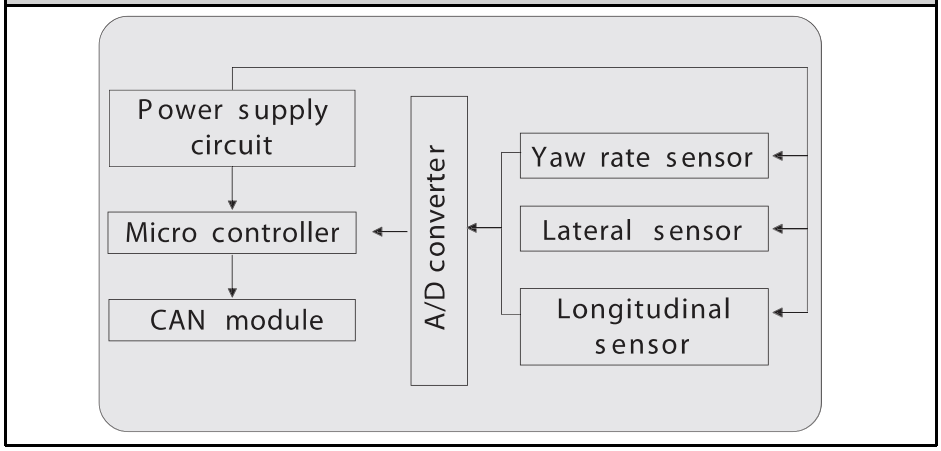
The ESP control operates when a divergence occurs between the vehicle yawing and the steering angle (i.e. the ESP operates when the driver's intended position differs from the vehicle position). Therefore, the occurrence of vehicle yawing does not imply the ESP operation.

4) Pressure Sensor Circuit



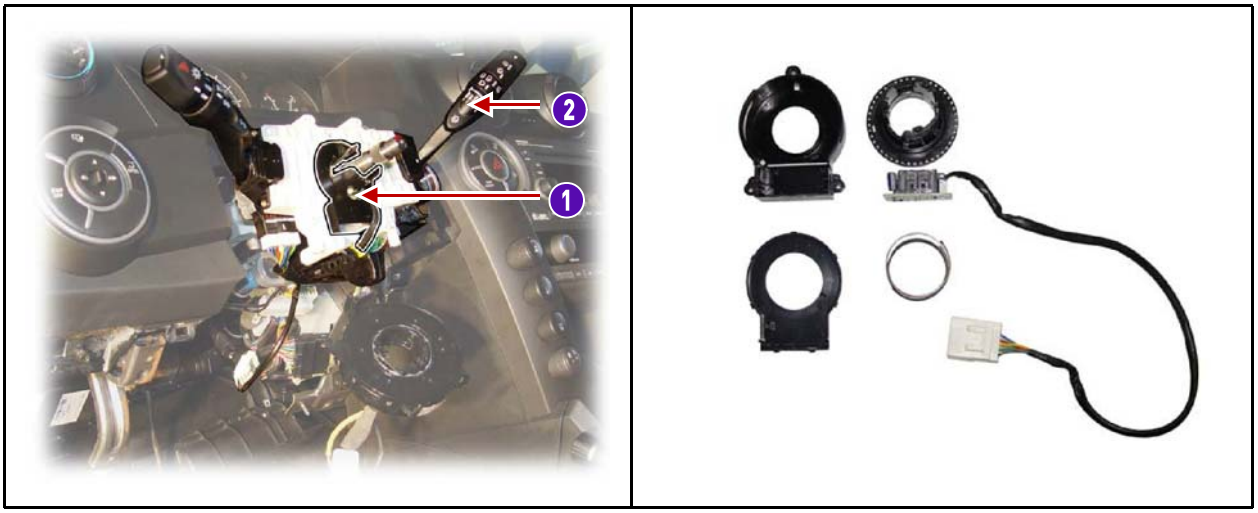
The ESP sensor cluster can be considered as one module.
The measured value by lateral/longitudinal and yaw rate sensors is transmitted to ESP unit via two CAN lines. The supplied voltage from ESP unit is approx.
5 V with ignition key "ON" and the output range through CAN line is approx. 0.2 ~ 4.8 V. When a sensor is faulty, the sensor cluster produces an output signal of 0 V (fail safe function in the yaw rate sensor).

Internal electric circuit of sensor cluster



S.G.N.
8510-21 SWAS(STEERING WHEEL ANGLE SENSOR)

1) Location of Steering Wheel Angle Sensor



1. SWAS (Steering Wheel Angle Sensor)
2. Multifunction switch assembly

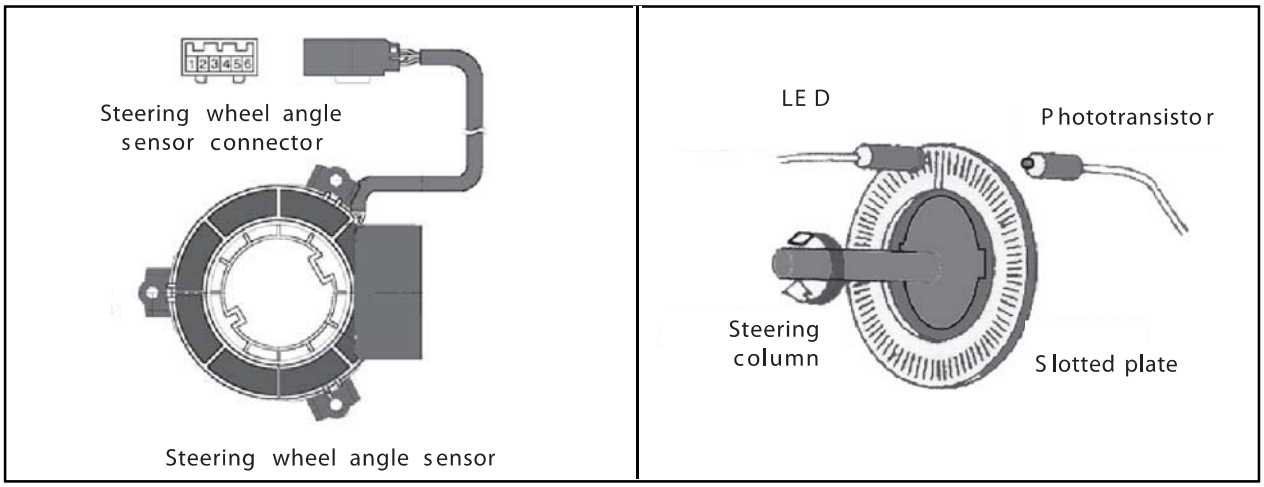
CAUTION
- For removal and installation, refer to "Removal and Installation of Multifunction Switch" section.

2) Specifications

Working voltage	9 ~ 16 V
Max. output current	10 mA
Detected max. angular velocity	1500°/S
Working temperature	- 30 ~ 75°C
Supplying voltage	9 ~ 16 V (battery voltage)
Output voltage (HI)	Approx. 3.50 V (3.0 ~ 4.1 V)
Output voltage (LO)	Approx. 1.50 V (1.3 ~ 2.0 V)

Modification basis	
Application basis	
Affected VIN	

3) Principle

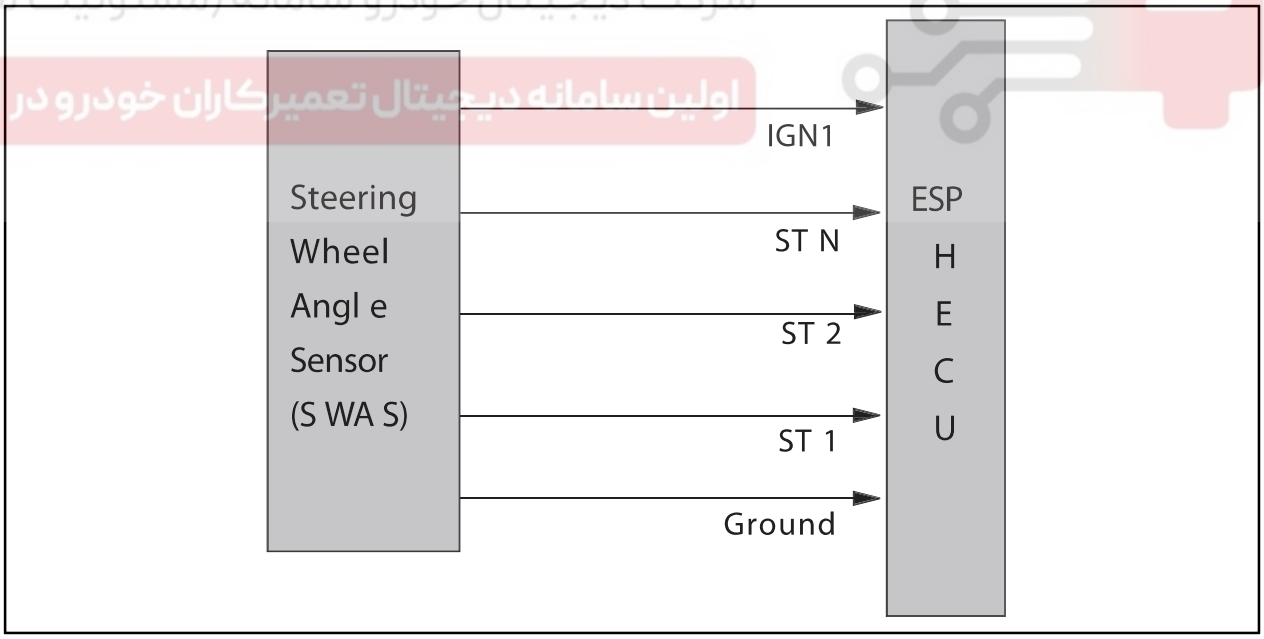


The steering wheel angle sensor is integrated with the phototransistor and the LED and there is a slotted plate between them.

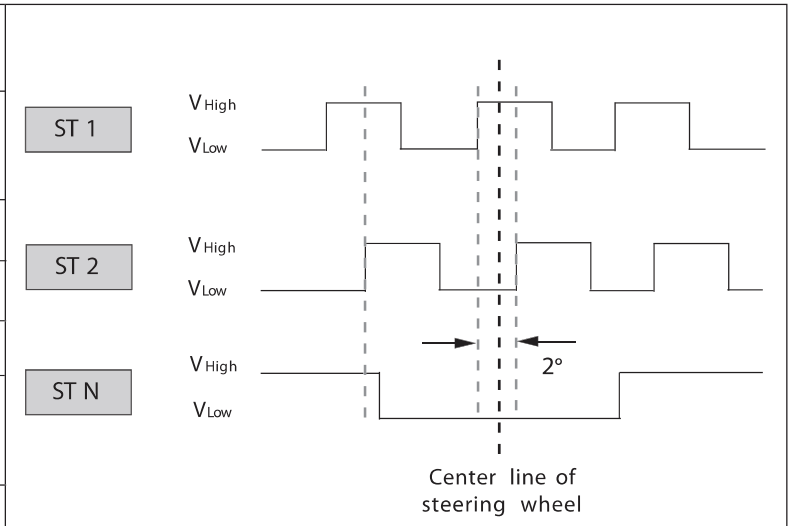
When the inner slotted plate rotates with the steering column shaft when the steering wheel is turned, the voltage occurs through the holes.

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.



Supplying voltage	9 ~ 16 V
Number of pulse per revolution	45 Pulses /1 rev
Duty	Approx. 50 %
High - V	3.0 ~ 4.1 V
Low - V	1.3 ~ 2.0 V
ST1 and ST 2	Detects steering wheel angle and angular velocity as an average value
ST N	Detects the center value of steering wheel



Modification basis	
Application basis	
Affected VIN	

S.G.N. 8510-56

ESP OFF SWITCH

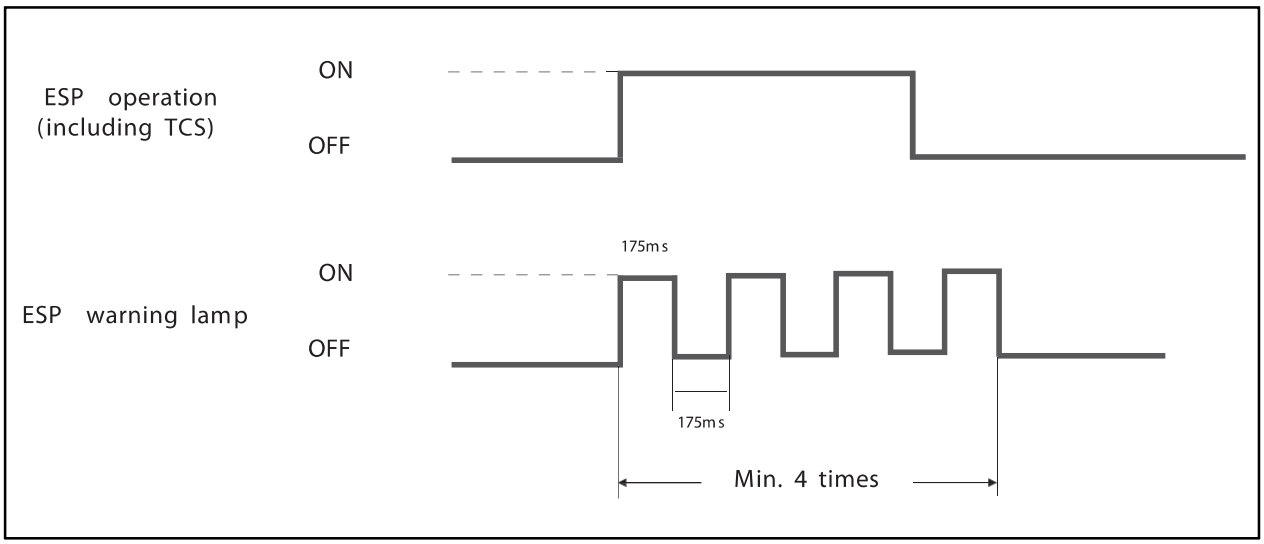
1) Location

ESP OFF Switch

2) Principle of ESP control

(1) ESP Warning Lamp Blinking in Control

ESP warning lamp blinks and a beep sounds when ESP control is activated. The ESP warning lamp goes off when ESP function is deactivated.
Even when the ESP is operated for a very short period of time, the ESP warning lamp blinks minimum of 4 times every 175 milliseconds. ESP function is a supplementary device to adjust the vehicle position when it is unstable.
Therefore, when ESP warning lamp blinks and a beep sounds, lower the speed and pay attention to the safe driving.



Modification basis	
Application basis	
Affected VIN	

(2) ESP System Cancellation Using the ESP OFF Switch

When the ESP OFF switch is pushed (for over approximately 150 ms), the ESP system will be cancelled and the vehicle will be driven regardless of the output values from the corresponding sensors. Then, the ESP warning lamp on the instrument panel comes on. (However, the ARP function still operates.) The detailed operation procedures are as follows:

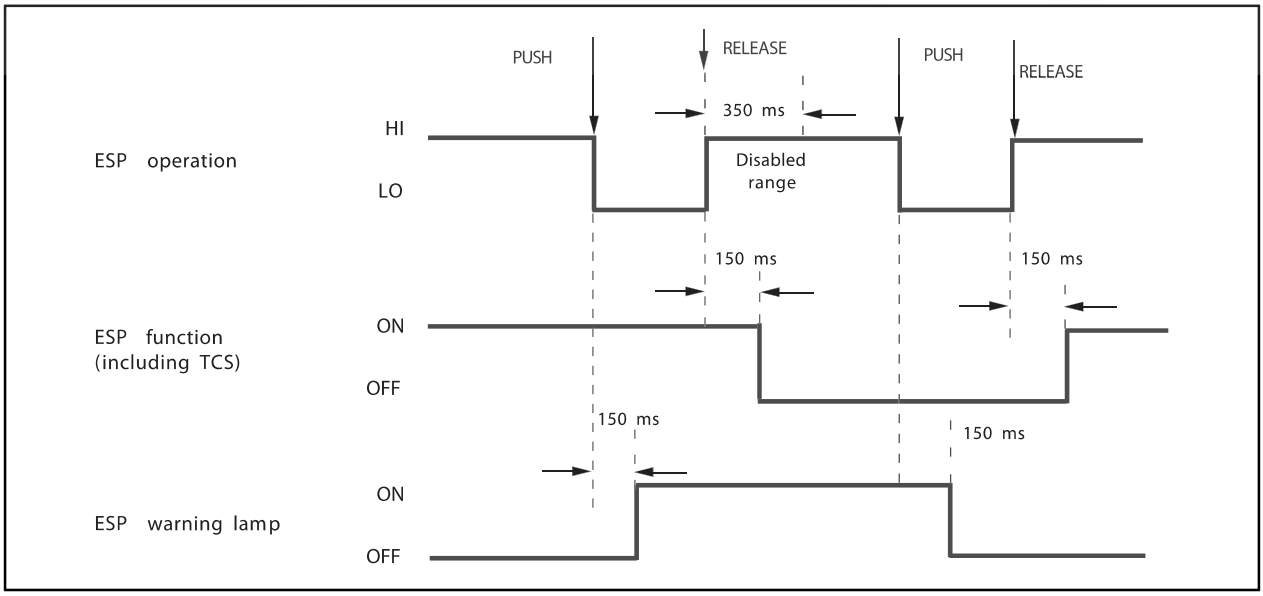
1. The ESP warning lamp comes on when the ESP OFF switch is pushed for over 150 ms.
2. The switch returns to normal position when the OFF switch is released.
3. The ESP system will be cancelled after approximately 150 ms.

Based on the above procedures, we can see that the ESP system will be cancelled after a certain period (approx. 150 ms) from releasing period of the switch to the original position.
The ESP system does not get cancelled immediately when the ESP warning lamp is turned on by pressing the ESP OFF switch.
When you turn the ESP system off by pressing the ESP switch for over 150 ms, the TCS system (including ABD function) is turned off.
And the ABS system is still operated.

(3) Resuming the ESP System by Using the ESP OFF Switch

The ESP system will be resumed and the ESP warning lamp at the instrument panel goes off when the ESP switch is pushed (for over approximately 150 ms) while the ESP system is not operating and the ESP warning lamp is on.
The detailed operation procedures are as follows.

1 The ESP warning lamp goes off when the ESP OFF switch is pushed for over 150 ms.
2. The switch returns to normal position when the OFF switch is released.
3. The ESP system will be resumed after approx. 150 ms.



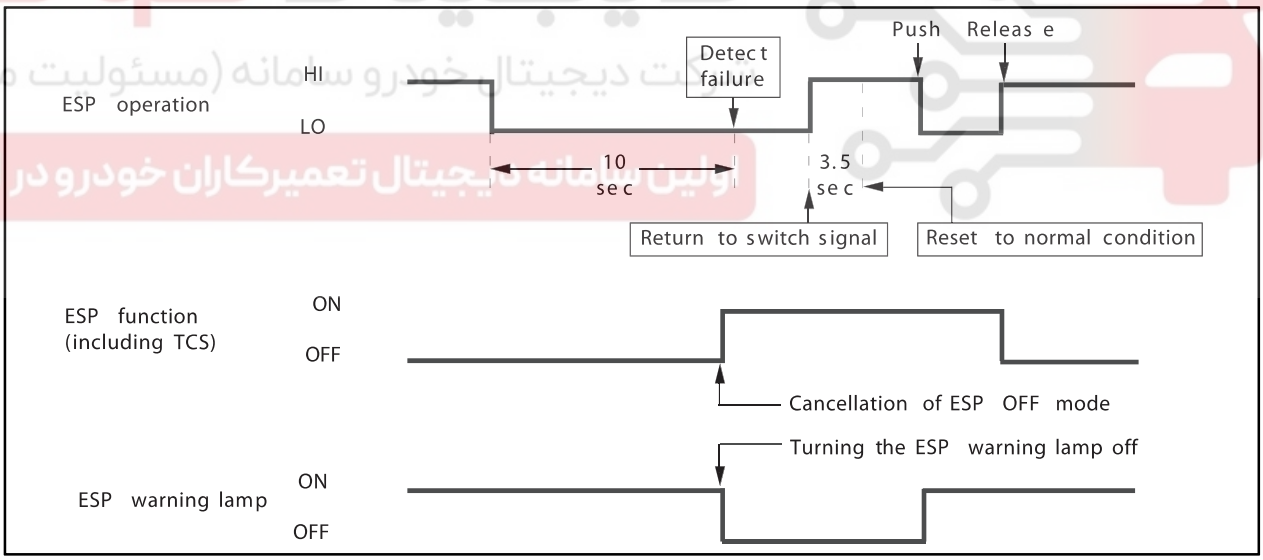
Modification basis	
Application basis	
Affected VIN	

CAUTION

- If turning the ignition switch off while the ESP system is activated or deactivating the ESP system, the ESP system will be resumed when ignition switch is turned on again.
- When the vehicle is controlled by ESP system during driving, the ESP OFF switch does not operate.
- The ESP OFF switch operates when it is pushed for over 150 ms. When it is pushed for less than 150 ms, the ESP OFF mode and the ESP warning lamp will not be changed.
- When the ESP OFF switch is pushed within 350 ms of being turned off, the ESP warning lamp and ESP system will not be turned on.
- The ARP function still operates after turning off the ESP system.

(4) ESP OFF Switch Monitoring

When the ESP unit recognizes that the ESP OFF switch is pushed for over 10 seconds, the ESP unit determines it as a ESP OFF switch malfunction.
When the ESP OFF switch is pushed, the ESP system is resumed after 10 seconds. However, the ESP warning lamp comes on when the ESP OFF switch is pushed (for over 150 ms) and then goes out when the ESP system is resumed.
When the ESP OFF switch returns to normal position, the ESP unit resets the ESP OFF switch for approx. 3.5 seconds.



(5) ESP Warning Lamp Operation Depending on System Conditions

The table shows ESP warning lamp operations when the ESP system is defective or ESP (including TCS function) is working.

	Warning Lamp		Controls			
	ABS W/L	ESP W/L	ABS	AS R	ABD	Ve hicle ya w contro l
Initial start (for 1.8 sec)	ON	ON	NO	NO	NO	NO
Normal mode	OF F	BLINKS WHEN ESP O PERA TIO N	OK	OK	OK	OK
ESP fault	OF F	ON	OK	NO	NO	NO
ABS fault	ON	ON	NO	NO	NO	NO
S ystem fault	ON	ON	NO	NO	NO	NO
Low battery voltage	ON	ON	NO	NO	NO	NO
High battery voltage	ON	ON	NO	NO	NO	NO
High brake pad temp.	OF F	ON	OK	NO	NO	NO
ESP-OFF mode	OF F	ON	OK	NO	NO	OK [1]
Entering diag. mode	ON	ON	NO	NO	NO	NO

CAUTION

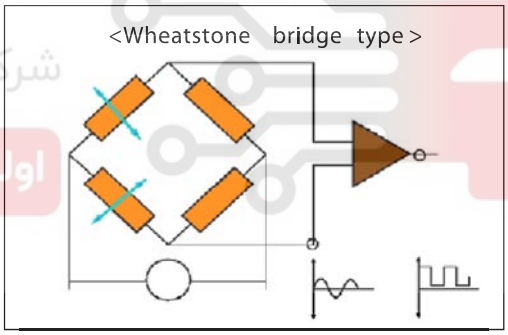
- When the driver depresses the brake pedal during the ESP OFF mode, the yaw control is performed to compensate the vehicle stability (posture) during ESP operation.

Modification basis	
Application basis	
Affected VIN	

S.G.N. 4890-01

AWSS(Active Wheel Speed Sensor)

The wheel speed sensor used in traditional ABS is made of permanent magnet and transmits the output voltage that changes as the wheel rotor rotates to the HECU system.
New wheel speed sensor detects the wheel speed through the current value that depends on the resistance that changes according to the magnetic field by using four resisters and supplying the 12 V power supply to the sensor.

<Front wheel speed sensor>	<Rear wheel speed sensor>
	
<Active wheel speed sensor>	**<Wheatstone bridge type>**
 For 4WD	

This sensor contains:

1. Four resisters 2. Supply voltage from HECU (12 V) 3. Internal printed circuit board

The system uses the wheatstone bridge that detects and compares the changes in each resistance value.
Before passing through the comparison measuring device, the sine wave current is obtained. But, after passing through it, a square wave, that is recognized by ECU, will be generated.
The data from the rear right and left wheel speed sensors is used to get the mean value for the actual vehicle speed.

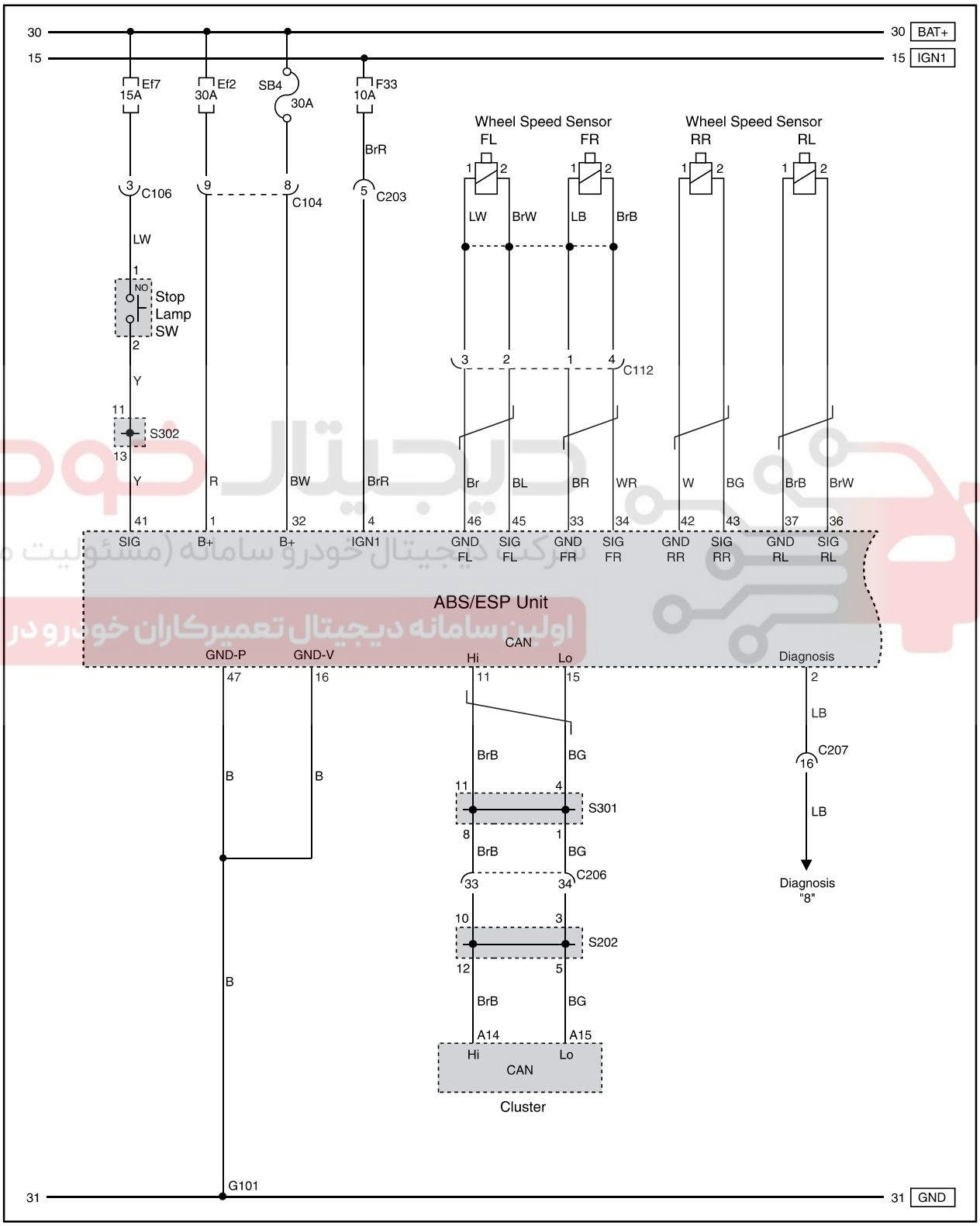
▶ Specification

Air gap between sensor and rotor wheel	Front:	2WD: 0.475 ~ 1.425 mm (Tightening torque: 6 ~ 8 Nm) 4WD: 0.1 ~ 0.7 mm (Tightening torque: 15 ~ 20 Nm)
	Rear :	0.037 ~1.175 mm
Wheel speed sensor current (vehicle speed: at approx. 2.75 Km/h)		I_{HIGH} : Approx. 14 mA I_{LOW} : Approx. 7 mA
Wheel speed sensor voltage (one rotation per second at -40 ~ +60)		7.5 ~ 20 V

Modification basis	
Application basis	
Affected VIN	

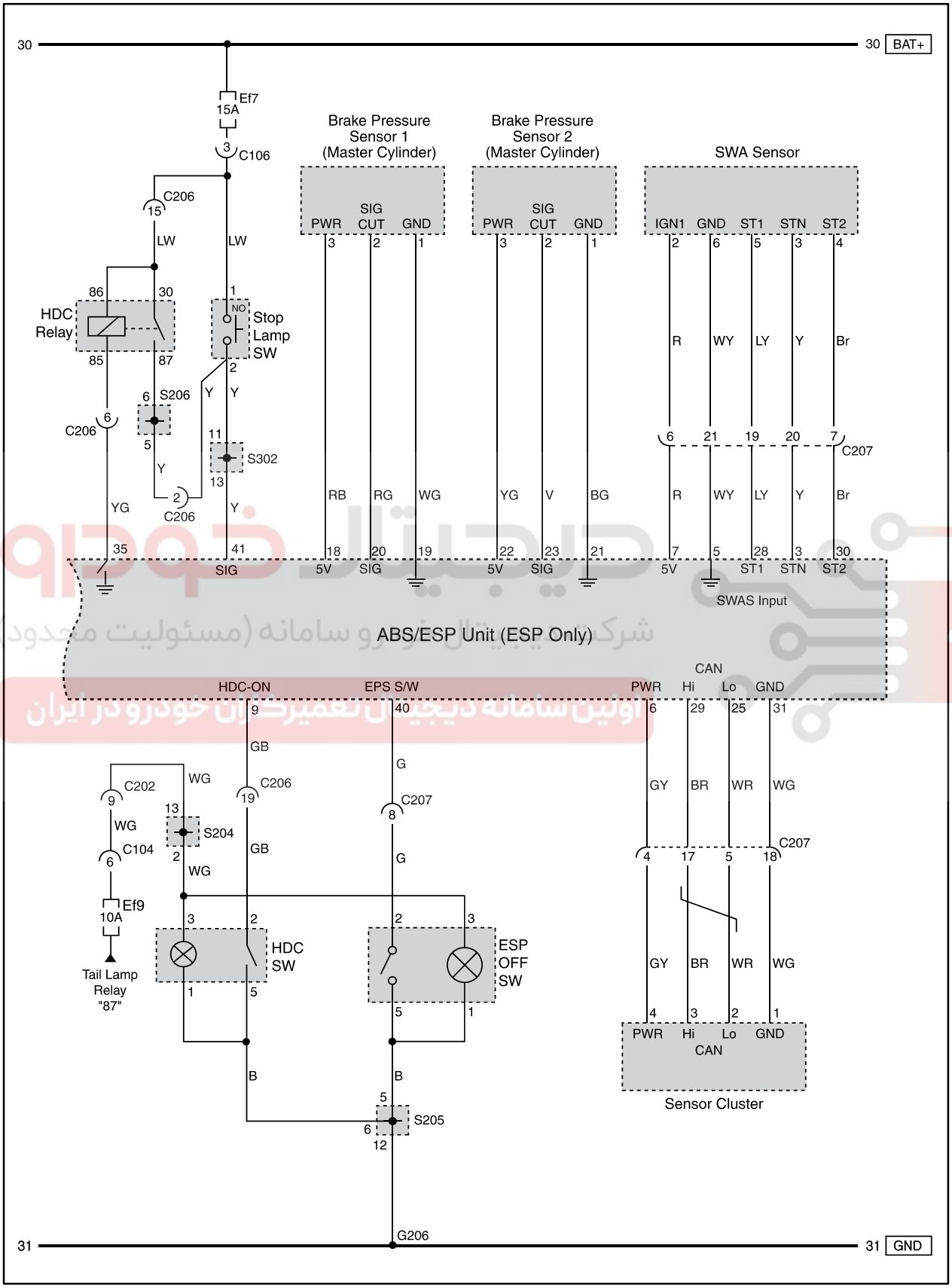
S.G.N. 4892-00 ABS/ESP

1) W/Speed Sensor, Stop Lamp SW, Diagnosis, Warning Lamp (ABS/ESP)



Modification basis	
Application basis	
Affected VIN	

2) Pressure Sensor, S.W.A Sensor, Cluster, ESP OFF SW, HDC SW

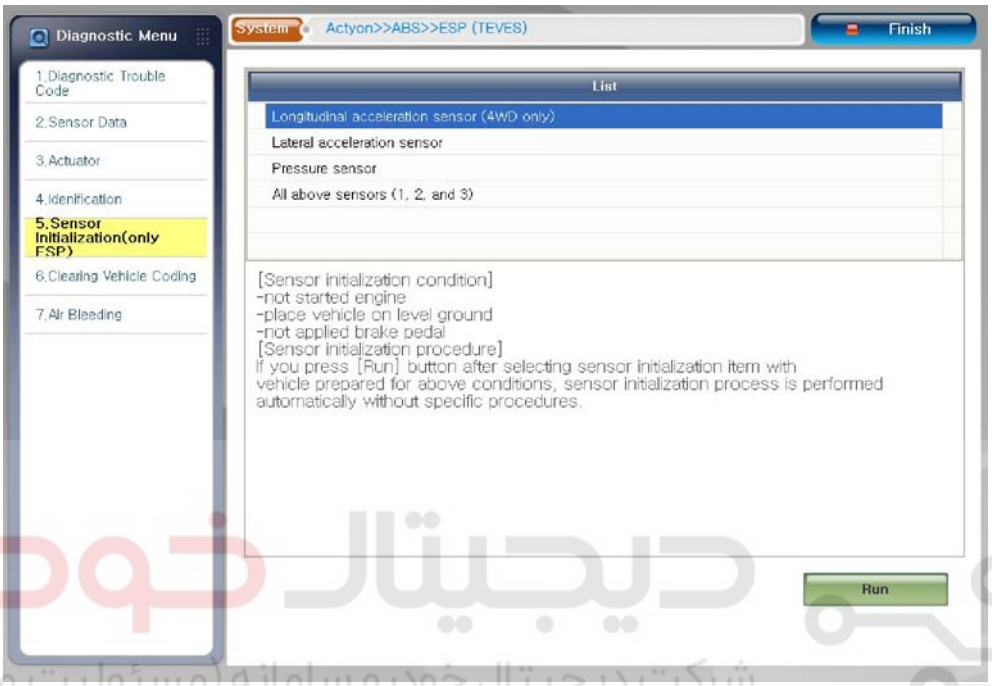


Modification basis	
Application basis	
Affected VIN	

REMOVAL AND INSTALLATION

S.G.N. 4892-01 HOW TO USE SCAN TOOL

(1) Sensor Calibration (Initialization)



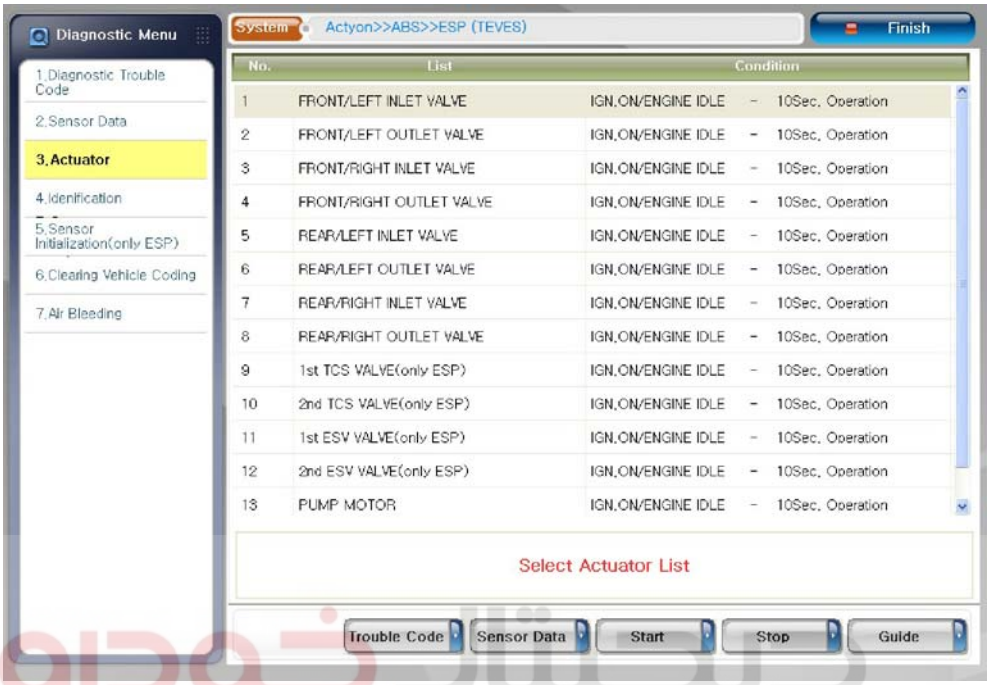
After confirming the vehicle conditions are met, click the "Run" button to start the initialization.

▶ **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).

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.

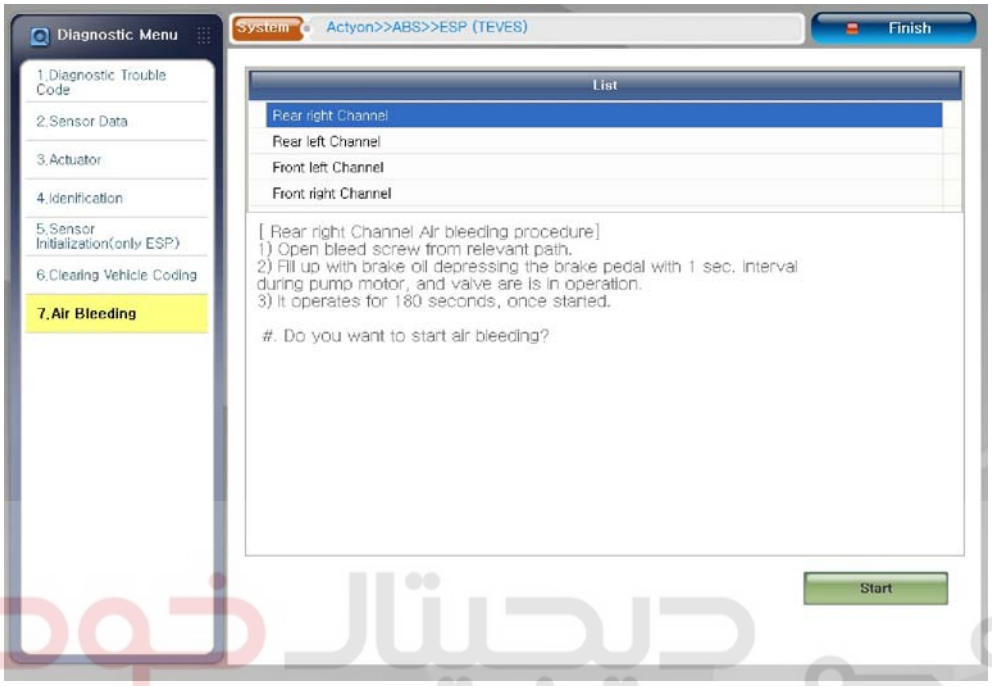
NOTE

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.

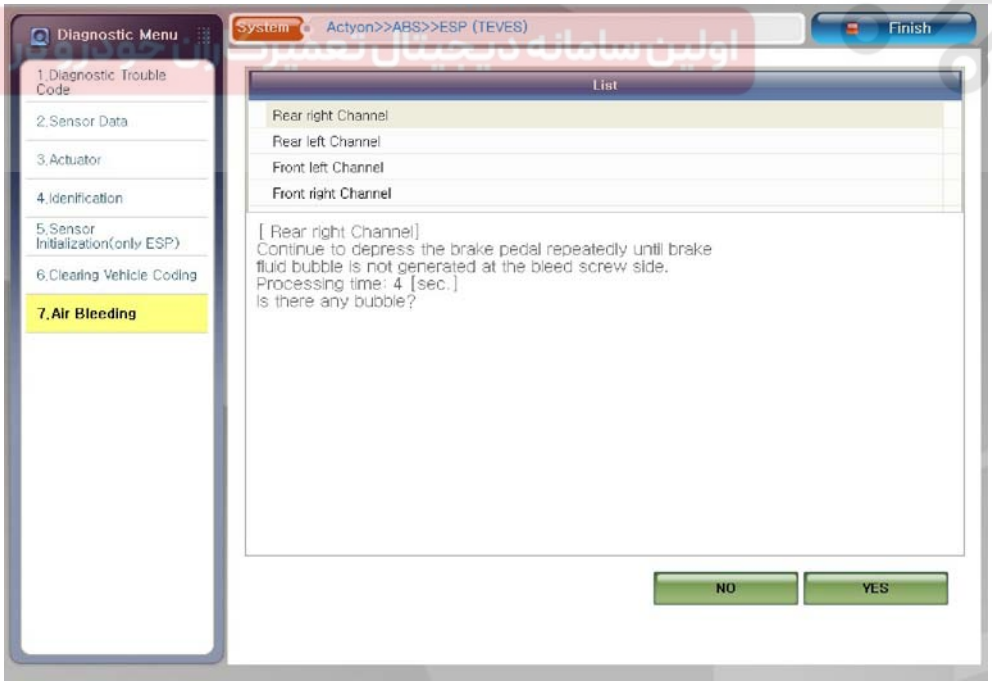
Modification basis	
Application basis	
Affected VIN	

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.

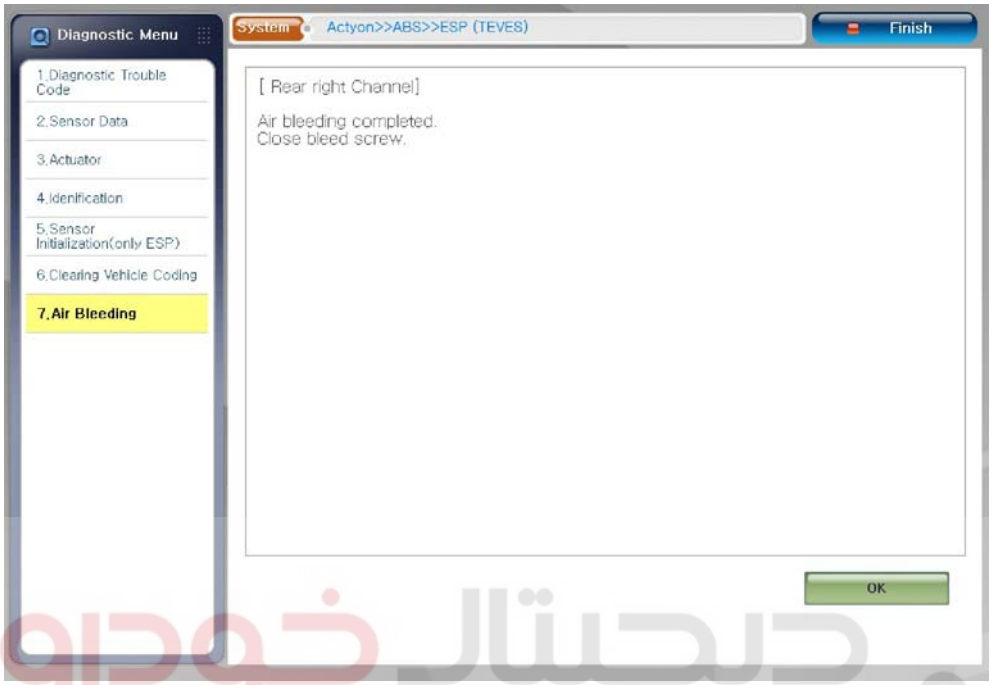


If no bubbles come out from the bleed screw, then click "YES".



Modification basis	
Application basis	
Affected VIN	

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	

4) ABS/ESP Sensor Value

No	Content	Unit	ESP	ABS
1	Wheel Speed FR	0.1 km/h	O	O
2	Wheel Speed FL	0.1 km/h	O	O
3	Wheel Speed RR	0.1 km/h	O	O
4	Wheel Speed RL	0.1 km/h	O	O
5	Battery Voltage	0.1 V	O	O
6	Longitudinal Acceleration Sensor	0.01 g-: Straight ahead	O	O
7	Lateral Aceleration Sensor	0.01 g +: Left Turn	O	X (Fixed Value: 0)
8	Yaw Rate Sensor	0.5 deg/s +: Left Turn	O	X (Fixed Value: 0)
9	Steering Wheel Angle sensor	5 deg +: Left Turn	O	X (Fixed Value: 0)
10	Pressure Sensor (Primary)	1 bar	O	X (Fixed Value: 0)
11	Pressure Sensor (Secondary)	1 bar	O	X (Fixed Value: 0)
12	EBD Control	Operation / Non-operation	O	O
13	BTCS Control	Operation / Non-operation	O	X (Fixed Value: 0)
14	Engine TCS Control	Operation / Non-operation	O	X (Fixed Value: 0)
15	ESP Control	Operation / Non-operation	O	X (Fixed Value: 0)
16	ESP/TCS OFF Switch	ON / OFF	O	X (Fixed Value: 0)
17	ABS Control	Operation / Non-operation	O	O
18	Stop Lamp Switch	ON / OFF	O	O

(O: Applied, X: N/A)

5) ABS / ESP Forced Operation

No	Name	Operatio n
1	FL Inlet Valve	Operation / Non-operation
2	FL Outlet Valve	Operation / Non-operation
3	FR Inlet Valve	Operation / Non-operation
4	FR Outlet Valve	Operation / Non-operation
5	Rear (or RL) Inlet Valve (*1)	Operation / Non-operation
6	Rear (or RL) Outlet Valve (*1)	Operation / Non-operation
7	RR Inlet Valve (*2)	Operation / Non-operation
8	RR Outlet Valve (*2)	Operation / Non-operation
9	TCS Valve Primary (*3)	Operation / Non-operation
10	TCS Valve Secondary (*3)	Operation / Non-operation
11	ESV Valve Primary (*3)	Operation / Non-operation
12	ESV Valve Secondary (*3)	Operation / Non-operation
13	-	-
14	-	-
15	Motor Pump	Operation / Non-operation

Modification basis	
Application basis	
Affected VIN	

S.G.N. 4892-01

ABS/ESP TROUBLE DIAGNOSIS

Function	Defective Components	Trouble Code	Descriptions	System	
Sensor Monitoring	**Front LH Wheel speed sensor**	C1011 C1012	Wheel speed sensor front left-electrical Wheel speed sensor front left-other	**ABS**	**ESP**
	1. C1011 **Cause** - Defective front LH wheel speed sensor - Short or poor contact wire to sensor **Action** - Check the connection of the wheel speed sensor connector - Check the connection of HECU connector - Check the harness connection **2. C1012** **Cause** - Defective front LH wheel speed sensor - No signals from wheel speed sensor and tooth wheel - Too large air gap between wheel speed sensor and tooth wheel - Different number of teeth in tooth wheel **Action** - Check the wheel speed sensor connector - Check the connection of HECU connector - Check air gap between wheel speed sensor and tooth wheel and tooth wheel mounting (Specified air gap: 0.475 ~1.425 mm (2WD), 0.1 ~ 0.7 mm (4WD)) - Check the number of teeth (48) in tooth wheel			**O**	**O**
	Front RH Wheel speed sensor	C1021 C1022	Wheel speed sensor front right-electrical Wheel speed sensor front right-other	**ABS**	**ESP**
	1.C1021 **Cause** - Defective front RH wheel speed sensor - Short or poor contact wire to sensor **Action** - Check the connection of the wheel speed sensor connector - Check the connection of HECU connector - Check the harness connection **2.C1022** **Cause** - Defective front RH wheel speed sensor - No signals from wheel speed sensor and tooth wheel - Too large air gap between wheel speed sensor and tooth wheel - Different number of teeth in tooth wheel **Action** - Check the wheel speed sensor connector and HECU connector - Check air gap between wheel speed sensor and tooth wheel and tooth wheel mounting (Specified air gap: 0.475 ~ 1.425 mm (2WD), 0.1 ~ 0.7 mm (4WD)) - Check the number of teeth (48) in tooth wheel			**O**	**O**

Function	Defective Components	Trouble Code	Descriptions	System	
Sensor Monitoring	**Rear RH Wheel speed sensor**	C1031 C1032	Wheel speed sensor rear left-electrical Wheel speed sensor rear left-other	**ABS**	**ESP**
	1. C1031 **Cause** - Defective rear RH wheel speed sensor - Short or poor contact wire to sensor **Action** - Check the connection of the wheel speed sensor connector - Check the connection of the HECU connector - Check the harness connection **2. C1032** **Cause** - Defective rear RH wheel speed sensor - No signals from wheel speed sensor and tooth wheel - Too large air gap between wheel speed sensor and tooth wheel - Different number of teeth in tooth wheel **Action** - Check the wheel speed sensor connector - Check the connection of the HECU connector - Check air gap between wheel speed sensor and tooth wheel and tooth wheel mounting (Specified air gap: 0.425 ~ 1.175 mm) - Check the number of teeth (48) in tooth wheel			**O**	**O**
	Rear LH Wheel speed sensor	C1041 C1042	Wheel speed sensor rear left-electrical Wheel speed sensor rear left-other	**ABS**	**ESP**
	1. C1041 **Cause** - Defective rear LH wheel speed sensor - Short or poor contact wire to sensor **Action** - Check the connection of the wheel speed sensor connector - Check the connection of the HECU connector - Check the harness connection **2. C1042** **Cause** - Defective rear LH wheel speed sensor - No signals from wheel speed sensor and tooth wheel - Too large air gap between wheel speed sensor and tooth wheel - Different number of teeth in tooth wheel **Action** - Check the wheel speed sensor connector and HECU connector - Check air gap between wheel speed sensor and tooth wheel and tooth wheel mounting (Specified air gap: 0.425 ~ 1.175 mm) - Check the number of teeth (48) in tooth wheel			**O**	**O**

Modification basis	
Application basis	
Affected VIN	

Function	Defective Components	Trouble Code	Descriptions	System	
Sensor Monitoring	**Pressure sensor**	C1051	Defective input sensor	**ABS**	**ESP**
	Cause - Abnormal signals from pressure sensor - Defective pressure sensor or harness **Action** - Check the connection of the pressure sensor connector			**X**	**O**
	Steering wheel angle sensor	C1061	Defective steering wheel angle sensor	**ABS**	**ESP**
	Cause - Internally defective steering wheel angle sensor - Abnormal signals from steering wheel angle sensor - Ground to signal and power supply line or short to power supply line - Abnormal signal voltage from steering wheel angle sensor - Poor installation of steering wheel angle sensor and abnormal signal **Action** - Check the supplying voltage: (Specified voltage: 9 ~ 16 V) - Check the output voltage: Check voltage between ESP unit terminals with ignition ON • ST1 voltage check: between ESP unit terminal No. 5 and ground (Specified voltage: 1.3 ~ 4.1V) • ST2 voltage check: between ESP unit terminal No. 2 and ground (Specified voltage: 1.3 ~ 4.1V) • STN voltage check: between ESP unit terminal No.12 and ground (Specified voltage: 1.3 ~ 4.1V)			**X**	**O**
	Longitudinal acceleration sensor	C1071 C1072	Longitudinal acceleration sensor-electrical Longitudinal acceleration sensor-other	**ABS**	**ESP**
	1. C1071 2. C1072 **Cause** - Internally defective steering wheel angle sensor - Abnormal signal from steering wheel angle sensor - Ground to signal and power supply line or short to power supply line - Abnormal signal voltage from steering wheel angle sensor - Poor installation of steering wheel angle sensor and abnormal signal **Action** - Check the supplying voltage: (Specified voltage: 9 ~ 16 V) - Check the output voltage: Check voltage between ESP unit terminals with ignition ON			**X**	**O**

Modification basis	
Application basis	
Affected VIN	

Function	Defective Components	Trouble Code	Descriptions	System	
Sensor Monitoring	**Sensor cluster**	C1073 C1074	Sensor cluster -electrical Sensor cluster-other	**ABS**	**ESP**
	1. C1073 **Cause** - Operating voltage exceeds specified range(Hi: 18.0 ± 1.0 V / Lo: 6.5 ± 0.5 V) - Poor contact or installation of harness **Action** - Check the connection of the sensor cluster connector - Replace the sensor cluster **2. C1074** **Cause** - Internally defective HECU - Abnormal internal A/D converter voltage: Over 5.0 ± 3 % - Abnormal supplying voltage (4.580 ~ 4.960 V) to sensor cluster → Short circuit between supplying voltage output of sensor cluster and ground - Poor ground of sensor cluster (0.0 ~ 0.5 V) → Short to ground on sensor cluster - Abnormal signals from lateral acceleration sensor - Abnormal signals from yawing sensor - Poor installation of sensor - Defective sensor cluster - Defective or short circuit of CAN communication line **Action** - Replace the sensor			**X**	**O**
Battery Voltage Monitoring	**Battery**	C1101 C1102	Battery under voltage Battery over voltage	**ABS**	**ESP**
	1. C1101 **Cause** - Low voltage out of specified range (9.7 ± 0.3 V) **Action** - Check the supplying voltage **2. C1102** **Cause** - Over voltage out of specified range (18.0 ± 1.0 V) **Action** - Check the supplying voltage			**O**	**O**
Brake Monitoring	**Brake disc**	C1111	Disk temperature is high	**ABS**	**ESP**
	Cause - Overheated brake disc due to braking force: over 500°C - Overheated brake disc due to excessive operation of HDC **Action** - Stop driving for a period of time after turning off the ESP			**X**	**O**

Modification basis	
Application basis	
Affected VIN	

Function	Defective Components	Trouble Code	Descriptions	System	
Brake Monitoring	**Brake lamp switch** **ESP OFF switch**	C1201 C1202	Defective brake lamp switch Defective ESP OFF switch	**ABS**	**ESP**
	1. C1201 (5201) **Cause** - Mechanical defective in brake switch - Defective brake switch harness **Action** - Check the harness and connector **2. C1202 (5202)** **Cause** - Mechanical defective in ESP OFF switch - Defective ESP OFF switch harness (short to ground) **Action** - Check the connection of the harness and connector for ESP OFF switch			**X**	**O**
Valve Monitoring	**Valve, valve relay**	C1301	Defective valve, valve relay in HECU	**ABS**	**ESP**
	Cause - Abnormal supplying voltage to valve solenoid - Internally defective HECU **Action** - Replace the HECU - Check the battery voltage - Check the HECU connector			**O**	**O**
Pump Monitoring	**Pump motor**	C1311	Defective pump motor	**ABS**	**ESP**
	Cause - Too low (below 6.0 V) or no supplying voltage to pump motor - Over 0.93 V of voltage from pump motor voltage - Poor contact in pump motor connector - Poor ground **Action** - Check the supplying voltage - Check the connection of the HECU connector - Replace the HECU			**O**	**O**
HECU and Sensor Monitoring	**HECU**	C1401	HECU-internal	**ABS**	**ESP**
	Cause - Internally defective HECU - Defective A/D converter, internal voltage regulator, and controller - Defective sensor and short to supplying voltage line - Abnormal temperature sensor signal **Action** - Replace the HECU			**O**	**O**

Function	Defective Components	Trouble Code	Descriptions	System	
CAN Communication Monitoring	**Sensor initialization**	C1501	Abnormal sensor initialization	**ABS**	**ESP**
	Cause - Abnormal signals from sensors - Abnormal sensor data **Action** - Check the sensors - Initialize the sensors			**X**	**O**
	Vehicle coding	C1170	Vehicle coding error or misinstallation of HECU	**ABS**	**ESP**
	Cause - Discrepancy between HECU coding and vehicle coding - Misinstallation of HECU - Defective CAN communication **Action** - Check the HECU coding and vehicle coding - Check engine ECU coding - Perform vehicle coding - Replace the exact HECU			**O**	**O**
	CAN communication	C1601	CAN communication error	**ABS**	**ESP**
	Cause - Short or open to CAN communication line - Poor connection of CAN communication line **Action** - Check the CAN communication line			**O**	**O**
	CAN communication	C1602	Communication error between CAN communication line and engine ECU	**ABS**	**ESP**
	1. C1602 **Cause** - Short circuit to CAN communication line - Overload to CAN communication **Action** - Check the engine ECU - Check the CAN communication line - Check the connection of the engine ECU connector			**X**	**O**

Modification basis	
Application basis	
Affected VIN	

Function	Defective Components	Trouble Code	Descriptions	System	
CAN Communication Monitoring	**CAN communication**	C1603 C1604 C1605	Communication error between TCU and CAN Communication error between TCCU and CAN Communication error between cluster (Meter) and CAN	**ABS**	**ESP**
	1. C1603 **Cause** - Short to CAN communication line - Overload to CAN communication **Action** - Check the A/T TCU - Check the CAN communication line - Check the connection of the TCU connector **2. C1604** **Cause** - Short to CAN communication line - Overload to CAN communication **Action** - Check the TCCU - Check the CAN communication line - Check the connection of the TCCU connector **3. C1605** **Cause** - Short to CAN communication line (communication with the cluster (meter)) **Action** - Check the CAN communication line - Check the connection of the cluster (meter) and connector - Replace the cluster (meter)			**X**	**O**
	CAN communication	C1612	Signal from engine ECU is abnormal	**ABS**	**ESP**
	Cause - Data error from engine ECU **Action** - Check engine ECU - Check the CAN communication line - Check the connection of the engine ECU connector			**O**	**O**

S.G.N. 4892-01

CAUTIONS WHEN REMOVING FRONT WHEEL SPEED SENSOR-ESP

The locking hub system (Part time 4WD) utilizes IWE (Integrated Wheel End) system that locks the 4WD depending on the vacuum condition within the actuator.
Thus, the wheel speed sensor is installed on the front wheel end area.
It is installed inside the backing plate to be protected from heat and foreign materials.
Therefore, the front wheel end system (including disc) should be removed before removing the front wheel speed sensor.

Front Wheel Speed Sensor

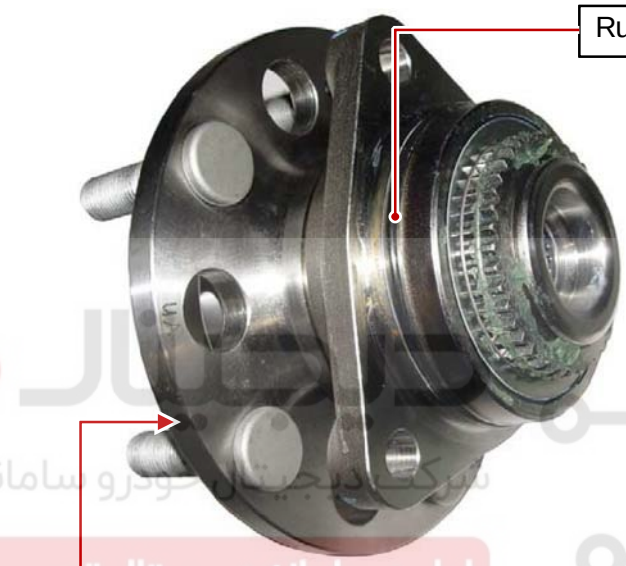
Rear Wheel Speed Sensor

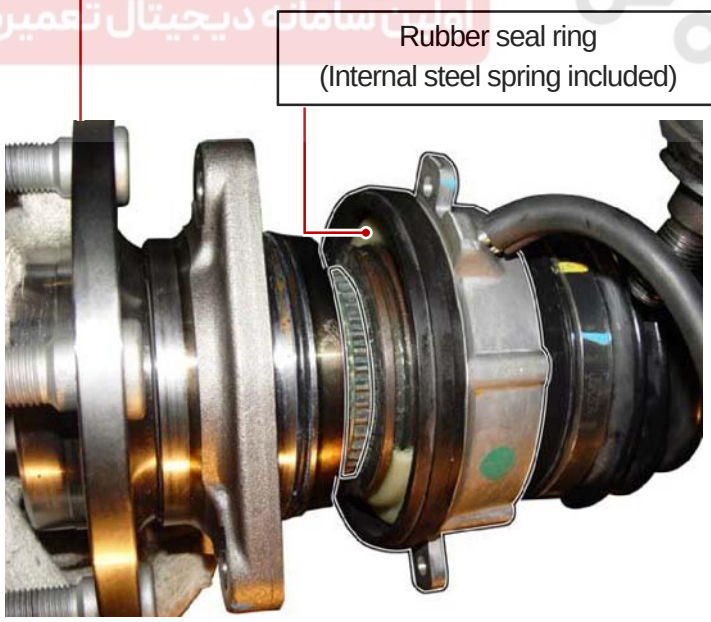
Wheel Speed Sensor

The wheel end should be removed before removing the wheel speed sensor.

Modification basis	
Application basis	
Affected VIN	

The rubber O-ring in IWE (Integrated Wheel End) should be replaced with new one when the front wheel end has been removed.
The rubber O-ring prevents moisture and foreign materials from entering the IWE system.
The hub actuator of the IWE system should be installed with the same angle with the drive shaft so that the inner rubber seal ring cannot be stuck. Also, the round steel spring is installed on the rubber seal ring.
If the rubber seal ring or the round spring is damaged, the actuator assembly should be replaced.





※ Please refer to the part time transfer case section for more specific information.

When the ESP system is added to the ABS system, some devices will be added to the ABS system including the HECU (Hydraulic & Electronic Control Unit) and wheel speed sensor.
The devices are as follows:

1. Two pressure sensors installed on the master cylinder
2. Sensor cluster (integrated yaw rate sensor and lateral sensor) and longitudinal sensor installed in IP. SWAS (Steering Wheel Angle Sensor) installed in the steering column.
3.

▶ Comparison with ABS System

Name	Specifications		Location
	ABS	ESP	
HECU (Hydraulic & Electronic Control Unit)	CPU: PEC 1 (32bit) Memory: 512 KB EEP ROM: 1KB	CPU: PEC 1 (32bit) Memory: 512 KB EEP ROM: 1KB	Side of brake booster
Wheel Speed Sensor	Active Type	Active Type	Mounted in each wheel (×4EA) Front airgap 2WD: 0.425 ~ 1.425 mm 4WD: 0.1 ~ 0.7 mm Rear airgap: 0.425 ~ 1.175mm
Steering Wheel Angle Sensor	N/A	Maximum angular velocity: 1500°/sec Working voltage: 9 ~ 16 V	In steering wheel
Sensor Cluster	N/A	Integrated yaw rate sensor, longitudinal and lateral sensors. Also, used for sensing G value for HDC (Hill Descent Control).	Under the center A/C panel of the instrument panel
Pressure Sensor	N/A	Analog Output	Under master cylinder

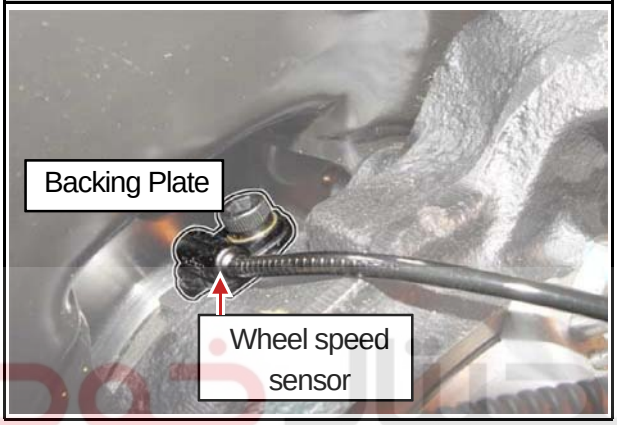
Modification basis	
Application basis	
Affected VIN	

S.G.N. 4892-01

CAUTIONS WHEN REMOVING FRONT WHEEL SPEED ABS

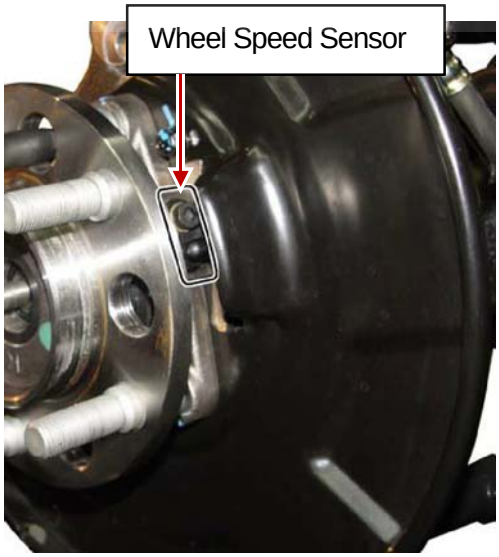
The locking hub system of the ACTYON part time 4WD utilizes IWE (Integrated Wheel End) system that locks the 4WD depending on the vacuum condition within the actuator.
Thus, the wheel speed sensor is installed on the front wheel end area. It is installed inside the backing plate to be protected from heat and foreign materials. Therefore, the front wheel end system (including disc) should be removed before removing the front wheel speed sensor.

Front Wheel Speed Sensor



Rear Wheel Speed Sensor

Wheel Speed Sensor



The wheel end should be remove before removing the wheel speed sensor.

Modification basis	
Application basis	
Affected VIN	

S.G.N. 4892-01

HECU-ESP

1. Disconnect the negative battery terminal.
2. Disconnect the ESP unit connector.

3. Disconnect the primary and secondary pipes between HECU and master cylinder.

Tightening torque

Master cylinder to HECU	13 ~ 20 Nm

4. Disconnect the front and rear wheel brake pipes.

Tightening torque

HECU to each hydraulic line	13 ~ 20 Nm

CAUTION
Be careful not to damage the HECU pipes and nut threads when reinstalling.

5. Unscrew two mounting nuts and remove the HECU.

Tightening torque

HECU mounting nut	4 ~ 8 Nm

CAUTION
Do not disassemble the removed HECU. Remove any foreign material on the openings of hydraulic pipe and seal it with tape.

Modification basis	
Application basis	
Affected VIN	

6. Install in the reverse order of removal.
7. Replenish with brake fluid and bleed air after installation. Refer to "Bleeding Using DSM" section.

CAUTION
- No coding is required when installing new HECU to the vehicle since it has automatic coding function.
- When installing HECU to another vehicle for test or any other reason, it is automatically coded with the vehicle's data.

8. Perform the variant coding.
9. Perform the sensor cluster calibration using "DSM". For the calibration procedure, refer to "Sensor calibration".

CAUTION
- Perform the variant coding and sensor cluster calibration if HECU or sensor cluster is replaced.

▶ Removal and Installation of Wheel Speed Sensor

Refer to "Wheel Speed Sensor in ABS system".

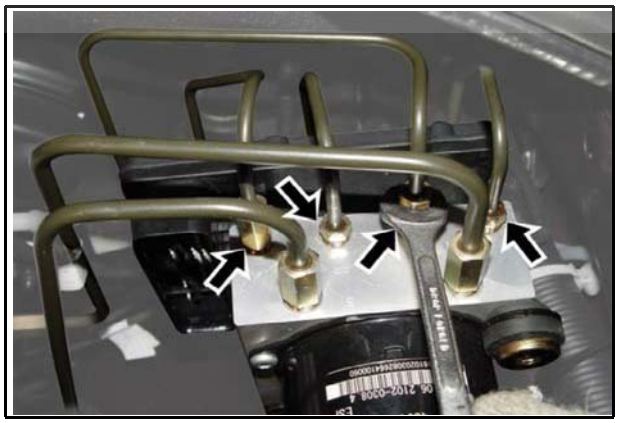
S.G.N.
4892-01 HECU-ABS

1. Disconnect the negative battery cable.
2. Disconnect the ABS hydraulic unit connector.

3. Disconnect the primary and secondary master cylinder pipes between HECU and master cylinder.

Tightening torque

Master cylinder - HECU	20 ~ 24 Nm



4. Disconnect the front and rear wheel brake pipes.

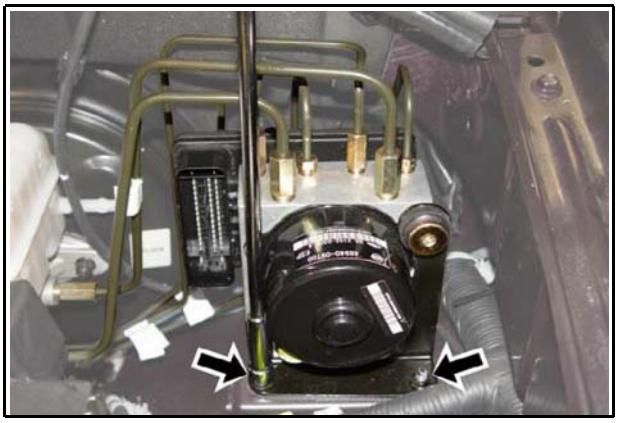
Tightening torque

HECU - Each hydraulic line	15 ~ 19 Nm

CAUTION

- If the thread of the hydraulic pipe and the thread of the HECU do not get fitted correctly when installing, the components may be damaged and the oil may be leaked.

Modification basis	
Application basis	
Affected VIN	



5. Unscrew two mounting nuts and carefully remove HECU.

Tightening torque

HECU mounting nut	4 ~ 8 Nm

CAUTION
- Do not attempt to disassemble the HECU assembly.
- Clean and Wrap the opening of pipes and HECU to prevent contamination.

6. Install in the reverse order of removal.
7. After reinstallation, add some oil and perform the brake air bleeding. Refer to the "Bleeding air using DSM" section.

CAUTION
- When you install a new HECU to the vehicle, coding is executed automatically.
  Thus, no additional coding is necessary.
  When installing HECU to another vehicle for test or any other reason, it is automatically coded with the vehicle's data.

8. Perform the variant coding.
9. Perform the sensor cluster calibration using "DSM".
   For the calibration procedure, refer to "Sensor calibration".

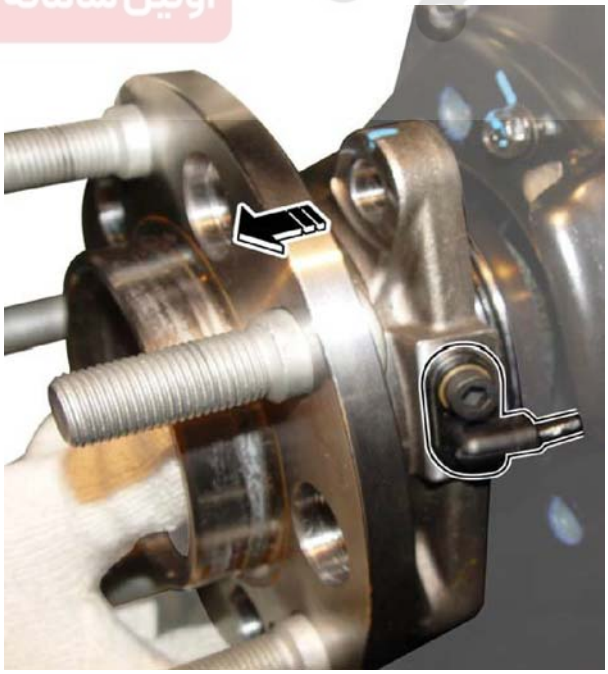
CAUTION
- Perform the variant coding and sensor cluster calibration if HECU or sensor cluster is replaced.

S.G.N.
4890-01

FRONT WHEEL SPEED SENSOR

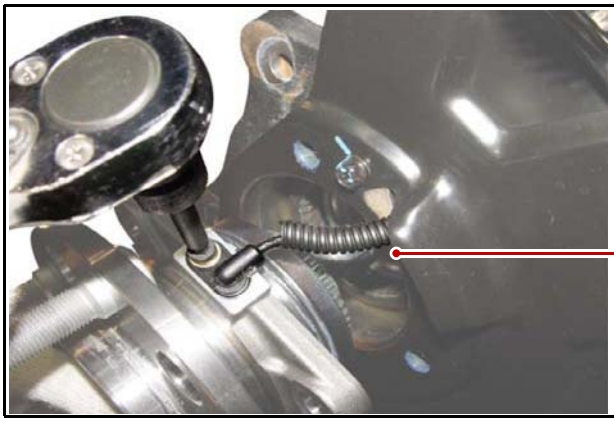
1. Disconnect the cable from the front upper arm and the front wheel speed sensor connector.

2. Remove the front brake disc. Loosen the hub end bolts (do not remove) and disconnect the wheel speed sensor.



Modification basis	
Application basis	
Affected VIN	

3. Remove one self-locking hexagon bolt.



When Installing

Keep the specified tightening torque and air gap.

Tightening torque

Front wheel speed sensor	2WD	6 ~ 8 Nm
	4WD	15 ~ 20 Nm
Air gap	2WD	0.475 ~ 1.425 mm
	4WD	0.1 ~ 0.7 mm

CAUTION

Tighten the bolts with the specified tightening torque.
Otherwise, the air gap between the wheel speed sensor and wheel rotor may be out of specified value, and this may cause an incorrect input value to HECU.

S.G.N. 4890-01 REAR WHEEL SPEED SENSOR

1. Disconnect the wheel speed sensor connector from under the rear seat. Set aside the wheel speed sensor cable to the wheel house side.



2. Remove one mounting bolt (10 mm) from the knuckle.
   Remove rear wheel speed sensor.


When Installing

Keep the specified tightening torque and air gap.

Tightening torque

Wheel speed sensor	6 ~ 8 Nm
Air gap (mm)	0.425 ~ 1.175

CAUTION

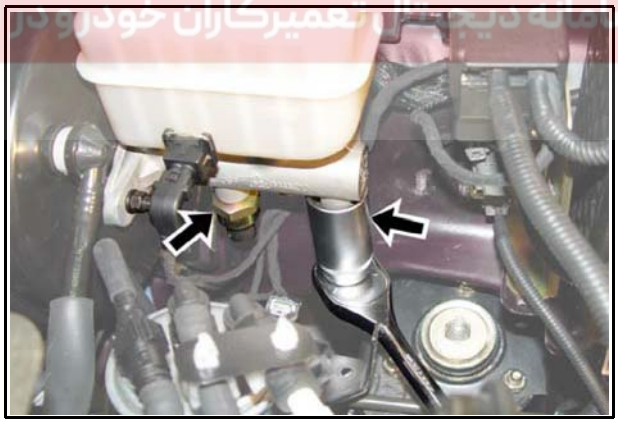
Tighten the bolts with the specified tightening torque.
Otherwise, the air gap between the wheel speed sensor and wheel rotor may be out of specified value, and this may cause an incorrect input value to HECU.

Modification basis	
Application basis	
Affected VIN	

S.G.N.
4850-01 PRESSURE SENSOR

1. Disconnect the battery negative terminal.
2. Remove the connector of the pressure sensor.

3. Remove the fuel filter bracket to remove the pressure sensor.
   Remove the fuel filter bracket.



4. Place an empty container under the pressure sensors to collect the oil.
5. Remove the primary and secondary pressure sensors.

When installing

Tightening torque 33 ~37Nm

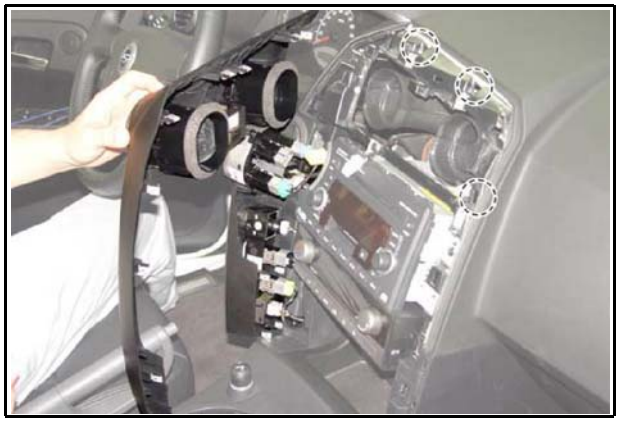
6. Install in the reverse order of removal.
7. Bleed the brake system after installation.

S.G.N. 4890-01

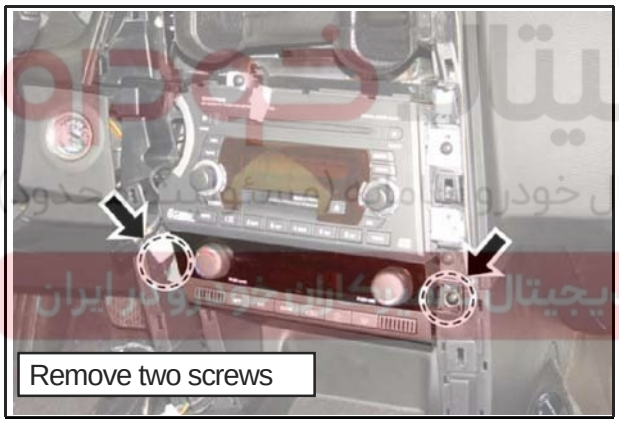
SENSOR CLUSTER

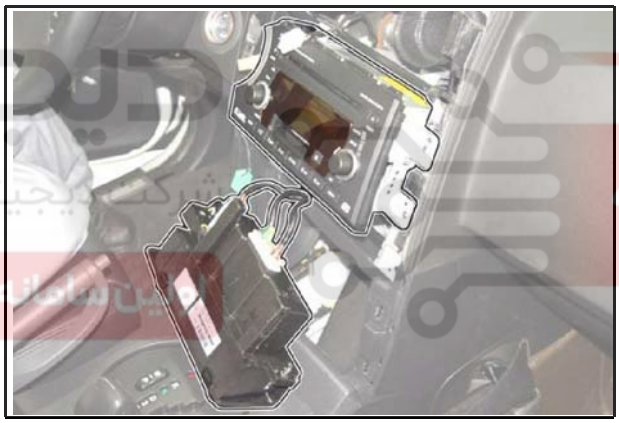
Preceding work 1. Disconnect the negative battery cable.

1. Separate the center fascia panel and disconnect the connector to remove the center fascia panel.



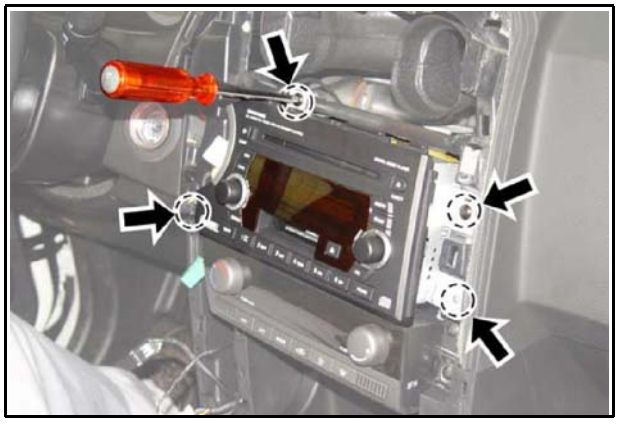
2. Unscrew two A/C controller mounting screws and remove the A/C controller.

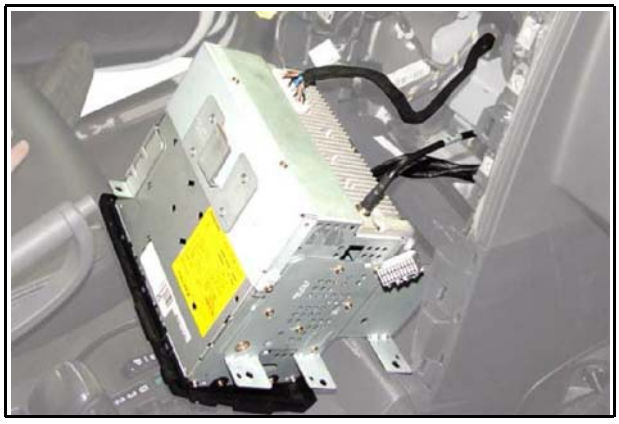




3. Remove the mounting screw and disconnect the connectors to remove the AV head unit assembly.

CAUTION
AV head unit may have different connectors according to the specifications.





Modification basis	
Application basis	
Affected VIN	

4. Unscrew the cluster mounting bolts at both sides and disconnect the connector.

When installing

Tightening torque 10Nm

5. Install in the reverse order of removal.

CAUTION

- The installing direction and location are very important when installing the sensor cluster. Make sure that there are not any foreign material and interference with floor carpet on the mounting surface.
- Sensors are integrated into the sensor cluster. Therefore, be careful not to impact on them when removing and installing.

6. Make sure to perform the sensor cluster calibration after replacing the sensor cluster. For the calibration, refer to "Sensor Calibration (Initialization)".

Modification basis	
Application basis	
Affected VIN	

Memo