

Volkswagen DCC Adaptive Chassis Control - Design and Function

DCC Adaptive Chassis Control

The rule for suspension systems has always been that increasing sportiness compromises the ride. In this new system – the DCC adaptive chassis control, the suspension constantly adjusts itself to the road conditions, the driving situation and the drivers requirements.

Adjustable shock absorbers are required to make this possible. The steering assistance is also adjusted in addition to the damping.

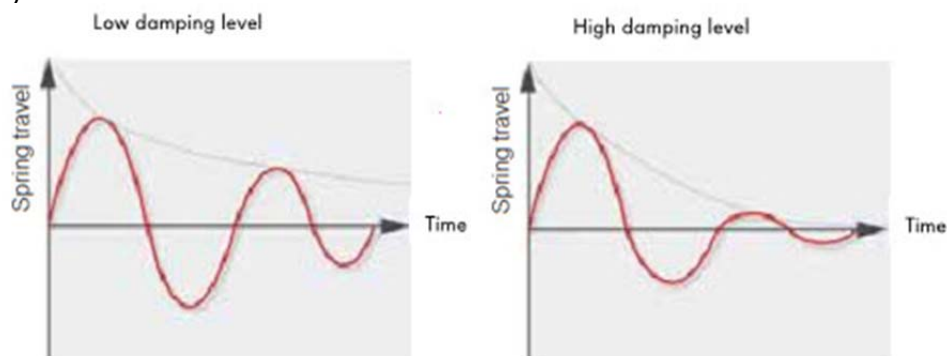
Basics of the damping system

The shock absorbers have the task of quickly reducing the vibration energy of the body and road wheel oscillations.

Suspension configuration

The compression cycle and extension cycle are features of the suspension. The damping force in the compression cycle is normally lower than in the extension cycle.

The shock absorbers prevent the body rocking due to bumps in the road and stop the wheels bouncing out of control on the road surface. Furthermore the body is also stabilised by the damping forces during dynamic manoeuvres.



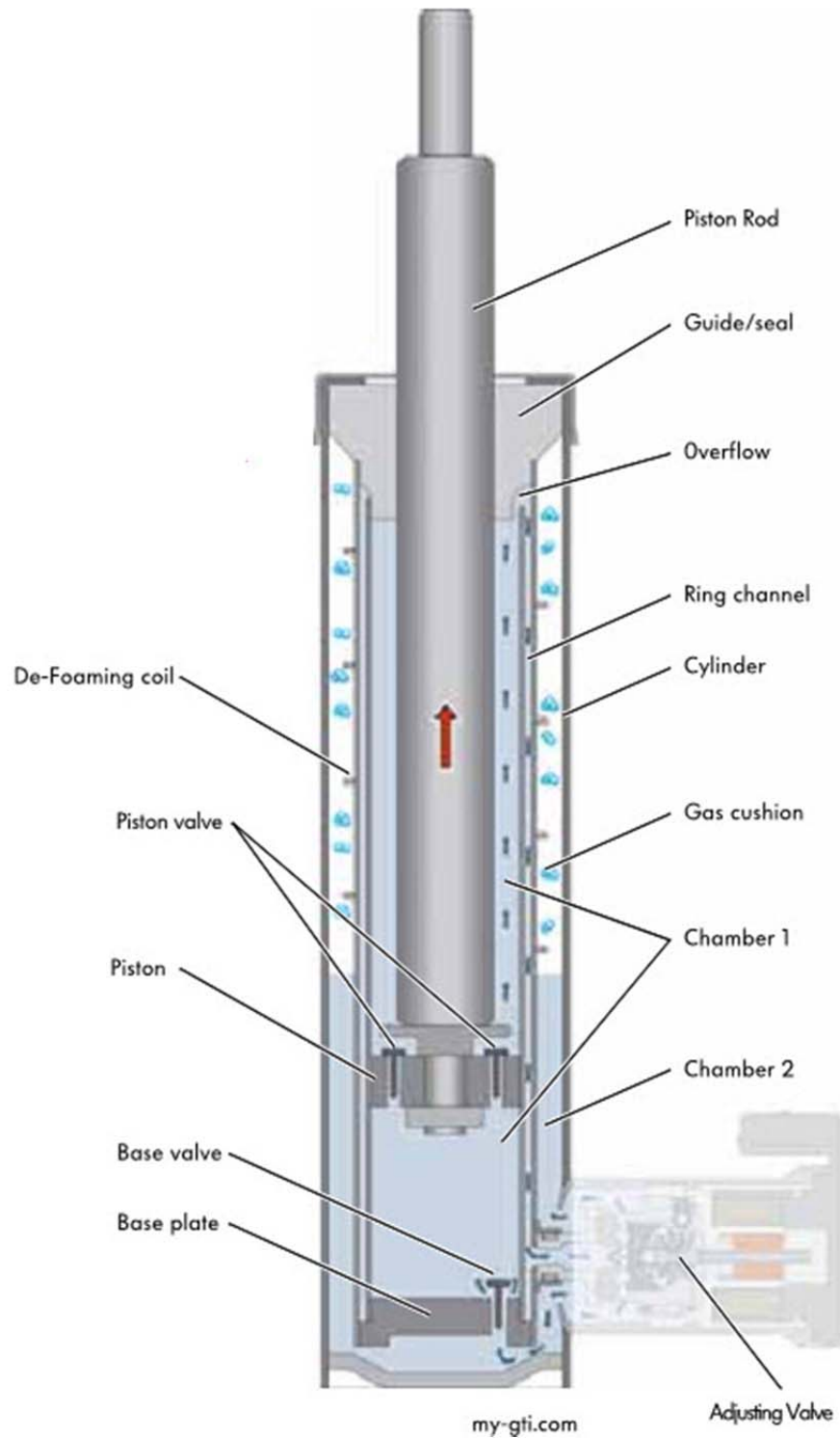
An even greater damping effectiveness is achieved with adjustable shock absorbers since the current driving situation can be taken into consideration more efficiently. The electronically controlled damping control unit determines within milliseconds what level of damping is required at which wheel and adjusts the shock absorber accordingly.

The damping level is the rate at which the vibrations are reduced. This is dependent on the damping force of the shock absorber and the size of the sprung masses.

Reducing the sprung masses increases the damping level.

Adjustable shock absorber

An adjustable shock absorber using a twin-tube design is employed for the DCC adaptive chassis control. The piston runs in chamber 1 and there is an additional gas chamber in chamber 2.



Function in extension and compression cycle

Check valves on the piston and base plate cause the oil to flow in the directions shown in the diagram during extension and compression.

The oil is fed to the adjustment valve through the ring channel and it flows in the same direction (uniflow) during extension and compression. The oil flows back into chamber 2 from the adjustment valve.

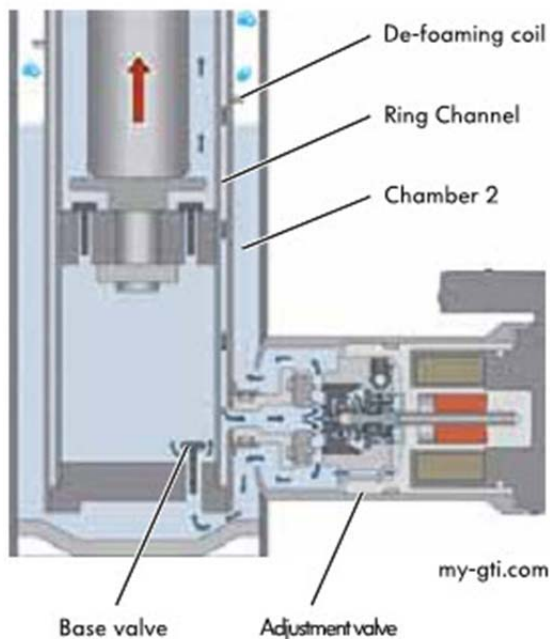
The adjustment valve determines the pressure in chamber 2 and thus the damping.

The cylinder contains chamber 2.

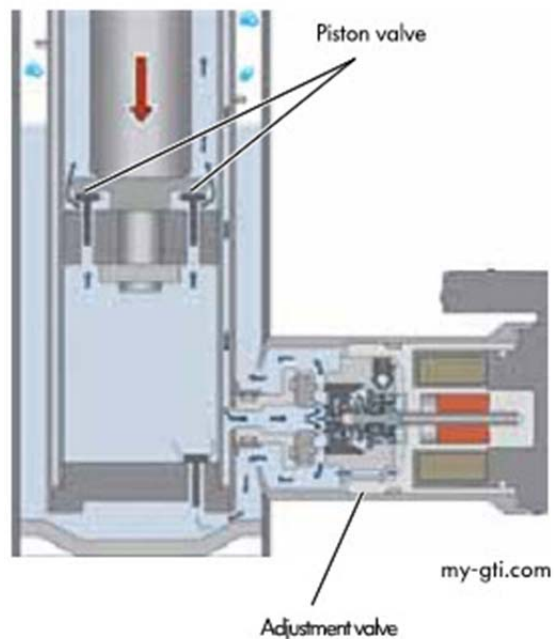
It is only partly filled with oil. There is a gas cushion with a de-foaming spiral above the oil filling. Chamber 2 is used to compensate changes in the oil volume.

The oil flow is controlled by the damping valve units on the piston, on the chamber base and in the adjustment valve. They consist of a system of flat springs, coil springs and valve bodies with oil flow ports.

Extension Cycle



Compression Cycle



During the extension cycle, the oil flow is controlled by:

- the adjustment valve,
- the base valve and
- to a limited extent the piston valve.

During the compression cycle, the oil flow is throttled by:

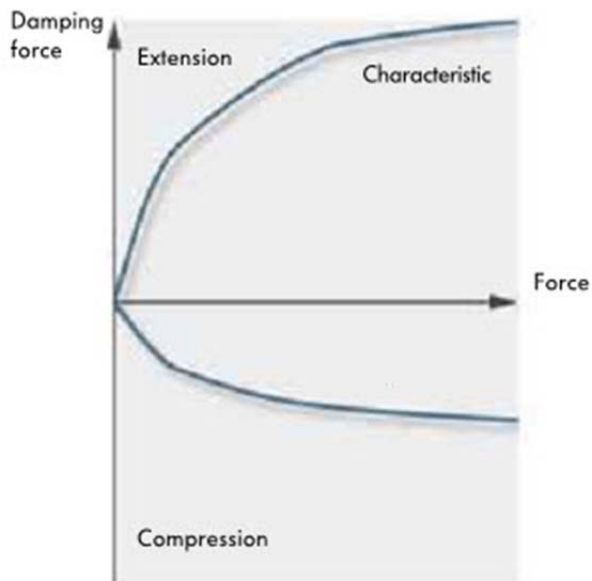
- the adjustment valve,

- the piston valve and
- to a limited extent the base valve.

Map for Adjustable shock absorber

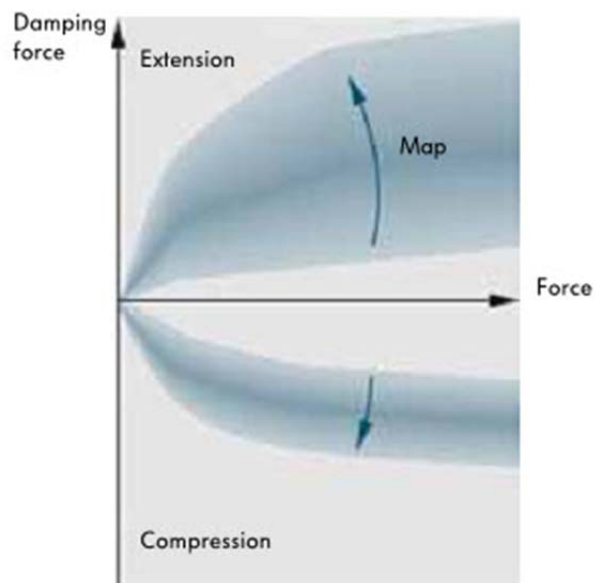
Compared with a conventional shock absorber with fixed map, the adjustable shock absorber has an adjustable characteristic curve within a map.

Conventional shock absorber



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Adjustable shock absorber



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Conventional shock absorbers have a characteristic curve that helps define the driving properties of the vehicle. Defining this characteristic curve is the result of the suspension configuration that is carried out for each vehicle. This depends, among other things on the weight distribution of the vehicle, the engine, the vehicle characteristics and the axle kinematics.

The damping characteristic curves of the adjustable shock absorber can be modified by varying the current supplied to the adjustment valve. This creates a map.

This adjustment is made in all driving modes ("Normal", "Sport" and "Comfort").

Depending on the current driving situation, the shock absorber rates are adjusted within the specified map even when a driving mode is selected.

In "Fail Safe" mode, the adjustment valves are not powered and the shock absorbers are thus operated with a defined characteristic curve.

System description

DCC adaptive chassis control system

The adjustable shock absorbers are regulated by a control unit that adjusts the damping according to a control algorithm developed by Volkswagen. Depending on the input signals, the whole map of the adjustable shock absorbers is used. This control algorithm can also be switched from "Normal" mode to "Sport" or "Comfort" mode using the button and thus adjusted to customer requirements.

The system can be adjusted when the vehicle is stationary or travelling.

The DCC adaptive chassis control is always active. It is an intelligent automatically controlled system that adjusts the vehicle shock absorbers depending on

- the road surface,
- the respective driving situation (e.g. braking, accelerating and cornering) and
- the driver's requirement.

Thus the driver always has the ideal suspension setting.

Notes:

- The driving mode last activated is also still active after the ignition is switched OFF/ON.
- The driving mode can be switched over while the vehicle is stationary or on the road.
- The adjustment valves are not powered when the vehicle is stationary.

Selectable DCC modes

The DCC mode can be set by the driver depending on individual requirements using the button to the right of the gear lever. Press the button until you obtain the required setting. You can repeat this as often as required. The modes are always switched through in the order "Normal" — "Sport" — "Comfort".



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Normal mode

“Normal” mode is active when neither the “Comfort” nor “Sport” labels on the button are illuminated yellow.

This setting provides an overall balanced, but still dynamic driving feel.

It is well suited for everyday use.



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Sport mode

This mode is active when the “Sport” label is illuminated yellow in the button.

This setting gives the vehicle sporty handling with a harder basic configuration. The steering is also set sporty and the chassis damping is stiffer.

This setting allows a particularly sporty driving style.



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Comfort mode

This mode is active when the “Comfort” label is illuminated yellow in the button.

This setting leads to a comfort-oriented, softer basic configuration of the chassis damping.

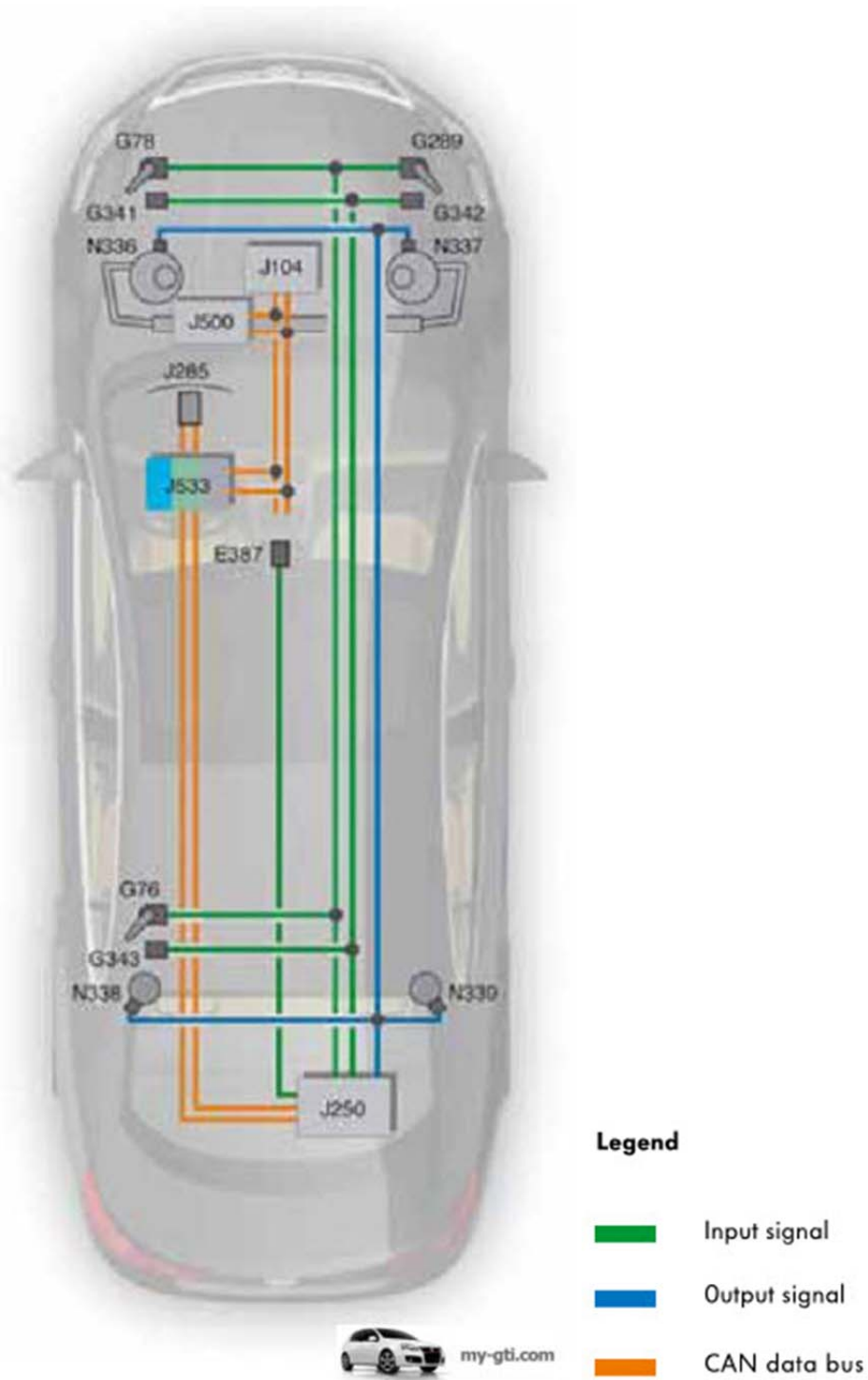
It is suitable, for example, for driving on bad roads and for long journeys.

The differences in the modes are noticeable from the varying hardness of the basic damping settings. They are superimposed by higher damping force requirements due to the driving situations.

System Description

Overview of components used in vehicle

The diagram is a simplified depiction of the components in the DCC adaptive chassis control system and their relationships (the senders each have a separate connection to the electronically controlled damping control unit J250 — they are combined for each axle in the diagram for reasons of simplicity).



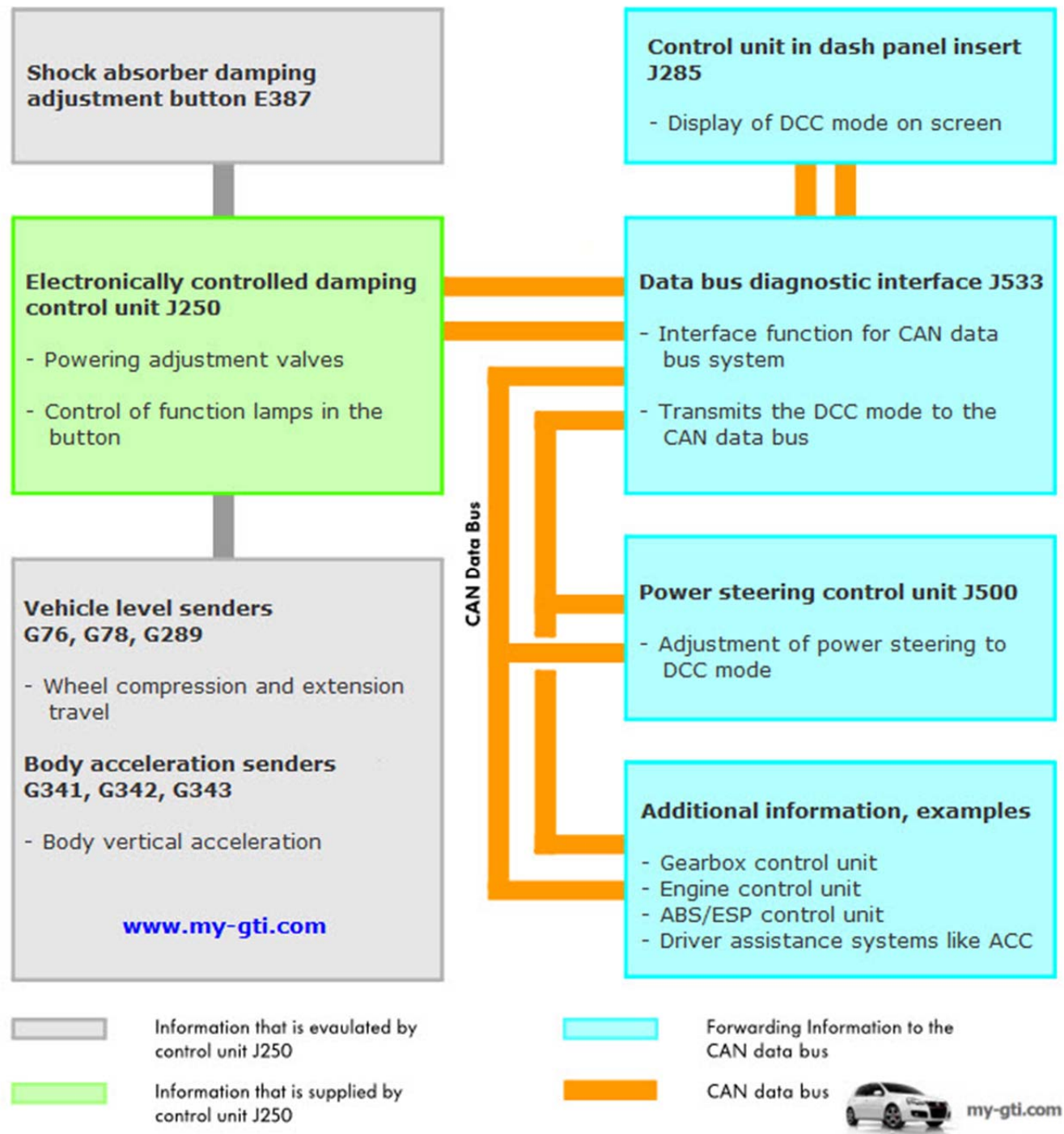
E387 Shock absorber damping adjustment button
 G76 Rear left vehicle level sender
 G78 Front left vehicle level sender
 G289 Front right vehicle level sender
 G341 Front left body acceleration sender
 G342 Front right body acceleration sender
 G343 Rear body acceleration sender
 J104 ABS control unit
 J250 Electronically controlled damping control unit
 J285 Control unit in dash panel insert
 J500 Power steering control unit
 J533 Data bus diagnostic interface

N336 Front left shock absorber damping adjustment valve
N337 Front right shock absorber damping adjustment valve
N338 Rear left shock absorber damping adjustment valve
N339 Rear right shock absorber damping adjustment valve

System link to brakes and steering

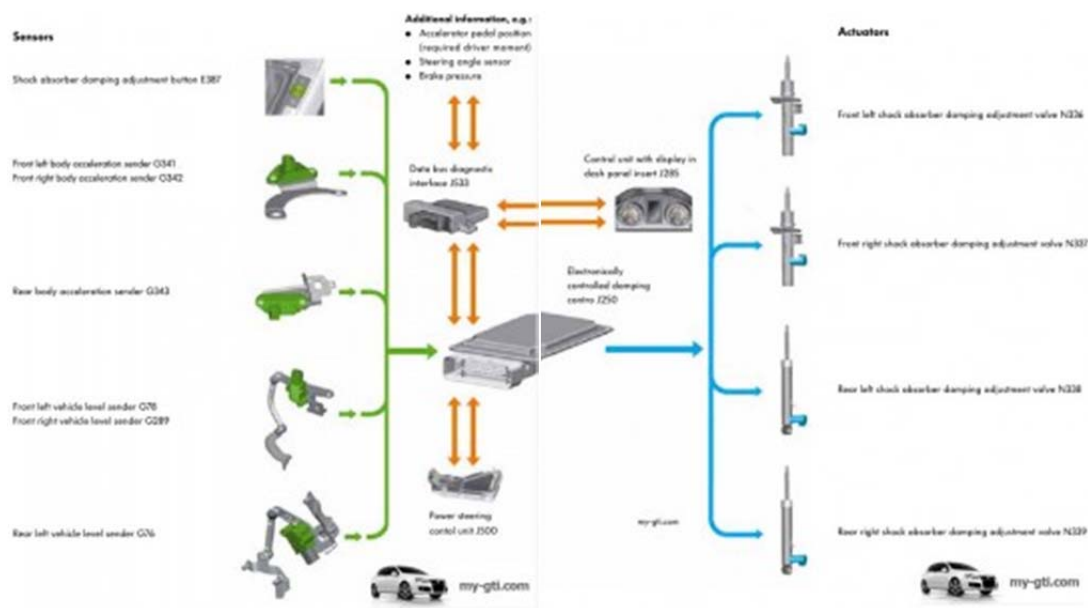
In the DCC adaptive chassis control, information is exchanged between the electronically controlled damping control unit and the associated networked control units via the CAN data bus.

The system overview shows an example of the information that is provided via the CAN data bus or is received and used by the networked control units.



System description

System overview



Function

Shock absorber for DCC adaptive chassis control

Twin-tube shock absorbers are used for the DCC adaptive chassis control. An electrically controlled adjustment valve mounted on the outside of the shock absorber regulates the damping force.

By varying the current, the damping force of the active shock absorber setting can be adjusted within a few milliseconds by the adjustment valve.

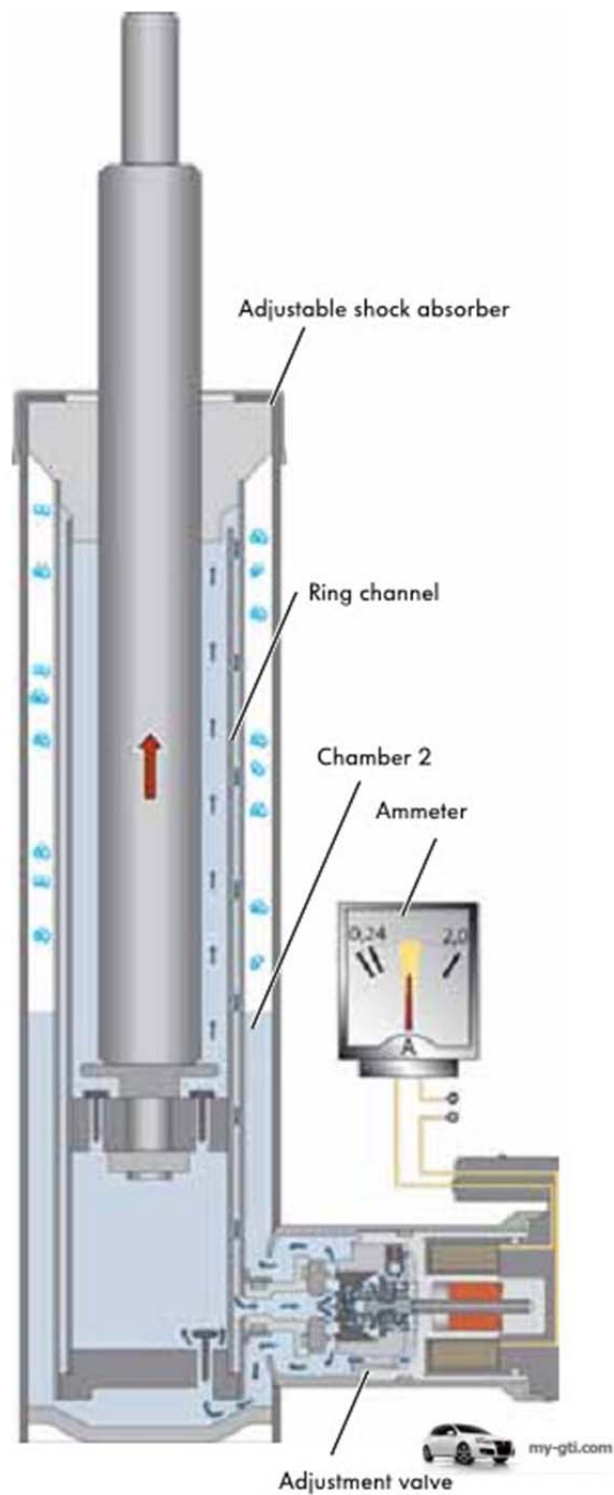
The 3 vehicle level senders provide signals that are required to calculate the necessary shock absorber setting together with the signals from the 3 body acceleration senders. The maps for the respective shock absorber setting are stored in the electronically controlled damping control unit J250.

In the diagram, the ammeter is shown simply to help explain the current supplied to the adjustment valve (ammeter in "Normal" mode).

A fixed current is not used to control the system within the "Normal", "Sport" and "Comfort" modes, instead a range of values are used (see yellow-coloured area in ammeter).

The following diagrams for the possible adjustment valve modes simply show the centre position of the ammeter needle within the yellow-coloured area.

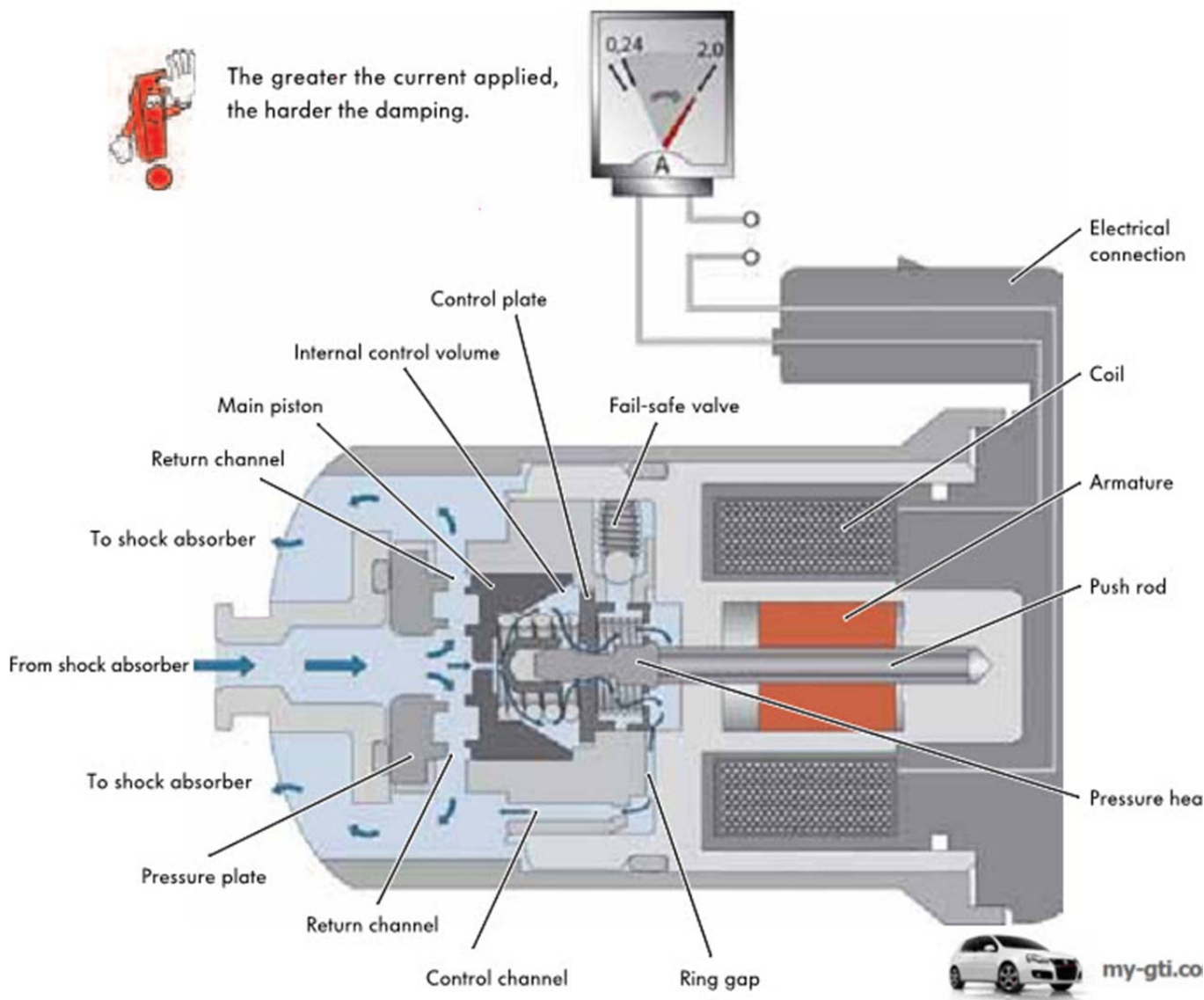
Shock absorber shown during extension cycle



Adjustment valve

The adjustment valve is mounted on the side of the shock absorber so that oil from the shock absorber ring channel flows to the valve. The oil supplied from the adjustment valve is sent to chamber 2 of the shock absorber.

The valve is adjusted by applying a current to the coil (0.24 A to max. 2.0 A) and the resulting changes inside the adjustment valve. Depending on the control position of the adjustment valve, the oil flowing from the shock absorber moves the main slider to a corresponding horizontal position so that a specific amount of oil can flow back to the shock absorber through the return channel. The main slider position is achieved by setting a differential pressure (compared with the pressure of the oil flowing from the shock absorber) in the inner control volume. The differential pressure is set by pre-tensioning the gap cross-section between the pressure head and control plate. If the pre-tension becomes greater, for example, the amount of oil flowing away centrally through the main slider and further through the ring gap and control channel is reduced, the pressure increases in the inner control volume and the main piston can only be moved slightly to the right. This changes the damping behaviour towards "hard". If the pre-tension becomes smaller, the system behaves in the opposite way. The damping behaviour is changed towards "soft"



Function

Adjustment valve in "Normal" mode

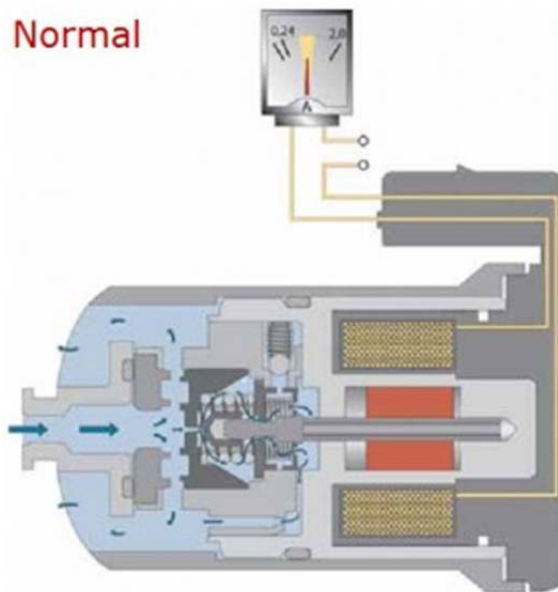
In "Normal" mode, a current in a middle range between 0.24 A and 2.0 A is supplied to the coil. The armature is moved together with the push rod and pressure head and is pre-tensioned slightly.

The oil flowing from the shock absorber presses the main piston to a horizontal centre position so that a medium quantity of oil can leave again via the return channel and be fed back to the shock absorber.

This is achieved by setting a medium pre-tension between the pressure head and control plate.

The differential pressure is also set accordingly in the internal control volume and the position of the main piston is set in a horizontal middle position.

The damping behaviour is thus between "soft" and "hard".



Adjustment valve in "hard"

In "hard", the coil is powered in a range up to a max. of 2.0 A. The armature is pressed to the left together with the push rod and pressure head with maximum pre-tensioning to the left.

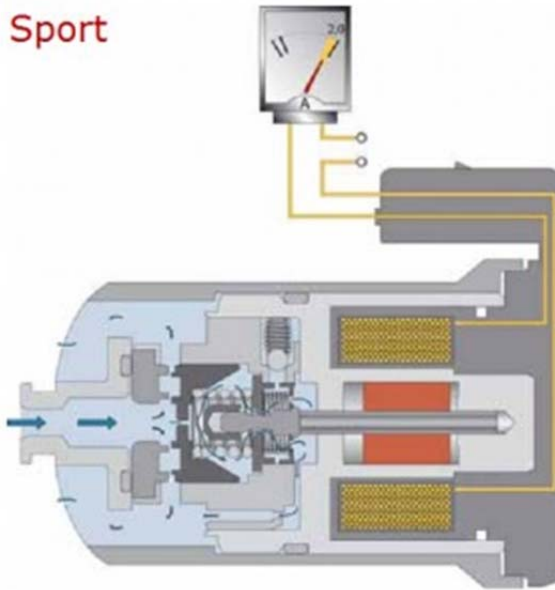
As a result, there are smaller gap cross-sections between the control plate and pressure head compared with "Normal" mode.

The differential pressure in the internal control volume increases and the main piston sets itself in its horizontal position so that a lower oil quantity flows back via the return channel to the shock absorber than in "Normal" mode.

This changes the damping behaviour towards "hard".

This is a typical state of the adjustment valve for a considerably dynamic maneuver.

Sport



Adjustment valve in "soft"

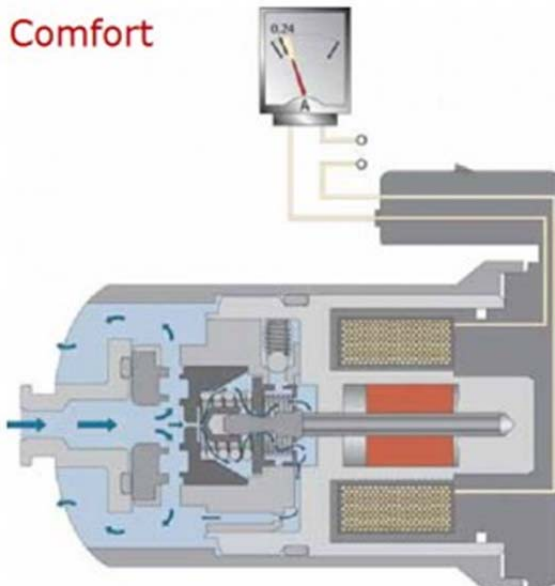
In "soft", the magnet is powered with 0.24 A, for example, and has less pre-tensioning together with the push rod and pressure head. The pressure head moves the control piston to the left by the same amount and releases the ring gap only in a slightly reduced cross-section. The oil flows via this gap and the subsequent control channel back to the shock absorber.

The gap cross-section between the control plate and pressure head increases with this slightly lower pre-tensioning of the pressure head. The differential pressure in the internal control volume drops. The main piston thus sets itself in its horizontal position so that a greater amount of oil flows back via the return channel than in "hard".

This changes the damping behaviour towards "soft".

This is a typical state of the adjustment valve for a considerably dynamic manoeuvre.

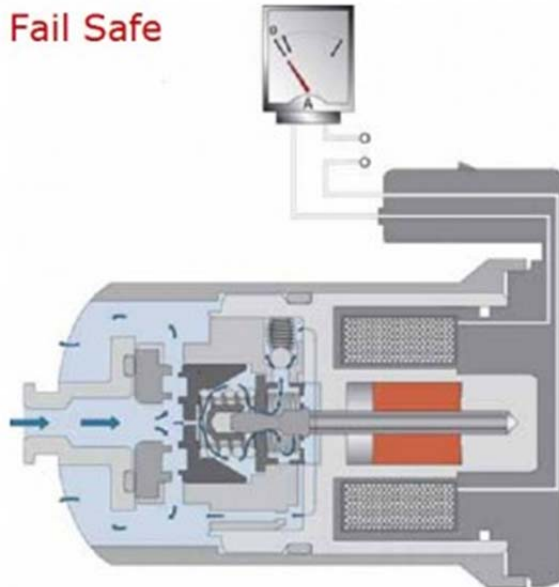
Comfort



Adjustment valve in "Fail Safe"

If a shock absorber, at least two sensors or the electronically controlled damping control unit J250 fail, "Fail Safe" mode is set.

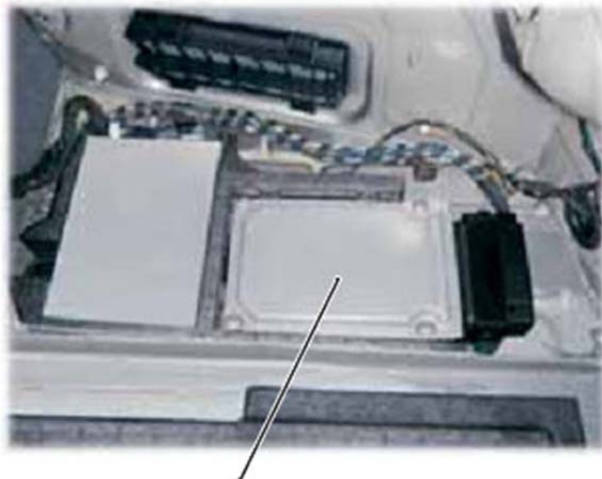
In "Fail Safe" mode, the shock absorbers are not powered and the vehicle behaves as if fitted with conventional shock absorbers. The armature moves together with the push rod and pressure head to the right until it rests against the valve housing. The control piston also moves and closes the direct access to the ring gap. The oil now opens the fail-safe valve and flows via the control channel to the shock absorber.



Electrics

Electronically controlled damping unit J250

The control unit J250 is in the boot on the right-hand side behind the panelling (Passat CC).



Electronically controlled
damping control unit J250



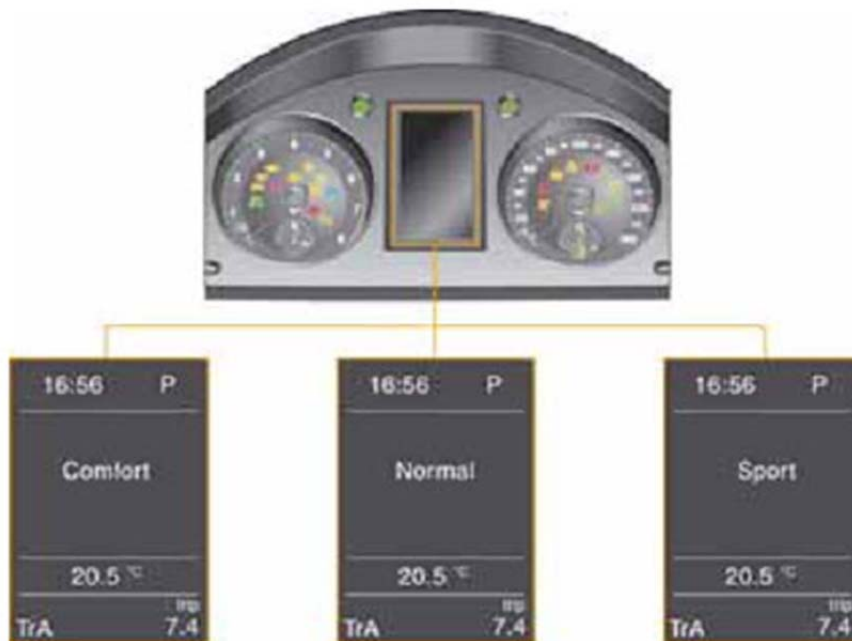
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It evaluates the signals from the vehicle level senders G76, G78, G289 and the body acceleration sender G341, G342, G343 and constantly calculates the respective optimum

current for the four shock absorbers taking the road, driving situation and driver requirement into consideration.
It adjusts the shock absorbers within milliseconds using a controlled current (approx. 0.24 A ... 2.0 A).

Indications in dash panel insert

The suspension setting that the driver selects manually using the shock absorber damping adjustment button E387 is displayed in the dash panel insert.
The setting/display last selected is available when the vehicle is started.



Volkswagen level senders G76, G78, G289

The vehicle level senders are so-called turn angle sensors.

They are all fitted near to the shock absorbers and are connected to the traverse links via coupling rods.

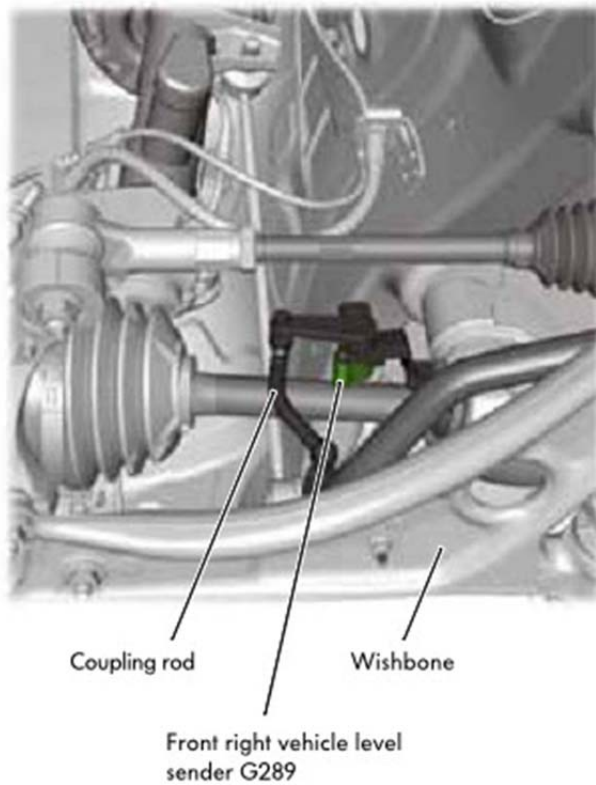
The wheel spring travel is forwarded to the sensors from the movement of the traverse links on the front and rear axle and on the coupling rods and converted into an angle of rotation.

The turn angle sensor used works with static magnetic fields and uses the Hall principle.

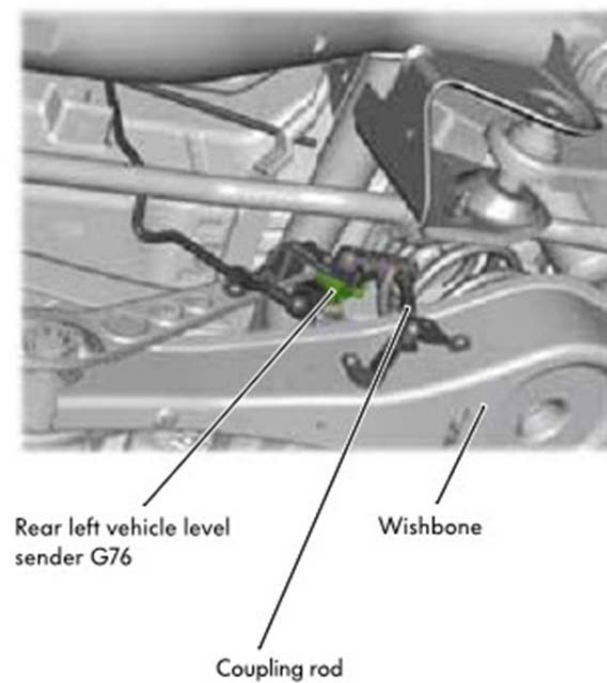
The signal output supplies a PWM signal (pulse-width modulated signal) proportional to the angle for shock absorber control.

The three level sensors are identical; only the mountings, the coupling rods and kinematics to the sides and axles.

Vehicle level sender - front axle (right)



Vehicle level sender - rear axle (left)



Electrics Design

The sender is set up in a two-chamber system.

On one side (1st chamber), there is the rotor and, on the opposite side, (2nd chamber) the circuit board with stator.

The rotor and stator are each fitted so they are sealed.

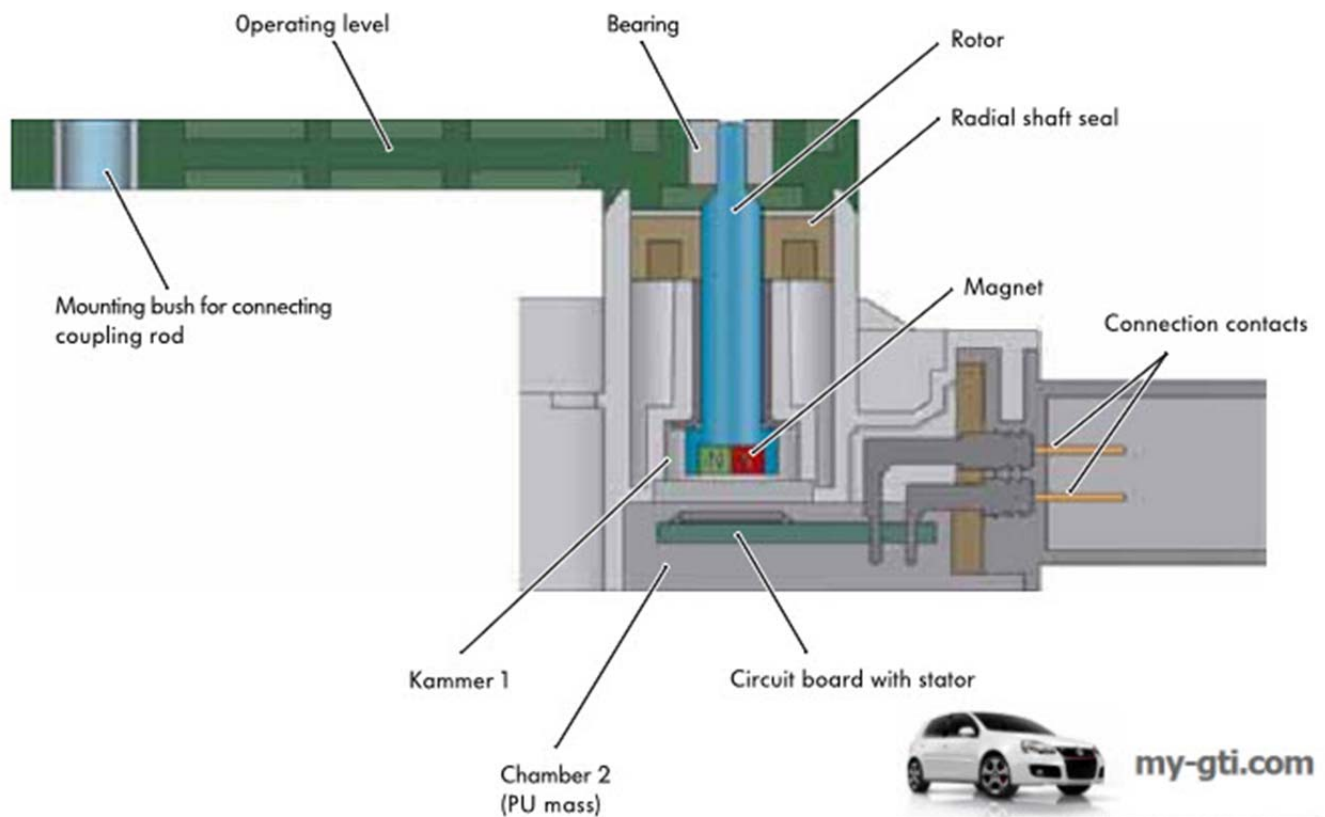
The rotor consists of a non-magnetised stainless steel shaft in which a rare-earth magnet is glued. Rare-earth magnets are used where high magnetic field strengths in conjunction with the smallest possible dimensions are needed.

The rotor is connected to the coupling rod by the operating lever and is also driven by it.

The rotor is mounted in a radial shaft seal in the operating lever. This protects the construction from the elements.

The stator consists of a Hall sensor that is located on a circuit board.

The circuit board is moulded in a PU mass (PU = polyurethane) and is thus also protected against external influences.

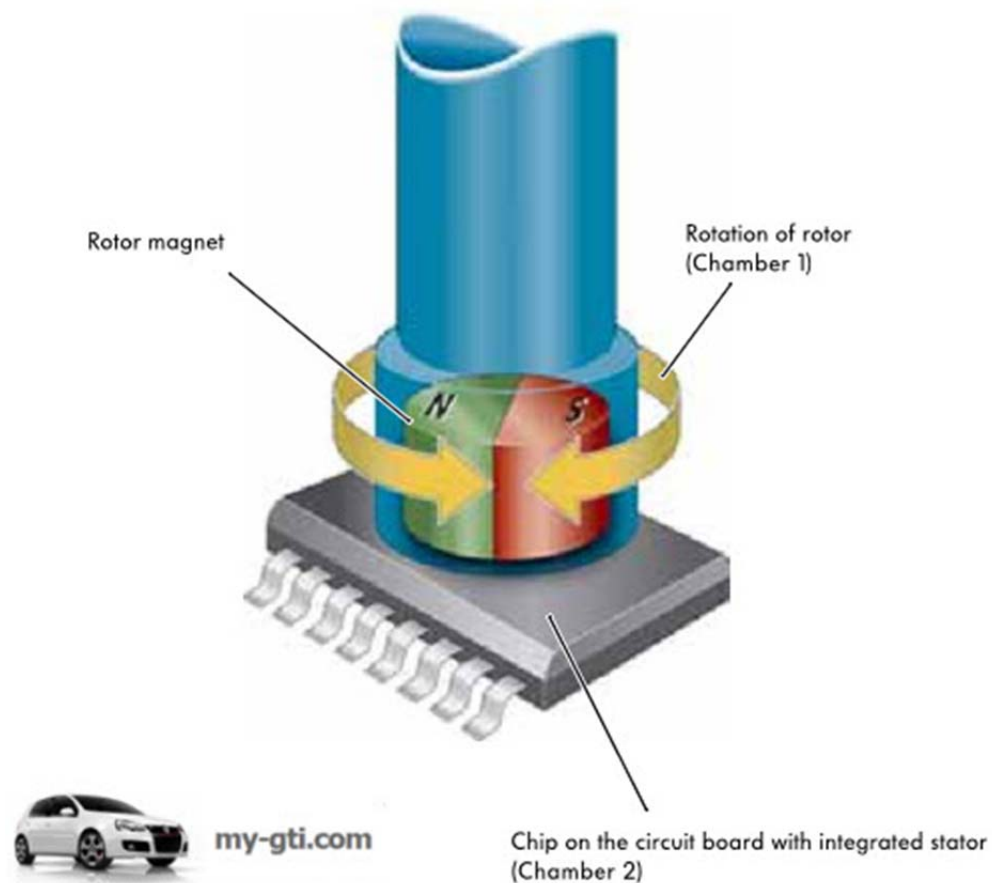


Function

The magnetic flow is transferred and amplified using the Hall plates.

Unlike conventional Hall senders, these elements deliver special sine and cosine signals.

In the chip on the circuit board, the signals are converted so that the level changes of the body are recognisable for the electronically controlled damping control unit J250.



Electrics

Body acceleration senders G341, G342, G343

The body acceleration senders measure the vertical acceleration of the body.

Body acceleration sender - front axle



Front left body acceleration sender G341

The front left body acceleration sender G341 and front right body acceleration sender G342 are mounted on the body at the top next to the shock absorbers.

Body acceleration sender - rear axle



The rear body acceleration sender G343 is mounted at the top next to the left-hand rear shock absorber.

Design and function

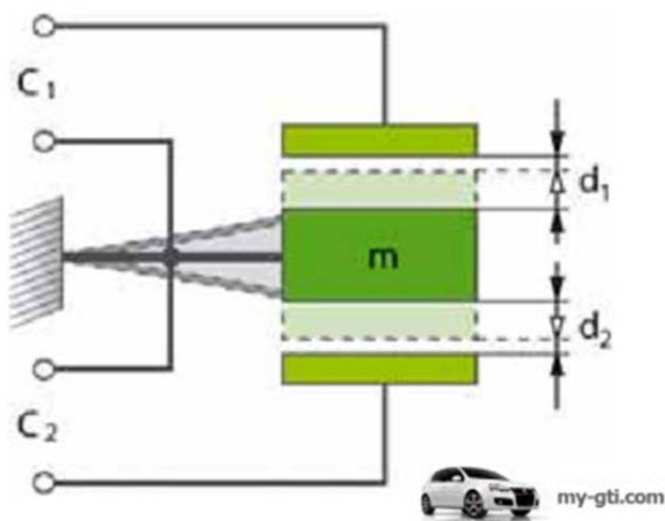
The body acceleration senders work according to the capacitive measuring principle.

An elastic mass m oscillates between capacitor plates as a middle electrode that pulls the capacities of capacitors C_1 and C_2 opposite the rhythm of their oscillation.

The plate spacing d_1 of one capacitor is increased by the amount that spacing d_2 in the other capacitor is reduced.

This changes the capacities of the individual capacitors.

Capacitive measuring principle of the acceleration senders



An electronic evaluation system delivers an analogue signal voltage to the electronically controlled damper control unit J250.

Sender measuring range

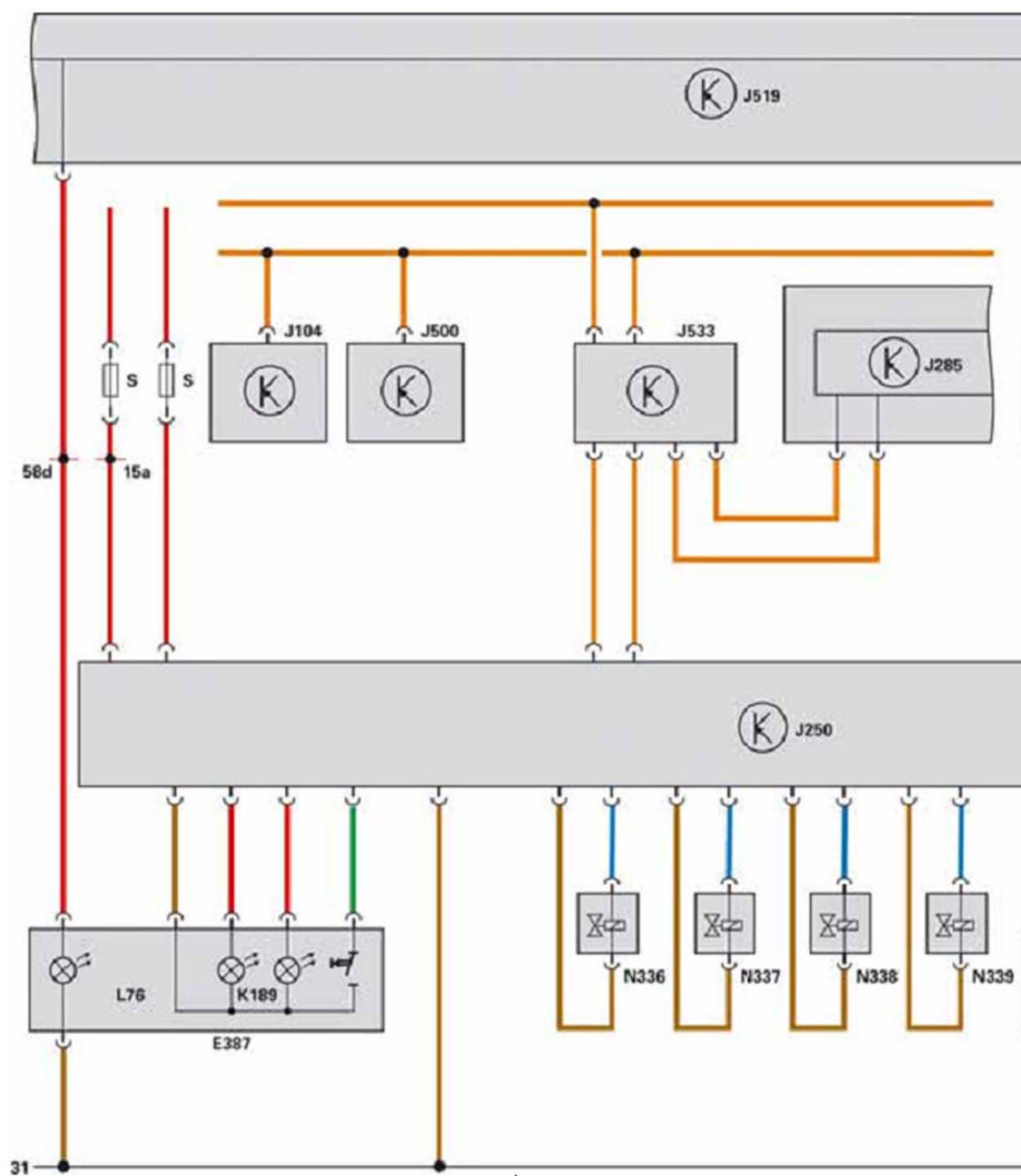
The measuring range of the sender is + or – 1.6g.


g = measurement for the acceleration

1g = 9.81 m/sec²

Electrics

Functional diagram



 Input signal

 Output signal

 Positive

 Earth

 CAN data bus

E387 Shock absorber damping adjustment button

G76 Rear left vehicle level sender

G78 Front left vehicle level sender

G289 Front right vehicle level sender

G341 Front left body acceleration sender

G342 Front right body acceleration sender

G343 Rear body acceleration sender

J104 ABS control unit

J250 Electronically controlled damping control unit

J285 Control unit in dash panel insert

J500 Power steering control unit

J519 Onboard supply control unit

J533 Data bus diagnostic interface

K189 Shock absorber damping adjustment warning lamp

L76 Button illumination bulb

N336 Front left shock absorber damping adjustment valve

N337 Front right shock absorber damping adjustment valve

N338 Rear left shock absorber damping adjustment valve

N339 Rear right shock absorber damping adjustment valve