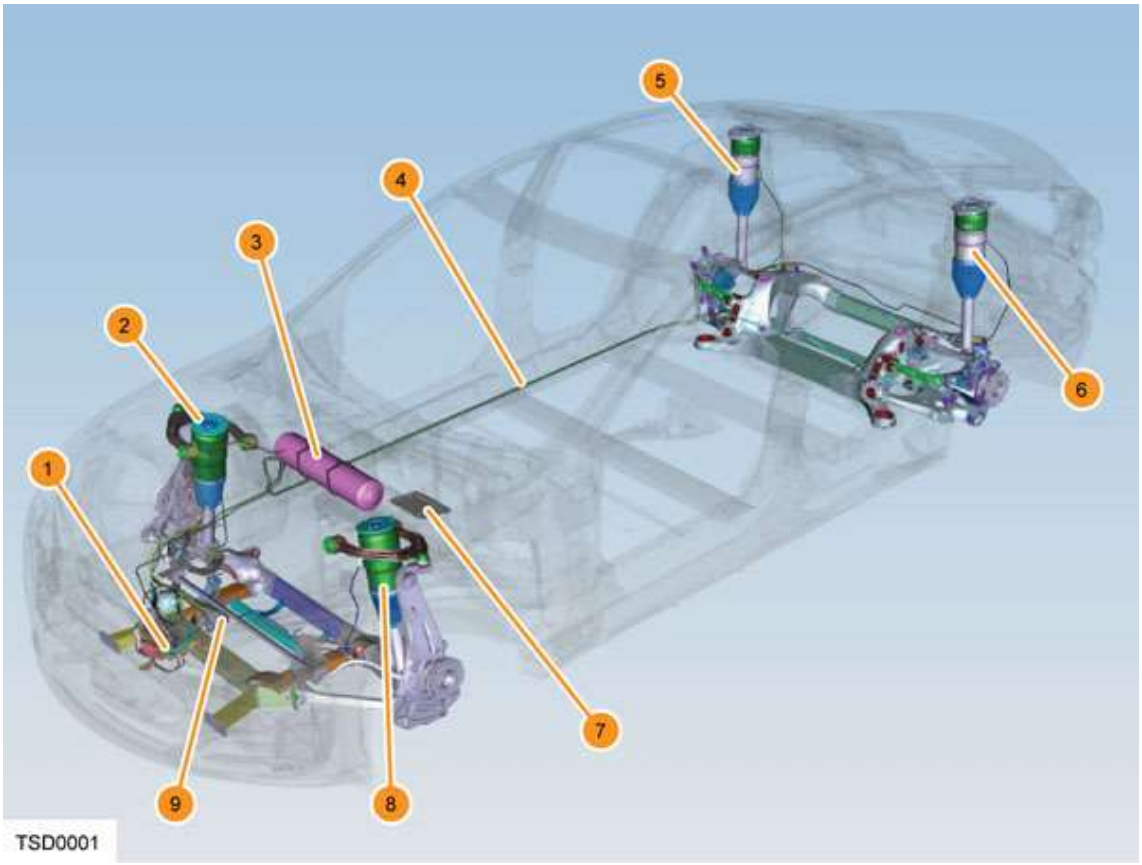
Air Suspension

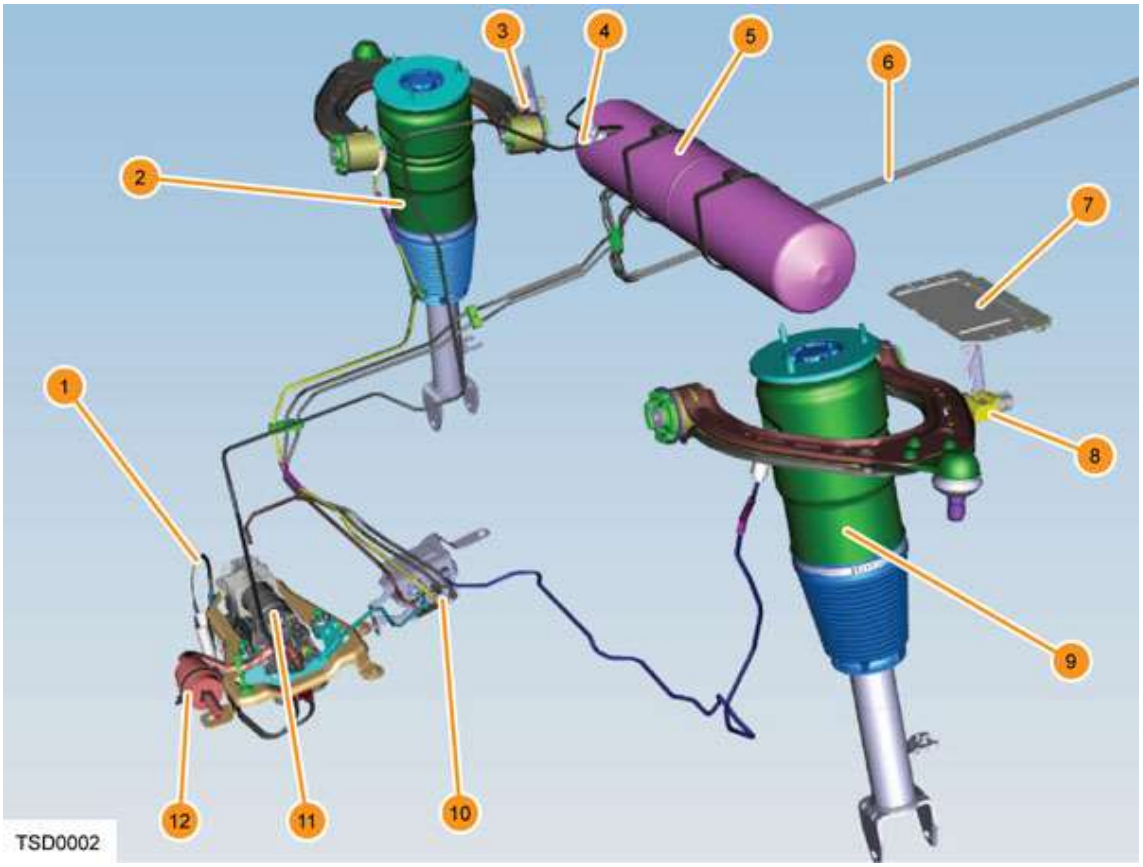
Overview

Component Location



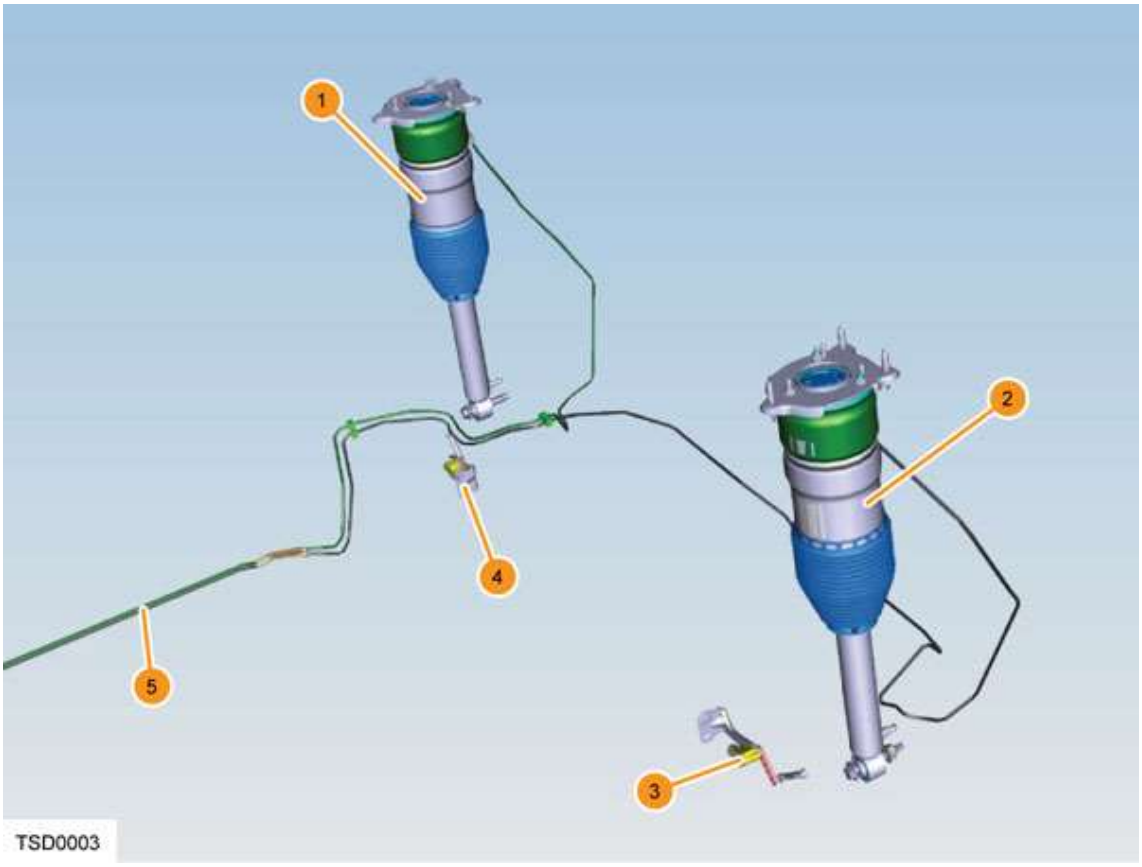
1. Air compressor
2. RH front suspension module
3. Reservoir
4. Air supply pipes
5. RH rear suspension module
6. LH rear suspension module
7. Air suspension Electronic Control Unit (ECU)
8. LH front suspension module
9. Solenoid valve block

Front Suspension



1. Ambient air temperature sensor
2. RH front suspension module
3. RH front height sensor
4. System filling valve
5. Reservoir
6. Air supply pipes
7. Air suspension Electronic Control Unit (ECU)
8. LH front height sensor
9. LH front suspension module
10. Solenoid valve block
11. Air compressor
12. Air filter

Rear Suspension



1. RH rear suspension module
2. LH rear suspension module
3. LH rear height sensor
4. RH rear height sensor
5. Air supply pipes

General

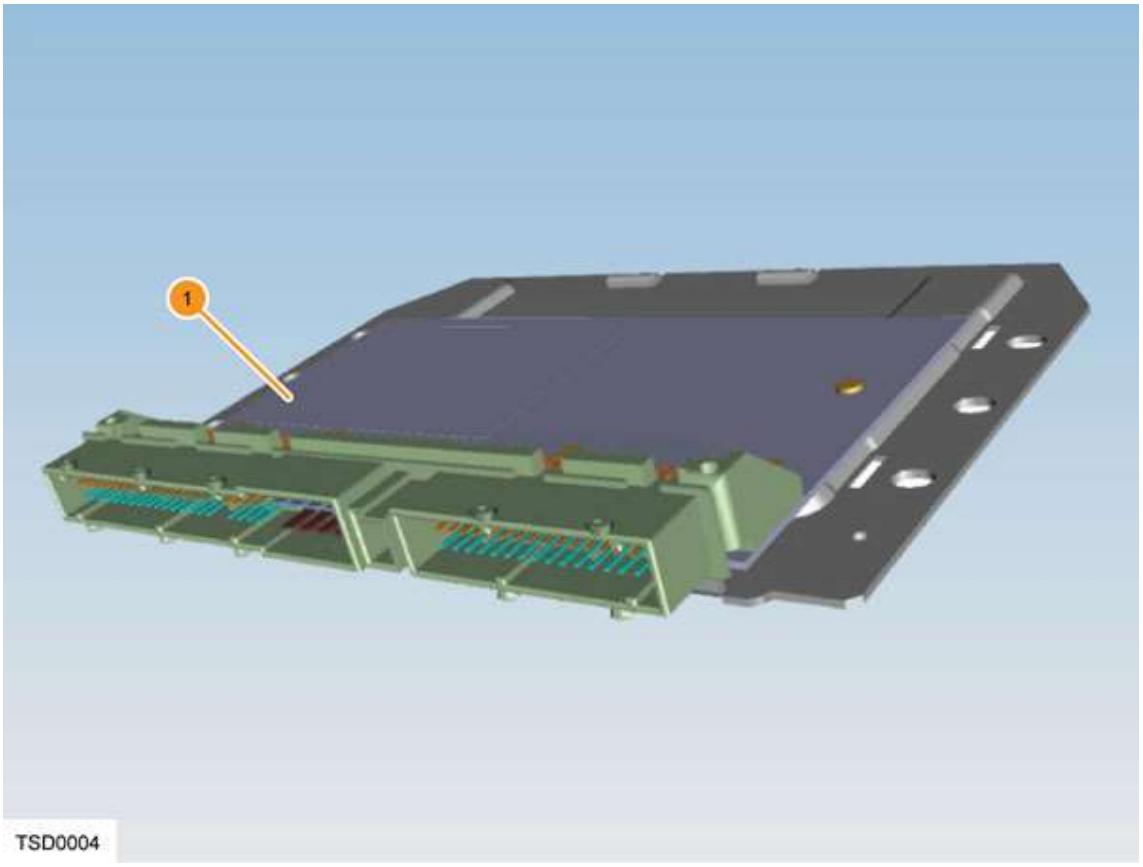
The suspension system operates on air pressure. Air is passed through the air filter to remove any impurities, then drawn into the system by the compressor. Compressed air is then fed to the reservoir, which directs the air to the front and rear suspension modules via the solenoid valve block and air supply pipes as determined by the ECU.

The ECU monitors the vehicle's axle height via the four height sensors. The ECU adjusts vehicle height based on road speed, ambient air temperature, the requested height level setting, and several other preconditions. This process maintains vehicle suspension at the correct height for all conditions. The ECU also monitors system pressure and switches the compressor on or off to maintain correct pressure.

Each suspension module contains a spring bellows that is inflated with compressed air as required by the system.

Component Descriptions

Air Suspension ECU



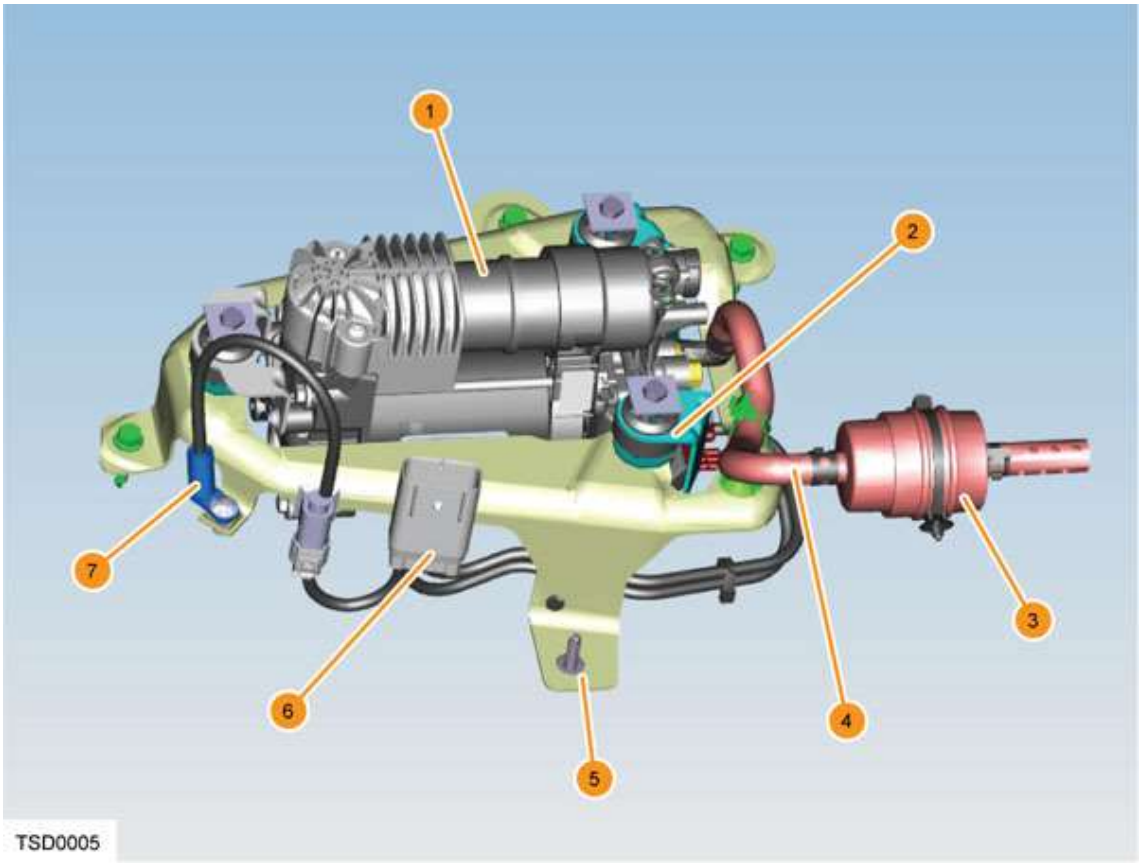
1. Air suspension Electronic Control Unit (ECU)

The ECU is located below the instrument panel, forward of the center console.

The ECU controls the height of the vehicle by managing the air pressure inside the suspension system. It calculates the height of each axle separately by averaging the height signals it receives from the height sensors located on each side of the front and rear axles. To prevent headlights from blinding oncoming traffic during height changes, the ECU keeps the rear axle higher than the front axle.

Using the touchscreen, the driver can manually choose between four height levels. When the vehicle is being driven, height levels can also change automatically, with the height decreasing depending on the vehicle's speed. When the vehicle is parked, height levels can also change automatically after loading and unloading passengers, once all doors are closed.

Compressor



1. Air compressor
2. Rubber mounting
3. Air filter
4. Suction hose
5. Mounting bracket
6. Electrical connector
7. Ambient air temperature sensor

The maintenance-free single-stage oil-free piston compressor is driven by an electric motor. The ECU controls the compressor. The compressor module contains the compressor motor, reversing valves, pressure relief valve, air dryer, and throttle/check valve.

Specification	Value
Voltage range	9 to 15 volts
Maximum permanent current	40 Amps
Operating temperature range	-40°C to 80°C, Max. 100°C for 3 minutes
Operating pressure range	0 to 16 bar (232 psi)

Reversing Solenoid Valves

The reversing solenoid valves are energized by the ECU to draw excess air from the air suspension bellows, back through the compressor, and into the reservoir.

Pressure Relief Valve

The relief valve limits the maximum system pressure at 17 to 23 bar (246 to 333 psi).

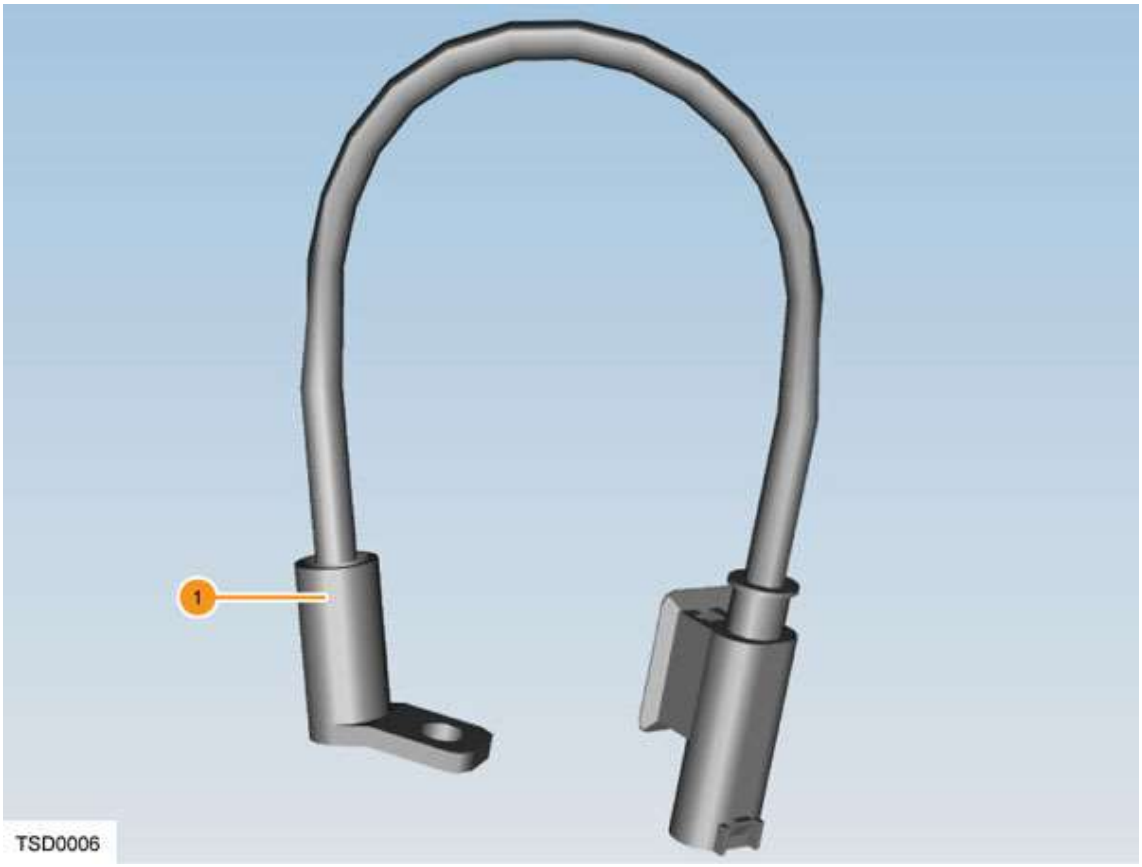
Air Dryer

The dryer absorbs humidity from the intake air. When regenerating, humidity is released to the environment.

Throttle/Check Valve

The throttle/check valve regulates the pressure being returned to the reservoir.

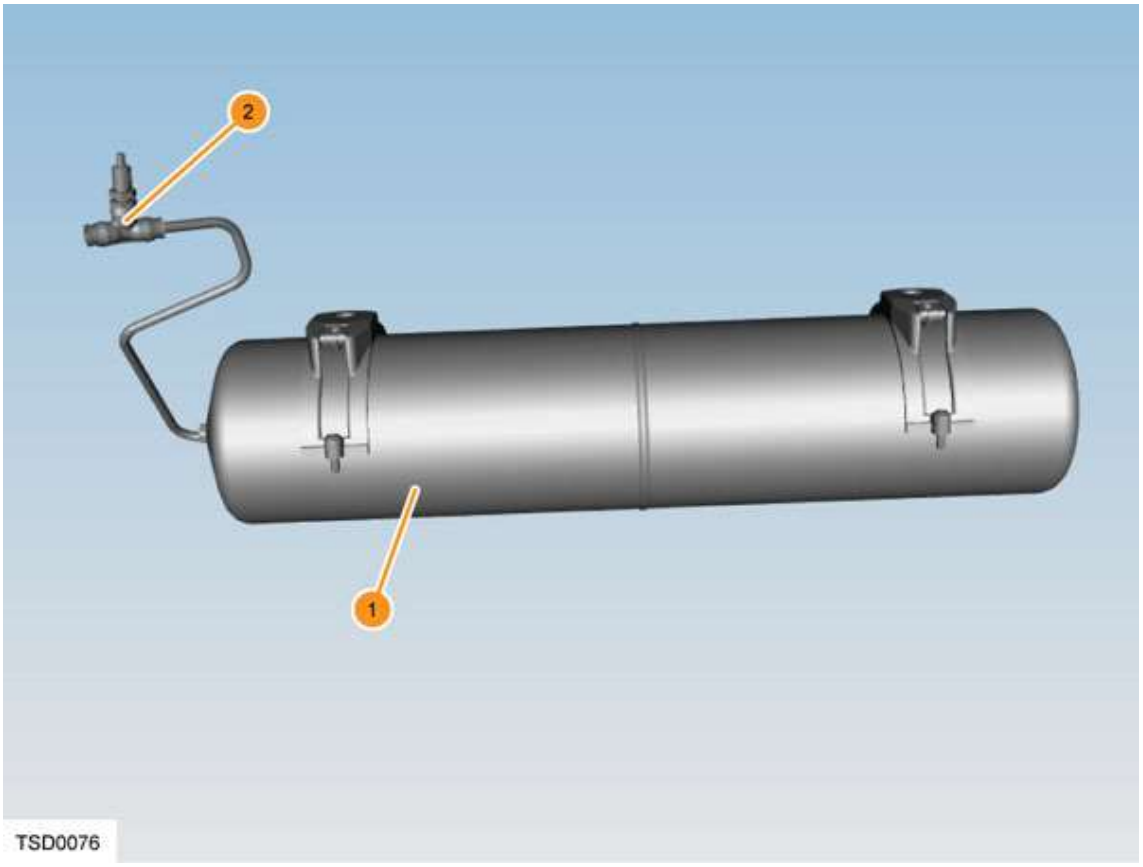
Ambient Air Temperature Sensor



1. Ambient air temperature sensor

The ambient air temperature sensor is mounted on top of the compressor. It provides ambient air temperature data to the ECU to maintain system performance in different ambient conditions.

Reservoir

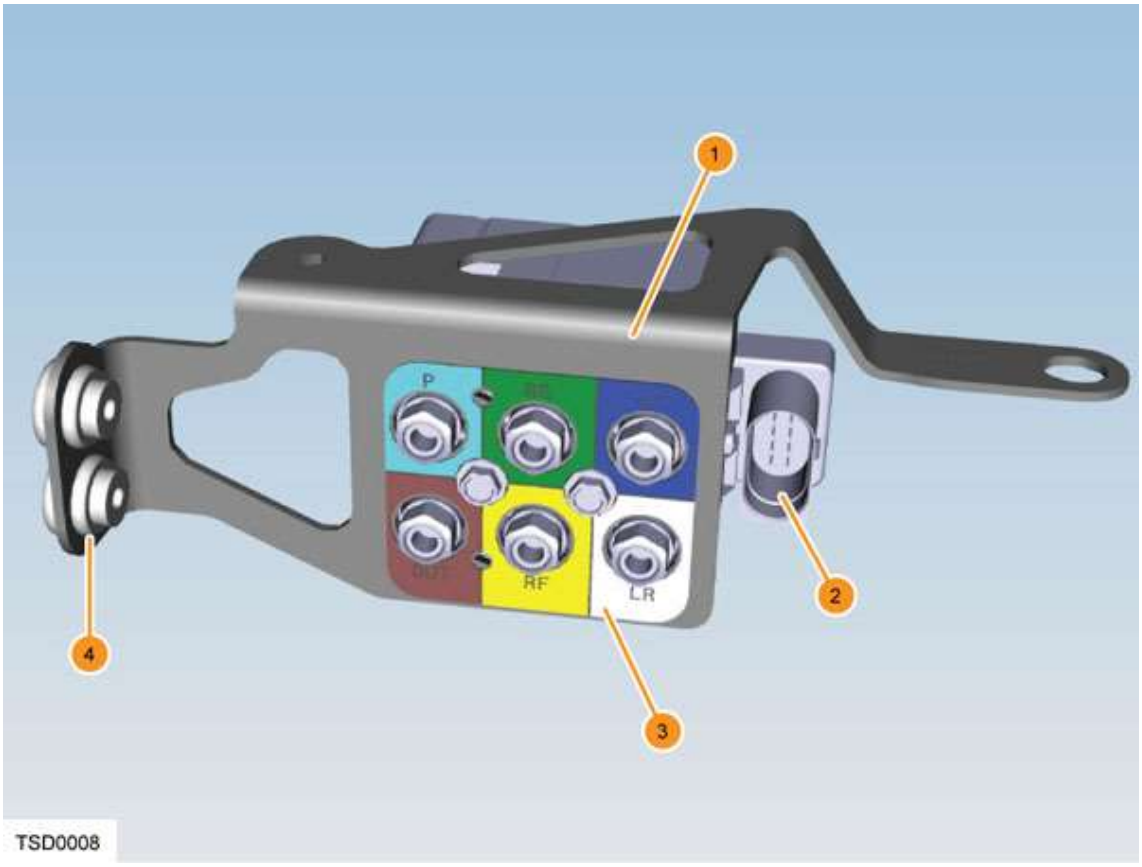


1. Reservoir
2. System filling valve

The reservoir provides the system with pressurized air when lifting the vehicle, and stores the air released from the suspension modules when lowering the vehicle. The reservoir has a maximum volume capacity of 317.32 cubic inches (5.2 liters) and a regular operation pressure of 217.55 psi (15 bar) absolute.

The system filling valve is used if the air suspension system must be filled from an external air supply.

Solenoid Valve Block



1. Mounting bracket
2. Electrical connector
3. Solenoid valve block
4. Rubber mountings

The solenoid valve block is located on the front subframe, to the rear of the air compressor. The valve block contains a pressure sensor, four solenoid valves, an air spring, and an environment valve. The four solenoid valves are held closed by system air pressure.

The ECU drives the valves open to deliver air pressure to the suspension modules as required.

Pressure Sensor

The pressure sensor measures the air spring module and reservoir pressures and keeps the system air mass constant.

Solenoid Valves

The solenoid valves are operated by the ECU to maintain the correct pressure in all parts of the system, according to information received from sensors or driver commands. This ensures that the vehicle is always at the correct height. These valves also control limp home modes (see System Failure, page 4-16).

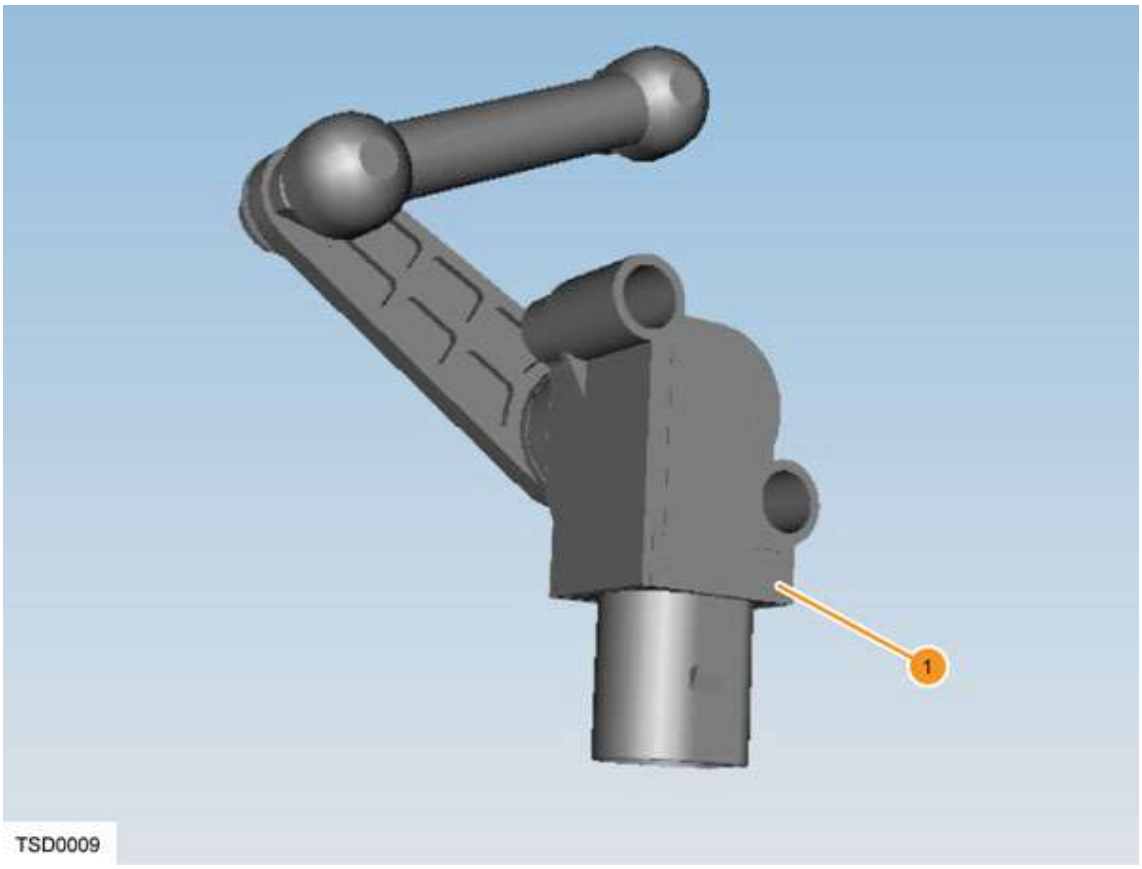
Air Spring

The air spring operates in conjunction with the solenoid valves to maintain system pressure and vehicle stability.

Environment Valve

The environment valve vents excess air pressure in the system to atmosphere.

Height Sensor



1. Height sensor

The contact-less Hall effect sensors fitted at each corner of the vehicle are supplied with 5 volts DC. The height sensors supply vehicle height information to the ECU as Pulse Width Modulation (PWM) output signals.

Indicator Lights

Depending on the severity of a fault, either a yellow or red indicator light displays in the instrument cluster to inform the driver of a fault. A yellow indicator light indicates a temporary fault, or one that does not require immediate servicing of the vehicle. A red indicator light indicates that the fault that needs immediate attention. When a fault occurs, the vehicle enters a limp home mode. See System Failure for more information.

Operation

ECU Operation

The ECU receives various signals from sensors and other vehicle systems via the CAN network.

Inputs	ECU	Outputs
Battery positive Ignition signal Chassis 500 Bd CAN Bus		Air suspension valves Air compressor

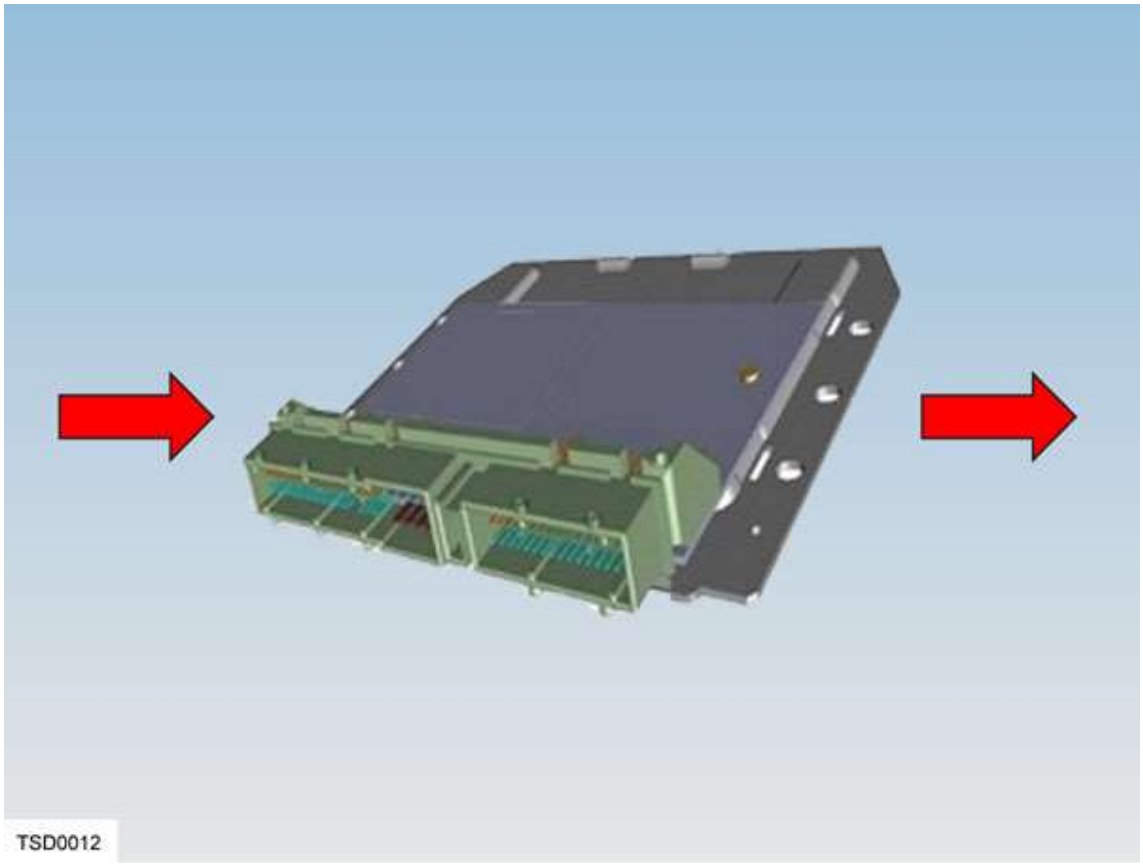
signal

Valve block pressure sensor

Ambient air temperature sensor

Height sensors

Touchscreen



Air compressor relay

Reverse solenoid valves

Environment solenoid valve

Air spring solenoid valves

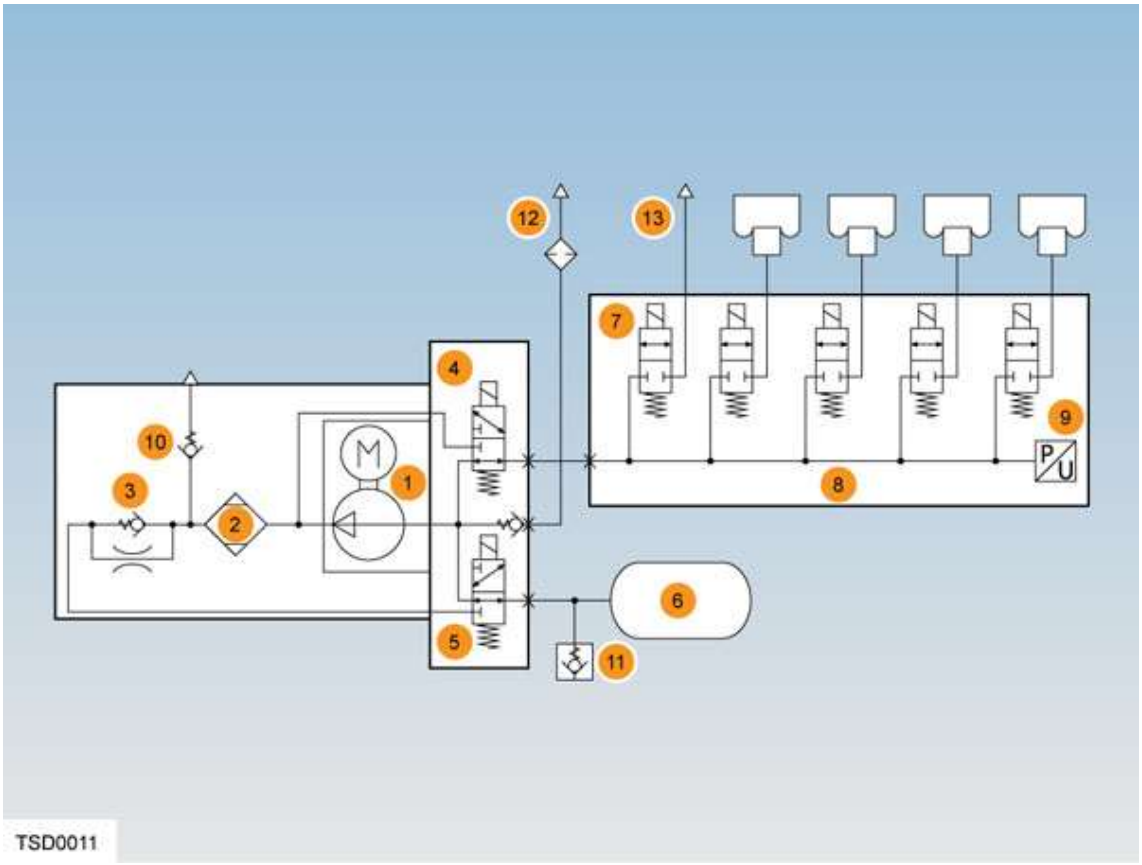
The ECU is pre-programmed with various operating modes to allow service and maintenance. When the driver selects a height level from the touchscreen, the requested level is transmitted to the ECU via CAN signals.

To fill the suspension modules and raise the height of the vehicle, the ECU operates the compressor via a relay located in the front relay/fuse box. The ECU energizes the reversing solenoid valves and the solenoid valves in the valve block to allow compressed air from the reservoir into the spring bellows in the suspension modules.

To deflate the suspension modules, the ECU energizes the reversing solenoid valves and solenoid valves in the valve block, allowing the compressor to pump compressed air from the spring bellows in the suspension modules back to the reservoir.

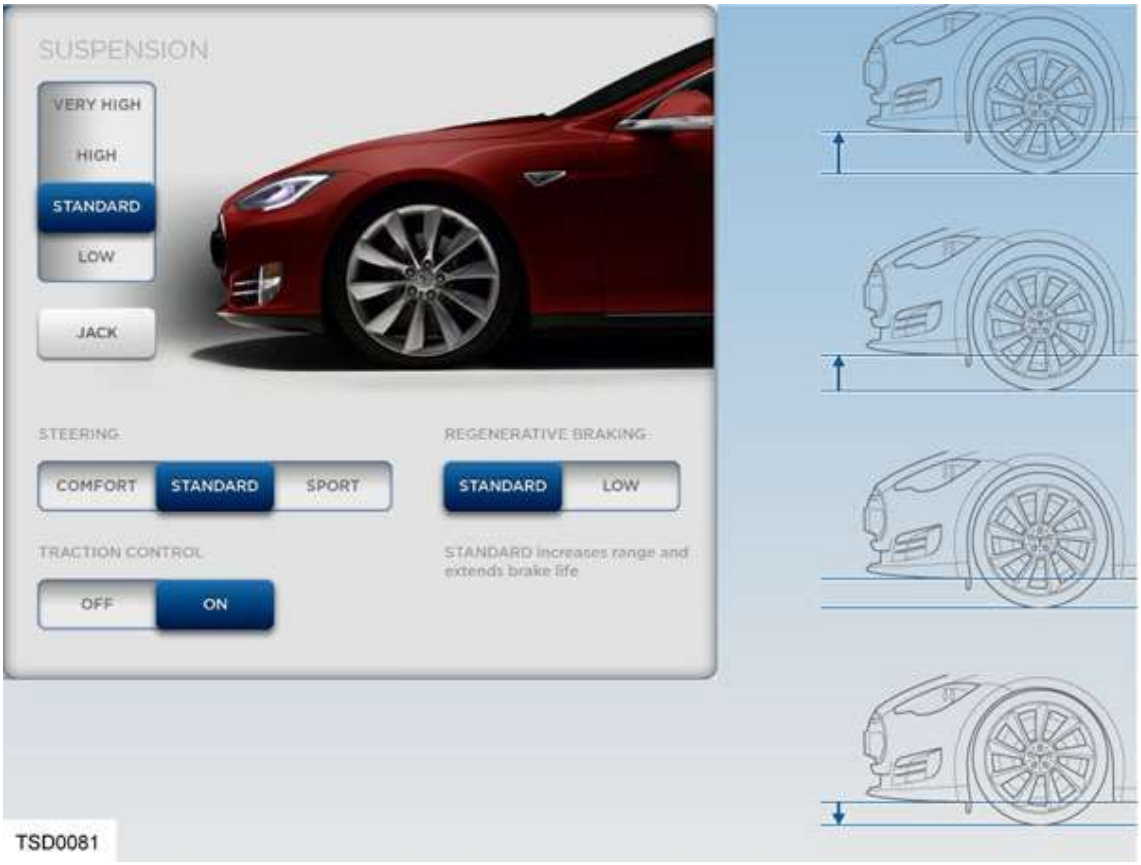
During maintenance, complete filling and deflating of the air suspension system is performed using an external filling station.

The dryer absorbs the humidity of the intake air and is regenerated when the air is vented from the system. The venting air decompresses in the dryer by means of a throttle/check valve. The dryer releases stored humidity through the reversing solenoid and environment valves in the valve block, then through the exhaust hose to atmosphere.



1. Air compressor
2. Air dryer
3. Throttle/check valve
4. Reversing valve
5. Reversing valve
6. Reservoir
7. Environment valve
8. Air spring solenoid valve
9. Pressure sensor
10. Pressure relief valve
11. System filling valve
12. Suction hose with air filter
13. Exhaust hose

User-Selectable Height Settings



The driver can select from four height levels using the touchscreen.

NOTE: *If a door is open, the system is prevented from lowering height.*

Very High

- Can be selected at speeds below 10 mph (16 km/h).
- Sets suspension at 1.3 inches (33 mm) higher than Standard.
- Used to gain extra ground clearance in unusual situations.
- If selected and vehicle speed exceeds 10 mph (16 km/h), the vehicle automatically lowers to High.

High

- Can be selected at speeds below 19 mph (32 km/h).
- Sets suspension 1 inch (23 mm) higher than Standard.
- Used to gain extra ground clearance in parking lots, parking garage ramps, large speed bumps, etc.
- If selected and vehicle speed exceeds 19 mph, the vehicle automatically lowers to Standard.

Standard

- The vehicle automatically levels to the Standard ride height to ensure optimum comfort and handling under all loading conditions (extra passengers, heavy luggage, etc.).
- This also ensures that the vehicle has the proper ride height under all loading conditions (the rear of the car does not sag down when heavily loaded).

Low

- Automatically lowers the vehicle by 0.75 inch (20 mm) for improved aerodynamics. Lowering starts when vehicle speed is between 60 mph (90 km/h) and 72 mph (115 km/h) for more than 30 seconds. When speed increases above 72 mph (115 kph), the vehicle immediately goes to Low level.
- Can be selected from the touchscreen when parked, for easier loading/unloading of passengers and cargo.
- If selected when stopped, the vehicle automatically rises to Standard when driven at a speed above 3 mph (6 km/h).

Jack Mode

Before jacking the vehicle to change a wheel or lifting the vehicle on a hoist, jack mode must be selected on the touchscreen.

Selecting jack mode can only be done when the vehicle is stationary. Jack mode turns the leveling system off, which allows the user to safely jack up the vehicle without the vehicle trying to adjust its height. Once the jacking procedure is complete, jack mode can be switched off using the touchscreen. The car automatically exits jack mode when driven.

Operating States

Post-Run Mode

The post-run mode occurs when the vehicle is switched off, but the level controller function of the ECU is still active. This allows the vehicle to re-level due to immediate heat effects, or after passengers or baggage are removed from the vehicle. After post-run mode, the system enters sleep mode.

Sleep Mode and Wake-up Mode

Sleep mode duration time is determined by software parameters, but can be up to a maximum of 9 hours. During sleep mode, a timer wakes the ECU up to three times, to enable any height adjustments. These height adjustment periods are known as wake-up mode. As the car cools (or heats up) after driving, the pressure in the air springs can fluctuate slightly, resulting in the vehicle not being level. The wake-up mode ensures that the vehicle is leveled after the car temperature has stabilized and before it is driven again.

Off Mode

The system enters the off mode after the vehicle has been in sleep mode for more than 9 hours. Level control is completely deactivated. The ECU has a low energy consumption of less than 250 microamps.

Service Mode

After replacing certain components (a height sensor, for example), the ride height must be recalibrated. Recalibrate ride height using Toolbox, with the system in service mode.

NOTE: *The disassembly of pressurized parts (reservoir, compressor, and air spring damper) requires deflation of the system components using Toolbox.*

System Failure

Failure of the air suspension system does not result in restriction of steering angle, nor contact between the tire and the vehicle body in any driving conditions. However, vehicle dynamics could be severely affected. Depending on the type of failure, a warning is sent to the instrument cluster via CAN signal.

There are three limp home modes, depending on the level of system failure. Mode 1 is the lowest priority and mode 3 is highest priority. A limp home mode with a high priority replaces a limp home mode with a lower priority.

Limp Home Mode 1

- Height increases are disabled.
- Only height decreases (via axle leveling) are possible until Standard Level is reached.
- Height decreases are possible only when vehicle speed exceeds 10 mph.
- Height decreases are achieved using the environment valve.
- Level changes using the touchscreen are disabled.

Limp Home Mode 2

- Level control is disabled.
- Level changes using the touchscreen are disabled.
- The air mass in the reservoir can be measured.

Limp Home Mode 3

- Level control actuators are switched off.
- The air mass in the reservoir cannot be measured.

Service Mode Functions

Service mode functions are all performed using Toolbox. Only perform service mode functions on a stationary vehicle. If the vehicle speed is above 20 mph (30 km/h), the system automatically exits service mode.

The ECU supports the following service mode functions:

- System filling (see Service Manual)
- Height sensor calibration
- Deflating air spring into reservoir
- Deflating components to atmosphere
- Actuator test by selecting height levels
- Limp home mode
- Selecting height level using Toolbox or touchscreen
- Measure pressure in individual component
- Measure pressure in all components
- Read and erase Diagnostic Trouble Codes (DTC)
- Finish service

Selecting Height Using Toolbox or Touchscreen

The ECU performs a height change to the selected height. The available heights are the same as in Standard mode.

NOTE: *In service mode, door latch signals are ignored and vehicle height can be lowered when a door is open. Be sure to close all doors before requesting a lower height level.*

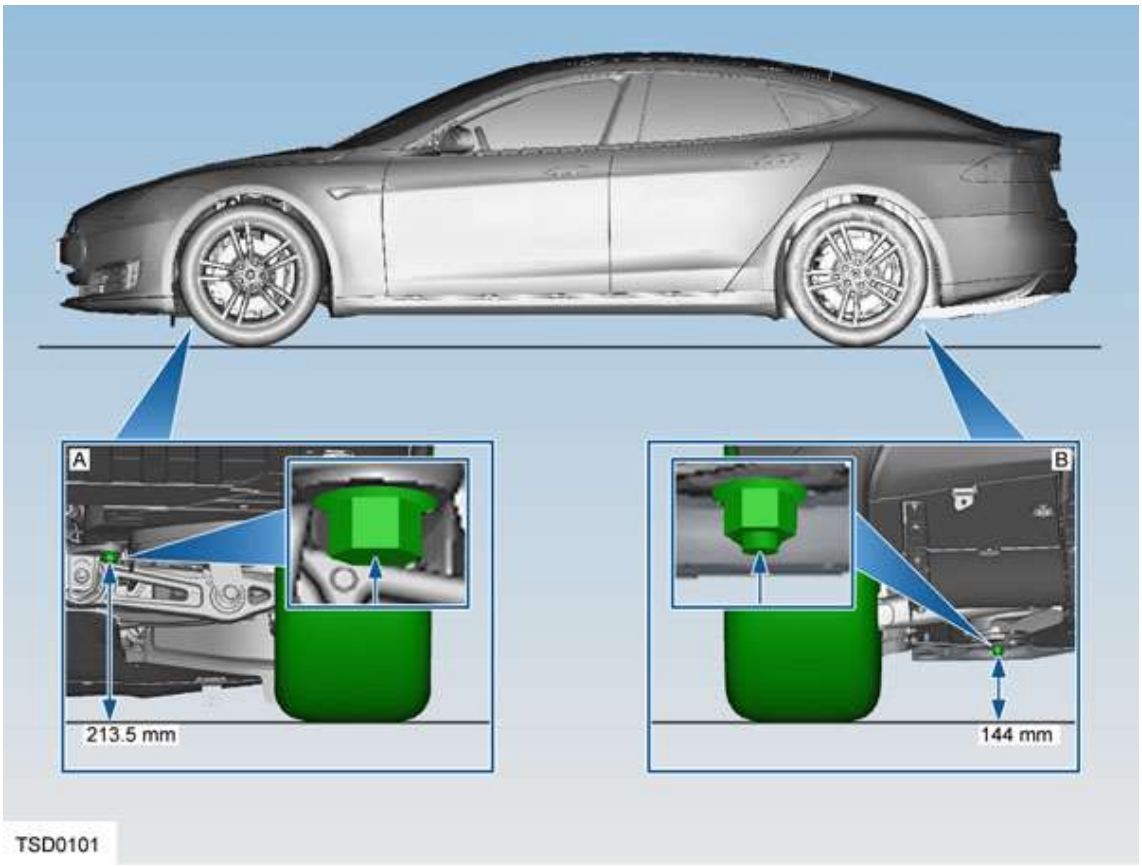
This function can only be performed when level control is enabled and the height sensors have been calibrated.

Height Sensor Calibration

If the ECU or a height sensor is replaced, the height sensor must be recalibrated. During the calibration process, a correction value for the four sensors is calculated and stored permanently in the ECU's EEPROM memory.

NOTE: *Calibration of the vehicle height must be performed at Standard Ride Height.*

Reference height values for the front and rear axles are stored in the ECU. The reference height values represent the height of the vehicle under ideal conditions at Standard height level. The vehicle's height level is measured between the ground and the bottom of the chassis.



NOTE: *The height data stored in the ECU is calibrated so that when the vehicle is at Standard ride height, the internal height signals read 0 mm.*

After the height sensor calibration, the calibration of each height sensor must be verified.

1. Perform a second measurement from ground to chassis at each corner.
2. Convert the relative deviation to normal level (reference height).
3. Compare these values with the height data (in mm) in Toolbox (height deviation data can be controlled by checking the data block values).
4. If the deviation for each corner is within +/– 0.118 inches (3 mm), the calibration process is accurate. If not, it must be repeated.

Deflating Air Spring into Reservoir

Precondition: The vehicle must be on a lifting platform.

The ECU deflates a single air spring into the reservoir. The single air spring module can be deflated for a short time to pre-defined values, or deflated completely using Toolbox.

Table 1. Filling Pressures Stored in ECU

Front axle	36.2 psi (2.5 bar)
Rear axle	36.2 psi (2.5 bar)

Deflating Components to Atmosphere

The selected component can be deflated for a short time to pre-defined values, or deflated completely using Toolbox.

If ‘Deflating Reservoir into Ambience for a short time’ is selected, reverse valves 1 and 2 are switched on. This causes a slow deflation with regeneration of the air dryer.

If ‘Deflating Reservoir into Ambience completely’ is selected, reverse valves 1 and 2 are switched on for the first deflating step. This causes a slow deflation, with regeneration of the air dryer. This is followed by deflating steps with only reverse valve 1 switched on. This causes a fast deflation without regeneration of the air dryer.

Actuator Test by Selecting Set Levels

The main hose is filled up for a short time by opening the reservoir. The pressure is then measured and stored. The environment valve is opened for a specified time to deflate the main hose. After deflating, the pressure in the main hose is measured again and the pressure difference is evaluated.

Measure Pressure in Individual Component

With the vehicle on the ground, the system performs a pressure check on the selected component.

Measure Pressure in All Components

With the vehicle on the ground, the system performs a pressure check on all components in sequence.

Finish Service

When the finish service function is selected, the service mode exits and the ECU switches to normal mode.