

INTRODUCTION

Antilock brake systems (ABS) help prevent the wheels from locking during sudden braking, especially on slippery surfaces. Figure 1.

- This helps the driver maintain control.
- Antilock brakes increase safety because they eliminate wheel/tire lockup and minimize the danger of skidding, allowing the vehicle to stop in a straight line.
- ABS also allows the driver to maintain steering control during heavy braking so the vehicle can be steered to avoid an obstacle or another vehicle.
- ABS can improve braking when road conditions are less than ideal, as when making a sudden panic stop or when braking on a wet or slick road.

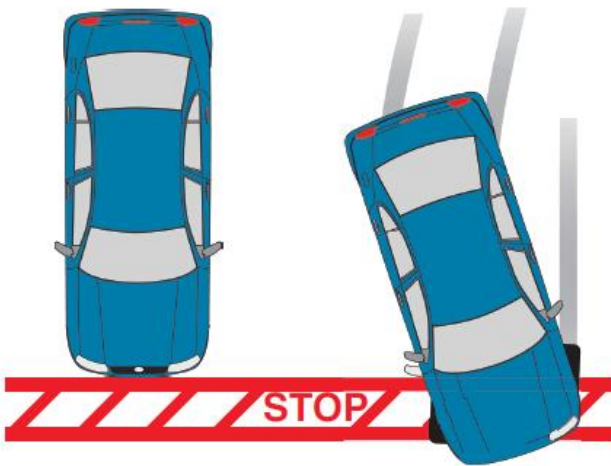


Figure 1. Being able to steer and control the vehicle during rapid braking is one major advantage of an antilock brake system.

All ABS control tire slip by monitoring the relative deceleration rates of the wheels during braking. Wheel speed is monitored by wheel speed sensors.

- If one wheel starts to slow at a faster rate than the others, or at a faster rate than that which is programmed in the antilock control module, it indicates a wheel is starting to slip and is in danger of losing traction and locking.
- The ABS responds by momentarily reducing hydraulic pressure to the brake on the affected wheel or wheels. This allows the wheel to speed up momentarily so it can regain traction. As traction is regained, brake pressure is reapplied to again slow the wheel.
- The cycle is rapidly repeated over and over until the vehicle stops or until the driver eases pressure on the brake pedal.

Control Module. The control module receives wheel speed information from the wheel speed sensors (WSS) and then sends a voltage signal to the control solenoids which then controls brake fluid pressure at the wheel brakes. The ABS controller may be referred to as:

A5-D. Electronic Brake Control Systems: Antilock Brake System (ABS), Traction Control System (TCS), and Electronic Stability Control System (ESC) Diagnosis and Repair

- Electronic brake control module (EBCM)
- Electronic brake module (EBM)
- Controller antilock brakes (CAB)

Valves. Electrically operated solenoid valves are used to hold, release, and reapply hydraulic pressure to the brakes. This produces a pulsating effect, which can be felt in the brake pedal during hard braking. Once the rate of deceleration for the affected wheel catches up with the others, normal braking function and pressure resume, and antilock reverts to a passive mode.

Pump. A pump is used in most antilock systems to restore brake fluid pressure after the valves have released the pressure in an effort to control wheel slippage.

Channels. The term *channel* always refers to the number of separate or individually controlled ABS hydraulic circuits in an ABS, not the number of wheel speed sensor electrical circuits. The various ABS use a different number of sensors, depending on how the system is configured. Figure 2.

- single-channel systems and three-channel systems (older vehicles)
- four-channel systems

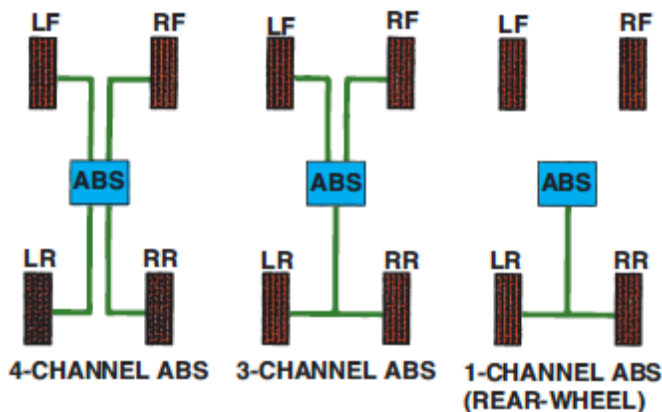


Figure 2. ABS hydraulic channels.

On most of today's vehicles, each wheel is equipped with its own speed sensor. This type of arrangement is called a "four-wheel, four-channel" system since each wheel speed sensor provides input for a separate hydraulic control circuit. Figure 3.



Figure 3. A four-channel ABS hydraulic modulator and EBCM.

Inputs. The key inputs for the ABS control module come from the wheel speed sensors and the brake pedal switch. The brake switch allows the controller to react faster to an ABS event. The signals being sent to the ABS controller (module) include the following, figure 4:

- Wheel speed—from wheel speed sensors
- Brake on/off—from the brake pedal switch
- Steering wheel position—used for electronic stability control
- Yaw and accelerometer sensors—used for electronic stability control system

Outputs. The ABS controller (module) controls the following components:

- System relay
- Inlet valves
- Outlet valve
- Pump motor
- ABS warning lamp (amber ABS dash light)

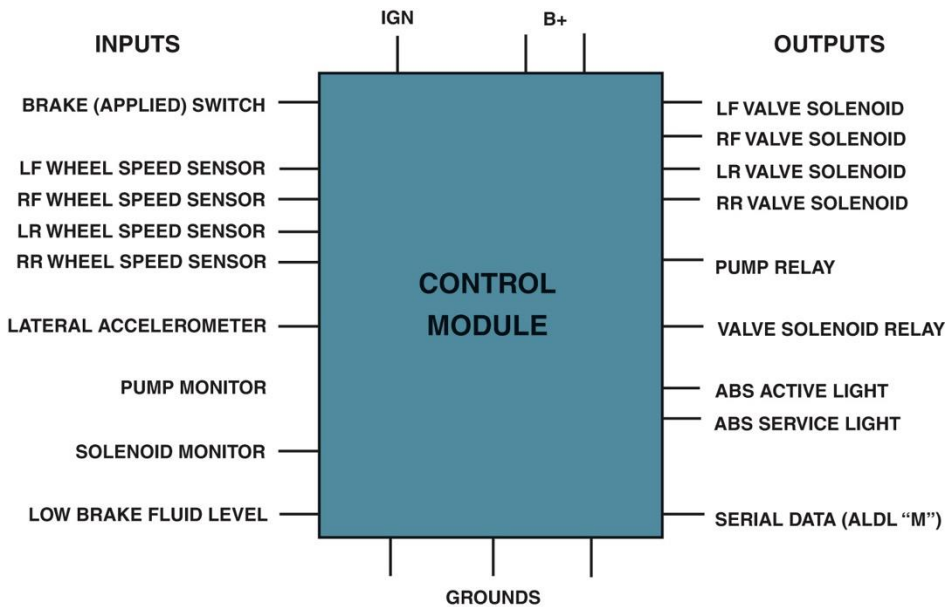


Figure 4. Typical inputs and outputs for brake control modules.

Other ABS Functions. Much of the same equipment that allows an ABS system to control wheel lockup during braking can be adapted to control other vehicle dynamics. Some of these advanced ABS functions are:

- Traction Control
- Stability Control, also called Vehicle Stability Enhancement System (VSES)
- Electronic front/rear proportioning
- Hill Start Assist
- Tire-pressure monitoring system (TPMS)

Automatic emergency braking (AEB) is often part of a safety package that includes radar cruise control and will apply the brakes in the event of a possible collision. Sensors such as radar, sonar, and/or cameras are used depending on the system to detect the distance to another object. The controller, usually an ABS controller, then issues a warning if a collision is possible. This warning can include one or more of the following:

- A buzzer
- A warning light flashing on the dash
- A vibration of the driver's seat

If the warnings are ignored, the automatic braking system will intervene and either provide brake assist or apply the brakes autonomously (by itself) to achieve maximum braking in an effort to avoid a collision.

ASE TEST TOPICS

1. Follow manufacturers' service and safety precautions when inspecting, testing and servicing electronic brake control system hydraulic, electrical, and mechanical components.

When diagnosing or servicing antilock brake systems (ABS), service information is needed to correctly service or repair vehicles because it contains all of the specifications, as well as the specified procedures to follow when servicing or repairing a vehicle. The most comprehensive and accurate service information is the service information from the vehicle manufacturer.

2. Diagnose increased stopping distance, wheel lock-up, false activation, pedal feel, pedal travel, pedal pulsation and noise concerns associated with the electronic brake control system; determine needed repairs.

Depending on the type of ABS, vehicles may exhibit some actions that are usually considered normal.

- Some ABS units will cause the brake pedal to move up and down slightly during cycling of the valves during a self-test.
- Sometimes customers state that they do not think that their antilock brake system (ABS) is working correctly because they heard the tires making noise (chirping sound) during hard braking. This is normal as the tires slip about 20% during an ABS stop.

If the ABS activates (brake pedal pulses) just before coming to a stop, a bad wheel speed sensor could have caused this problem, which is often called false modulation. Other causes include a bent wheel, mismatched tire sizes, or metal debris around the sensor.

3. Observe electronic brake control system indicator/light(s) at start-up and during road test; determine if further diagnosis is needed.

An important step in the diagnosis of an antilock brake system problem is to check the status of the red and amber brake warning lamps. Before driving the vehicle, start the engine and observe the red and amber brake warning lamps. Do not drive the vehicle until the base brakes are restored to proper operation.

A red brake warning lamp (RBWL) warns of a possible dangerous failure in the base brakes, such as:

- Low brake fluid level
- The parking brake is applied

If the amber warning lamp is on, then the vehicle can be carefully driven, but the antilock brake system will not likely be functioning when the warning lamp is on. The amber ABS warning lamp usually comes on after a vehicle start during the initialization or start-up self-test sequence. If the amber warning lamp stays on after the vehicle is started, this means that a fault in the ABS system has been detected. Figure 5.



Figure 5. The amber ABS warning lamp comes on at start-up and stays on if there is a fault in the ABS.

4. Diagnose electronic brake control system, electronic control(s), components and circuits (with or without DTCs) using on-board diagnosis and/or recommended test equipment such as: scan tool, digital multimeter (DMM), digital storage oscilloscope (DSO); determine needed repairs.

Most vehicles built since 1996 use the OBD-II diagnostic connector to transmit ABS diagnostic trouble code information to a scan tool. A factory scan tool or an enhanced factory-level scan tool will be needed to retrieve ABS diagnostic trouble codes (DTCs) and scan tool data such as wheel speed sensor information. Figure 6.



Figure 6. Scan tool connected to the data link connector (DLC).

5. Bleed and/or flush the electronic brake control hydraulic system following manufacturers' procedures.

Air trapped in the ABS hydraulic unit may require that a scan tool be used to cycle the valves.

To bleed the system using a scan tool, use the following steps:

Step 1 Check service information and determine the specified procedure to follow. This usually involves manually bleeding the wheel brakes before using a scan tool.

Step 2 Use a factory scan tool or one that is capable of performing an automated bleed procedure.

Step 3 Connect the scan tool to the data link connector (DLC). This connector can be located under the dash or in the center console or even covered by a panel. Check service information for the exact location of the DLC for the vehicle being serviced. Figure 7.



Figure 7. Connect a factory or enhanced scan tool to the data link connector (DLC) located under the dash on this vehicle.

Step 4 Enter vehicle information as shown on the display of the scan tool and locate the antilock brake system (ABS) function area.

Step 5 Select ABS automated bleed from the ABS menu. The instructions on the scan tool could include several steps including manually bleeding the system, then allowing the scan tool to cycle the hydraulic ABS solenoid valves and then bleeding again. Figure 8.

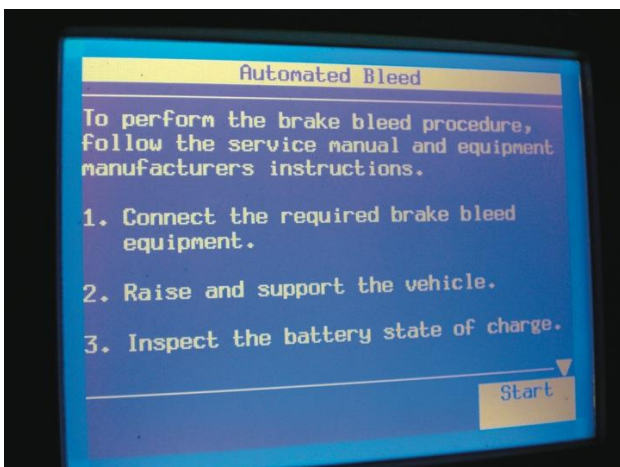


Figure 8. Scroll through the menus and select automated bleed procedure and follow the on-screen instructions.

6. Remove and install electronic brake control system components following manufacturers' procedures and specifications; perform module set-up/initialization.

When an ABS module is replaced, it usually needs to be programmed to match the vehicle's specifications. Even modules from the same make and model may require programming, as some modules are VIN-specific. When changing sensors such as steering angle sensor or wheel speed sensor calibration procedures, may be required to ensure the module functions correctly with the new sensor. Figure 9.

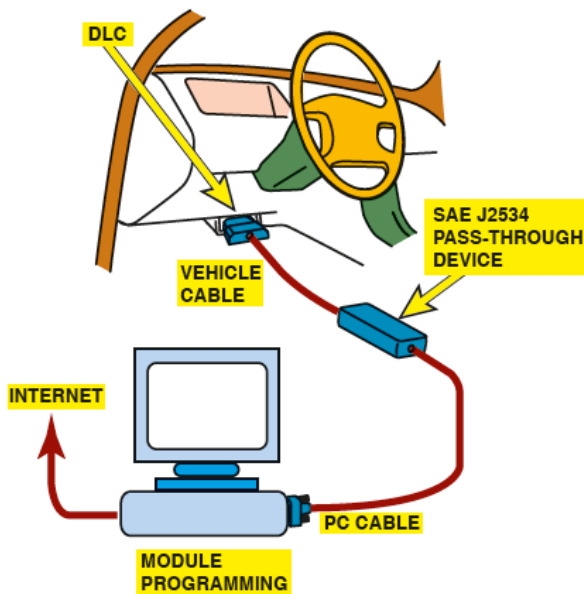


Figure 9. Typical setup for module programming.

7. Test, diagnose and service electronic brake control system sensors (speed, yaw, steering angle, brake pedal position, etc.) and circuits following manufacturers' recommended procedures (includes output signal, resistance, amperage, shorts to voltage/ground and frequency data).

After performing a good visual check of the wiring and connectors, a DVOM and/or oscilloscope is used to check the wheel speed sensors (WSS). The resistance of most WSS ranges from 800 to 2,500 ohms (Ω). After checking resistance set the meter to read AC volts. Rotate the wheel by hand at a rate of one revolution per second. A good WSS should produce voltage of at least 0.1 volt (100 mV). Figure 10.

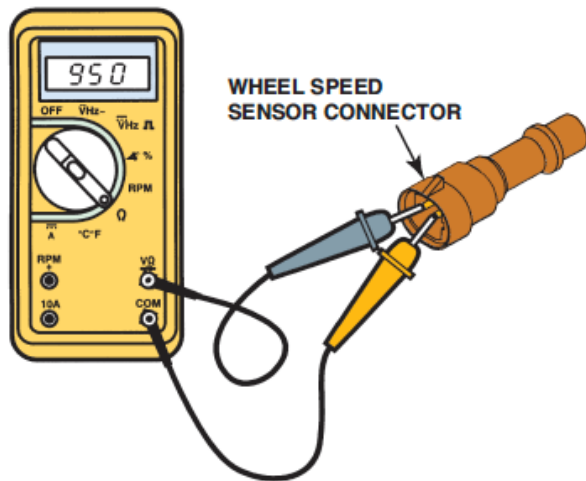


Figure 10. Checking WSS resistance.

To check for a short-to-ground, connect either lead of the ohmmeter to one of the WSS wires and the other to a good, clean chassis ground. The resistance should be infinity (OL).

To test a wheel speed sensor using a scope, attach the scope leads to the sensor terminals. Rotate the wheel by hand. Figure 11.

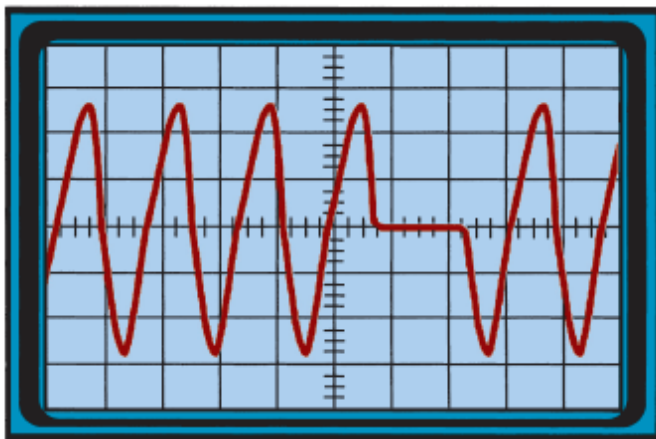


Figure 11. This scope trace shows a faulty wheel speed sensor.

The handwheel sensor produces two digital signals, which are used by the electronic brake control module (EBCM). These signals are produced as the steering wheel is rotated. Figure 12.

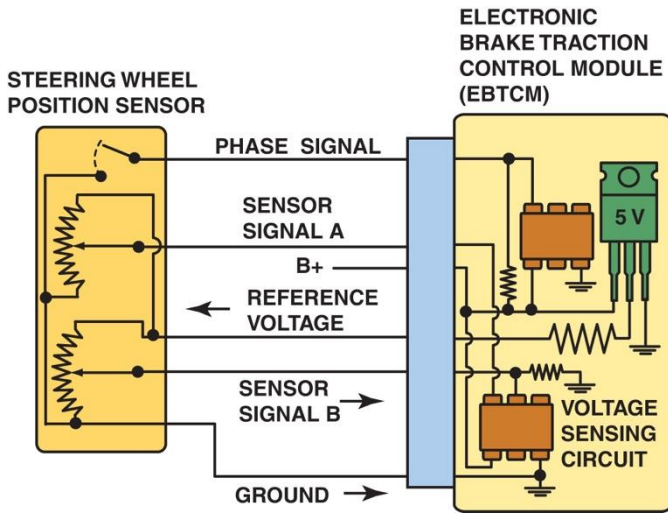


Figure 12. Steering wheel (handwheel) position sensor schematic.

A scan tool provides DTC (diagnostic trouble code) faults for this sensor. If there is an intermittent concern with a steering wheel position sensor, select snapshot and slowly turn the steering wheel lock to lock. After the snapshot is complete, plot the analog sensor voltage to see if the signal dropped out. Any dropout is an indication of an intermittent problem.

8. Diagnose electronic brake control system braking concerns caused by vehicle modifications (wheel/tire size, curb height, final drive ratio, etc.) and other vehicle mechanical and electrical/electronic modifications (communication, security, radio, etc.).

Modifications to the vehicle standard equipment can cause the ABS to not function or set a diagnostic trouble code (DTC) when there is actually nothing wrong with the ABS. Some examples:

- If a vehicle has been using a small space saver-type spare tire, then the difference in outside diameter may trigger a wheel speed sensor diagnostic trouble code (DTC) and turn on the amber ABS warning lamp.
- Mounting the antenna for any transmitting device near the ABS control unit or anything that transmits a signal such as amateur radios.
- Mounting tires of different diameter than that of the original tires. Different size tires generate different wheel speed sensor frequencies, which may not be usable by the ABS controller.

9. Repair wiring harness and connectors following manufacturers' procedures.

A terminal is a metal fastener attached to the end of a wire, which makes the electrical connection. The term connector usually refers to the plastic portion that snaps or connects together, making the mechanical connection. Wire terminal ends usually snap into, and are held by, a connector.

Terminals are retained in connectors by the use of a lock tang. Using a pick in the slot in the plastic connector where the lock tang is located, depress the lock tang, and gently remove the terminal from the connector. Figure 13.

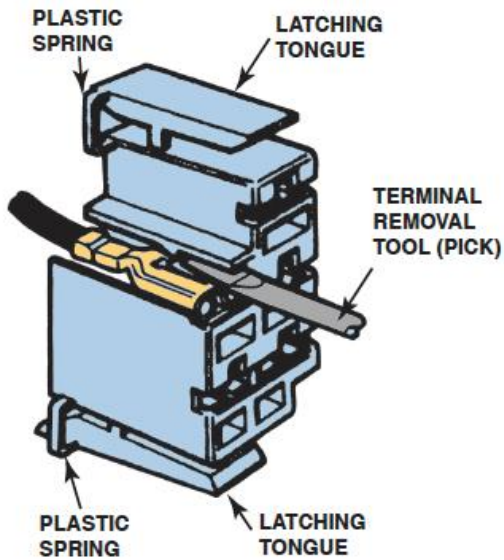


Figure 13. Removing a terminal from the plastic connector.

For splicing wires, some manufacturers recommend the use of crimp-and-seal connectors as the method for wire repair. Crimp-and-seal connectors contain a sealant and shrink tubing in one piece.

This type of connector is first crimped to retain the ends of the wires and then it is heated. The tubing shrinks around the wire splice, and thermoplastic glue melts on the inside to provide an effective weather-resistant seal. Figure 14.



Figure 14. Crimp-and-seal connectors.

10. Diagnose brake problems resulting from failures of interrelated systems (for example: electronic stability control, antilock brake, traction control, collision avoidance/mitigation).

Electronic stability control (ESC) is a system designed to help drivers to maintain control of their vehicles in situations where the vehicle is beginning to go out of control. The electronic stability control system is able to apply individual wheel brakes to bring the vehicle under control.

A5-D. Electronic Brake Control Systems: Antilock Brake System (ABS), Traction Control System (TCS), and Electronic Stability Control System (ESC) Diagnosis and Repair

The ESC system must be able to apply all four brakes individually. This means that the vehicle must be equipped with a four-channel antilock brake system (ABS) which uses a wheel speed sensor at each wheel. The ESC system must work when the antilock brake system and/or traction control is activated.

Traction control allows an ABS to control wheel spin during acceleration. Traction control is usually a part of the electronic stability control system. Most speed traction control systems use accelerator reduction and engine power reduction to limit slip before applying the brakes to the wheel that is spinning. Figure 15.

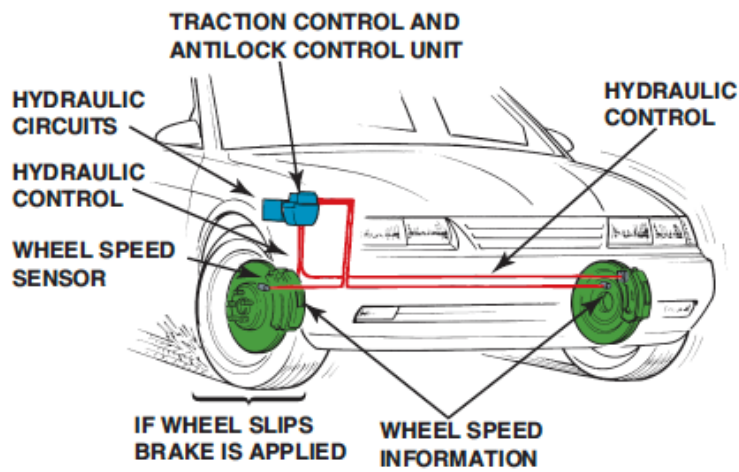


Figure 15. Wheel speed sensor information is used to monitor if a drive wheel is starting to spin.

The main controller for the traction can include one of the following, depending on make, model, and year of vehicle:

1. The body control module (BCM)
2. The powertrain control module (PCM)
3. The antilock electronic brake system controller (EBCM)

In most applications, a “TRAC CNTL” indicator light or “TRACTION CONTROL ACTIVE” message flashes on the instrumentation when the system is engaging traction control. This helps alert the driver that the wheels are losing traction. Figure 16.



Figure 16. “Traction control active” lamp.

A5-D. Electronic Brake Control Systems: Antilock Brake System (ABS), Traction Control System (TCS), and Electronic Stability Control System (ESC) Diagnosis and Repair

These systems share information and control strategies using the vehicle communication system. A fault in any one system that sets a DTC will cause the related function to be disabled. For example, if an ABS fault sets a wheel speed sensor code, it will disable ABS operation. This will also disable the traction control system and the stability control system.

11. Clear diagnostic trouble codes (DTCs) and verify the repair.

After repairing the vehicle, road test the vehicle under the same conditions that were performed to verify the fault to be sure that the fault has been repaired.

Check service information for the specified procedure to follow to retrieve and clear diagnostic trouble codes. Most vehicles require the use of a factory-brand scan tool. Figure 17.



Figure 17. The use of a factory scan tool is often needed to diagnose the ESC system.