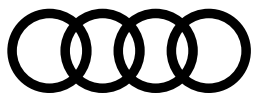




# Active suspension

eSelf Study Program 960393



Audi of America, LLC  
Service Training  
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The eSelf-Study Program (eSSP) teaches a basic understanding of the design and mode of operation of new models, new automotive components or new technologies.

**It is not a repair manual! Figures are given for explanatory purposes only and refer to the data valid at the time of preparation of the SSP.**

For further information about maintenance and repair work, always refer to the current technical literature.



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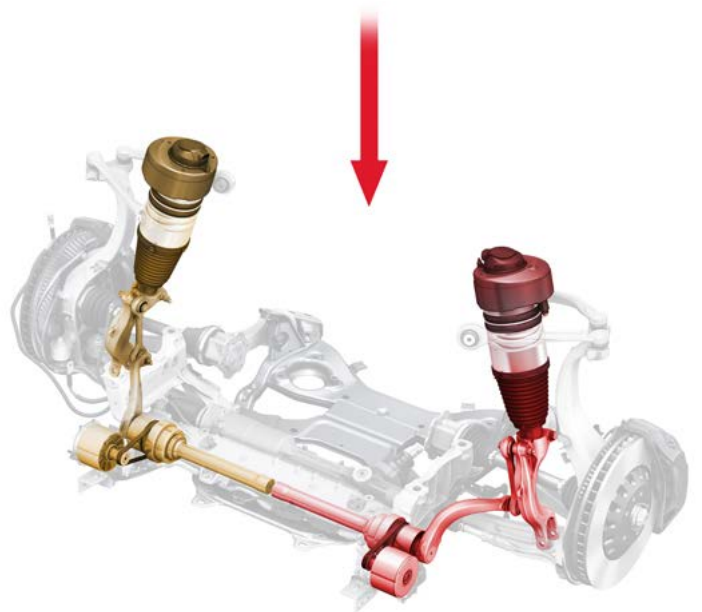
# Introduction

The Audi active suspension is an electromechanically operated suspension system. It can increase or reduce the load on each wheel individually to adjust to the road as needed. This means the system can actively control the position of the vehicle body in every driving situation.

For each wheel there is one electric motor supplied by a 48-volt electrical system. The Driver Assistance Systems Control Module sends control signals to the active suspension every five milliseconds. A single Suspension Stabilization Control Module per axle processes the signals for the electric motors. A belt drive and compact gearing arrangement step up the torque of the electric motor and transfer it to a steel rotary tube. The tube houses and is rigidly joined to a titanium torsion bar. This bar is more than 15.7 in (40 cm) long, approximately 0.9 in (22 mm) thick and, despite its high strength, can be twisted more than 20 degrees. The force is transferred from the end of the torsion bar to the suspension via a lever and a coupling rod. This force is exerted at the front axle on the pneumatic strut of the adaptive air suspension and at the rear axle, on the transverse link.

The range of ride characteristics takes on a whole new dimension thanks to the flexibility of the active suspension. If the driver chooses “Dynamic” mode in the Audi drive select system, the car becomes a sports car. It turns firmly into corners and body roll angles are reduced by half compared with a conventional suspension. The body hardly dives at all during braking. In “Comfort” mode, however, it glides smoothly over any and all road surface irregularities. The active suspension settles the superstructure by continuously adding energy to or removing energy from the body depending on the respective driving situation.

The active suspension also enhances passive safety. The system uses the sensors networked in the Driver Assistance Systems Control Module (zFAS) to detect risks of a collision around the vehicle. In the event of an imminent side impact of more than 15.5 mph (25 km/h), the suspension actuators raise the body on the exposed side by up to 3.1 in (80 mm) within half a second. As a result, the collision is directed to the even stronger areas of the vehicle, such as side sills and floor structure. The load on occupants is reduced by up to 50 percent compared with a side impact when the body is not raised.



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# Running gear concepts compared

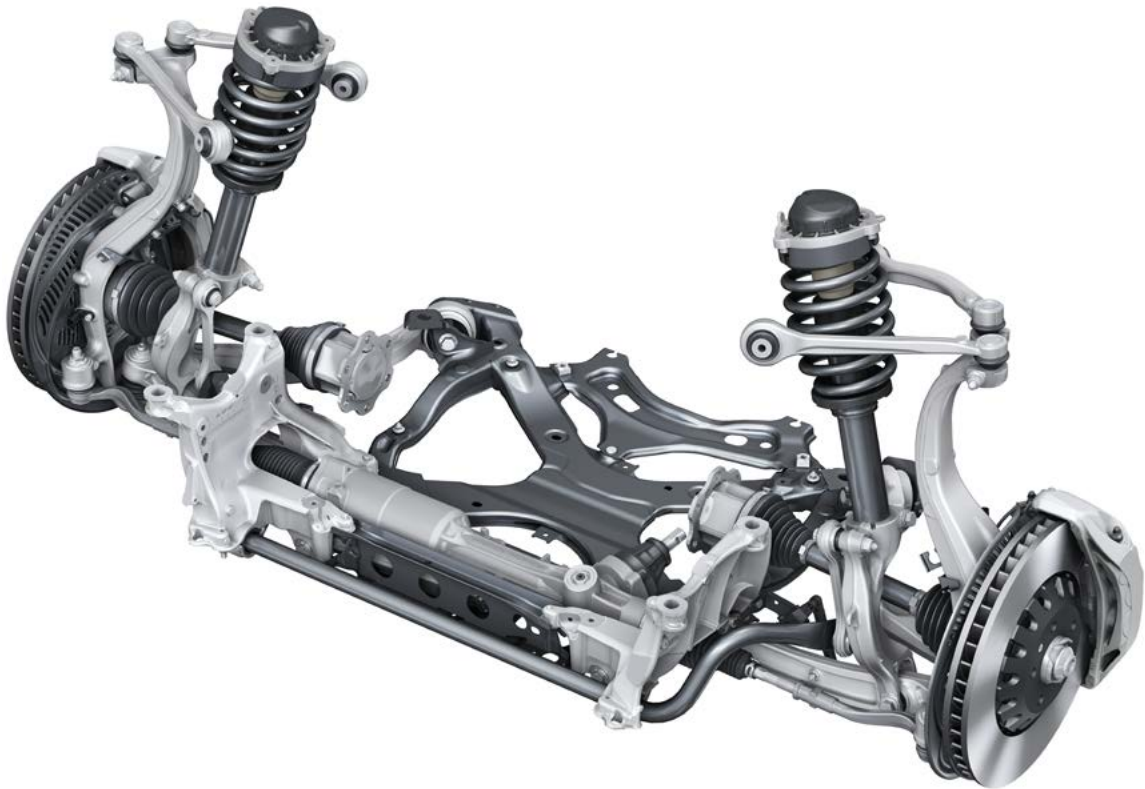
## Conventional running gear

Springs, dampers and anti-roll bars for conventionally constructed axles are designed to the special conditions for which the vehicle is used. These systems, which cannot change when the vehicle is moving, are always a compromise. The usage possibilities of the vehicle are limited.

In addition, there is a conflict between designing the components with a focus on dynamic driving or on comfort. Running gear designed for sporty driving cannot offer the comfort which can be provided by running gear designed for comfort.

Conversely, a vehicle with running gear designed for comfort will not be able to offer the driving dynamics which can be offered by a sporty design. Furthermore, the self-steering behavior of the vehicle is defined by the relation between the fixed anti-roll bar rigidities on the front and rear axles. Depending on the design of the anti-roll bars, the vehicle will understeer, oversteer or handle almost neutrally when driven on the limit.

In the past, springs with progressive rates were used along with dampers on which the damping characteristics changed depending on the spring travel. However, this also meant no opportunity to react to external conditions or the driver's wishes via a targeted adjustment of the spring and damping forces.



Front axle of conventional, non-regulated running gear

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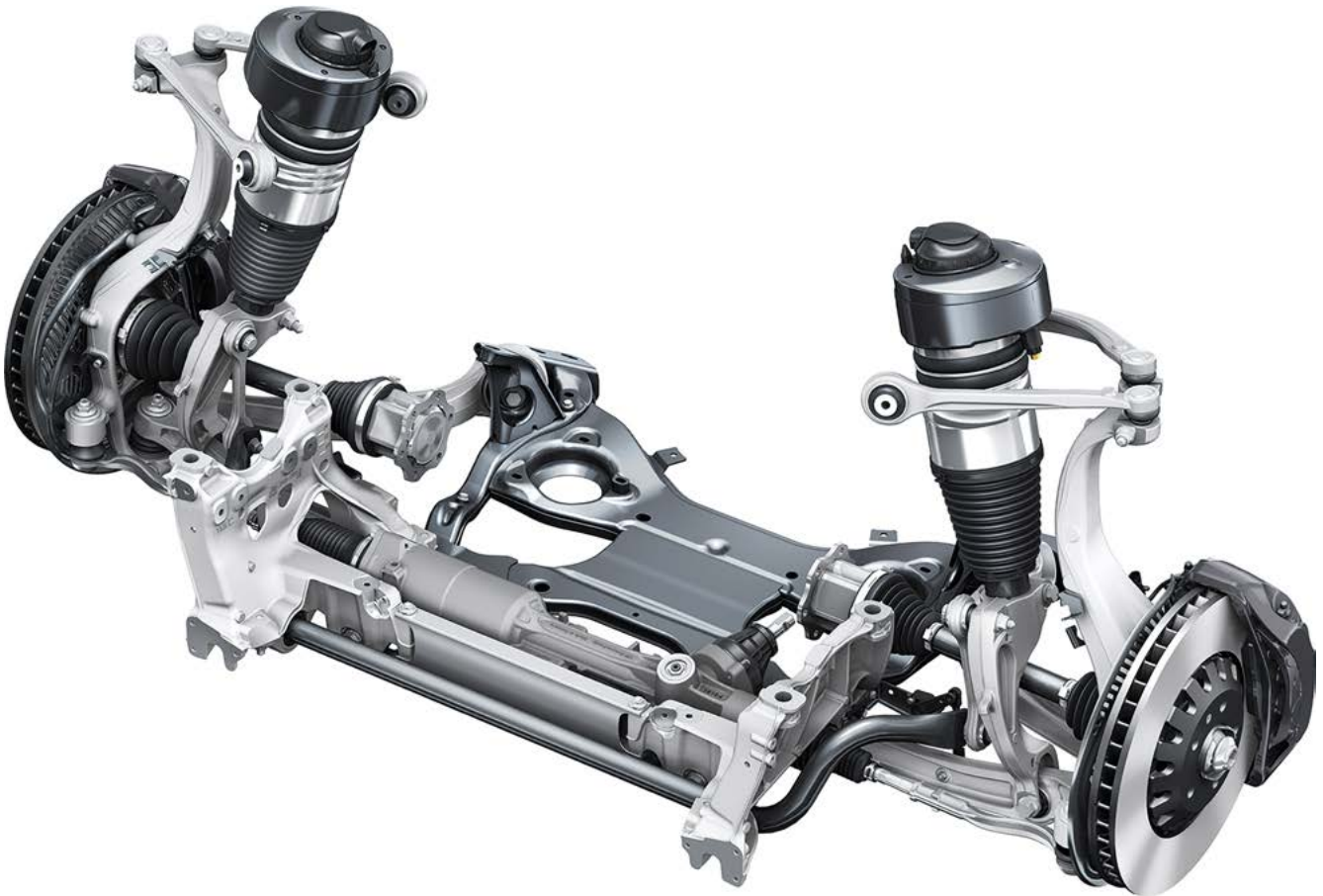
## Adaptive air suspension

To deal with the compromises of conventional running gear, dampers with the capability of adjustment while the vehicle is moving can be used.

Using air springs instead of steel springs also allows for regulation of the vehicle ride height. Corresponding sensors record dynamic driving parameters such as vehicle speed, accelerations and torques. The damping forces are adjusted to the situation depending on the dynamic driving conditions. The driver can also choose between sporty, balanced and comfortable handling by selecting specific driving programs which activate specific characteristic maps.

Thanks to the option of changing the volume of air in the air springs, different vehicle ride heights can be achieved. If the vehicle ride height remains the same, changes to the vehicle's load cause corresponding changes to the air pressure in the air springs. The natural frequency of the vehicle body remains almost exactly the same as a result, irrespective of the load. As a result, the driver does not notice any significant changes to vehicle comfort and driving dynamics, even if the load is changed.

Because air is compressible, a short amount of time is needed between when the pump starts delivering and an increase in volume in the air springs can be measured. Therefore, changes to the vehicle level/vertical forces cannot occur in real time. Furthermore, it is not possible to initiate forces in the opposite direction; that is to have the wheel "pull" on the vehicle body.



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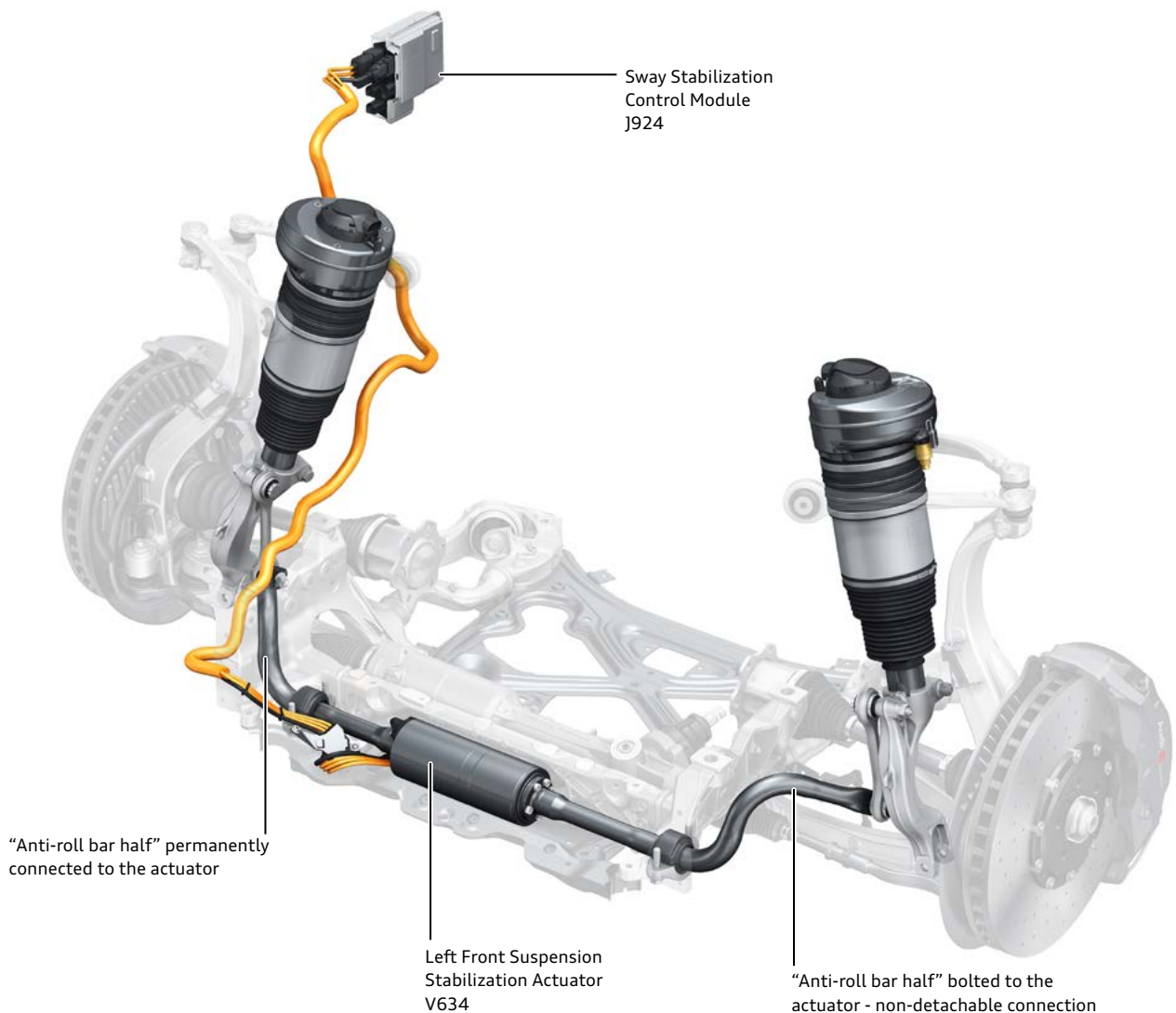
Front axle of regulated running gear with air suspension and damping control (adaptive air suspension)

## Adaptive air suspension with Electromechanical Roll Stabilization (ERS)

This system was offered for the first time as an option in the Audi SQ7 in other markets. With the use of electromechanical control elements, the torsional rigidity of the anti-roll bars on the front and rear axles can be varied separately. The control elements connect the anti-roll bar “halves” on one axle and tension them against each other with correspondingly regulated forces. As a result, it is possible to increase the support provided by the outer wheels in corners, which effectively restricts the roll inclination of the vehicle body.

In addition, the self-steering behavior of the vehicle is affected by achieving a defined relation between the anti-roll bar rigidities on the front and rear axles.

The force-transmitting connection between the wheels on an axle via the anti-roll bar can be reduced to a minimum, but the application of forces via a corresponding rigidity change always occurs alternately on both wheels of an axle at the same time.



Front axle of the Audi SQ7 with Electromechanical Roll Stabilization (ERS)

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## Vehicles with active suspension

The active suspension is an electromechanical suspension system. With this system, four separate vertical forces per wheel plus their direction can be set between the vehicle body and the wheels.

As a result, the wheels on a single axle are no longer coupled (as on the ERS system) and the corresponding application of identical (opposing) forces on both wheels no longer occurs. Force can be applied to a wheel without affecting the other wheel on the corresponding axle.

In addition, the vertical forces can be applied in both directions, therefore making it possible for the vehicle body to be “pulled” in the direction of the road by the wheels. This method of applying force to all four wheels separately provides additional new options for influencing driving dynamics and comfort.

The active suspension combines the following functions:

- › Active roll stabilization.
- › Active pitch stabilization.
- › Active vertical body control.
- › Dynamic height adjustment (elevated entry function, crash lifting function).

The “classic” conflict between driving comfort and dynamic driving is resolved with the active suspension. The driver experiences a vehicle with the dynamics of a sports car and the comfort of the luxury class.



Audi A8 with active suspension

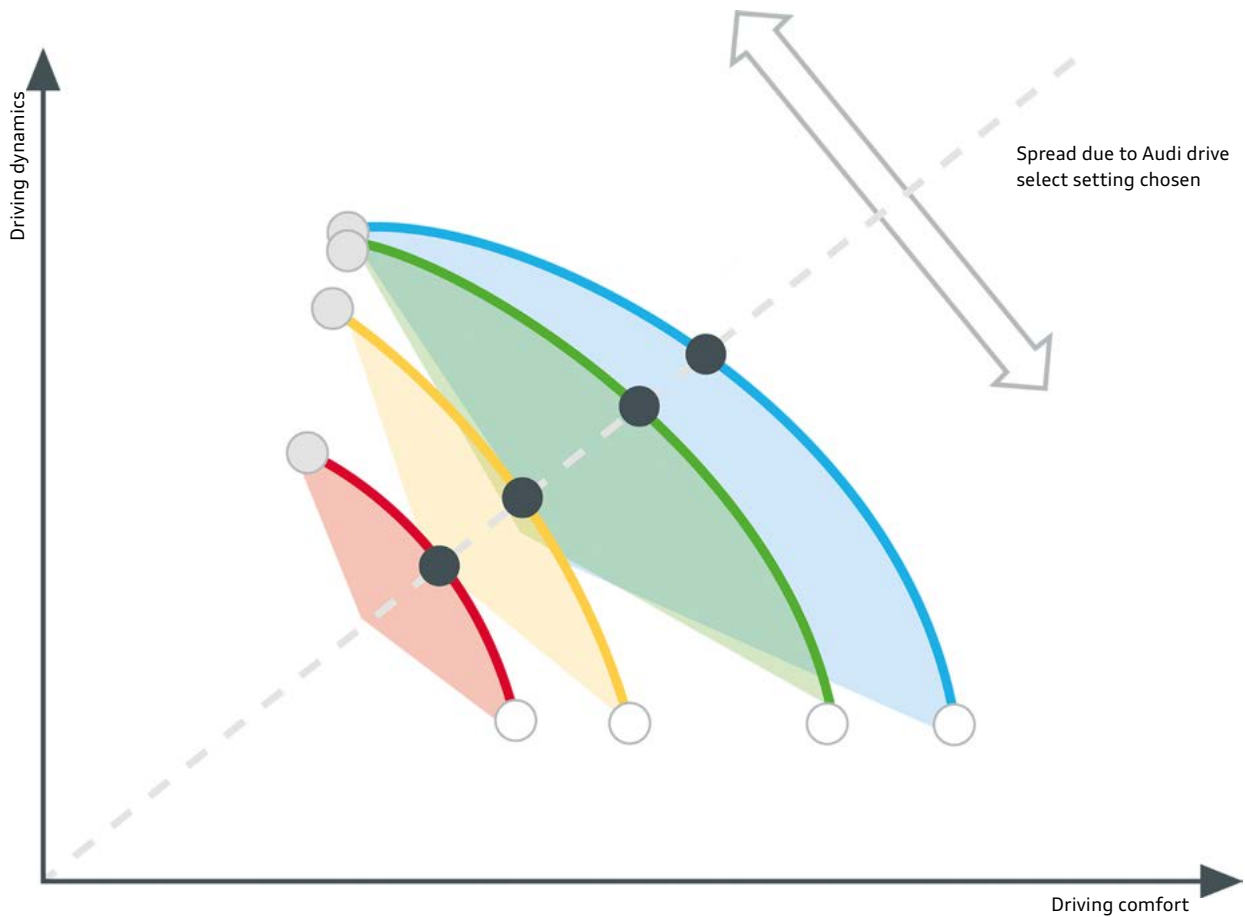
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The illustration below compares the driving dynamics and comfort characteristics of the adaptive air suspension (AAS, red) with those of the electromechanical active roll stabilization (ERS, yellow), the Active suspension basic system (green) and the Active suspension basic system with additional functions (blue).

By selecting the desired driving program in Audi drive select, the driver can decide whether to prioritize driving dynamics (sportiness) or to drive more comfortably. This is made possible by the system-specific spread which is also illustrated in the diagram.

The adaptive air suspension was used as the reference.



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**Key:**

- AAS (Adaptive air suspension)
- AAS + ERS (Adaptive air suspension + ERS [active roll stabilization])
- Active suspension (basic system)
- Active suspension (basic system)+ additional functions
- Audi drive select setting "auto"
- Audi drive select setting "dynamic"
- Audi drive select setting "comfort"

# Basic principle

## Design of the system

The principle of the active suspension system can be depicted using the electromechanical roll stabilization as a basis. On the roll stabilization system, the anti-roll bar is divided into two components, approximately in the center. The two components are connected by an electromechanical actuator. This actuator tensions the two components against each other, which causes the torsional torque and therefore also the vertical forces which act on the axles of the vehicle body to increase as the tension increases.

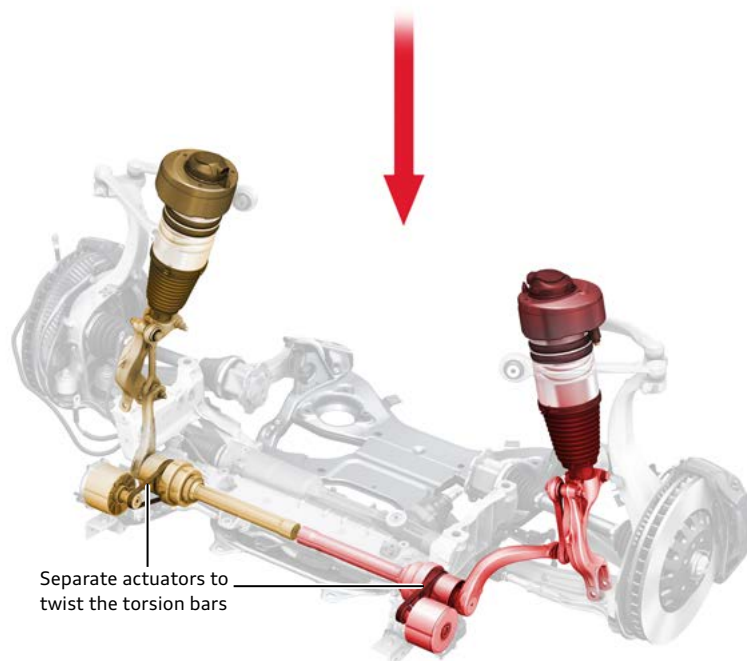
To regulate individual wheels, the two “halves” of the anti-roll bar on the active suspension are not connected and tensioned against each other. Each “half” of the anti-roll bar is tensioned by a separate actuator. The actuators are driven by electric motors.

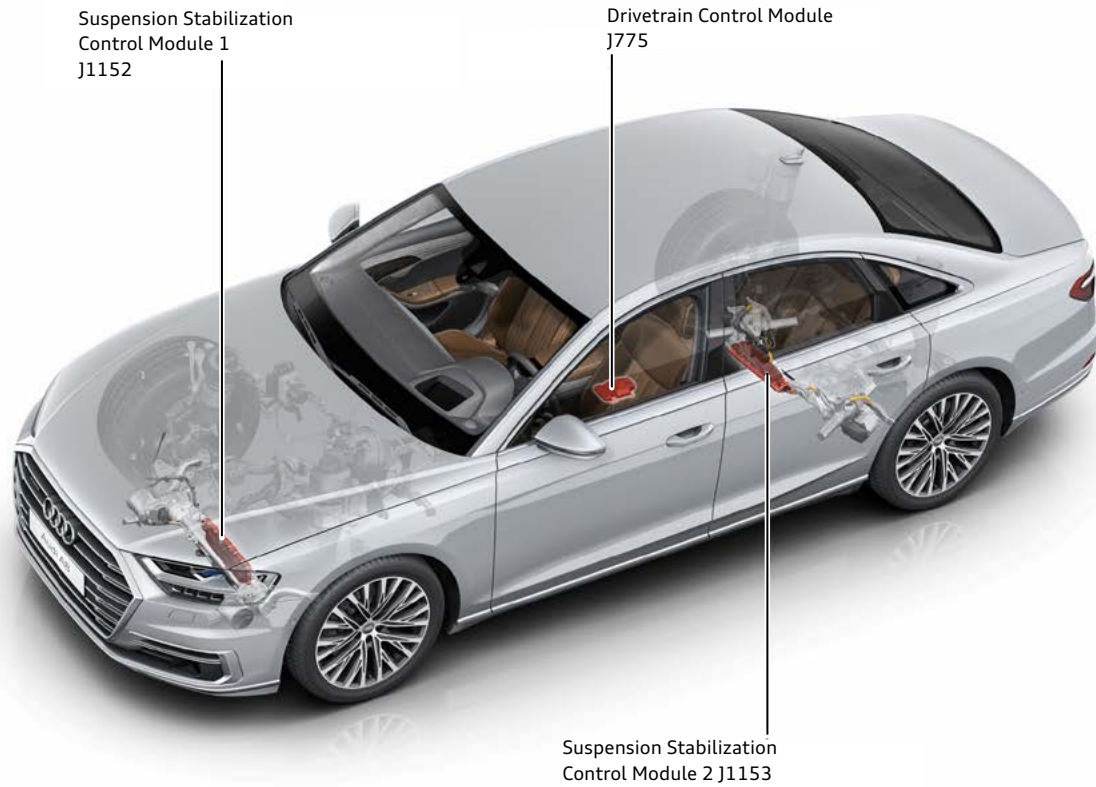
Compared with a hydraulic system, the electric actuation also significantly reduces the energy required, in addition to many other benefits. The electric motors are activated by a single Suspension Stabilization Control Module per axle. Drivetrain Control Module J775 activates the two control modules via a sub-bus.

### Adaptive suspension with ERS



### Active suspension



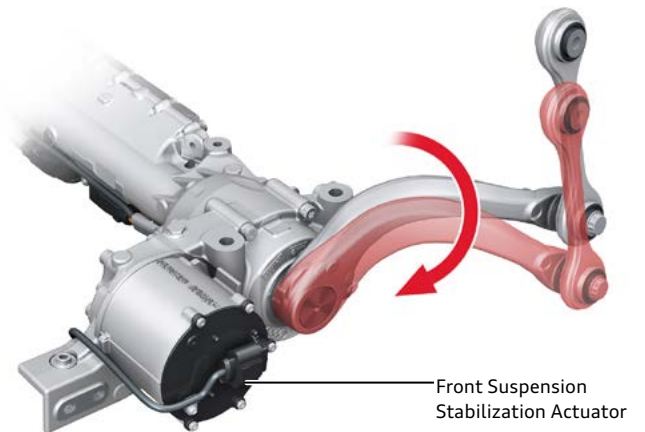


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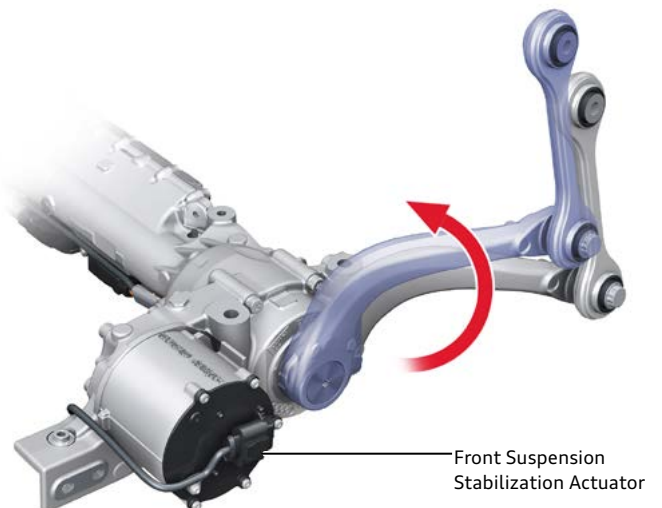
J775 calculates the regulating inputs required at the front and rear axles. The two chassis stabilization control modules implement the specifications by activating the electric motors on the front and rear axles for each wheel individually.

The actuators are bolted to the vehicle underbody (body-mounted) together with the subframes for the front and rear axles. When an actuator is operated, the lever which it actuates turns. A coupling rod connected to the end of the lever is connected to the damper stalk on the front axle and the transverse link on the rear axle.

Because of the turning movement of the lever, a vertical force component acts on the corresponding damper stalk or the corresponding transverse link via the relevant coupling rod. As a result, the distance between the wheel and the vehicle body is reduced or increased depending on the direction in which the actuator is turning (springs moving up or down).



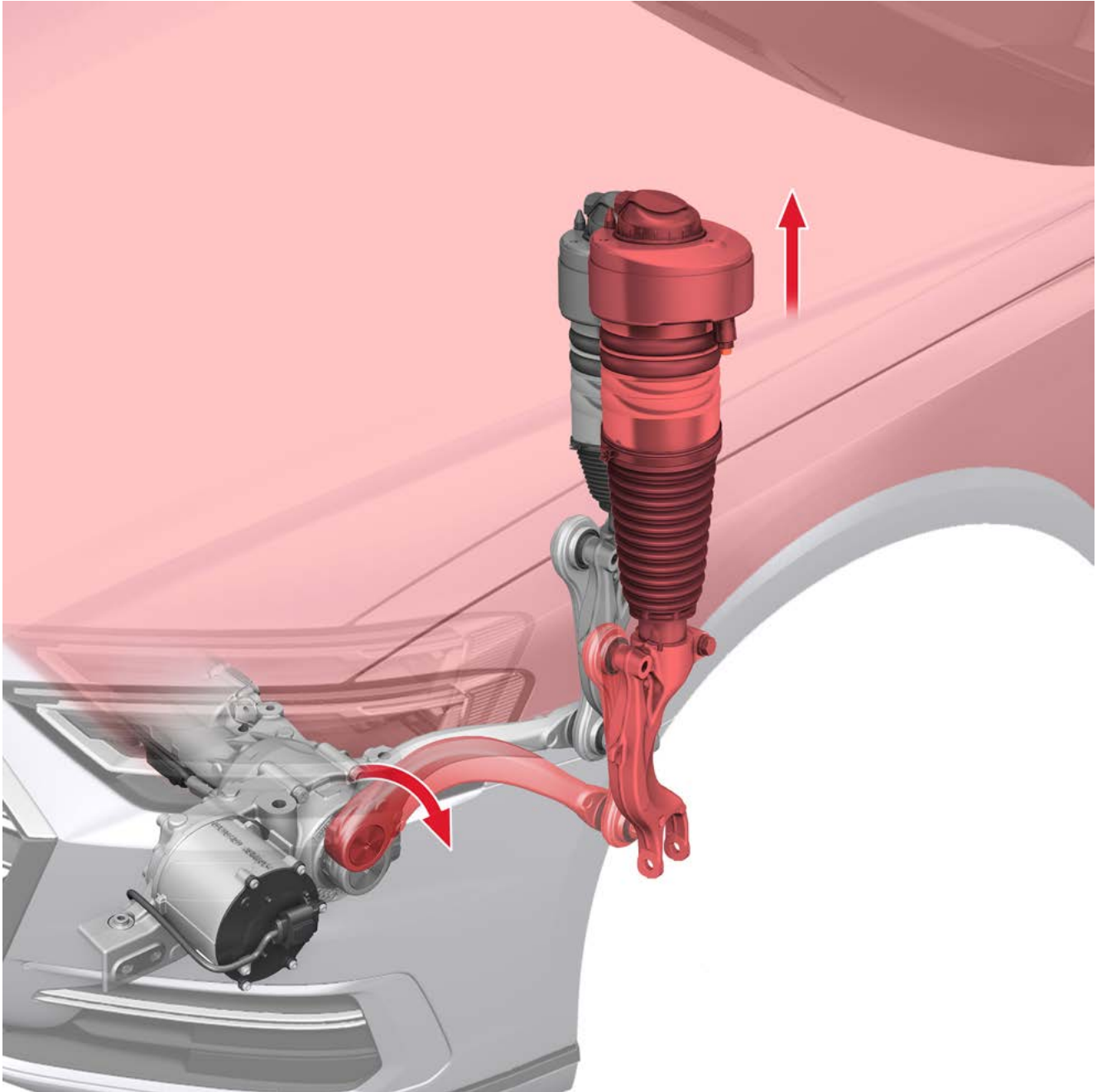
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The illustration below shows the activation of a front axle actuator as an example. The actuator lever is connected to the damper stalk via the coupling rod. The actuator supports itself on the wheel contact point via the lever, coupling rod, damper stalk and transverse link. The turning movement of the lever illustrated (shown in red) causes the actuator and the vehicle body directly connected to it to be raised.

The piston rod of the damper is put under tension (rebound damping). If the lever is turned in the opposite direction, the vehicle body is lowered. The suspension strut compresses and the piston rod of the damper is put under load (compression damping).



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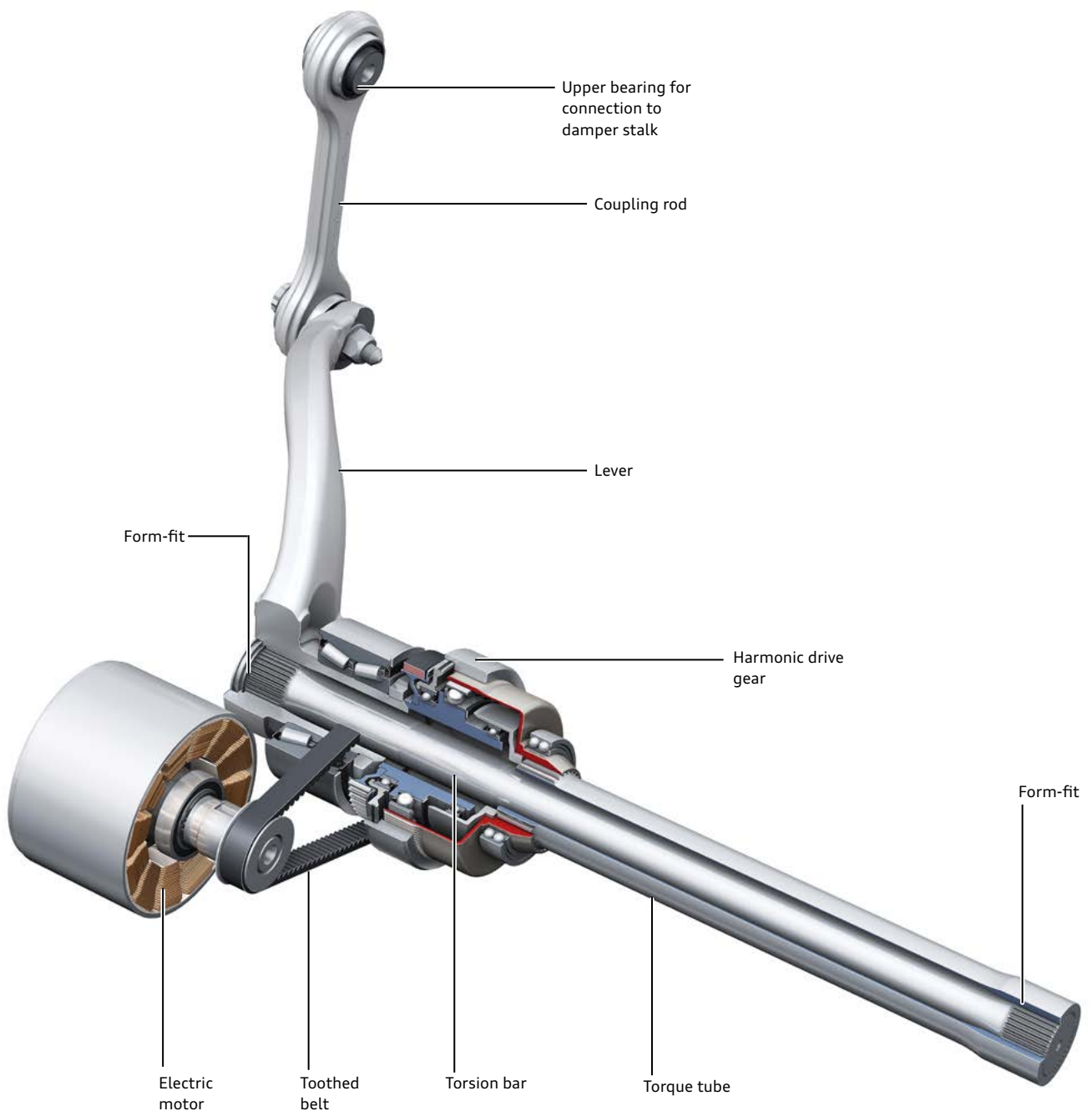
# System components

## Actuators for running gear stabilization

### Design

The coupling rod is connected to the upper bearing at the damper stalk of the front axle damper and at the top transverse links of the rear axle. The lower bearing of the coupling rod is connected to a lever. The end of the lever is form-fit to the torsion bar. The other end of the torsion bar is form-fit to the end of the torque tube.

The torque tube forms the extension of the output of the harmonic drive gear (strain wave gearing). The input shaft of this gearing is connected to the rotor of the electric motor via a toothed belt. The power is transmitted from the electric motor via the toothed belt to the harmonic drive gear, where it is output to the coupling rod via the torque tube, torsion bar and lever.

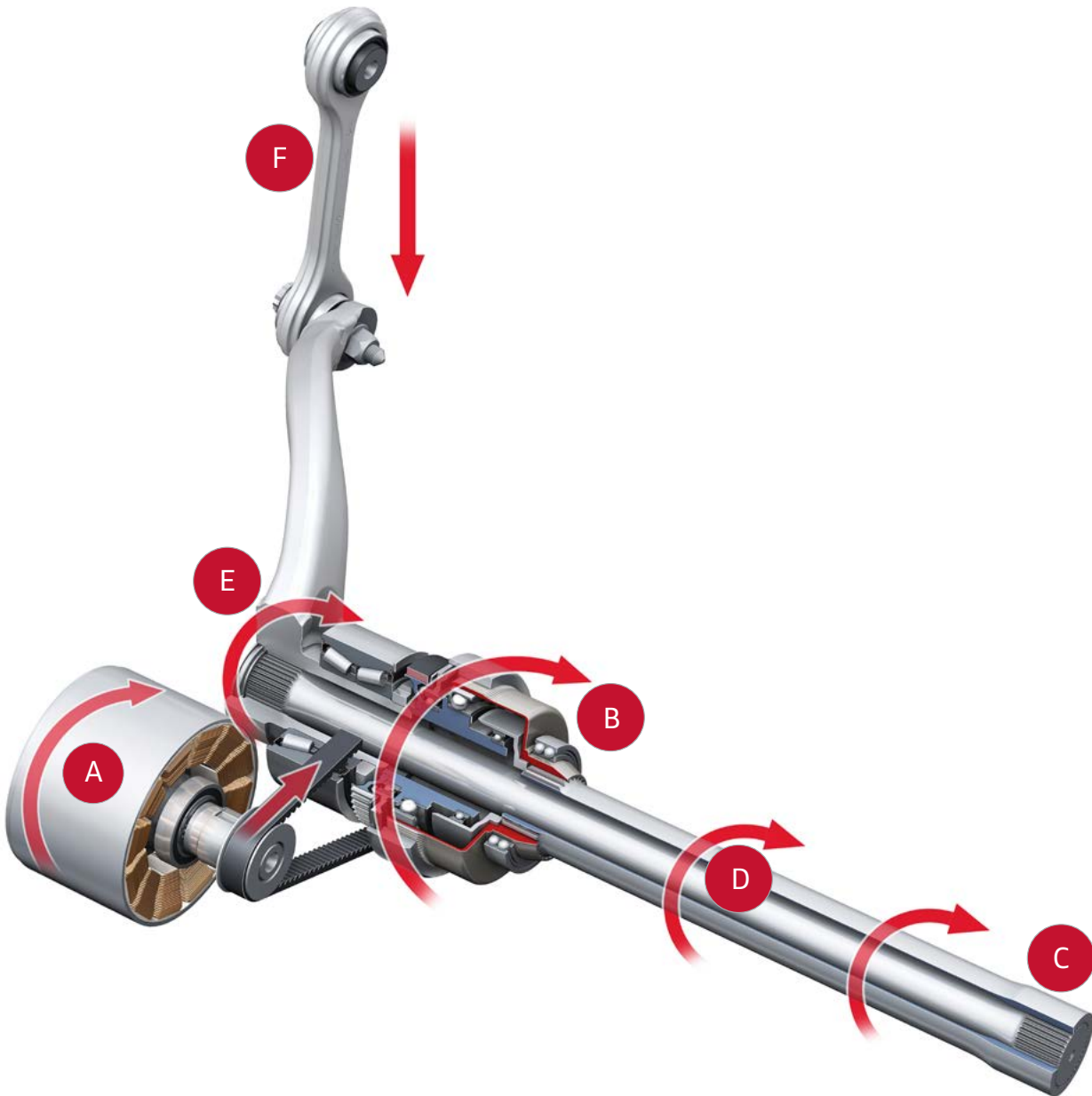


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## Function

The actuator provides a torque of approximately 811.3 lb-ft (1,100 Nm) at the drive gear output; the maximum force at the coupling rods is approximately 1124.40 lb (5.0 kN) on the front axle and approximately 1011.65 lb (4.5 kN) on the rear axle.

Lever angles of +/- 42° can be set from the zero position. The body can be raised by approximately 3.34 in (85 mm) from the center position at all four corners in just five tenths of a second.



1. The electric motor **A** drives harmonic gear **B** via a toothed belt
2. Harmonic gear **B** drives torque tube **C**
3. Torque tube **C** drives torsion bar **D**
4. Torsion bar **D** moves lever **E**
5. Lever **E** moves coupling rod **F**

# Harmonic drive gear

## Design and function

Harmonic Drives are a strain wave gearing system used wherever zero backlash, precision and high reliability are required. They are ideal for the operation of the actuators of the active suspension system. As the main component, they transmit the rotation of the electric motor into relatively small angles of rotation and high torque to the torque tube/torsion bar which are converted into the vertical motion of the coupling rod. Harmonic drives are used extensively in robotic devices because of their precision (no backlash), reliability and long service life. Harmonic drives were first used by Audi in the dynamic steering system of the Audi A4.

Harmonic drive component sets consist of only three components: wave generator, flex sleeve and circular ring gear. The elliptical shaped wave generator is the driven element of the gear set and has specially designed ball bearings.

The flex sleeve is a high strength torsionally stiff yet flexible shell-like component with external teeth which reliably transmits high loads.

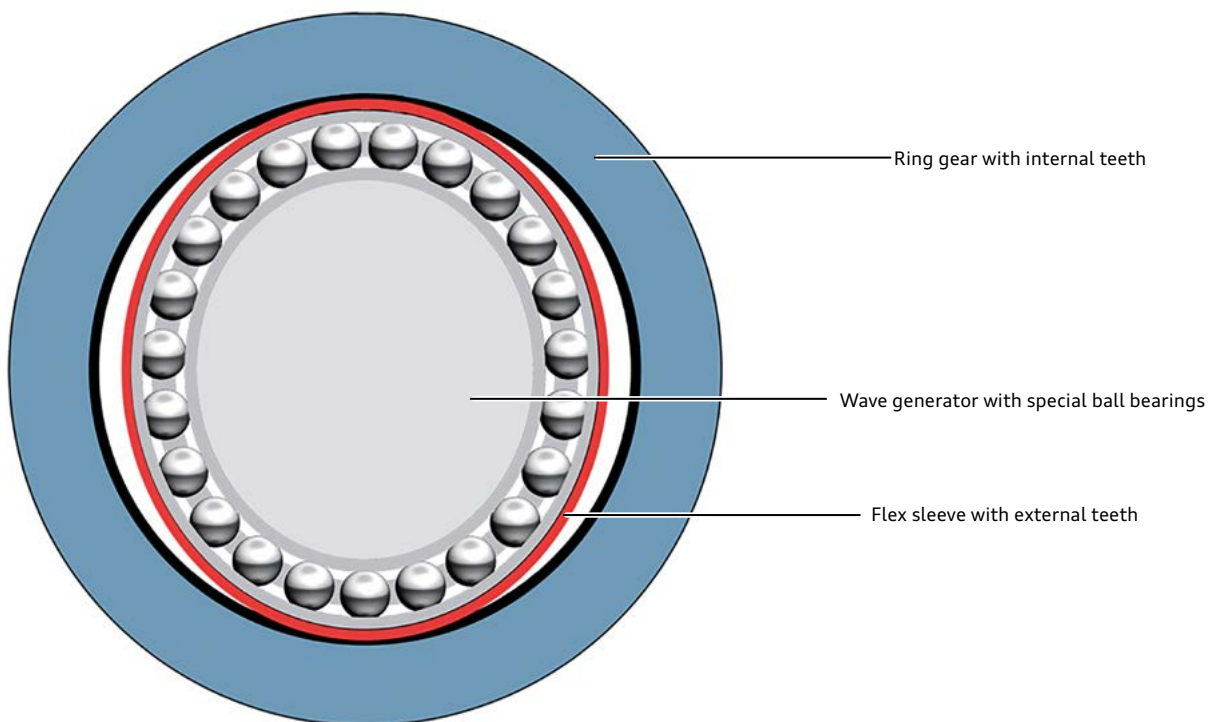
The outer circular ring gear has internal teeth. It is installed over the flex sleeve. The rigid ring gear has two teeth more than that of the flex spline.

By inserting the wave generator into the flex sleeve, the flex sleeve takes on the elliptical shape of the wave generator. When the wave generator rotates, it causes the flex sleeve to radially deform. The external teeth of the flex sleeve only mesh with the internal teeth of the circular ring gear in two places around the circumference of the ring gear as the wave generator rotates.



Flex sleeve and wave generator

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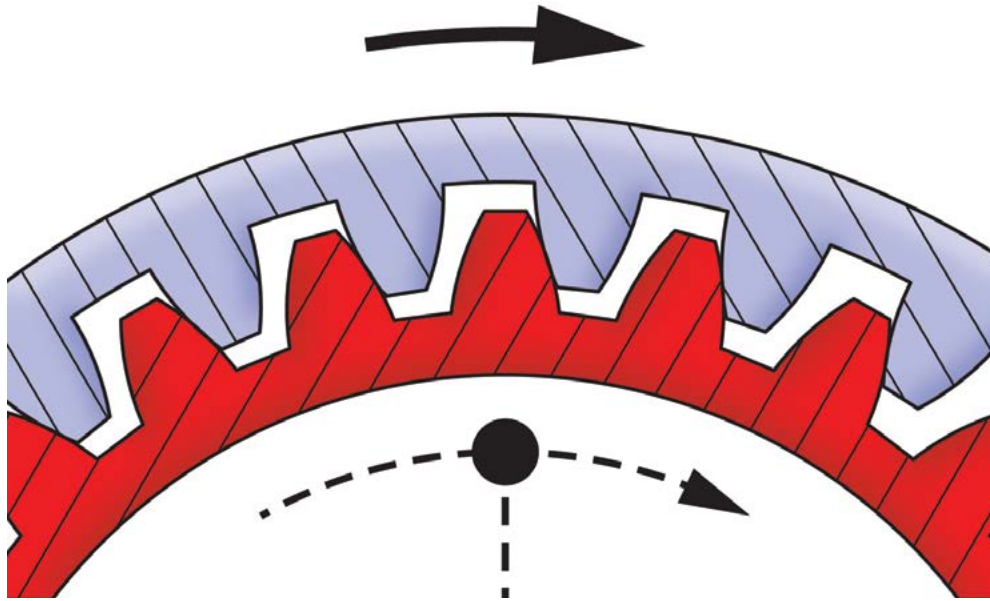


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When the electric motor is actuated, the wave generator rotates. Because the number of teeth on the flex sleeve and on the ring gear are not the same, the teeth on the flex sleeve do not mesh exactly with the teeth on the ring gear. The teeth on the flex sleeve engage the tooth flanks of the ring gear in a laterally offset manner. This eliminates backlash.

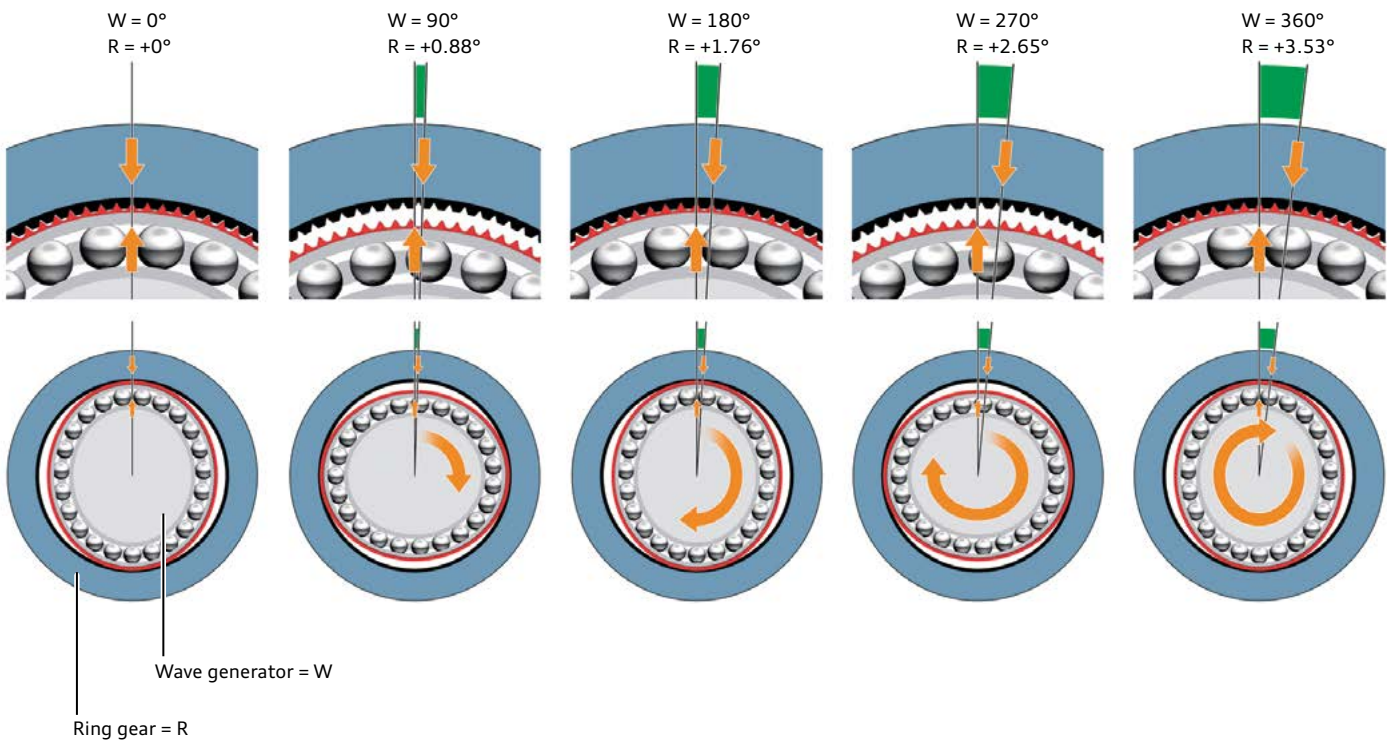
The force acting on this tooth flank produces a minimal continuous rotational movement of the ring gear.

All the teeth on the circumference of the ring gear mesh in a time-shifted manner due to the "rotation" of wave generator.



Laterally offset meshing of flex sleeve and ring gear teeth

402\_013



402\_014

All the teeth on the circumference of the ring gear mesh in a time-shifted manner due to the "rotation" of wave generator. This produces a continuous rotational movement of the ring gear at a defined ratio without any backlash.

This illustration shows the difference in movement (measured in degrees) between the wave generator and the ring gear. The ratio can be changed during the design process by changing the number of teeth.



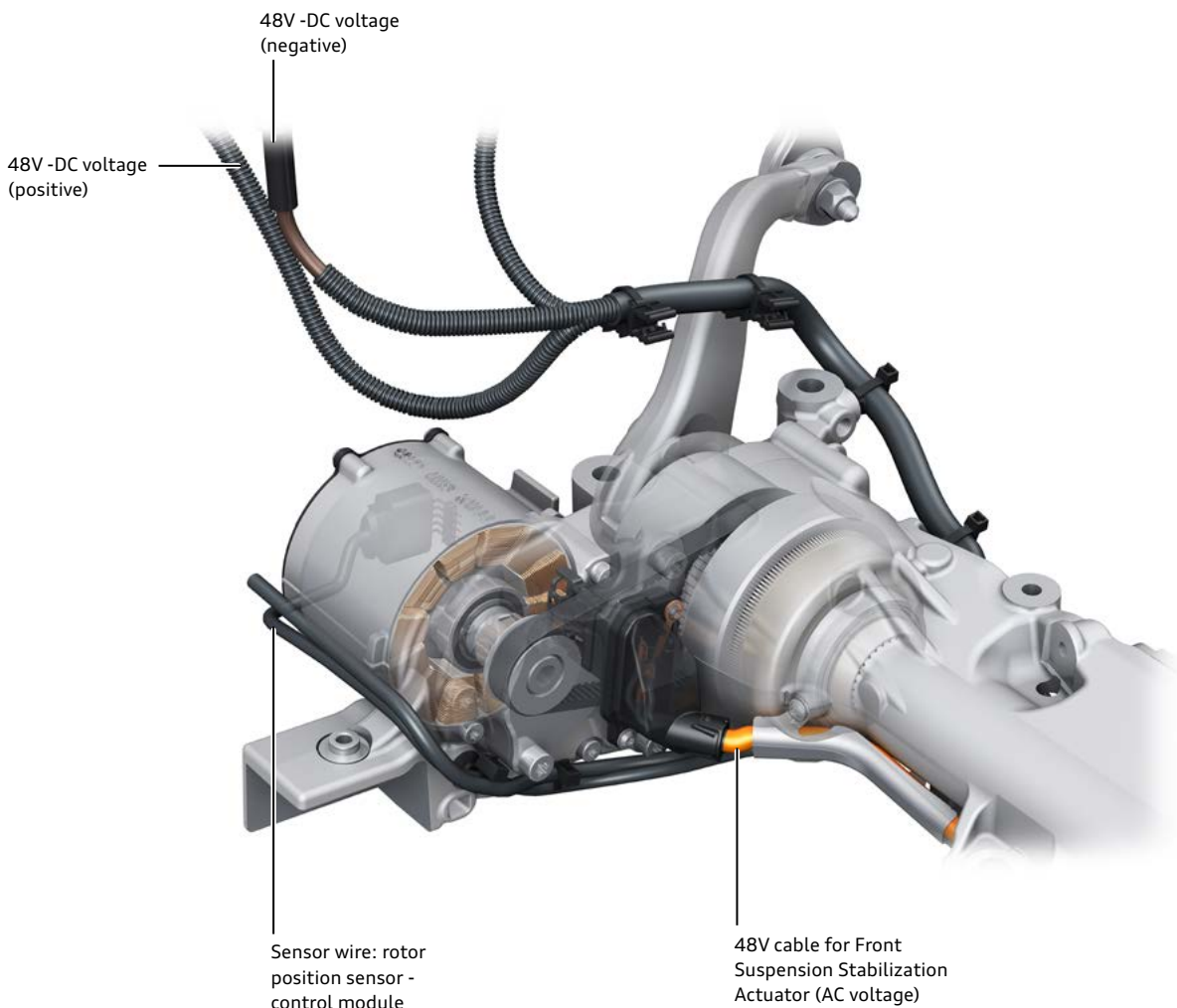
# Electric motor

## Design and function

The drive source for the actuator is a star connected permanently excited 48 Volt AC motor with five pole pairs with electronic commutation (brushless). The maximum power of the motor is approximately 2.0 kW; this is however only briefly required within a few milliseconds. The average power required is relatively low and is between approximately 10 and 200 watts, depending on the driving style and the road conditions.

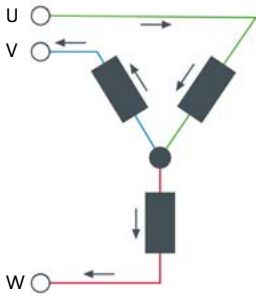
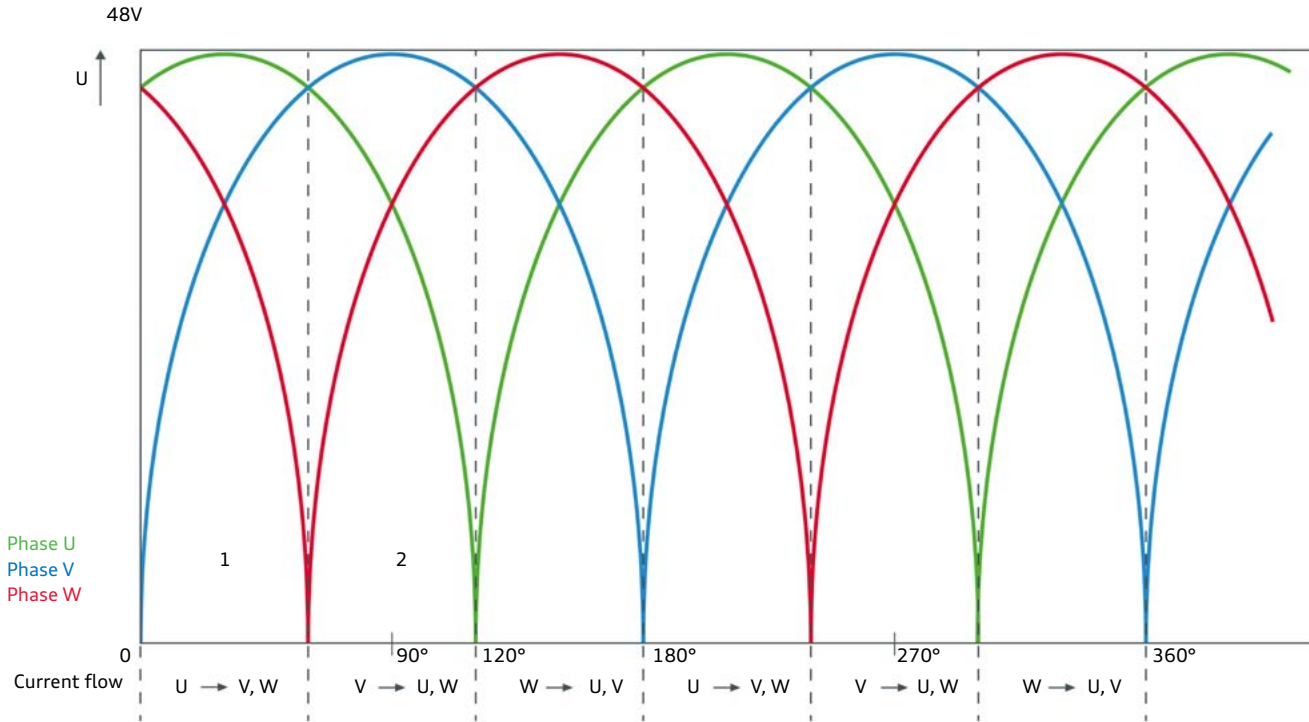
The motor is activated by AC voltages between 0 and 48 Volts with a phase rotation of 120°. This generates currents in the stator coils in alternating directions (see illustration below). Corresponding magnetic fields are generated around the coils through which the current is flowing. Their polarity changes each time the direction of the current changes. This generates a magnetic field with rotating polarities which surrounds the rotor. This magnetic field exerts corresponding force effects on the permanent magnets which are permanently connected to the rotor, thereby generating a torque which causes the rotational movement of the rotor. Depending on the activation (rotational direction of the magnetic field), turning clockwise or counter-clockwise can be achieved.

The position of the rotor is detected by a sensor. This sensor is on the end of the rotor, on the opposite end to the belt pulley. There is a permanent magnet in the hollow shaft of the rotor. Its position is measured by a magnetoresistive sensor. The magnetoresistive measuring principle is based on the fact that the electrical resistance in ferromagnetic metals changes due to the effects of external magnetic fields. Analyzing the changes in resistance allows the position of the magnet in the rotor shaft, and therefore also the angle of the rotor, to be determined.



The image shows the voltage curve of the phases. Electric currents are generated by corresponding differences in potential between the individual phases. The flow of current through the coils is shown as an example in section 1 of the graph. As the phase voltage U is the greatest in this section, the induced current flows from U to V and W via the star point.

In section 2, the greatest voltage is at V so the current changes direction and flows from V to U. The rotating magnetic fields generated by these alternating currents cause corresponding force effects on the permanent magnets of the rotor, which then generate torque.



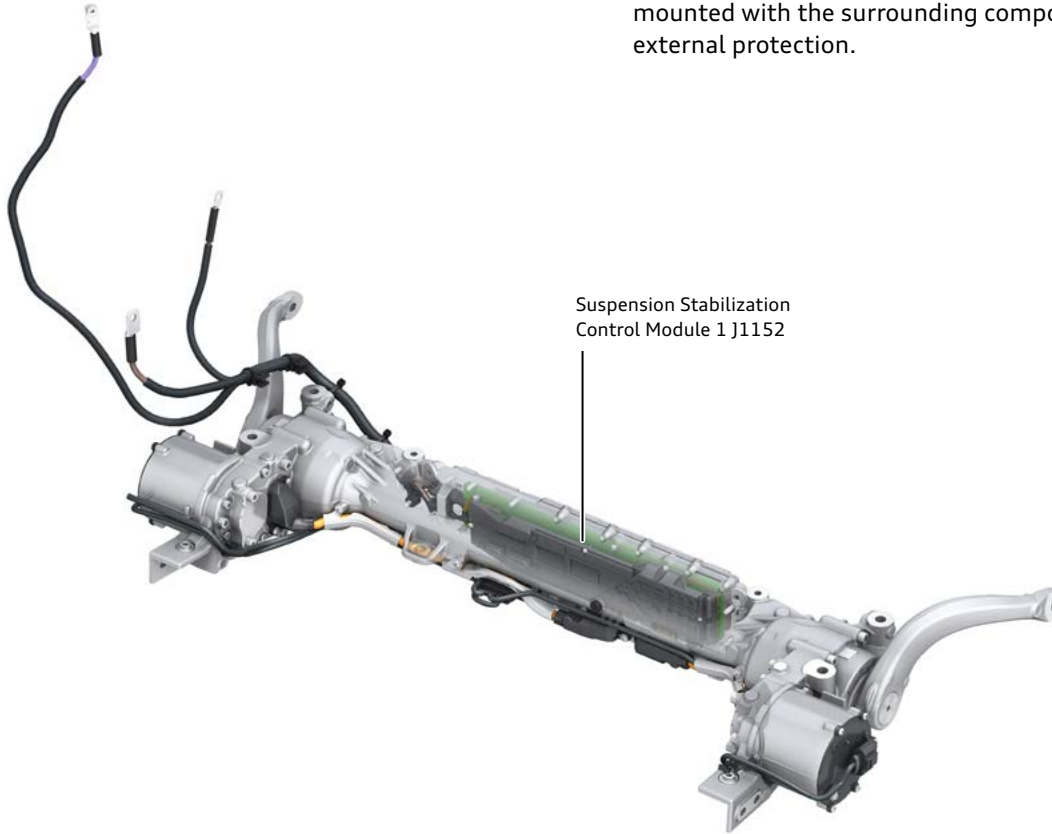
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## Suspension stabilization control modules

The electric motors are activated on a per axle basis by separate control modules. The control modules are supplied 12V Terminal 30 power which enables their participation in the vehicle Networking system and a 48V power supply (Terminal 40) for the power path.

Both Suspension Stabilization Control Module 1 J1152 and Suspension Stabilization Control Module 2 J1153 are controlled by Drivetrain Control Module J775. They communicate via a sub-bus system.

The control modules are installed between the actuators on the subframes of the front and rear axles. They are flush mounted with the surrounding components which provides external protection.



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**Front axle unit: the control module, actuators and integrated connector console with wiring.**



677\_020

**Rear axle unit: the control module, actuators and integrated connector console with wiring.**

# Drivetrain Control Module J775

Drivetrain Control Module J775 (2nd generation) includes the regulating software for the active suspension in addition to the regulating software for other suspension system features and the corresponding sensors. It acts as the master control module for the Suspension Stabilization Control Modules. J775 communicates with the other data bus nodes via FlexRay and with the Suspension Stabilization Control Modules via a sub-bus.

The regulating software is modular and mainly contains the modules described below. A more detailed description of the functions can be found on the following pages in the "System functions" chapter.



Drivetrain Control Module J775

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## Body control module

The aim is to pacify the vehicle body and to neutralize road excitation of up to approximately 5 Hz. Vehicle body vibrations have a frequency range of approximately 1-5 Hz.

## Preview module

This module evaluates data from the front camera to detect the surface of the road ahead. This enables the vehicle to react to upcoming road excitation (for example, speed bumps or bumpy road surfaces) in time, providing a significant increase in comfort.

## Pitch module

The pitch of the vehicle (rotational movement about the vehicle's transverse axis) when moving off and braking is reduced. This positively influences the vehicle's dynamics and comfort by shortening the braking distance and better supporting the vehicle body.

## Roll module

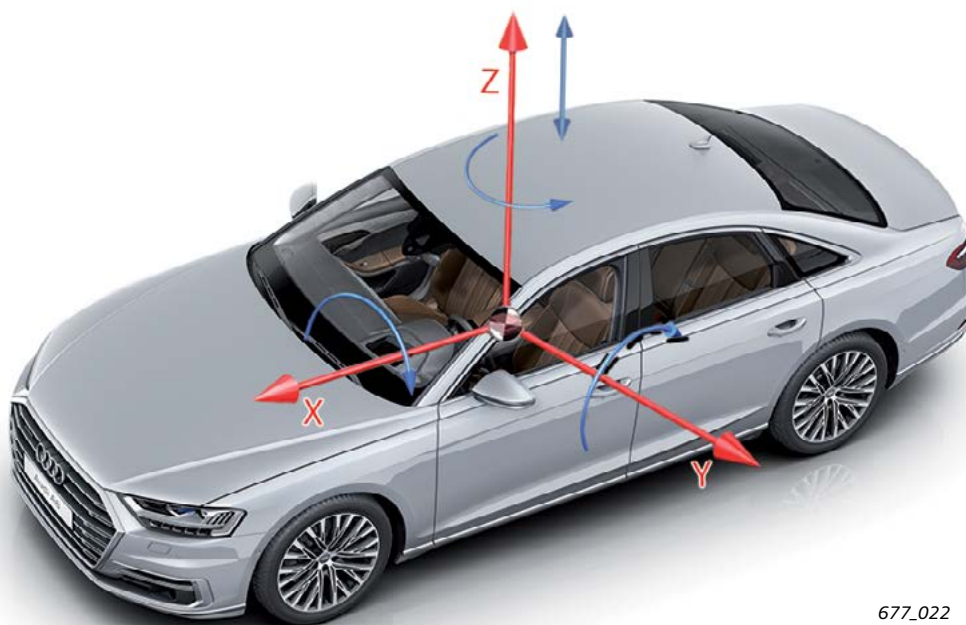
The roll of the vehicle (rotational movement about the vehicle's longitudinal axis) in corners is reduced. This positively influences mainly driving dynamics and driving safety due to better steering response and neutral vehicle handling.

## Crash module

If an impending side impact is detected, that side of the vehicle is raised very quickly. Instead of impacting the door area, the colliding object hits a larger proportion of the more rigid sill area, which can reduce the effects of the accident.

## Elevated entry module

When a door is opened, the vehicle body is raised to make it easier to get in/out of the vehicle.



677\_022

J775 detects the rotational movement of the vehicle around the main axes and the vertical acceleration of the vehicle body. Additional data is read in to determine the full current status of the driving dynamics (for example, the lateral acceleration from the Airbag Control Module, the vehicle speed from the ABS Control Module).

# System functions

## Basic function

The regulation of the stabilization rates, air springs and dampers is closely linked. The air spring system assumes the task of balancing the load and implementing both manual and automatic changes to the specified vehicle level. The damping required due to the actuators is taken into account when the damping forces are calculated.

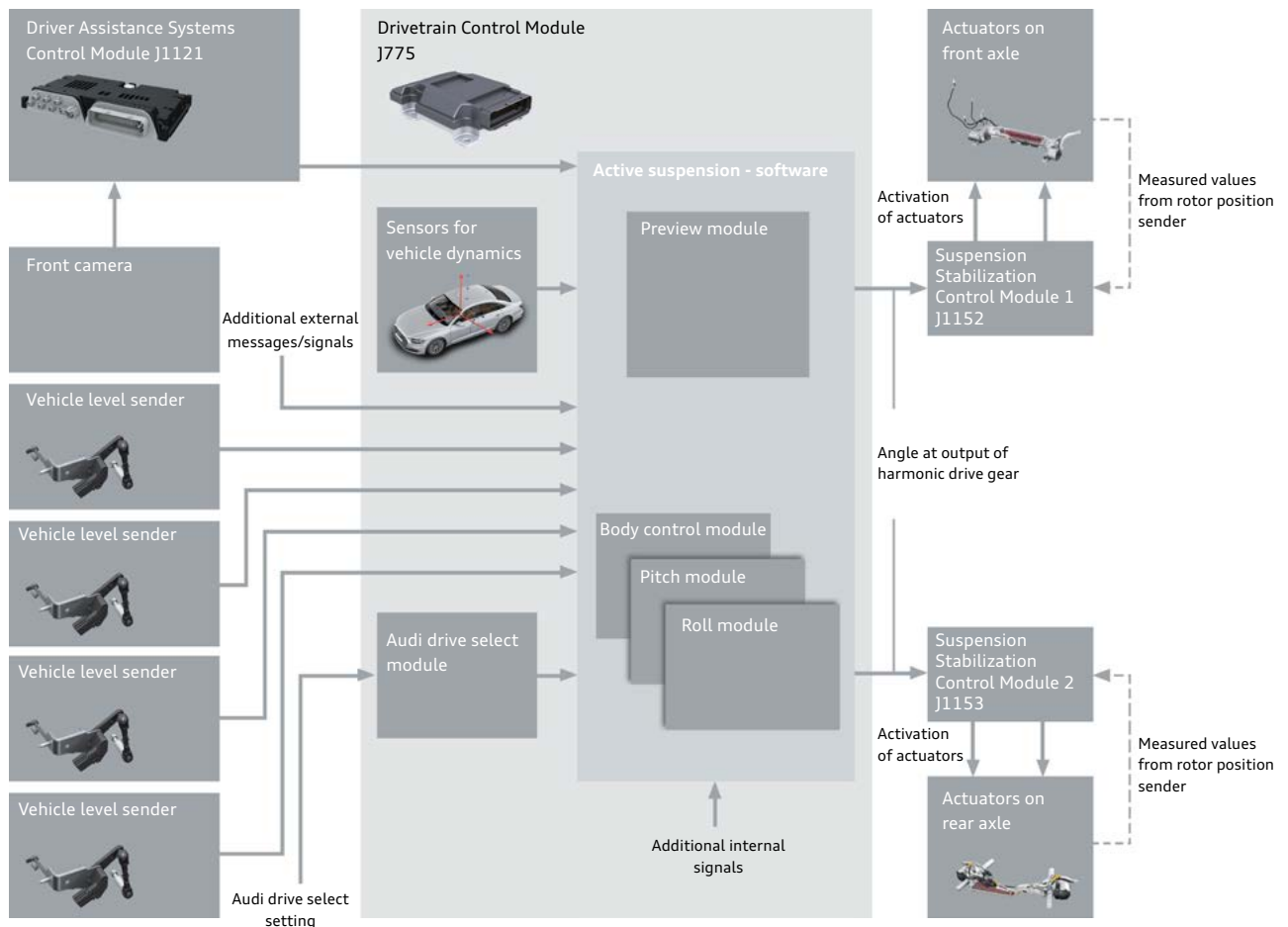
Drivetrain Control Module J775 calculates the torque with which the torsion bar should be tensioned for each wheel individually and almost in real time. This torque corresponds to a defined angle of rotation at the output of the harmonic drive gear.

These angle figures are provided as control inputs to Suspension Stabilization Control Modules 1 and 2 for the front and rear axles. The control modules achieve these positions by activating the electric motors of the actuators. The measured values from the rotor position sensors form the basis for determining the angles.

The total ratio for the angle of rotor rotation to the angle of rotation at the drive gear output is 189:1 (belt drive of rotor – drive gear input: 1:2.36: drive gear input – drive gear output: 80:1). This means that the rotor of the electric motor must turn 189 times to achieve one rotation at the drive gear output.

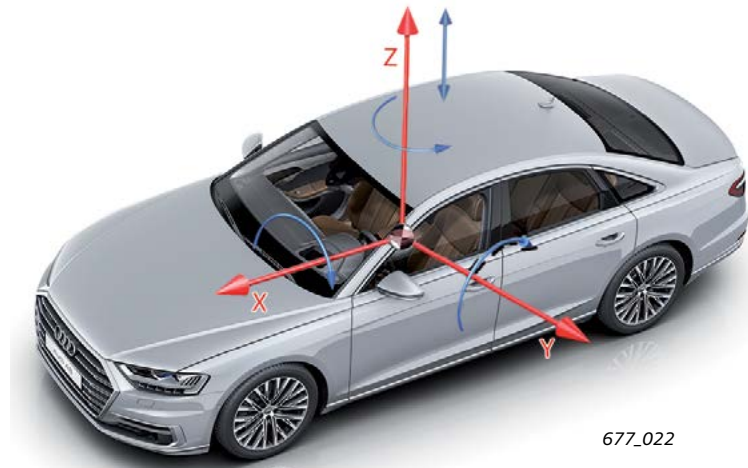
The basis for the calculation of the coupling force/tension of the torsion bars required is both the Audi drive select setting chosen by the driver and the relevant driving state or the vehicle dynamics determined by the relevant sensors. Corresponding sensors are implemented in J775 itself. Torques are measured about the x axis (roll torques), the y axis (pitch torques) and the z axis (yaw torques). The yaw torques are used to estimate the lateral acceleration; these figures are then compared with the measured values from the Airbag Control Module. Special software determines the vehicle speed. The vehicle level is determined, as with adaptive air suspension (AAS), by four separate level senders. The vertical movements of the vehicle body are measured by an acceleration sensor, which is also part of the running gear control unit.

The actuators are always supplied with current during active operation. There are phases of electrodynamic damping in every control operation. The permanently excited rotors of the electric motors are then “driven”. The rotating magnetic fields generated as a result induce electric voltages in the stator coils. The electric currents generated are used for recuperation of the 48 Volt battery. The maximum recuperation is approximately 3 kW; this may however only be effective very briefly.

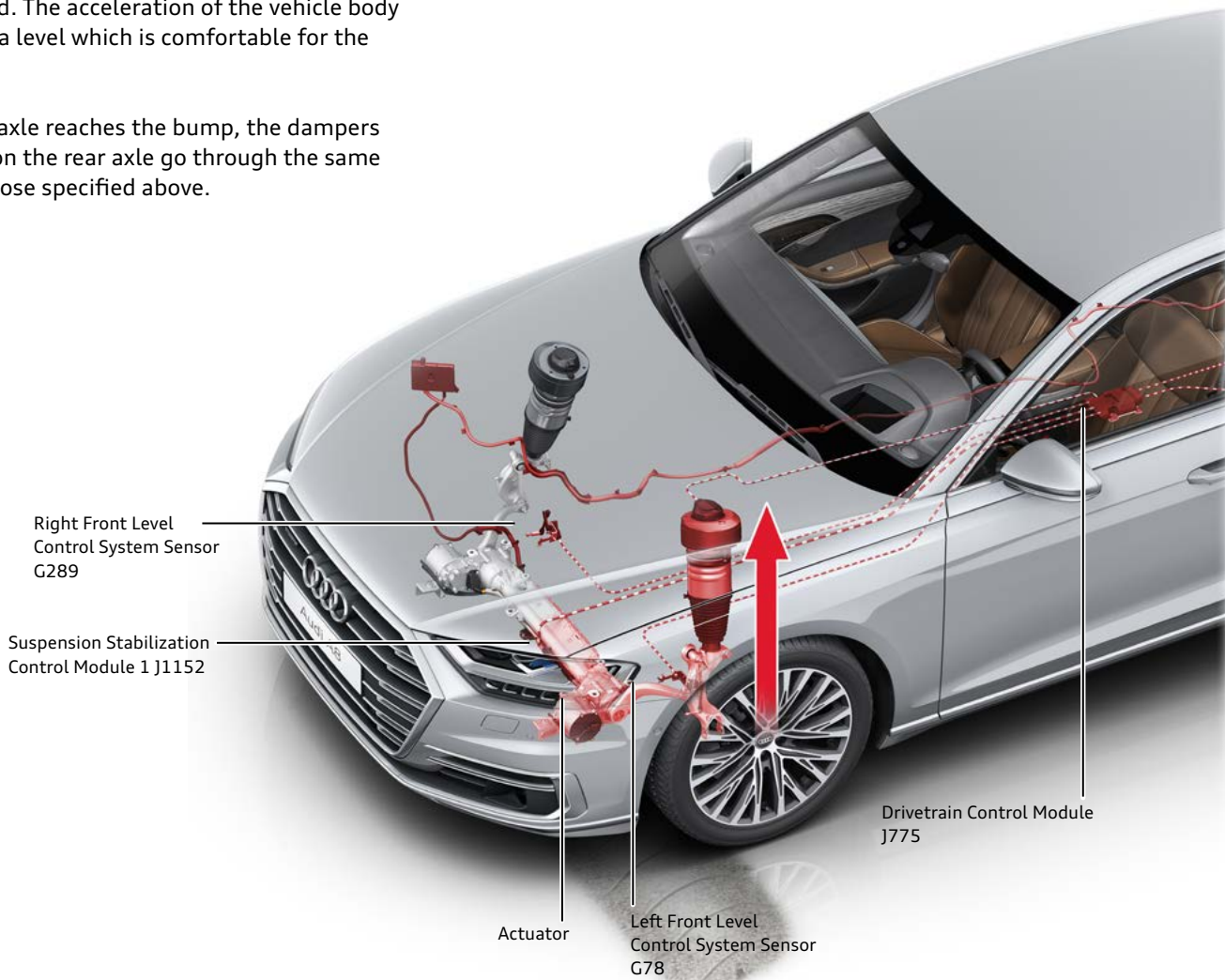


The system principle is illustrated using the example of driving over a bump (“positive” obstacle) with the left front wheel. The aim of the regulating activities is to calm the vehicle body as far as necessary to achieve the best possible compromise between driving comfort and dynamics. Dynamics and comfort are weighted on the basis of the Audi drive select setting chosen by the driver.

- > When the bump is reached, the vehicle body experiences vertical acceleration (z direction) at the front axle/above the left front wheel. This vertical acceleration is measured by the sensors in Drivetrain Control Module J775. In addition, the suspension at the left front wheel may compress slightly. This is also detected by the allocated vehicle level sender. Alongside a large amount of additional information (for example, vehicle speed, lateral acceleration etc.), this information is evaluated by J775. J775 proceeds to reduce the damping force of the left front damper in the compression stage. At the same time, the control module determines how much the tension of the torsion bars of the actuators on the front axle (stabilization rate) needs to be reduced by to calm the vehicle body accordingly. The control module calculates the changes to the angles of rotation of the actuators required to do so and requests that this be implemented by chassis Suspension Stabilization Control Module 1 J1152 on the front axle.
- > The lower damping force and stabilization rate allows for suitably large spring deflection on the front wheel. The vertical forces applied to the vehicle body are thereby reduced. The acceleration of the vehicle body is restricted to a level which is comfortable for the occupants.
- > When the rear axle reaches the bump, the dampers and actuators on the rear axle go through the same processes as those specified above.



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# Additional preview function

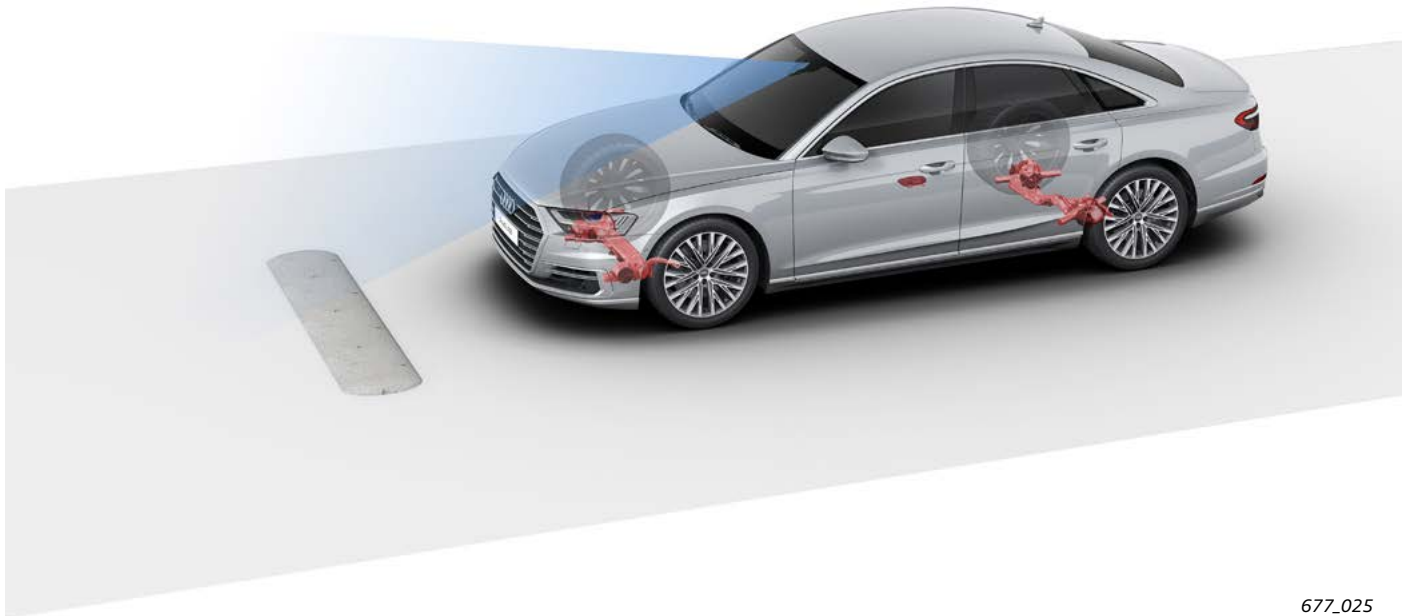
## Additional functions

In addition to the basic functions, additional functions can be achieved by the active suspension.

One function makes use of the option to detect certain irregularities in the road surface in advance. This is achieved by evaluating the optical signals from Driver Assistance Systems Front Camera R242. Driver Assistance Systems Control Module J1121 evaluates the camera data according to defined criteria. It determines the height and, on that basis, the type of obstacle. Typical obstacle types include harmonic bumps and speed bumps. Smaller road irregularities (potholes) are usually not detected due to their “edges” being on the same level as the road itself. Drivetrain Control Module J775 also receives information about the resolution quality from Driver Assistance Systems Control Module J1121 to assist it with the analysis.

On the basis of this information, J775 decides on the relevance of regulating and the ongoing procedure. Driver Assistance Systems Control Module J1121 provides Drivetrain Control Module J775 with current data approximately 18 times per second.

The main benefit of the preview function is the option of initiating corresponding measures in advance. The basic function can only be activated when measured values from the relevant sensors show that the vehicle has already begun driving over the obstacle. With the preview function, the counter-measures have already been initiated when the front wheels reach the obstacle. The function is active at speeds of up to approximately 37.28 mph (60 km/h). The preview function has the following regulating components:



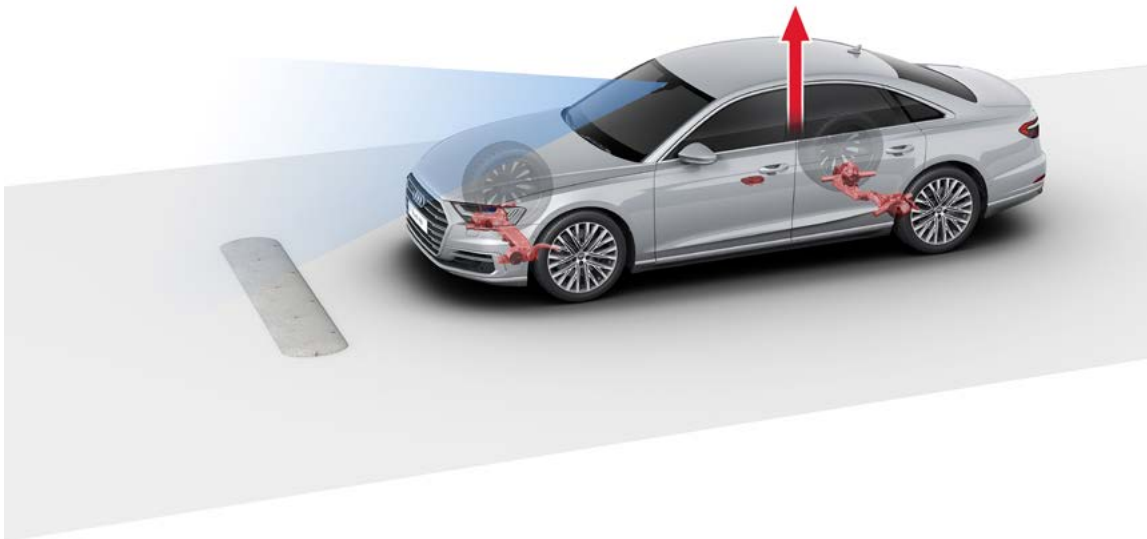
677\_025

### Pro lift

When the vehicle drives over a “positive” obstacle (for example, speed bump, see image), the vehicle’s suspension compresses. Vehicle occupants find it particularly uncomfortable if the entire spring travel is used during spring deflection. If the preview function detects a “positive” obstacle, pro lift initiates a corresponding activation of the actuators. The vehicle body is raised early so that there is sufficient spring travel available when the vehicle drives over the obstacle. As a result, it is possible for the vehicle to be raised by up to 1.57 in (40 mm) before it reaches the obstacle, depending on the type of obstacle detected. This occurs gently and is hardly noticeable for the driver.

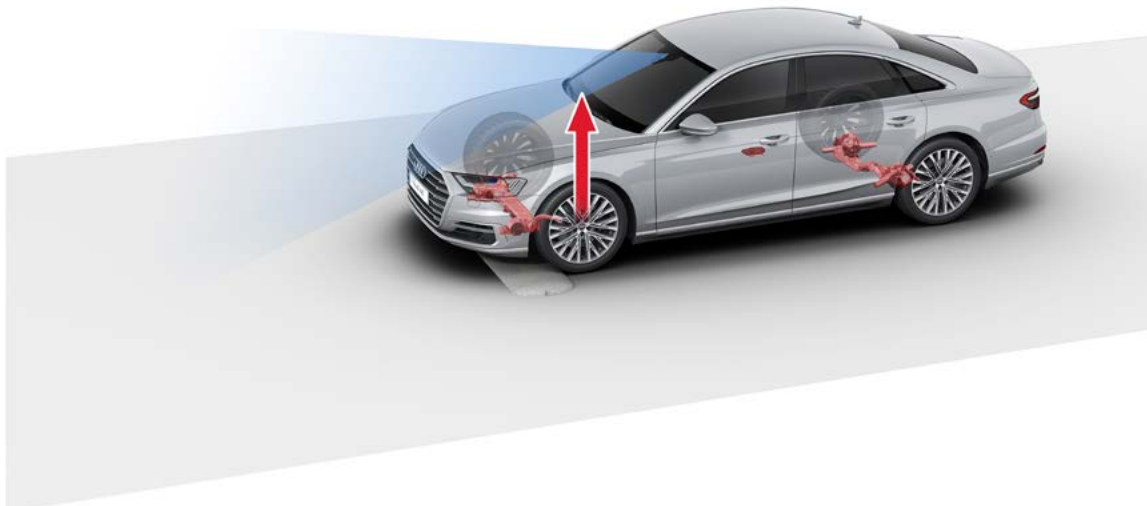
### Pro comp

Almost exactly at the same time that the relevant wheel “arrives” at the obstacle, this regulating component initiates a further regulation to follow the contour of the obstacle. This actively moves the wheel towards the vehicle body by activating the relevant actuator. This corresponds to a spring travel movement. Thanks to pro lift, it has already been ensured that sufficient spring travel reserves are available. The aim is to eliminate (or at least significantly reduce) the impulse caused by the ramp-shaped contour of the obstacle at the moment when it first makes contact with the wheel. As part of this, the damping forces are also adjusted accordingly. A similar process occurs when the vehicle is moving off the obstacle. In this case, the wheel’s suspension is actively extended so that it can follow the contour of the road closely as possible.



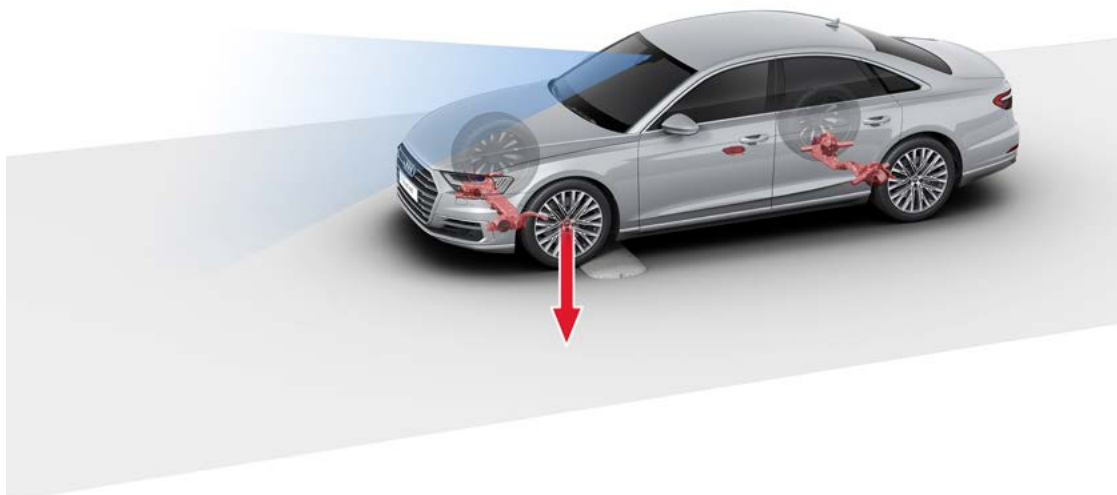
677\_026

An obstacle is detected by evaluating the camera data. It is classified as a “positive” obstacle (protruding from the road surface). For this type of obstacle, the highest level of spring travel possible must be made available. Drivetrain Control Module J775 calculates the specified angle for the lever and requests that Suspension Stabilization Control Modules 1 and 2 implement this. The vehicle body is raised accordingly before the wheel reaches the obstacle. The spring travel available is thereby increased by up to 1.57 in (40 mm).



677\_027

Immediately before the calculated moment that the vehicle arrives at the obstacle, Drivetrain Control Module J775 triggers the process to raise the wheel affected. This avoids hard contact with the obstacle.



677\_028

“Leaving” the obstacle is supported by adjusting the vertical movement of the wheel to the contour of the obstacle. The extension of the springs is supported, if necessary, by the active activation of the actuator.



## Additional crash lifting function

Despite many protective systems, injury to the occupants cannot be ruled out in the event of a traffic accident. Side collisions also constitute a certain injury risk for the vehicle occupants affected. The main cause of this is the relatively small space for deformation between the vehicle occupants on the side of the collision and the exterior of the vehicle. The structural elements in-between must absorb the kinetic energy of the colliding vehicle.

Depending on the force of the impact, the structural elements may deform in the direction of the vehicle interior (intrusion).



Side collision without crash lifting function

677\_029



Side collision with crash lifting function

677\_030

The area surrounding the side of the vehicle is monitored by four corner radar sensors, which are also required for Audi pre sense side. Driver Assistance Systems Control Module J1121 evaluates these data.

Depending on the situation, it determines the potential risk posed by a vehicle approaching from the side. It calculates the criticality (a numerical figure which represents the potential risk from the approaching vehicle) and the expected time until the collision. This information is sent to the Airbag Control Module J234 which initiates the following actions if necessary (pre sense side cascade). As part of this, Drivetrain Control Module J775 is requested to raise the vehicle for a collision.

If the relevant object/vehicle is no longer in the detection area, the request is canceled by the Airbag Control Module and the vehicle is returned to its original level.

If the less common case occurs in which a vehicle on a collision course swerves away, the vehicle is lowered again after a defined period of time. The collision function is also active in towing mode, with unchanged parameters.

For the collision function to be activated when necessary, all doors, the trunk and hood lids must be closed, Terminal 15 must be activated and the vehicle must have exceeded a speed of 4.9 mph (8 km/h) once. The function is no longer active when a door is opened or Terminal 15 is switched off. The collision function is also deactivated if ESC and/or pre sense is deactivated.

## Additional elevated entry function

This optional function raises the vehicle body when a door is opened. The vehicle is raised approximately 1.57 in (40 mm) (compared to the reference level in Audi drive select mode “auto” or “comfort”) in approximately one second.

The original level is reset:

- > Approximately 10 seconds after all four doors have been closed.
  - > When the vehicle starts moving.
  - > When the vehicle is locked.
  - > When the Audi drive select mode is changed.
  - > When the engine is switched off and the door is open, after a defined period to retain the battery charge level.
- The raised condition is displayed in the MMI touch screen.



677\_032

## Additional corner tilting function



This function is only activated if the comfort+ mode is chosen in Audi drive select.

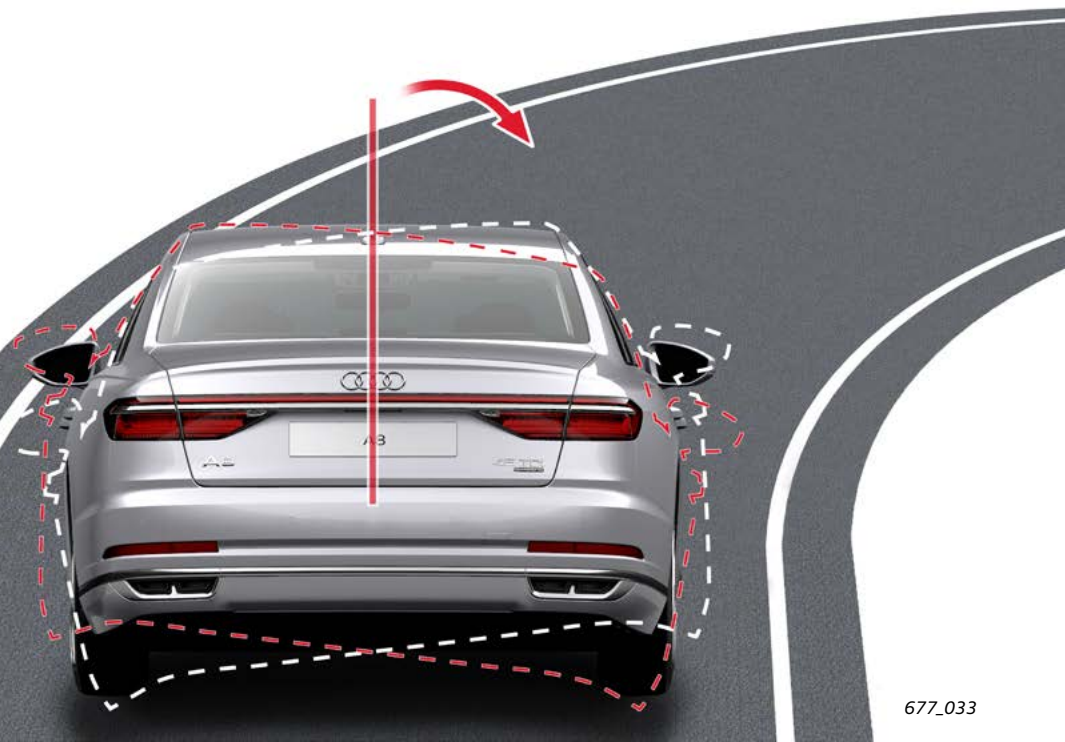
Because of the centrifugal forces acting on the vehicle body in corners, the body tilts towards the outside in corners. This undesired (from the perspective of driving dynamics and comfort) roll is reduced by the active damping control or largely neutralized if the vehicle is equipped with electromechanical roll stabilization.

The active suspension regulates in a more engaged manner in corners because it actually tends to tilt the vehicle body in the opposite direction. This is done by lowering the body on the inside of the corner and raising it on the outside. This causes the vehicle to tilt up to approximately 3° into the corner and achieves even more effective support via the wheels on the outside of the corner. At the same time, a significant improvement in comfort for the vehicle occupants is achieved as the lateral forces acting on them are reduced.

The regulating software mainly evaluates the vehicle speed and the lateral acceleration transmitted by the Airbag Control Module.

### Key

-  Vehicle body tilt in corners caused by the centrifugal force acting on the vehicle's center of gravity
-  Vehicle body tilt in corners caused by the active suspension



## Additional helicopter function

Forces also act on the vehicle body when undergoing longitudinal acceleration (forward propulsion or braking).

When the vehicle accelerates, the body supports itself on the wheels of the rear axle due to the effect of the inertial force; the load on the front axle is reduced. As a result, the rear axle suspension deflects and the front axle suspension extends.

When the vehicle is braking, the inertial force works in the opposite direction; the suspension deflects at the front axle and extends at the rear axle. On vehicles with damping control, these pitching movements are counteracted by adjusting the damping forces.

The regulating function of the active suspension also works to compensate for the effects of these dynamic driving situations. Under braking, the front axle is not only prevented from dipping forward, but the body is actually raised slightly at the front.

When the vehicle accelerates, the system regulates in the opposite direction and causes the body to be lowered (suspension compressed) at the front axle and the suspension to be extended at the rear axle.

This raising/lowering is mostly unnoticeable for the vehicle occupants. What can be noticed, however, is increased seating comfort thanks to the reduction of longitudinal forces acting on the occupants in or against the direction of travel.



677\_035

Raising the vehicle at the front axle and lowering it at the rear axle under braking counteracts the inertial force and enables significant comfort improvements by reducing the longitudinal forces acting on the occupants.



677\_034

When the vehicle is accelerating, the body is lowered at the front axle and raised at the rear axle. A significant improvement in comfort due to a reduction in the longitudinal forces acting on the occupants is also the result here.

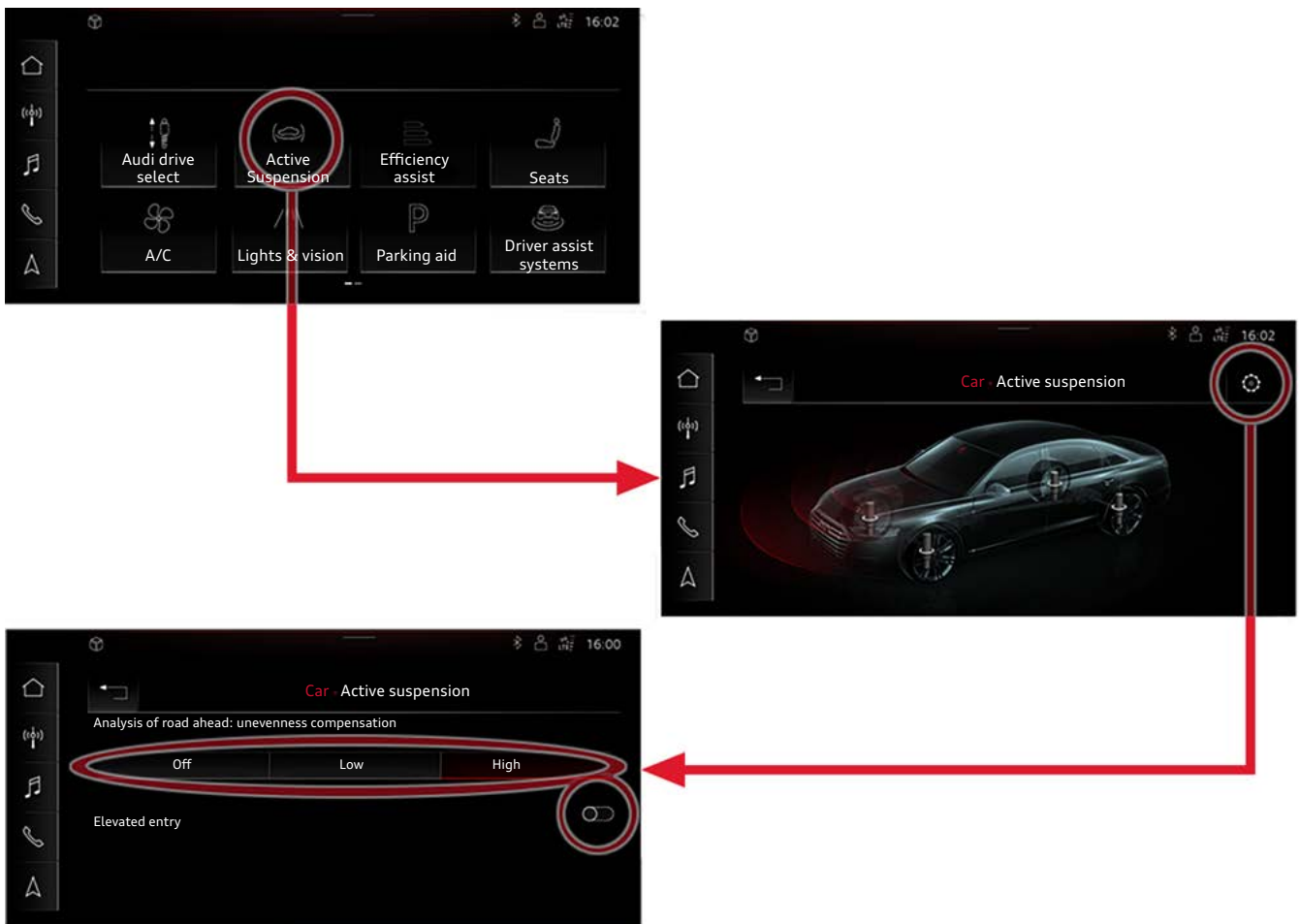
# Operation and servicing

## Operation and driver information

The driver cannot deactivate the basic functions of the active suspension, but can directly influence the regulation through Audi drive select. The driver also has the option of being informed of the status of the function while the system is actively regulating. To do this, the menu option “Active suspension” must be selected (Car – Vehicle info – Active suspension). The display shows, for each wheel individually, to what extent the movements of the vehicle body are being compensated for. The driver can also choose to what extent the system should compensate for bumps in the road.

By selecting the sprocket symbol in the active suspension display, the driver can switch off the unevenness compensation function (preview function) or choose between gentle and strong unevenness compensation.

The elevated entry function can also be activated or deactivated by the driver. Detailed information on the operation and displays of the relevant vehicle model can be found in the Owner’s Manual.

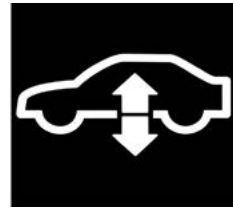
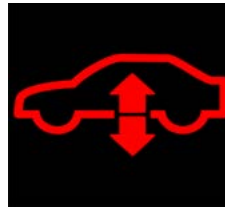


677\_037

# System behavior in the event of a fault

Drivetrain Control Module J775 performs a system diagnosis and reacts accordingly to implausibilities, system faults and special effects in the immediate surroundings (temperature, system utilization and electrical load).

The driver may be notified via warning lamps (neutral white, yellow, red) and a driver message. The warning lamp symbol is identical to the symbol for the air suspension system. The driver message indicates whether the notification is about the air suspension or the active suspension. The various displays are described in the Owner's Manual.



677\_039

A two-level concept of system degradation has been developed. The aim is to avoid emergency running mode. The first level involves a relatively small reduction in the power and torque of the actuators. The negative effects caused to comfort are, for the most part, not noticeable to the vehicle occupants. The driver is informed of the activation of the second level by a white warning lamp and a text in the display. The reduction in the vehicle's roll rigidity achieved in this level approximately corresponds to that of the normal running gear.



677\_040

If an actuator fault is detected, all actuators are switched off and the dampers are actuated with constant current. This achieves significant hydraulic damping which allows for sufficient roll stability with corresponding restrictions in comfort. The driver is informed of emergency running mode by the yellow warning lamp and a corresponding text.



677\_039

If there is a fault on a damper, the activation of the damping valves of all dampers is switched off. A damper fault has no effect on the activation of the actuators. Here, the driver also receives a fault message via the activation of the yellow warning lamp and a text on the display.



677\_042



677\_039

If a vehicle level sender fails, the damping valves also receive constant current and the activation of the actuators is switched off. As a result, significant damping forces are achieved on the front and rear axles. The driver is also informed of this via the yellow warning lamp and a corresponding text.



677\_041

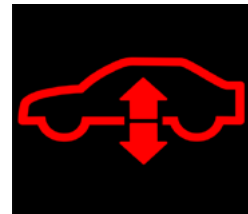


677\_039

If there is a fault with Drivetrain Control Module J775 which makes it necessary to switch off the actuators, the air spring system and the damping control are also affected because this module is also responsible for regulating these systems. This condition is shown by the red warning lamp. Because it is only possible to continue driving the car with restrictions due to significantly reduced stability, a driver message is displayed requesting the driver to stop the vehicle.



677\_038



677\_039

# Service operations

The following components can be replaced if necessary:

- > The entire module, including the control module, actuators and integrated connector console.
- > The wiring harnesses.
- > The stone deflector covers for the control motors on the rear axle.

The Suspension Stabilization Control Modules have the following Address Words:

- > 00D4 - Suspension Stabilization Control Module 1 J1152.
- > 00D5 - Suspension Stabilization Control Module 2 J1153.

Basic setting is required for each of these modules after they have been replaced. This involves allocating the vehicle ride heights (measured values from vehicle level senders) at the four wheel positions to the relevant actuator angles (measured values from the rotor position senders) and storing this information in the control modules.

The vehicle ride heights were already adapted when Basic setting of Drivetrain Control Module J775 was performed. This involved allocating the measured values from the vehicle level senders to the actual ride heights measured at the four wheel positions.

Therefore, after successfully performing Basic setting of control modules J1152 and J1153, intended changes to the vehicle ride height can be converted directly into the angle changes required at the actuators/electric motors by the control modules and also set accordingly.



677\_043

The crash lifting function must be deactivated for work in an inspection pit or on a hoist. This is done by switching off the ignition (Terminal 15 off) and opening the driver's door once. On vehicles with active suspension, the vehicle may raise or lower itself via the elevated entry function when the ignition is switched off. This function must also be deactivated. For information on this, please refer to the Owner's Manual.

The active suspension actuators operate at 48V. It is required that the system be de-energized before performing relevant removal/installation procedures. Follow all work steps and sequences specified in ElsaPro.

## System behavior in Shipping Mode

Regulation remains active in Shipping Mode. However, the elevated entry function is deactivated. This prevents the vehicle's ride height from being raised when a door is unlocked/opened. This reduces the possibility of damage to body panels when vehicles are loaded and unloaded from a car transporter.

## System behavior in Transport Mode

Regulation is deactivated in Transport Mode. This relieves the load on the electrical system because the battery is not utilized by the regulating processes.



### Note

Caution! Before working on vehicles with active suspension, read and follow all the safety precautions given in ElsaPro.

# Knowledge assessment

An On-Line Knowledge Assessment (exam) is Available for this eSelf-Study Program.

The Knowledge Assessment is required for Certification credit.

You can find this Knowledge Assessment at: [www.accessaudi.com](http://www.accessaudi.com)

From the [accessaudi.com](http://accessaudi.com) Homepage:

- > Click on the “App Links”
- > Click on the “Academy site CRC”

Click on the Course Catalog Search and select 960393B - “Active suspension”.

Please submit any questions or inquiries via the Academy CRC Online Support Form which is located under the “Support” tab or the “Contact Us” tab of the Academy CRC.

*Thank you for reading this eSelf-Study Program and taking the assessment.*



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