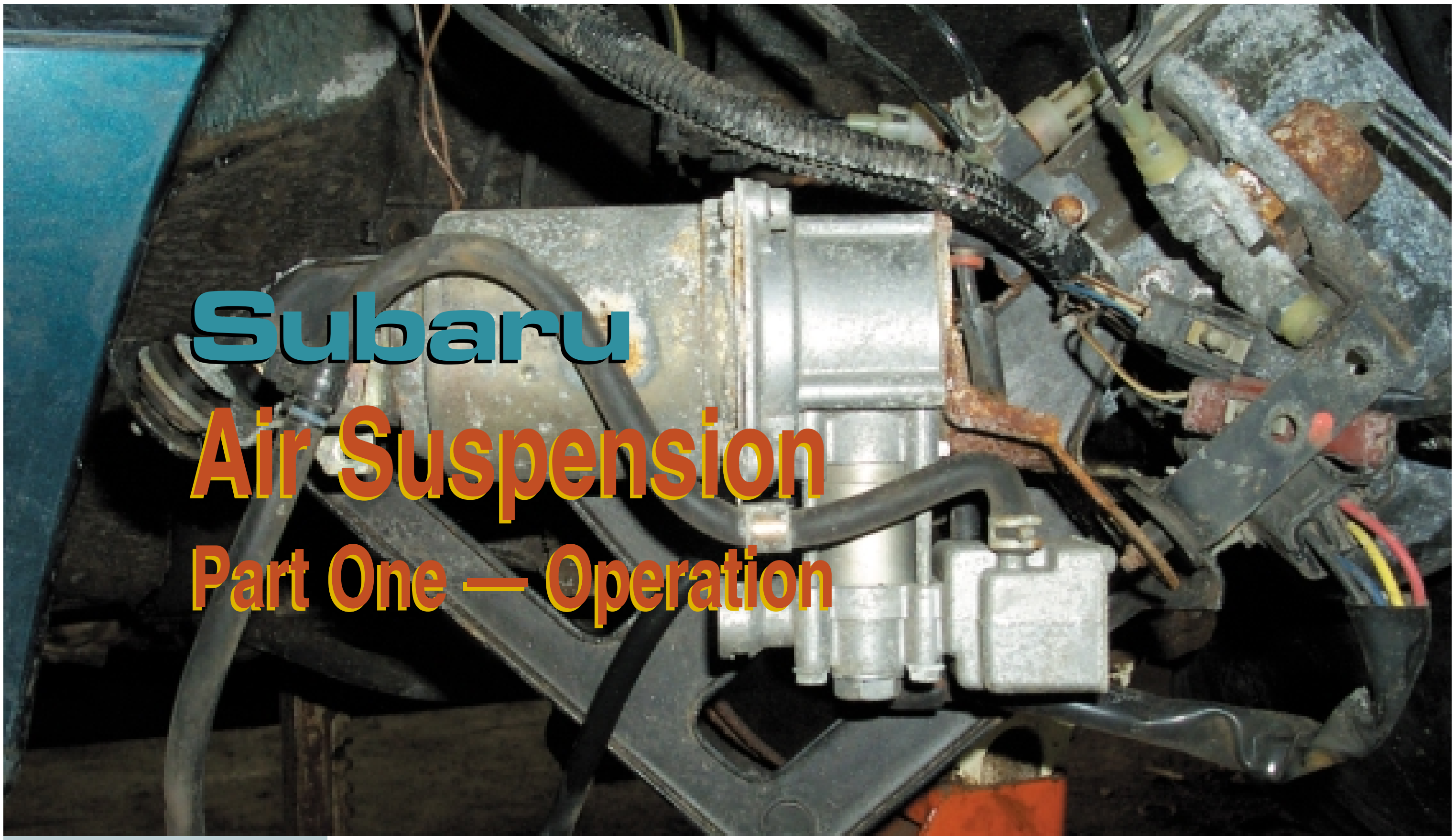
Subaru Air Suspension

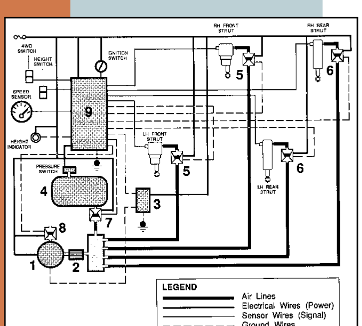
Part One — Operation



Compared to coil springs, air suspension systems offer several advantages. The most important of these is the air suspension system's ability to maintain uniform ride height in the presence of changing vehicle loads. Using a height sensor and an individually controllable air spring at each wheel, the Subaru air suspension system can adjust ride height at all four corners.

A coil spring is nearly fully compressed when heavily loaded. As a coil spring compresses, it loses some of its ability to respond to the loads imposed by pavement irregularities and braking or cornering. An air spring, on the other hand, can maintain roughly the same ability to respond because its working length is maintained by changing its internal air pressure.

Using an electronic controller, the Subaru air suspension system is able to automatically make adjustments as vehicle loads change. As a result, it can provide a comfortable ride and proper handling during braking, cornering, and over road surface irregularities–whether the vehicle is nearly empty or loaded with people and luggage.



Air Suspension System

Overview

Air suspension can be found on selected models of the following Subaru vehicles: Legacy, L Series GL10, XT, and XT6.

System Components

The Subaru air suspension system is made up of the following components: four suspension struts with air bladders and built in height sensors, an electrically driven air compressor with drier assembly, an air tank, air lines, six solenoid-controlled valves, an electronic control unit (ECU), a pressure switch, a relay, a height switch (most models) and a height indicator.

The component locations in the vehicle are as follows (reference diagram at left):

- compressor (1) – in left-hand front wheel well,
- drier assembly (2) – on compressor,
- compressor relay (3) – near top of left-hand, front strut,
- air tank (4) – near compressor, in left-hand front wheel well,
- front solenoid controlled valves (5) – on bracket near top of each front strut,

- rear solenoid controlled valves (6) – on each rear strut,
- air charge solenoid (7) – on air tank,
- air discharge solenoid (8) – on compressor,
- electronic control unit (9) – beneath driver's seat.

Component Descriptions: Compressor

The compressor is a small air pump driven by an electric motor. Mounted on the compressor is a drier assembly filled with silica gel to absorb moisture as air is drawn into the system; it gives up moisture as air is expelled from the system.


Air Tank

Air Tank

The air tank is a reservoir for the system.

Struts

The suspension struts are similar to ordinary struts, except that the coil spring is replaced by an air bladder.

Strut Valves

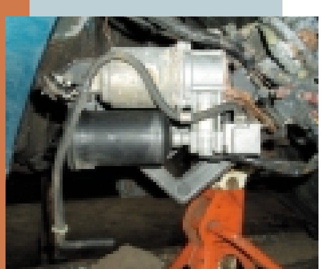
A solenoid valve is simply a valve that is controlled by an electric solenoid. Four solenoid-controlled air valves are fitted into the air lines that connect the strut air bladders to the system. These open to let bladder pressure equalize with pressure in the lines.

Air Charge

The air charge solenoid valve opens or closes the connection between the air tank and the system.

Air Discharge

The air discharge solenoid valve is mounted on the compressor. The system uses this valve to vent pressure from the system. In addition, when the compressor is running, air flows into the system through this valve. To vent air, the solenoid must be energized. However, the solenoid does not have to be energized for air to flow in.


Compressor Assembly

If the compressor discharge pressure becomes excessively high, the air discharge solenoid valve functions as a pressure relief valve.

Relay

The contacts of the compressor relay open or close the path to ground for the compressor motor. The electronic control unit uses the relay to turn the compressor ON and OFF.

Height Sensors

There is a height sensor mounted inside each strut assembly. A height sensor consists of four reed switches and a permanent magnet. The magnet moves past the switches as ride height changes and toggles them OPEN or CLOSED.

Pressure Switch

The pressure switch senses the pressure in the tank. At ambient (normal) pressure, the contacts in the switch are closed and it conducts current. When the pressure applied to the switch rises, it opens at 137 psi and no longer conducts current. With the pressure coming back down, the switch closes again at 109 psi.

Height Switch

The height switch is a driver-controlled switch. When it is activated, the system temporarily raises the suspension for increased ground clearance.

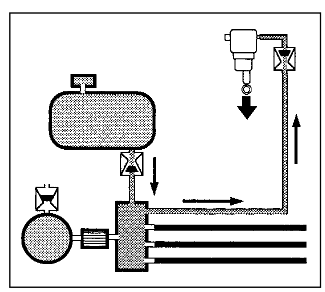
Height Indicator

This indicator is used to alert the driver that the system is making an adjustment in ride height. The indicator also flashes continuously when the ECU has detected a malfunction.

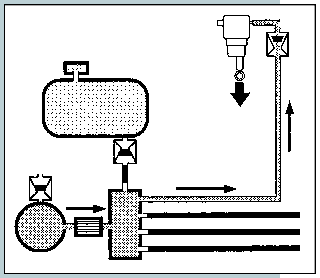
ECU

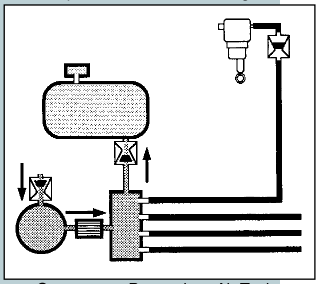
The ECU, or electronic control unit, controls the compressor relay, the solenoid valves, and the height indicator. It receives signals from the height sensors, the pressure switch, the height switch, the 4WD switch, and the speed sensor.

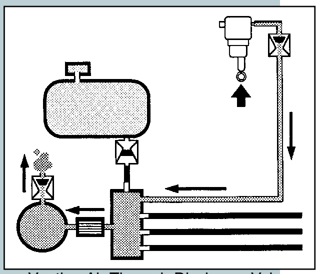
System Operation


Inflating Strut With Tank Pressure

To raise a strut, the control unit opens the charge solenoid and a strut solenoid valve at the same time. Through the open valves, the distribution block, and the air lines, the tank and the strut air bladder are now connected. Because pressure in the tank is high and pressure in the bladder is low, air flows from the tank into the strut bladder. This flow of air continues until the strut is high enough or until the pressures are equalized.


Compressor Pressure Inflating Strut


Compressor Pressurizes Air Tank


Venting Air Through Discharge Valve

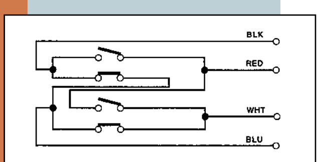
If there isn't enough pressure in the tank to fully raise the strut, the system turns on the compressor and—after a delay of 10 seconds—closes the charge solenoid valve. With the compressor running, pressure in the distribution block and in the lines is higher than strut bladder pressure, the bladder continues to inflate, and the strut continues to raise.

When the strut has been raised enough, the system closes the strut solenoid valve, opens the charge solenoid, and keeps the compressor running to bring tank pressure back up to the desired level.

To lower a strut, the system opens the discharge solenoid valve and a strut solenoid at the same time. Instead of being connected to the tank, the strut's air bladder is now connected to the open air discharge valve. Since air pressure outside is lower than pressure in the air bladder, air flows out of the bladder. The bladder deflates and lowers the strut.

Height Sensor Logic

There are four reed switches and a magnet built into each strut. These are arranged so that the switches move past the magnet as vehicle ground clearance increases and decreases. Like all reed switches, these are opened and closed by a magnetic field. However, unlike ordinary reed switches, these are self-holding.

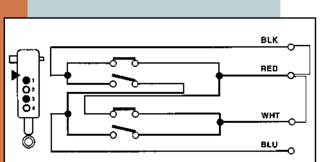


Height Sensor Reed Switches

Each strut is connected to the control unit with four wires: black, red, white, and blue. During normal operation, the control unit monitors the four wires from each strut for continuity in four different combinations:

- black with red
- black with blue
- white with red
- white with blue

The control unit sees these different combinations of continuity, depending on how the reed switches are set: OPEN or CLOSED. Unless there is a fault, only two switches in any one height sensor are ever closed at the same time. This is because of the way the switches toggle as the magnet moves by them and then hold until the magnet passes again.



Height Sensor Indicating Too Low

With the suspension all the way down, switches 2 and 4 are CLOSED and switches 1 and 3 are OPEN. With the suspension in this position, the magnet is positioned below reed switch number four. With the magnet there, the control unit sees continuity between the black and blue wires and the white and blue wires. This combination of signals from the reed switches tells the control unit that the vehicle is TOO LOW.

As the system increases air pressure, the suspension begins to extend, raising the vehicle. The magnet moves past switch four and it opens. The control unit now sees continuity only between the black and blue wires. That tells it the vehicle is now at LOW NORMAL height.

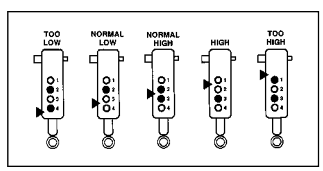
As the magnet continues to move up, it next passes reed switch number three and it closes. The control unit now sees continuity between the black and blue wires and the red and white wires. This tells it the vehicle is at HIGH NORMAL height.

As the magnet passes reed switch number two it opens. The control unit sees continuity between the red and white wires. The vehicle is HIGH.

Finally, as the magnet passes reed switch number one, it closes. The control unit sees continuity between the black and red wires and the red and white wires, telling it the vehicle is TOO HIGH.

That represents the entire range of normal signals from the reed switches. When the suspension compresses and ground clearance is reduced, the same things happen in reverse order.

To sum up, the normal reed switch signals are: too low, normal low, normal high, high, and too high. If a set of reed switches sends any signal other than one of these five, the control unit treats it as a sign of trouble.



Normal Reed Switch States

Control Unit Logic

The electronic control unit has been programmed to perform its functions according to certain logic rules:

- If one strut is high and another is low, always lower a strut before raising a strut.
- If front and rear of vehicle are both low, always raise rear first.
- If both front and rear of vehicle are high, always lower front first.

Always successfully complete one task before proceeding to the next.

If the ECU cannot complete a task in 8 to 10 minutes, it flashes the height indicator and shuts off the system. This time limit keeps the system from attempting one task indefinitely, while allowing sufficient time to complete routing tasks. However, if the ECU receives an 'impossible' signal (more than two switches closed at the same time or an 'illegal' continuity combination), it immediately shuts off the system and flashes the indicator, without waiting 8 to 10 minutes.

Here are some additional system characteristics:

- The height indicator flashes if the vehicle has been jacked up for 10 minutes or more with the ignition switch turned to ON (this is normal).
- If one wheel is in a hole or on a bump (more than several centimeters lower or higher than the other three wheels) the ECU will neither raise nor lower any strut, even with the ignition key turned to ON.

  The ECU begins height adjustments about one minute after the ignition switch has been turned to ON.
- The ECU does not raise any strut when vehicle speed is over 55 MPH, and the ECU does not raise or lower any strut when the vehicle is moving and the FRONT height sensors send opposite signals (high/low). When this occurs, the ECU assumes the vehicle is leaning because of body roll during cornering.

In Legacy vehicles, the ECU logic has been slightly modified. In these vehicles, the compressor starts immediately after the height switch is pressed ON (high). This change was made to reduce the time needed to raise the vehicle to the high state.

System Diagnosis

Reed Switch Malfunctions

If the height indicator lamp flashes immediately after you turn the ignition key to ON, you know the control unit is getting an impossible signal from the reed switches in one or more of the struts. When that happens, take care not to shake or otherwise disturb the vehicle as you work. The reed switches are so sensitive that rocking the car might accidentally toggle one from on to off or vice versa. That would give you a false result during troubleshooting.

To begin troubleshooting, turn the ignition key to OFF and disconnect the height sensor at one of the struts. Turn the ignition key to ON–and see if the height indicator flashes immediately. If it does not flash, you've probably isolated the malfunctioning height sensor. Just to be sure, reconnect the sensor and see if the indicator flashes again.

If the height indicator still flashes after you disconnect the first height sensor, it means the malfunctioning sensor is still connected. Repeat the steps until you find the bad sensor.

Turn the ignition key to OFF between each test. Also, leave each sensor disconnected as you disconnect the next–until you get a positive result (the indicator does not come ON when you turn the ignition ON). Although it is unlikely, there could be more than one failed height sensor in the system. To check for that possibility, leave the last sensor (the one you identified as being faulty) disconnected and, one by one, reconnect the remaining sensors.

As you reconnect each sensor, again turn the ignition switch to ON to see if the indicator begins to flash. If it does, you have identified a second failed height sensor. If you get all the other sensors reconnected without the height indicator flashing, you know the first sensor you identified as bad is the only failed sensor.

Note: Do not shake the vehicle as you work.

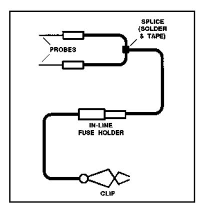
When you are sure you have identified a bad strut, replace it then retest the system.

If the problem is intermittent, you will have to do a roadtest after you disconnect each sensor. If you drive for a while and then the height indicator begins to flash, that tells you the malfunctioning sensor is still connected. You will know you have probably disconnected the bad sensor when your roadtest does NOT cause the light to flash. However, if the indicator continuously comes on after eight to ten minutes, it may mean that there's some other kind of malfunction and not an impossible signal from a reed switch.

Using a Fused Jumper Wire

The ECU energizes components by closing a path to ground for them. This gives you a convenient way to manually energize selected components. To energize a component, connect a fused jumper wire between a known good ground and that component's ground wire. A convenient place to connect the jumper is at the control unit's connector.

When you make the connection at the control module connector, make sure you get the right wire.



Look up its color and position in the connector in the appropriate model-year service manual. Then carefully back-probe the connector without separating it from the control module. To perform the test, you'll have to turn the ignition switch to ON so that power is supplied to the control unit. However, make sure the ignition is OFF while you make the connections.

If you do not already have a fused jumper, construct one with a length of suitably heavy wire, two small electrical probes, an alligator clip, and a fuse holder. Solder and tape the splice connection. Before using your jumper wire, put a 7.5 amp fuse in the holder.

More on Subaru air suspension diagnosis in the next End Wrench.