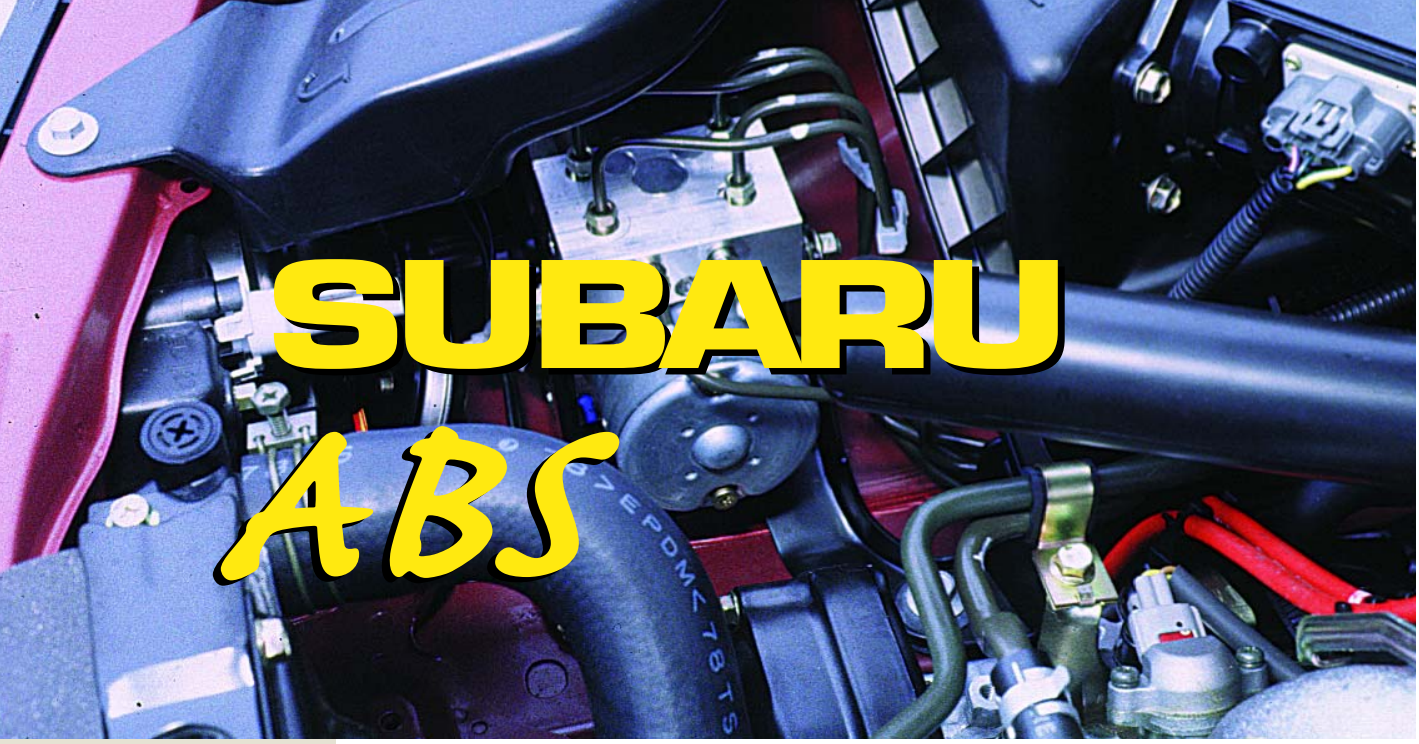


SUBARU ABS

Introduction

A variety of antilock braking systems (ABS) have been installed in Subaru vehicles since the first systems were installed in the 1990 Legacy. The following chart provides a handy spotter's guide to help you identify the various systems and to understand each system's design and diagnostic capabilities. In the sections that follow, we'll give you a brief overview of each system and explain proper diagnostic techniques.

1990-94 Legacy

	Hydraulic Unit	*Computer Location*	*Long Term Memory?*	*Select Monitor?*
NIPPON	Brake lines come into top of unit. Has brake bleeders on top of unit.	Under Passenger's Seat	*No*	*No*
BOSCH	Brake lines come in top of unit in shape of a square.	Under Passenger's Seat	*No*	*No*
ABS-2E	Brake lines come in top of unit lined up in straight line.	Under Passenger's Seat	*Yes*	*No*

1995-Present Legacy

	Hydraulic Unit	*Computer Location*	*Long Term Memory?*	*Select Monitor?*
ABS-2E	Brake lines come in top of unit lined in straight line.	Under Passenger's Seat	*Yes*	*No*
ABS/ICS 95 *front wheel drive Legacy Auto only*	Two brake lines come in top and two in side of unit.	Under Passenger's Seat	*Yes*	*Yes*
ABS 5.3	Motor stands upright, brake lines come in the side of the unit.	To the right of the glove box in the Legacy. To the left of the steering column in the Impreza.	*Yes*	*Yes*
ABS 5.3i	Motor lies down, brake lines come in the top in the shape of a square.	Computer part of the hydraulic unit.	*Yes*	*Yes*

1993-97 Impreza — **ABS-2E**
1997 Impreza — **ABS 5.3**
1998 to present Impreza — **ABS 5.3i**
1992-96 SVX — **Nippon**
1998 to present Forester — **ABS 5.3i**

Early Subaru Antilock Brake Systems

The original Legacy Antilock Brake System (ABS) was licensed by Bosch and manufactured by Nippon ABS, Ltd. The system electronically controls brake fluid pressure supplied to the brake system. This control helps to prevent "wheel lockup" during braking on slippery surfaces and emergency situations. The system includes a fail-safe feature, which indicates a malfunction by illuminating the warning lamp. The system is then returned to a conventional power brake system. The four channel system provides accurate individual wheelspeed control and improves the directional stability of the vehicle during braking.

ABS Components

- Tone wheels (4)
- Electronic control unit (ECU)
- G sensor (manual transmission models)
- Speed sensors (4)
- Hydraulic control unit (HCU)
- Warning lamp

A tone wheel is attached to each wheel hub and rotates at the same speed as the hub. The magnetic speed sensor is mounted in the axle housing. The notched tone wheel acts as a reluctor which modulates the magnetic field of the speed sensor. The tone wheels are individually replaceable.

The speed sensor provides an alternating voltage signal to the ECU. The alternating voltage and frequency corresponds to wheelspeed.

The ECU receives the wheelspeed sensor signals from the four sensors. It computes and compares the speed of each wheel. This results in the slip ratio between the wheels and the vehicle. The ECU sends a control signal to the hydraulic control unit (HCU) to prevent wheel lockup.

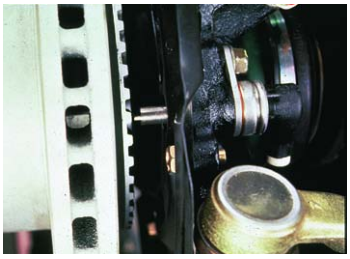
In a vehicle equipped with 4EAT, the ABS ECU also signals the TCU. This signal forces shift control during downshifts from 4th to 3rd. It cancels engine braking during ABS operation by deactivating the overrunning clutch. It also fixes the duty ratio of the MPT clutch solenoid at 95 percent *On* providing mostly FWD.

The hydraulic control unit receives a signal from the ECU and in turn individually controls the fluid pressure to each wheel. The HCU is inactive until a predetermined slip ratio occurs. The HCU is located in the right front of the engine compartment.

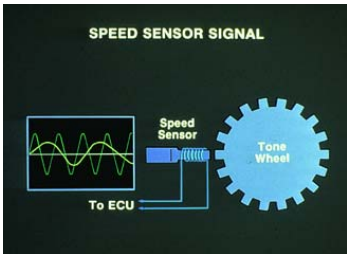
The HCU is an electronically controlled, motorized plunger pump. There are four magnetic control valves, two fill valves, a motor relay and a valve relay. The relays may be replaced individually, but the HCU cannot be serviced. When the HCU is removed from the vehicle, do not bump or drop the HCU, turn it on its side or upside down, or allow dirt, etc. to enter the unit. Always apply rust-preventive wax to the bracket attaching bolts when installing a new HCU.

The G-sensor is a two stage mercury switch which detects the rate of deceleration of 4WD MT equipped Legacy vehicles. It is required due to the small wheel speed differential caused by the FT4WD system. The G sensor is located on the RF strut tower.

The ABS warning lamp located on the instrument panel illuminates during vehicle start-up to check lamp operation, and during ABS malfunction.



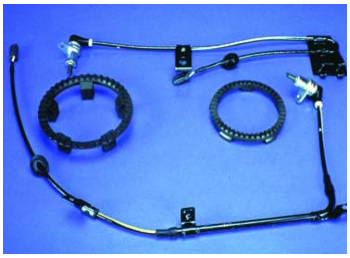
Tone Wheel and Speed Sensor



Speed Sensor Signal

ABS System Operation

The ABS system has a passive and an active mode. During the passive mode, the ABS system is not activated and normal power braking is available. The ABS system is activated when the ECU computes a slip ratio at the preset value. Fluid pressure is decreased and restored to each wheel based on the acceleration/deceleration of each wheel to prevent wheel lockup. If the wheel is accelerating too quickly, the ECU signal causes the HCU to restore the fluid pressure to that wheel. Vice versa, the fluid pressure is reduced if the wheel is decelerating too quickly. The system will pump the fluid 2-3 times per second until wheel slip ceases.



ABS Components

No Current Position (Passive)

This is the passive mode of the ABS system. The magnetic valves are not activated, and the system operates as a normal power brake system. System pressure developed by the master cylinder when the brake pedal is depressed is routed to the F valve. The pressure causes the valve piston and stem to retract. Fluid pressure will reopen the check valve and allow the brake fluid to flow through the magnetic valves directly to the wheel cylinders. The HCU reservoir and the accumulator are not affected during the no-current position.

When the brake pedal is released, master cylinder pressure decreases, which allows wheel cylinder pressure to return via the return check valve. When the

master cylinder pressure is less than 142 psi the F valve return spring opens the valve, and residual pressure is returned to the master cylinder.

Maximum Current Position (Active)

When the slip ratio approaches wheel lockup the ECU signals the HCU to energize the magnetic valves. The check valve to the master cylinder is *Closed,* and the check valve to the HCU reservoir is *Open*. This allows wheel cylinder pressure to flow to the HCU reservoir preventing wheel lockup. The pump motor is energized, and the pump operates at 2-3 strokes per second.

Each upward stroke of the pump transfers fluid to the accumulator for use during the *No Current* position. When system pressure exceeds the F valve spring pressure, the check valve seats, which prevents pressure flow to the master cylinder and prevents brake pedal kickback. Each downward stroke of the pump reduces fluid pressure to the HCU reservoir, which reduces pressure to the wheel cylinder.

No Current Position (Active)

When the ECU detects that wheel speed is resuming too quickly, a signal is sent to the HCU to de-energize the magnetic valve. The magnetic valve port opens allowing fluid pressure to flow to the wheel cylinder from the accumulator, which slows wheel speed. The cycle is repeated until wheel slip is controlled.

Half Current (Active)

When the ECU senses that the wheel slip is controlled because the calculated vehicle speed equals the actual vehicle speed, the signal to the magnetic valve is decreased. The check ball to the master cylinder is *Closed,* and the check ball to the HCU reservoir is *Closed*. This holds optimal fluid pressure at the wheel cylinder.

Increased brake pedal pressure is held in the master cylinder, and the accumulator stores excess fluid pressure from the HCU plunger pump. This only applies to the hydraulic circuit when half current is applied to the magnetic valve. Other circuits (which may be passive) can function in a normal manner.

When the brake pedal is released, master cylinder and system pressure decrease. Fluid returns to the master cylinder via the check ball opening. Reduced pressure on the F valve opens the check ball, and residual accumulator pressure returns to the master cylinder The plunger pump motor is switched to *Off*.

The ABS warning lamp illuminates on the instrument panel to indicate a malfunction of the system. The ECU cannot identify mechanical problems, only electrical problems. A trouble code is flashed by the LED located on the ECU to indicate problems with the following:

- magnetic valves
- G-sensor
- plunger pump motor relay
- speed sensors
- valve relay
- plunger pump motor

To access the trouble codes, drive the vehicle at a speed greater than 25 MPH for more than one minute. Stop the vehicle with the engine at idle, the trouble code flashes on the LED.

Note: *The ECU only displays one trouble code, the lowest numbered code. Correct the fault indicated by the trouble code and recheck ECU for another code. Repeat self-diagnostic procedure listed above, and the next highest code will be displayed. Refer to the appropriate model year service manual for the trouble codes and corrective actions.*

While the ABS ECU is in the fault mode, the ABS will go to fail-safe and remain passive under all braking conditions. The brake system will function as a conventional power assisted system without ABS.

ABS Service And Brake Bleeding Procedures

Note: *For detailed servicing procedures refer the appropriate model year Service Manual Section 4-4, [W00].*

Always check the fluid level of the master cylinder and bleed the wheel cylinders following the procedure listed in the service manual. When the HCU has been removed and/or replaced, the fluid must be drained.

Refer to the Service Manual Section 4-4 [W18D1] and [W18D2] for detailed system bleeding and HCU primary bleeding procedures.

Replace the cone screws with bleed screws and attach a hose to drain fluid to a container.

Use extreme care when performing this procedure to prevent damage to the internal components of the HCU. Do not apply AV signal for more than 5 seconds for each application.

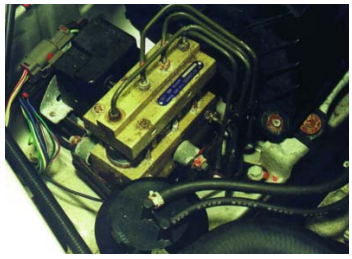
If no AV signal is received, it is not necessary to close bleed screw between brake pedal applications.

Antilock Brake System Notes and Cautions

The ECU on early Subaru ABS systems can only display one trouble code—the lowest numbered code. Correct the fault indicated by the trouble code and recheck ECU for another code. Repeat the self-diagnostic procedure listed above, and the next highest code will be displayed. Refer to the appropriate model year service manual for the trouble codes and corrective actions.

While the ABS ECU is in the fault mode, the ABS will go to fail-safe and remain passive under all braking conditions. The brake system will function as a conventional power-assisted system without ABS.

ABS-2E



ABS-2E Hydraulic Control Unit

Early model Subaru vehicles were fitted with either of two antilock braking systems. One is a Robert Bosch unit; the other is the ABS-2SL system from Nippon ABS, Limited. The third-generation antilock braking system was also manufactured for Subaru by Nippon ABS, Limited.

The Nippon system is designated ABS-2E. This system uses ABS components also found in previous antilock braking systems. These are as follows:

- four tone wheels
- hydraulic control unit (HCU)
- ABS warning light.
- four wheel speed sensors
- electronic control unit (ECU)

The HCU incorporates two relays, three solenoid valves, a mechanical valve and a fluid pump and motor.

Note: *The Service Manual refers to the solenoid valves in the HCU as "magnet valves." We use "solenoid valve" because it is a name more commonly used in the U.S. market.*

Like its predecessors, ABS-2E is a four-sensor, four-channel system. However, it is smaller and lighter than the earlier designs. In addition, the ABS-2E system incorporates improvements in the areas of trouble code memory, self-diagnostics, inspection and maintenance.

G-Sensor

The ABS-2E system appeared in production at the start of the 1993 model year and was available on the Legacy model if equipped with an automatic transmission. Also, early Impreza models equipped with ABS were fitted with the ABS-2E system.

ABS-2E System Differences

The ABS-2E system differs from the earlier ABS designs in four ways:

- Earlier designs used four solenoid valves. The ABS-2E hydraulic control unit (HCU) uses three solenoid valves and one mechanical valve.
- Its electronic control unit can store up to three trouble codes, rather than just one.
- The number of separate error conditions the ECU can recognize has been increased. That means there are more trouble codes available.
- There is a revised bleeding procedure.

ABS Operating Modes

During antilock braking, the HCU operates one or more of the solenoid valves to control the hydraulic pressure acting on the brakes. Each solenoid valve can operate independently in any of three pressure modes. These are pressure-reduce, pressure-hold and pressure-increase. These modes are related to the amount of current flowing through the solenoid valve, as determined by the ABS ECU.

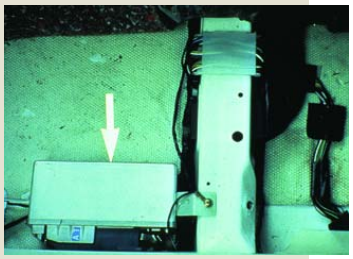
Note: *The term "pressure-increase" may suggest that the HCU raises pressure above that achieved by pressing the brake pedal. This is not the case.*

The Mechanical Valve

In the ABS-2E hydraulic control unit, the fourth solenoid valve has been replaced by a mechanical valve containing a plunger piston. This mechanical valve controls the left rear hydraulic brake circuit.

Chambers And Connections

In the right side of the valve is a pressure equalization chamber. The head of the plunger piston divides this chamber in half (zones A and B). If pressures in both



ABS Electronic Control Unit

halves of the chamber are equal, spring tension keeps the plunger piston in the home position, all the way to the right.

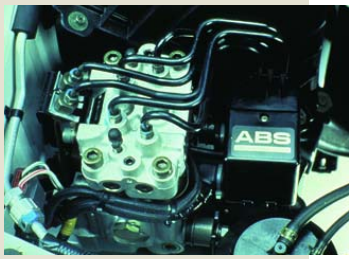
The right half of the chamber is connected to the master cylinder (port 2) and to the pump in the HCU (port 6). The left half of the pressure chamber is connected to the right rear hydraulic circuit (port 5).

During conventional braking, the master cylinder pressurizes both sides of this chamber. However, if pressure in the left half of the chamber is lower than pressure in the right half, the plunger piston is allowed to move to the left.

The other side of the mechanical valve contains a passage (zone E). One end of this passage is connected to the master cylinder (port 1); the other side is connected to the pump (port 3). The passage is also connected through a pressure port to a second pressure chamber (zone D). This chamber is connected to the left rear hydraulic brake circuit (port 4). Also in this chamber is a second piston, piston 2. Piston 2 is connected to the plunger piston by means of a pushrod.

Moving The Plunger Piston

When the system puts the right rear hydraulic circuit in pressure reduce mode, the solenoid valve in that circuit closes the inlet and opens the outlet. Wheel cylinder pressure is then reduced because brake fluid is allowed to bleed back to the reservoir in the HCU.



ABS Hydraulic Control Unit (Bosch System)

Through port 5, there is a hydraulic connection between the wheel cylinder circuit and the left half of the pressure chamber (zone B). With wheel cylinder pressure reduced, pressure acting on the left side of the plunger piston is also reduced. Master cylinder pressure acting on the right side of the plunger piston (zone A) now overcomes spring tension and begins to move the plunger piston to the left. As the plunger piston moves, the push rod causes piston 2 to move along with it.

As piston 2 moves to the left, it first closes the pressure port to isolate the left rear wheel cylinder (port 4) from master cylinder pressure (port 1).

As piston 2 moves farther to the left, it exposes the left rear wheel cylinder (port 4) to the right side of the second chamber (zone D). As piston 2 continues to move to the left, the expanding volume in the second chamber decreases pressure in the left rear hydraulic circuit.

When the system once again allows pressure to increase in the right rear hydraulic circuit, pressure in zone B moves the plunger piston back to the right.

In actual practice, this process of moving the piston happens very quickly and repeats many times per second as the system cycles.

Damping Oscillations

An additional benefit of this arrangement is that the mechanical valve damps out some of the unwanted oscillation in the brake pedal as the ABS pump runs. Because of this, the F valve used on the ABS-2SL system is no longer needed and has been eliminated from the circuit.

ABS Operating Modes

To illustrate the four operating modes of this ABS system, we'll assume that the ECU is operating only the solenoid for the right rear brake circuit. Recall that this circuit also affects the left rear brake circuit through the mechanical valve.

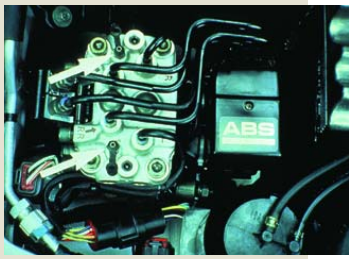
Normal Braking

- Driver depressing pedal
- Zero current in solenoid valves
- Plunger piston full right, pressure port open
- Master cylinder pressure supplied to all wheel cylinders
- ECU passive (monitoring)
- Pump off

Pressure-Reduce

- Pump pressure raising pedal
- ECU controlling solenoid valves and pump
- Full current in the right rear solenoid valve
- Pump running
- Plunger piston moves left, closes pressure port; system balances the two rear wheel cylinders.

ABS Dashboard Warning Light



Bleeding ABS Hydraulic Control Unit

Pressure-Hold

- Pedal firm
- ECU controlling solenoid valves and pump
- Half current in the right rear solenoid valve
- Pump Off
- Pressure port closed
- Plunger piston is stationary, maintains reduced pressure in the right and left rear wheel circuits.

Pressure-Increase

- Driver pressing pedal, pedal falling
- Zero current in solenoid valves
- Pump off
- Master cylinder pressure applied to right rear wheel circuit, raises pressure.
- Plunger piston begins to move right, opens pressure port. Master cylinder pressure drives plunger piston full right.
- Full master cylinder pressure applied to the left and right wheel cylinders

Note: *If necessary, the ECU cycles each brake circuit through the various ABS modes as required to control wheel lock-up.*

ABS Self-Diagnostics

The ABS-2E electronic control unit, or ECU, can store up to three trouble codes in its memory. It does this whenever it detects an out-of-range signal in any of its inputs.

When a fault condition is active, the ECU goes into fail-safe mode and turns on the ABS warning lamp. The brake system then functions only in conventional mode.

If the fault condition is caused by an intermittent problem, the ABS warning lamp may go off at the next ignition switch *On-Off* cycle, but the code will still be stored in the ECU's memory.

Displaying Codes

To display any stored codes, use the following procedure:

- Remove the small kick panel on the lower driver's door A-pillar.
- Enter ABS system diagnostic mode by jumpering terminal L in the ABS check connector to body ground. Check the schematic in the service manual to identify terminal L.

Note: *Some models have a grounding lead attached to the check connector.*

- Turn the ignition switch to *On.*
- Observe the ABS warning lamp. It will begin to flash out one or more codes.

When you enter diagnostic mode, the ECU displays the newest code first, then the second code and then the oldest.

Each code display cycle begins with the start code 11. After code 11, the ECU displays any stored trouble codes. When you see code 11 again, you know the ECU is repeating the cycle.

Interpreting Codes

Each code is made up of long and short flashes, just like those used by the fuel system. Count each long flash as 10, each short flash as one.

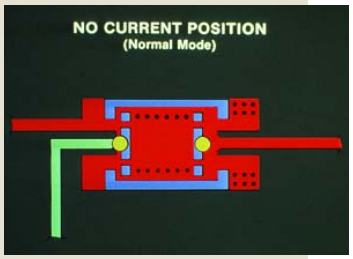
For example, if the lamp flashes one long and one short–that represents code 11. If it flashes two long and one short–that is code 21.

Self-Tests

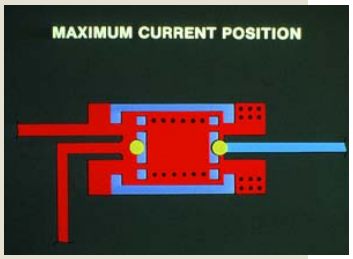
Each time the ignition switch is turned from *Off* to *On*, the self-diagnostic function begins to look for fault conditions. These self tests occur in two stages: one at key *On* and another as soon as the vehicle has been driven at a speed of 6 miles per hour or more for 20 seconds.

Assume that a particular vehicle has no ABS codes stored. If the ECU detects a fault condition, it goes into fail-safe mode and turns on the ABS warning lamp. In fail-safe mode, the ABS system is essentially shut down and completely passive, while the brake system operates conventionally. The system remains in fail-safe mode until the ignition switch is turned *Off*.

The next time the ignition switch is turned *On,* the ECU again initializes and looks for fault conditions, first at key *On* and again after 20 seconds at 6 miles per hour or more. If the fault condition is still there, the ECU simply returns to fail-safe mode.



No Current Position (Normal Mode)
Early Nippon System



Maximum Current Position
Early Nippon System

Note: *Even though the ECU can store up to three codes, this can happen only if at least two of the fault conditions are intermittent.*

This means the ECU stays in fail-safe mode as long as the first fault condition remains in effect, and will neither detect nor store in memory any additional fault conditions. If the first fault condition clears, the ECU again exercises active ABS control at the next key *On*.

If a second fault condition occurs, the ECU will then store the second code.

To get a third code into memory, the second fault condition must also be intermittent. When it clears, the ECU can come out of failsafe mode at the next ignition "*On-Off*" cycle. At that point, the ECU can detect, then store the third code.

If the ECU detects another fault condition once three codes are in memory, the newly arriving code displaces the oldest stored code. The newest code takes the first place in line for display.

Clearing Codes

To clear the memory of all stored codes, alternately disconnect and reconnect the jumper between ground and terminal L in the ABS check connector. Do this three times in the span of about 12 seconds.

Tip: *At the moment the ECU clears its memory, you can hear the relays in the HCU cycle once.*

Troubleshooting Process

To troubleshoot ABS systems, it's best to follow a step-by-step procedure like the one on page 31 of the 1992 Legacy ABS-2E Service Manual Supplement.

Enter the flow diagram with the symptom reported on the repair order. The diagram calls that *Trouble Occurs*.

The first step in the procedure is "Basic Checks." This calls for a visual inspection to look for obvious problems and includes the following items:

- improper battery voltage
- brake fluid leaks
- condition of the brake pads and rotors
- size, type, and condition of the tires (Check the tires to confirm that they are the correct tires for the vehicle, that they are in good condition, and that they are inflated to the correct pressure).
- low brake fluid level
- brake drag

If you find something wrong at this stage, correct it and see whether it eliminates the reported symptom. If not, continue to Step 3.

Step 3 is *Self-diagnosis*. At this time, put the ECU into self-diagnostic mode, and monitor the ABS warning lamp for trouble codes.

If the lamp functions properly and there are no trouble codes stored, you will see a continuously flashing Code 11. In that case, go to the *General Troubleshooting Chart*.

There you will find separate procedures for the following symptoms:

- brake pedal vibration and noise
- too much or too little pedal travel
- frequent ABS operation
- excessive stopping distance
- inoperative ABS system

Proceed to Step 4 in the diagram if the ECU has stored one or more codes or if the ABS warning lamp is malfunctioning. Step 4 directs you to "troubleshoot in accordance with trouble code." That means, turn to Section T6 and look for the specific chart that matches the trouble code you recorded. There is a chart in Section T6 to cover every possible ABS trouble code.

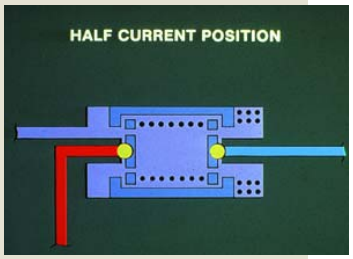
A table lists all of the codes, tells you where to look for diagnostic information and summarizes the reason for the trouble code. Notice that in some cases you have to look all the way over to the right column to find out to which component a specific trouble code refers.

Once you've identified a specific trouble code, the Basic Troubleshooting Procedure tells you what to do next:

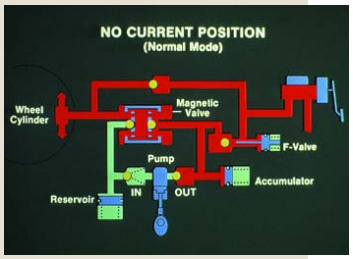
- Follow the troubleshooting steps in the chart.
- Make the necessary repair.
- Clear the memory.
- Repeat the self-diagnostic check.

In all cases, road test the vehicle when the preceding steps are done. This is necessary because some codes will not set until vehicle speed has been driven at six miles per hour or more for at least 20 seconds.

Note: *Do not substitute spinning the wheels on the service lift for a road test. On FWD vehicles, this can cause the ECU to incorrectly set a fault code.*



Half Current Position
Early Nippon System



No Current Position (Normal Mode)
Early Nippon System

Air Bleeding Overview

The air bleeding procedure for the ABS-2E system is similar to that used for other systems, with a few added steps. Refer to the Service Manual for general rules and step-by-step instructions.

As always, pay attention to the basics. Before you begin, make certain there are no leaks in the system.

Then bleed the secondary chamber of the master cylinder first and the primary chamber second. To accomplish this, work in the following order:

1. Right front brake
2. Left front brake
3. Left rear brake
4. Right rear brake

Pedal Travel Measurement

To properly perform the following procedure, you will need a pedal effort gauge (SOA 636500). With all four brake circuits bled, check pedal travel as follows:

- Put the wheel in a convenient position.
- With the engine idling, use the pedal effort gauge to apply 110 pounds of load to the brake pedal.
- Measure the distance between the brake pedal and the rim of the steering wheel.
- Release the brake pedal and take the same measurement.

Tip: *Tie one end of a length of string to the brake pedal. Press the brake pedal, and at the opposite end of the string, place a paper clip to mark the first distance. Then release the brake pedal and place a second paper clip to mark the second distance. Measure between the two paper clips with a ruler or tape measure.*

- Bleed the secondary chamber first.
- Pedal effort gauge measures force.

Measuring Brake Pedal Travel

The difference between the two distances (pedal depressed, pedal released) must be less than 3.75 inches (95 mm). If it is greater than that, there is air trapped in the HCU. Expel this air using Sequence Control.

Sequence Control

Sequence Control is the name of a mode in which the system automatically runs the HCU pump motor and cycles the solenoid valves. The Sequence Control actions help to purge air out of the hydraulic control unit.

To activate Sequence Control, proceed as follows:

- With the ignition off, jumper both the “L” and “K” terminals in the ABS check connector to ground.
- Turn the ignition switch to *On* and watch the ABS warning lamp.
- When the lamp goes off, immediately press and hold the brake pedal.
- The ECU now runs the pump and cycles all the solenoid valves. You will hear and feel this happening.
- When you hear the pump stop, you know Sequence Control is done.
- Release the brake pedal and turn the ignition to *Off*.

When you have completed Sequence Control, bleed all four brake circuits again. Top off the master cylinder reservoir after bleeding each circuit. Then road test the vehicle at low speed. Apply the brakes hard two or three times to make sure the brakes are working properly.

HCU Pressure Check Overview

It is possible to check the operation of the hydraulic control unit using a hydraulic pressure gauge. To do this, connect the gauge to one of the pressure output ports of the HCU, then start Sequence Control. As you start Sequence Control, press the pedal so that a specified initial pressure shows on the pressure gauge. Once Sequence Control starts, the ECU cycles the solenoid valves so that each brake circuit decompresses (pressure reduce mode) and re-compresses (pressure increase mode). As this happens, the reading on the pressure gauge should decrease to 71 psi or less, then come back to 498 psi or more.

Setting Up A Pressure Gauge

To build a set-up for checking HCU pressures, you will need the following parts:

- pressure gauge (1500 or 2000 psi)
- 3/16" steel brake line, 8" long, with 5/16" flare fittings (Gibson PN 308CK)

- 3/16" steel brake line, 8" long, with 10 x 1.0 mm flare fittings (Gibson PN 308MJ)
- 1/4" NPT to 1/8" NPT reducer (Edelman PN 219420)
- 3/16" inverted flare to 1/8 NPT (Edelman PN 124320)
- 3/16" to 3/16" compression union

You should be able to find the brake tubing and the connecting parts at most auto parts stores. For the pressure gauge itself, check industrial supply houses.

Follow these steps to assemble the parts:

- Cut each of the two 8" steel brake lines in half (to remove one of the fittings on each line).
- Join the two cut ends with the 3/16" compression union.
- Connect the pressure gauge to the 1/4" NPT to 1/8" NPT reducer (use Teflon® tape).
- Connect the 3/16" inverted flare to 1/8 NPT to the reducer (use Teflon® tape
- Connect the 5/16" flare fitting to the gauge assembly; the 10 x 1.0 mm fitting will connect to the HCU.

Tip: *When the tester is not in use, put a rubber cap from a bleeder screw over the open fitting to keep dirt out.*

Description

When Sequence Control starts, the left front solenoid cycles first, then the right front solenoid and finally the right rear. As the right rear solenoid works, pressure in the left rear brake circuit is simultaneously regulated by the mechanical valve.

It is not necessary to exactly match the values in the pressure table during your tests. The important thing is that you observe the sequence shown in the table below:

The pressure check is repeated for each of the four HCU pressure output ports. Recall that three of the brake hydraulic circuits are controlled by solenoid valves (all but the left rear circuit). If a check of any one of these circuits yields incorrect pressure readings, this may indicate a non-functioning solenoid valve.

- Intitial Value: the hydraulic circuit pressurizes as you press the brake pedal.
- Decompressed: the circuit automatically loses pressure as the HCU cycles the solenoid valve to pressure-reduce mode.
- Compressed: the circuit regains pressure (at least equal to the initial reading) as the system returns to pressure-increase mode.

Normal Pressure Readings

Circuit	Initial Value	Decompressed	Compressed
Front Brakes	498 psi (3432 kPa)	71 psi (490 kPa)	498 psi (3432 kPa)
Rear Brakes	498 psi (3432 kPa)	71 psi (490 kPa)	498 psi (3432 kPa)

Typical incorrect readings are shown in the two tables below. In the first example, the pressure does not decrease from the initial value. In the second example, the pressure fails to reach the initial value at the start of Sequence Control.

Pressure Does Not Increase – May Indicate Fault in Solenoid Valve

Circuit	Initial Value	Decompressed	Compressed
Any	498 psi (3432 kPa)	498 psi (3432 kPa)	498 psi (3432 kPa)

Pressure Does Not Reach Initial Value At Start of Sequence Control

Circuit	Initial Value	Decompressed	Compressed
Any	Less than 498 psi (3432 kPa)	71 psi (490 kPa)	Less than 498 psi (3432 kPa)

Pressure Values For Right Rear Circuit Are Correct, But Left Rear Pressure Does Not Decrease.

Circuit	Initial Value	Decompressed	Compressed
Right Rear Left Rear	498 psi (3432 kPa) 498 psi (3432 kPa	71 psi (490 kPa) 498 psi (3432 kPa)	498 psi (3432 kPa) 498 psi (3432 kPa)

The third example shows the readings for the right rear circuit are correct, but the readings in the left rear circuit do not change from the initial reading, this may indicate a malfunction in the HCU's mechanical valve.

Caution: *For this check, use a pressure gauge that is reserved exclusively for brake fluid. Do NOT use a gauge that has been used for transmission pressure tests; doing so could lead to brake system malfunctions.*

Note: *Before you start the HCU pressure checks, pump the brake pedal several times. That will bleed vacuum from the vacuum booster so that it is at atmospheric pressure.*

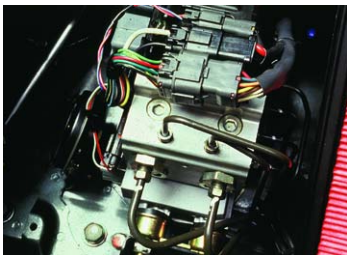
Note: *This check requires that you press on the brake pedal so that the pressure gauge displays a pressure equal to or more than the initial value in the table. Be prepared to press on the brake pedal with considerable effort for the duration of the check.*

To perform an HCU pressure check, follow these steps:

- At the HCU, loosen the hydraulic fluid line for the left front brake circuit.
- In its place, attach a suitable pressure gauge.
- Bleed air from the pressure gauge.
- Activate the Sequence Control mode.
- Observe the pressure gauge as the system cycles the left front solenoid valve through pressure reduce, pressure hold, and pressure increase. Compare the readings to the values in the table.
- Move the pressure gauge to the right front brake circuit connection at the HCU and reconnect the previously disconnected pipe. Then repeat Steps 3 through 5.
- Repeat these steps for the two remaining HCU ports (left and right rear).

When you have finished these checks, make sure all of the brake fluid pipe connections are secure and free from leaks and that the system is bled properly.

ABS 5.3



ABS Hydraulic Control Unit (ABS 5.3 System)

Beginning in approximately December of 1996, a new antilock braking system called ABS 5.3 was installed on Legacy vehicles equipped with ABS. This system uses a Bosch hydraulic control unit and a Nippon electronic control unit.

ABS 5.3 is a four channel control design which can independently control the front wheels and utilize select low control to control the rear wheels (a system which provides the same fluid pressure control for the two rear wheels if either wheel starts to lock up).

Although similar to other Subaru ABS systems, there have been enhancements to component operation and location. Diagnosis has also improved because of the ability of the 5.3 ABS system to communicate with the Select Monitor.

The hydraulic control unit or HCU is located under the hood on the right side of the engine compartment. The size of the HCU has decreased by approximately a third from that of the ABS-2E system, used on previous model year vehicles.

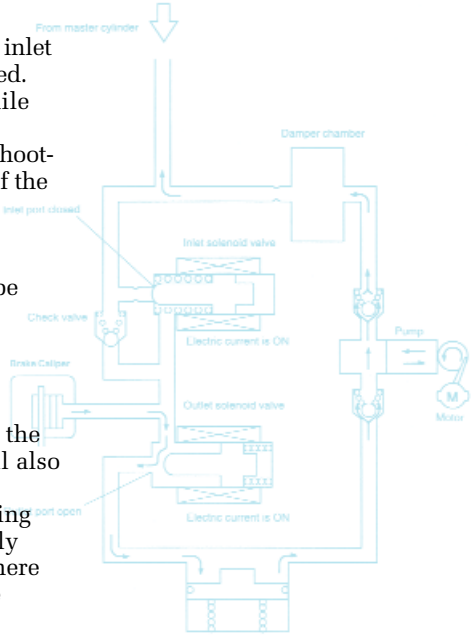
The HCU controls brake fluid flow by utilizing eight solenoid valves. There is an inlet solenoid valve and an outlet solenoid valve for each wheel. Mechanically, the inlet solenoid valve is open during normal braking, and the outlet solenoid valve is closed.

The HCU also contains a motor and pump assembly, which operates only while ABS is actively controlling the brake fluid flow—preventing a wheel lock.

Externally the HCU of the ABS 5.3 has a relay box attached. This allows troubleshooting of the valve and motor relay area to be kept separate from the troubleshooting of the solenoid valves and pump motor.

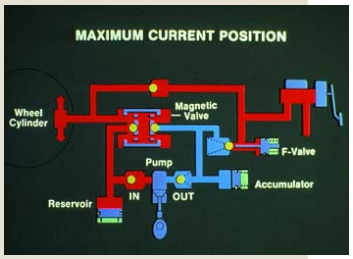
There are four modes of operation for the ABS 5.3 system. They are normal, pressure-drop, pressure-hold and pressure-increase.

When wheel lockup is sensed, Mode Two, Mode Three and Mode Four may be activated. They are described as follows:

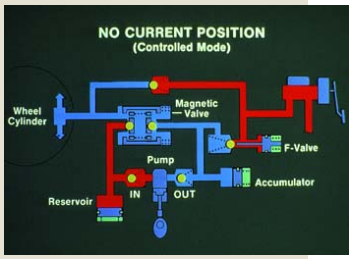


Mode Two—Pressure-Drop

The electronic control unit will activate the inlet solenoid valve of the affected wheel or wheels causing it to mechanically close, preventing the pressure from the master cylinder from reaching the brake caliper. The electronic control unit will also activate the outlet solenoid valve of the affected wheel or wheels causing it to mechanically open releasing the brake fluid pressure from the caliper, eliminating lock up. The pressure is absorbed by the reservoir and the motor pump assembly will activate. This action will allow brake fluid flow to the damper chamber where some of the oscillations are removed; however some kickback will be felt at the brake pedal.



Maximum Current Position
Early Nippon System



No Current Position (Controlled Mode)
Early Nippon System

Mode Three–Pressure-Hold

When the ideal wheelspeed is achieved the electronic control unit will activate the pressure-hold mode. The pump and motor assembly will continue to operate and the outlet solenoid will electronically turn off. This will cause the outlet solenoid valve to be mechanically closed. At this point the inlet and outlet solenoid valves are both closed and the remaining brake fluid pressure is retained in the caliper.

Mode Four–Pressure-Increase

Pressure increase solenoid valve orientation is the same as normal braking. The only difference is that the pump and motor assembly are in operation, assisting the master cylinder in applying the affected caliper.

The ABS 5.3 electronic control unit is located behind and to the right of the glove box. The cruise control unit has been moved to the driver side of the vehicle to make room for the ABS control unit.

Warning: *Remove the bolts securing the dash pad to the dash frame. Use minimum force to prevent damaging the dash pad.*

ABS operation, self check and system diagnosis is a summary of the work performed by the ABS control unit. Self check, which is performed when the ignition is first turned on and when the vehicle speed has reached 3 mph with no brake applied and 8 mph if the brake has been applied, has been enhanced so that its operation is not objectionable to the customer. The length of time in which the self check can be felt or heard has been reduced from 800 milliseconds to 200 milliseconds. If any problems are detected, this information will continue to be communicated to the operator through the ABS warning light, and as in previous model years, the ABS system will be passive (non-operational) with the warning light on.

On-Board Diagnostics

Using on board-diagnostics is very similar to the ABS-2E system. Three trouble codes are the limit of memory retention with the newest code being displayed first. Accessing of trouble codes is achieved by first turning off the ignition switch, then grounding terminal 3 of the 6 pole service connector B82 located above the accelerator pedal, then turning on the ignition switch. The codes can be viewed on the ABS warning light. The trouble codes for the ABS 5.3 system are the same as the 2E system with the addition of trouble code 29. This code will be generated when the speed of one of the wheels is 1.25 times faster than the others for at least one minute.

Sequence Control

Sequence control is also activated by the use of the six pole service connector B82. Ground terminals 3 and 6, turn on the ignition and apply the brake, as described in the service manual, within .5 seconds after the warning light has turned off. The left front wheel and the right rear wheel, while in sequence control, are activated together. First pressure drop will occur (the service manual describes the procedure for connecting the pressure gauge). Observe and record the pressure drop. Pressure hold will then be activated followed by Pressure Increase Mode.

In each case observe and record the pressure readings. Compare your results with the specifications in the service manual. The operation of the right front and left rear sequence control immediately follows the left front and right rear. So if you do not have four pressure gauges you must enter Sequence Control enough times to check the operation of each wheel.

Clearing past trouble codes is accomplished by entering D-Check and then grounding terminal 6 of B82, three times within 12 seconds, with the ground pulse lasting at least .05 seconds.

All AWD 5.3 vehicles use a G-sensor. The G-sensor for the ABS 5.3 system is a capacitance type and its input to the electronic control unit modifies the computed average vehicle speed. This sensor varies its output with changes of G-forces by changing the capacitance of an internally located capacitor. The G-sensor is located under the center console just behind the hand brake lever.

The Select Monitor and the 1996 Legacy cartridge are used to communicate with the ABS 5.3 electronic control unit.

A word of caution: *Do not confuse ABS/TCS with ABS when choosing the correct pathway for communications with the ABS 5.3 system.*

After choosing *ABS* you have many pieces of information that are very useful in performing diagnostics. FO1 through FO8 tell you the speed of each wheel as seen by the wheel speed sensors in (mile/h) and (km/h). F09 will indicate that the brake

switch has been activated by indicating a reference voltage of 5 volts which comes from the electronic control unit, not the brake switch directly. F10 is the input voltage from the G-sensor. At rest or cruising the voltage should be 2.3 volts and should decrease upon acceleration, increasing upon deceleration.

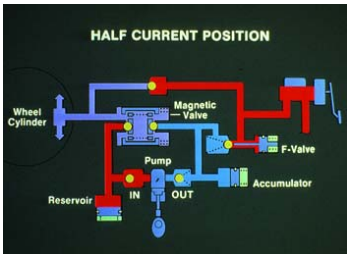
The FAO mode has nine light-emitting diodes that communicate information indicating on and off signals from the following:

- LED 2 and 7 turn on only when the valve relay is off. During normal operation the valve relay is always on.
- LED 4 represents the signal from the ABS electronic control unit to the 4EAT electronic control unit. This signal will order the transmission to go to mainly front wheel drive, shift to 3rd gear and disable the overrunning clutch (preventing engine braking).
- LED 9 monitors the electrical circuit between the ABS electronic control unit and the transmission electronic control unit. However it only performs this function while ABS is active. The wire carrying the signal for LED 9 parallels into the wire carrying the signal for LED 4.
- Mode FB1 is used to call up trouble codes.

Note: *If a particular trouble code is not properly stored in memory (due to a drop in ABS Control Module power supply, etc.) when a problem occurs, the trouble code, followed by a question mark ''?," appears on the Select Monitor display. This shows it may be an unreliable reading.*

Mode F01 will enable you to perform a sequence control in the same manner as previously described, however the Select Monitor eliminates the need to connect terminals 3 and 6 to body ground. Follow the instructions displayed on the Select Monitor and in the service manual for performing this task. Mode FC0 is used to clear the memory.

Caution: *Record all trouble codes in memory before clearing codes.*



Half Current Position
Early Nippon System