

# ABS (ANTI-LOCK BRAKE SYSTEM) (WABCO MAKE)

BR03-001

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# ABS

## OVERVIEW

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ABS is a system that makes effective use of the friction between the tires and the road surface to maintain vehicle stability while the brakes are being applied and for stopping the vehicle.

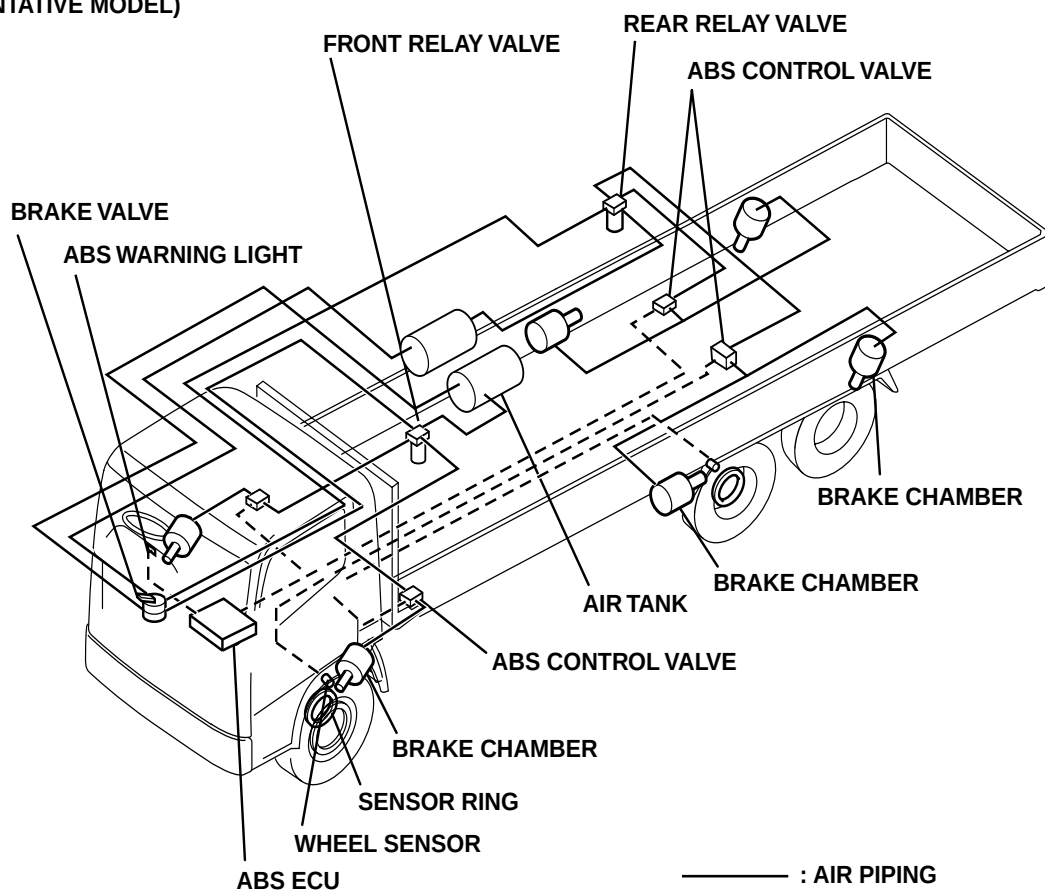
Applying the brakes forcefully on a slippery road surface can cause the wheels to be locked, due to excessive braking force. This causes the vehicle to lose a stability because the locked wheels lose resistance in the lateral direction. More specifically, if the front wheels are locked, it becomes impossible to steer the vehicle, and if the rear wheels are locked, the rear of the vehicle may fishtail from side to side.

Also, when wheel-locking occurs, it is not possible to make effective use of friction between the tires and the road surface. This may cause the braking distance to be increased.

ABS uses wheel sensors mounted on the axles to constantly monitor the rotation of the wheels. If any of the wheels is starting to lock up, the ABS ECU sends signals to the ABS control valve and immediately adjusts the brake pressure to prevent wheel-locking.

In this way, ABS maintains the stability of the vehicle while stopping by making effective use of the friction between the tires and the road surface.

(REPRESENTATIVE MODEL)



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COMPOSITION AND OPERATION

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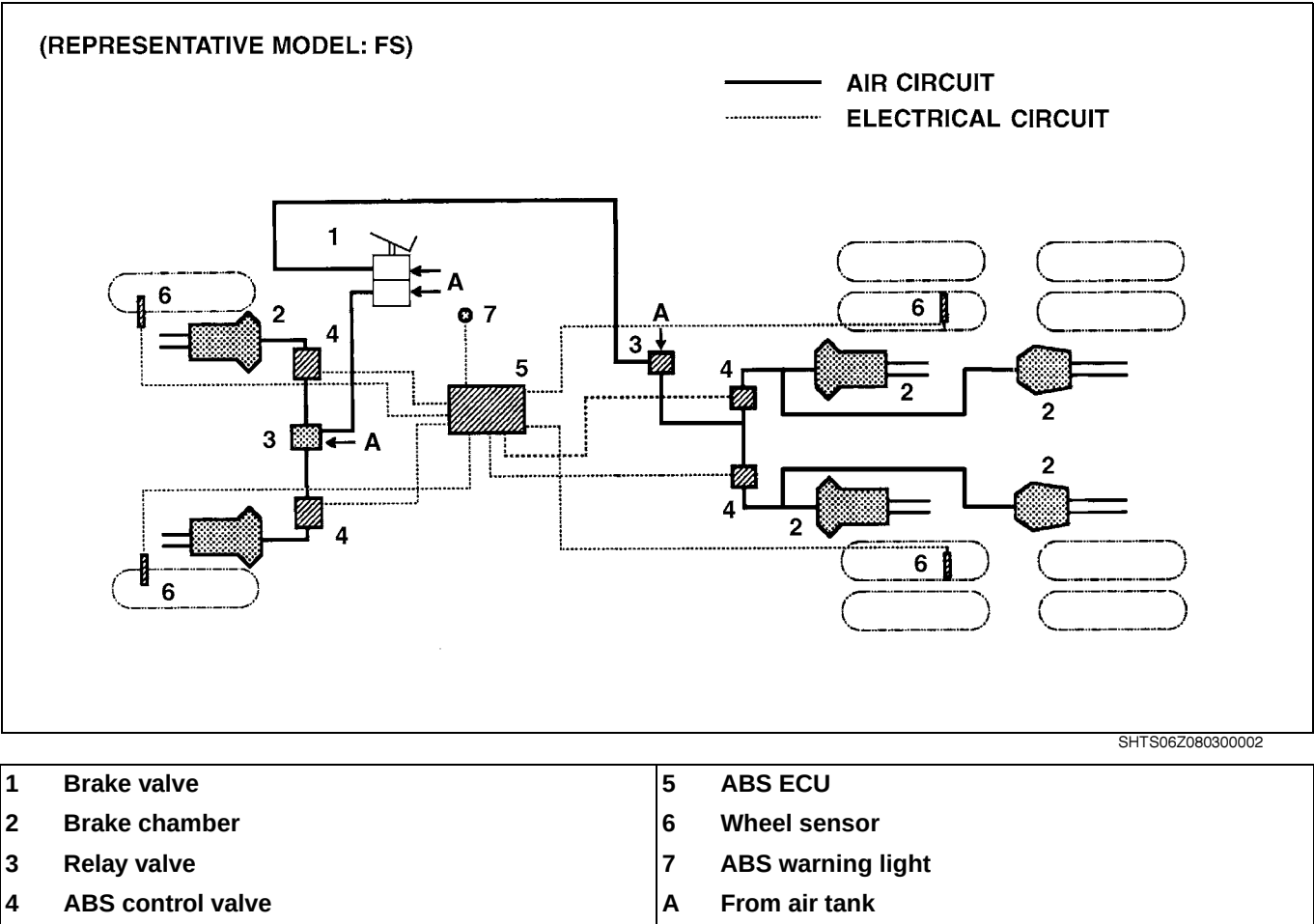
The ABS system is comprised of the sensor rings mounted on the wheels, the ABS ECU, which receives signals from the wheel sensors that monitor the rotational speed of the wheels and outputs control signals to maintain the appropriate braking force; ABS control valves, which increase or decrease the braking force, based on the control signals; the warning light, which gives an alarm if the system malfunctions; the piping, wire harnesses, etc., that link together the various units that compose the system.

Pulse signals transmitted by the sensor rings mounted on the wheel hubs, rotated together with the wheels, and the wheel sensors mounted near sensor ring on the axles are sent to the ABS ECU. The ABS ECU then calculates the wheels' rotational speed, acceleration, deceleration, and amount of slippage, based on these signals.

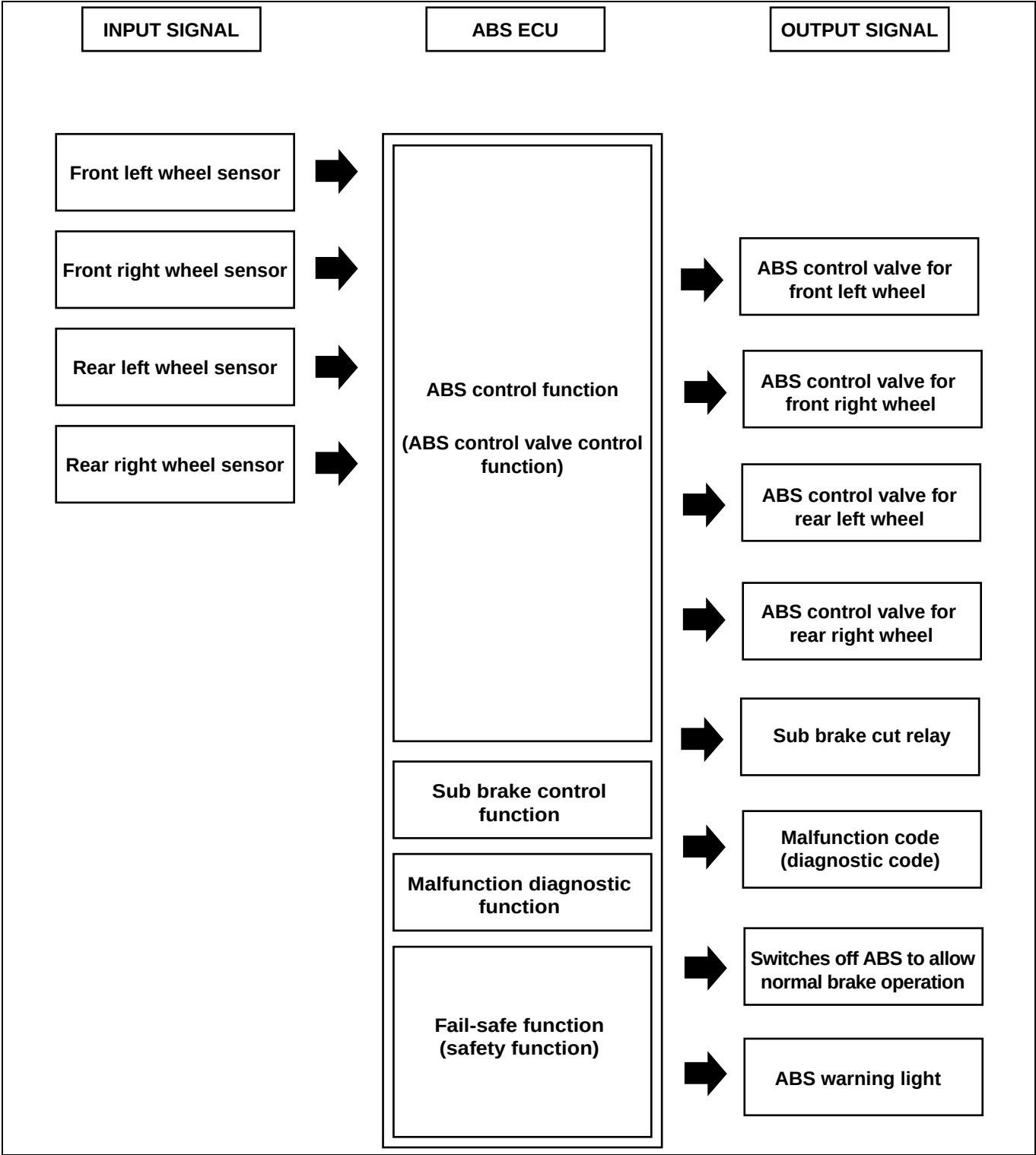
If the limit values for the wheel's deceleration, or slippage ratio are exceeded, the ABS ECU immediately transmits signals to the ABS control valves to adjust any excess braking force.

This ABS system controls the four wheels, front, rear, right, and left, independently.

SYSTEM COMPOSITION DIAGRAM



ABS CONTROL FLOWCHART



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## BASIC PRINCIPLE

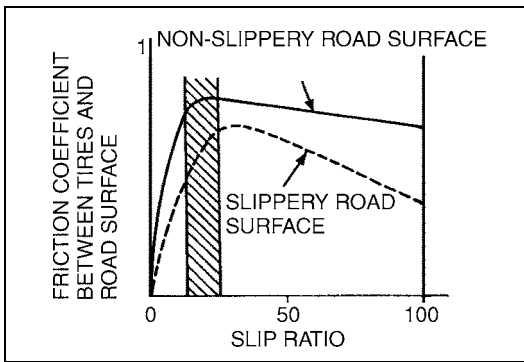
Based on its relationship with the slip ratio, which is determined from the wheels' rotational speed and the vehicle's speed, ABS controls the brake force so that it will be most effective.

When the driver applies the brakes, the rotation of the wheels is controlled and the vehicle speed drops. However, the momentum of the vehicle attempts to push it forward further even though the rotation of the wheels is being braked. At this point, slipping will occur if there is a gap between the wheels' rotational speed and the vehicle's speed. The slip ratio is a value that indicates the rate of slippage.

$$\text{Slip ratio} = \frac{\text{Vehicle's speed} - \text{Wheel's rotational speed}}{\text{Vehicle's speed}} \times 100 \%$$

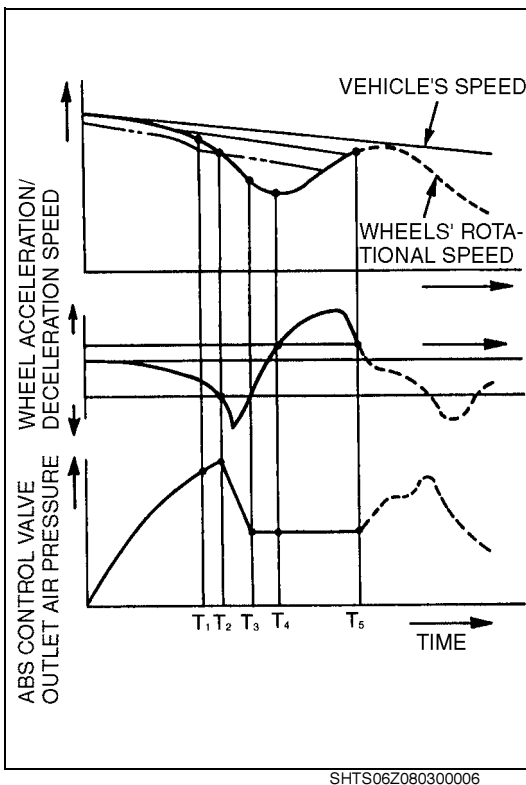
**Slip ratio 0 %:** No slipping between the wheels and the road surface

**100 %:** Wheels locked



The graph shown at left shows the relationship between the friction coefficient of the tires and of the road surface and the slip ratio.

In an ABS-equipped vehicle, the brake force is controlled to ensure that it is within the range where the friction coefficient is high (shaded portion of the graph) without locking the wheels. This ensures efficient braking performance.



## OPERATION

The ABS control characteristics line graph at left illustrates how the vehicle's speed, the wheels' rotational speed, the wheel acceleration/deceleration, and the air pressure at the ABS control valve outlet change over time after the brakes are applied.

When the brakes are applied, the vehicle's speed and the wheels' rotational speed drop and at the same time, the wheel acceleration/deceleration speed also drops. At point T1, a gap begins to open between the wheels' rotational speed and the vehicle's speed. Passing on point T2, the ABS ECU detects that the wheels are beginning to lock and is lowering the outlet air pressure of the ABS control valve to prevent wheel locking from occurring.

At point T3, the wheel acceleration/deceleration speed is starting to return to normal one, and the ABS ECU stops lowering the air pressure at the ABS control valve outlet and maintains it at a constant level.

At point T5, the wheels' rotational speed and the vehicle's speed are about the same. The ABS ECU detects that the wheels are no longer likely to be locked and increases the air pressure at the ABS control valve outlet.

The above processes is repeated over and over until the vehicle comes to a complete stop.

## FUNCTION

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### FAIL-SAFE FUNCTION

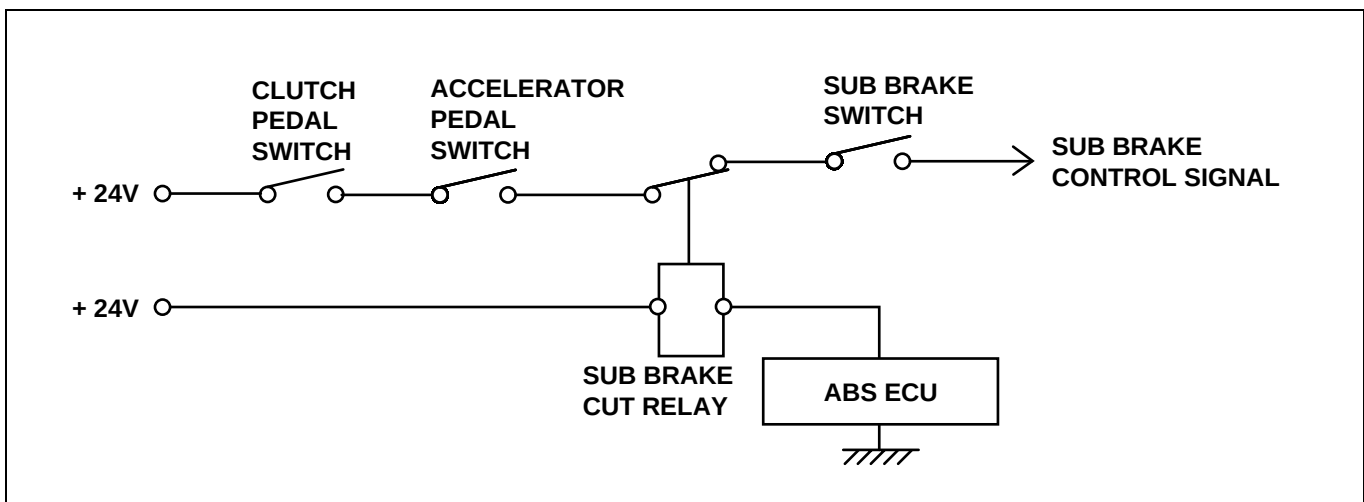
This ABS system is equipped with a fail-safe function that causes the ABS warning light on the instrument panel to light and to restore the normal (non-ABS) brake system, should an ABS malfunction occur.

Note that the ABS system consists of two independent circuits. Should a malfunction occur for whatever reason in the electrical circuits, that system's ABS is switched off and the normal brake system is restored while ABS control continued for the other system. This configuration is designed to minimize the effects of any malfunction on ABS function.

### SUB BRAKE CONTROL FUNCTION

The ABS system of this vehicle is equipped with a function that controls the sub brake while ABS is operating.

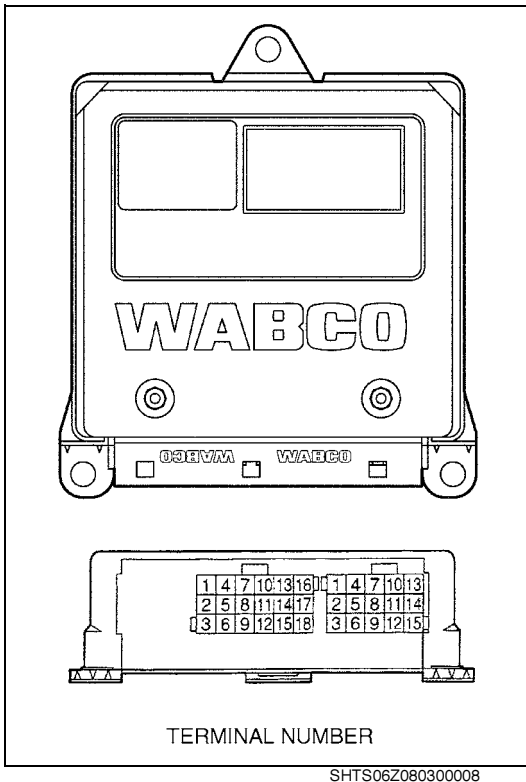
If the sub brake is applied independently or together with the service brake on a road surface with very low friction coefficient, the driving wheels may lock. This ABS system prevents the driven wheels from locking in such cases by automatically releasing the sub brake, if necessary, during ABS operation.



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## OVERVIEW AND FUNCTION

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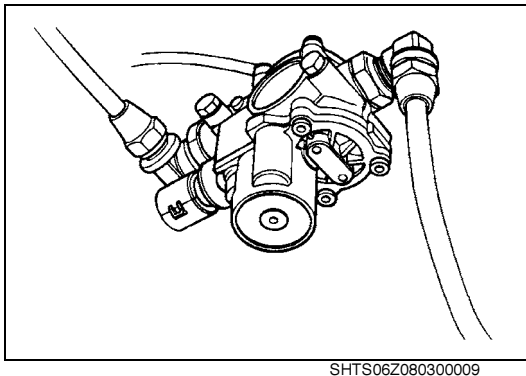


### 1. ABS ECU

Based on pulse signals from the wheel sensors, the ABS ECU mounted in the vehicle calculates and evaluates the slip ratio and the acceleration/deceleration speed of the wheels. Based on the results, it sends signals to the various control valves as necessary, causing them to operate and apply the brakes to maintain the slippage of the wheels within the optimal range.

During braking, the air pressure applied to the brake chambers is regulated to prevent the wheels from locking. The brakes are applied so as to maintain the slippage of the wheels within the optimal range.

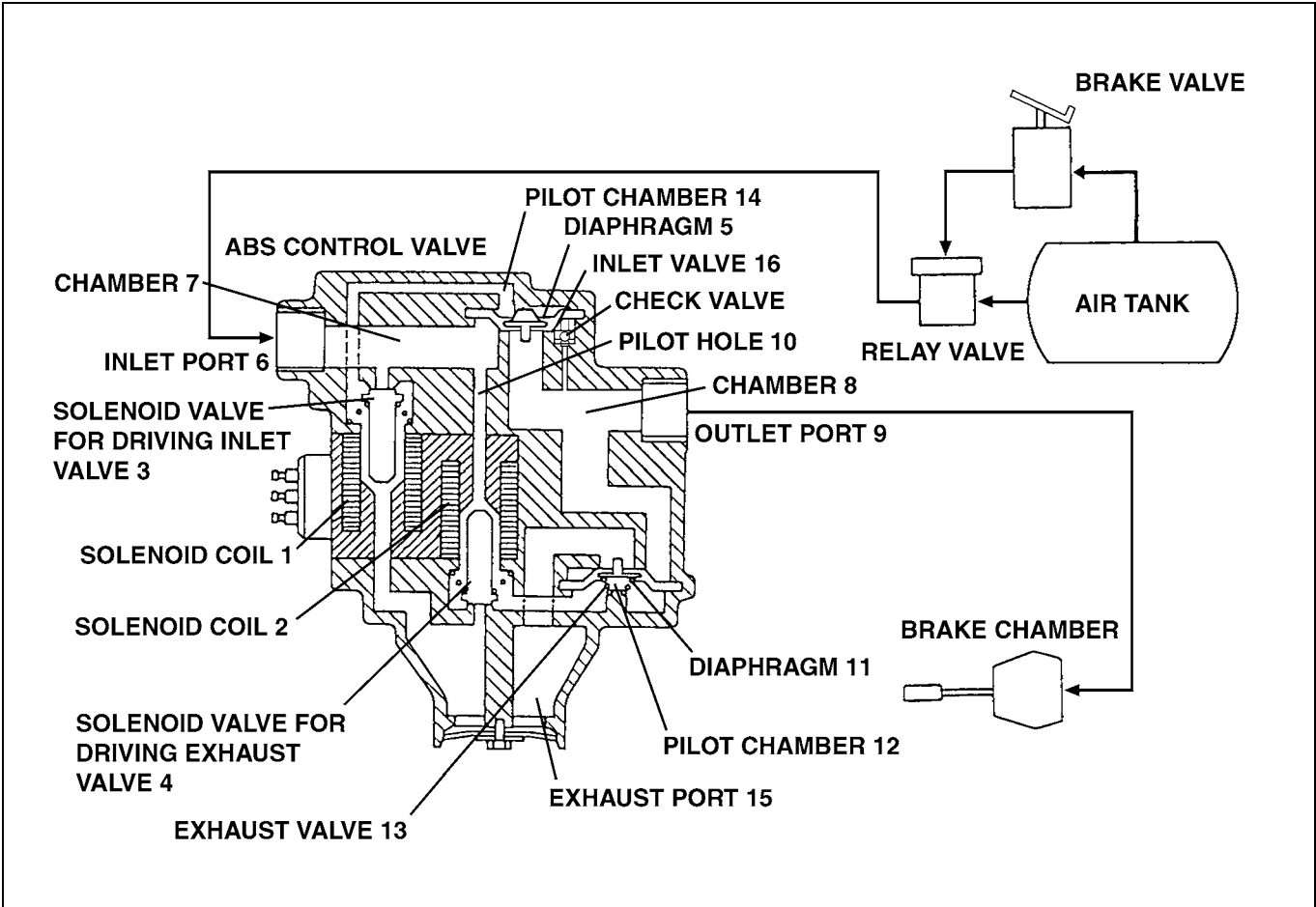
Regardless of whether the vehicle is stopped or being driven, and whether or not the brakes are being applied, the circuit consisting of the wheel sensors, control valves, ABS ECU, and wire harnesses are constantly being checked by the ABS ECU's fail-safe circuit. If some sort of malfunction occurs, the fail-safe circuit warns the driver by lighting the ABS warning light. At the same time, the ABS system that is experiencing the malfunction is shut off and braking is restored to normal (non-ABS) operation.



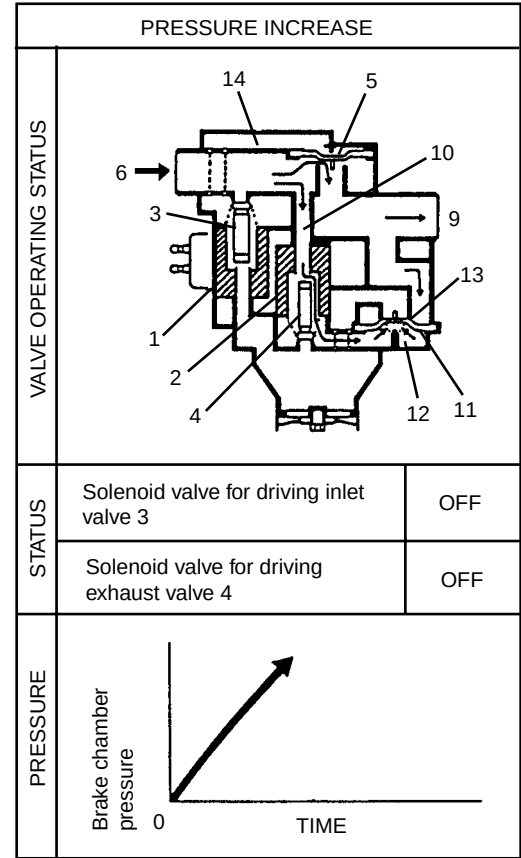
### 2. ABS CONTROL VALVES

#### (1) Overview

- The ABS control valves are positioned in the brake air circuit between the relay valves and brake chambers. Based on signals from the ABS ECU, they adjust the air pressure sent to the brake chambers in one of three modes: pressure increase, pressure reduction, or pressure maintenance.

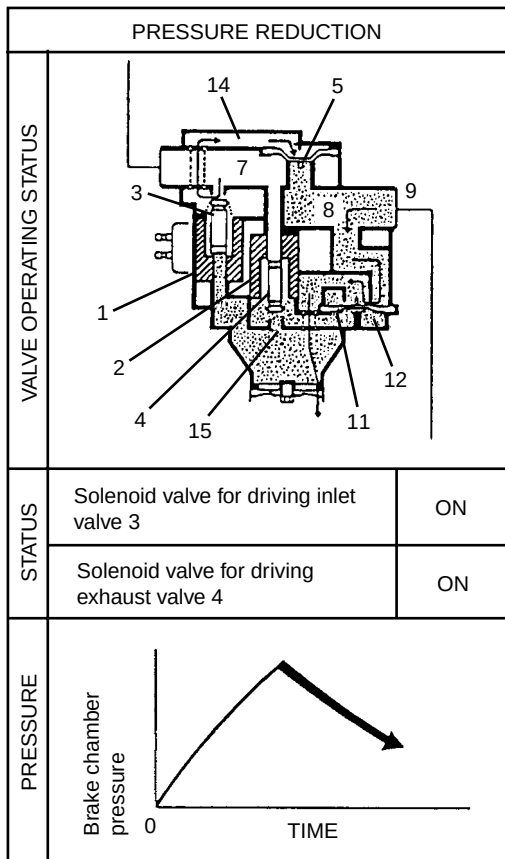


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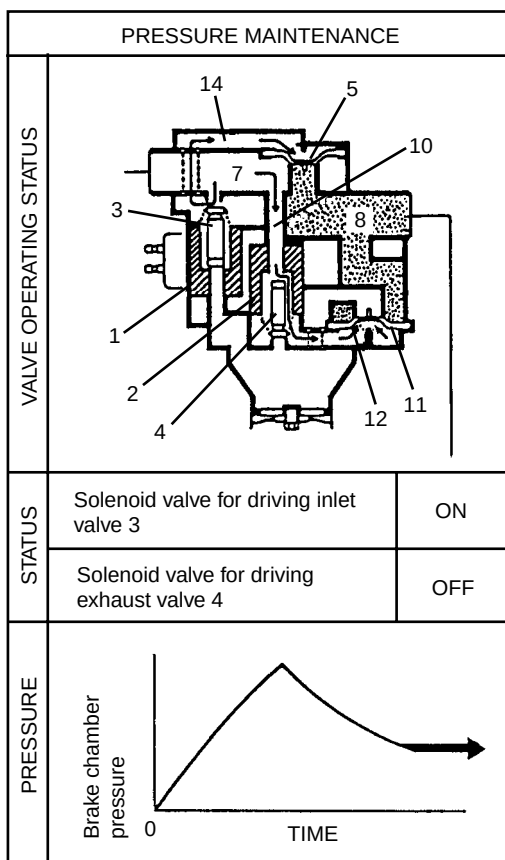
- (2) Operation
- a. PRESSURE INCREASE MODE
- When the driver steps on the brake pedal, air from the relay valve enters through inlet port (6), pushes open diaphragm (5), passes through outlet port (9), and flows into the brake chamber. At this point, solenoid coil (1) is not energized, so solenoid valve (3) is closed and pilot chamber (14) is open to the atmosphere. Also, solenoid coil (2) is also not energized, so solenoid valve (4) is closed. As a result, air passes through pilot hole (10) and enters pilot chamber (12). It then pushes up diaphragm (11) and closes exhaust valve (13).



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## b. PRESSURE REDUCTION MODE

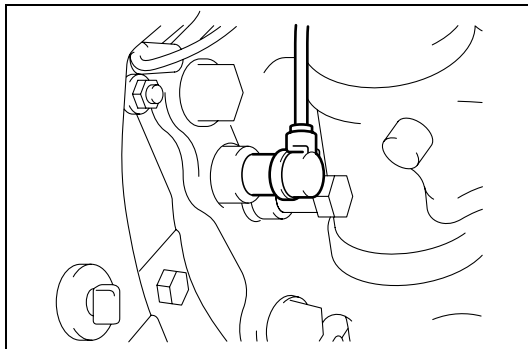
- When solenoid coil (1) is energized, solenoid valve (3) opens and air also flows into pilot chamber (14). It pushes down on diaphragm (5), shutting off chambers (7) and (8). At the same time, solenoid coil (2) is also energized. This causes solenoid valve (4) to open and the operating air from pilot chamber (12) passes through exhaust port (15) and is released into the atmosphere. Consequently, the air from the outlet port (9) side (brake chamber) pushes down on diaphragm (11) and air is released into the atmosphere. This causes the air pressure of the brake chamber to decrease.



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## c. PRESSURE MAINTENANCE MODE

- When solenoid coil (1) is energized, solenoid valve (3) opens and air flows through chamber (7) and acts on pilot chamber (14). On the other hand, since solenoid coil (2) is not energized, solenoid valve (4) is closed and air flows through pilot hole (10) and acts on pilot chamber (12). This causes diaphragms (5) and (11) to shut off their air passages, and the chamber (8) pressure, that is to say the air acting on the brake chamber, is maintained at the pressure that was current when the switch from the pressure reduction mode to the pressure maintenance mode took place.



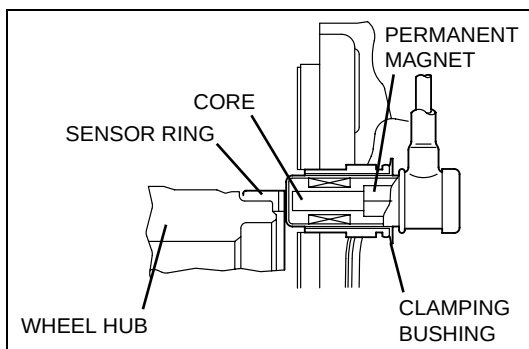
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### 3. WHEEL SENSORS

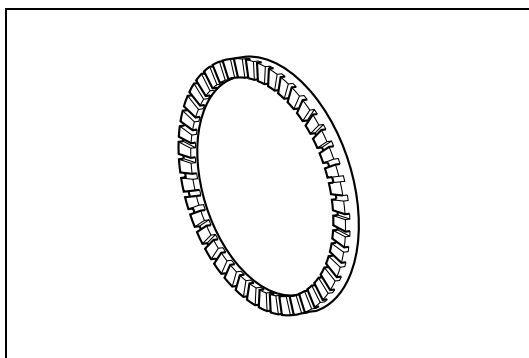
These sensors are mounted, facing the sensor rings on each wheel on the front and rear axles.

The wheel sensors are electromagnet sensors consisting of a permanent magnet core with a coil of wire wrapped around it.

The frequency of the pulse signals generated by magnetic inductance between the sensors and the sensor rings they face is proportional to the rotational speed of the wheels. These pulse signals are sent to the ABS ECU and are used to determine the wheels, rotational status.



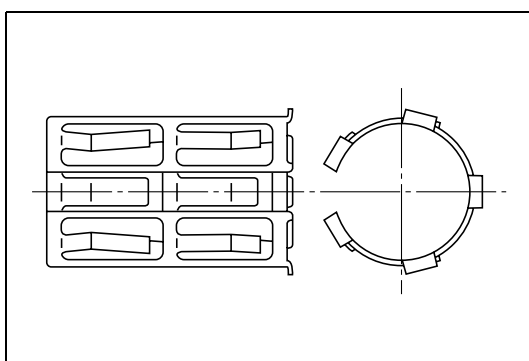
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### 4. SENSOR RINGS

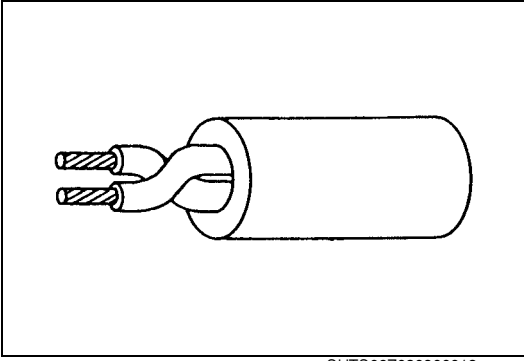
The sensor rings are press-fitted into the insides of the wheel hubs of each wheel on the front and rear axles, and they face the wheel sensors described in the preceding section. The sensor rings are made of a magnetic material, and teeth are cut into the surface which faces the wheel sensor at regular intervals. Also, when the sensor ring performs one complete rotation, the sensor generates pulse signals corresponding to the number of teeth.



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### 5. CLAMPING BUSHINGS

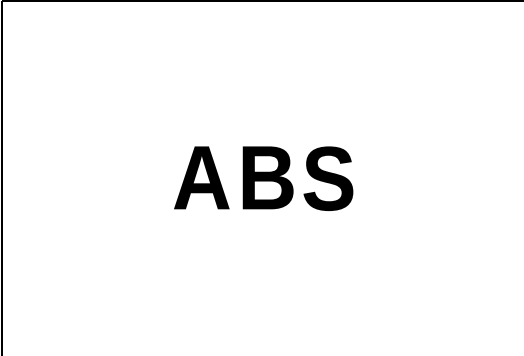
The wheel sensors are held in place through friction by clamping bushings that are inserted into the mounting brackets. If they are assembled properly, the clamping bushings serve to eliminate the need to adjust the clearance between the wheel sensors and sensor rings.



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**6. WHEEL SENSOR HARNESSES**

Each wheel sensor wire harness employs a two-conductor twisted wire cable. Its function is to protect the wheel sensor signals, which are vital to the proper operation of the ABS system, from electromagnetic interference. Under no circumstances should any part of the wheel sensor wire harnesses be cut or connected to any other wire.



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**7. ABS WARNING LIGHT**

The status of the ABS system is indicated.

It lights when the starter switch is turned "ON" and automatically goes off when the system functions correctly.

If malfunction occurs in the ABS system while the vehicle is being driven, the light goes on to alert the driver.

However, when a defects code is eliminated after repairing it and the starter switch is turned "ON", the light will remain lit until the vehicle speed reaches 7-10 km/h {11.2 - 16 mile/h}.

Then, note that even when the warning light is lit, the ABS system, unaffected by the malfunction, continues to operate. Also, the brake whose ABS system experiences the malfunction is reverted to normal braking operation without ABS.

When a diagnosis switch is turned "ON", this light will go on and off, which indicates defect code.

**8. SUB BRAKE CUT RELAY**

When this relay is energized during ABS operation, the relay contact opens, the current to the solenoid valve for the sub brake is shut down, and the sub brake is released.

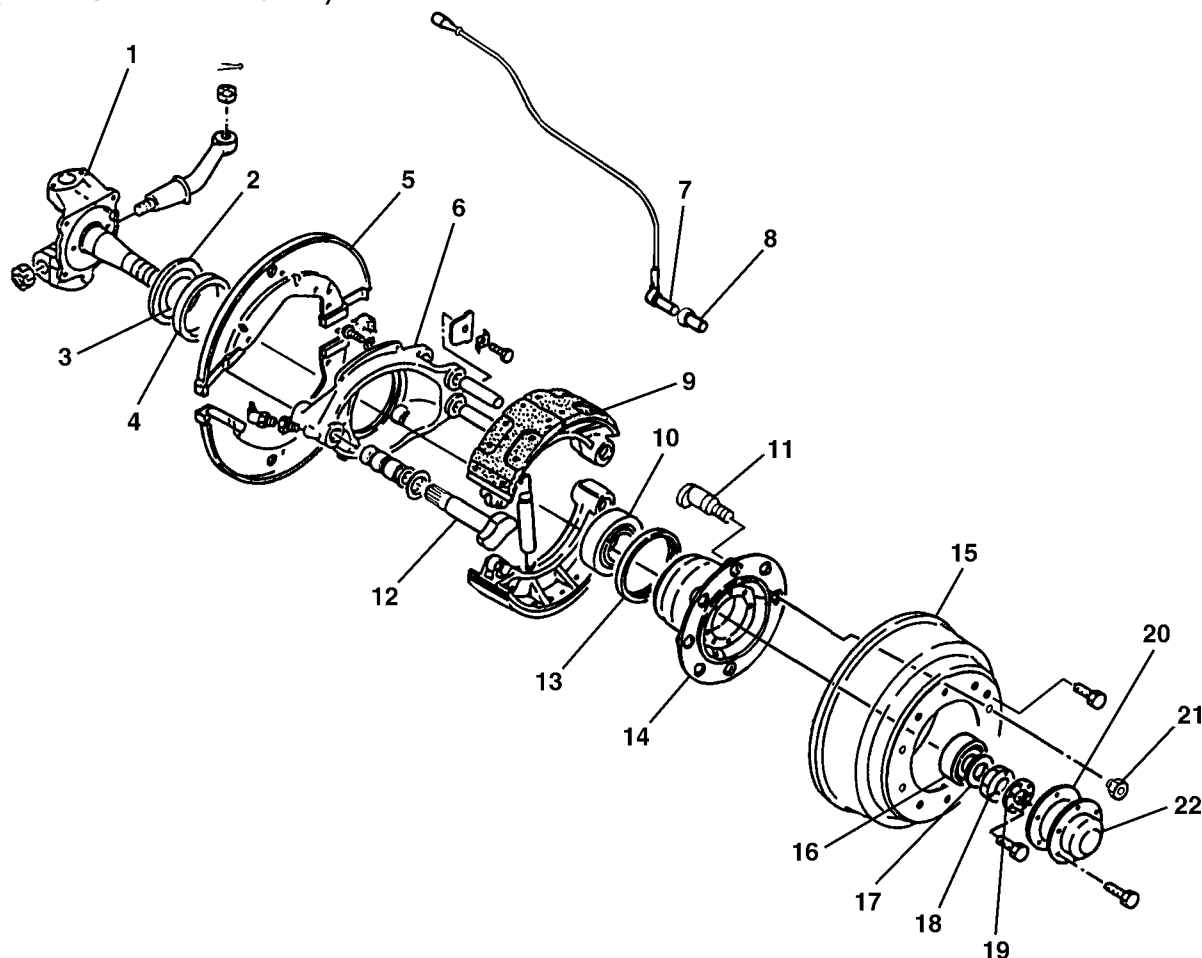
# FRONT WHEEL BRAKE

## COMPONENT LOCATOR

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### FRONT AXLE

(REPRESENTATIVE MODEL)



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|    |                         |    |                            |
|----|-------------------------|----|----------------------------|
| 1  | Knuckle                 | 12 | Cam shaft                  |
| 2  | Oil seal guide          | 13 | Sensor ring                |
| 3  | O-ring                  | 14 | Wheel hub                  |
| 4  | Oil seal                | 15 | Brake drum                 |
| 5  | Brake drum cover        | 16 | Outer wheel hub bearing    |
| 6  | Brake spider            | 17 | Washer                     |
| 7  | Wheel sensor            | 18 | Wheel hub bearing lock nut |
| 8  | Clamping bushing        | 19 | Lock plate                 |
| 9  | Brake shoe              | 20 | Gasket                     |
| 10 | Inner wheel hub bearing | 21 | Wheel nut                  |
| 11 | Hub bolt                | 22 | Wheel hub cap              |

## OVERHAUL

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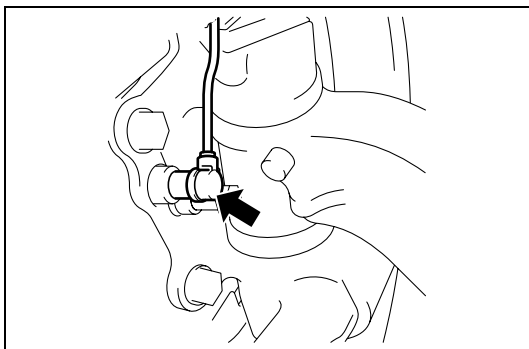
### IMPORTANT POINTS - DISASSEMBLY

#### 1. REMOVE THE WHEEL SENSOR.

- (1) Remove the brake drum cover.
- (2) Pull off the wheel sensor.

#### NOTICE

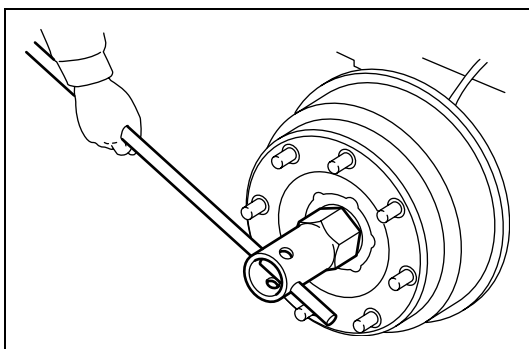
Exposing the wheel sensor to strong bumps could cause interior damage. Never hit the wheel sensor with a hammer or bang it into other parts.



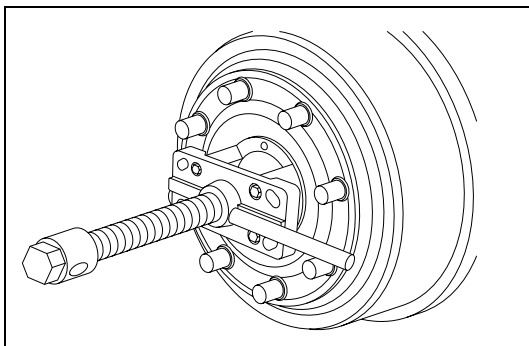
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#### 2. REMOVE THE WHEEL HUB, WHEEL HUB BEARINGS AND BRAKE DRUM.

- (1) Refer to chapter FRONT AXLE.



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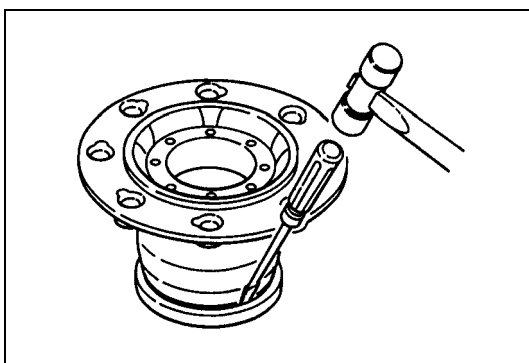
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#### 3. REMOVE THE SENSOR RING.

- (1) Use a screwdriver or the like to gradually remove the sensor ring by tapping evenly on its outer ring.

#### NOTICE

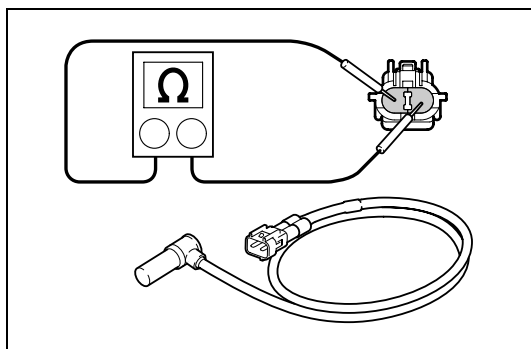
- When tapping on the sensor ring to remove it, be careful not to scratch the wheel hub.
- Do not remove the sensor ring unless it is required.
- Do not reuse the removed sensor ring, be sure to replace it with new one.



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## INSPECTION

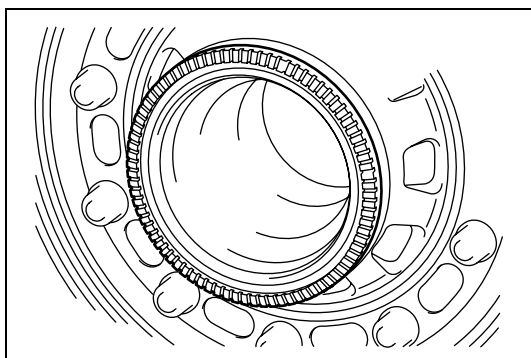
EN06Z0803H300001



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### 1. INSPECTION OF ONLY WHEEL SENSOR

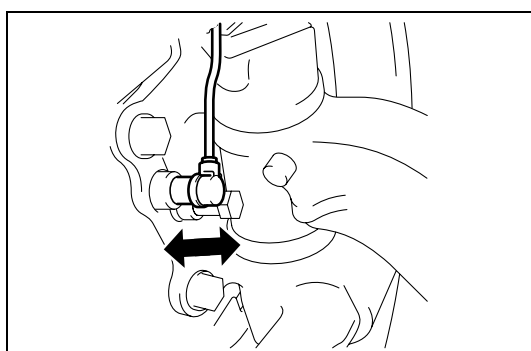
- (1) With a tester, measure the resistance of wheel sensor.  
**Standard: 1.0-1.3 kΩ**
- (2) When the measured value is out of the basic standard, change the wheel sensor as it might be considered presumably to be abnormal.



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### 2. INSPECTION OF THE SENSOR RING.

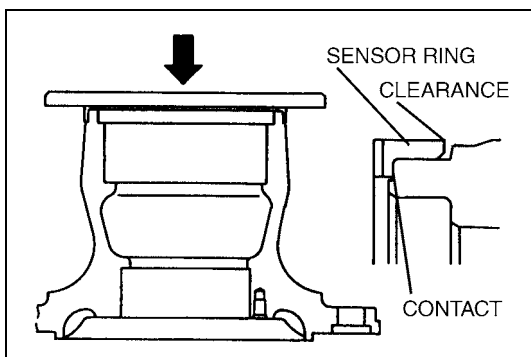
- (1) Make a visual inspection to check for damage or deformation of the sensor ring, and also to make sure it is not coming loose from the wheel hub.
- (2) If any damage or malformation is discovered, replace the sensor ring.
- (3) If the sensor ring is coming loose from the wheel hub, use a dolly block and press in it with a press again.



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### 3. INSPECTION OF THE CLAMPING BUSHING.

- (1) Make sure that wheel sensor is securely fixed.
- (2) Change the clamping bushing when it can be pulled off or pushed in with a lightly force.



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### 4. MOUNTING THE SENSOR RING

- (1) Place the sensor ring on the wheel hub and use the dolly block and a press to evenly pressure mount it.

#### NOTICE

Warming up the sensor ring with hot water will make it easier to pressure mount it. Do not use a gas burner or the like to warm the sensor ring. Doing so could cause malformation of the sensor ring.

- (2) After pressure mounting it, check for flutter of the sensor ring in the axle direction.

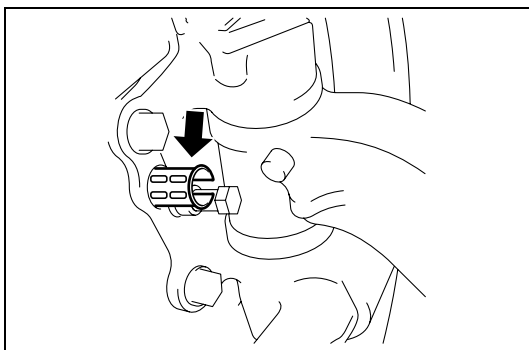
**Assembly standard: 0.2 mm {0.0078 in.} or less**

### 5. MOUNTING THE WHEEL HUB AND BRAKE DRUM

- (1) Refer to chapter FRONT AXLE.

#### NOTICE

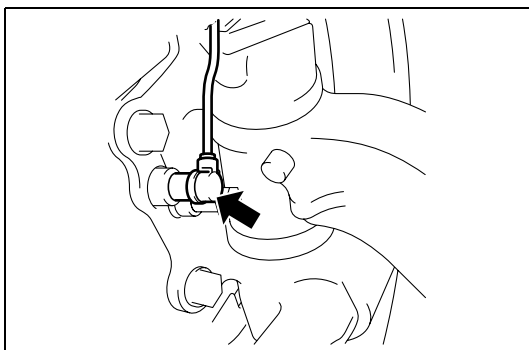
If the wheel sensors are mounted, hammering on the wheel hubs and the like on that axle could cause internal damage to the wheel sensors. Either mount the tire and then tap on the tire or tap on the wheel hub after removing the right and left wheel sensors.



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## 6. MOUNTING THE WHEEL SENSOR

- (1) Apply a light coating of chassis grease to the inner surface of the knuckle wheel sensor boss. Then push in the clamping bushing until the stopper makes contact with the knuckle's wheel sensor holder.



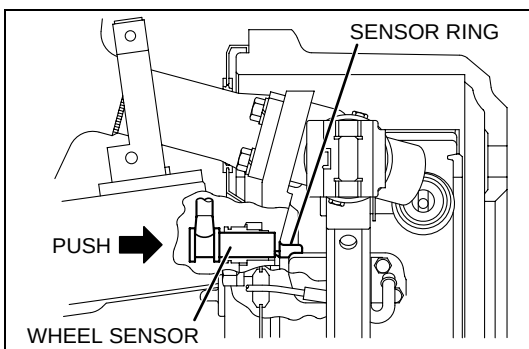
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- (2) Apply a light coating of chassis grease to the hub of the wheel sensor. Then push it forcefully into the clamping bushing until you feel that the wheel sensor has made contact with the sensor ring.

### NOTICE

**When inserting the wheel sensor, do not tap on it with a hammer or attempt to pry it into place with a screwdriver, or the like. Doing so could damage the wheel sensor.**

- (3) Slowly turn the wheel hub and brake drum and confirm that they move smoothly.
- (4) Mount the drum dust cover.



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## 7. INSPECT THE WHEEL SENSOR

- (1) Arrange the wire harness.
- (2) With a circuit tester, confirm the output voltage of the wheel sensor (By rotating the tire by one time for 5 seconds)

**Standard: 150-1,999 mV**

**(Range of Alternating Current Voltage)**

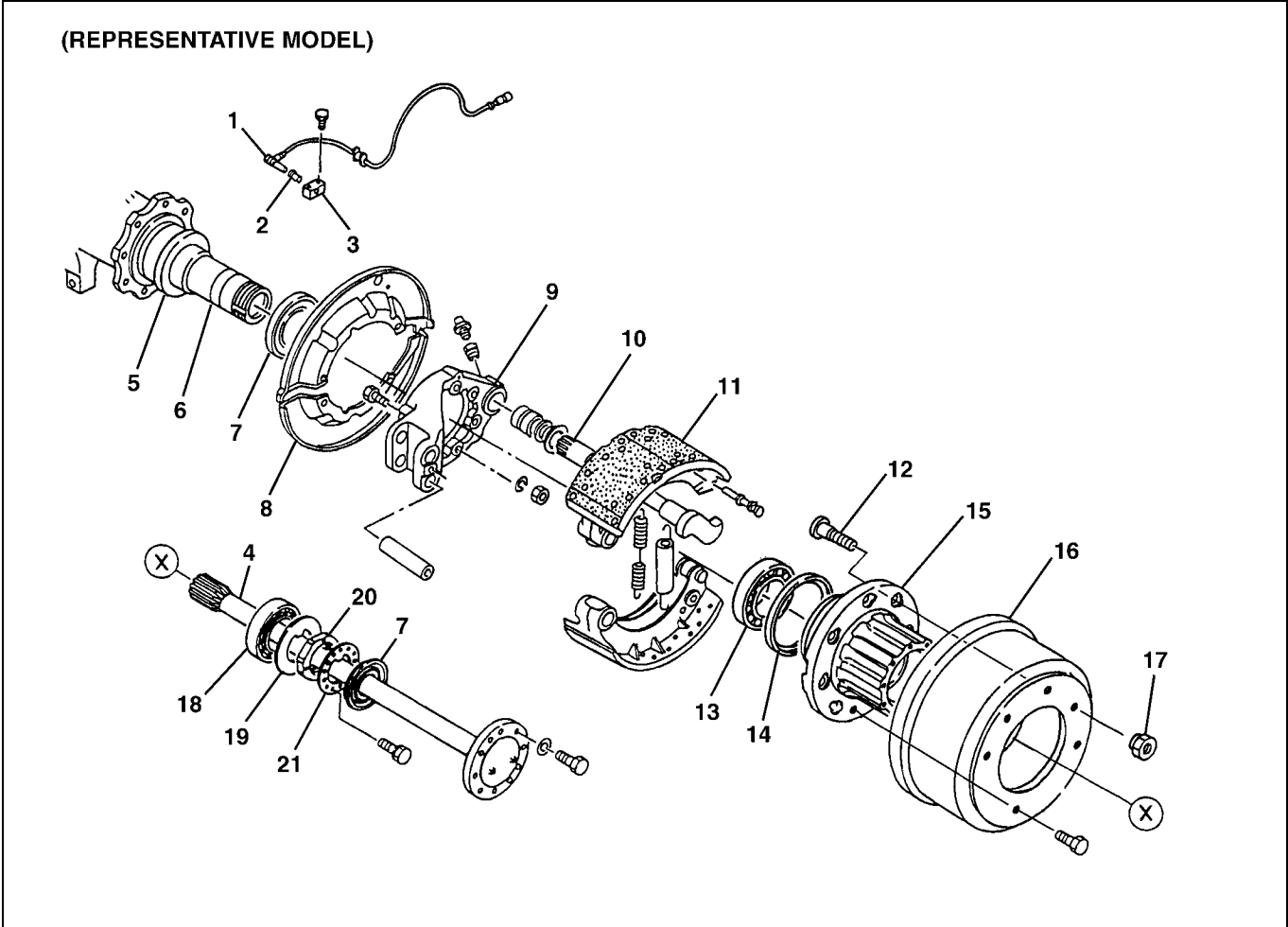
- (3) In case of out of the standard range at (2), push the wheel sensor softly by fingers until the sensor contacts with the sensor ring, then inspect again from (1).

REAR WHEEL BRAKE

COMPONENT LOCATOR

EN06Z0803D100002

REAR AXLE

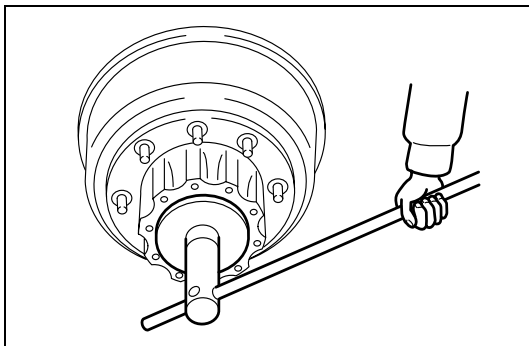


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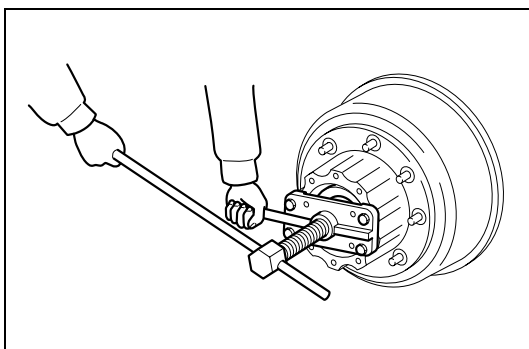
|    |                       |    |                         |
|----|-----------------------|----|-------------------------|
| 1  | Wheel sensor          | 12 | Hub bolt                |
| 2  | Clamping bushing      | 13 | Inner wheel hub bearing |
| 3  | Wheel sensor holder   | 14 | Sensor ring             |
| 4  | Axle shaft            | 15 | Wheel hub               |
| 5  | Oil seal collar       | 16 | Brake drum              |
| 6  | Axle housing assembly | 17 | Wheel nut               |
| 7  | Oil seal              | 18 | Outer wheel hub bearing |
| 8  | Brake drum cover      | 19 | Washer                  |
| 9  | Brake spider          | 20 | Lock nut                |
| 10 | Cam shaft             | 21 | Lock plate              |
| 11 | Brake shoe            |    |                         |

## OVERHAUL

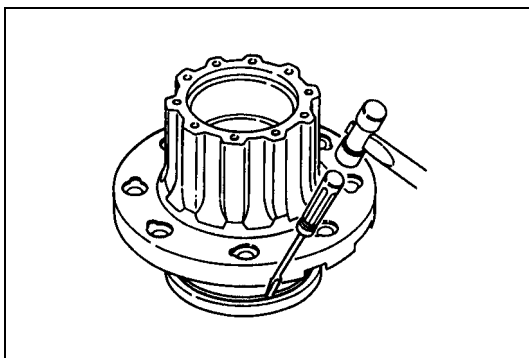
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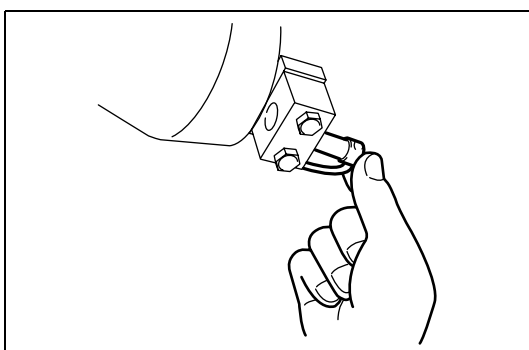
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SHTS06Z080300036

### 1. REMOVE THE WHEEL HUB, WHEEL HUB BEARINGS AND BRAKE DRUM.

- (1) Refer to chapter REAR AXLE.

### 2. REMOVING THE SENSOR RING

- (1) Use a screwdriver or the like to gradually remove the sensor ring by tapping evenly on its outer ring.

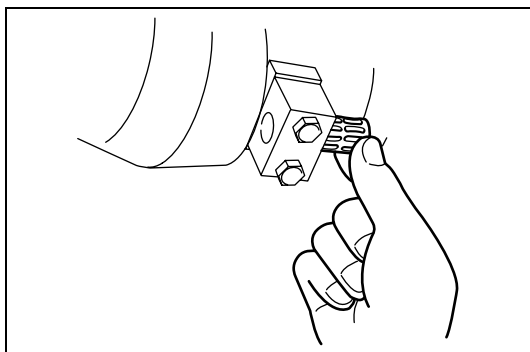
#### NOTICE

- When tapping on the sensor ring to remove it, be careful not to scratch the wheel hub.
- Do not remove the sensor ring unless it is required.
- Do not reuse the removed sensor ring, be sure to replace it with new one.

### 3. REMOVING THE WHEEL SENSOR

#### NOTICE

- Exposing the wheel sensor to strong bumps could cause interior damage. Never hit the wheel sensor with a hammer or bang it into other parts.
- Pull out the wheel sensor from the sensor holder by hand.



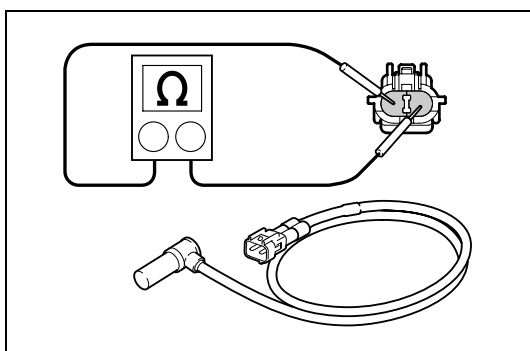
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#### 4. REMOVING THE CLAMPING BUSHING.

- (1) Remove the clamping bushing out of the wheel sensor holder.

## INSPECTION

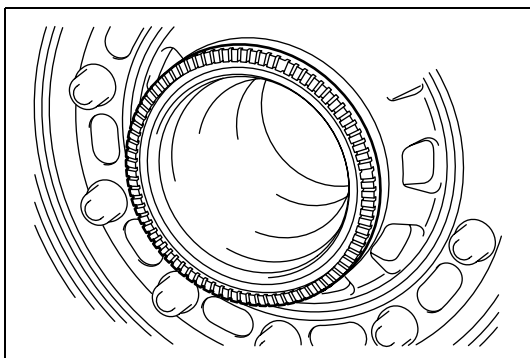
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SHTS06Z080300038

#### 1. INSPECTION OF ONLY WHEEL SENSOR

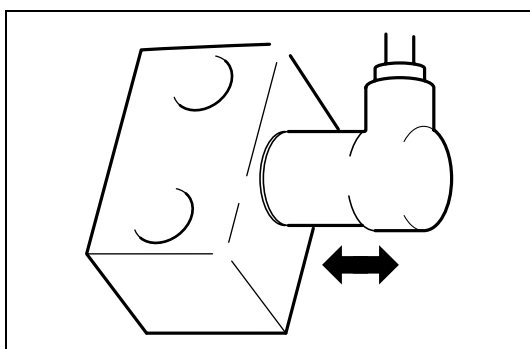
- (1) With a tester, measure the resistance of wheel sensor.  
**Standard: 1.0-1.3 kΩ**
- (2) When the measured value is out of the basic standard, change the wheel sensor as it might be considered presumably to be abnormal.



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#### 2. INSPECTION OF THE SENSOR RING.

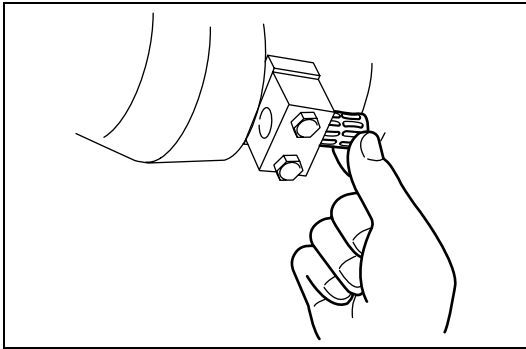
- (1) Make a visual inspection to check for damage or deformation of the sensor ring, and also to make sure it is not coming loose from the wheel hub.
- (2) If any damage or malformation is discovered, replace the sensor ring.
- (3) If the sensor ring is coming loose from the wheel hub, use a dolly block and a press to pressure mount it again.



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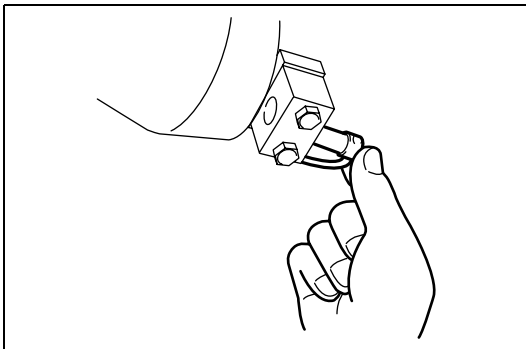
#### 3. INSPECTION OF THE CLAMPING BUSHING.

- (1) Make sure that the wheel sensor is securely fixed.
- (2) Change the clamping bushing when it can be pulled off or pushed in with a lightly force.



#### 4. MOUNTING THE WHEEL SENSOR

- (1) Apply a lightly coating of chassis grease to the inner surface of the wheel sensor holder. Then push in the clamping bushing until the stopper makes contact with the wheel sensor holder.

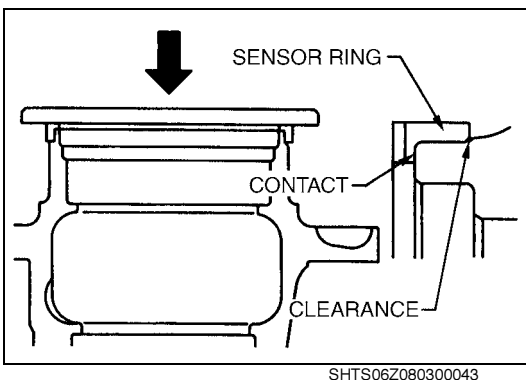


- (2) Push the wheel sensor fully in the wheel sensor holder with hands until the wheel sensor makes contact with the clamping bushing.

#### NOTICE

**When inserting the wheel sensor, do not tap on it with a hammer or attempt to pry it into place using a screwdriver, or the like. Doing so could damage the wheel sensor.**

- (3) Arrange the wire harness.



#### 5. MOUNTING THE SENSOR RING

- (1) Place the sensor ring on the wheel hub and use the dolly block and a press to evenly pressure mount it.

#### NOTICE

**Warming up the sensor ring with hot water will make it easier to pressure mount it. Do not use a gas burner or the like to warm the sensor ring. Doing so could cause malformation of the sensor ring.**

- (2) After pressure mounting it, check for flutter of the sensor ring in the axle direction.

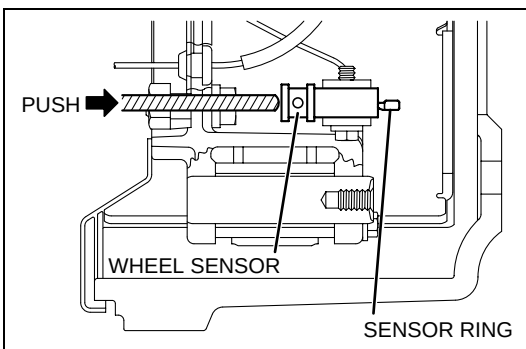
**Assembly standard: 0.2 mm {0.0078 in.} or less**

#### 6. MOUNTING THE WHEEL HUB AND BRAKE DRUM

- (1) Refer to chapter REAR AXLE.

#### NOTICE

- Be careful not to push back the wheel sensor too far when mounting the wheel hub and brake drum. Also, make sure they are straight so that you do not bump the tip of the wheel sensor.
- When inserting the outer hub bearing, avoid tapping on it with a hammer as this will expose the wheel sensor to bumps. Insert the outer hub bearing carefully with a lock nut.



#### 7. INSPECT THE WHEEL SENSOR.

- (1) Arrange the wire harness.
- (2) With a circuit tester, confirm the output voltage of the wheel sensor (By rotating the tire by one time for 5 seconds)

**Standard: 150-1,999 mV**

**(Range of Alternating Current Voltage)**

- (3) In case of out of the standard range at (2), remove the dust cover located on the back plate unit, and the wheel sensor softly by using round end bar until the sensor contacts with the sensor ring. Then inspect again from (1).

#### NOTICE

**Do not tap by hammer or turn when pushing the wheel sensor. This may damage the wheel sensor.**

- (4) Mount the axle shaft to the wheel hub and tighten the bolt on the axle shaft.  
Refer to chapter REAR AXLE.

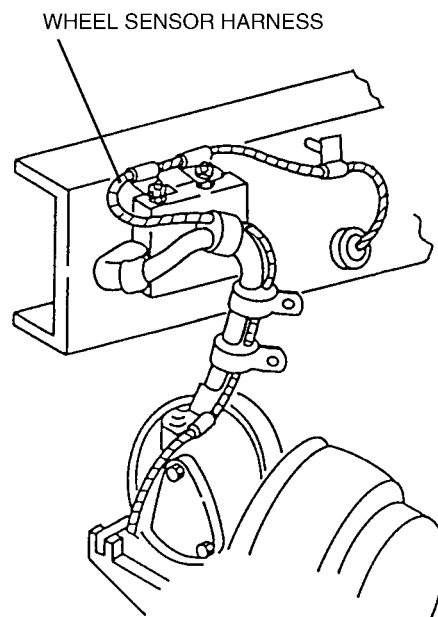
## 8. ABS WIRE HARNESES

### (1) Front axle ABS wire harnesses

- The front axle chassis harnesses, particularly the ones that pass over the front axle and extend as far as the wheel sensors, must absorb the movement when the wheels are turned and when the springs move. It is therefore necessary to always maintain an optimal spacing between the clips.

In addition, if there is a large amount of variation in the spacing between the clips, the wheel sensor harnesses can come into contact with tire chains and sustain damage.

The wire harness for the front axle wheel sensor extends directly from the clip on top of the king pin cover to the frame. In particular, make sure that the distance between the clip on top of the king pin cover and the clip on the frame side is as indicated in the diagram below. There are markings on the wheel sensors in cases where the wheel sensor harness clips are in locations where the relative movement is particularly great. These places should be inspected regularly to ensure that the clip positions are still meeting with the same marking.



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### (2) Rear axle chassis harness

- The rear axle chassis harnesses are arranged so that the left and right wheel sensor harnesses are near each other. Therefore, special care should be taken not to make incorrect connections if the harnesses have been removed for inspection or repairs.

If incorrect connections are made, it will interfere with the functioning of the ABS system. For this reason, caution plates indicating "LEFT" and "RIGHT" are affixed to the harnesses. Be sure to check when connecting the harnesses. (The left harness is on the left side of the vehicle when viewed from the behind and facing toward the front, and the right harness is on the right side of the vehicle.)

The wheel sensor harnesses are arranged along the top of the rear axle housing. Therefore, make sure to allow sufficient harness length between the chassis and the rear axle so that the harnesses can absorb the up-and-down motion of the rear axle.