ANTI-BRAKE SYSTEM

4892-01

GENERAL

1. REPAIR INSTRUCTIONS

1) ON-VEHICLE SERVICE

(1) Service Precautions

NOTE

Brake Fluid may irritate eyes and skin. In case of contact, take the following actions:
- Eye contact - rinse thoroughly with water.
- Skin contact - wash with soap and water.
- Ingestion - consult a physician immediately.

To help avoid personal injury due to poor braking. DO NOT Tap into the vehicle's brake system to operate a trailer brake system.

When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread-locking compound will be called out. The correct torque values must be used when installing fasteners that require them. If the above procedures are not followed, parts or system damage could result.

Use only DOT-3 equivalent hydraulic brake fluid. The use of DOT-5 (silicone) brake fluid is not recommended. Reduced brake performance or durability may result.

Avoid spilling brake fluid on any the vehicle's painted surfaces, wiring, cables or electrical connectors. Brake fluid will damage paint and electrical connections. If any fluid is spilled on the vehicle, flush the area with water to lessen the damage.

(2) Electronic system service precautions

Take care to avoid electronic brake control module (HECU) circuit overloading. In testing for opens or shorts, do not ground or apply voltage to any circuit unless instructed to do so by the diagnostic procedure. Test circuits only with a high-impedance multi-meter. Never remove or apply power to any control module with the ignition switch in the ON position. Always turn the ignition to the OFF position before removing or connecting battery cables, fuses or connectors.

(3) General service precautions

Disconnect the HECU connector before performing any vehicle welding work using an electric arc welder. Do not attempt to disassemble any component designated as nonserviceable. The hydraulic modulator and the HECU cannot be separated from each other. They have no replaceable parts, and there is no replaceable parts, and there is no access to the components they contain.

(4) Bleeding system

Replacement modulators are shipped already filled and bled. In normal procedures requiring removal of the modulator, such as to replace the HECU, air will not enter the modulator, and normal bleeding will be all that is needed. If air enters the hydraulic modulator, or if an unfilled modulator is installed, use the brake bleeding program in the scan tool to bleed the modulator. Manual bleeding of the hydraulic modulator is not possible.

Modification basis	
Application basis	
Affected VIN	

OVERVIEW AND OPERATION PROCESS

1. SUMMARY

The aim of the ABS is to mmaintain steerability and driving stability and to take the burden off the driver. If the stopping distance is shorter on some road surfaces (carriageway conditions), this is a gift of physics and not a development aim.
ABS is a device which senses that one or more of the wheels are locking up during braking. It monitors the rotational speeds of the wheels and reduces hydraulic pressure to any wheel it senses locking up. It is controlled by both mechanical and electronic components. When you apply the brakes, the ABS will regulate the flow of brake fluid being delivered to the brake calipers. By the use of electronic computers, the brakes rapidly alternate (at a rate of 30 times per second) from full pressure to full release.

1) DRIVING PHYSICS

To give you a better understanding of the tasks and functions of ABS, we will first look at the physics principles.

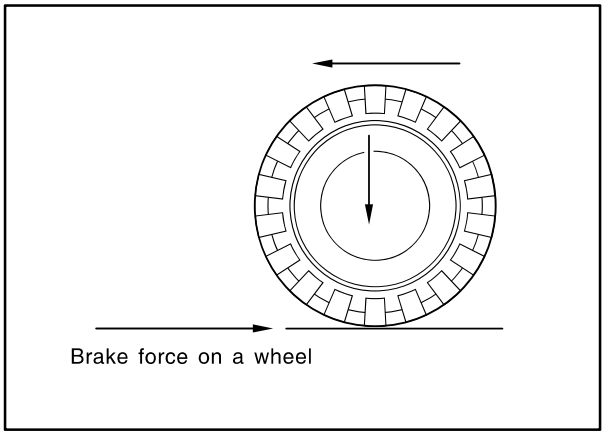
(1) The Stopping Distance

The stopping distance depends on the vehicle weight and initial speed when braking starts. This also applies for vehicle with ABS, where ABS always tries to set an optimum brake force on each wheel. As great forces are exerted between the tires and the carriageway when braking, even with ABS the wheels may scream and rubber is left on the road. With an ABS skid mark one may be able to clearly recognize the tire profile. The skid mark of an ABS vehicle does not however leave any hint of the speed of the vehicle in the case of an accident, as it can only be clearly drawn at the start of braking.

(2) Brake Force On A Wheel

The maximum possible brake force on a wheel depends on the wheel load and the adhesion coefficient between tire and carriageway. With a low adhesion coefficient the brake force, which can be obtained is very low. You are bound to know the result already from driving on winter roads. With a high adhesion coefficient on a dry road, the brake force, which can be obtained, is considerably higher. The brake force, which can be obtained, can be calculated from below formula:

(3) Maximum brake force


Brake force on a wheel

FB_{max} = Wheel load F_R x Adhesion coefficient$_{mh}$

The braking process cannot be described sufficiently accurately with the brake forces calculated. The values calculated only apply if the wheel is not locked. In the case of a locking wheel, the static friction turns into lower sliding friction, with the result that the stopping distance is increased. This loss of friction is termed "slip" in specialist literature.

(4) Slip

The brake slip is the difference between the vehicle speed and the wheel circumference speed. If the wheel locks, the slip is greatest, that is 100 %. If the wheel is running freely and unbraked, the slip is the lowest, equal to 0 %. Slip can be calculated from the vehicle speed Vveh and the wheel speed Vw. The equation for this is:

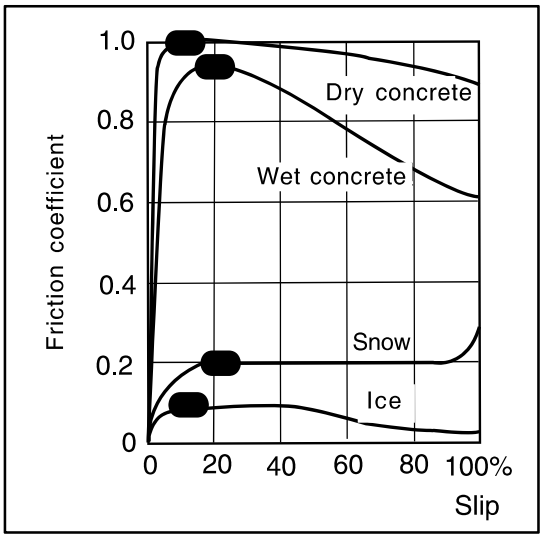
$$S = \frac{V_{veh} - V_w}{V_{veh}} \text{ X } 100\ \%$$

V_{veh} = 100 km/h, V_w = 70 km/h

$$S = \frac{100 - 70}{100} \text{ X } 100\ \%$$

Modification basis	
Application basis	
Affected VIN	

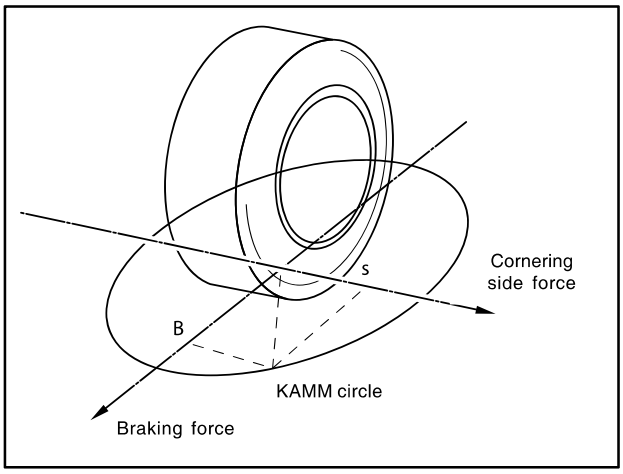
(5) Typical slip curves



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

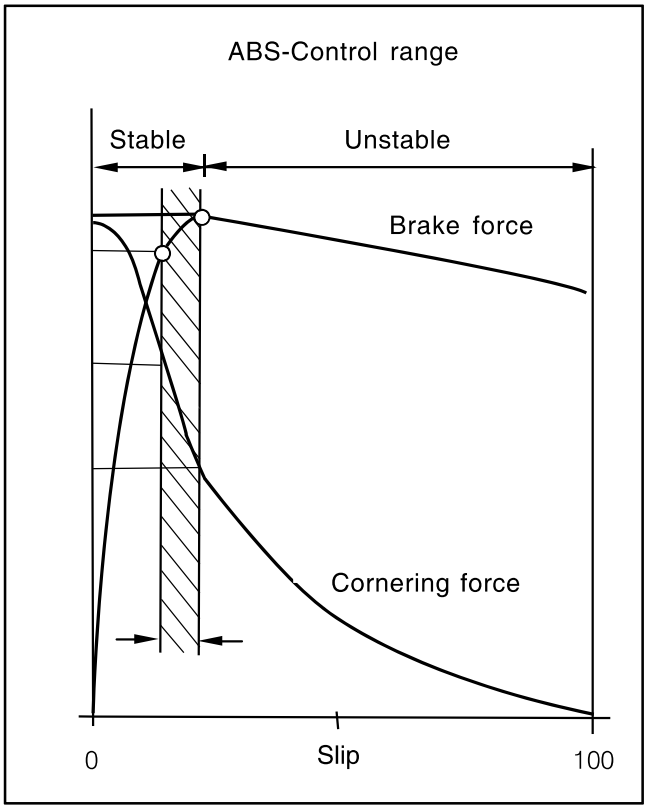
The reason for this is based in physics and not in the Anti-Lock System. However, as mentioned before, ABS is not about the stopping distance, but maneuverability and driving stability, for with ABS you can steer round an obstacle. A device with locking wheels without ABS cannot be steered. So what use then is the shorter stopping distance if the vehicle has already hit the car in front, because you did not have a chance to steer round the obstacle?

(6) Kamm circle



Before we go into the Kamm circle, you should know that a tire offers a maximum of 100 % transmissibility. It is all the same for the tire whether we require 100 % in the direction of braking or in the direction of the acting lateral force, e.g. when driving round curves. If we drive into a curve too fast and the tire requires 100 % transmissibility as cornering force, the tire cannot transmit any additional brake force. In spite of the ABS the car is carried out of the curve. The relationship between brake force B and cornering force S is shown very clearly in the Kamm circle. If we put a vehicle wheel in this circle, the relationship becomes even clearer. In this relationship: as long as the acting forces and the resulting force remain within the circle, the vehicle is stable to drive. If a force exceeds the circle, the vehicle leaves the road.

(7) Brake and cornering force



▶ **Brake force**

When depressing the brake pedal the brake force increases to the maximum, then the brake force decreases until the wheel locks.

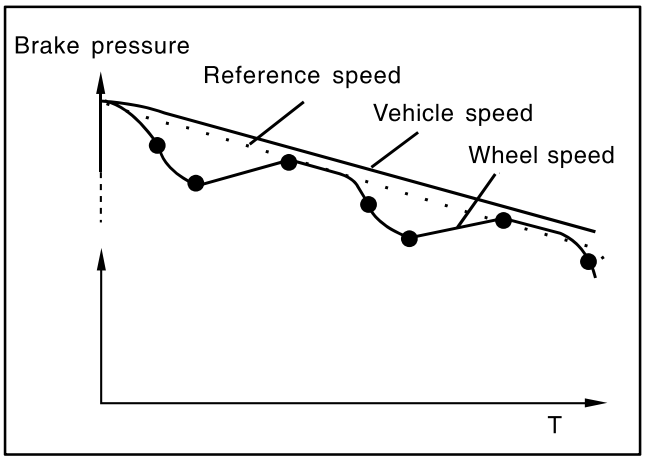
▶ **Cornering force**

The cornering force is a maximum when the wheel is turning freely with zero slip. When braking the cornering force falls to zero if the wheel locks (slip 100 %).

▶ **ABS operating range**

The operating range starts just before the maximum brake force and ends in maximum, for the unstable range then begins, in which no further modulation is possible. The ABS controls the regulation of the brake pressure so that the brake force only becomes great enough for a sufficient proportion of cornering force to remain. With ABS we remain in the Kamm circle as long as the car is driving sensibly. We will leave driving physics with these statements and turn to the braking systems with and without ABS.

(8) Basic ABS Controls



Applications of the ABS control unit The signals produced by the wheel sensors are evaluated in the electronic control unit. From the information received, the control unit must first compute the following variables:

- Wheel speed
- Reference speed
- Deceleration
- Slip

Modification basis	
Application basis	
Affected VIN	

(9) Reference speed

The reference speed is the mean, I.e. average speed of all wheel speeds determined by simple approximation.

▶ Simplified ABS control

If, during braking, one wheel speed deviates from the reference speed, the ABS control unit attempts to correct that wheel speed by modulating the brake pressure until it again matches the reference speed. When all four wheels tend to lock, all four wheels speeds suddenly deviate from the previously determined reference speed. In that case, the control cycle is initiated again in order to again correct the wheel speed by modulating the brake pressure.

▶ Selector low control

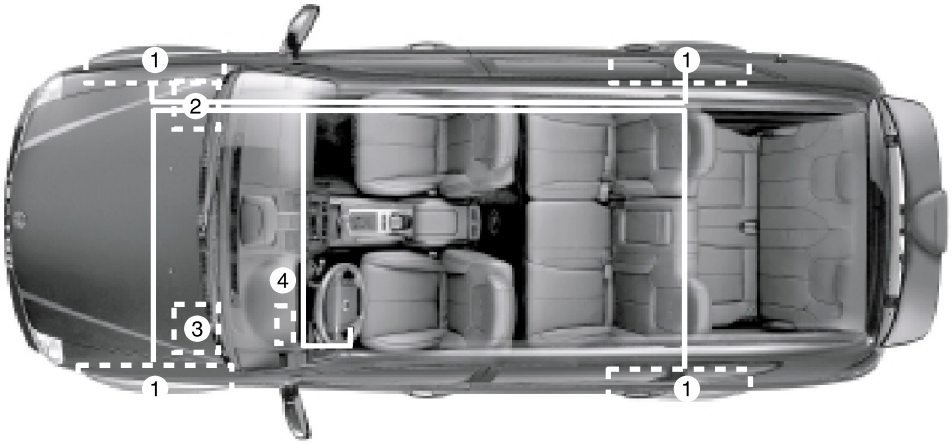
This control is used for regulating the brake pressure for rear axle during ABS operation. This control uses lower adhesion coefficient to prevent the rear wheels from locking.

2. SYSTEM LAYOUT

Newly introduced ABS has a different shape of integrated hydraulic modulator and HECU (Hydraulic and Electronic Control Unit) compared to existing ABS. And, the wheel speed sensor uses different method to detect wheel speed. The basic function of the ABS that maintains the vehicle stability by controlling the steerability of the vehicle when braking has not been changed.

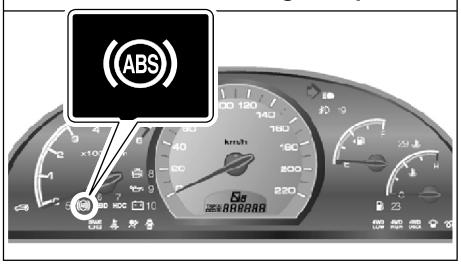
1. Wheel speed sensor

2. ABS HECU



3. Brake master cylinder

4. ABS warning lamp

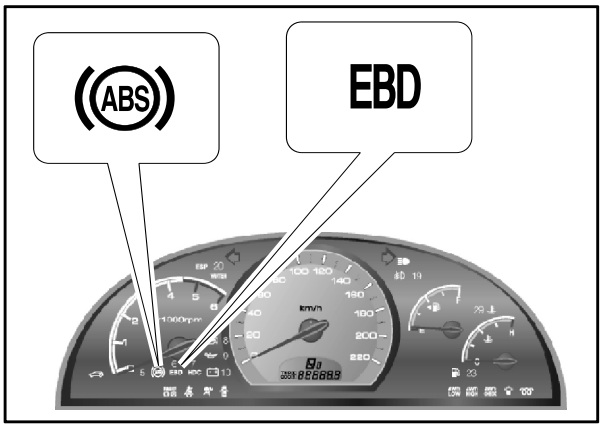


Modification basis	
Application basis	
Affected VIN	

1) SYSTEM FUSE

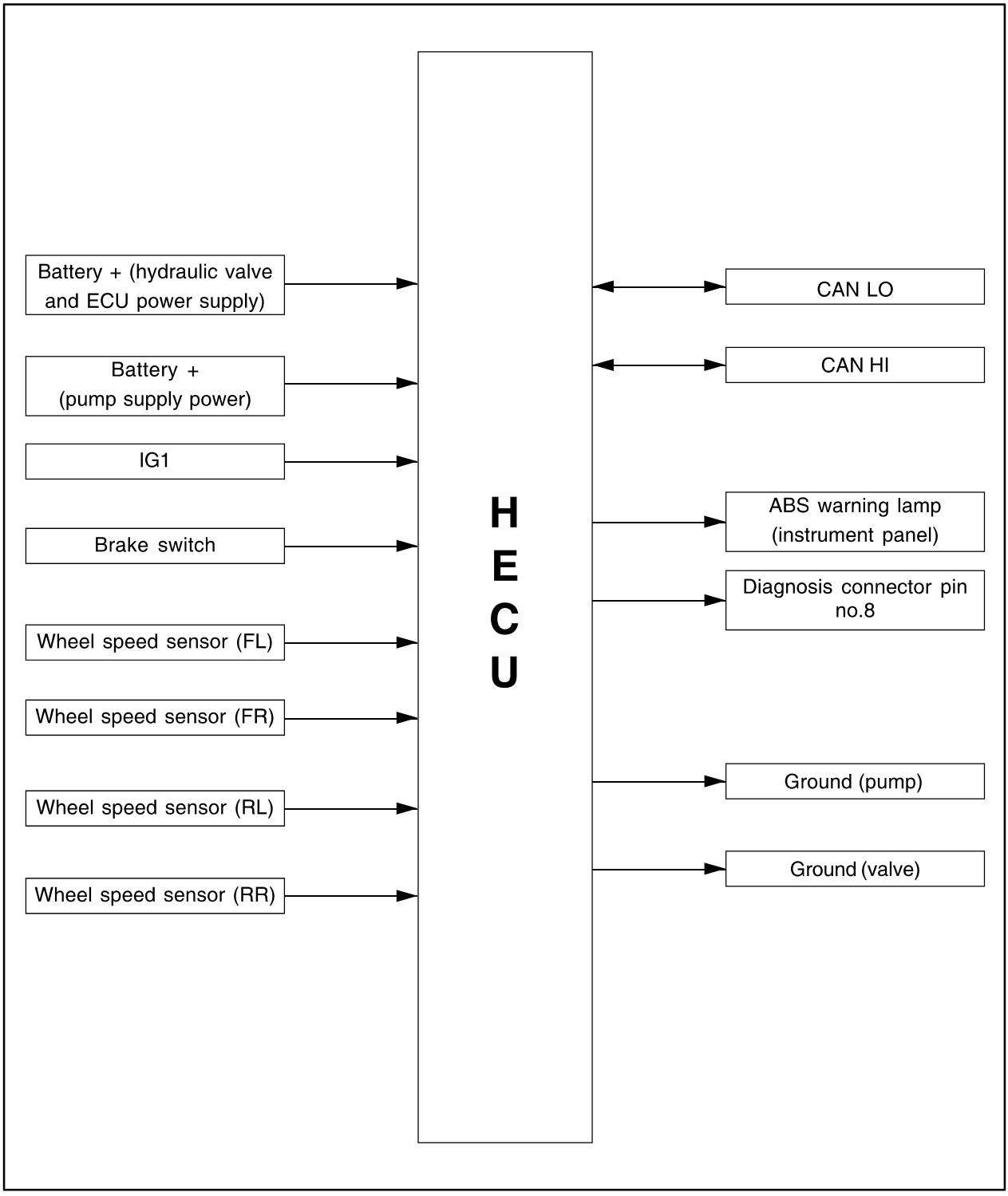
The ABS/TCS system fuse and SB2 is located at the fuse box in engine compartment.

2) INDICATORS



The ABS and TCS indicators are in instrument cluster.

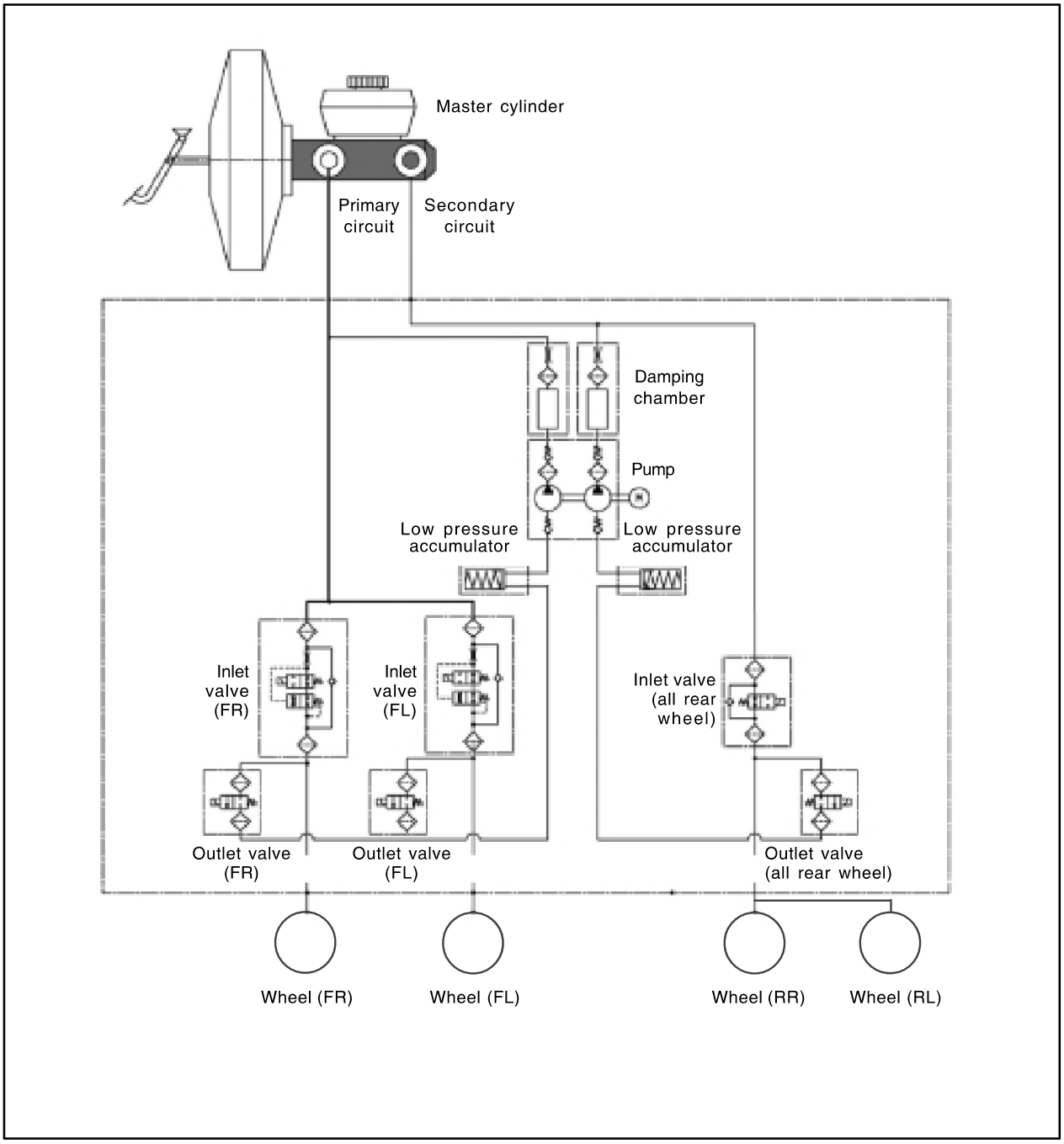
3. INPUT AND OUTPUT DIAGRAM OF ABS UNIT



Modification basis	
Application basis	
Affected VIN	

4. HYDRAULIC CIRCUIT DIAGRAM

1) ABS HYDRAULIC CIRCUIT DIAGRAM

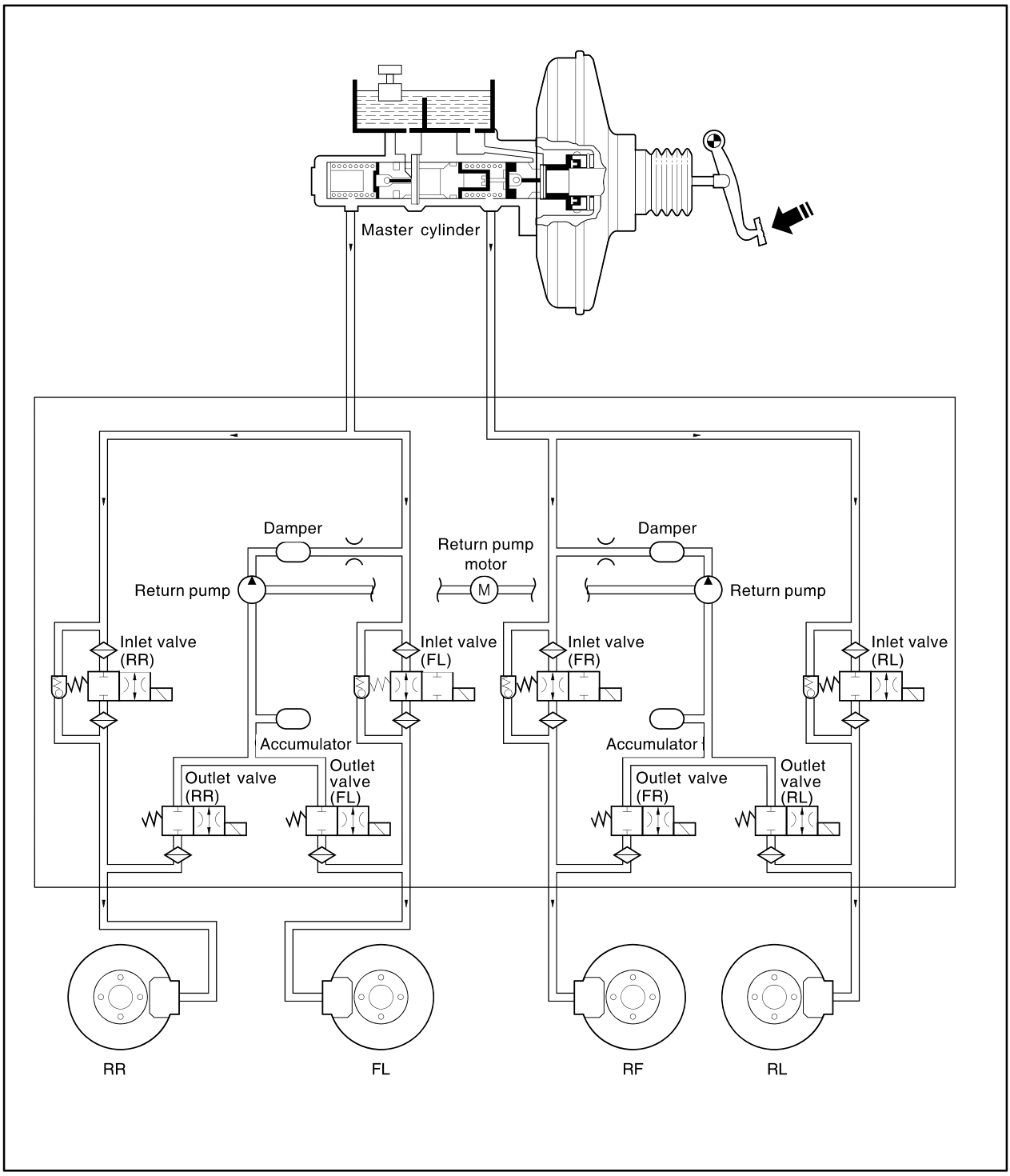


The vehicle equipped only with the ABS controls the wheel's braking force using three 3-channel 4-sensor method. The front wheels that are the primary circuit of the brake system is composed of two wheel speed sensors and two channel valves system with two inlet valves and two outlet valves. The rear 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.

2) ABS/EBD HYDRAULIC CIRCUIT DIAGRAM

▶ When the EBD is Operating

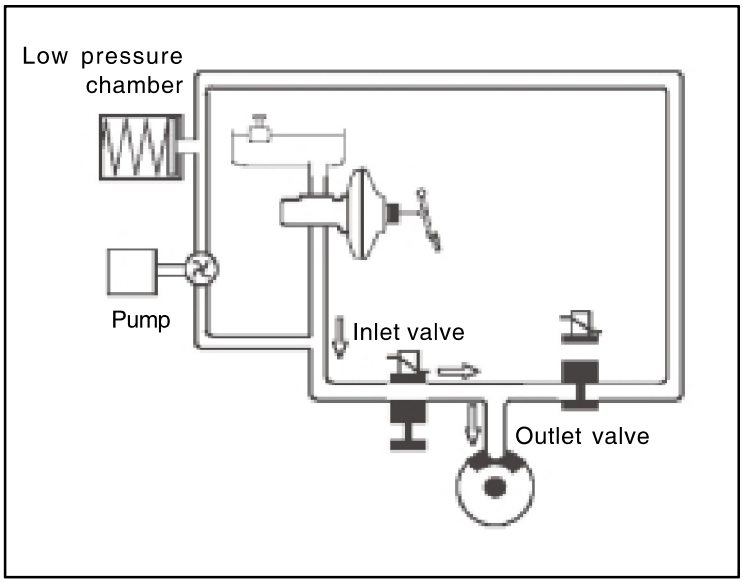
To prevent the rear wheels locking when braking, HECU receives the signals from wheel speed sensors and brake signals to calculate the reduced braking speed, and controls the brake pressure to rear wheels by operating the intake 2-channel valve to provide the optimal braking conditions.



Modification basis	
Application basis	
Affected VIN	

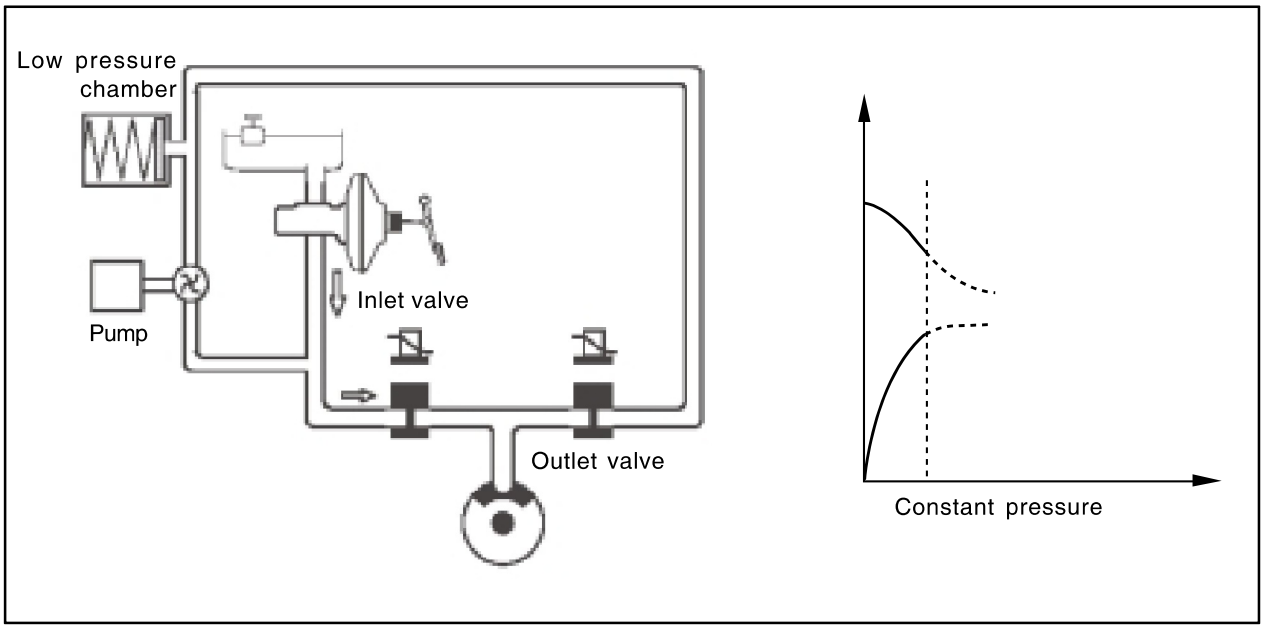
3) ABS HYDRAULIC CIRCUIT PER ABS OPERATION RANGE

▶ 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 .

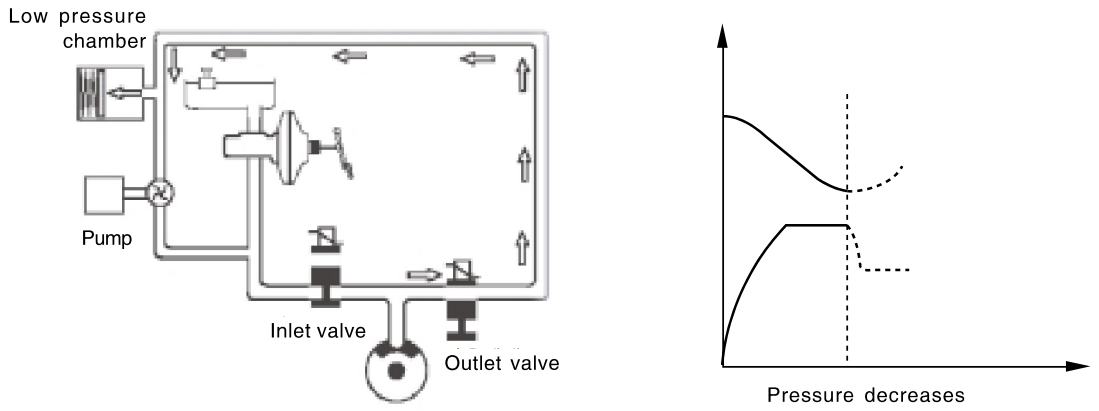
▶ No Hydraulic Pressure Circuit when ABS is Operating



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.

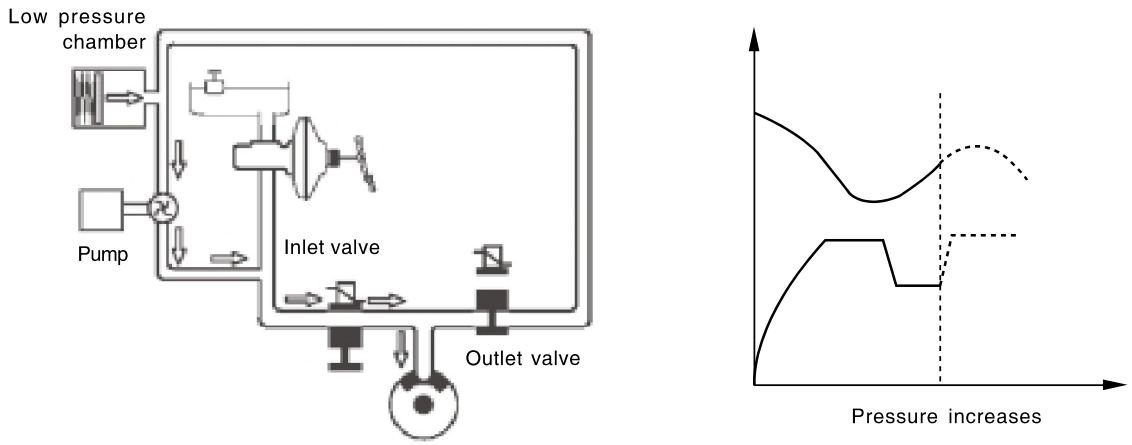
Modification basis	
Application basis	
Affected VIN	

▶ 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 changer 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 noises

▶ 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 and the wheel speed decreases as the hydraulic pressure at wheel increases. This operation continues repetitively until there are no signs that the 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	

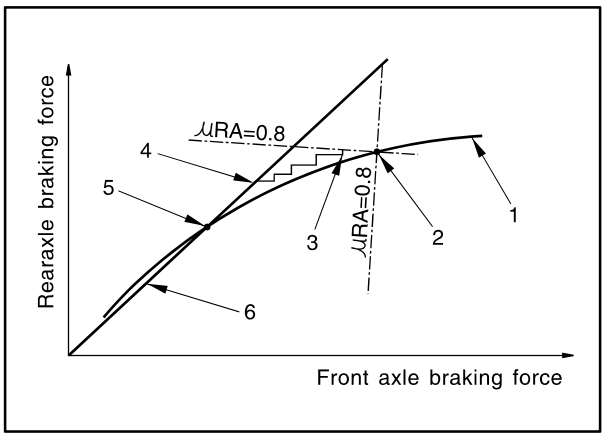
5. EBD (ELECTRONIC BRAKE FORCE DISTRIBUTION) SYSTEM

1) System Description

As an add-on logic to the ABS base algorithm, EBD works in a range in which the intervention thresholds for ABS control are not reached yet.
EBD ensures that the rear wheels are sensitively monitored for slip with respect to the front axle. If slip is detected, the inlet valves for the rear wheels are switched to pressure hold to prevent a further increase in pressure at the rear-wheel breaks, thus electronically reproducing a pressure-reduction function at the rear-wheel brakes.
ABS features an enhanced algorithm which includes control of the brake force distribution between the front and rear axles. This is called Electronic Brake Distribution. In an unloading car condition the brake efficiency is comparable to the conventional system but for a fully loaden vehicle the efficiency of the EBD system is higher due to the better use of rear axle braking capability.

2) The Benefits of EBD

- Elimination of conventional proportioning valve EBD utilizes the existing rear axle wheel speed sensor to monitor rear wheel slip.
- Based on many variables in algorithm a pressure hold, increase and/or decrease pulsetrain may be triggered at the rear wheels insuring vehicle stability.
- Vehicle approaches the ideal brake force distribution (front to rear).
- Constant brake force distribution during vehicle lifetime.
- EBD function is monitored via ABS safety logic
  (conventional proportioning valves are not monitorable).
- "Keep alive" function.



▶ Service precautions

Observe the following general precautions during any ABS/ TCS service. Failure to adhere to these precautions may result in ABS/TCS system damage.

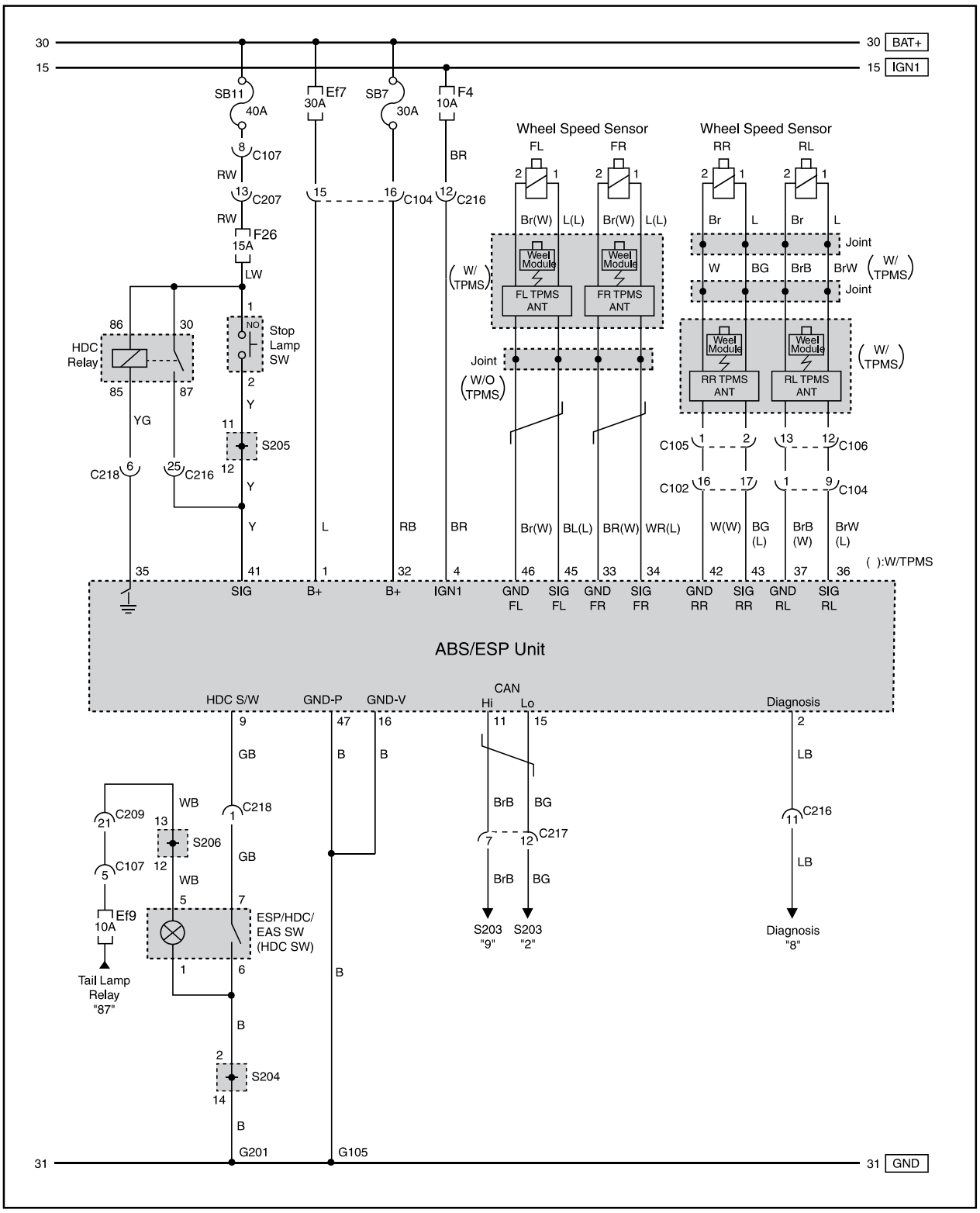
1. Disconnect the EBCM harness connector before performing the electric welding procedures.
2. Carefully note the routing of the ABS/TCS wiring and wring components during removal. The ABS/TCS components are extremely sensitive to EMI (eletromagnetic interference). Proper mounting is critical during component service.
3. Disconnect the EBCM connector with the ignition OFF.
4. Do not hang the suspension components from the wheel speed sensor cables. The cables may be damaged.
5. Do not use petroleum based fluids in the master cylinder. Do not use any containers previously used for petroleum based fluids. Petroleum causes swelling and distortion of the rubber components in the hydraulic brake system, resulting in water entering the system and lowering the fluid boiling point.

Modification basis	
Application basis	
Affected VIN	

6. ELECTRIC CIRCUIT DIAGRAM

1) ABS

▶ W/SPEED SENSOR, STOP LAMP SW, DIAGNOSIS, HDC, TPMS (ABS/ESP)



Modification basis	
Application basis	
Affected VIN	