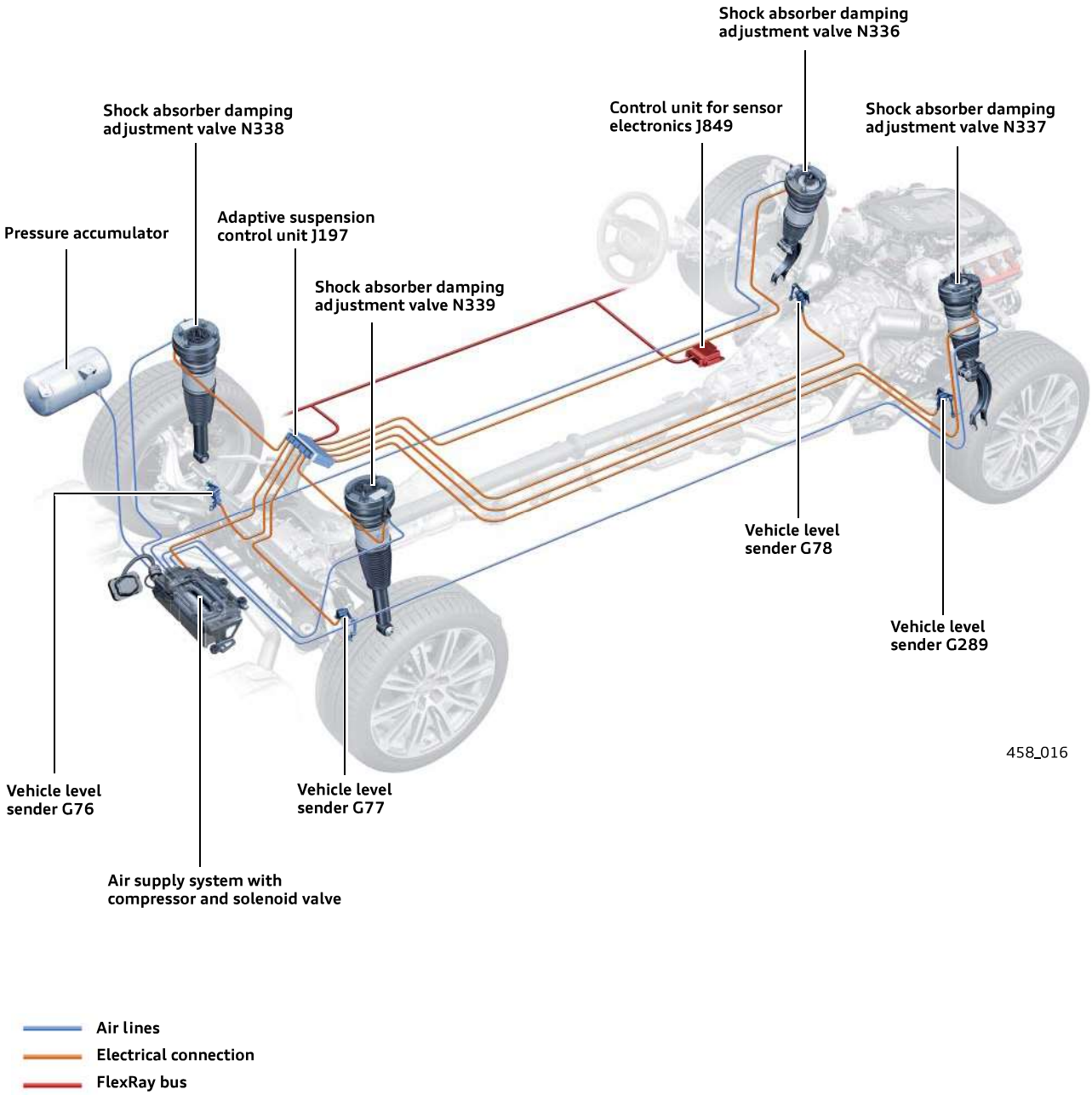
adaptive air suspension

Overview

The main objective when developing the air suspension system in the Audi A8 ’10 was to achieve "best in class" in terms of driving comfort and driving dynamics. To achieve this objective all major system components were newly developed. The control logic differs for the different running gear and suspension variants.

The main feature is the integration of the body acceleration sender in the control unit for sensor electronics. The adaptive suspension control unit communicates via the FlexRay data bus. On the Audi A8 ’10, display and operation tasks have been integrated in the Audi drive select.



System components

Adaptive suspension control unit J197

The main innovation is the connection of the control unit to the FlexRay data bus. This enables improved performance in all aspects of the control system. The adaptive suspension control unit receives the relevant vehicle acceleration values from the control unit for sensor electronics J849 via this bus system.

Changes compared to the predecessor mainly concern the control procedures themselves as well as the display and operating concept. The control unit is installed behind the rear panel in the luggage compartment.
The parameters for the various running gear and suspension variants are adapted by writing corresponding data sets as part of the online coding procedure.

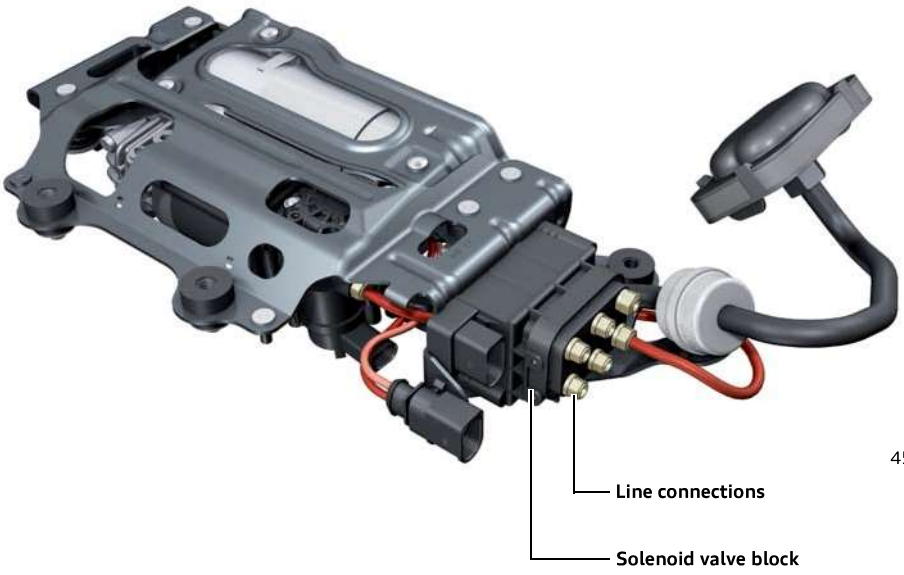
458_017

The control unit actuates the solenoid valves and the compressor for vehicle level adjustment as well as the damper valves. However, the damper valves are only operated while the vehicle is driving when a vehicle speed signal is sent from the ESP control unit.

The actuating currents are in the range from 0 A to 1.8 A. The maximum damping force is achieved at 0 A while an electrical current of 1.8 A is required for the minimum damping force.
To achieve maximum driving comfort, the basic electrical current applied at the damper valves is 1.8 A in all modes.

In terms of its design and pneumatic functional principle, the solenoid valve block corresponds to the components already known from the predecessor and used for the adaptive air suspension on the Audi A6.

Compared to the predecessor and the Audi A6, the positions of the line connections have been changed, however, the colour identification markings are identical.
(Refer to SSP 292 for detailed information on the design and functional principle)



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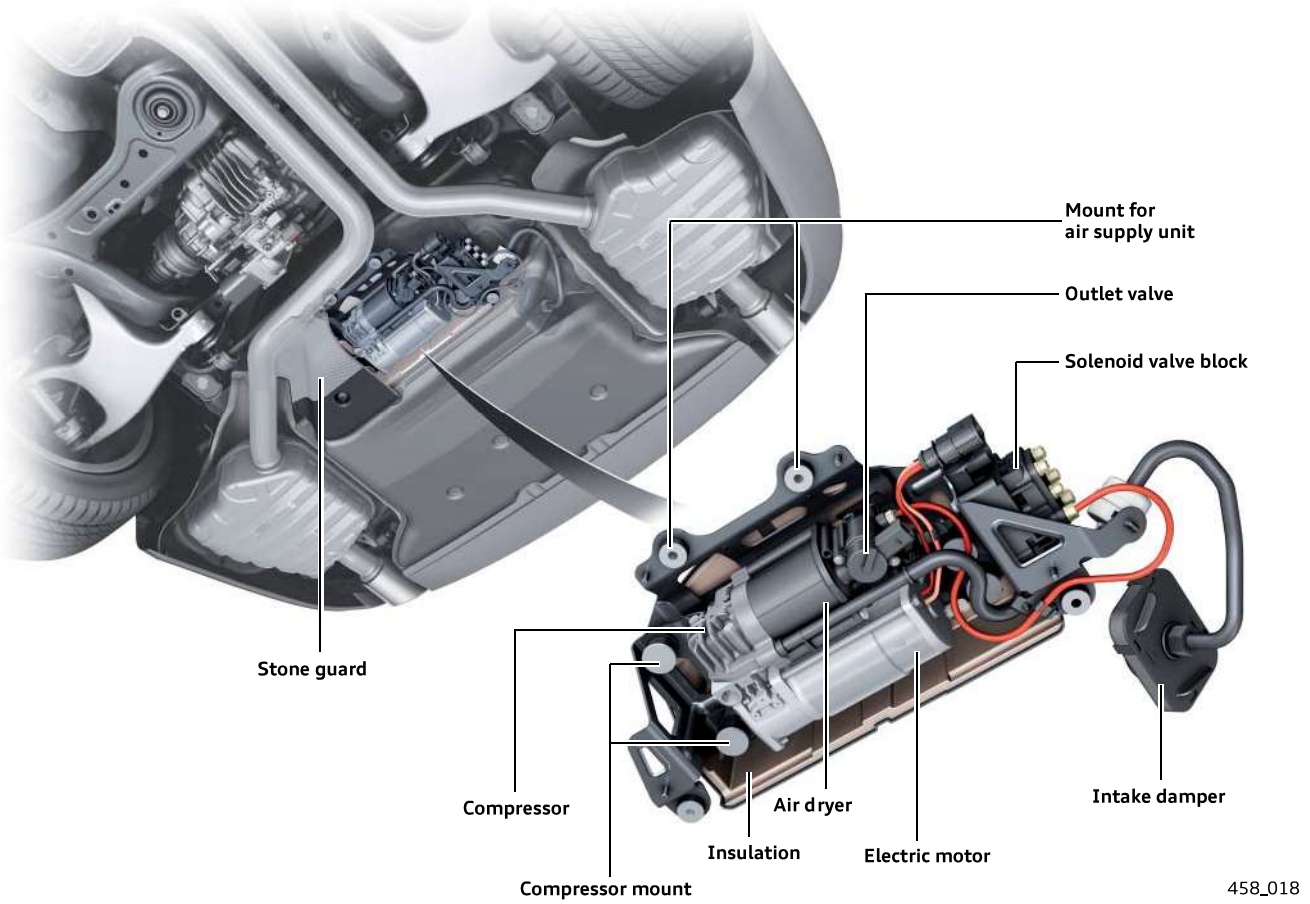
Air supply system

The air supply system consists of the dry-running, electric motor driven compressor, air dryer, intake, solenoid valve block and the corresponding pneumatic lines.
The fully acoustically encapsulated system is installed under the spare wheel well in the rear end. The complete unit is decoupled from the vehicle body by means of four harder rubber-metal mounts. The compressor is fitted on a separate bracket, which is also mounted by four softer rubber-metal mounts on the first bracket of the air supply system.
The components are shielded from the road.

The single-stage compressor generates a system pressure of 18 bar. A pressure limiting valve arranged in the compressor protects the system from overloading. The air intake takes place via the intake damper and air dryer from the spare wheel well. As on the predecessor, the air dryer is self-regenerating and requires no maintenance. The control rate for raising the vehicle level with the compressor is approx. 2-3 mm/s at the front and rear axle.
The level is reduced by blowing off air at a rate of approx. 10 mm/s.
The compressor temperature is now determined based on a model calculation that renders a temperature sensor unnecessary. The temperature is determined by evaluating the change in resistance of the magnetic coil in the outlet valve.



Pressure accumulator

The task of the pressure accumulator is to maintain system availability. It also improves the acoustic characteristics, especially during control procedures when the vehicle is stationary and at low vehicle speeds. In these situations, control procedures are predominantly carried out only with the pressure accumulator, i.e. without the compressor running. In addition, the vehicle level is raised at a faster rate with the pressure accumulator than with the compressor running. The control rate is approx. 4 mm/s for the front axle and approx. 8 mm/s for the rear axle.
The accumulator has a volume of 5.8 l and a pressure of 18 bar. To reduce weight, an aluminium structure is used. The pressure accumulator is also installed in the rear end.
To rapidly charge the accumulator, 6 mm outside diameter (instead of 4 mm) air lines are used between the solenoid valve block for the pressure accumulator and the solenoid valve block for the compressor.

Vehicle level sender

The four vehicle level senders are adopted from the Audi A4. The mounting brackets for the senders on the front axle are adapted to the vehicle geometry while the mounting brackets on the rear axle are adopted from the Audi Q5. The senders operate at a sampling rate of 800 Hz.

458_022

Control unit for sensor electronics

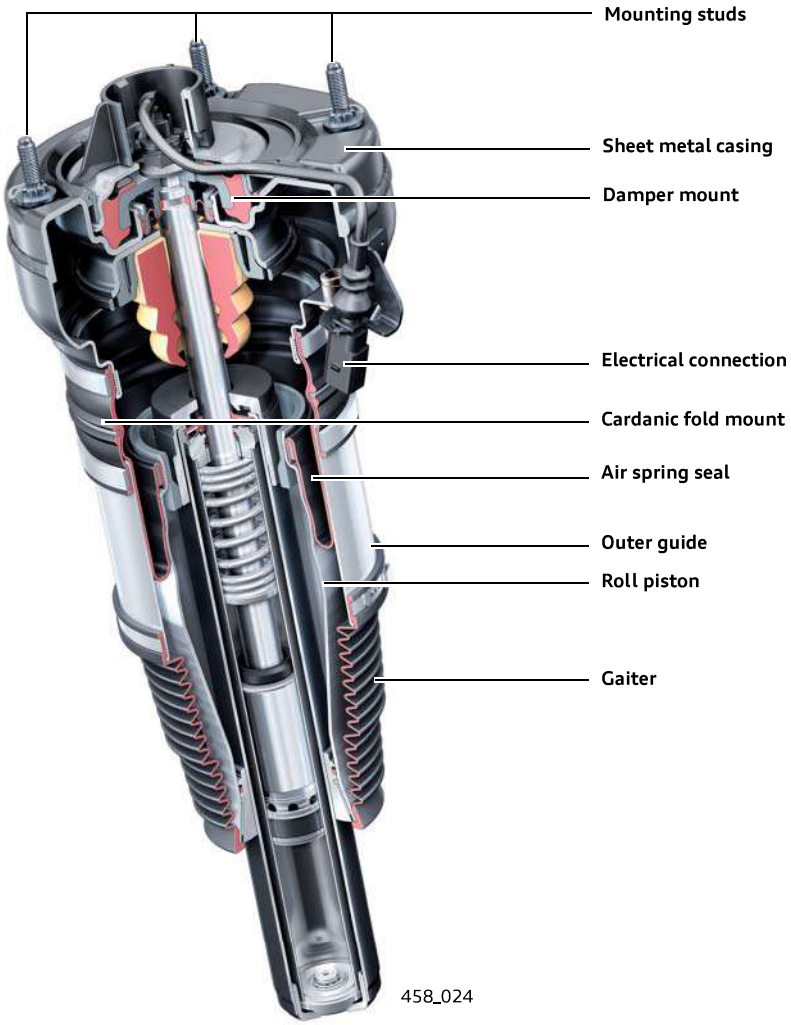
The control unit for sensor electronics sends the vehicle acceleration values in x-, y- and z-direction as well as the corresponding yaw rates to the adaptive suspension control unit. The adaptive suspension control unit calculates the vehicle movement from this information. The body acceleration senders are therefore no longer required. Communication between the control units takes place on the FlexRay data bus.
(For detailed information, see Control unit for sensor electronics, Page 33)

458_023

Air spring strut

The air spring struts are a new development. Infinitely variable twin-tube dampers are used. The controlled valve is located in the camper piston. The electrical line for actuating the magnetic coil in the valve is routed through the hollow piston rod. As on the predecessor, a CDC control system with internal valve is used. The volume of air is located in the area above the damper and essentially formed by the sheet metal casing, air spring seal and roll piston. The sheet metal casing accommodates the damper mount and serves the purpose of securing the spring strut to the vehicle body. The cardanic fold mount joins the sheet metal casing and the outer guide. This mount decouples the torsional and cardanic movements acting on the air spring seal and therefore relieves the mechanical load on the air spring seal.

To optimise damping and rolling comfort, an axial fibre gaiter is used as the air spring seal. The air spring seal is clamped to the sheet metal casing and the aluminium roll piston. The damper has been optimised in that the response characteristics have been substantially improved by minimising the friction between the piston rod and seal. A gaiter prevents dirt entering the air spring seal. Residual pressure retention valves are connected to the air lines of the spring struts. As on the predecessor, they have the task on maintaining a minimum air pressure of approx. 3 bar in the air spring even when an air line is defective or the air spring strut is removed. In this way, the air spring seal is protected from extreme deformation that could otherwise reduce its service life.

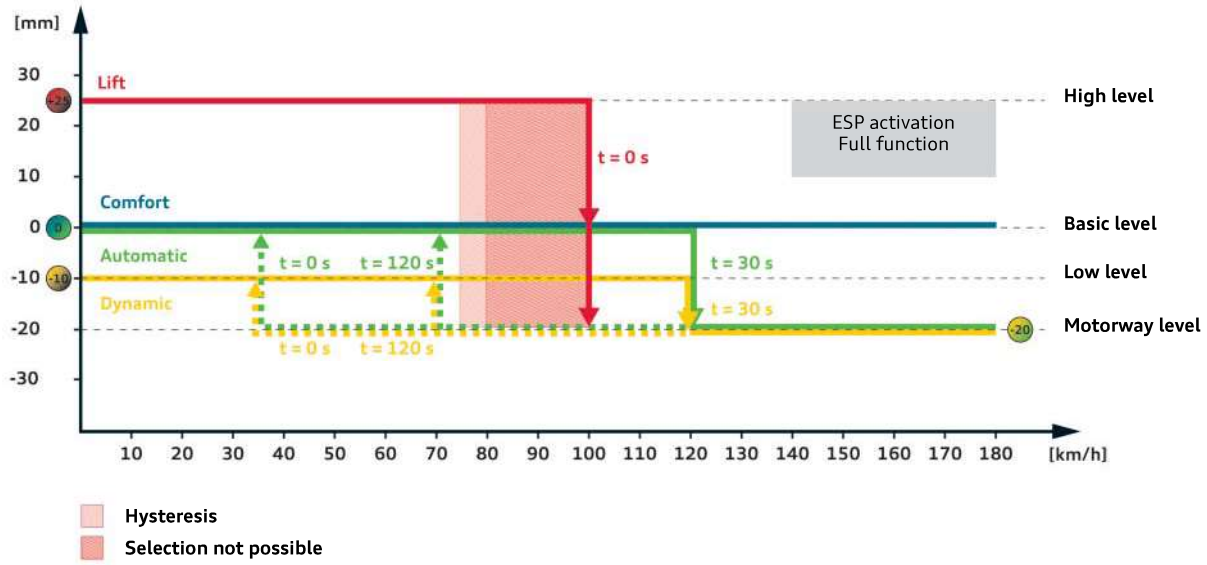


Control strategy

The control algorithms generally differ corresponding to the running gear and suspension variant. There are additional differences in operation with and without a trailer.

When towing a trailer the vehicle suspension can generally not be lowered to motorway level in order to avoid fluctuations in draw bar load when towing trailers.

Control strategy - standard running gear and suspension 1BK without trailer operation



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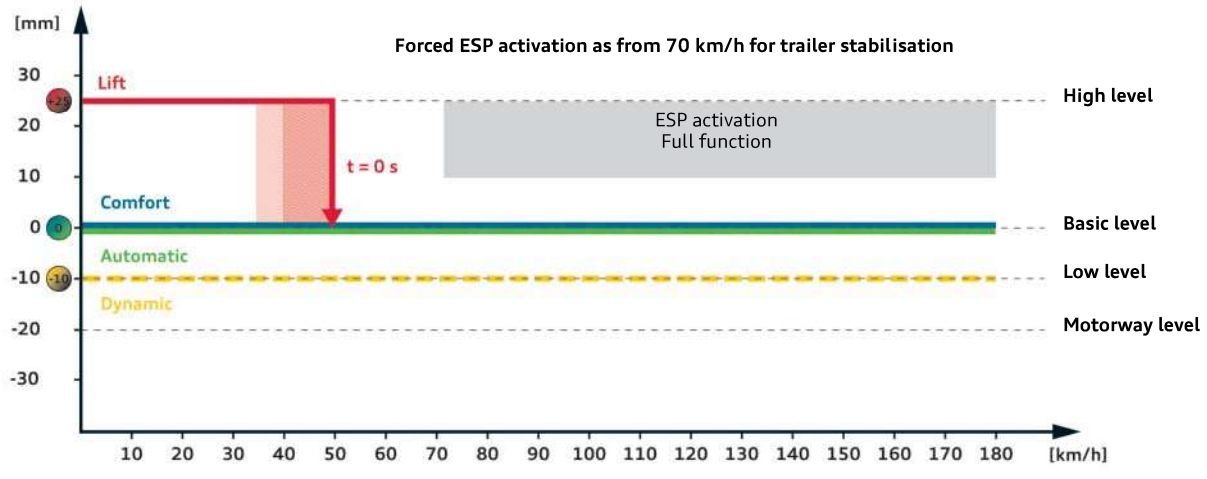
Hysteresis
Selection not possible

By way of example, the above control strategy of the standard running gear and suspension without trailer operation is described in the following.
Essentially, the control system facilitates four different vehicle height modes (= levels). Starting from the basic level, lift mode can be set by raising the vehicle by 25 mm. Lift mode is immediately deactivated automatically on reaching or exceeding a vehicle speed of 100 km/h. This mode can be selected up to a speed of 80 km/h.
The level is lowered by 10 mm by activating dynamic mode. In automatic and dynamic mode, the level is further reduced to "motorway level", 20 mm below the basic level, when the vehicle is driven at a speed of 120 km/h for 30 seconds.

The vehicle is not lowered to motorway level in comfort mode. Motorway level is deactivated automatically when the vehicle speed drops below 70 km/h for a duration of 120 seconds or immediately when the speed drops below 35 km/h.
On activating comfort mode, the basic level is set together with a comfort-orientated damper control. The ESP full function is deactivated and activated automatically as from a speed of 140 km/h when ESP sport mode is switched on by pressing the ESP button.

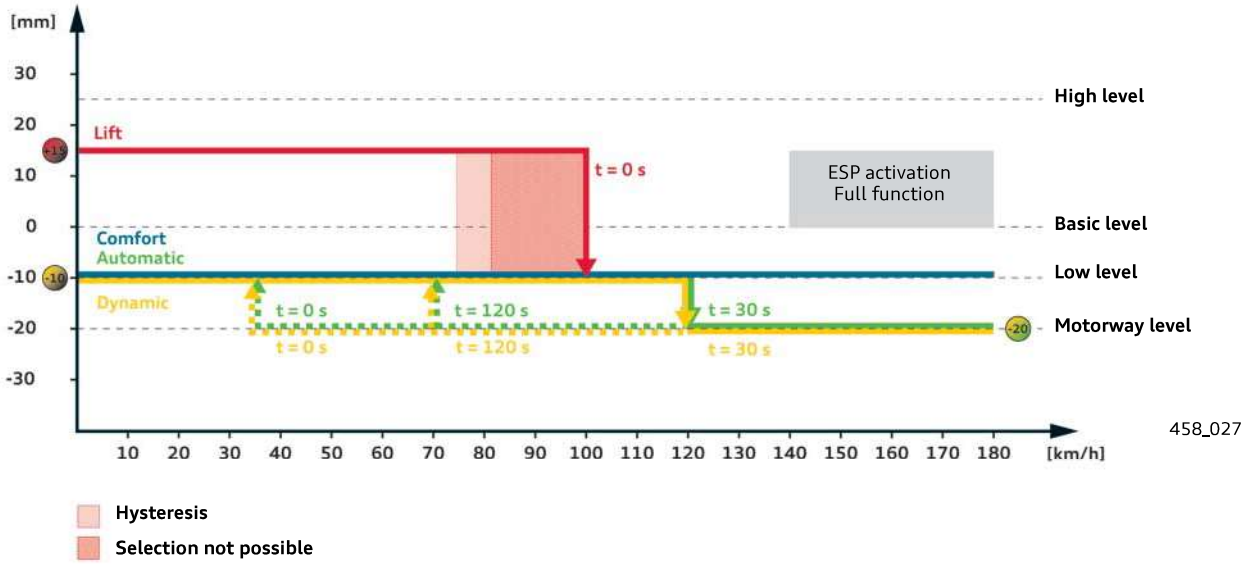
Control strategy - standard running gear and suspension 1BK with trailer operation



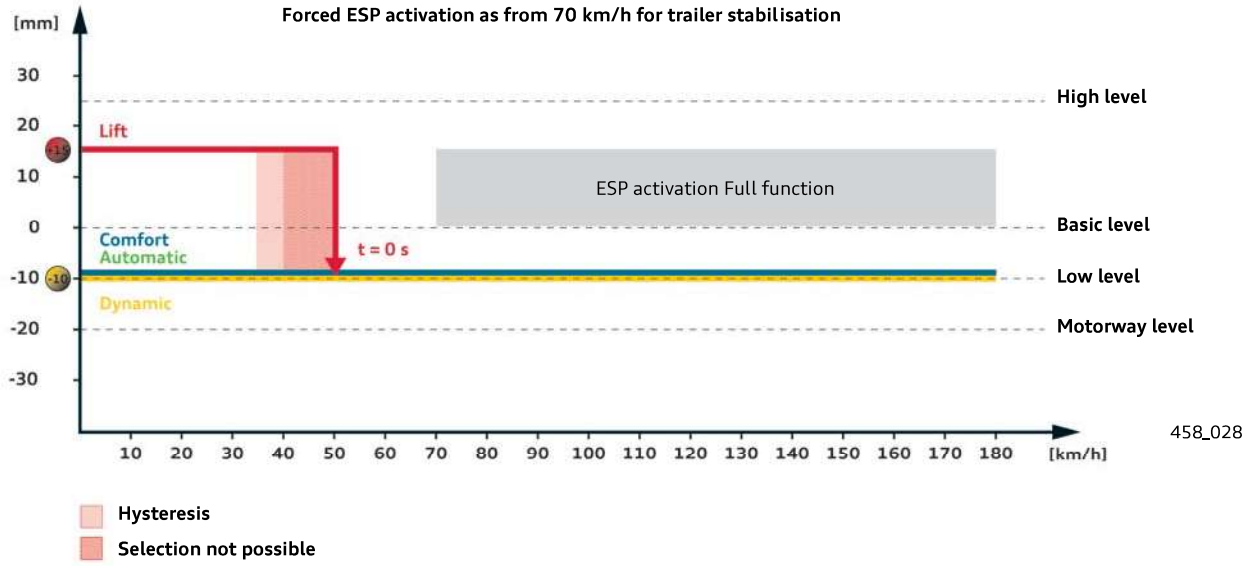
458_026

Hysteresis
Selection not possible

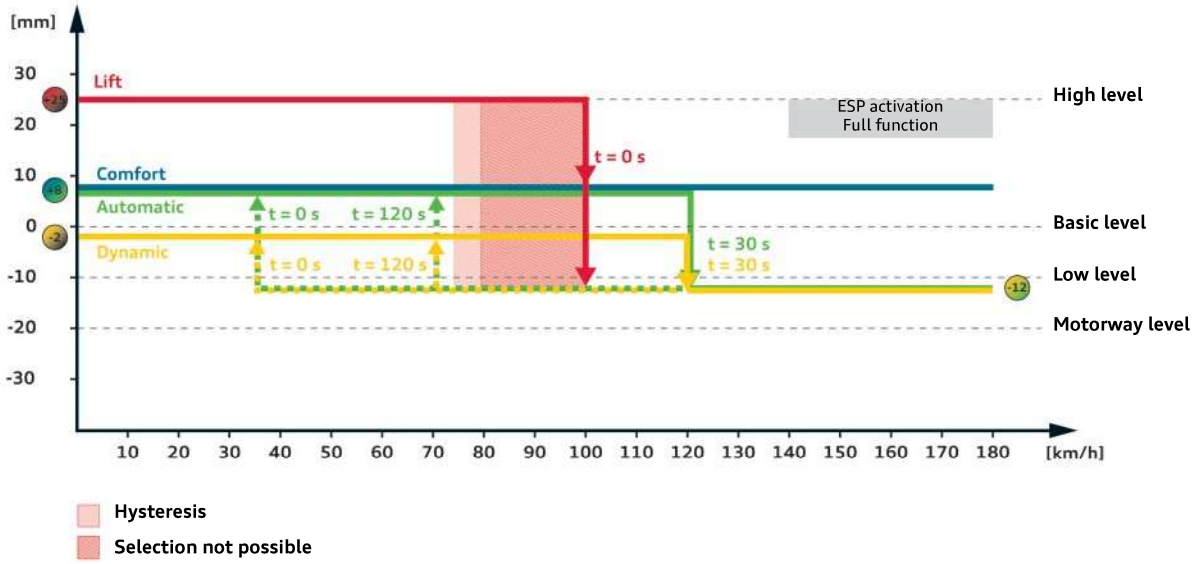
Control strategy - sport running gear and suspension 2MA without trailer operation



Control strategy - sport running gear and suspension 2MA with trailer operation



Control strategy - poor road running gear and suspension 1BY without trailer operation

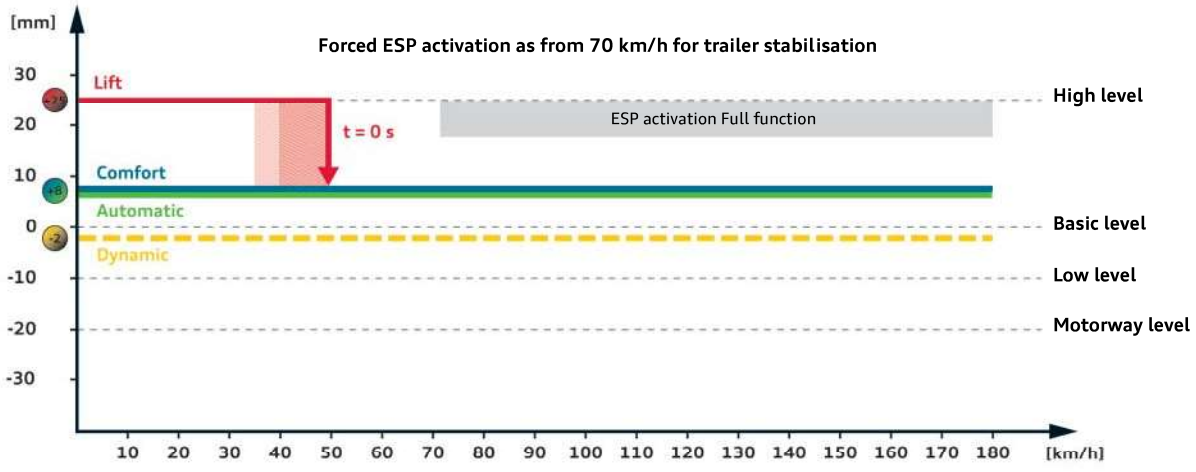


458_029

Hysteresis

Selection not possible

Control strategy - poor road running gear and suspension 1BY with trailer operation



458_030

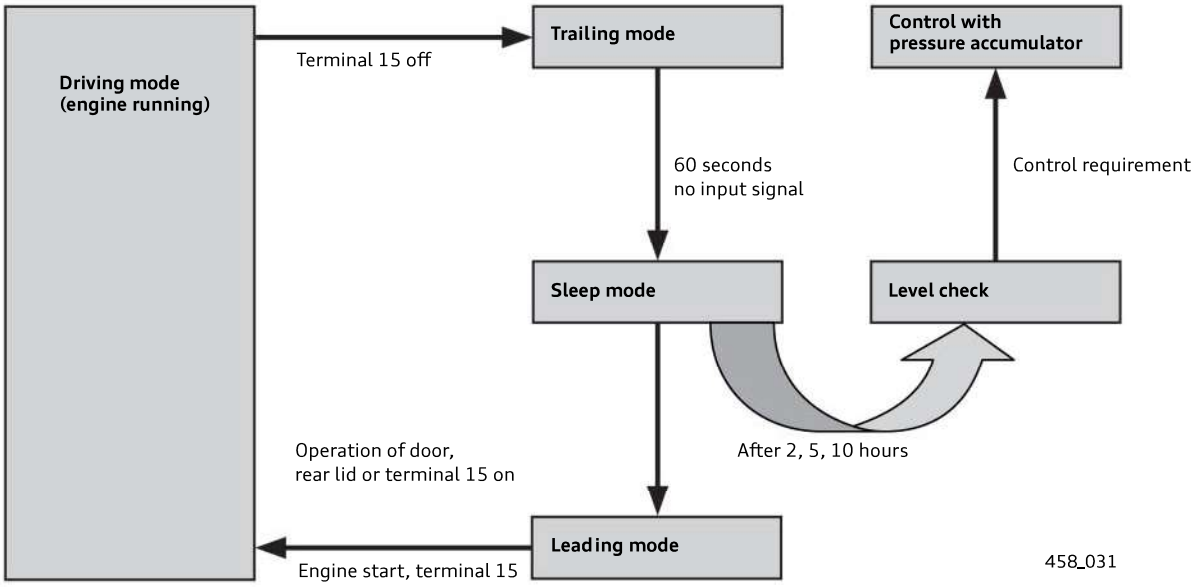
Hysteresis

Selection not possible

Characteristics of the control strategy

- Control procedures (changing the level) during vehicle operation are effective in the centre of the axle on the front axle and at the wheels on the rear axle.
- Control procedures (changing the level) when learning the control position are effective at the wheels on the front and rear axle to ensure the control position is set with the greatest accuracy.
- After the ignition has been turned off, the control unit remains active for a further 60 seconds and waits for further input signals. If no signals are received, energy-saving sleep mode is activated. In sleep mode, the vehicle level is checked after 2,5 and 10 hours in sleep mode. For this purpose, the adaptive suspension control unit J197 supplies operating voltage to the vehicle level senders and their measured values are read.

If the adaptive suspension control unit J197 recognises that control intervention is required, the system checks whether there is sufficient accumulator pressure for this purpose (min. 3 bar higher than the pressure in the air spring to be regulated). If this is the case, the vehicle level is then corrected. No further control procedures take place if the accumulator pressure is too low. When the antitheft alarm system is activated, the level is raised in such a way as to ensure the difference in level is does not exceed 0.3°.



- The door/rear lid signals are no longer sent via discrete lines to the adaptive suspension control unit as on the predecessor but rather via the bus systems.
- The vehicle level can drop distinctly over prolonged vehicle downtimes. To ensure the vehicle is already set to a defined minimum level at the start of operation, in these exceptional cases, compressor operation is already started after the ignition is turned on even though the engine is not yet running. The precondition for this is that there is a sufficient charge level in the vehicle battery.

Operation and driver information

In the Audi A8 ’10, the adaptive air suspension system is no longer set up in a separate menu as in the predecessor. The settings are combined with those of other systems in the Audi drive select user interface. These settings can be made by selecting the car menu with the corresponding function key.

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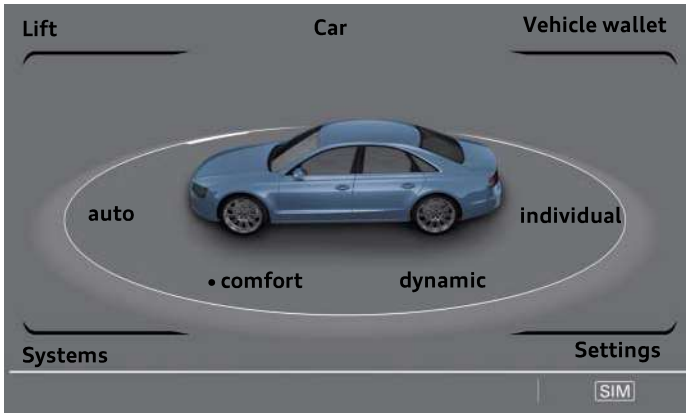
By selecting "comfort", "auto" or "dynamic", the various modes are activated in connection with the corresponding settings of other systems (engine, transmission, etc.). Different system settings (e.g. "dynamic" setting of adaptive air suspension with "comfort" engine and transmission setting) can be combined by selecting "individual" mode.

Lift mode is activated by selecting "lift". The lifting and lowering procedure is indicated in the display by flashing arrows on the front and rear axle. The arrow indication becomes static when the lift level is reached.



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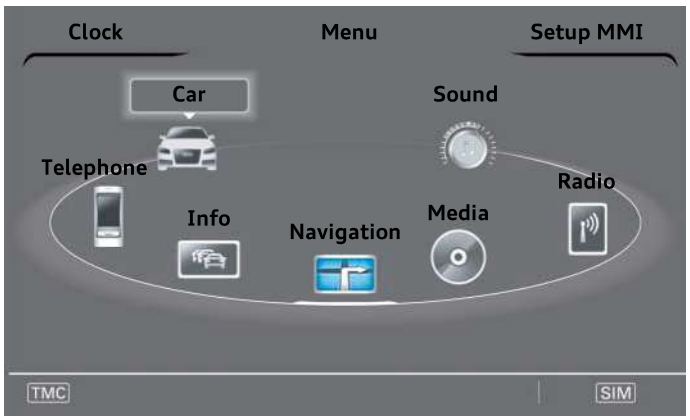
The menu for choosing the various modes can also be accessed by selecting "Car" in the general menu.



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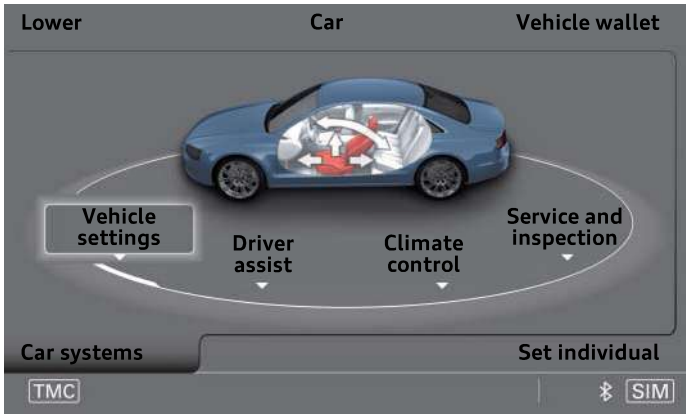
Reference
Please refer to SSP 456, Audi A8 ’10 for detailed information on Audi drive select.

The following functions can be called up by selecting "Systems" in the "Car" menu and then choosing "Vehicle Settings"/"Service and Inspection":

"Air spring: Trailer"

"Air spring: Wheel change" (see "Service jobs")



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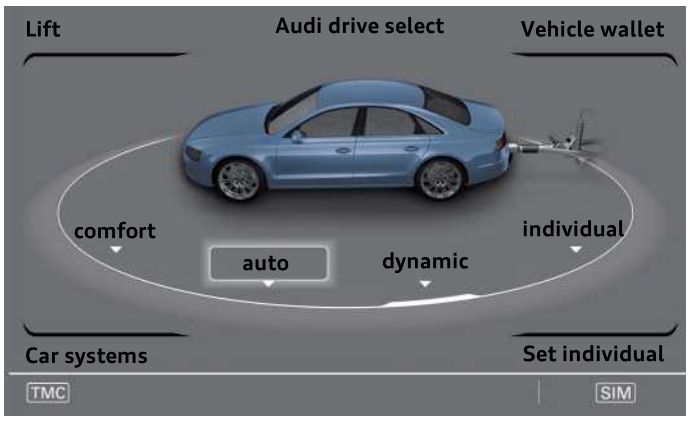
A correctly hitched trailer is detected automatically. In this case, the vehicle is shown in the MMI after pressing the "Car" function key in the "Audi drive select" with towing hitch.



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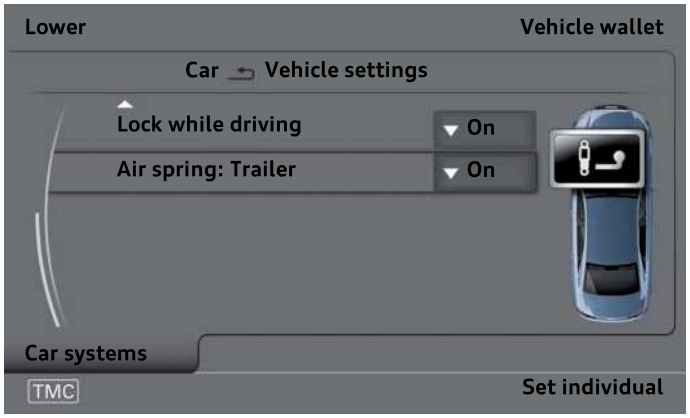
If the trailer is not recognised automatically, trailer operation can be activated by pressing the function keys "Car" – "Car Systems" – "Vehicle Settings" – "Air spring: Trailer" – "On".
In addition, the detected trailer can be deselected if bicycle rack systems are used.



458_037

Messages / Warnings

Text messages relating to the adaptive air suspension in the Audi A8 '10 are shown in the central display to inform the driver.

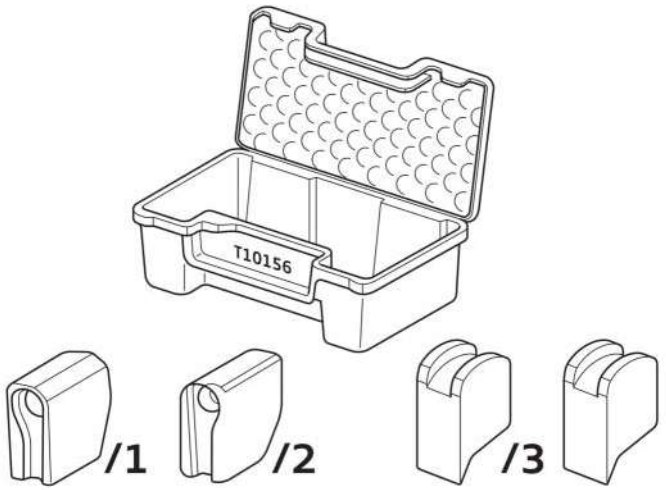
Driver information/warning messages are always shown prioritised according to urgency.

There are three priority levels: Driver information in white, warnings in yellow and highest priority warnings in red.

Service jobs

1. Vehicle transport

The vehicle is to be raised with the spring blocker set -T10156 for transport purposes. The vehicle must no longer be operated with the engine! Steering movements are to be restricted as far as possible (maximum half a turn of the steering wheel).



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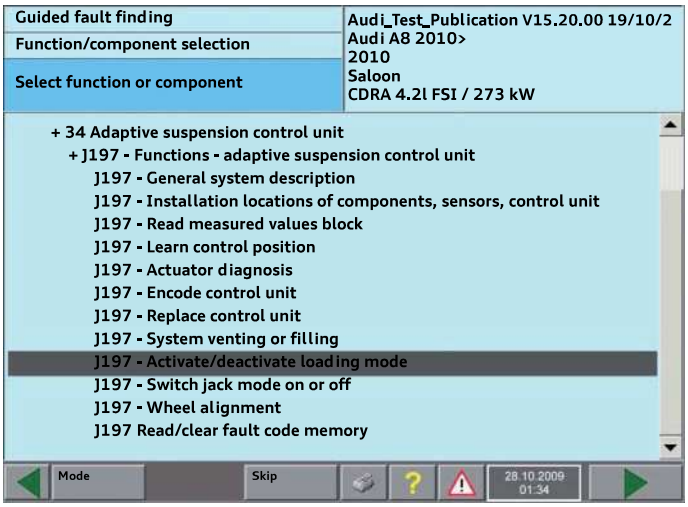
Loading mode

Loading mode is used to ensure sufficient ground clearance and the largest possible ramp angle for loading operations. When this mode is activated, the vehicle is set to and then maintained at a level of 50 mm above the standard level. Other levels cannot be set as long as this mode is active. Loading mode is activated/deactivated with the vehicle diagnostic tester. For safety reasons, the mode is deactivated automatically on exceeding a vehicle speed of 100 km/h or after covering a distance of 50 km.



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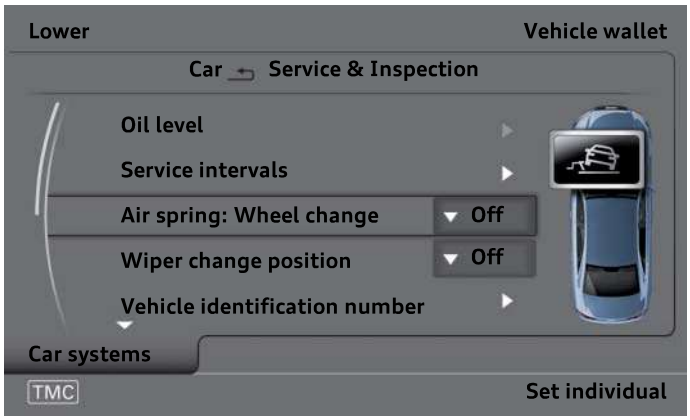
Transport mode

The data bus diagnostic interface J533 sets shut-down level 4 when transport mode is activated. The adaptive suspension control unit responds by preventing/deactivating leading and trailing mode (see graphic on Page 20) and switches off the power supply to the damper valves. The control unit remains in sleep mode even when input signals are received (operation of door/rear lid, change in terminal 15 status). Transport mode is automatically deactivated when the engine is started.
If both transport and loading mode are to be activated, loading mode must always be activated before transport mode.

Note
Service jobs essentially correspond to those of the predecessor. The most important service jobs are outlined in the overview.
This description only serves as an overview and is not a substitute for the repair manual!

2. Removing and installing/replacing system components and additional jobs

The system recognises when the vehicle is raised on a hoist or at the wheel and consequently prevents all control procedures. Air is released for a short time prior to automatic detection. For safety reasons, it is recommended to always additionally switch off the control system manually before starting any service jobs. The system is switched off by selecting "air spring: Wheel change" in the MMI. This setting corresponds to the "Jack mode" setting in the predecessor.
The deactivated function is automatically activated again at a driving speed in excess of 10 km/h.



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Adaptive suspension control unit J197

After installation, a new control unit must be encoded. Encoding takes place online. The software parameters required for operation of the control unit in this specific vehicle are defined and activated by writing data sets as part of the encoding procedure. The coding defines whether the vehicle is equipped with adaptive cruise control (ACC), towing hitch and dynamic steering. Since the adaptation values of the level sender signals have not yet been stored in this new control unit, it is additionally necessary to carry out the "Learn control position" function.

458_017

Air spring strut, solenoid valve block, compressor, pressure accumulator

The air system must be opened in order to remove these components. The system must be vented beforehand. Particular care must be taken when connecting the air lines, especially at the solenoid valve block, to ensure the connections are not interchanged. The air pressure must be corrected (refilled) before installing new air spring struts. The "Learn control position" function must be carried out before reinstalling the air springs.

458_022

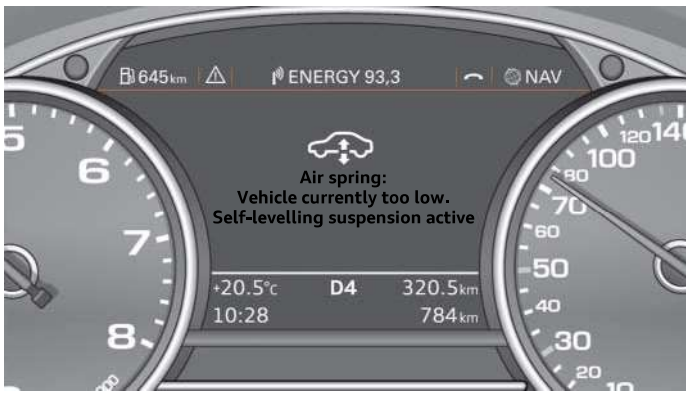
Vehicle level sender

The "Learn control position" function must be carried out after replacing a sender. Since, for tolerance reasons, the new sender returns different measured values for the same vehicle level, the measured value - vehicle ride height allocation must be sent to and store to the control unit. The control unit "recognises" the characteristic curve of the senders and their mechanical ratio when installed (vehicle level change to measured value change). Consequently, when the assignment of the vehicle level to measured value is known for all level positions through the "Learn control position" function, the control unit can determine the assigned level for all other measured value.

3. Special system statuses

Low level

After prolonged vehicle down periods or when carrying heavy loads, it is possible that the vehicle level may drop below a level suitable for driving. This behaviour is consistent with the system and does not constitute a fault. This situation is caused by the connections of the air lines and the air spring seals themselves that are naturally subject to slight air loss. After the ignition is turned on, a warning appears in the central display, drawing the driver's attention to this situation. The compressor is already activated although the engine has not yet been started. The aim is to raise the vehicle level as fast as possible to an operational level.



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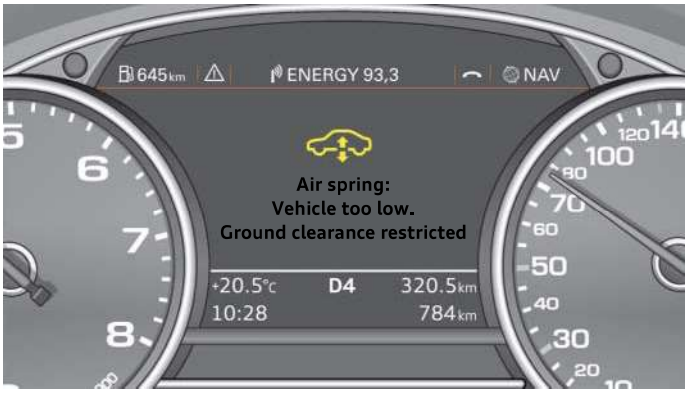
If the low level is caused by a major leak in the system, i.e. a defect, it will not be possible to raise the vehicle to the required level within a defined period of time. The control unit recognises that there is a fault in the system and issues a corresponding medium priority warning (yellow) on the central display.

Extreme high level

In rare cases it is also possible that the vehicle assumes extreme high level. This can briefly occur when very heavy loads are removed rapidly from the vehicle. If this situation persists, a system fault can be assumed and a high priority warning (red) is shown in the central display.



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