

# Participant's Manual

## Chassis control systems



The information contained in this Participant's Manual is intended solely for the participants of this seminar run by BMW Aftersales Training.

Refer to the latest relevant "BMW Service" information for any changes/supplements to the Technical Data.

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# **Participant's Manual**

## **Chassis control systems**

**Steering systems**

**Longitudinal dynamics**

**Transverse dynamics**

**Ride-height control systems**

**Damper systems**


**Tyre inflation pressures**



## Notes concerning this Participant's Manual

### Symbols used

The following symbols are used in this Participant's Manual for clearer understanding and to emphasize important information:

 Contains information that provides clearer understanding in relation to the systems described and their operation.

◀ Indicates the end of a note item.

### Editorial status of the Participant's Manual

There may be deviations between this Participant's Manual and the vehicles available in training courses due to ongoing developments in design and the equipment of BMW vehicles.

Only left-hand-drive vehicles were documented at the time of publication. The arrangement of some of the operating and control elements on right-hand-drive vehicles may differ from the arrangement shown in the illustrations of this Participant's Manual.

### Additional sources of information

You find further information about individual vehicle topics in the BMW diagnostics and repair systems or on the Internet at [www.bmw.com](http://www.bmw.com).

# Contents

## Steering systems history

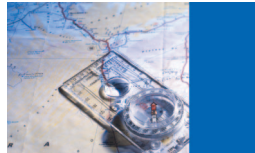


### Objectives

Useful information for the reader

1

1



### Introduction

History/steering

3

3



# Objectives

## General information on steering systems

### Useful information for the reader

Steering systems at BMW - this is a field which is becoming increasingly complex. To maintain an overview and to be able to deal with these systems confidently, support and assistance is provided on the following pages. You will be able to familiarize yourself with the most important steering systems at BMW Group and also find out how they are put together and how they work.

Afterwards, you will understand their construction and interaction, which will mean that you will be equipped with all the knowledge you need for successful troubleshooting of steering system faults.

This understanding will enable you to base your approach on the codes of engineering practice when working on modern BMW vehicles.





# Introduction

## General information on steering systems

### History/steering

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A steering system must be able to convert a turning motion input by the driver at the steering wheel into a change of steering angle at the steered wheels on the vehicle. This is the essential requirement of a steering system irrespective of whether it is a simple, conventional steering system or the latest modern BMW Group steering system.

Steering systems must have the following characteristics:

- The construction of the steering gearbox in each case must enable the vehicle to respond to the slightest steering adjustments.
- When the steering wheel is released, the wheels must return to the centre position (straight-ahead travel).
- The steering kinematics must follow the Ackermann rule, i.e. when the left and right wheels are locked over, the extension of the wheel axes must intersect the extension of the rear axle.
- The steering system must compensate for unevenness in the road whilst ensuring that the driver remains in control.
- To achieve the best possible handling, the steering system must have a low transmission ratio, i.e. number of steering-wheel turns from lock to lock.

On the whole, two types of steering meet these requirements - rack-and-pinion steering and recirculating-ball steering.

#### **Rack-and-pinion steering:**

Rack-and-pinion steering essentially consists of a pinion and toothed rack. The transmission ratio is determined by the ratio between the number of pinion revolutions (steering wheel turn) and the rack travel. The transmission ratio varies with the rack travel and corresponding gearing of the rack. Steering corrections and operating forces are dealt with by this system.


#### **Recirculating-ball steering:**

A low friction endless row of balls transmits forces between the steering worm and steering nut. The steering nut exerts a force on the steering shaft via gear teeth. A variable ratio is also possible with this steering gear.

An extensive and wide-ranging development history lies behind the modern steering systems used nowadays incorporating power steering assistance.



1 - View of steering system



However, this development has given rise to conflicting objectives. Greater assistance is required during parking whereas less assistance is required at high road speeds as high servo assistance in the latter situation would lead to a loss of desirable road surface contact. This conflict has been resolved by power steering systems with speed-dependent control. The servo assistance decreases as the driving speed increases. In this way, the steering conveys the familiar good contact between the road and wheel.

An additional step also changes the transmission ratio. A decisive milestone here was also the introduction by BMW of a dynamic steering system, which represented a new level in driving comfort, pleasure and safety. This new global optional product is known as active steering. BMW technicians call this system AL. The abbreviation AL stands for active steering.

If a vehicle begins to lose grip on the road surface, the DSC attempts to restore driving stability by braking wheels individually. However, it might in fact be more logical to counter these kind of situations through steering system intervention. Active Steering has made this and other things possible. The variable steering gear transmission ratio has made driving on winding roads an enjoyable experience and saves the driver unnecessary work at the wheel.

Another clear advantage of active steering is evident when observing the number of steering wheel turns required when parking. Considerably less steering effort is required in this situation compared to vehicles without active steering.

# Contents

## Active steering

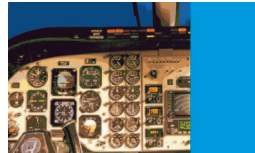


### Introduction

1

Advantages of active steering

1



### System overview

3

Mechanical system overview

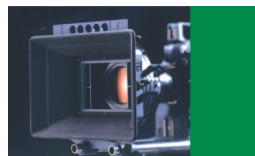
3

Inputs/outputs on the E60 as an example

4

Bus overview using the E60 as an example

6



### Functions

9

Motor position sensor of the actuating unit

9

Cumulative steering angle sensor

10

Steering angle sensor

11

Active Steering control unit

12

Safety and gateway module (SGM)

13

Hydraulic pump

14

Power steering cooler

16

Active Steering actuating unit

17

System safety

25



### System components

27

System circuit diagram using the E60 as an example

27



### Service information

29

Service information

29



# Introduction

## Active steering

### Advantages of active steering

The dynamic steering system known as active steering is now being used at BMW for the first time since the E60. In addition to the power assisted torque provided by the power steering, the electronically-controlled steering system also employs a variable steering gear transmission ratio to assist the driver. During this process and depending on the vehicle speed, an electric motor uses a worm drive to intervene in a planetary gearbox with override function. This means that, depending on the driving situation, the steering system generates an additional/reduced steering angle for the front wheels by changing the transmission ratio of the steering shaft pinion. In critical situations, the steering system can selectively change the steering lock when the wheels are turned by the driver thus stabilizing the vehicle more quickly than the driver could. The active steering is networked with the DSC driving stability program and can intervene and correct the steering angle via a yaw rate control at the first sign of instability. This means that active steering reduces DSC interventions in the lower response range thus providing optimum control comfort.

Active steering offers optimum **agility, convenience and active driving safety.**

#### Increased agility

Due to the direct transmission ratio, the vehicle is perceived as having a greater agility and handling performance up into the medium driving speed range (approximately 100 km/h). The driver also has far greater control when swerving, for example - this combined with considerably enhanced steering precision and reduced steering effort. Direct contact with the road via the steering wheel is maintained throughout.

#### Increased convenience

Some BMW models require more than 3 full steering-wheel turns to achieve a full wheel lock from the far left over to far right. Active Steering reduces this at low speeds to less than 2 steering-wheel turns from lock to lock. The benefit: less steering effort is required when turning in city traffic or manoeuvring in narrow parking spaces. On twisting roads in mountainous regions, for example, the reduced steering angle also ensures that hands always remain in the optimum position on the steering wheel, which means that crossing of hands, or even arms in some cases, is no longer necessary. The multifunction buttons on the steering wheel or the gearshift paddles for the SMG sequential manual transmission therefore always remain conveniently within reach in all road situations.

#### Increased active driving safety

The situation at high speeds is somewhat different:

A more indirect transmission ratio during high-speed journeys moderates driving errors as well as sudden steering wheel movements arising from fright reactions. Active steering stabilizes yaw (turning motion of the vehicle about its vertical axis) at the outset. Yaw motion occurs for example when changing lane, when swerving or when a load change occurs during cornering. Active steering intervenes electronically at all speeds without the driver being aware of this. The electronic stability program - dynamic stability control (DSC) - therefore does not need to intervene as frequently or as powerfully.



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## Characteristics of active steering

At high speeds, the steering gear transmission ratio becomes increasingly indirect, reaching, and even extending beyond the level of conventional steering systems. The corresponding increase in steering-wheel torque level prevents undesirable steering wheel movements and therefore supports driving stability.

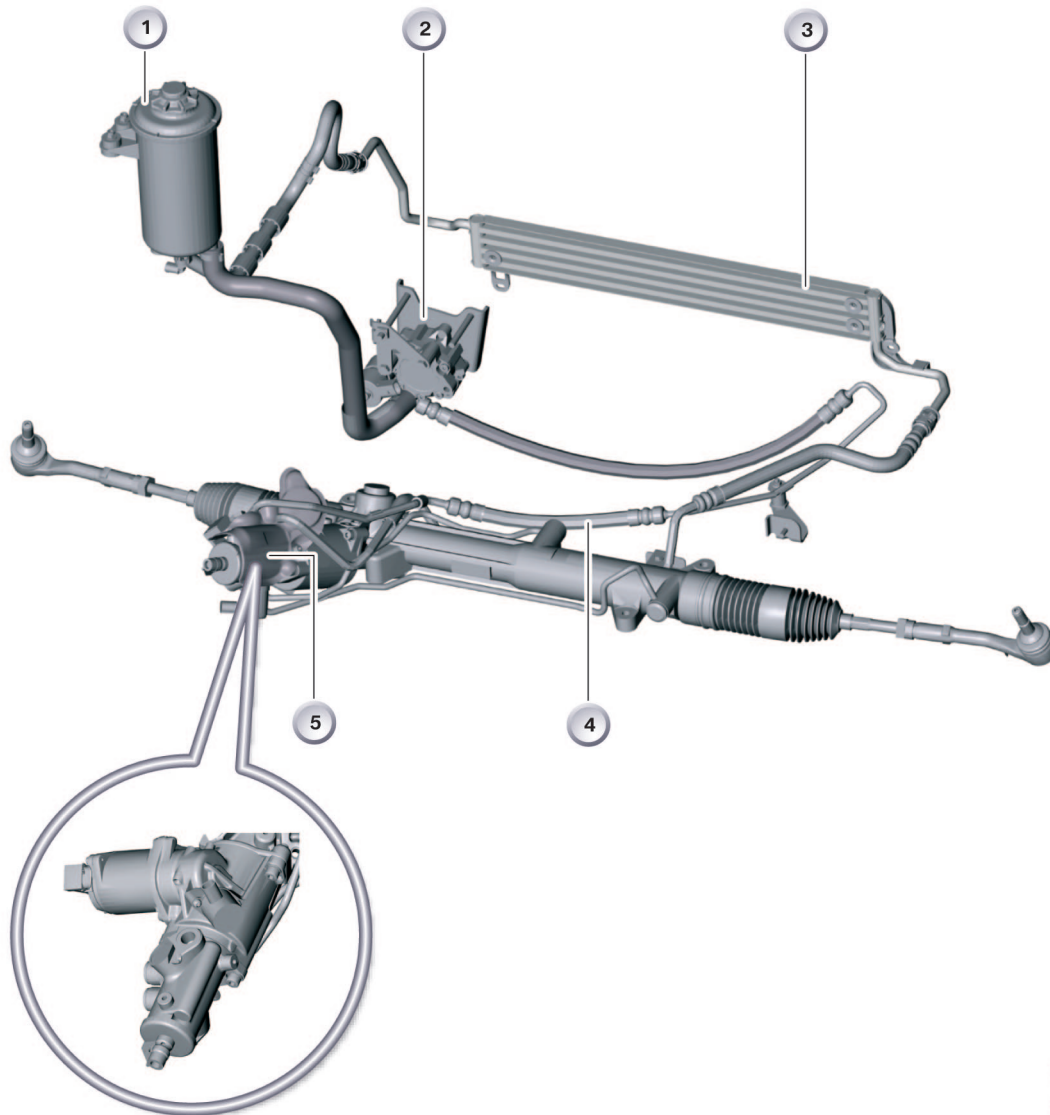
Undesirable vehicle movements, e.g. oversteering, are compensated for without requiring corrective intervention on the part of the driver.

When parking, only small steering wheel movements are required to achieve a large wheel lock: less than 2 revolutions from steering wheel lock to lock.

# System overview

## Active steering

### Mechanical system overview

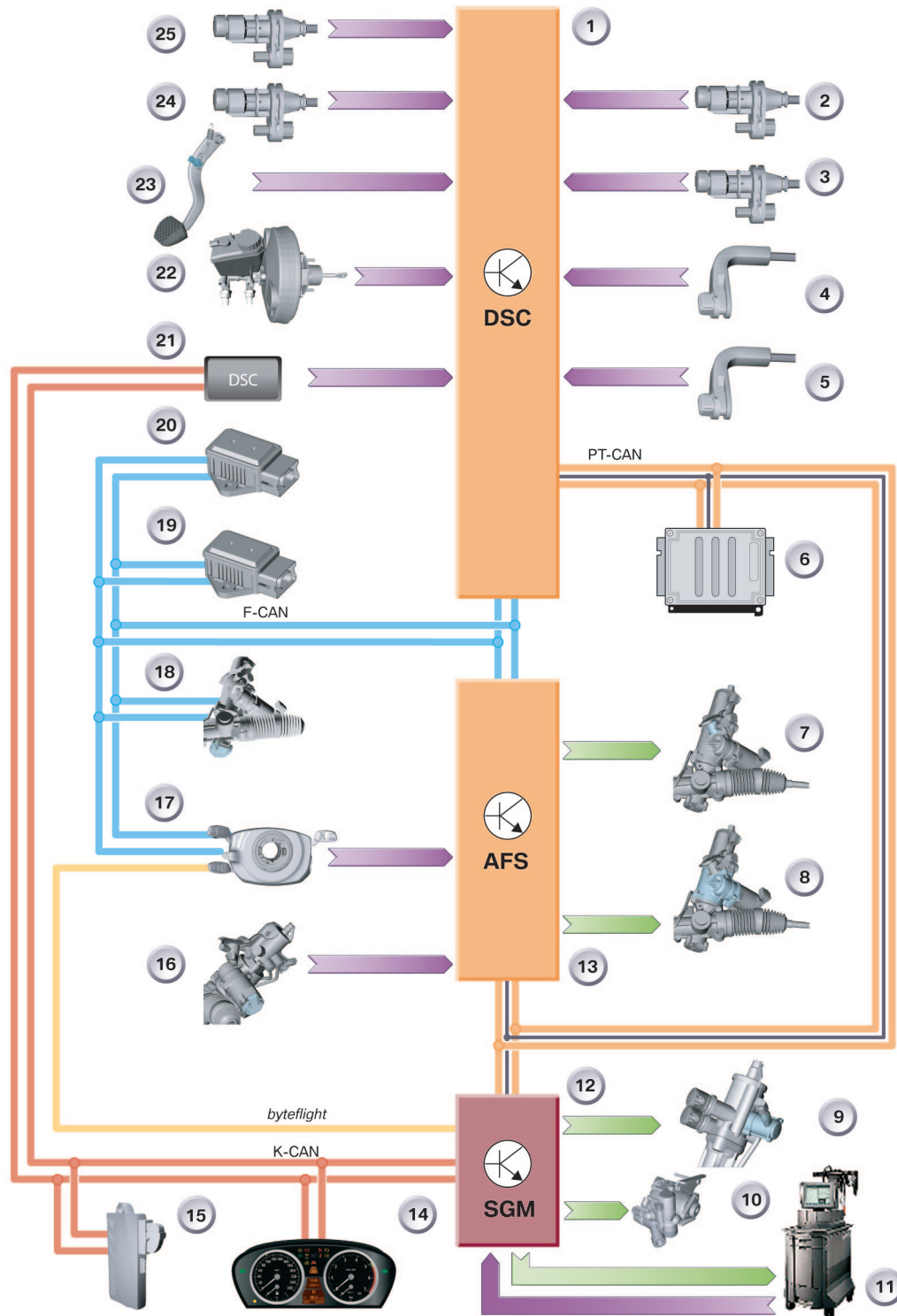


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1 - System overview

Index	Explanation	Index	Explanation
1	Hydraulic oil reservoir	4	Hydraulic hose
2	Hydraulic pump with ECO valve	5	Steering gear with actuating unit
3	Power steering cooler for the hydraulic fluid		

## Inputs/outputs on the E60 as an example



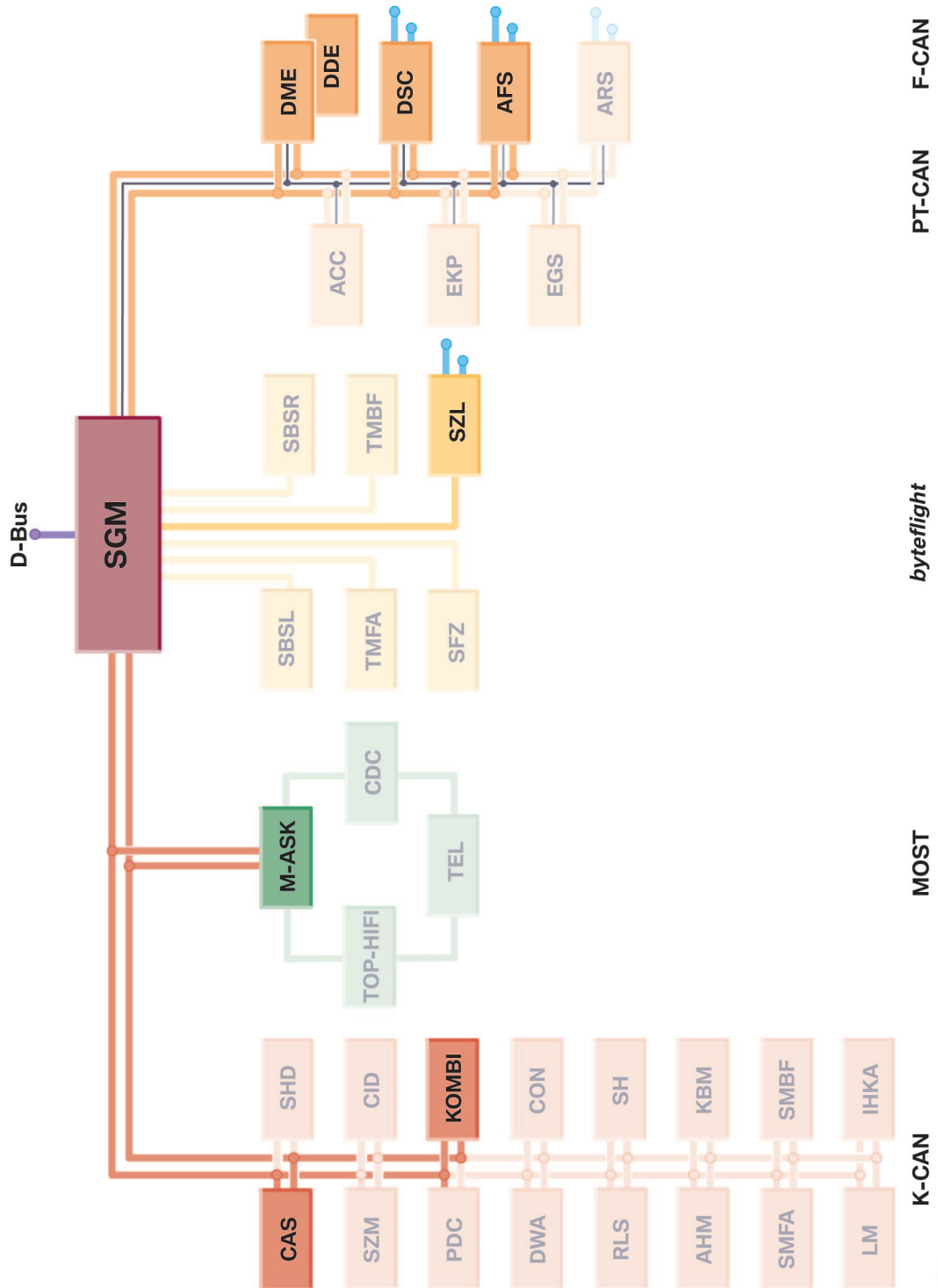
2 - Input/Output

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<b>Index</b>	<b>Explanation</b>	<b>Index</b>	<b>Explanation</b>
1	Dynamic stability control DSC	16	Motor position sensor
2	Wheel speed sensor, front right	17	Steering angle sensor
3	Wheel speed sensor, rear right	18	Cumulative steering angle sensor
4	Brake pad wear sensor, front left	19	DSC sensor 2
5	Brake pad wear sensor, rear right	20	DSC sensor
6	Digital motor electronics DME (or digital diesel electronics DDE)	21	DSC button in the centre console switch cluster SZM
7	Electromagnetic lock	22	Brake-fluid level switch
8	Actuator motor at the superimposed gear unit	23	Brake light switch
9	Servotronic valve	24	Wheel speed sensor, rear left
10	Power steering pump with ECO valve	25	Wheel speed sensor, front left
11	BMW diagnostic system	<b>bytelight bytelight</b>	
12	Safety and gateway module SGM	F-CAN	Chassis CAN
13	Active steering control unit	K-CAN	Body CAN
14	Instrument cluster	PT-CAN	Powertrain CAN
15	Car access system CAS		

## Bus overview using the E60 as an example



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<b>Index</b>	<b>Explanation</b>	<b>Index</b>	<b>Explanation</b>
CAS	Car access system	CDC	Telephone
SZM	Centre console switch cluster	CDC	CD changer
PDC	Park distance control	SGM	Safety and gateway module
DWA	Anti-theft alarm system	SBSL	B-pillar satellite, left
RLS	Rain/driving lights sensor	TMFA	Door module, driver
AHM	Trailer module	SFZ	Vehicle centre satellite
SMFA	Driver's seat module	SZL	Steering column switch cluster
LM	Light module	TMBF	Door module, passenger
IHKA	Integrated automatic heating/air conditioning	SBSR	B-pillar satellite, right
SMBF	Passenger's seat module	ACC	Active cruise control
KBM	Body basic module	EKP	Electric fuel pump
SH	Auxiliary heating	DSC	Dynamic stability control
CDN	Controller	EGS	Electronic transmission control unit
Kombi	Instrument cluster	ARS	DynamicDrive
CID	Central information display	AFS (AL)	Active steering
SHD	Slide/tilt sunroof	DME	Digital engine electronics
M-ASK	Multi-audio system controller	DDE	Digital diesel electronics
Top-HiFi	Top HiFi amplifier		

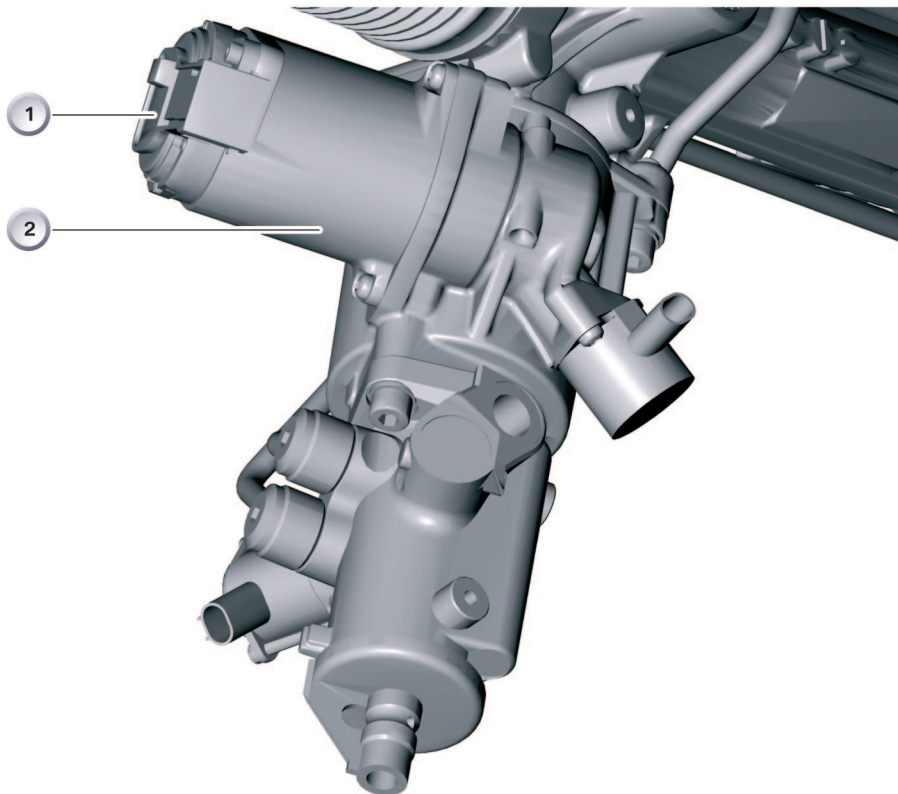


# Functions

## Active steering

### Motor position sensor of the actuating unit

The motor position sensor of the actuating unit of the active steering actuating unit is located on the rear of the electric motor



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1 - Motor position sensor

Index	Explanation	Index	Explanation
1	Motor position sensor	2	Electric motor

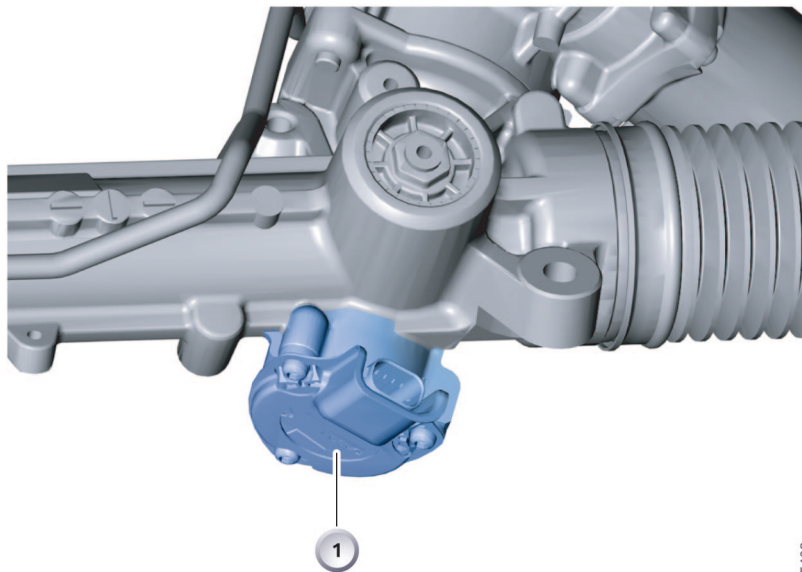
## Cumulative steering angle sensor

The vehicle is only equipped with a cumulative steering angle sensor if it is also equipped with active steering.

The cumulative steering angle sensor detects the angle of rotation of the steering pinion and thus the steering angle of the vehicle.

The cumulative steering angle sensor is mounted on the actuating unit of the active steering and cannot be replaced individually.

The cumulative steering angle sensor operates in accordance with the magneto-resistive principle.



TF04-5408

2 - Steering angle sensor installation location

Index	Explanation
1	Cumulative steering angle sensor

## Steering angle sensor

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The steering angle message is forwarded to the active steering control unit by the steering column switch cluster SZL.

There is a second processor in the SZL for the redundant steering angle calculation. The second processor is only fitted if the vehicle is equipped with active steering. The second processor is used for plausibility monitoring of the signal.

The steering angle sensor is located in the steering column switch cluster.



## Active Steering control unit

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The active steering control unit is located in the right-hand footwell. The control unit is bolted to the floor of vehicle.

The active steering control unit is housed to prevent damage caused by the feet of vehicle occupants.

The control unit is integrated into the vehicle electrical system by the PT-CAN and the F-CAN.

The active steering control unit uses various input signals to calculate the signals for controlling the active steering actuating unit.

The active steering control unit is initialized after the ignition is switched on. The active

steering actuating unit cannot be operated during initialization. The sensor signals are checked and calibrated if necessary. If errors are detected, either the "Error" fault status is activated immediately or the yaw rate control is deactivated. The actuating unit cannot be operated when the "Error" fault status is active. If initialization is successful, the "Drive" status is activated.

The active steering control unit sends the information about the required volumetric flow of the power steering pump to the SGM.



## Safety and gateway module (SGM)

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The SGM comprises the junction of the same central gateway module (ZGM) used on the E65 and the safety and information module (SIM).

In the SGM housing, there are 2 separate motherboards linked by CAN connection.

The output stages for controlling the Servotronic valves and the ECO are integrated in the SGM.

The SGM is located in the equipment carrier behind the glove compartment.

The SGM receives the volumetric flow information for controlling the Servotronic valve and the ECO from the active steering control unit. The signal from the SGM for

controlling the Servotronic valve and the ECO is pulse-width modulated.

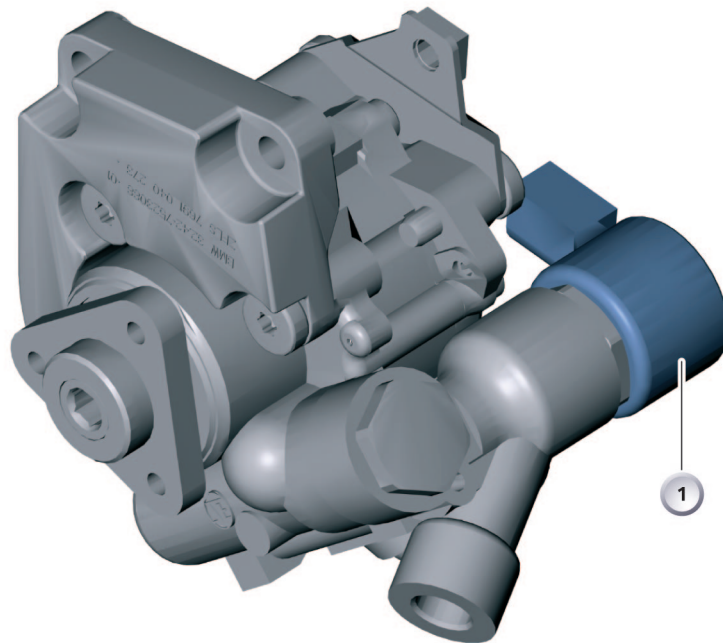
The software for controlling the Servotronic valve and the ECO is installed in the SGM on vehicles with active steering. The active steering control unit sends the information required for controlling the Servotronic valve and the ECO to the SGM. The information is sent via the PT-CAN.

The software for controlling the Servotronic valve is installed in the SGM on vehicles with active steering. No ECO valve is installed in vehicles without active steering.

## Hydraulic pump

The hydraulic pump is a vane-type pump and has an electrically regulated valve for regulating the volumetric flow of the hydraulic

fluid. The name of this valve is electrically controlled orifice (ECO).



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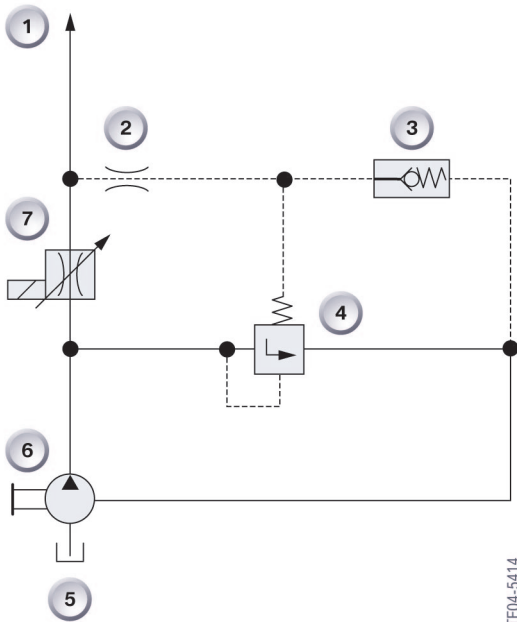
3 - Hydraulic pump

Index	Explanation
1	Electrical controlled orifice (ECO)

The active steering system is able to generate greater angular velocities of wheels by comparison with conventional power-assisted rack and pinion steering. A correspondingly high level of hydraulic power must be maintained in the hydraulic system for these high angular velocities. An adequately dimensioned, conventional vane pump would generate a high loss of power. Fuel consumption would be increased

unnecessarily. A better solution would be achieved using a controllable hydraulic pump.

The hydraulic pump with the ECO controls the volumetric flow corresponding to requirements. At the same time, the hydraulic pump reduces the ram pressure in the steering system.



4 - ECO valve hydraulic circuit diagram

TF04-5414

Index	Explanation
1	Power-assisted rack and pinion steering
2	Damping orifice
3	Pressure limiting valve
4	Pressure regulating valve
5	Hydraulic reservoir
6	Hydraulic pump
7	ECO valve

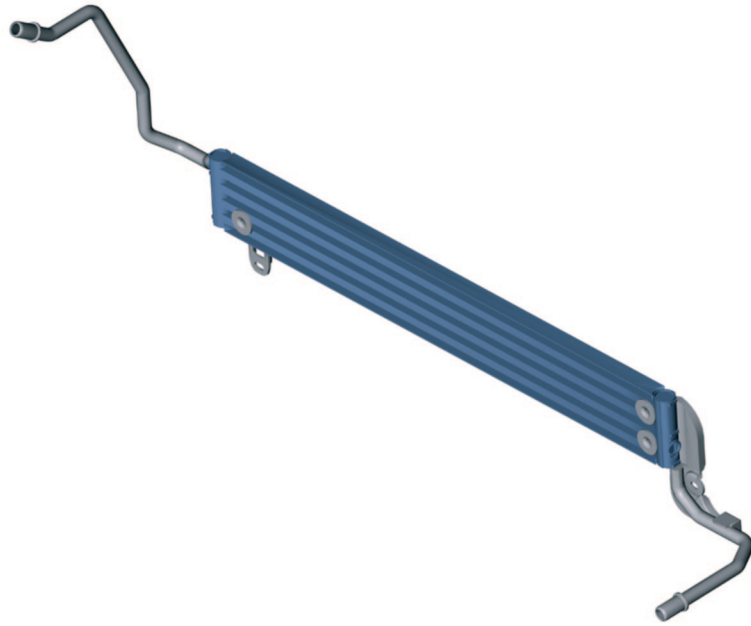
The low power consumption of the hydraulic pump reduces fuel consumption and thus the CO<sub>2</sub> emissions of the vehicle.

When the ECO is supplied with maximum current, the hydraulic pump delivers a maximum of 15 litres/minute, depending on the engine speed.

When the ECO is supplied with no current, the hydraulic pump delivers a reduced volumetric flow of approximately 7 litres/minute for power steering assistance.

## Power steering cooler

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5 - Power steering cooler

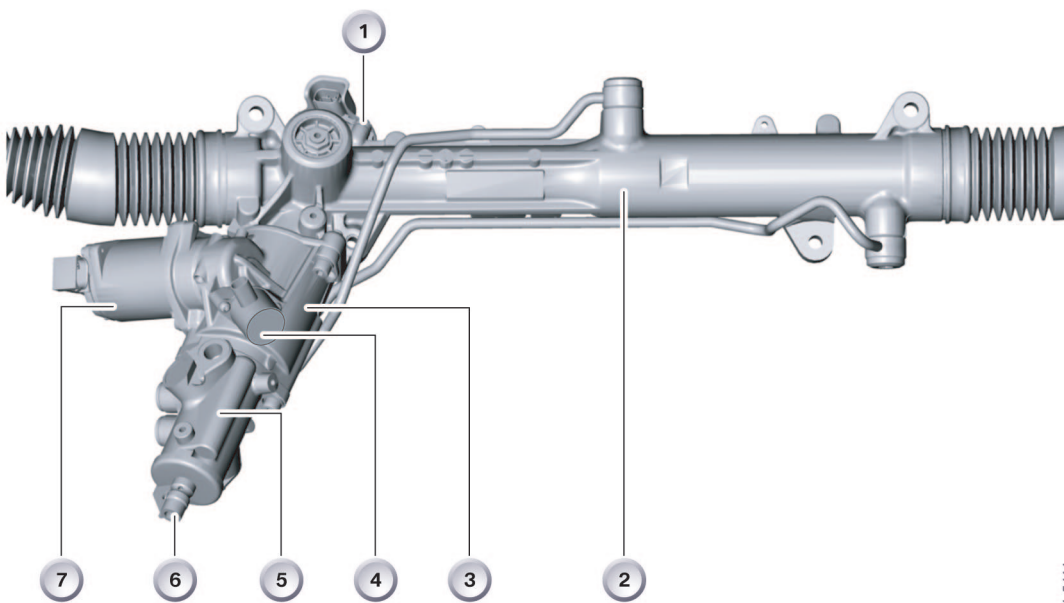
The power steering cooler is located at the engine cooling module.

The power steering cooler comprises 4 pipes with a right-angle cross section and soldered fins.

## Active Steering actuating unit

The active steering actuating unit is located in the steering gear. The active steering actuating unit is fitted in the divided steering column between the Servotronic valve and the rack.

The active steering actuating unit comprises a brushless DC synchronous electric motor and a planetary gear train.



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
6 - Actuating unit with rack

Index	Explanation	Index	Explanation
1	Cumulative steering angle sensor	5	Servotronic valve
2	Rack	6	Steering shaft
3	Planetary gear train housing	7	Electric motor
4	Solenoid lock		

The core component of the active steering actuating unit is a superimposed gear unit with 2 input shafts and one output shaft.

The input shaft is connected to the lower steering shaft as with standard Servotronic. The second input is driven by the electric motor via a self-locking reduction worm drive.

The self-locking feature of the worm drive ensures that the worm is turned only by the electric motor. The worm drives a worm wheel that superimposes the front wheel steering angle input by the driver at the steering wheel.

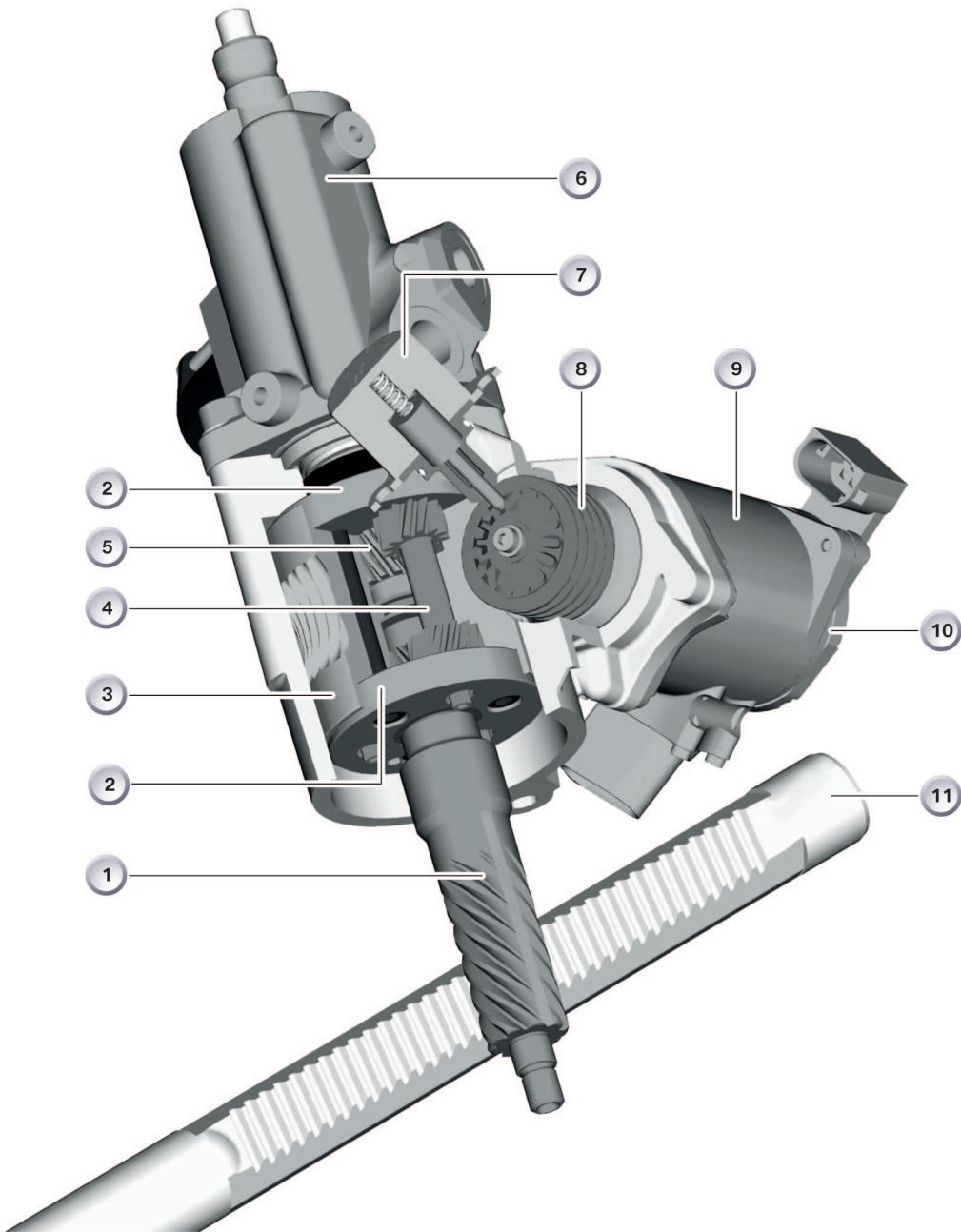


The electric motor is permanently connected to the worm drive and engages, free of play, in the worm wheel. The direction, speed and duration of motor rotation are monitored by motor angle sensor to calculate the redundant steering angle.

The superimposed gear unit essentially comprises the worm wheel, two planet carriers and three planet wheels. The permanent connection forms a compact unit.

The planetary gears form the mechanical connection between the upper (shaft of the Servotronic valve) and the lower sun wheel. The lower sun wheel and the drive pinion are designed as a single component. Direct drive to the splines on the rack is ensured through the Servotronic valve, even in the opposite direction.

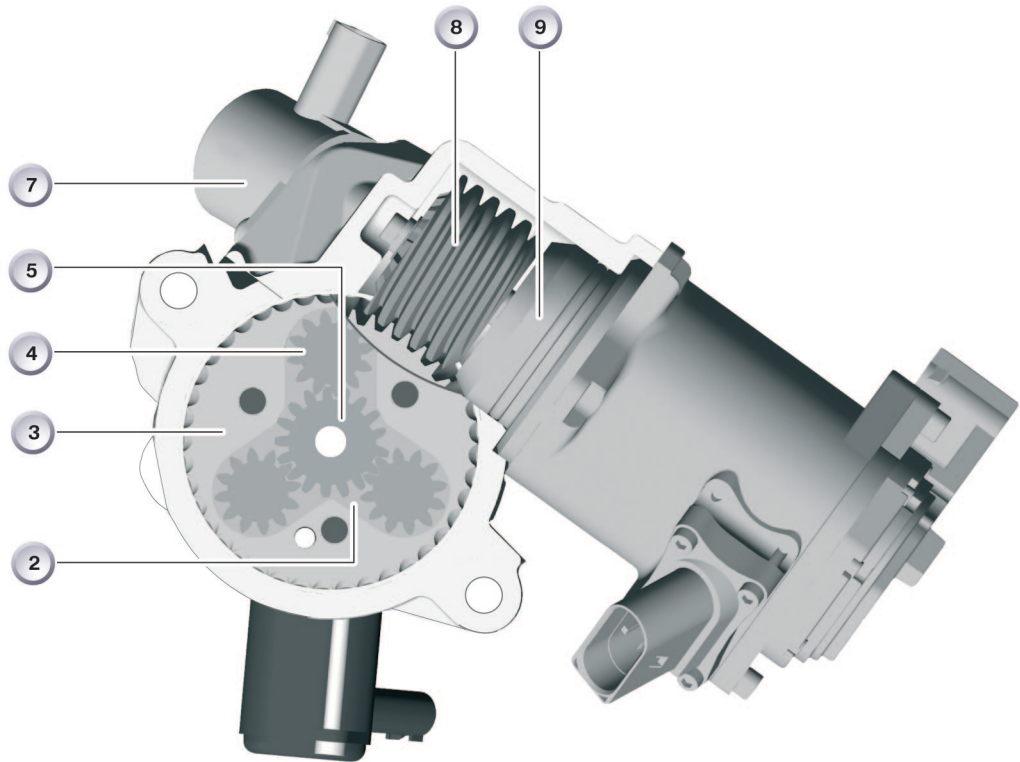
Turning the worm wheel, induced by the electric motor, causes the planetary gears to turn around two sun wheels. The two sun wheels turn at different speeds because the planetary gears have different numbers of teeth. The steering wheel and worm movement meet at the lower sun wheel and are transferred to the rack by the drive pinion. The movement of the rack produces an additional steering angle. This steering angle is smaller (negative) when the worm wheel and upper sun wheel move in the same direction. However, in this case, the effective steering angle is larger (positive) than defined by the basic gear ratio.



TF04-5729

7 - Active steering

Index	Explanation	Index	Explanation
1	Drive pinion	7	Safety lock
2	Planet gear, ECO valve carrier	8	Worm drive
3	Worm wheel	9	Electric motor
4	Planetary gear	10	Motor position sensor
5	Sun wheel (shaft)	11	Rack
6	Servotronic valve		



8 - Active steering planetary gear

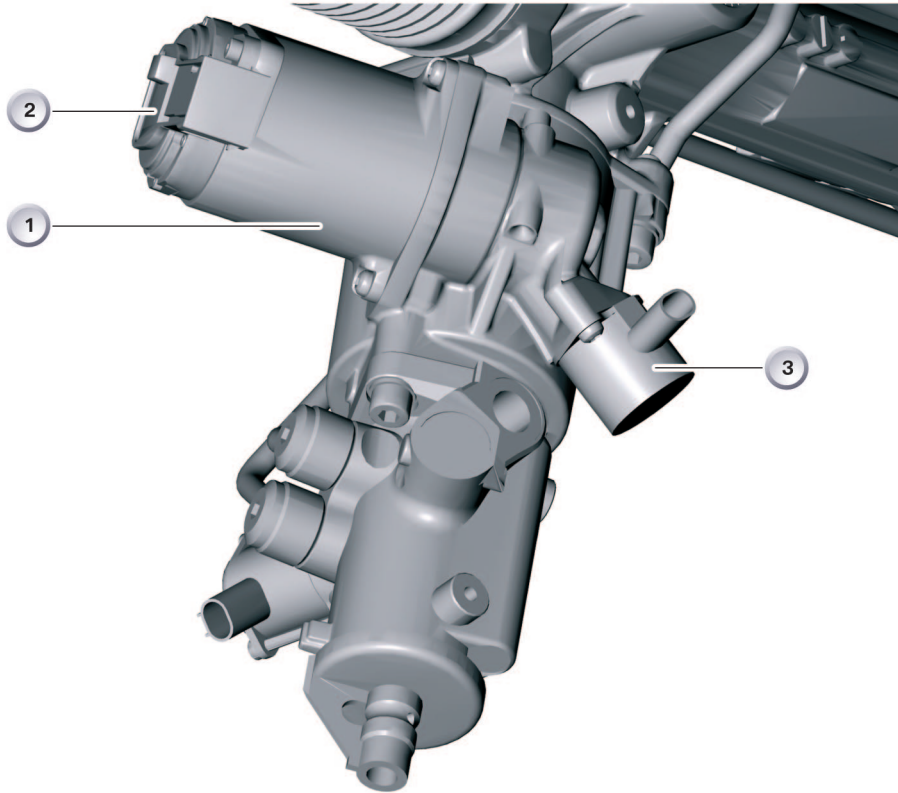
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Index	Explanation	Index	Explanation
2	Planet wheel carrier	7	Safety lock
3	Worm wheel	8	Worm drive
4	Planetary gear	9	Electric motor
5	Sun wheel (shaft)		

A solenoid-operated safety lock is fitted. The safety lock engages under spring load in the locking splines of the gear drive when no voltage is applied.

The safety lock is released when there is a current of approximately 1.8 A.





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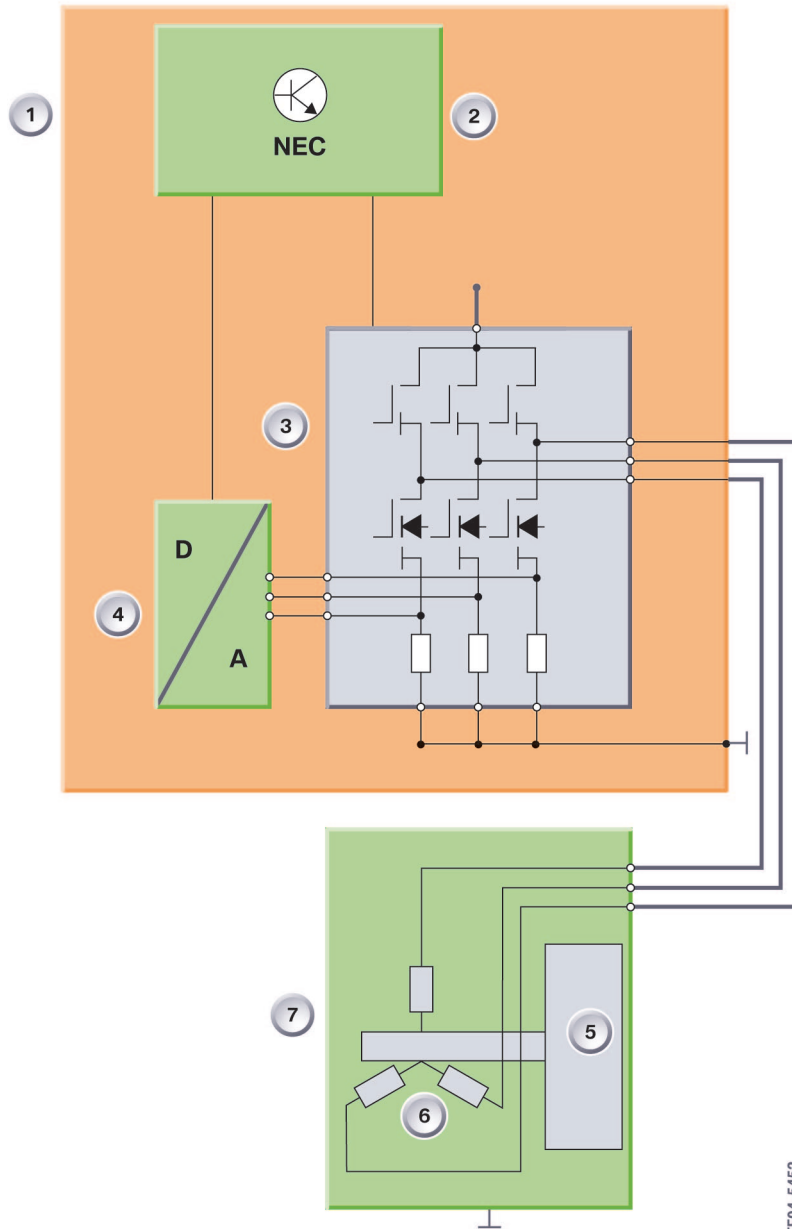
9 - Solenoid lock layout

Index	Explanation	Index	Explanation
1	Electric motor	3	Solenoid lock
2	Motor position sensor		

The position of the electric motor's rotor is detected by the motor position sensor on the electric motor.

The voltage of the electric motor is supplied via the 3 phases. The 3 phases are supplied with current alternately by the electronics of the active steering control unit.

The shielding is realized by the ground connection of the electric motor housing to the body.



TF04-5452

10 - Power supply

Index	Explanation	Index	Explanation
1	Active steering control unit	5	Motor stands
2	Processor	6	Motor coils
3	Circuit in the control unit	7	Electric motor
4	Analogue/digital converter		

The actuating forces for turning the wheels are not produced by the electric motor, however, but by the separate power steering assistance as with conventional steering.

## Functions of the active steering

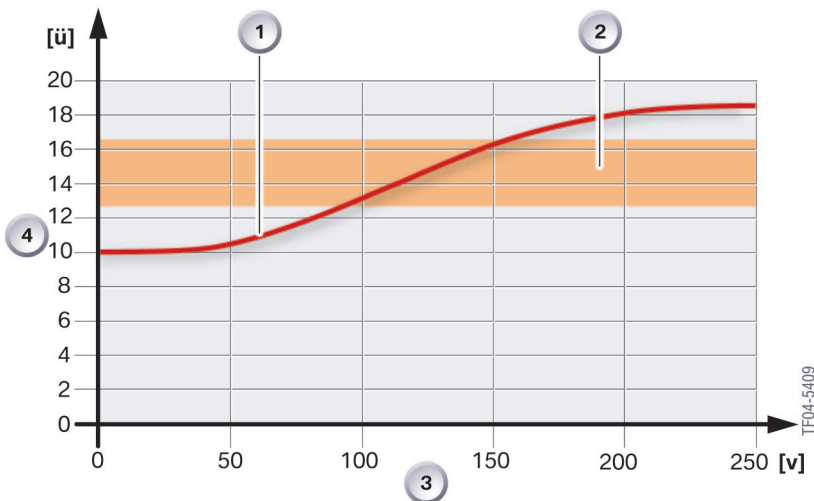
### Variable steering gear ratio

This function adapts the steering gear ratio to the driving speed and the steering angle required by the driver. The steering is indirect at high driving speeds. The steering is direct at slow driving speeds.

The ease of handling the vehicle at low speeds or when parking is greatly increased by the active steering actuating unit. It is no longer necessary to grapple with the steering wheel. Just two turns of the steering wheel when the

vehicle is stationary are enough to move the steering wheel from one lock to the other.

At high speeds (> 120 km/h), the active steering provides a more indirect steering gear ratio by comparison with conventional steering systems. The actuator motor operates against the steering wheel angle at high speeds. Together with the elevated steering torque level (Servotronic), this has the effect of improving directional stability.



11 - Steering gear ratio

Index	Explanation	Index	Explanation
1	Active steering design	3	Road speed
2	Conventional design	4	Ratio

### Yaw rate control

The active steering system supports the vehicle stabilization functions of DSC.

In critical vehicle dynamics situations, the active steering specifically changes the steering lock of the wheels defined by the driver. The vehicle is stabilized much faster than possible by the driver.

The intervention thresholds of DSC are higher than the intervention thresholds of the active steering. If oversteering is detected, active steering initially intervenes in an attempt to stabilize the vehicle. DSC only intervenes if the steering is unable to stabilize the vehicle on its own.



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## Power steering assistance

Power steering assistance is realized by conventional hydraulic rack and pinion steering.

The magnitude and direction of the auxiliary hydraulic force acting on the rack depend on the rotational angle of the torsion rod. The torsion rod is located between the steering shaft and pinion.

Servotronic, the speed-dependent power steering assistance, is available as option SA 216.

The electronics and the software for Servotronic are located in the SGM if the vehicle is not equipped with active steering.

On vehicles with active steering, the software for the power steering assistance is installed in the active steering control unit. The output stage for activating the Servotronic valve and the valve in the hydraulic pump (ECO) is located in the SGM and controls the volumetric flow in the hydraulic pump such as to make available only the volumetric flow required for the power steering. The ECO therefore controls the power intake of the hydraulic pump, thus reducing the fuel consumption and the CO<sub>2</sub> emissions of the combustion engine.

## System safety

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A situation that would critically affect driving safety would be for the active steering to initiate steering movements on its own.

The safe system status (fail-safe) is when the actuator motor of the actuating unit is without power. Irrespective of whether the safe status is initiated by loss of power or by specific system shutdown, the fail-safe system ensures: the actuating unit does not engage in the steering. The actuating unit is arrested by a lock that engages in the worm drive of the actuating unit. The lock is pretensioned by a spring and held against this pretension by the power supply. The actuator unit is inhibited by a break in the power supply.

The arrested superimposed gear unit ensures that it is still possible for steering wheel movements input by the driver to be transferred along the steering column. The steering then responds in the same way as conventional steering. The purely mechanical transmission between the steering wheel and the front wheels is retained.

The electric motor of the active steering actuating unit is connected to 3 phases. A short circuit to earth will therefore prevent the electric motor from completing a full turn, the maximum possible being only 120° (360° : 3).

The Servotronic valve switches under no electrical load to the fast driving characteristic curve. The power steering assistance is reduced accordingly. The volumetric flow

when the ECO is without power is 7 litres/minute.

If the active steering control unit does not send a valid message on the PT-CAN, the SGM will operate with a speed-dependent substitute characteristic curve after 100 ms. The substitute characteristic curve guarantees sufficient steering response for the passive active steering system.

The driver is made aware of faults in the system in the form of an indicator lamp symbol as well as check control messages in the instrument cluster.



12 - Indicator lamp

The check control message reads:  
Active steering failure! Steer with care.

The following or similar message will appear in the control display:  
Steering behaviour altered! Possible to continue the journey. Steering wheel may be at an angle. Have the problem checked by the nearest BMW Service.



## Activation conditions

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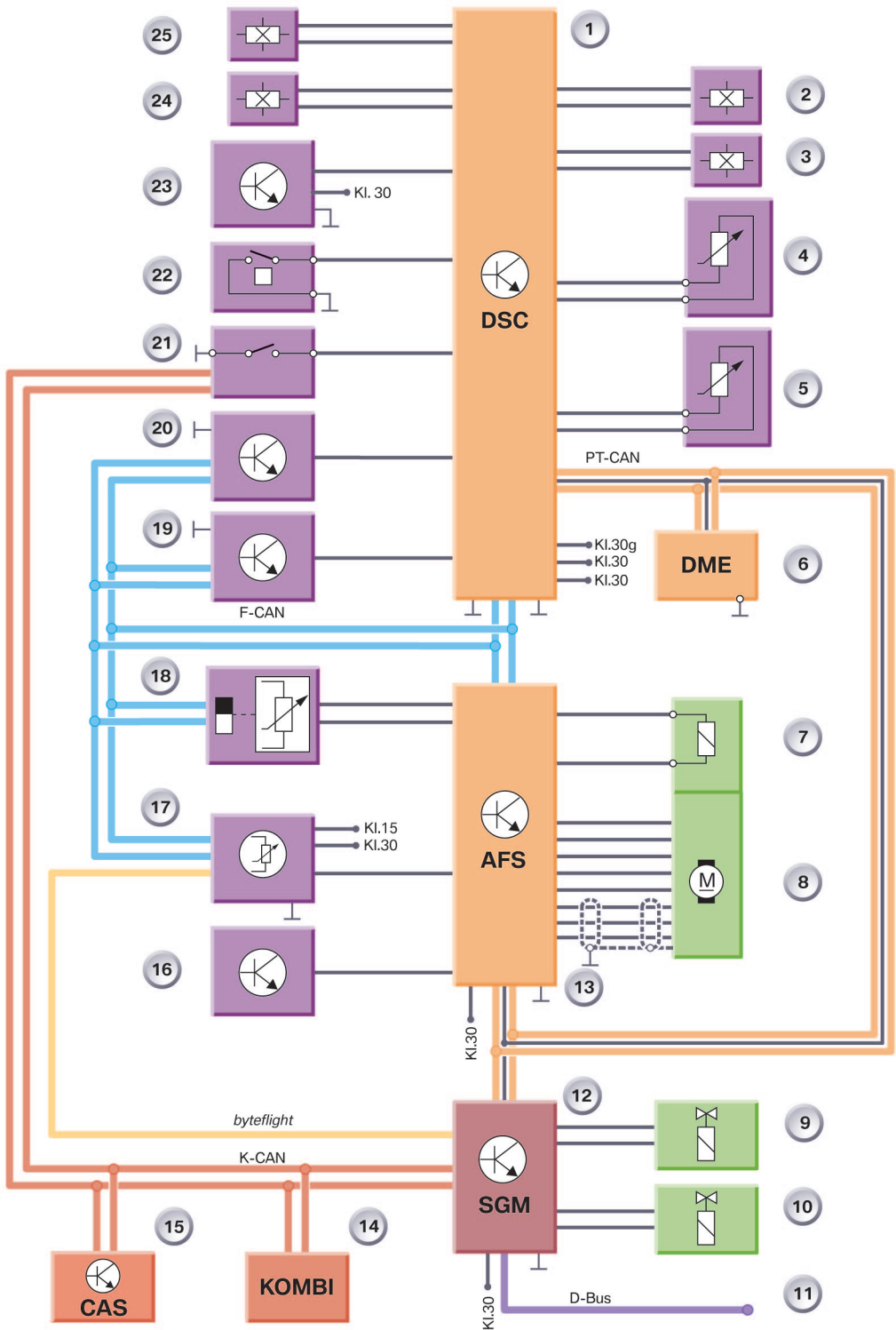
The activation conditions for the active steering system are terminal 15 ON and a running engine.

After the engine is started, the system synchronizes the position of the steering wheel and the wheel lock. This ensures steering wheel movements are detected when the system is switched off (passive state). The steering wheel position and wheel lock always agree. Steering wheel or wheel movements may be perceived.

# System components

## Active steering

### System circuit diagram using the E60 as an example



TF04-5401

1 - System circuit diagram

Index	Explanation	Index	Explanation
1	Dynamic stability control DSC	19	DSC sensor 2
2	Wheel speed sensor, front right	20	DSC sensor
3	Wheel speed sensor, rear right	21	DSC button in the centre console switch cluster SZM
4	Brake pad wear sensor, front left	22	Brake-fluid level switch
5	Brake pad wear sensor, rear right	23	Brake light switch
6	Digital engine electronics DME (or digital diesel electronics DDE)	24	Wheel speed sensor, rear left
7	Electromagnetic lock	25	Wheel speed sensor, front left
8	Actuator motor at the superimposed gear unit	Kl. 15	Terminal 15
9	Servotronic valve	Kl. 30	Terminal 30
10	Power steering pump with ECO valve	Kl. 30 g	Terminal 30g
11	BMW diagnostic system	Kl. 31	Terminal 31
12	Safety and gateway module SGM	Kl. R	Radio terminal
13	AFS control unit (active steering)	<b>byteflight</b>	<b>byteflight</b>
14	Instrument cluster	D-Bus	Diagnosis bus
15	Car access system (CAS)	F-CAN	Chassis CAN
16	Motor position sensor	K-CAN	Body CAN
17	Steering angle sensor	PT-CAN	Powertrain CAN
18	Cumulative steering angle sensor		

This overview shows how the vehicle stability control systems are networked with the dynamic stability control (DSC). Sensors and signals used by the DSC are also used by the active steering control unit. The steering lock turned by the driver is specifically counteracted in critical driving situations. This enables the vehicle to be stabilized more quickly and more effectively. It is also possible to compensate for undesirable vehicle movements, e.g. oversteering, by the active

steering, without the driver having to intervene with corrective steering. The intervention thresholds of DSC are higher than the intervention thresholds of the active steering. The active steering initially intervenes when control of the vehicle dynamics is required. DSC will intervene if intervention by the steering is not sufficient to stabilize the vehicle on its own.



# Service information

## Active steering

### Service information

---

#### Steering angle sensor adjustment

A steering angle sensor adjustment (offset) must be carried out if the steering column switch cluster (SZL) or the steering gear and rack are replaced.

The cumulative steering angle sensor in the steering gear is calibrated to rack centre by the steering gear manufacturer.

#### Radio reception interference

Radio interference may be caused by a broken connection between the shielding of the

3 phases of the actuating unit to the housing of the active steering control units.

#### Diagnostics, coding

For diagnostics purposes, the active steering can be controlled as a control unit in its own right. The control unit is an individual component.

Coding only enters vehicle-specific configurations.



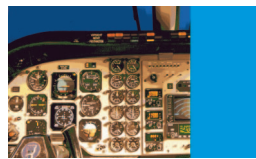
# Contents

## EPS steering systems



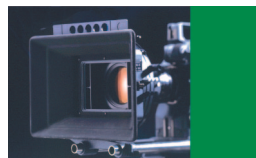
### Introduction

Electromechanical power steering	1
New system features	2
System advantages	3



### System overview

Vehicle electrical system diagram	5
IN/OUT overview	7



### Functions

System functions	9
------------------	---



### System components

Components	11
Servo unit	14
Steering wheel torque sensor	17
Steering angle sensor	18
EPS control unit	19
Electric motor and worm gear	20
Lower steering shaft	21
Steering gear with rack	23



### Service information

Notes for service staff	25
Coding and diagnostics	27





# Introduction

## EPS steering systems

### Electromechanical power steering

---

Electromechanical power steering, abbreviation EPS, is used by BMW for the first time in the E85. It offers the same steering force and steering feel characteristics that are typical of BMW steering systems. Another term you may find used for EPS is Electric Power Steering.

EPS offers very direct, sporty steering that makes it possible to switch between standard and sports mode using the Dynamic Driving Control button.

EPS operates according to road speed and actively centres the steering.



## New system features

---

### New features by comparison with previous BMW developments

The EPS allows for an extremely high degree of flexibility in steering tuning as adaptation of the damping, the active return and of the steering characteristic takes place by way of the software.

The EPS is a "dry system". There are no hydraulic components such as the expansion tank, pump, cooler, lines and hydraulic oil (environmental aspect).

A dampened pressure piece is used in the steering gear.

Electromechanical power steering is used in vehicles that require less steering force owing to the vehicle's low weight (e.g. Audi A3, Golf V, Vauxhall Corsa).

## System advantages

### Benefits by comparison with previous BMW developments

Electromechanical power steering offers the customer, the maintenance service and the fitter a range of benefits by comparison with hydraulic power steering. EPS has the following benefits:

- Improved driving dynamics
- Enhanced driving comfort
- Greater driving safety
- Less harmful to the environment
- Simplifications for the vehicle manufacturer

#### Improved driving dynamics

- Good steering response due to direct transfer of steering force
- Active centring
- Selectable steering characteristics (sports mode)
- Longitudinal dynamics benefit of 1.6 kW
- Use of low-weight sports steering wheels

#### Enhanced driving comfort

- Decoupling of axle vibrations with no impact on the transfer of relevant road surface information (different road conditions) to the driver
- Better protection from road surface defects, less jarring

- Controlled, speed-dependent steering force support (e.g. when parking)

#### Greater driving safety

- At high speeds and with low steering force, EPS reproduces the feel of a direct connection with the road and directly transfers road surface information.
- Speed-dependent active damping reduces the movement of the steering wheel.

#### Less harmful to the environment

- Fuel saving of approximately 0.23 l per 100 km
- A dry system cannot have leaks

#### Simplifications for the vehicle manufacturer

- Simplified fitting and testing in works because delivered as a complete system
- Fewer component variants than in hydraulic systems (pumps, hoses, steering wheels)
- Easier tuning of steering force support through programming
- Great future potential: Drive by wire, networking of systems in the vehicle (brakes, chassis)

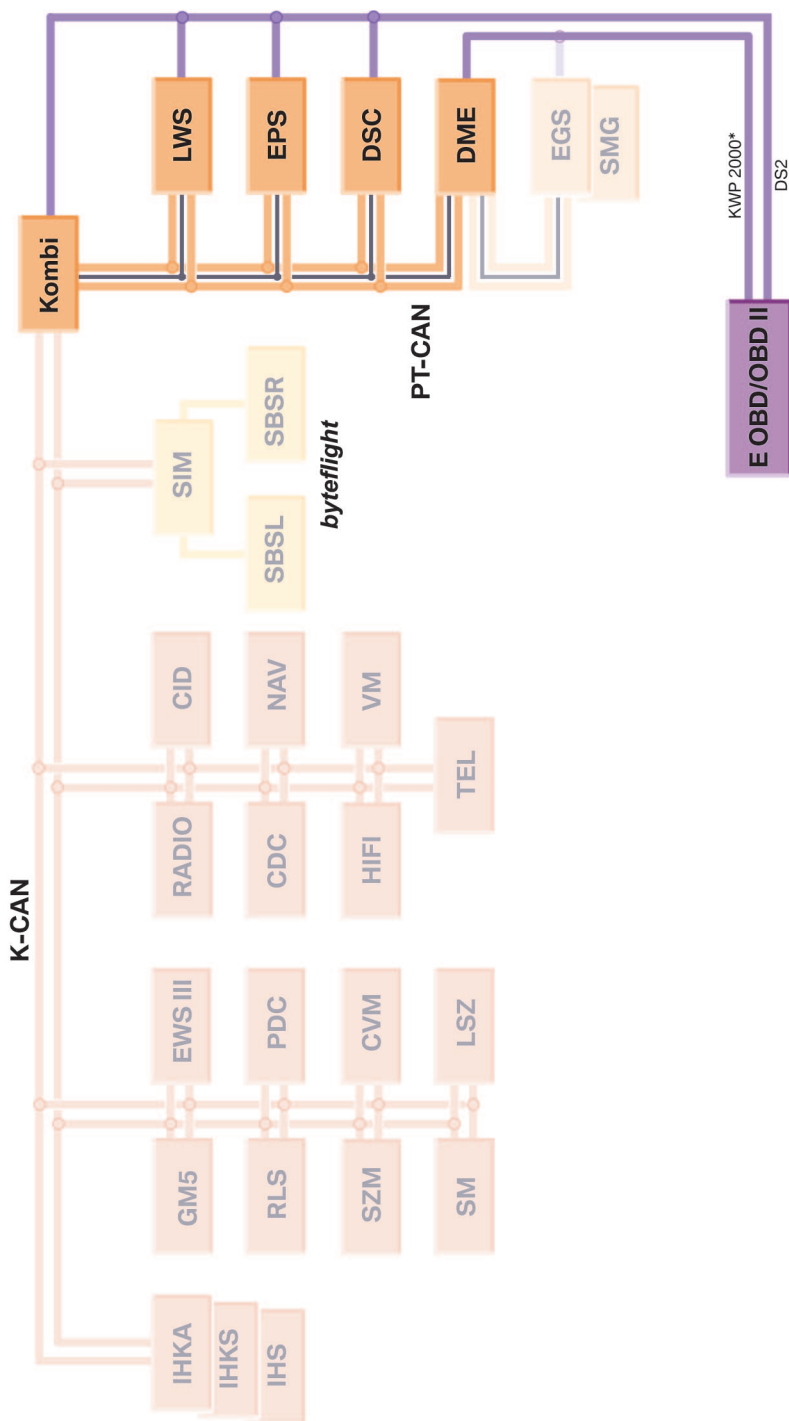




# System overview

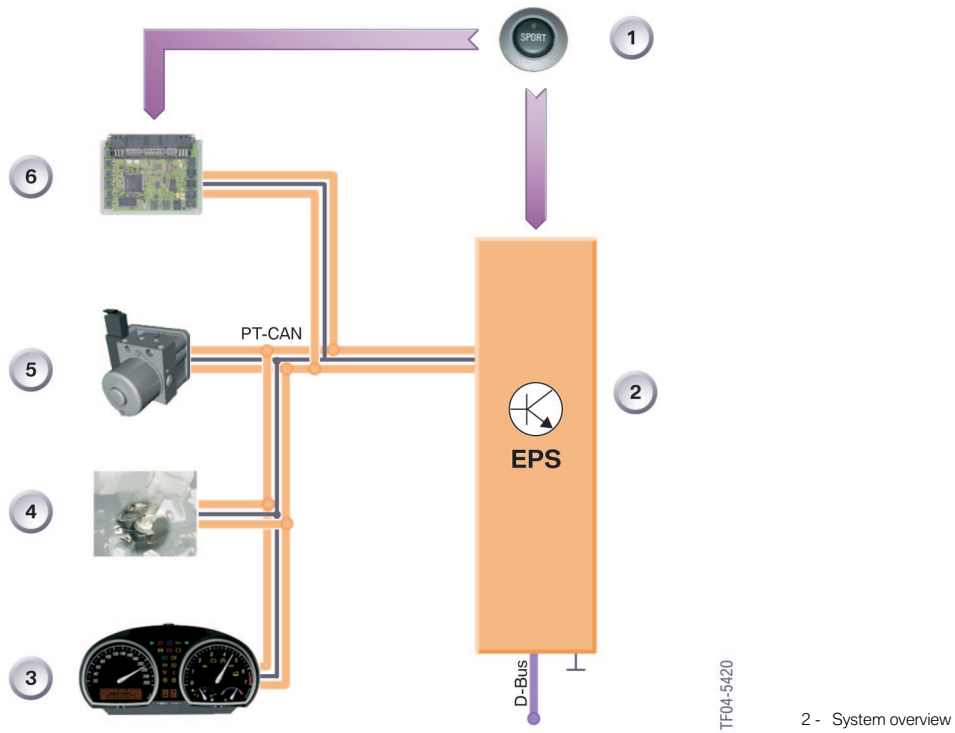
## EPS steering systems

### Vehicle electrical system diagram



<b>Index</b>	<b>Explanation</b>	<b>Index</b>	<b>Explanation</b>
CDC	CD changer (Compact Disc Changer)	LWS	Steering angle sensor
CID	Central information display	NAV	Navigation computer
CVM	Convertible soft top module	PDC	Park distance control
DME	Digital engine electronics	RADIO	Radio
DSC	Dynamic stability control	RLS	Rain/driving light sensor
EGS	Electronic transmission control unit	SBSL	B-pillar satellite, left
EPS	Electric power steering	SBSR	B-pillar satellite, right
EWS	Electronic immobilizer	SIM	Safety and information module
GM5	General module 5	SM	Seat module
HiFi	Top-HiFi amplifier (DSP)	SMG	Sequential manual gearbox
IHKA	Integrated automatic heating and air conditioning	SZM	Centre console switch cluster
IHKS	Integrated heating and air conditioning control	TEL	Telephone control unit
IHS	Integrated heating control	VM	Video module
LSZ	Light switch cluster		

## IN/OUT overview



Index	Explanation	Index	Explanation
1	FDC button with function indicator lamp	5	DSC control unit
2	EPS servo unit with control unit, steering wheel torque and EPS motor speed sensor	6	MS45.0 engine control
3	Instrument cluster	PT-CAN	Powertrain CAN
4	Steering angle sensor	D-Bus	Diagnosis bus



# Functions

## EPS steering systems

### System functions

- The EPS system has the following functions:
- Power steering assistance with Servotronic
  - Adjustment of steering force
  - Active steering centring
  - Check display

---

### Power steering assistance

The system is integrated with Servotronic, which electronically regulates the speed-dependent power steering assistance. The control unit determines the amount of power steering assistance required from a range of input variables.

Characteristic maps for assistance and damping characteristics are stored in the control unit. The power assistance torque required is derived from the values calculated from the input variables in conjunction with the characteristic curve. The power assistance torque is produced by the electric motor and the transmission.

Important input variables for power steering assistance:

- Road speed
- Steering input by the driver
- Steering angle speed
- Steering angle
- FDC button
- System temperature

The operating voltage range is 9 V to 16 V.

---

### Adjustment of steering force

The sports-oriented driving function is selected with the vehicle dynamics control button (FDC button). The engine management then sends the corresponding signal via the PT-CAN to the EPS control unit.

The EPS control unit switches to a map for a sporty driving. The deflection and holding forces are tuned for a more sporty driving style.

One of two characteristic curve sets is selected when the "FDC button ON" CAN message is sent from the engine control. Characteristic curve set 1 is the standard characteristic curve set.

Characteristic curve set 2 is the sports characteristic curve set.

---

### Active steering centring

Active steering centring is controlled based on steering angle information from the steering angle sensor.

Active steering centring ensures that steering return behaviour is the same across the entire operating temperature range.

## Check display



1 - Indicator lamp

The vehicle's instrument cluster is equipped with an indicator lamp for the EPS system. The indicator lamp informs the driver of a significant reduction in steering force support or of a complete power assistance shutdown.

The possible reasons for system shutdown are:

- Fault in the EPS control unit or another control unit in the system (DSC control unit, steering angle sensor, engine control unit)
- Thermal overload of the EPS
- Under/overvoltage

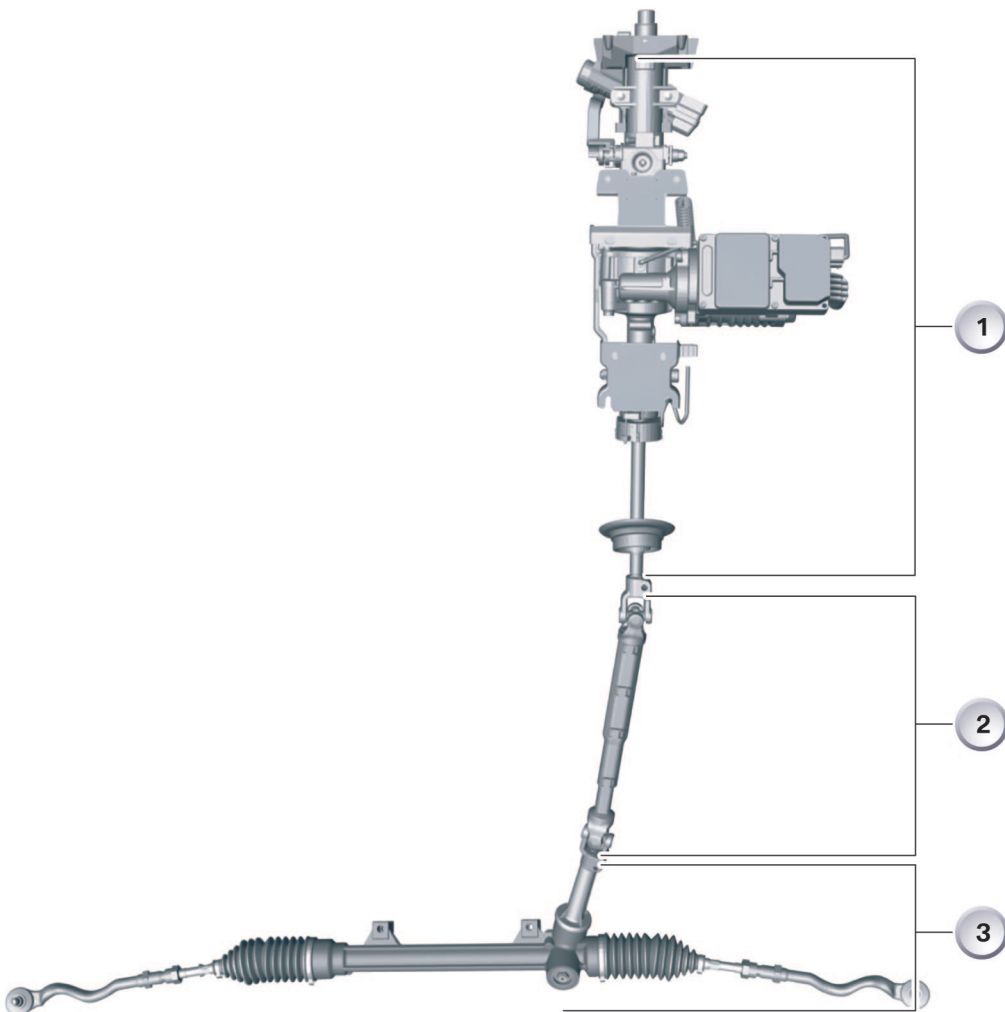
# System components

## EPS steering systems

### Components

The EPS system can be divided into 3 assemblies:

- Upper steering column
- Lower steering shaft
- Steering gear with rack



1 - EPS assemblies

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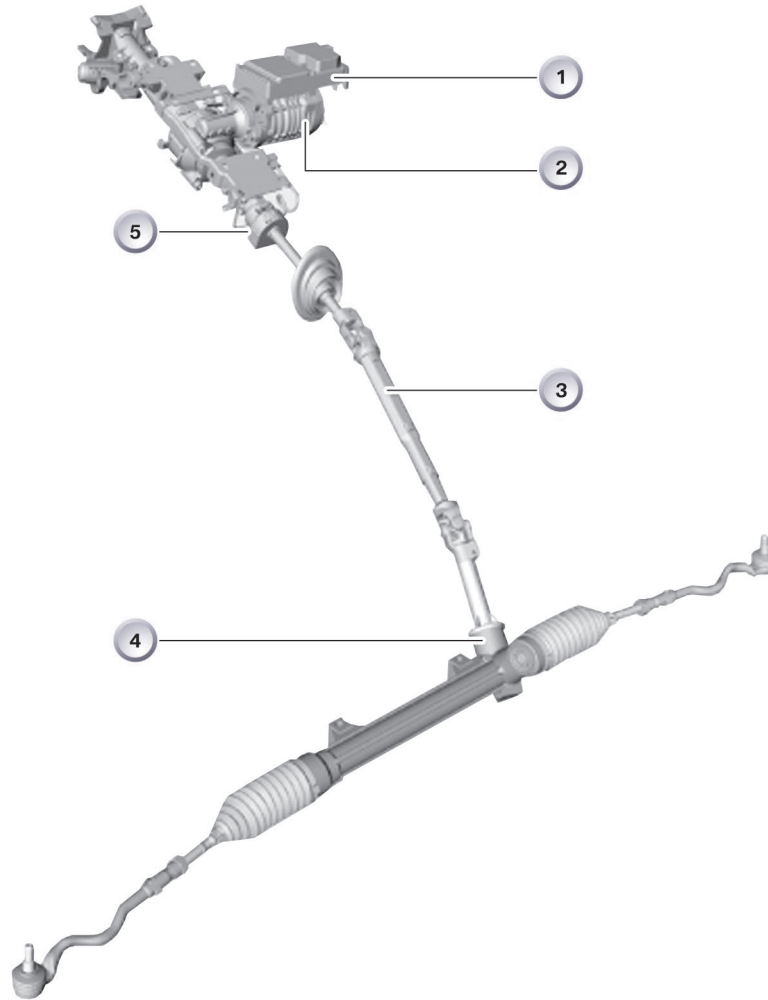
Index	Explanation	Index	Explanation
1	Upper steering column	3	Steering gear with rack
2	Lower steering column		

In the after-sales service organization, these assemblies are replaced individually as a unit if their components require replacement.

The visible components of the upper steering column are the EPS control unit, the electric

motor with worm gear and the steering angle sensor.

The lower steering shaft and the steering gear with rack are separate assemblies.



TF04-5426

2 - Complete EPS system

Index	Explanation	Index	Explanation
1	Control unit	4	Steering gear with rack
2	Electric motor with worm gear	5	Steering angle sensor
3	Lower steering shaft		





---

## Upper steering column assembly

The upper steering column is secured to a bracket by 4 bolts, the bracket itself is welded to the instrument cluster support pipe.

The bracket for the support pipe is secured to the body by 4 bolts.

It is possible to distinguish the mechanical section of the upper steering column assembly from the electrical section: the servo unit.

The mechanical section of the upper steering column begins with the steering wheel and ends with the connection to the lower steering shaft. The mechanical section of the upper steering column transfers the entire steering wheel torque to the lower steering shaft. The electrical section provides the power steering assistance.

The following components are part of the upper steering column assembly:

- Steering lock with ignition switch
- Mechanical steering wheel adjustment
- Servo unit: the servo unit comprises the EPS control unit, the EPS electric motor with worm gear and internal EPS sensors.
- Steering angle sensor: the steering angle sensor is part of the mechanical section of the upper steering column.

The steering angle sensor and the steering lock are the only parts of the upper steering column that may be replaced individually.

This section describes in detail the individual main components of the servo unit.

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## Lower steering column assembly

The lower steering shaft transfers the high steering forces from the upper steering column to the steering gear.

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## Steering gear with rack assembly

The steering gear is purely mechanical.

The following components are part of the steering gear assembly:

- Rack
- Track rods



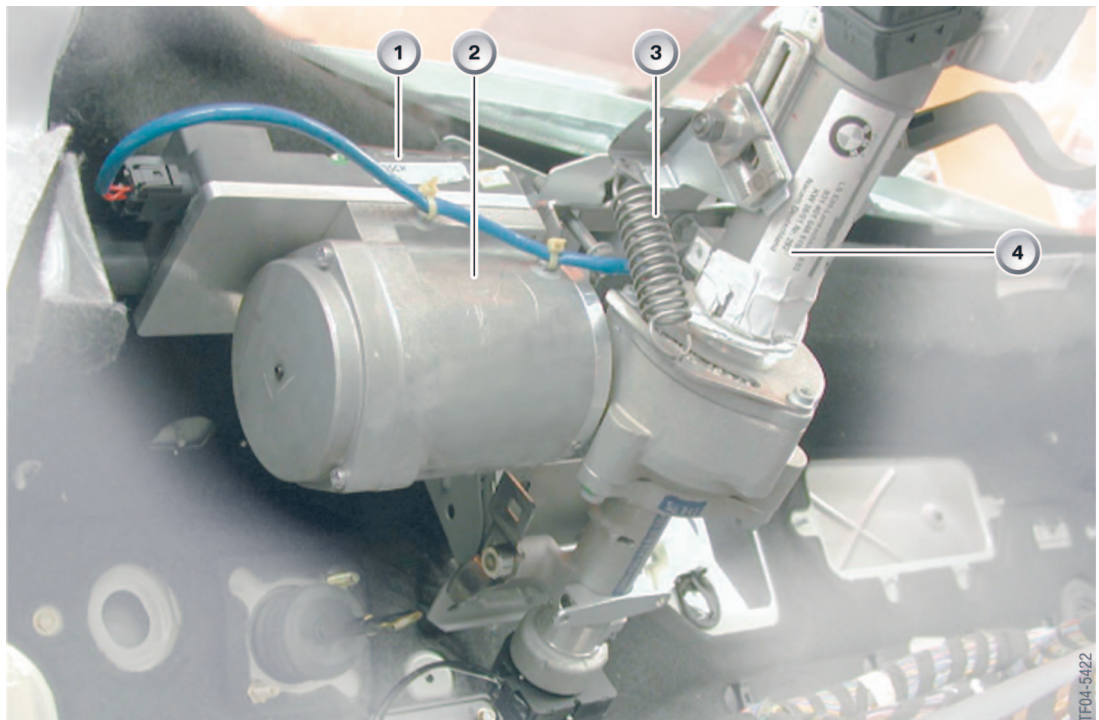
## Servo unit

The servo unit is the electrical part of the upper steering column. The role of the servo unit is to provide active

steering force support as a function of steering forces and system conditions.

### Installation location

The servo unit is located on the upper steering column, housed in the vehicle interior.



3 - Servo unit on the steering column

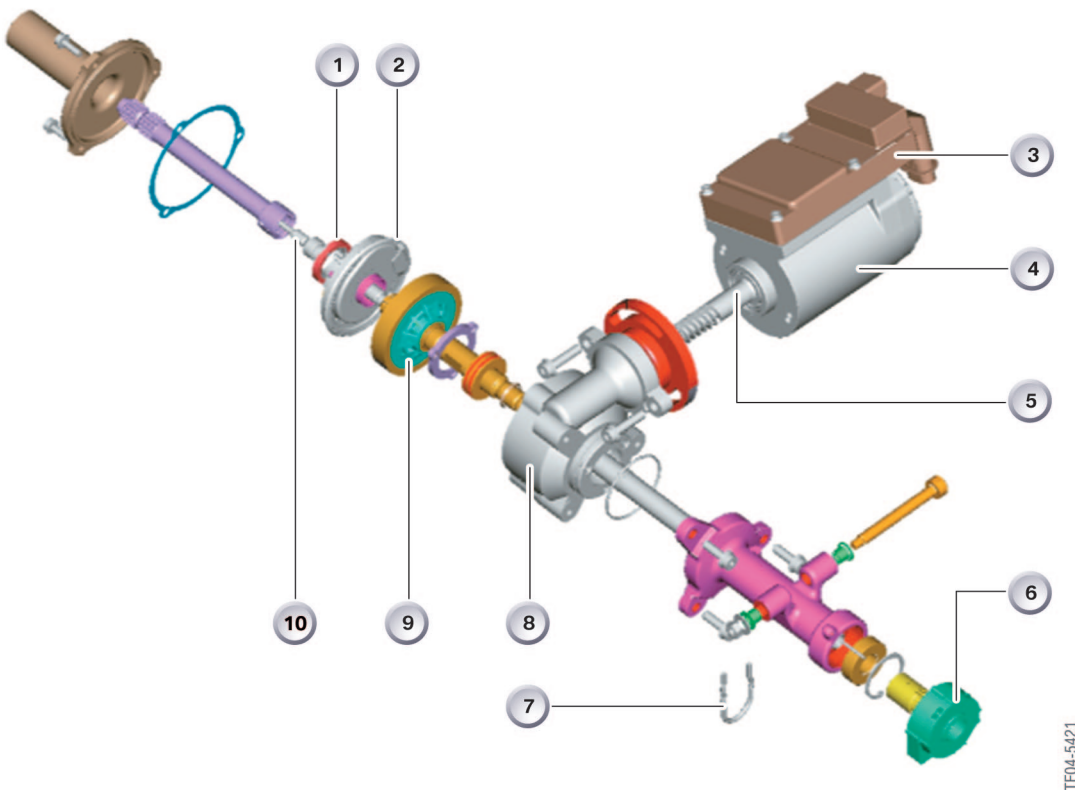
Index	Explanation	Index	Explanation
1	EPS control unit	3	Balancing spring
2	Servo unit electric motor	4	Column tube of the upper steering shaft



## Design

The servo unit comprises the following components:

- Various internal sensors. They serve the purpose of registering
  - the speed of the electric motor
  - the steering torque
  - the system temperature
- the system voltage
- Flat spring cassette for the current draw of the internal steering wheel torque sensor
- EPS control unit
- Electric motor with mechanical worm gear



TF04-5421

4 - Design

Index	Explanation	Index	Explanation
1	Magnet wheel	6	Steering angle sensor
2	Steering wheel torque sensor with flat spring cassette	7	Anti-twist lock
3	EPS control unit	8	Housing for the worm gear and steering wheel torque sensor
4	Servo unit electric motor	9	Worm gear
5	Worm gear shaft	10	Torque rod



---

## Operating principle

The servo unit makes the required amount of power steering assistance available. The servo unit detects the steering input from the steering wheel by means of steering wheel torque sensors.

The EPS control unit calculates the required steering assistance. The electric motor is actuated. The electric motor in the servo unit transfers the amount of power steering assistance required to the worm gear.



## Steering wheel torque sensor

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### Installation location

The steering wheel torque sensor is fitted in the servo unit and thus forms part of the upper steering column assembly.

The steering wheel torque sensor is located in the worm gear housing of the servo unit on the upper steering shaft.

---

### Design

The steering wheel torque sensor comprises the input shaft, torque rod, output shaft and magnetoresistive element. The signal transfer, power supply and earth lines of the steering wheel torque sensor are routed inside a flat spring cassette.

The flat spring cassette is secured to the output shaft of the upper steering shaft and is located in the housing for the worm gear and the magnetoresistive element.

---

### Operating principle

Operation of the steering wheel torque sensor is based on the magnetoresistive principle. The magnetoresistive elements generate different voltage signals that are forwarded to the control unit. The control unit calculates the

power assistance torque to be generated by the electric motor.

As in the case of a hydraulic steering gear, the input shaft of the upper steering shaft is connected to the output shaft of the upper steering shaft by a torque rod.

---

### Notes for service staff

The steering wheel lock must be locked in zero position when performing all work on the steering column. The locking device must be additionally installed to ensure the signal line in the coil spring package is not broken.



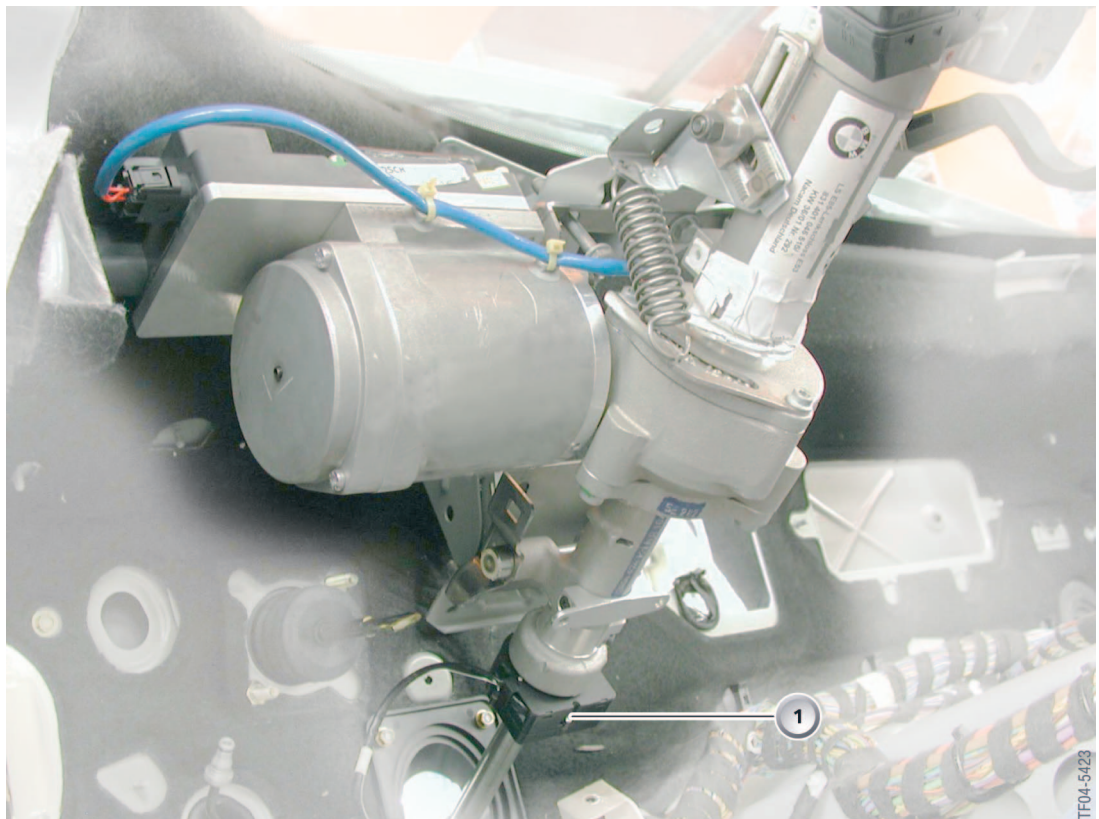
## Steering angle sensor

The steering angle sensor (LWS) is part of the upper steering column assembly. The steering angle sensor used is the same as

the one on the E46. With the EPS system, the LWS is only important for the active steering centring.

### Installation location

The steering angle sensor is located on the upper steering column in the vehicle interior.



5 - Steering angle sensor installation location

Index	Explanation
1	Steering angle sensor

### Note for service staff: Steering angle sensor replacement

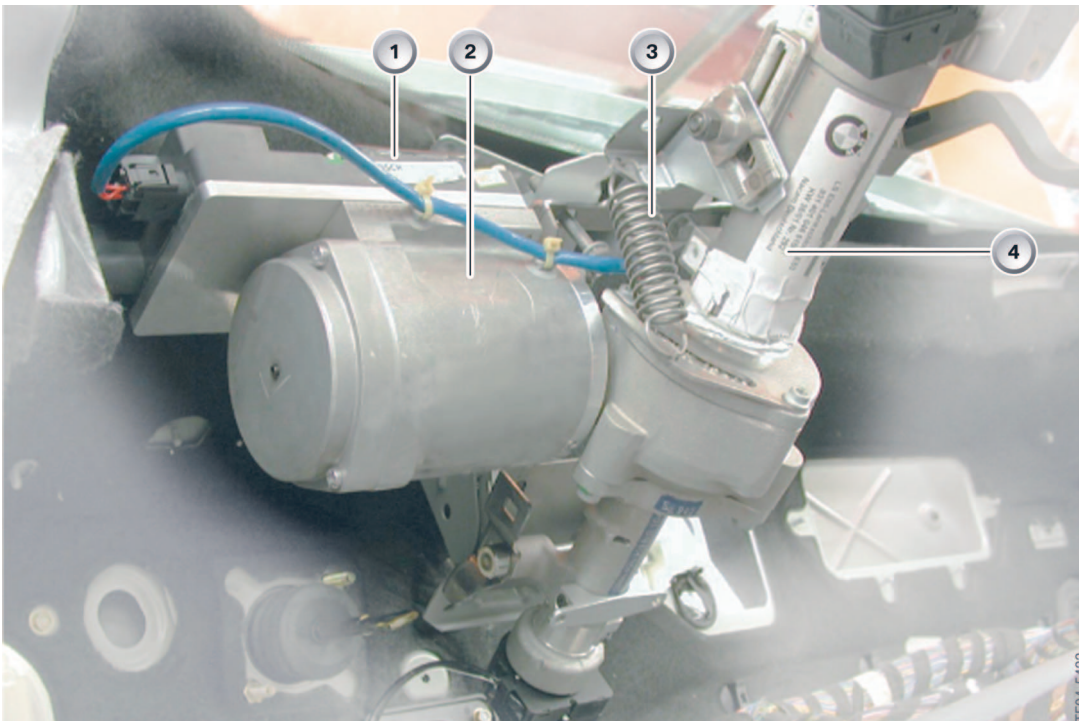
The steering angle sensor can be replaced as an individual part. The upper steering column must be removed to permit replacement of the steering angle sensor. After the steering angle sensor has been refitted, the steering angle must be calibrated and re-encoded.

## EPS control unit

The EPS control unit is fitted in the servo unit and thus forms part of the upper steering column assembly.

### Installation location

The EPS control unit is part of the servo unit. The EPS control unit is permanently connected to the top of the electric motor.



6 - Servo unit on the steering column

Index	Explanation	Index	Explanation
1	EPS control unit	3	Balancing spring
2	Servo unit electric motor	4	Column tube of the upper steering shaft

### Operating principle

The EPS control unit calculates the required steering assistance from the signals of the steering torque sensor. At the same time, the EPS control unit actuates the electric motor. The EPS control unit receives the information, relating to the steering assistance currently set by the electric motor, from the speed sensor of the electric motor. The EPS control unit calculates the steering

angle speed from the speed information of the electric motor. The steering angle speed is necessary for the active steering reset and steering damping functions.

## Electric motor and worm gear

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### Installation location

The electric motor and worm gear are part of the servo unit.

---

### Design

The electric motor and worm gear form one unit.

---

### Operating principle

The electric motor transfers the steering torque necessary for power steering assistance to worm gear supported by resilient bearings. The worm gear transfers the steering torque to the steering column at a ratio of 1:20. The whole mechanical force transfer of the steering thus begins at the

upper steering column.

The steering forces are transferred from the upper steering column to the lower steering shaft and forwarded from the lower steering shaft to the steering gear.

---

### Noise characteristics

The electric motor and the worm gear of the servo unit produce a new sound pattern (acoustics) in the vehicle interior.

The EPS has distinct, system and design-related noise characteristics.

These system and design-related noise characteristics can be heard in specific situations:

- When the steering wheel is turned rapidly
- When the steering wheel is turned with the vehicle stationary
- When the steering wheel turned in quiet surroundings (e.g. radio switched off)

These noises do not mean that there is a fault in the system.

There will be no noises associated with hydraulic steering (pump modulation, limit valve).





## Lower steering shaft

The lower steering shaft connects the upper steering column to the steering gear.

### Installation location

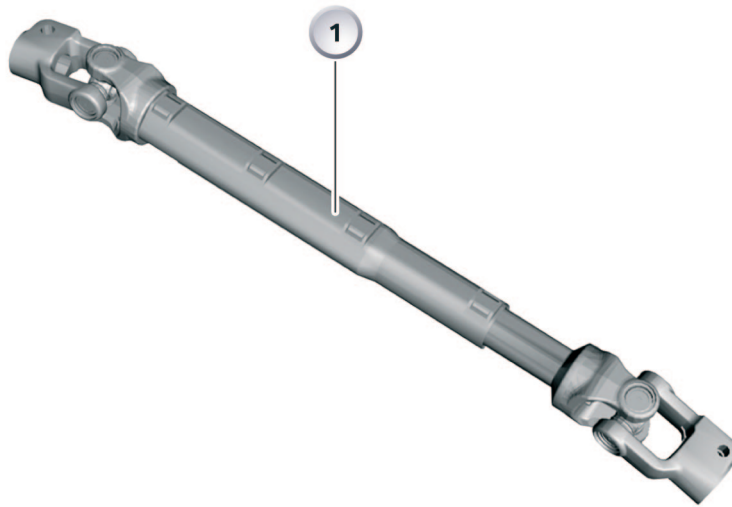
The lower steering shaft runs from the bulkhead inside the engine compartment to the front axle. At the bulkhead end, the lower steering shaft is connected to the upper

steering column by a universal joint. A universal joint at the front axle end connects the lower steering shaft to the steering gear.

### Design

The lower steering shaft is housed in a plastic sleeve that protects it from corrosion. The lower steering shaft is formed of two parts. The lower section, mounted in ball bearings, slides into the upper section.

The sleeve is manufactured from heat-resistant plastic because the lower steering shaft on right-hand-drive vehicles is located near to the exhaust manifold.

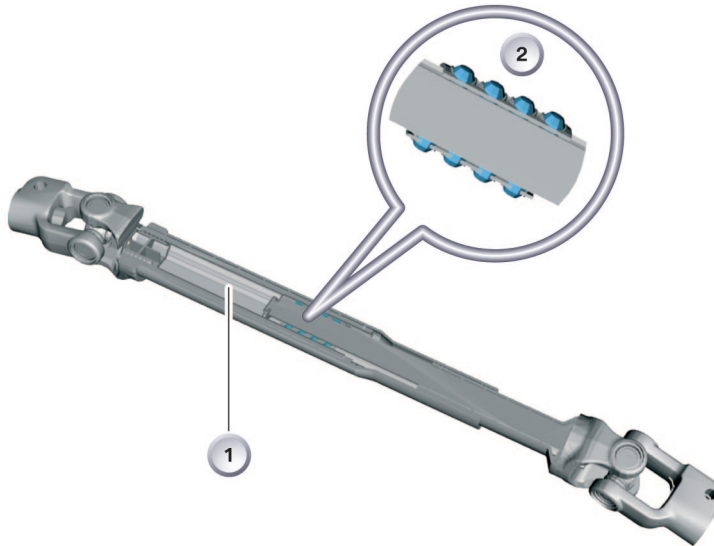


TF04-5427

7 - Lower steering shaft

Index	Explanation
1	Plastic sleeve





8 - Cross section of the lower steering shaft

Index	Explanation	Index	Explanation
1	Ball bearing	2	Telescopic chamber

### Operating principle

The lower steering shaft transfers the high steering torques from the upper steering column to the steering gear.

The ball bearing for the 2 parts of the lower steering shaft is necessary for the following reasons:

- Installation length compensation
- Compensation for steering wheel height adjustment
- Telescopic feature in the event of an impact

### Note for service staff: Plastic sleeve replacement

It is possible to replace the plastic sleeve with a new one if it is damaged during installation.

### Note for service staff: Fitting the lower steering shaft

If the lower steering spindle has been disconnected, it is essential that the lower steering spindle be reconnected cleanly.  
New bolts must be used.  
The threads must be recut.



## Steering gear with rack

This steering gear is a purely mechanical system.

The track rods, the sleeves and the tension straps have all been adopted from the E46.

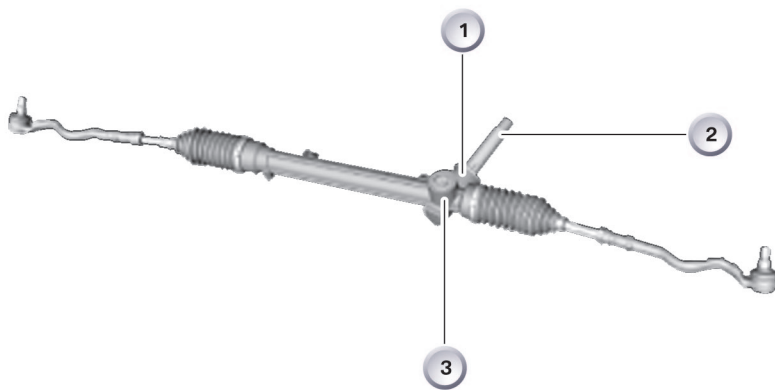
### Installation location

The steering gear is located on the front axle. It is connected to the front axle in the same way as on the E46.

### Design

A new, damped pressure piece has been integrated into the steering gear. A damper

has been integrated to supplement the spring common to conventional pressure pieces.



TF04-5429

9 - Steering gear

Index	Explanation	Index	Explanation
1	Steering gear	3	Damped pressure piece
2	Position indicator		



---

## Function

The steering forces transferred along the steering column are then transferred to the rack by a pinion. High deflection forces act on the rack due to the high steering torque transmitted by the lower steering shaft. The deflection forces push the rack away from the pinion. To counter these forces, a new,

damped pressure piece has been integrated into the steering gear.

The rack may be pushed away by high deflection forces when the steering wheel is turned rapidly. The damped pressure piece reduces design-related knocking noise when the rack suddenly returns.

---

## Note for service staff: Pressure piece play

It is no longer necessary and also no longer possible to readjust the play in the pressure piece.

# Service information

## EPS steering systems

### Notes for service staff

#### System shutdown

If the system becomes overloaded, it attempts to protect itself by reducing the power steering assistance. The driver notices the increased steering torque that needs to be applied. At the same time, the indicator lamp provides the driver with a visual signal.

Possible reasons for the initiation of protective measures:

- Power steering assistance is reduced if a fault is detected in one of the control units that are part of the system (MS45.0, DSC control unit, steering angle sensor). An entry is then stored in the fault code memory.  
The indicator lamp in the instrument cluster lights up when the system is completely shut down. The indicator lamp goes out when the fault is no longer present.
- Power steering assistance is reduced if the system temperature rises. If this reduction is not sufficient for the system to cool down, the power steering assistance will be reduced to zero. An entry is then stored in the fault code memory.  
The indicator lamp in the instrument cluster

lights up. If the system temperature falls, the power steering assistance will be restored to the value currently required. The indicator lamp goes out.

- Power steering assistance shuts down immediately to protect the end stages if there is an overvoltage greater than 17 V. An entry is then stored in the fault code memory. The indicator lamp in the instrument cluster lights up. If the voltage drops back below 16 V, the power steering assistance will be restored to the value currently required within 2 seconds. The indicator lamp goes out.
- If an undervoltage of less than 9 V is detected, the power steering assistance will immediately be reduced to zero. An entry is then stored in the fault code memory. The indicator lamp in the instrument cluster lights up when the system is completely shut down. If the voltage rises back above 10 V, the power steering assistance will be restored to the value currently required within 2 seconds. The indicator lamp goes out.

#### Steering shaft installation anti-twist lock

The steering wheel lock must be engaged in the zero position if work is to be carried out on the steering column.

The anti-twist lock below the servo unit for retaining the steering shaft in position must also be secured during repair work.

Engaging the steering wheel lock in the zero position and applying the anti-twist lock prevent the steering shaft from turning when the upper steering column is refitted. Turning the steering shaft would tear the internal steering wheel torque sensor connection cables in the flat spring cassette. The flat spring cassette is located in the housing of the worm gear and the steering wheel torque sensor.

---

## Position marking and foolproof fitting

If the lower steering shaft is removed from the steering gear, it is essential that the centre marking on the lower steering shaft be located opposite the steering gear when the spindle is refitted.

There are plastic indicators on the upper steering shaft and steering gear that indicate whether the lower steering shaft has been

fitted correctly.

These plastic indicators also ensure that the parts are fitted into each other far enough before the lower spindle can be bolted to the upper steering shaft and the steering gear. The connecting bolts must pass through the hole in the indicator.

---

## Maintenance

The balancing spring should be detached before work is carried out on the upper steering column.

The pretensioning force of the balancing spring is sufficient to bend the retainers.

The following replacement parts are only available as complete assemblies:

- Upper steering column
- Lower steering shaft
- Steering gear with rack

The only mechanical components of the upper steering column that may be replaced individually are the ignition switch, the lock cylinder and the steering angle sensor. If replaced, the steering angle sensor must be recalibrated.

The only parts of the steering gear with rack that may be replaced individually are the track rods.

## Coding and diagnostics

---

### EPS control unit

The EPS control unit must be recoded if the EPS is replaced. The coding procedure is the same regardless of whether or not there is an FDC button.

---

### Steering angle sensor

The steering angle sensor must also be recoded if replaced.

---

### Diagnosis

EPS system diagnosis is fully compatible with the application program of all diagnosis queries.





# Contents

## Servotronic

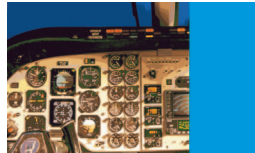


### Introduction

Servotronic

1

1

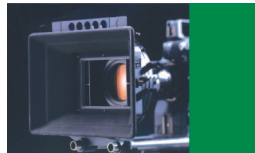


### System overview

General overview E83

3

3



### Functions

Control units

System functions

E83 Servotronic control unit (SVT)

E83 Servotronic valve

E83 general information for service staff  
concerning

5

5

6

8

9

10



# Introduction

## Servotronic

### Servotronic

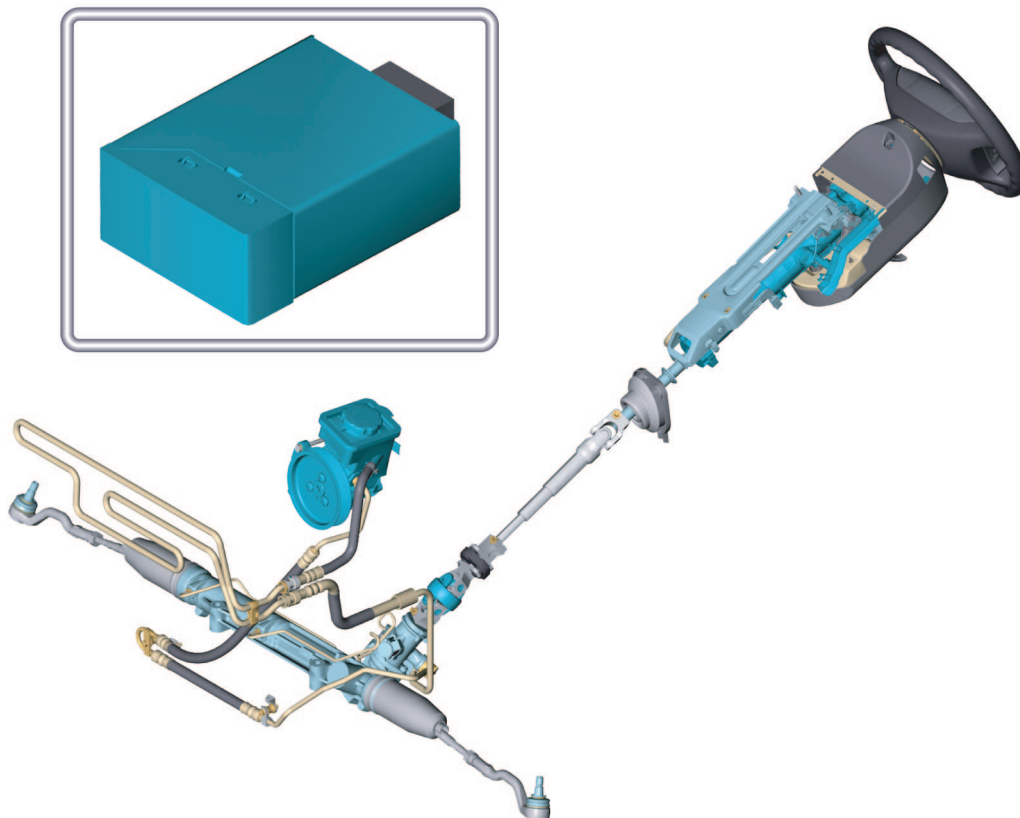
The following component and function descriptions are based on the BMW X3 (E83) as an example. Servotronic is available as an option (SA 216).

Servotronic steering is based on the proven power-assisted rack and pinion steering. The special feature of Servotronic is the control of steering force support as a function of road speed and not engine speed, as is the case with conventional systems. This is made possible by an electrohydraulic pressure converter (Servotronic valve). Servotronic regulates the hydraulic pressure in the power steering pump. The adjustment of hydraulic

pressure in relation to road speed has the following effects:

- high steering force support at low road speeds
- minimal steering force support at high road speeds

This means that only minimal effort is required to steer at low speeds. Steering force support is continuously reduced with increasing road speed. Steering feedback is more direct and more precise. The result is a marriage between high levels of comfort and maximum manoeuvrability, e.g. when parking.



1 - Servotronic steering diagram

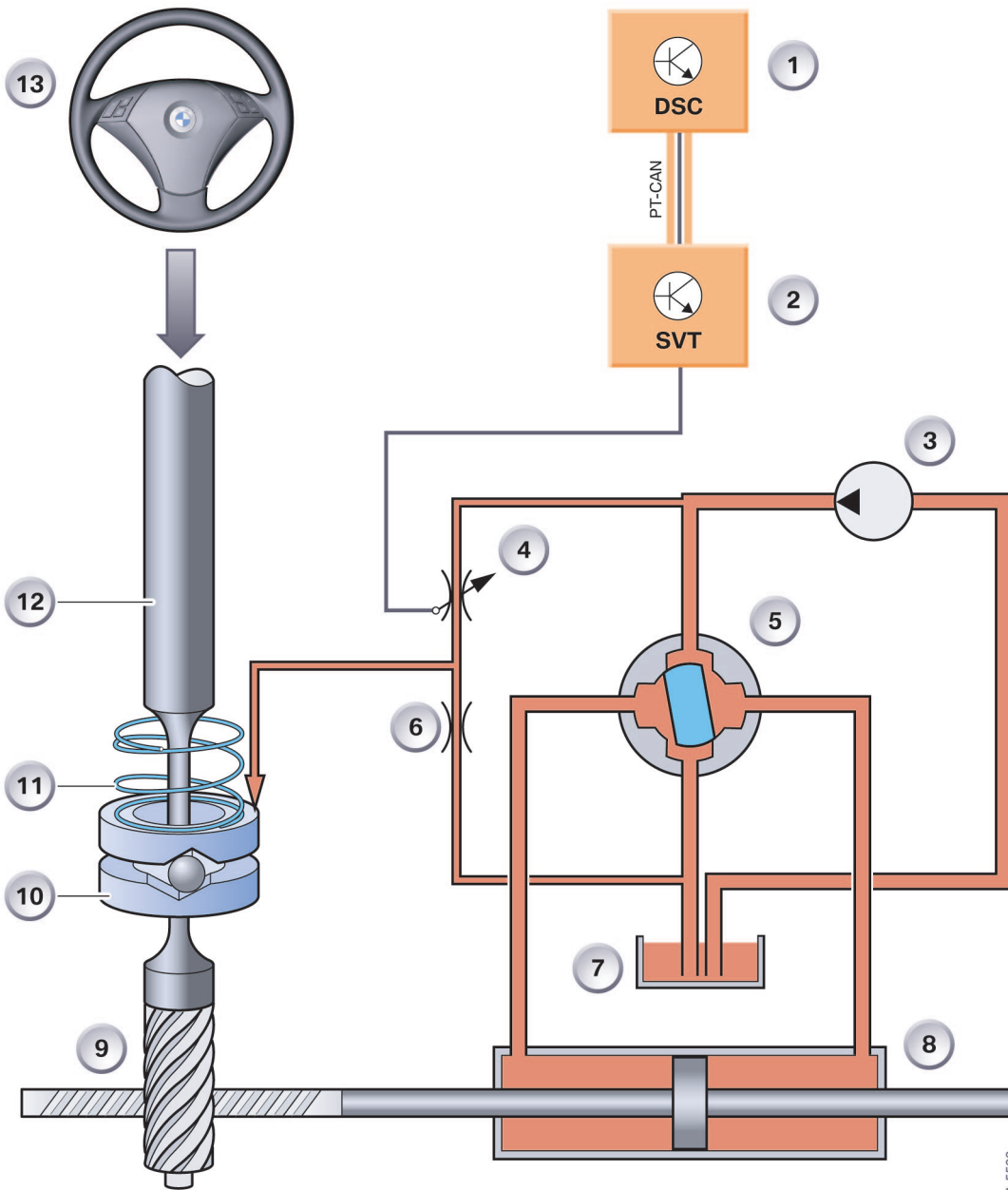
TF04-5520



# System overview

## Servotronic

### General overview E83



TF04-5523

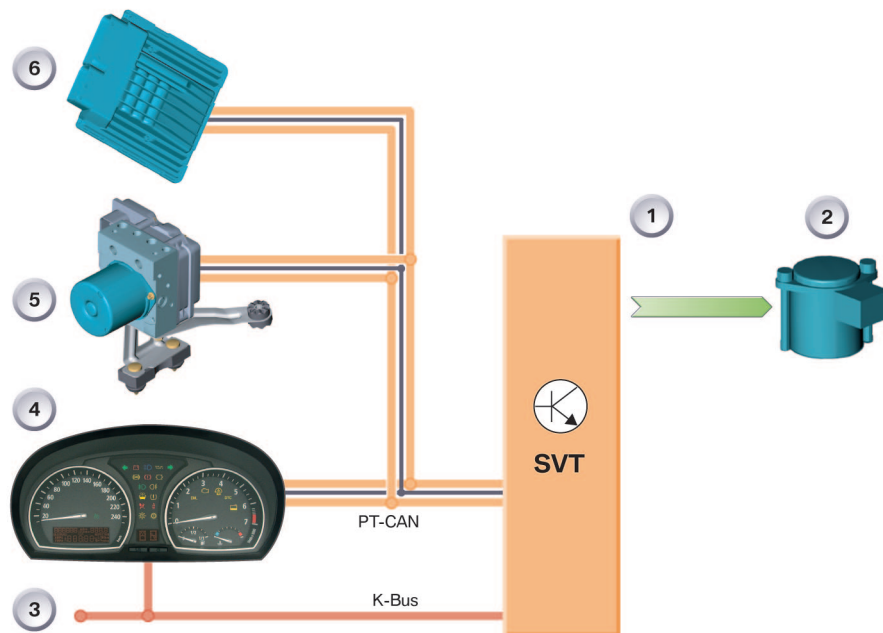
1 - Hydraulic circuit diagram general overview

Index	Explanation	Index	Explanation
1	Dynamic stability control (DSC)	8	Piston on the rack
2	Servotronic (SVT)	9	Steering gear
3	Power steering pump	10	Centring unit
4	Servotronic valve	11	Spring for the centring unit
5	Rotary slide in the steering gear	12	Torque rod
6	Throttle	13	Steering wheel
7	Expansion tank		

The torque bar's main priority is to generate the return forces for the steering. There is a centring unit integrated into the steering gear.

The centring unit assists the steering in restoring the steering wheel centre position. The behaviour of the centring unit is another variable in the design of the steering.

## E83 inputs/outputs



2 - CAN with components

Index	Explanation	Index	Explanation
1	Servotronic (SVT)	5	Dynamic stability control (DSC)
2	Servotronic valve	6	Digital engine electronics
3	Connection to body bus	K-Bus	Body bus
4	Instrument cluster	PT-CAN	Powertrain CAN

TF04-5521

# Functions

## Servotronic

### Control units

The following control units are part of the Servotronic system:

- Servotronic control unit (SVT)
- DSC control unit
- Digital motor electronics or digital diesel electronics (DME or DDE)
- Instrument cluster (KOMBI)

---

#### Servotronic control unit (SVT)

The SVT control unit issues the reference values for controlling the Servotronic valve (hydraulic pressure). The SVT control unit is connected to the PT-CAN (Powertrain CAN) and the K bus (body bus).

Servotronic does not shut down if the mileage signal fails (no function restriction). The

"Mileage 0000" entry is stored in the fault code memory. The SVT control unit enters idle status (sleep mode) within 30 seconds of terminal 15 OFF.

The SVT control unit is woken again when terminal 15 is switched ON.

---

#### DSC control unit (dynamic stability control)

The DSC control unit sends the signal for the road speed. The DSC control unit and the SVT control unit are connected by the PT-CAN.

---

#### Digital motor electronics and digital diesel electronics (DME and DDE)

The DME or DDE sends the signal indicating whether the engine running to Servotronic on the PT-CAN. Servotronic only controls the

Servotronic valve when the engine is running and terminal 15 is switched ON.

---

#### Instrument cluster (KOMBI)

With the aid of the K-bus, the instrument cluster makes available the terminal status (e.g. terminal 15 ON) and the kilometre reading.

## System functions

Servotronic operation requires following system functions/conditions:

- Initialization of Servotronic
- Detection of road speed
- Current supplied to the Servotronic valve
- Undervoltage and overvoltage detection

---

### Initialization of Servotronic

Servotronic is activated when terminal 15 is switched ON. A brief Servotronic initialization phase (less than one second) is necessary for the low-speed characteristic curve to be

achieved as rapidly as possible. A plausibility check for the supply of current to the Servotronic valve is carried out during this initialization phase.

---

### Detection of road speed

The speed signal is calculated by the DSC and sent on the PT-CAN. Servotronic specifies an acceleration value for checking the plausibility of the speed signal. A speed signal is calculated from this acceleration value. With low acceleration, the speed signal sent

by the DSC is used.

With high acceleration, the Servotronic control unit calculates the road speed internally. The road speed is stored in the Servotronic control unit.

---

### Current supplied to the Servotronic valve

The Servotronic valve is supplied with current as a function of road speed. The power steering assistance characteristics are represented in a characteristic curve. The characteristic curve indicates the current in relation to the road speed. The characteristic curve is described by 16 reference points.

When the engine switched OFF (via PT-CAN), the Servotronic valve is no longer supplied with current. Minimal power steering assistance is set when the Servotronic valve is not supplied with current (high speed). In addition, the Servotronic valve is no longer supplied with current if an entry is stored in the fault code memory.

---

### Undervoltage and overvoltage detection

The Servotronic valve stops being supplied with current under the following conditions:

- Supply voltage less than 9 V
  - Supply voltage greater than 17 V
- Voltage dips are detected in ignition faults.





---

## Activation conditions

The activation conditions for Servotronic are:

- Terminal 15 ON
- Engine running.

Servotronic only controls the Servotronic valve if the engine is running.

Servotronic sets the maximum power steering assistance available if no speed signal is present when the engine is started.

If a plausible speed signal is detected, the Servotronic valve is controlled according to the characteristic curve. Minimum power steering assistance is set if still no speed signal (or no plausible signal) is detected within 5 seconds of the engine start.



## **E83 Servotronic control unit (SVT)**

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### **Installation location on E83**

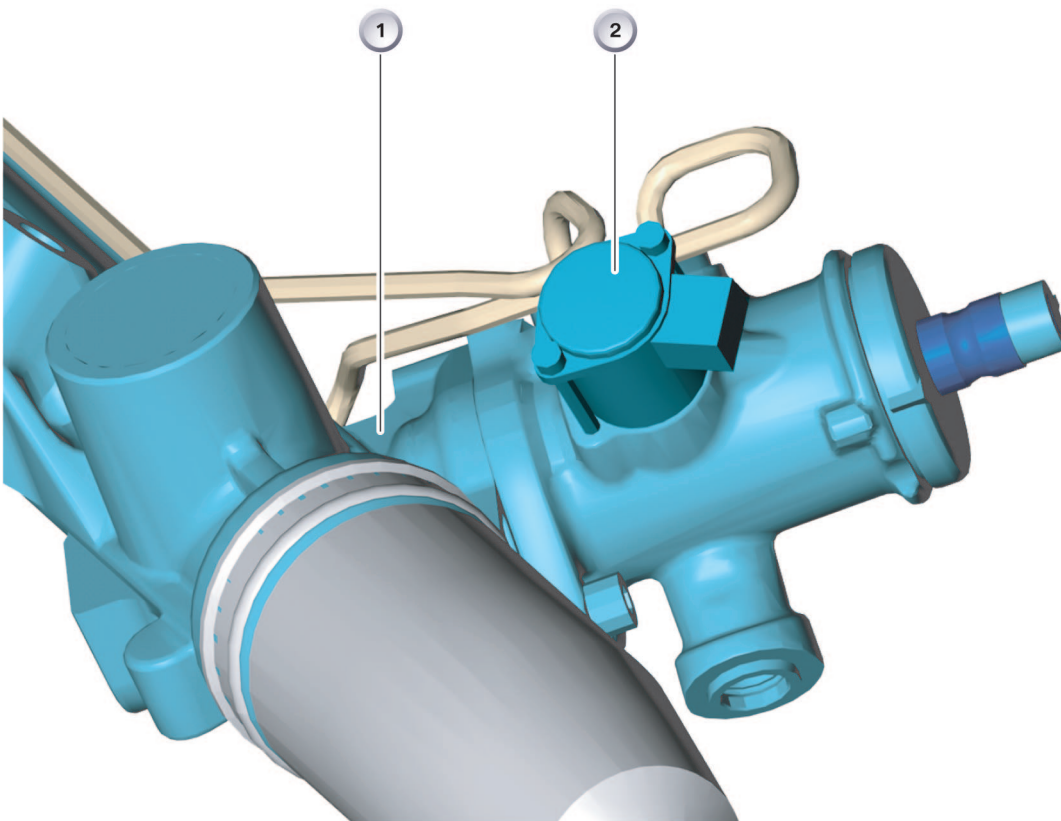
The SVT is fitted to the equipment carrier behind the glove compartment. The installation location is the same on right-hand-drive and left-hand-drive vehicles, but the installation position of the Servotronic control unit within the equipment carrier is different.

## E83 Servotronic valve

The Servotronic valve is an electrohydraulic converter located in the power steering hydraulic fluid circuit. The Servotronic valve throttles the flow of hydraulic oil and thus reduces the hydraulic pressure.

The Servotronic valve is controlled directly by the Servotronic control unit in relation to a characteristic curve and therefore works like an actuator.

The Servotronic valve is fitted directly to the steering gear.



TF04-5525

1 - Servotronic valve

Index	Explanation	Index	Explanation
1	Steering gear	2	Servotronic valve

### Design

The Servotronic valve is an electrohydraulic converter. A variable stop is integrated into the Servotronic valve. The diameter of the variable stop is between 0.0 and 0.7 millimetres.

## E83 general information for service staff concerning Servotronic

⚠ Do not hold the steering wheel at full lock for longer than is necessary. The power steering pump does not have a limit stop shut down. Holding the steering wheel at full lock for long periods (more than 1 minute) could damage the power steering pump. ◀

⚠ Different power steering pump depending on the engine variant. Different power steering pumps may be fitted, depending on the engine variant. On vehicles with a petrol engine, the expansion tank is not fitted directly to the power steering pump. The expansion tank is bolted to the power steering pump on vehicles with a diesel engine. ◀

⚠ Cooling fins instead of cooling loop. The power steering cooler on vehicles with a diesel engine is designed with cooling fins rather than a cooling loop (design also planned for vehicles with a petrol engine). ◀

# Contents

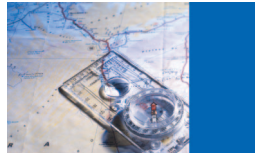
## Traction control and stability systems



### Objectives

Useful information for the reader

1  
1



### Introduction

History

3  
3



# Objectives

## Traction control and stability systems

### Useful information for the reader

Development shows that traction control and stability systems are becoming ever more complex. In addition to providing basic information, the following pages describe how these systems are integrated into dynamic driving control systems.

You will become familiar with the layout and operation of the important features of traction control and stability systems. The notes for service staff provide useful information with reference to your daily activities.

Particular emphasis is placed on the new and latest DSC8.0 and MK60 systems.

You will be able to perform diagnostics and fault finding on BMW vehicles to a professional standard.





# Introduction

## Traction control and stability systems

### History

In 1978, BMW was the first automobile manufacturer to introduce ABS systems into the series production of luxury class vehicles. ABS was available on the BMW 745i as standard, otherwise it was available as an option. There were doubts in the engineering world at first, however, concerning the longevity and reliability of the electronics in the ABS that, as you should appreciate from your work, have long since been maintenance-free. The high levels of reliability already achieved in the 1980s changed the outlook completely. Every automobile manufacturer came to recognize the benefits of ABS. As the number of manufactured systems grew into the millions, their cost fell considerably. Nowadays even the absence of ABS on a vehicle is considered to be a shortcoming. BMW set the course for ongoing development of dynamic driving control systems in vehicles.

Modern BMW vehicles are equipped with the most efficient and responsive safety system in the world as standard. Today, brake management is not only responsible for ensuring high braking efficiency at all times, it is also a component of dynamic stability control (DSC) essential to maintaining directional stability. It plays a role in achieving the most important aims of driving dynamics, such as:

- Lane handling under braking
- Avoidance of the risk of skidding when cornering
- Manoeuvrability despite full braking
- Improved pulling away on slippery surfaces and
- Reduction of braking distance in emergency situations

In short, dynamic driving control systems are among the most important developments in active driving safety in recent years. The DSC system and its modules help the driver to not only master critical situations but to drive relaxed in the knowledge that the system itself will undertake within a fraction of a second many of the decisions for which the driver would otherwise be responsible.

In the context of dynamic driving control systems, we make distinctions between translatory movements (lengthwise movements):

- front - back (along the longitudinal axis)
- right - left (along the transverse axis)
- up - down (along the vertical axis)

and rotary movements (rotational motion)

- about the longitudinal axis (rocking, rolling: suspension more heavily compressed on one side of the vehicle when cornering)
- about the transverse axis (pitching: front suspension heavily compressed, e.g. under full braking)
- about the vertical axis (yawing: the vehicle drives through a bend)

**No dynamic driving control system is able to overcome the laws of physics and take full responsibility away from the driver.**

**Drivers remain responsible for themselves and others at all times and must adapt their driving style to suit prevailing road and traffic conditions.**



# Contents

## ABS - DSC modules



### Introduction

Brake modules

1  
1



# Introduction

## ABS - DSC modules

### Brake modules

As previously described, BMW plays a decisive role in the chassis control topic. Electronic brake management is not only responsible for ensuring high braking efficiency at all times, it is also a component of dynamic stability control (DSC) essential to maintaining directional stability.

DSC optimizes:

- directional stability when pulling away and under acceleration and braking
- traction

DSC also detects unstable driving conditions such as under or oversteering. DSC helps to keep the vehicle on a safe course within physical limits.

For this to be possible, DSC must know the following dynamic driving parameters:

- the yaw rate as a measure of the rotational motion of the vehicle about the vertical axis
- transverse acceleration as a measure of the friction coefficient of the road surface
- the road speed

Also detected are the steering angle desired by the driver and the brake pressure exerted by the driver at the brake pedal. In addition, wheel speed sensors provide information about the speed of individual wheels. The actual status of vehicle movement at a given time is determined from the measured values available. The actual status is compared with target values calculated in the DSC control unit. Where current actual values differ from the target status, DSC is activated and actively intervenes in the brake system or the engine control.

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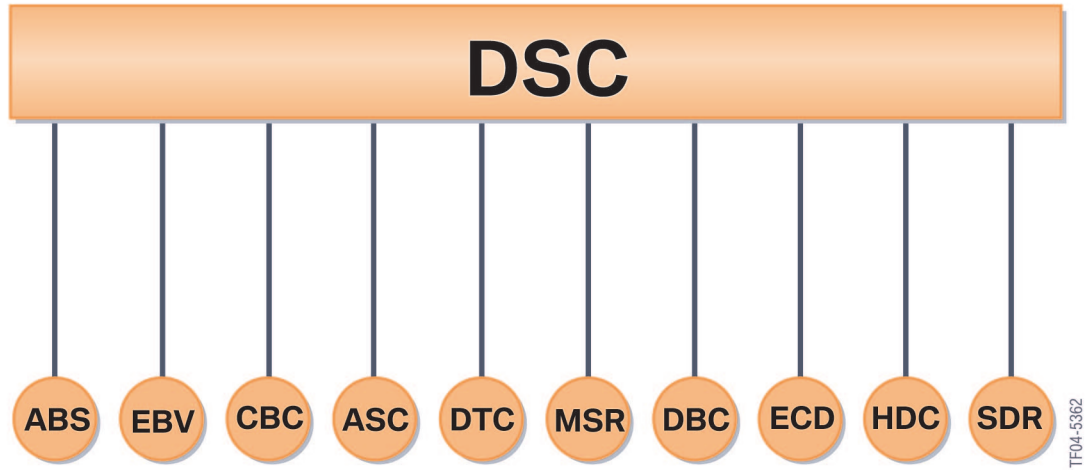
### Benefits:

With active engine and brake interventions, DSC provides outstanding directional stability and excellent traction in all road situations. DSC counteracts all negative, dynamic driving forces and thus provides, within physical limits, the highest degree of active safety possible.

DSC also enhances driving comfort through relaxed driving.

DSC, the driving assistance system, comprises various modules that work together in a complex data bus.

The most important modules of DSC are:



1 - DSC components

Index	Explanation	Index	Explanation
ABS	Anti-lock braking system	EBV	Electronic brake power distribution
CBC	Cornering brake control	ASC	Automatic stability control
DTC	Dynamic traction control	MSR	Engine drag torque control
DBC	Dynamic braking control	ECD	Electronically controlled deceleration (only with ACC)
HDC	Hill descent control	SDR	Overrun differential control

**This list shows the most important DSC components used in vehicles with Mk60 and DSC 8.0.**

---

## Dynamic Stability Control DSC Mk60

The system supplier for **DSC Mk60** is Continental Teves.

The E85 is equipped with Dynamic Stability Control Mk60 as standard. DSC Mk60 was

first used in the E46 from 09/2000, but without the DTC function (DTC = dynamic traction control). The DTC function has been available as part of DSC Mk60 since 09/2001.

---

## Dynamic Stability Control Bosch DSC 8.0

The system supplier for the **DSC 8.0** is Bosch.

The new 5 Series BMW (E60, E61) and the new 6 Series BMW are equipped with dynamic stability control DSC 8.0 as standard.

DSC 8.0 is a further development to DSC 5.7 known from the E65.

The essential new features of DSC 8.0 by comparison with DSC 5.7 are:

- very compact DSC unit, approximately 25 % smaller
- approximately 30 % lighter (saving of 700 g in the module, saving of 1.8 kg through omission of the electric precharging pump)

- Connection of the DSC unit to the Chassis CAN (F-CAN) in addition to the connection to the Powertrain CAN (PT-CAN)
- Control unit memory 768 kB ROM (previously 256 kB ROM)
- Processor computing cycle time 5 to 10 ms (previously 20 ms)

There is no longer an electric precharging pump in either of the systems. This has particular consequences for changing or topping up the brake fluid. These guidelines must be observed and are described in the Notes for service staff section.

Before the DSC Mk60 and 8.0 systems are described in more detail, there now follows more general information concerning ABS.

---

## Design and operation of the passive ABS wheel speed sensor

The wheel speed sensors in a simple ABS system are passive and operate in accordance with the induction principle. It states that an induction voltage is generated in a coil if the coil is moved through a magnetic field. The permanent magnet and coil are fixed in the form of a speed sensor. Therefore the magnetic field itself must be changed. This is made possible by an increment wheel.

The wheel speed sensors detect the wheel speeds through contactless sensing of the increment wheels and they forward these values to the brake control unit as sinusoidal alternating voltage signals. There they are converted into a measurable square wave signal.

Passive wheel speed sensors do not require a power supply because the voltage is generated by the wheel rotations in the

sensor. The voltage produced in the form of a sinusoidal signal is also forwarded as a sinusoidal signal to the control unit.

The wheel speed sensor comprises a permanent magnet surrounded by a coil. The cable ends of the coil lead into a connector housing for a cable connection. The permanent magnet and the coil are cast watertight in a plastic housing.

The wheel speed sensor is fitted contact-free in the wheel carriers.

The wheel speed sensor sends the control unit decisive information concerning different wheel peripheral speeds, wheel deceleration, wheel acceleration and wheel slip. These signals are used to calculate the control variables.

---

## Summary

If an electrical conductor is moved inside a magnetic field or alters the strength of the magnetic field, the conductor will generate an electrical voltage. This voltage is known as an induced voltage.

The level of the induced voltage depends on:

- the strength of the magnetic field
- the speed with which the field is passed through
- the number of windings in the coil

Disadvantages of passive wheel speed sensors:

- Unable to detect a reversing motion of the vehicle. This is necessary for the hillholder function, which brakes the wheels accordingly to prevent the vehicle from rolling back when pulling away on uphill gradients.
- Failure to detect reversing motion on vehicles with a navigation system.
- The brake control unit cannot determine the signal quality on vehicles with passive wheel speed sensors. Consequently, the driver is not requested in good time to visit his/her BMW dealer in response to the first sign of sensor defects.



## Design and operation of the active wheel speed sensor

More and more of today's vehicles are being equipped with active, or magneto-resistive, wheel speed sensors.



TF04-5465

2 - Wheel speed sensor

Index	Explanation
1	Sensor ring/ferromagnetic wheel bearing seal carrier
2	IC sensor with Hall sensor
3	Sensor housing

This type of sensor operates in accordance with the Hall principle and has the notable feature of being able to detect forwards and reverse motion. Rotation direction detection is made possible by the internal signal offset of three appropriately arranged Hall elements in the sensor. With this type of wheel speed sensor, magnets assume the same function as the teeth of the increment wheel. The magnets are differentiated by north and south pole and are arranged alternately on a pole ring.

Unlike the passive wheel speed sensor, the active wheel speed sensor is supplied with a defined voltage and sends a square wave signal generated in the wheel speed sensor to the control unit as a data log. This data log is

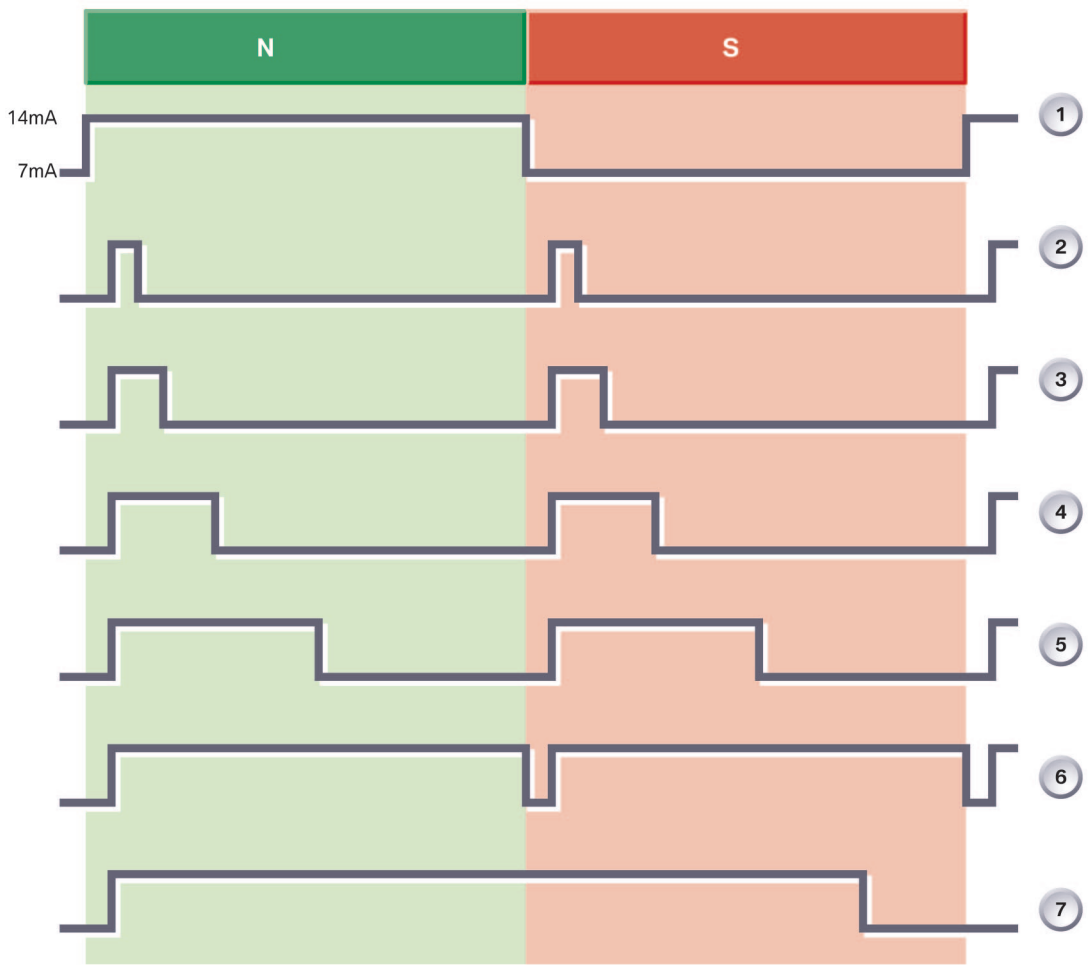
transferred as a current signal by pulse width modulation (PWM).

The current signal has levels of 14 mA and 7 mA. The latter provides evaluation information for the fault code memory. The 14 mA level is an information signal.

The brake control unit is able to derive a range of information from the width of the square wave pulse and the interval between pulses.

The wheel speed sensor at a stationary wheel sends a pulse once every 0.75 seconds.

The following chart shows the important output signals of the active wheel speed sensor.



TF04-5472

3 - PWM sensor signals

Index	Explanation	Index	Explanation
1	Internal signal sensor	6	Installation limit position, direction of rotation B
2	Air gap reserve too low	7	Stationary signal
3	Direction of rotation A	N	North pole (magnet)
4	Direction of rotation B	S	South pole (magnet)
5	Installation limit position, direction of rotation A		



### Main features of the active wheel speed sensor

1. Installation location detection:  
Indicates whether the change in magnetic field strength can be guaranteed for correct operation with a high degree of certainty.

This signal is no longer required after approximately 20 km/h.

2. Stationary detection:  
The power supply is switched on if the wheel is stationary for more than 1 second. A signal is sent to the control unit every 740 ms so that the availability of the sensor can be checked.

3. Speed signal:  
This is a frequency-dependent signal for determining the peripheral wheel speed

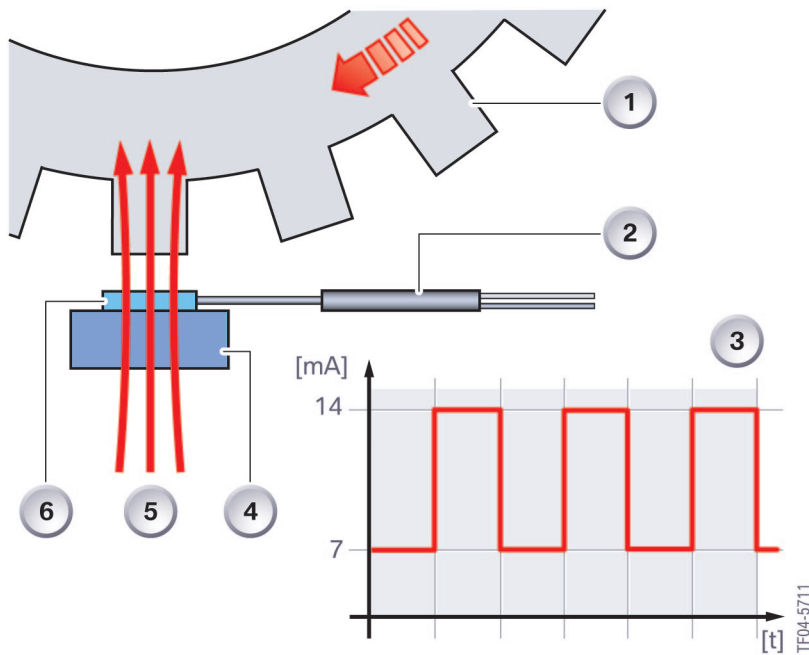
4. Rotation direction detection:  
Indicates the direction of rotation, clockwise/anticlockwise

5. Air gap reserve:  
Indicates whether the change in magnetic field strength is below the necessary value for correct operation

A two-wire line is used to transfer the signal. This two-wire interface is a combined earth and data line.

The permanent magnet in the wheel speed sensor generates a magnetic field. The lines of the magnetic field run perpendicular to the sensor layer on the sensor element.

The deviation of the fields lines caused by the increment wheel produces changes in resistance in the thin ferromagnetic layer of the sensor element.

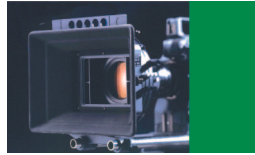


4 - Wheel speed sensor operation

Index	Explanation	Index	Explanation
1	Increment wheel	4	Permanent magnet
2	Electronic evaluation unit	5	Magnetic field lines
3	Signals from the wheel speed sensor	6	Sensor element

# Contents

## DSC 8.0 Bosch



### Functions

1

What the DSC function makes possible:

1



### System components

13

Hydraulic schematic

13



### Service information

15

Notes for service staff

15



# Functions

## DSC 8.0 Bosch

### What the DSC function makes possible:

#### System functions

DSC uses sensor signals to calculate the current driving status.

DSC corrects detected handling instabilities through active braking interventions and interventions in engine power output.

If the vehicle oversteers, for example, the front wheel on the outside of the bend is actively braked by a stabilizing torque acting in the opposite direction. In the event of vehicle understeering, active interventions at the inner cornering wheels provide a stabilizing counter-torque.

Vehicle stabilization by the DSC is implemented in all driving situations, i.e. when coasting, accelerating and braking.

#### Dynamic Stability Control DSC

The control unit uses the vehicle speed, steering angle and transverse acceleration signals to calculate the setpoint yaw angle of the vehicle while cornering. The DSC sensor supplies the actual value. A comparison is made in the control unit between the calculated yaw value and the actual yaw value. The DSC initiates control if a deviation is detected that is above a control threshold defined in the control unit.

The DSC control responds accordingly to oversteer or understeer. The control procedure involves intervening in engine management in order to reduce the tractive forces. Braking pressures are built up at the wheels which serve to stabilize the vehicle again.

The DSC function can be deactivated by means of the DSC button.

The system comprises the following functions:

- ABS Anti-lock Braking System
- ASC Automatic Stability Control
- MSR Engine drag torque control
- DBC Dynamic brake control
- CBC Cornering brake control
- ECD Electronically controlled deceleration (ACC only)
- EBV Electronic brake force distribution
- FLR Driving performance control
- DTC Dynamic traction control
- BTM Brake temperature model
- RPA Tyre failure indicator
- BBV Brake pad wear indicator
- SDR overrun differential control

#### Anti-lock Braking System ABS

ABS prevents the wheels from locking under braking.

Benefit: lane handling for the entire braking distance, the vehicle remains stable.

The braking pressure at all wheels is controlled in such a way that each wheel turns in an optimum traction range. Traction is controlled in such a way that high braking and cornering forces can be transferred.

### **Automatic Stability Control ASC**

ASC prevents wheel spin during acceleration on all types of road surface.

Control takes place at a control threshold stored in the control unit. Brake interventions are performed as well as intervention in engine management for the purpose of reducing the tractive force.

The ASC function can be deactivated by pressing and holding the DSC button for longer (3 s).

### **Engine drag torque control MSR**

The engine drag torque control prevents the rear end of the vehicle swerving out when the throttle is reduced abruptly or in the event of inappropriate downshift to a lower gear. Significant load changes are realized by temporary increases in the engine torque.

The engine drag torque control function is only activated from a driving speed of 15 km/h.

### **Dynamic Brake Control DBC**

The DBC (dynamic brake control) function is divided into 3 subfunctions:

- Dynamic brake support (DBS)
- Maximum brake support (MBS)
- Fading brake support (FBS)

Dynamic brake support (DBS):

DBS assists the driver in emergency braking situations.

The DBS function is activated when the brake pedal is depressed rapidly enough (6 bar per 1/1000 s). The driver exerts a braking pressure. As a result, the hydraulic pressure increases to such an extent that ABS control is implemented on the front and rear axle. The driver can thus achieve full deceleration with low pedal force. The system is deactivated as soon as the driver eases off the brake pedal.

Maximum Brake Support (MBS):

MBS assists the driver in normal, non-emergency braking situations. When the ABS control range is reached at the front axle, MBS increases the pressure at the rear axle until the ABS control limit is reached. Optimum braking deceleration is thus achieved as normally the driver stops pressing the brake in this situation. The system is deactivated as soon as the driver eases off the brake pedal.

Fading Brake Support (FBS):

The FBS function assists if the driver is unable to achieve full vehicle deceleration on account of poor brake pad friction coefficients, e.g. due to high thermal loads. The requirement is a high braking pressure with a simultaneously low vehicle deceleration and high brake disc temperature.

The FBS function compensates for the brake force loss through an increase in temperature.

The diminishing braking effect when brakes are hot requires the driver to press the brake pedal more firmly. This increase in pressure is now assumed by an activation of the hydraulic pump.

The brake disc temperature is not measured but rather calculated by means of the following input variables:

- Peripheral wheel speed
- Individual wheel brake pressure
- Ambient temperature
- Braking time
- Driving style (cooling phase)



## Cornering Brake Control CBC

CBC (cornering brake control) is an extension of ABS. It improves directional stability, particularly under braking when cornering.

The CBC function is activated at medium to high transverse acceleration.

If a vehicle enters a bend under braking and threatens to oversteer, an improvement in stability is achieved by partially releasing or delaying pressure build-up at the brake at the rear wheel on the inside of the bend.

In the case of braking on bends, the pressure in the rear-axle wheel brake cylinders is individually controlled. Essentially this prevents the vehicle from oversteering.

If the vehicle decelerates when cornering, CBC ensures the best possible directional stability by means of optimum brake force distribution.

CBC

- performs its control function ahead of ABS or DSC
- also functions when DSC is deactivated
- is deactivated only in the event of an ABS failure

## Electronically Controlled Deceleration ECD

ECD (electronically controlled deceleration) responds to the request of the ACC signals.

DSC executes braking retardation when deceleration is requested by ACC.

This is realized by way of automatic brake intervention at the four disc brakes. This depends on the vehicle speed, the distance and speed of the preceding vehicle at maximum  $3 \text{ m/s}^2$  deceleration.

On downhill gradients at a preselected driving speed, ECD maintains the driving speed

continuously at the preset value by way of automatic brake intervention.

The new brake pressure sensors can guarantee more uniform braking at the front and rear axles. This allows longer activation without compromising on comfort or overheating of the brakes on one axle.

In the case of automatic braking, the brake lights are activated in line with legal requirements.

The light module (LM) only lights the brake lights from deceleration of  $\geq 1 \text{ m/s}^2$ . This prevents the brake lights from coming on frequently and for brief periods.

## Electronic Brake Force Distribution EBV

When the system is intact, the electronic brake force distribution function prevents overbraking the rear axle. Rear axle influencing (HAB) ensures the rear wheels are not controlled by the ABS before the front wheels while braking. The control takes place both while driving straight ahead as well as when cornering, thus ensuring high vehicle stability.

The EBV emergency operation function prevents overbraking under the following conditions:

- Effective until the failure of 2 wheel speed sensors. The failure can occur in any order.
- Effective with intact pump motor activation (pressure-holding function or pressure decrease meeting requirements at the rear axle).
- Effective even if the admission pressure sensor fails.

In the event of system malfunctions or additional sensor faults, the driver is alerted by the red brake warning lamp in the instrument cluster.

### **Driving performance control FLR**

The FLR function protects the brakes from overload under misuse conditions.

The engine power output is reduced to a defined boundary when a temperature in excess of 600 °C is reached. This value depends on the type of vehicle. When the temperature drops below a lower limit (typically 500 °C), the reduced engine torque is increased in ramps, time-controlled, to the maximum torque.

The driving performance control function is activated as from a speed of 60 km/h.

This reduction of the engine torque is stored as a fault (driving performance control active). Should the customer find fault with the lack of engine power, this can be established by the garage/workshop and explained as brake overloading.

This function is stored in the fault code memory.

### **Dynamic Traction Control DTC**

The DTC function can be activated by means of the DSC button. The active DTC function increases the ASC slip thresholds for improving propulsion up to a speed of approximately 70 km/h. Basically the permissible slip is doubled but there is a program map in the background. This function offers advantages when driving on poor roads and thick fresh snow. Driving is not safety- but rather traction-orientated. With increasing transverse dynamics, measured by the yaw rate sensor, the slip thresholds are reduced back to the normal mode for stability reasons.

DTC may appear in the instrument cluster if DTC traction mode is activated, depending on the vehicle model concerned (no DTC display in the E46).

### **Brake Temperature Model BTM**

The BTM function determines the temperature of all four brake discs by means of a calculation model integrated by way of the software in the DSC control unit. This function uses the following input variables:

- Peripheral wheel speed
- Individual wheel brake pressure
- Ambient temperature
- Braking time
- Driving style

If the critical brake disc temperature is exceeded ( $t > 600\text{ °C}$ ) at one wheel, DSC functions may be restricted depending on the prevailing driving conditions:

- Locking interventions are reduced to zero for each individual wheel.
- Symmetrical braking torques on the corresponding axle are prohibited.
- The engine torque is limited temporarily via an algorithm for driving-performance control.

The restrictions are cancelled again when the temperature drops below another threshold ( $t < 500\text{ °C}$ ).

### **RPA Tyre failure indicator**

The RPA function is integrated in the DSC control unit.

The system is addressed separately in the training course.

### **Brake Pad Wear Indicator BBV**

The evaluation of the 2-stage brake pad wear sensors is integrated in the DSC control unit.

### **Overrun Differential Control SDR**

SDR is a special function of DSC. The SDR function switches the DSC control characteristics from understeer to oversteer and vice versa in response to a sudden change in the vehicle handling. The sudden change in vehicle handling, e.g. in connection with a load change, occurs in a bend. This has the effect of bypassing the control tendency towards neutral.

---

## **Operation**

The DTC and DSC functions can be activated and deactivated using the DSC button in the centre console switch cluster (SZM).

One brief press of the button activates the DTC function.

Pressing the button for longer (approximately 3 s) deactivates the DSC function.

However, ABS will remain active.

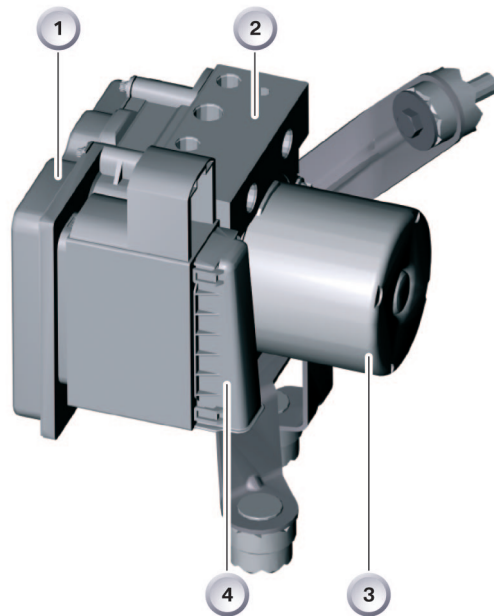
Activation and deactivation of the DTC and DSC function is indicated in the instrument cluster by warning and indicator lamps.

If the DSC button is pressed for longer than 10 s, the DSC function is activated and cannot be deactivated until the next time the ignition is switched ON. This is a safety function to account for the possibility of an object placed on the centre console (e.g. a handbag) pressing the DTC/DSC OFF button.

## Components and their functions

### DSC module as a complete component

The DSC module is located in the engine compartment.



1 - DSC module

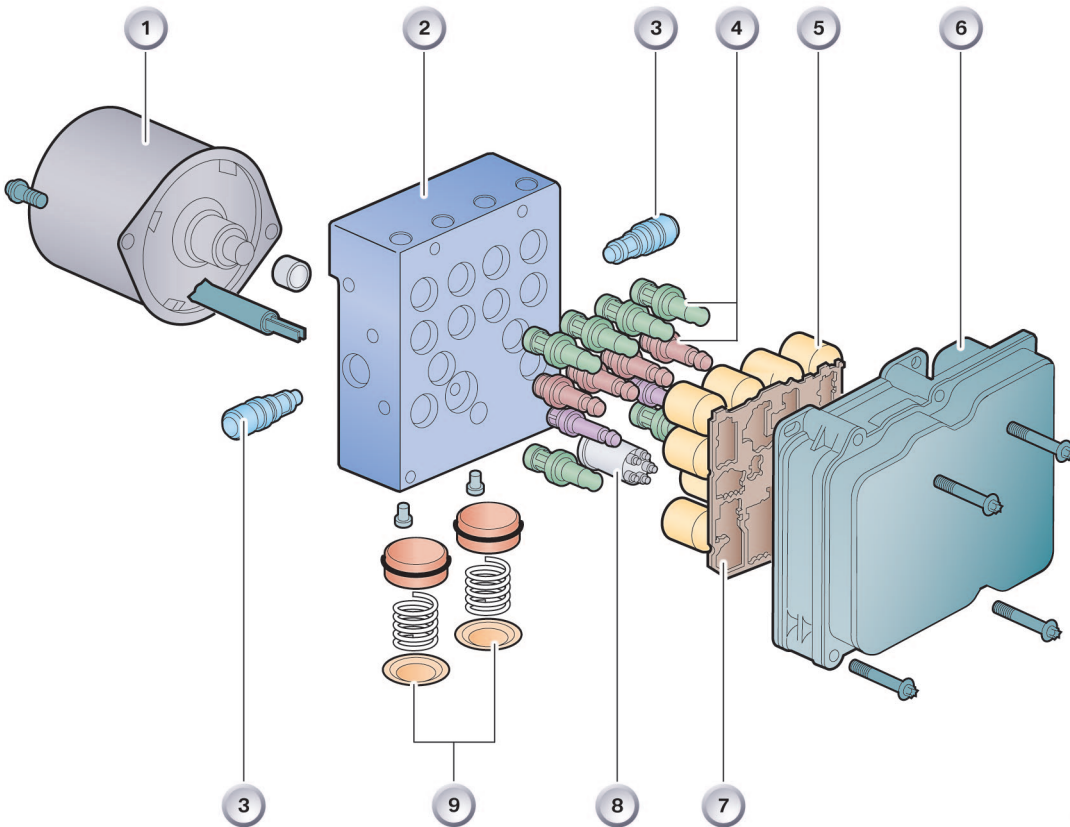
Index	Explanation
1	DSC control unit
2	Valve block
3	Electric motor (pump)
4	Plug connector

The brake pressure is built up with the aid of an electric motor during a DSC control procedure.

The brake pressure is registered by a pressure sensor integrated in the valve block. The driver determines the brake pressure by operating the brake.

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
**DSC module dismantled**  
**Design**



TF04-5367

2 - Exploded view of the DSC unit

Index	Explanation	Index	Explanation
1	Pump motor	6	Control unit housing
2	Valve block	7	Circuit board
3	Pump element	8	Internal brake pressure sensor
4	Solenoid valves	9	Accumulator chamber
5	Valve coils on the circuit board		



The DSC unit comprises the DSC control unit and hydraulic control unit. The hydraulic control unit essentially comprises the valve block and the pump motor.

The valve block contains:

- 2 pump elements driven by eccentric discs (front axle brake circuit and rear axle brake circuit)
- 12 solenoid valves
  - 2 intake valves
  - 2 changeover valves
  - 4 inlet valves
  - 4 outlet valves

- 1 internal brake pressure sensor
- 2 accumulator chambers

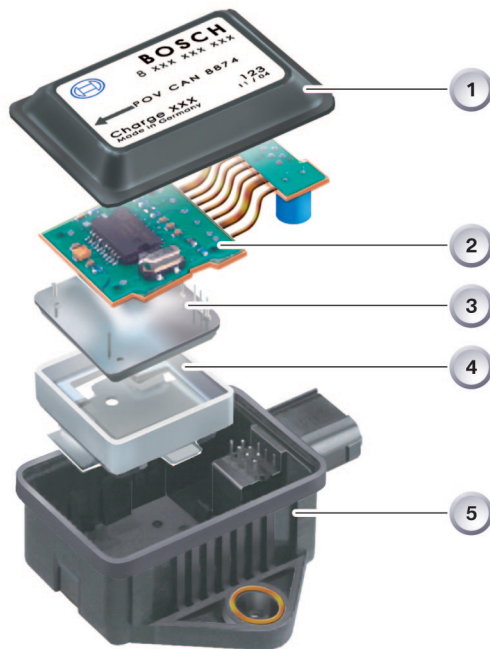
In design terms, the dividing line between the DSC control unit and the hydraulic control unit runs through the solenoid valves. The electrical components of the solenoid valves (valve coils) are assigned to the DSC control unit and directly connected to the circuit board. The mechanical components of the valve are secured in the hydraulic unit. These components mainly comprise valve domes with valve plungers.

## DSC sensor dismantled

### Installation location

The DSC sensor fitted as standard is located under the driver's seat. For safety reasons (redundancy), there is a second sensor on vehicles with active steering in addition to the standard DSC sensor. The second DSC sensor is located under the front-passenger seat.

### Design



3 - DSC sensor

TF04-5369

Each of the DSC sensors is a combination of a transverse acceleration and yaw rate sensor.

The DSC sensor comprises:

- Housing cover
- Circuit board with electronic evaluation unit for signal processing
- Sensor electronics. These are formed of 2 piezoelectric acceleration sensors. There is a spring-mounted mass in the measuring cell of the acceleration sensors.
- Damper to prevent mechanical overloading
- Housing with connector

The two DSC sensors are almost identical in technical terms. However, DSC sensor 2 has an additional terminating resistor. The two DSC sensors have different part numbers. The DSC sensors also have different identification on the CAN bus. This rules out the possibility of confusing the DSC sensors.

### Operating principle

When the vehicle accelerates, the spring-mounted mass also accelerates. The force required to do this generates a mechanical voltage in the piezoelectric material. This produces a shift in electrical charge. The shift in electrical charge is attenuated by electrodes and processed as an electrical signal. The yaw rate is derived from the difference between the two acceleration signals.

The second DSC sensor is used for redundant signal detection of the transverse acceleration and yaw rate.

The use of 2 DSC sensors makes plausibility monitoring possible. Each of the DSC sensors is triggered (excited) by the DSC control unit in a 10 millisecond cycle.

The DSC sensors output their signals on the F-CAN in response.

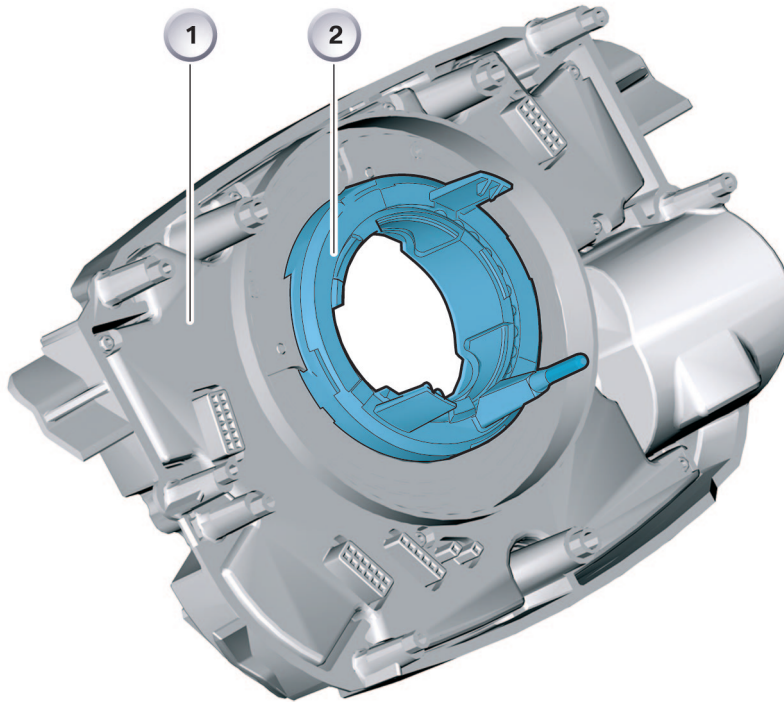
Index	Explanation
1	Housing cover
2	Circuit board with electronic evaluation unit
3	Sensor element
4	Mechanical damper
5	Housing with connector

## Steering angle sensor

### Installation location

The steering angle sensor is integrated in the steering column electronics module or

secured to the bottom of the steering shaft, depending on the vehicle model. The steering column electronics module is a component of the steering column switch cluster (SZL).



TF04-5370

4 - Steering angle sensor

Index	Explanation	Index	Explanation
1	Steering column electronics module (lower section of the steering column switch cluster)	2	Steering angle sensor

### Design

The steering angle sensor is a potentiometer with 2 sliding contacts offset by 90°. The use

of 2 sliding contacts makes it possible to detect the direction of rotation.



## Operating principle

DSC requires a steering angle value to carry out control interventions. The steering angles (2 voltage values) detected by the sliding contacts cover one full turn of the steering wheel. The voltage values are repeated after a 360° turn of the steering wheel. The steering angle sensor is thus able to count the number of steering wheel turns.

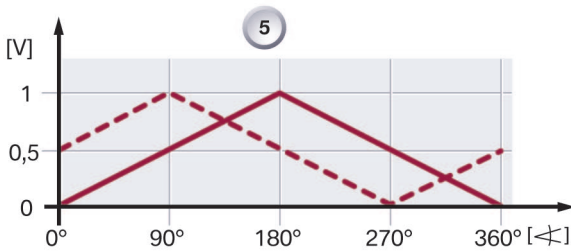
The total steering angle determined by the steering angle sensor is derived from:

- A correction value of the steering angle sensor

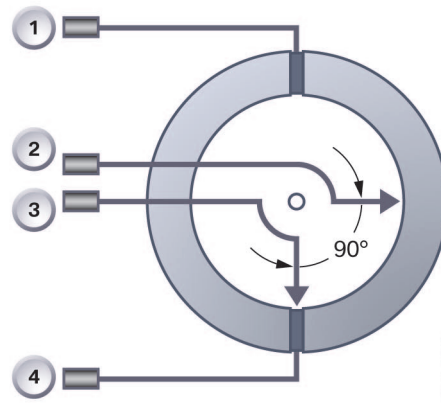
This correction value defines the straight-ahead position of the steering wheel. The correction value is defined and stored during steering angle sensor calibration.

- The currently measured steering angle
- The number of steering wheel turns

A cumulative steering angle is also detected by the cumulative steering angle sensor if the vehicle is equipped with active steering. The cumulative steering angle is the steering angle at the output of the steering gear.



5 - Function of the steering angle sensor



TF04-5743

Index	Explanation	Index	Explanation
1	Reference voltage	4	Earth
2	Sliding contact 1 voltage	5	Steering angle sensor signal
3	Sliding contact 2 voltage		

The steering angle and the number of steering wheel turns must be available when the ignition is switched ON.

For this reason, the steering column switch cluster (SZL) and thus the steering angle sensor are continuously supplied with current

via terminal 30. This means that steering wheel movements are detected even after terminal R is switched OFF.

Open circuits would lead to the loss of the steering wheel centre position stored in the steering angle sensor. For the steering angle sensor to remain functional following an open circuit, the DSC control unit must learn the steering angle by plausibility check (initialization). The DSC control unit calculates the steering angle using the wheel speeds detected at the front axle. By comparing other sensor signals, the plausibility check detects whether the vehicle is operating with the steering angle sensor calibrated incorrectly.

The following measures are initiated if the initialization process after the vehicle has pulled away does not reach a speed threshold of approximately 18 mph (30 km/h):

- DSC is shut down
- The DSC warning lamp is lit

- A fault code entry is stored in the DSC control unit (not in the steering angle sensor)

⚠ Steering angle sensor failure  
ABS remains active in the event of a steering angle sensor failure. ◀

### **Brake pressure sensors on the E60**

If the car is equipped with ACC, the left front axle and rear axle brake lines each incorporate a brake pressure sensor.

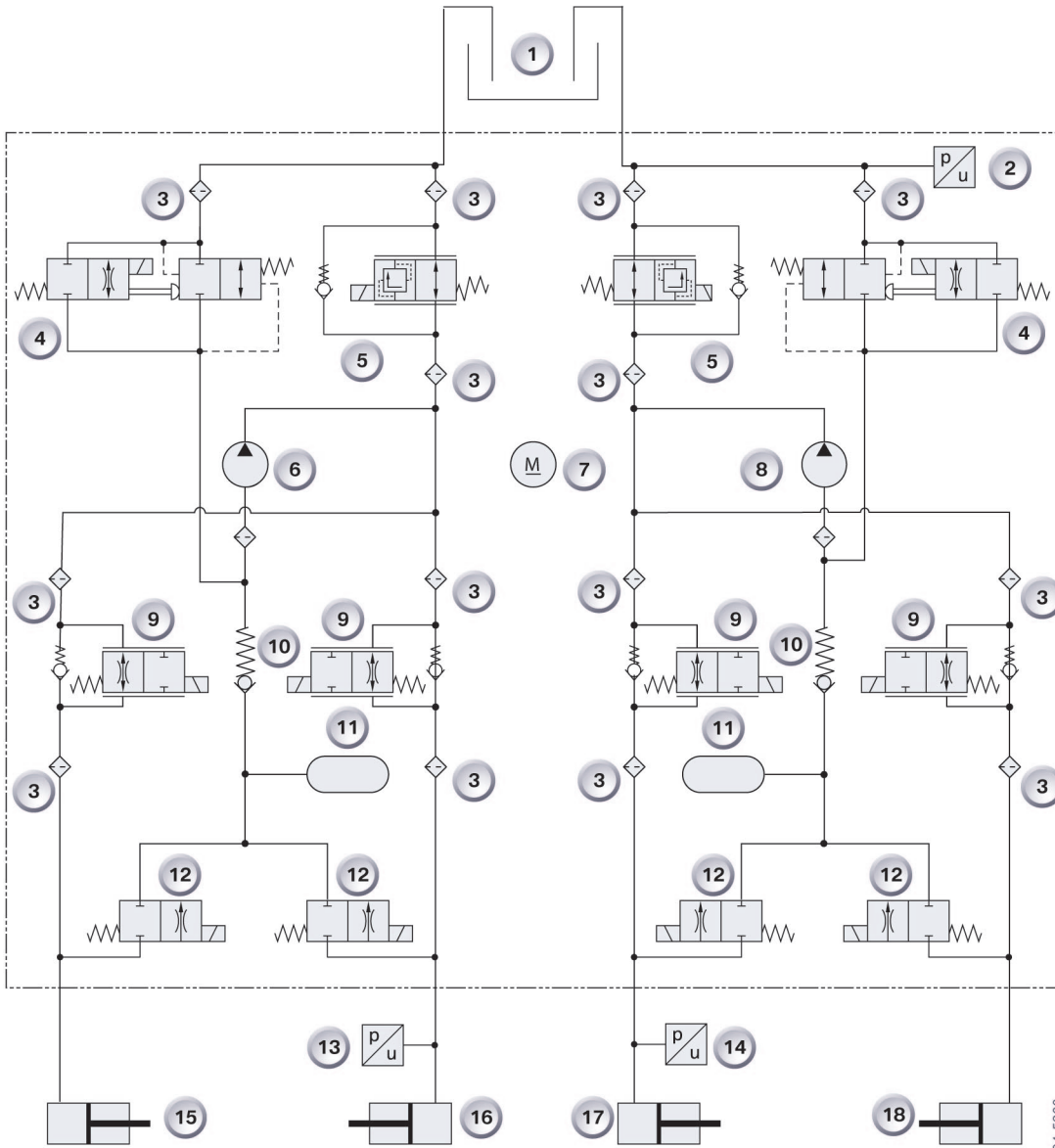
The brake pressure sensor for the front-axle brake circuit is located on the front right wheel arch.

The brake pressure sensor for the rear-axle brake circuit is located on the left side of the engine compartment at the rear.

# System components

## DSC 8.0 Bosch

### Hydraulic schematic



TF04-5366

1 - Hydraulic schematic

<b>Index</b>	<b>Explanation</b>	<b>Index</b>	<b>Explanation</b>
1	Tandem master brake cylinder	10	Non-return valve
2	Internal brake pressure sensor 2	11	Accumulator chamber
3	Fine filter	12	Exhaust valve
4	Intake valve (high-pressure switch valve)	13	Rear axle brake circuit brake pressure sensor (only with active cruise control ACC)
5	Changeover valve	14	Front axle brake circuit brake pressure sensor (only with active cruise control ACC)
6	Pump element (rear axle brake circuit)	15	Wheel brake, rear left
7	Pump motor with return pump with automatic intake	16	Wheel brake, rear right
8	Pump element (front axle brake circuit)	17	Wheel brake, front left
9	Inlet valve	18	Wheel brake, front right

# Service information

## DSC 8.0 Bosch

### Notes for service staff

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#### Service information

An open circuit to the rotation rate sensor is not detected.

The steering angle sensor has to relearn its offset after the battery has been disconnected.

The DSC control unit does not learn the steering angle until the vehicle has pulled away. The DSC indicator and warning lamp in the instrument cluster lights up if the DSC

control unit is not taught the offset steering angle before the vehicle has reached a speed of 15 mph (25 km/h).

A different DSC control unit is used in vehicles equipped with active steering. The control units for vehicles with active steering and without active steering differ in the matching resistors they use.

---

#### New features

There is a new brake fluid specification. All vehicles with DSC without a precharging pump (currently DSC8.0 and MK 60) must be filled with a new low-viscosity DOT 4 brake fluid.

All other vehicles may be filled with the new

low-viscosity DOT 4 brake fluid mixed with DOT 4. Containers marked DOT 4 brake fluid, container size 0.25 - 0.5 litres: Cap coloured red. Containers marked DOT 4 low-viscosity brake fluid, container size 0.25 - 0.5 litres: Cap coloured black.

---

#### Diagnosis

Diagnosis is performed by means of the PT-CAN.

---

#### Programming

Flash programming of the control unit is possible by means of the PT-CAN.

---

## Coding

The DSC control unit detects automatically whether the relevant vehicle is fitted with ACC, DynamicDrive or Active Front Steering.

### Important:

Do not code the steering angle sensor on vehicles with DSC 8.0. The coding as carried out on the E65 is not necessary. As a component of the steering column switch cluster, the steering angle sensor is uniquely assigned to the vehicle model.

---

## Steering angle sensor calibration

Calibration is required after the following work:

- Replacement of the steering column switch cluster (SZL)
- Programming of the steering column switch cluster (SZL)
- Replacement of the steering gear and the cumulative steering angle sensor (on vehicles with active steering)
- Work on the steering and the front axle
- Adjustment work on the steering geometry

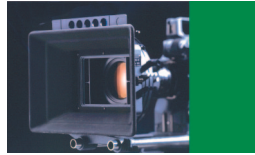
During calibration, the current position of the steering wheel is stored in the steering angle sensor as the steering wheel straight-ahead position. The front wheels and the steering wheel must therefore be brought into the exact straight-ahead position as part of the calibration process. Calibration must be carried out using the BMW diagnostic system.

**⚠** Note concerning different chassis numbers

It is not possible to calibrate the steering angle sensor if the chassis number entered in the steering column switch cluster differs from the number stored in the instrument cluster. ◀

# Contents

## DSC Mk60



### Functions

1

What the DSC function makes possible:

1



### System components

13

Hydraulic schematic

13



### Service information

15

Notes for service staff

15





# Functions

## DSC Mk60 on the E85

### What the DSC function makes possible:

- A sporty automatic stability control (ASC) and DSC tuning.
- Significantly improved traction characteristics, particularly on surfaces with low friction and high slip (gravel, deep snow).
- Greater individual freedom for the driver, because interventions have higher thresholds.

---

### DSC Mk60 has the following subfunctions:

#### Anti-lock Braking System ABS

ABS prevents the wheels from locking under braking.

Benefit: lane handling for the entire braking distance, the vehicle remains stable.

The braking pressure at all wheels is controlled in such a way that each wheel turns in an optimum traction range. Traction is controlled in such a way that high braking and cornering forces can be transferred.

#### Electronic brake force distribution EBV

EBV is a component of ABS and controls the distribution of brake force between the front and rear axle.

Benefit: Optimum braking distances and high levels of directional stability are achieved regardless of the vehicle load.

EBV permanently monitors slip values to prevent overbraking of the rear wheels in certain situations. EBV controls slip at the rear axle in relation to the front axle.

#### Cornering Brake Control CBC

CBC is an enhancement of ABS. CBC improves directional stability under braking when cornering.

Benefit: CBC ensures the best possible directional stability under braking when cornering through optimum brake force distribution.

Shifts in wheel loads when cornering (even under gentle braking) can result in a reduction in directional stability. Where necessary, CBC generates a stabilizing counter-torque under gentle braking outside the ABS intervention range.

#### Automatic Stability Control ASC

ASC prevents the wheels from spinning under acceleration.

Benefit: More traction and the vehicle remains stable.

ASC brakes the wheel that is likely to spin if a situation arises whereby one wheel on the driven axle moves over a slippery section of the road surface while the other remains on a section with adequate grip.

ASC may also intervene in the engine control (reduction in the ignition timing angle, the injection amount, the throttle valve position).

### **Dynamic traction control DTC**

The DTC function is equivalent to DSC but with a somewhat modified intervention strategy. DTC can be activated by deactivating DSC (DSC button). DTC reproduces the function of a conventional differential lock by means of brake intervention.

Benefit: Greater traction available with DTC.

Interventions to stabilize the vehicle (e.g. reduction in engine output) later than with DSC. There is therefore an improvement in traction occasionally at the expense of directional stability. A compromise between vehicle stability and traction is required particularly in connection with coefficient of friction with increased slip. Such driving situations can be found when accelerating and driving uphill on loose ground and in deep snow. DTC provides improved traction in the event of occasionally reduced stability and is therefore only recommended for exceptional situations (e.g. driving in deep snow).

### **Engine drag torque control MSR**

Engine drag torque control MSR prevents: the tendency of the drive wheels to lock on slippery surfaces under downshifts or a sudden load reversal.

Benefit: The drive wheels retain their lateral cornering forces even in overrun mode.

MSR uses the wheel speed sensors to detect the existing lockup tendency. MSR temporarily reduces engine drag by gently increasing engine throttle.

### **Dynamic braking control DBC**

DBC assists the driver in emergency braking situations by automatically boosting the brake pressure.

Benefit: Shortest possible braking distances in emergency braking situations through ABS interventions at all four wheels.

It is often the case that the brake pedal is not depressed hard enough in emergency braking situations. The result of this is that the ABS intervention range is not reached.

The return pump brings the brakes to the ABS intervention range by boosting the brake pressure:

- if the brake pedal is depressed with insufficient pedal pressure (from the signal of the brake pressure sensors)
- if the brake pedal is depressed slowly and then a high rate of deceleration is required (determined from the signal from the brake pressure sensors) if a wheel reaches the ABS intervention threshold.

The wheel that locks first depends on the load and the road surface friction characteristics.

These situations are typical:

Traffic conditions demand only gentle braking at first but then require a short braking distance.

### **Electronically controlled deceleration ECD**

ECD (electronically controlled deceleration) responds to the request of the ACC signals.

When the ACC requests deceleration, the DSC brakes the vehicle by way of automatic brake intervention at the four disc brakes. This depends on the vehicle speed, the distance and speed of the preceding vehicle at maximum  $3 \text{ m/s}^2$  deceleration.

On downhill gradients at a preselected driving speed, ECD maintains the driving speed continuously at the preset value by way of automatic brake intervention. The new brake pressure sensors can guarantee more uniform braking at the front and rear axles. This allows longer activation without compromising on comfort or overheating of the brakes on one axle.

In the case of automatic braking, the brake lights are activated in line with legal requirements.

The light module (LM) only lights the brake lights from deceleration of  $> 1 \text{ m/s}^2$ . This

prevents the brake lights from coming on frequently and for brief periods.

### **Hill Descent Control HDC**

Controls the road speed of the vehicle on steep mountainous descents by automatically initiating braking interventions. HDC makes driving down steep descents safe at all times even under the most arduous road conditions, e.g. no reduction in safety on mountain descents if the downhill gradient sharpens suddenly.

### **Overrun Differential Control SDR**

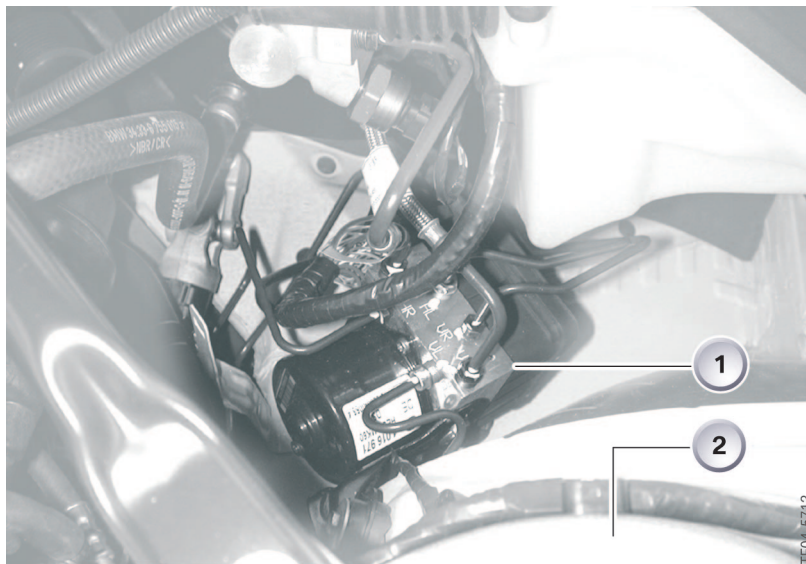
SDR is a special function of DSC. The SDR function switches the DSC control characteristics from understeer to oversteer and vice versa in response to a sudden change in the vehicle handling. The sudden change in vehicle handling, e.g. in connection with a load change, occurs in a bend. This has the effect of bypassing the control tendency towards neutral.

## Components and their functions

The system comprises the following components:

- DSC module (Mk60)
- DSC sensor
- DSC button

### DSC module



1 - Hydraulic control unit installation location

Index	Explanation	Index	Explanation
1	DSC module	2	Spring strut dome

Installation location:

The DSC module is located on the spring strut dome to the front of the engine compartment on the left-hand side.

Design:

The control unit and the valve block form one unit. However, the DSC unit is formed of electrical and mechanical components.

The electrical components of the valves (valve coils) are assigned to the DSC control unit and directly connected to the circuit board.

The mechanical components of the valve (essentially the valve cone with valve tappets) are permanently secured inside the hydraulic assembly. The valve tappets move as a result of the magnetic field generated by the valve coils. The valve tappets close/open hydraulic connections by means of the valve seat. The return pump is integrated in the hydraulic assembly. The return pump has 2 pump elements (driven by eccentric discs) that supply the front and rear axle brake circuit. The return pump is driven by an electric motor (see also Notes for service staff).

## DSC sensor

Installation location:

The DSC sensor for detecting transverse acceleration and yaw rate is located under seat on the right-hand side of the vehicle.

The DSC sensor combines the functions of the yaw rate sensor and the acceleration sensor. The DSC sensor comprises:

- Housing with connector
- Damper to prevent mechanical overloading
- Sensor element
- Housing cover

The sensor element is formed of 2 piezoelectric acceleration sensors.

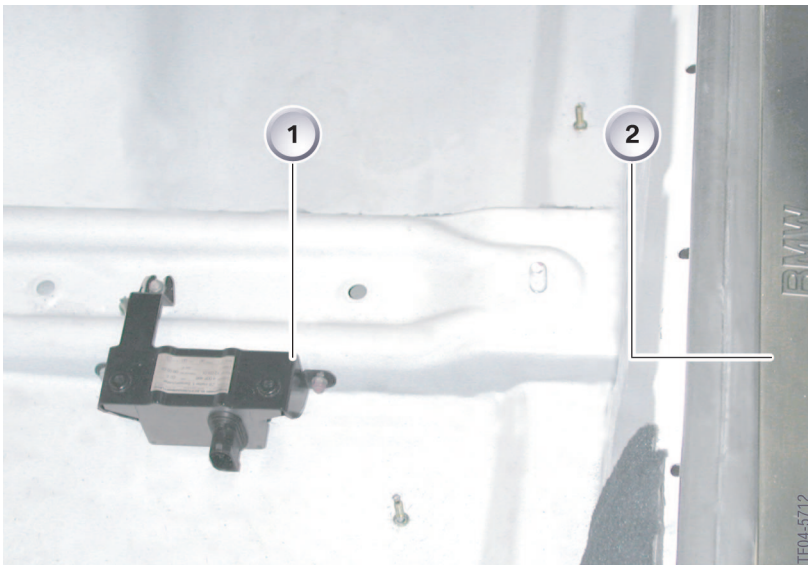
There is a spring-mounted mass in the measuring cell of the acceleration sensors.

The DSC sensor is connected to the DSC control unit by a separate CAN interface (private CAN).

### Operating principle

When the vehicle accelerates, two spring-mounted masses also accelerate. The force required to do this generates a mechanical voltage in the piezoelectric material. The resulting shift in electrical charge is attenuated by metal electrodes and processed as an electrical signal. The yaw rate is derived from the difference between the two acceleration signals.

The DSC sensor thus supplies both a yaw rate and an acceleration signal.



2 - DSC sensor installation location

Index	Explanation
1	DSC sensor
2	Sill

Operating principle:

The DSC sensor is connected to the DSC module by a separate CAN (private CAN).

### DTC button

Installation location shown on the E85:  
The DTC button is located next to the RPA button in the centre console switch cluster above the ashtray insert.



3 - Control panel

Index	Explanation	Index	Explanation
1	DTC button	3	DTC indicator lamp in instrument cluster
2	RPA button	4	DSC indicator and warning lamp in the instrument cluster

## DTC button operation

The DTC button has two different functions that are selected by pressing the button for different lengths of time.

### 1. Deactivating the DSC function

Briefly pressing the DTC button deactivates the DSC function but the DTC function remains active. The DTC indicator lamp in the instrument cluster lights up.

### 2. Deactivating the DSC and DTC function

The DSC, ASC, DTC and DBC functions are deactivated by pressing the button uninterruptedly (longer than 3 s). The DSC indicator and warning lamp in the instrument cluster lights up when the DSC functions are deactivated.

Button pressed	Function	Remark
Briefly $\leq 3$ seconds	DTC function activated	DTC indicator lamp on
And held $\geq 3$ seconds	DSC function completely deactivated.	DSC indicator and warning lamp on. This mode is intended for service staff. (e.g. on the brake dynamometer)

## Reactivating DSC:

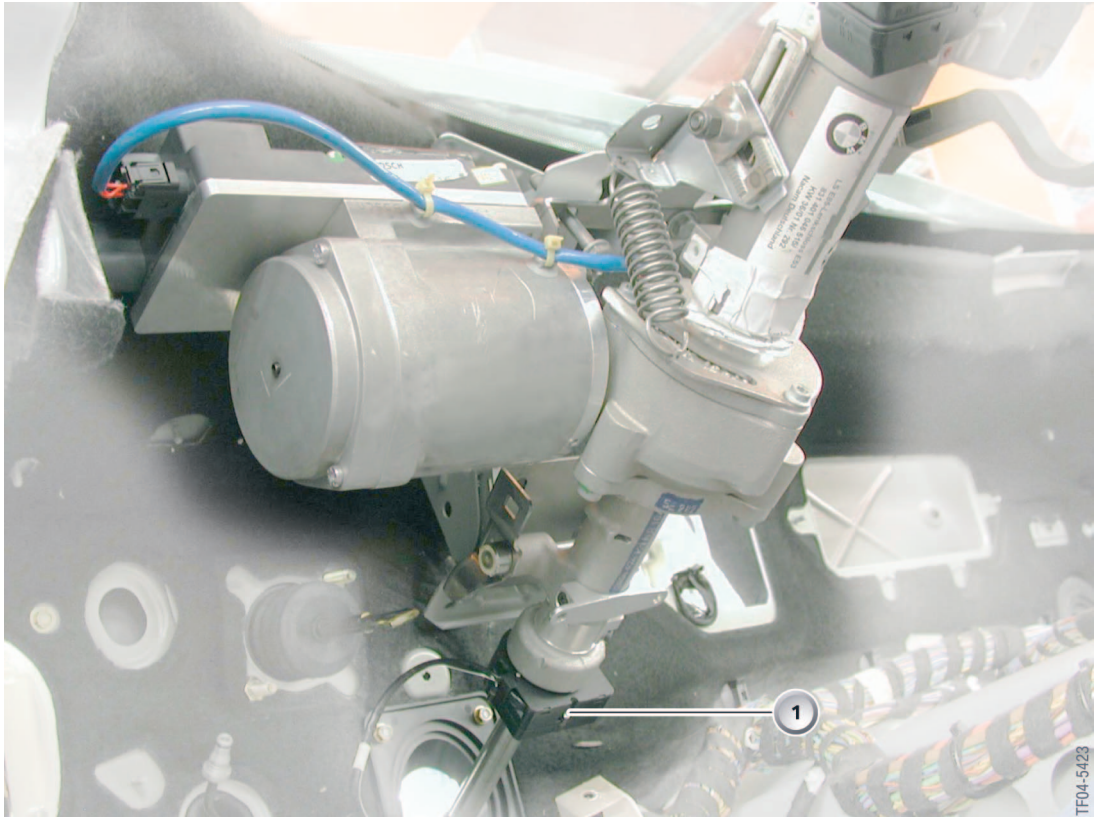
Pressing the button once more reactivates the DSC function. The DSC indicator and warning lamp goes out (except in the event of a system fault).

DSC is automatically reactivated after every engine start.

The RPA button is required for initializing (teaching in the tyre pressures) the RPA tyre failure indicator. The tyre failure indicator is a function integrated in DSC (albeit with no dynamic driving function). Reason: The speed signals from all 4 wheels are already present in the DSC.

## E85 steering angle sensor Installation location

The steering angle sensor is fitted to the steering shaft.



4 - Steering angle sensor installation location

Index	Explanation
1	Steering angle sensor

### Design

The steering angle sensor is a potentiometer with 2 sliding contacts offset by 90°. The use of 2 sliding contacts makes it possible to detect the direction of rotation.

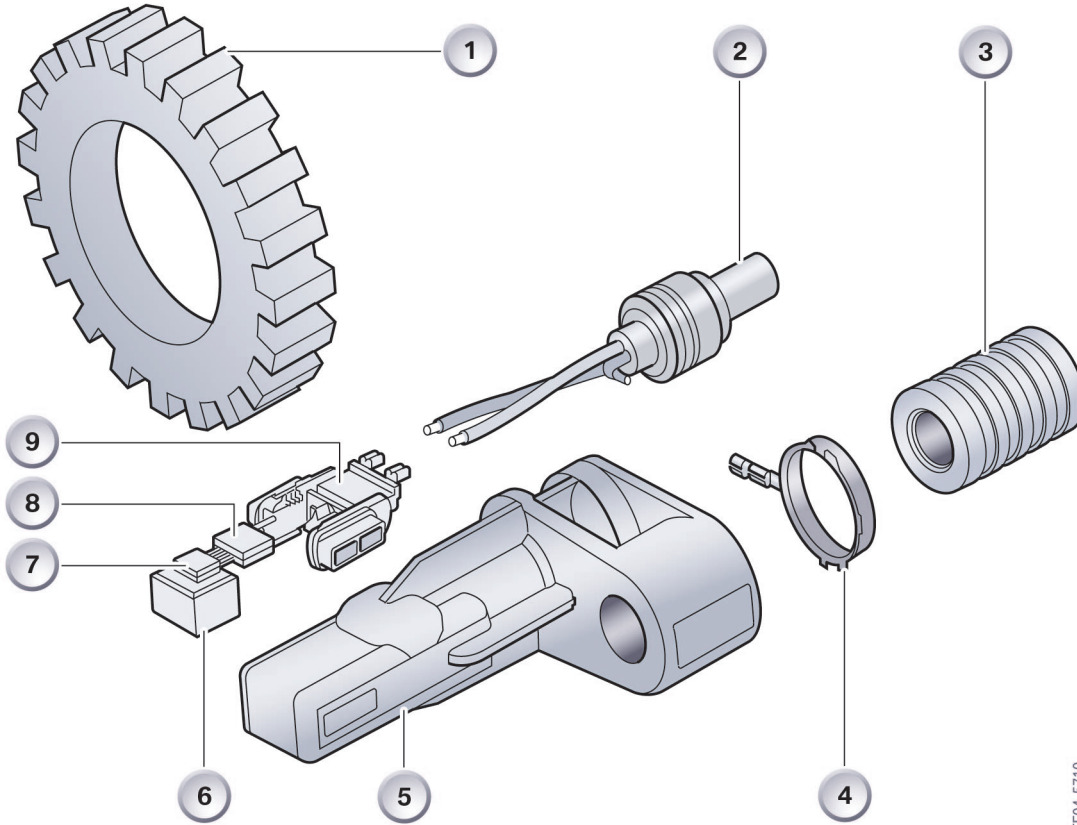
### Operating principle

DSC requires a steering angle value to carry out its functions. The steering angles (2 voltage values) detected by the sliding contacts cover one full turn of the steering

wheel. The voltage values are repeated after a 360 degree turn of the steering wheel. The steering angle sensor is thus able to count the number of steering wheel turns. The total steering angle is thus derived from the current measured steering angle and the number of steering wheel turns. The signal is converted into a digital data record (CAN message) by the steering angle sensor.



## MK60 wheel speed sensor



TF04-5710

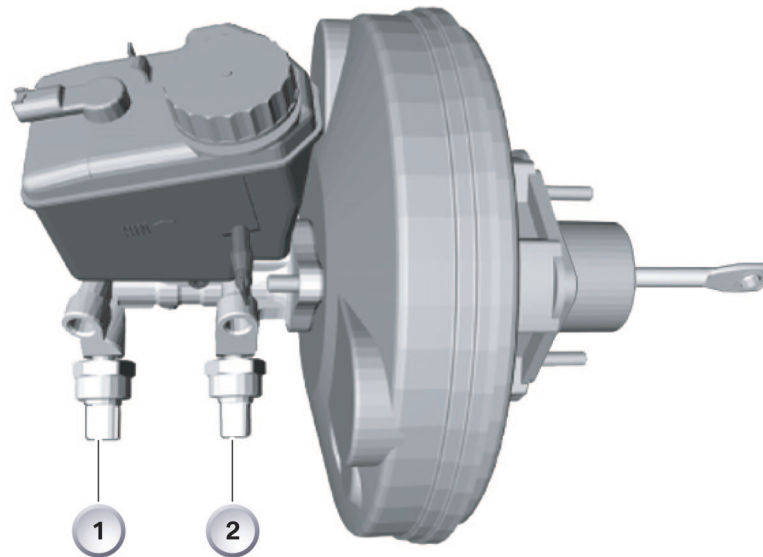
5 - Wheel speed sensor

Index	Explanation	Index	Explanation
1	Increment wheel	6	Permanent magnet
2	Sensor cable with grommet	7	Sensor element
3	Fastener	8	Electronic evaluation unit
4	Contact ring	9	Carrier for the sensor element
5	Sensor housing		

## E85 brake pressure sensors

### Installation location

The two brake pressure sensors (1 and 2) are fitted to the tandem master brake cylinder in the pressure connection with the front axle brake circuit and the rear axle brake circuit.



TF04-5717

6 - Brake pressure sensor installation locations

### Design

The brake pressure sensors are capacitive sensors. A plate capacitor acts as a pressure sensor. One plate of the plate capacitor is fixed. The other plate is spring-mounted and moves.

### Operating principle

The pressure in the hydraulic circuit exerts force on the plate capacitor. The plate gap is modified if the force acting on the moving plate of the plate capacitor changes. Changes in the plate gap change the capacitance.

The brake pressure sensor supplies an analogue signal in the measuring range of 0 to 250 bar.

The following is derived for DSC from the signal from the brake pressure sensors:

- Estimate of variables such as lateral cornering force and brake force for all relevant driving conditions (unbraked, partially braked, ABS intervention range).
- Evaluation of the pressure correction information at a wheel braked by the DSC but only if the brake is pressed during the control procedure.



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## System functions

### Dynamic traction control DTC

The driver is able to activate the DTC function by pressing the DSC button. The engine thresholds of ASC (slip thresholds) are increased up to a speed of approximately 90 mph (150 km/h) to improve propulsion.

Driving is not safety- but rather traction-orientated.

The slip thresholds are reduced again with increasing levels of transverse dynamics, measured by the transverse acceleration sensor, or increasing instability.

The DTC indicator lamp in the instrument cluster lights up when DTC traction mode is activated.

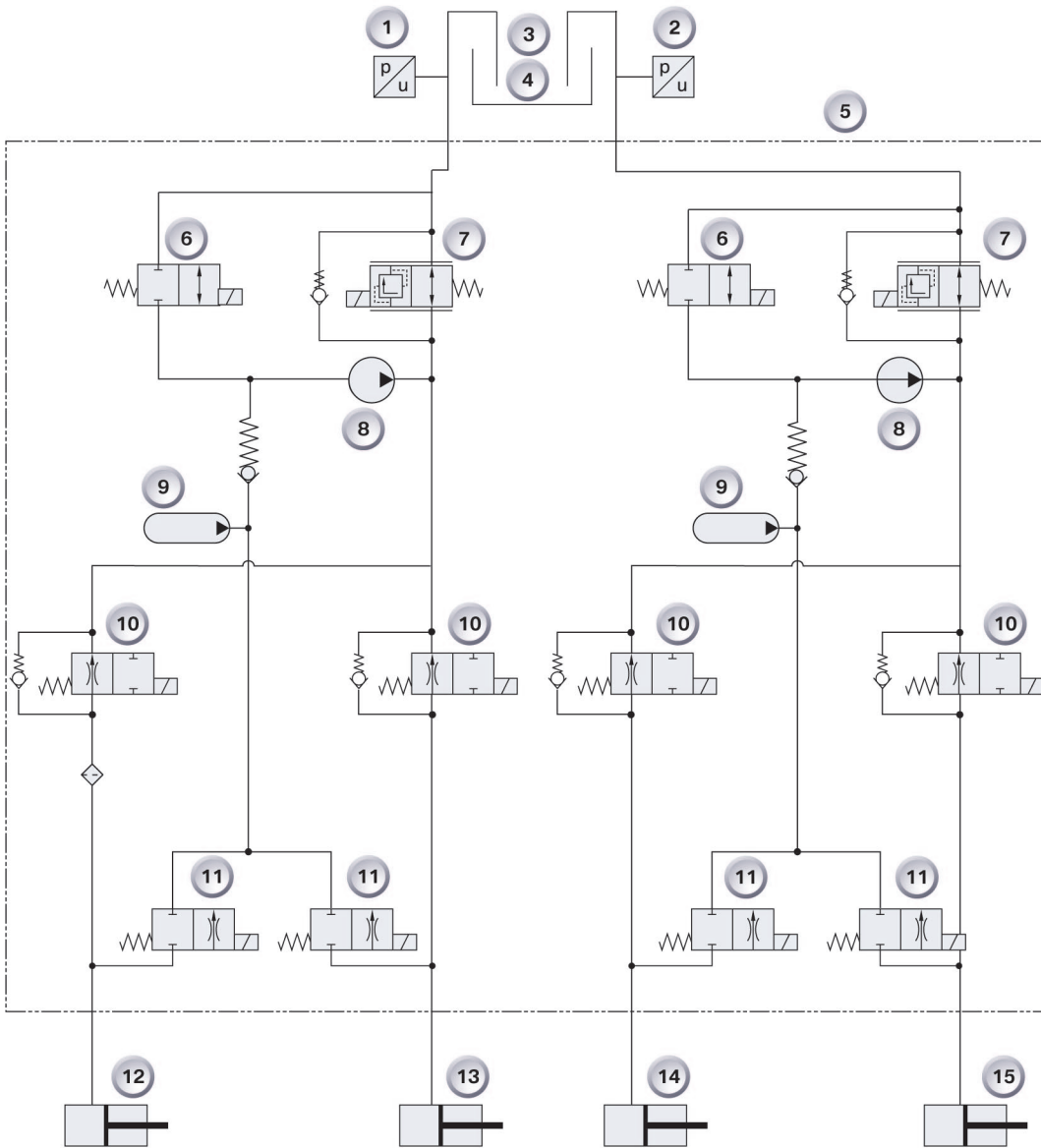
This function is beneficial on roads with loose surfaces (gravel) or deep snow.



# System components

## DSC Mk60 on the E85

### Hydraulic schematic



TF04-5/09

1 - Hydraulic schematic

<b>Index</b>	<b>Explanation</b>	<b>Index</b>	<b>Explanation</b>
1	Brake pressure sensor 1 (front axle brake circuit)	9	Low-pressure accumulator
2	Brake pressure sensor 2 (rear axle brake circuit)	10	Inlet valve
3	Expansion tank	11	Outlet valve
4	Tandem master brake cylinder	12	Wheel brake, front left
5	DSC hydraulic unit	13	Wheel brake, front right
6	Intake valve	14	Wheel brake, rear left
7	Changeover valve	15	Wheel brake, rear right
8	Return pump (pump element for the front axle brake circuit and rear axle brake circuit)		

# Service information

## DSC Mk60 on the E85

### Notes for service staff

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#### Service information

The sensors must be calibrated if the DSC control unit is replaced or if sensors that are part of the DSC system are replaced.

---

#### New features

There is a new brake fluid specification. All vehicles with DSC without a precharging pump (currently DSC 8.0 and Mk60 ) must be filled with a new low-viscosity DOT 4 brake fluid.

All other vehicles may be filled with the new

low-viscosity DOT 4 brake fluid mixed with DOT 4. Containers marked DOT 4 brake fluid, container size 0.25 - 0.5 litres: Cap coloured red. Containers marked DOT 4 low-viscosity brake fluid, container size 0.25 - 0.5 litres: Cap coloured black.

---

#### Diagnosis

The DSC Mk60 system is fully compatible with diagnostics.

---

#### Coding

##### DSC control unit

The DSC control unit must be recoded if the DSC control unit is replaced. The repair instructions must be observed.

##### Steering angle sensor

The steering angle sensor must be recoded if the DSC control unit or the steering angle sensor itself is replaced.

---

#### Calibration of sensors for DSC

Calibration is required after the following work:

- Replacement of the DSC control unit
- Steering angle sensor replacement
- Replacement of a DSC sensor
- Replacement of a brake pressure sensor
- Adjustment work on the steering geometry
- Work on the steering of the front axle

The actual values must be calibrated as part of the sensor calibration process for DSC.





# Contents

## xDrive four-wheel drive

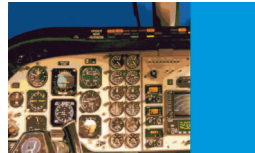


### Introduction

What is xDrive?

1

1

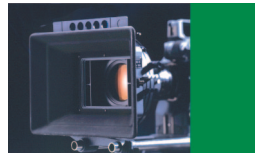


### System overview

xDrive general overview

3

3



### Functions

Functional description

Components and their functions

7

7

8



### Service information

Limp-home operation

21

21





# Introduction

## xDrive four-wheel drive

### What is xDrive?

xDrive is a four-wheel drive system with an infinitely variable distribution of drive torque between the front and rear axle. The central component is an electronically controlled clutch, the plates of which are pressed together within milliseconds by an electric motor. The higher the pressure exerted on the multi-plate clutch, the more force is transferred to the front axle. When the clutch is open, all of the engine power is transmitted to the rear axle. xDrive is in constant communication with DSC. xDrive receives the following information from DSC:

- Rotation speeds of the four wheels
- Setting of pedal position sensor
- Steering angle

Through continuous analysis of this information, xDrive is permanently able to detect whether the vehicle can fully respond to the driver's commands. xDrive will intervene with corrective measures if the wheels are likely to spin or if the vehicle is threatening to understeer or oversteer. When the vehicle tends to understeer while cornering, the drive forces are reduced at the front axle and increased at the rear axle. If a tendency towards oversteering is detected (if the rear is threatening to break out), the distribution of

drive forces is shifted away from the rear axle to the front axle. xDrive controls the distribution of drive torque between the two axles as required.

On roads with varying surface conditions (e.g. snow, ice, gravel), the drive torque is variably transferred to the axle with the better traction.

xDrive, the intelligent BMW four-wheel drive system, is an innovative concept with active vehicle dynamics control. The following advantageous features have been created by the synergy of the new all-wheel drive train with the DSC system which now includes longitudinal torque management. Vehicle stability, driving safety, agility, traction and comfort have been further improved while at the same time achieving the best possible driving performance characteristics at maximum efficiency.

- Acceleration
- Flexibility
- Top speed

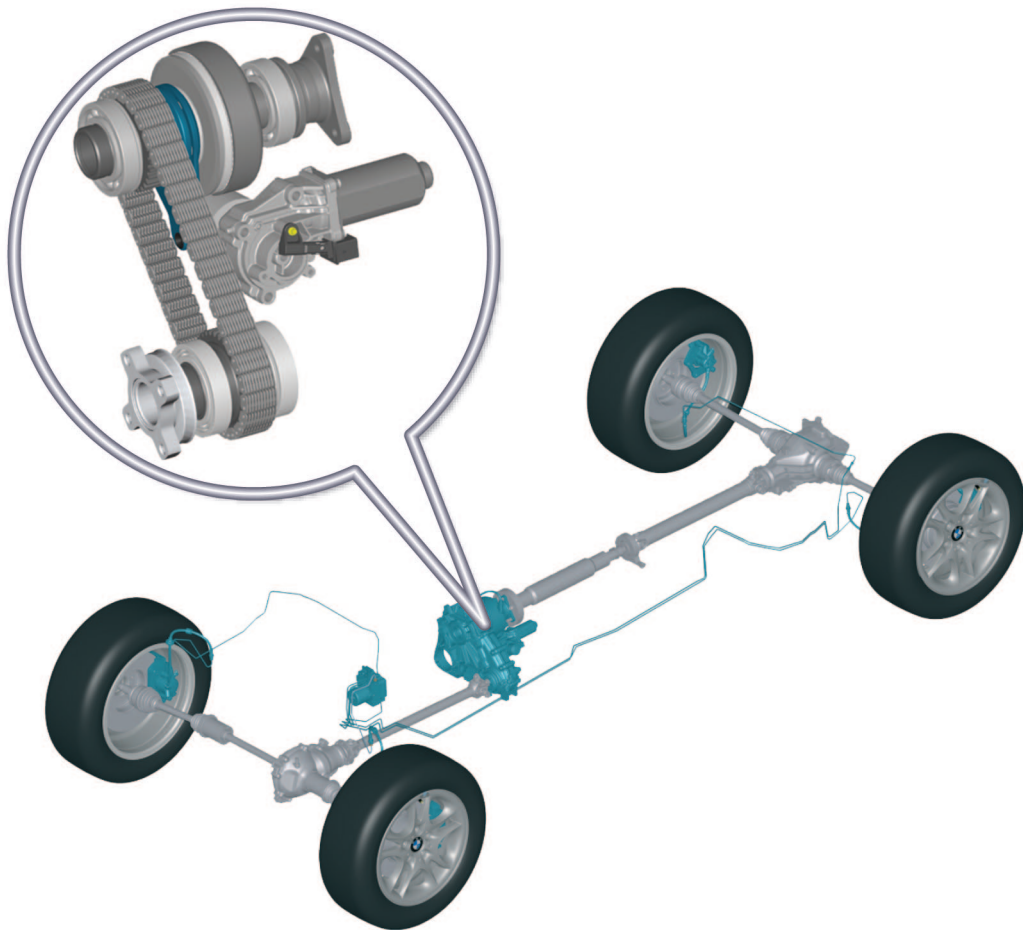
In short, excellent handling in all driving situations.



# System overview

## xDrive four-wheel drive

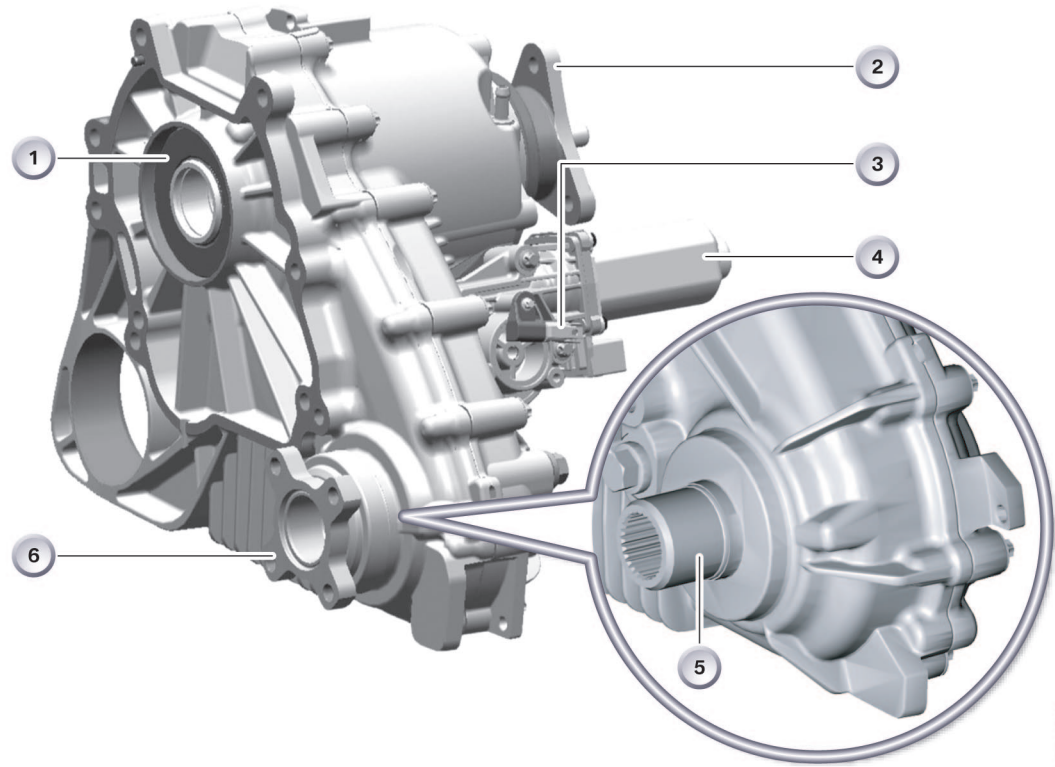
### xDrive general overview



1 - Overview of mechanical system

TFC4-5509

## Mechanical layout of transfer case

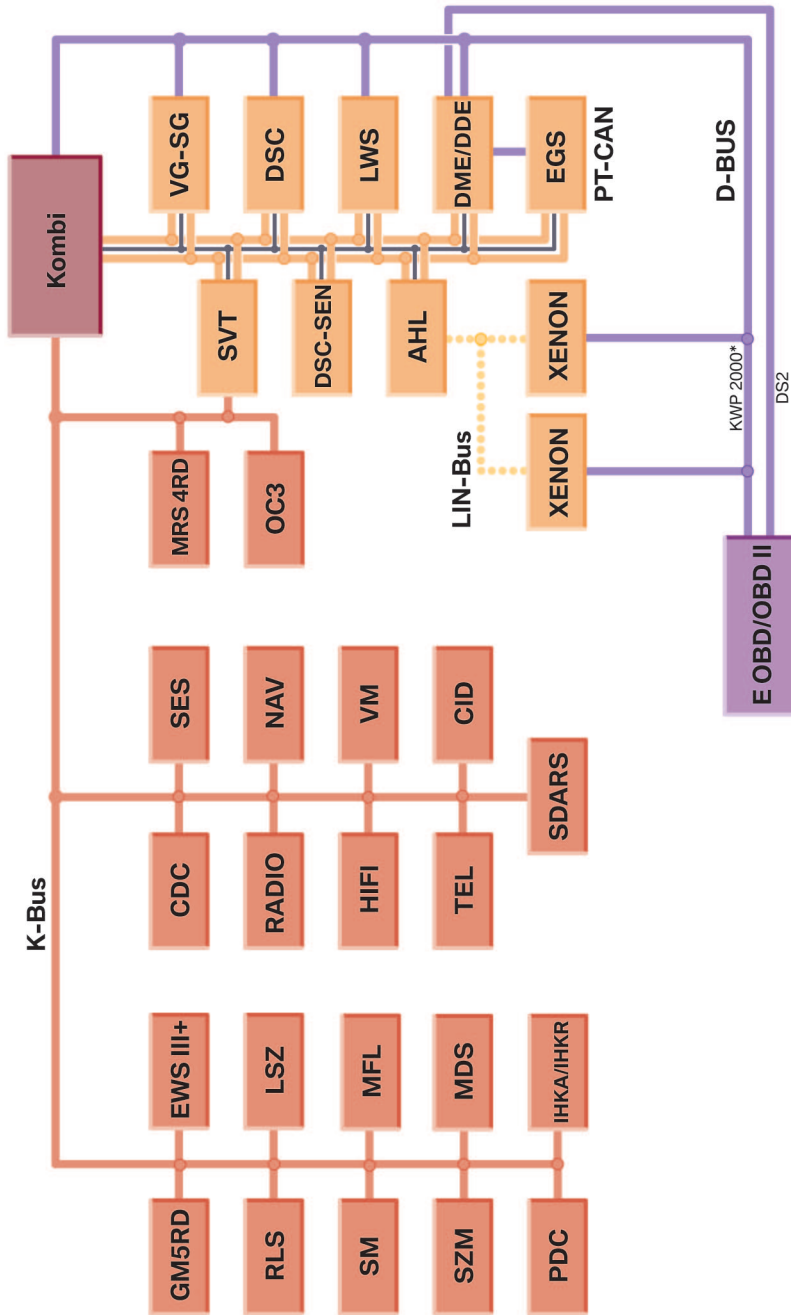


TF04-5518

2 - Overview of transfer case mechanism

Index	Explanation	Index	Explanation
1	Connection to the manual transmission or the automatic transmission	4	Servomotor
2	Connection to the rear axle	5	E53: Connection to the front axle
3	Classification resistor	6	E83: Connection to the front axle

# Bus overview



3 - Bus overview

TF04-5453

<b>Index</b>	<b>Explanation</b>	<b>Index</b>	<b>Explanation</b>
AHL	Adaptive headlight	NAV	Navigation computer
AHM	Trailer module	OC3	Occupation 3
CDC	CD changer	PDC	Park distance control
CID	Central information display	RADIO	Radio
DME	Digital motor electronics	RLS	Rain/driving light sensor
DSC-SEN	Dynamic stability control - sensor	SES	Voice-activated control system
EGS	Electronic transmission control unit	SDARS	Satellites
EWS III+	Electronic immobilizer III	SM	Seat memory
GM5RD	General module 5 Redesign	SMG	Sequential manual gearbox
HI-FI	Top-HiFi amplifier (DSP)	SVT	Servotronic
IHKA	Integrated automatic heating and air conditioning	SZM	Centre console switch cluster
IHKR	Integrated heating and air conditioning control	TEL	Telephone control unit
LSZ	Light switch cluster	VG-SG	Transfer case electronic control unit
LWS	Steering angle sensor	VM	Video module
MDS	Panoramic glass roof	XENON	Xenon light electronic control unit
MRS4RD	Multiple restraint system 4 Redesign		



# Functions

## xDrive four-wheel drive

### Functional description

xDrive, the dynamic drive control system, monitors slip behaviour at the front and rear axle. The role of xDrive is to achieve optimum traction and to stabilize or maintain the stability of the vehicle.

The following evaluation criteria are used for monitoring:

- Wheel speeds
- Yaw rate
- Transverse acceleration
- Steering angle

Under normal driving conditions with four-wheel drive, the drive torque is distributed as follows:

- 40 % to the front axle
- 60 % to the rear axle

The distribution of drive torque is dependent on the torque that can be supported at each axle. When the vehicle pulls away in 1st gear, for example, a higher load is placed on the rear axle than the front due to dynamic axle load

transfer. The rear axle is thus able to support a greater drive torque.

If, for example, the front wheels are moving on a surface with high friction and the rear wheels move over black ice, almost 100 % of the available drive torque will be transferred to the front axle. The rear axle, under hardly any load, will only be able to support a low drive torque.

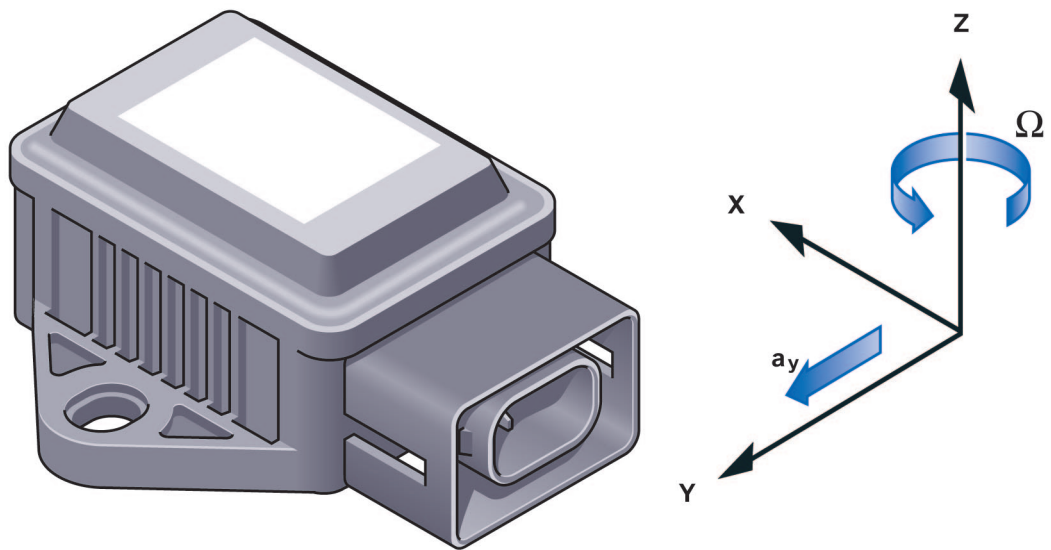
A centrifugal force is produced on a bend by transverse acceleration, which forces the vehicle to the outside of the bend. The vehicle loses stability if the centrifugal force is greater than the maximum possible lateral cornering forces of the wheels. The phenomenon whereby the front wheels of the vehicle slide towards the outside of the bend is known as understeering. Conversely, oversteering is where the rear wheel lose their grip. The rear of the vehicle is forced outwards.

The xDrive minimizes the tendency to understeer or oversteer. This is realized by optimum distribution by drive force between the rear axle and front axle.

## Components and their functions

### Yaw rate and transverse acceleration sensor

The sensor cluster in the E83 and E53 is located on the transmission tunnel level with the rear seat cross member.



1 - Transverse acceleration/yaw rate sensor

TF04-5457

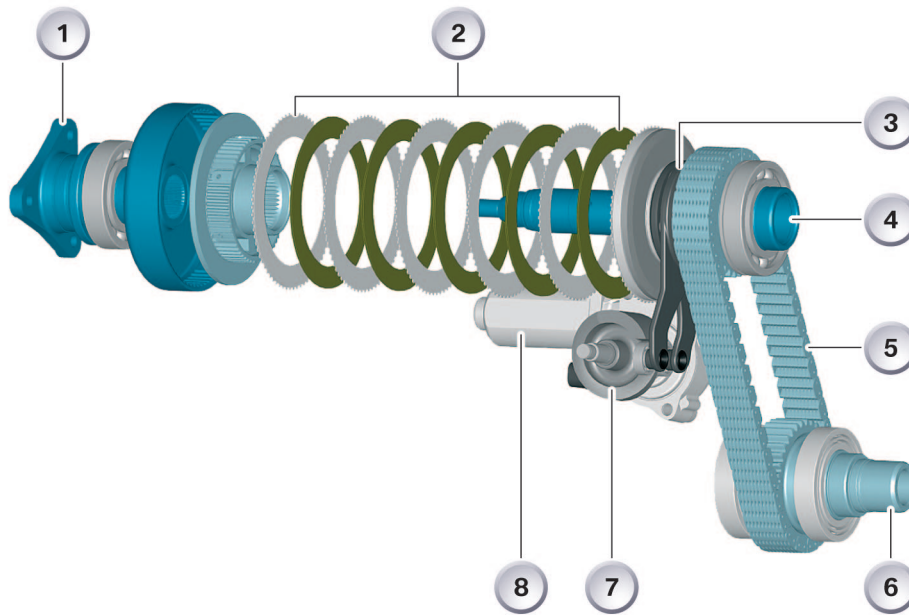
Index	Explanation	Index	Explanation
x	Vehicle longitudinal axis	$a_y$	Transverse acceleration
y	Vehicle transverse axis	$\Omega$	Yaw rate
z	Vehicle vertical axis		



## ATC 400/ATC 500 transfer case

The E83 is fitted with the ATC 400 transfer case, the E53 with the ATC 500. In connection with the ATC 500, the propeller shaft leading to the front axle gearbox has a slide-on fit. In connection with the ATC 400, the propeller shaft is secured by means of four

bolts to a flange. The multidisc clutch of the ATC 500 features an additional disc. The distance between the input shaft and output shaft to the front axle on the ATC 500 is 19 mm greater than on the ATC 400.



TF04-5517

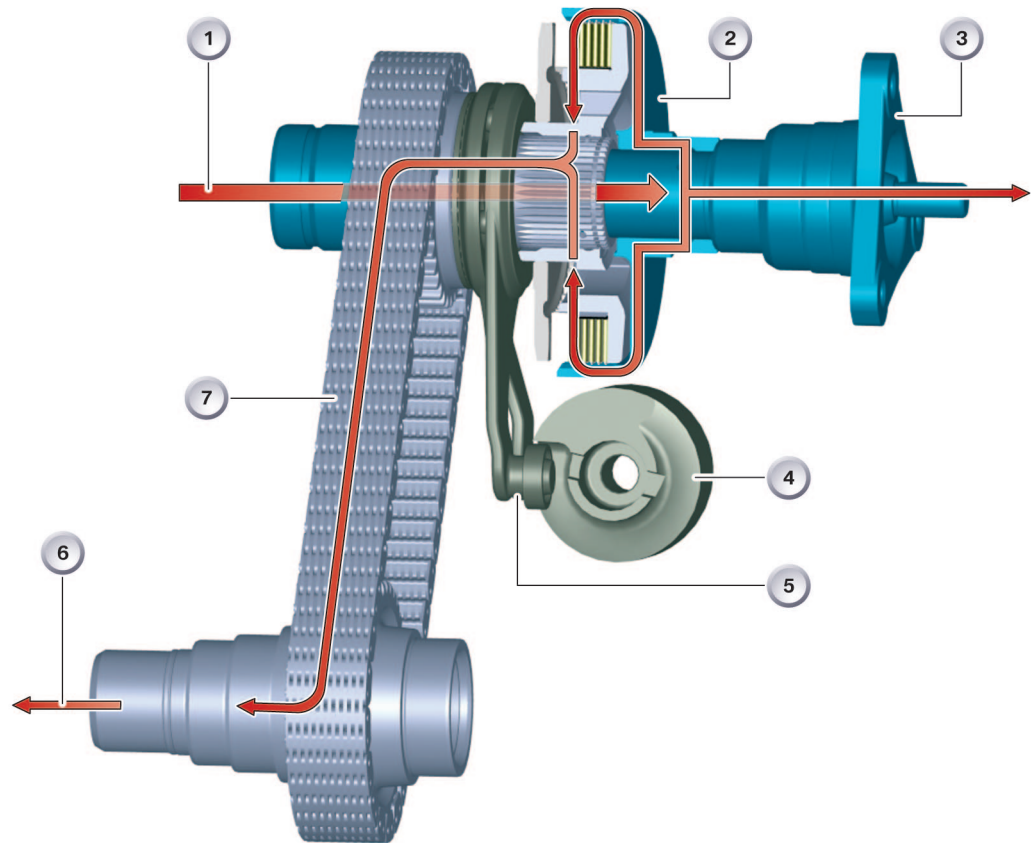
2 - Transfer case housing

Index	Explanation	Index	Explanation
1	Output to rear axle	5	Chain
2	Plate assembly	6	Output to front axle
3	Control lever	7	Disc cam
4	Drive from the manual transmission or the automatic transmission	8	Servomotor

The flange illustration of the ATC transfer case is the same for automatic and manual gearboxes.



## Power flow



3 - Transfer case operation

TF04-5508

Index	Explanation	Index	Explanation
1	Drive from the transmission	5	Control lever
2	Multi-plate clutch	6	Output to front axle
3	Output to rear axle	7	Chain
4	Disc cam		

### Operating principle

When the multi-disc clutch in the transfer case is open, no driving torque is transmitted to the front axle; instead, the entire driving torque is directed to the rear differential.

When the multi-disc clutch is fully closed, the front and rear axles turn at the same speed. Torque distribution is dependent on the torque that can be supported on each axle. If, for example, the driver moves off from traffic lights in first gear at full throttle, there is a higher load placed on the rear axle as a result of dynamic axle-load transfer. Consequently, the drive torque support at the rear axle is

greater. This means that the transmittable drive torque corresponds to the axle-load distribution when the coefficient of friction is identical on the front and rear axles.

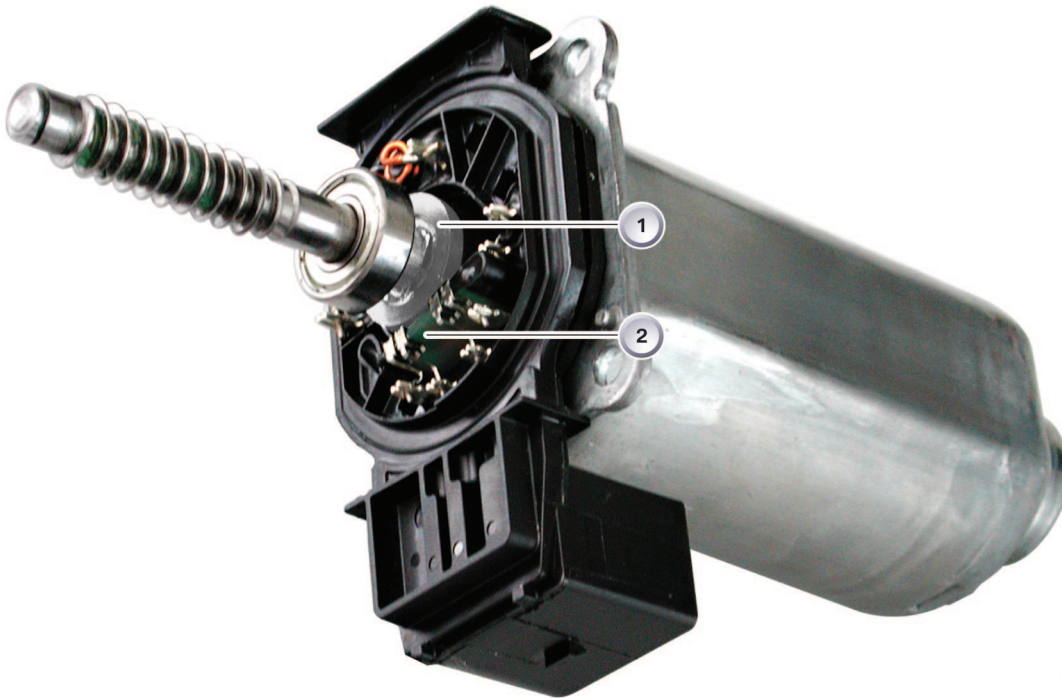
An exception is made when the front axle is on a surface with a high friction coefficient and the rear axle is on black ice, for example. In this case, almost 100% of the available drive torque is transmitted to the front axle since almost no torque can be supported at the rear axle.



## Servomotor with motor position sensor

This actuator motor is a DC motor which also contains a Hall sensor for registering the position and swivel speed of the motor shaft.

The motor shaft is arranged proportional to the closing rate of the multi-disc clutch.



TF04-5461

4 - Servomotor

Index	Explanation	Index	Explanation
1	Magnetic ring	2	Motor position sensor (Hall sensor)

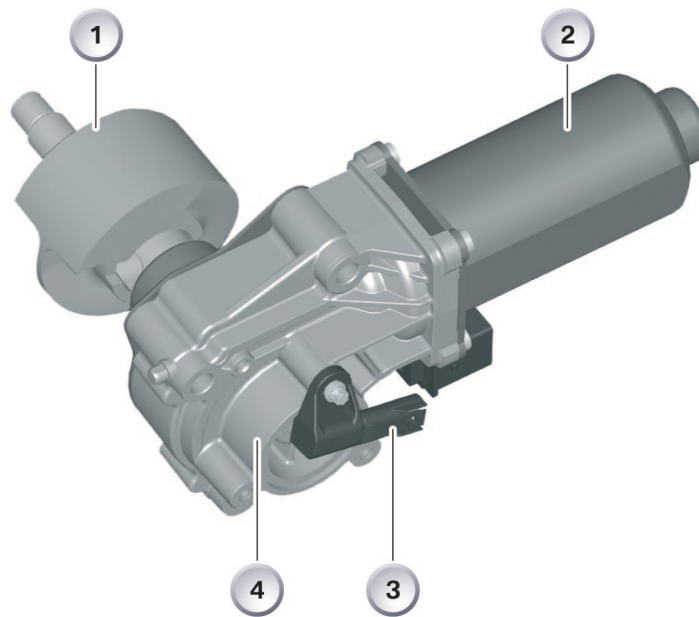


### Coding resistor

Because of mechanical tolerances in production, the characteristic curve of the multi-plate clutch locking torque can vary slightly. The actual locking torque is therefore measured with the aid of the coding resistor.

The measured value represents a reference for the progression of the locking torque.

Each time the engine is started, the transfer case control unit measures the resistance value once and in such a way that the optimum program map for the transfer case fitted is selected.



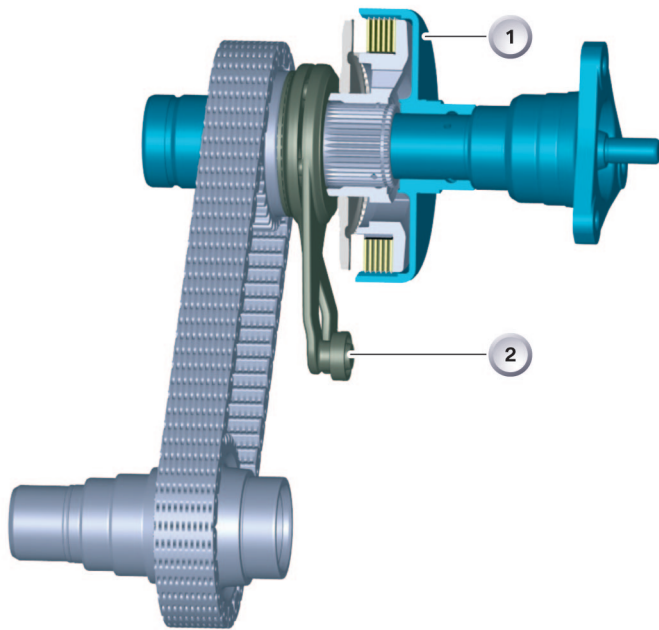
TF04-5515

5 - xDrive servomotor

Index	Explanation	Index	Explanation
1	Disc cam	3	Classification resistor
2	Servomotor	4	Worm gear



## Control lever



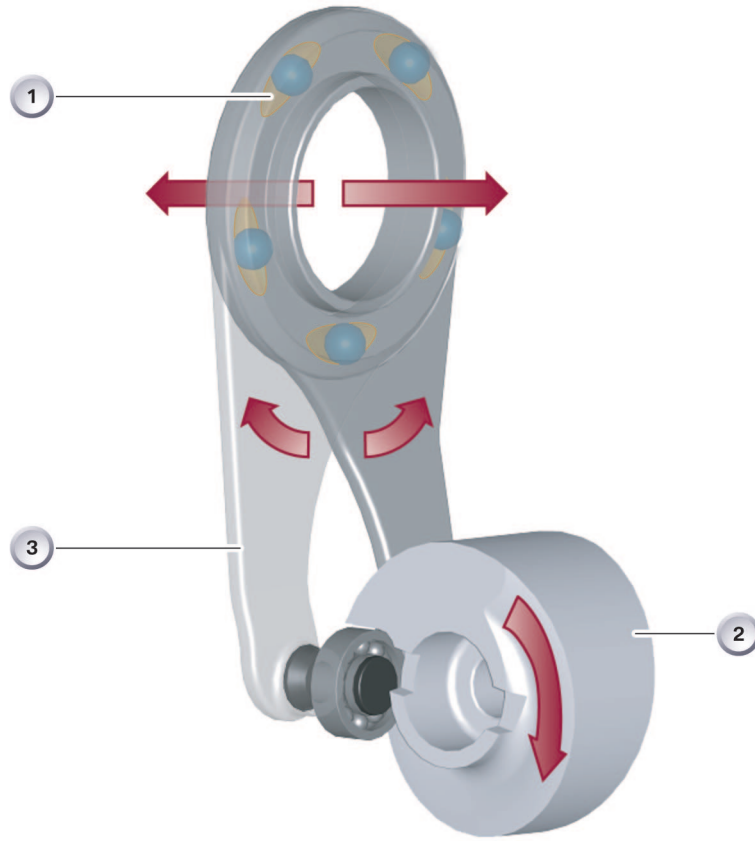
TF04-5519

6 - Control lever

Index	Explanation	Index	Explanation
1	Multi-plate clutch	2	Control lever

When the servomotor is running, the disc cam turns and forces the arms of the control lever apart. As the lever arms are forced apart, an axial motion is produced by the ball ramps. This axial motion of the control arm forces the plates in the multi-plate clutch together. The multi-plate clutch is closed.





TF04-5516

7 - Control lever operation

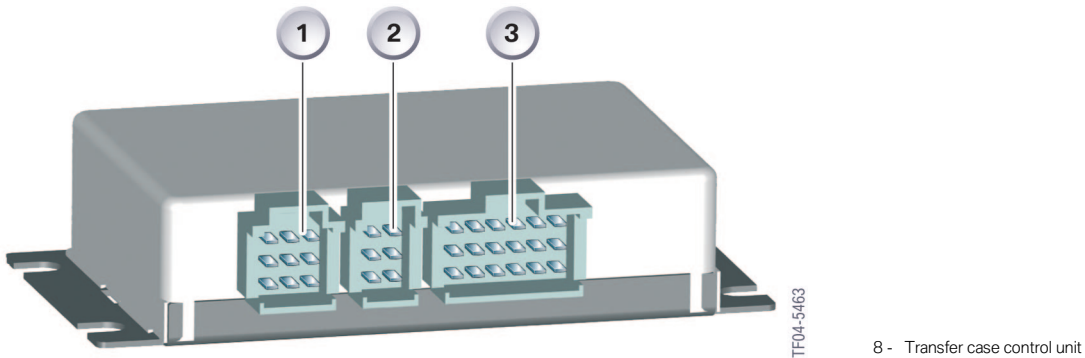
Index	Explanation	Index	Explanation
1	Ball ramp	3	Control lever
2	Disc cam		





## Transfer case electronic control unit

The transfer case control unit is installed in the E83 on the rear floor panel under the luggage compartment trim. In E53 it is located underneath the rear bench seat on the left.



8 - Transfer case control unit

Index	Explanation
1	9-pin ELO connector (unassigned)
2	6-pin ELO connector
3	18-pin ELO connector

### Operating principle

The transfer case control unit regulates the closing torque of the multi-plate clutch in the transfer case. The control and power electronics required for this task are integrated in the transfer case control unit.

The transfer case control unit is sent information about the currently required closing torque by the DSC control unit. This information is translated into a corresponding turning motion of the servomotor. The distribution of drive torque to the front and rear axle is derived from the closing torque. The closing torque to be applied is calculated from the driver's input and from a higher-level traction and dynamic driving controller.

A reference run is formed every time the engine is turned off in order to assign a corresponding clutch closing torque to a certain angle position of the actuator motor. This reference run also takes into account the influences of wear. The clutch is opened and closed completely during the reference run. The current intake is measured at the respective angle position of the actuator motor while the clutch is closed and opened. The start and end of the clutch closing procedure are determined in this way. The angular position is determined by means of a Hall sensor integrated in the servomotor.



A clutch and oil wear model is also calculated in the transfer case control unit. If necessary, the clutch and oil wear model limits the closing torque in order to reduce frictional work.

In the event of DSC failure, an emergency strategy for actuating the transfer case clutch is integrated as a fall-back level in the transfer case control unit, ensuring all-wheel drive is maintained also in this case.

The transfer case clutch is controlled by the DSC mounted control unit. Nevertheless, even when DSC is deactivated, DTC remains active for the purpose of maximum traction and driving dynamics.

Permanent all-wheel drive is cancelled in only 3 control cases:

- during very tight cornering manoeuvres with little engine torque to permit speed compensation between the front and rear axles (e.g. parking)
- at speeds in excess 180 km/h
- when the vehicle understeers markedly

The control algorithm of transfer case clutch control can be described in three main modules:

- Pre-control
- Traction control / driving-dynamics control
- Tyre tolerance logic

### **Pre-control**

The pre-control algorithm reflects the driver's command and calculates as a function of

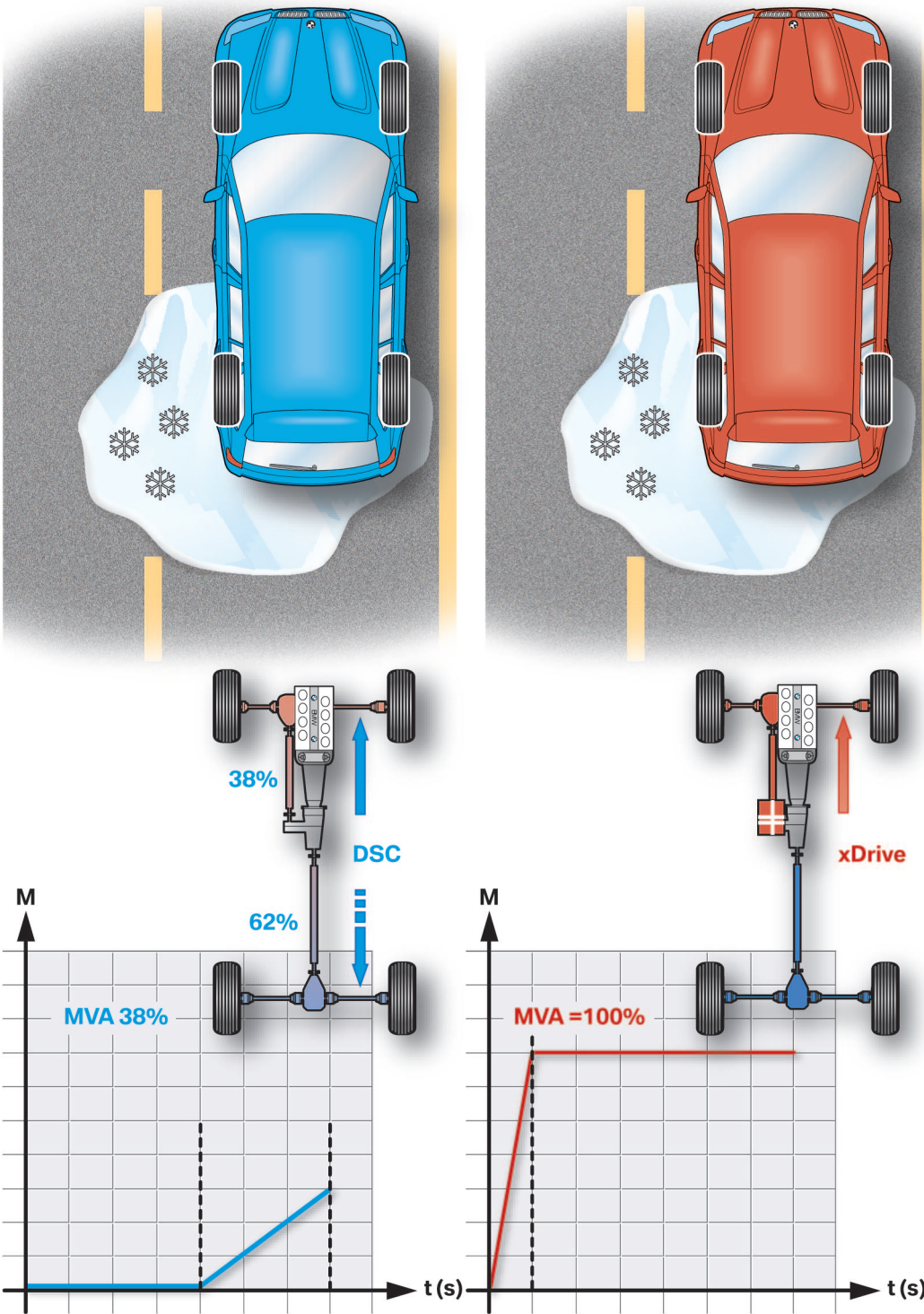
- accelerator pedal value,
- engine torque,
- engine speed,
- vehicle speed,
- gear,
- and steering angle

the required closing torque while taking into account the maximum clutch, transfer case and axle drive loads.

Under normal driving conditions, the drive torque is distributed in a proportion of 40 % to the front axle and 60 % to the rear axle.

The pilot control ensures rapid response of the system even in the case of different coefficient of friction at the front and rear axle (rear axle on sheet of ice). The system is illustrated in the following graphic.

In contrast to vehicles with an open longitudinal differential, in this case with xDrive, no brake intervention is required at the rear axle as no slip an occur.



9 - Overhead view of DSC/xDrive on an icy road

TF04-5471

**Index Explanation**

M	Drive torque
M VA	Drive torque at front axle
t	Time

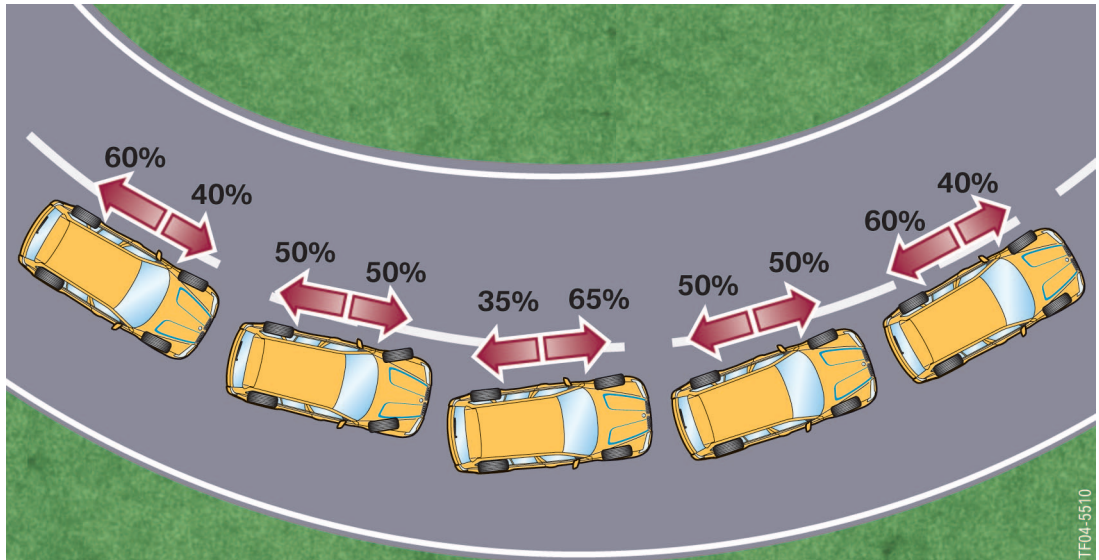
## Traction control / driving-dynamics control

Traction control monitors the slip ratios at the front and rear axle. The wheel speeds, yaw rate and transverse acceleration serve as the input signals here.

The role of traction control/driving-dynamics control is to achieve optimum traction and to stabilize or maintain the stability of the vehicle.

As can be seen in the following graphics, in the event of an oversteer tendency, the transfer case clutch is completely closed and thus the maximum supportable driving torque on the front axle is transmitted.

### Drive torque distribution with oversteer tendency

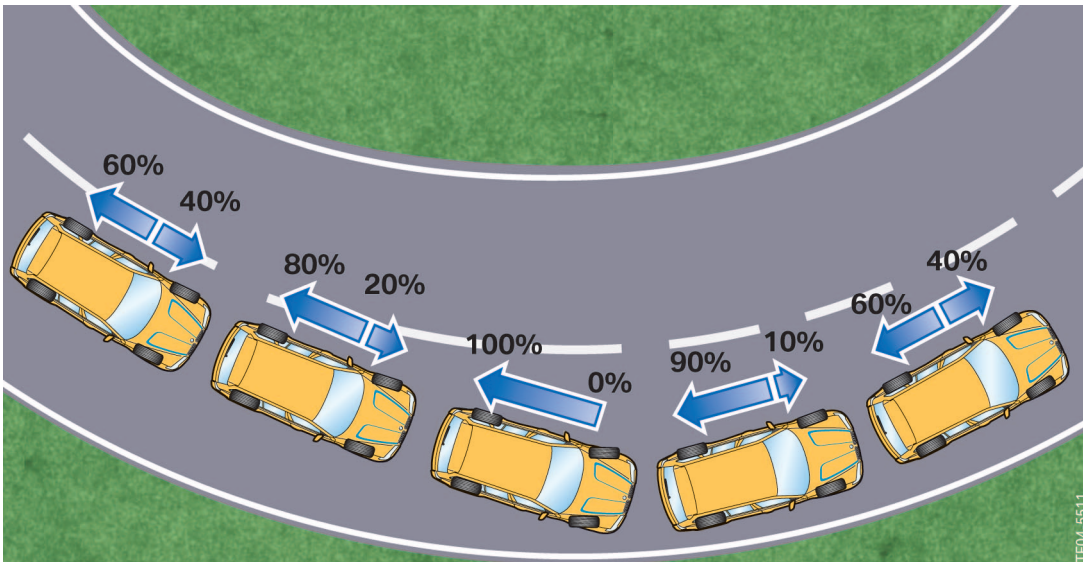


10 - Oversteering

The drive torque that can be supported on the front axle is basically determined by the relationships in Kamm's circle.



### Drive torque distribution with understeer tendency



11 - Drive torque distribution

In the event of an understeer tendency, the clutch can be fully opened if necessary. In this way, the front axle is separated from the

drivetrain and the drive torque can only be transmitted to the rear axle.



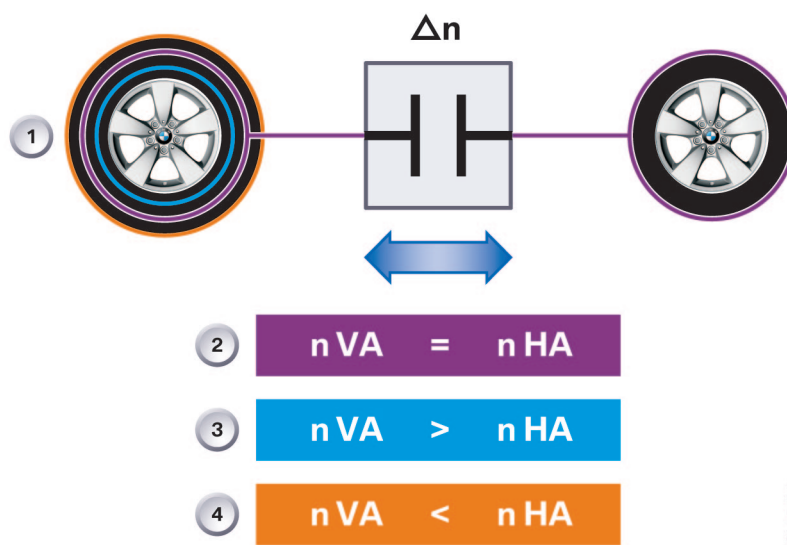
## Tyre tolerance logic

The tyre tolerance logic detects different tyre-tread circumferences on the front and rear axles. The tyre tolerance logic may be active when:

- mixed tyres are used
- an inflatable spare tyre is fitted

- tyres are used that have been worn down to markedly different levels

With a normally pre-controlled multi-plate clutch, tyre circumference deviations result in drivetrain torque bias. The axle that is turning at a higher speed is braked and the other axle is driven at the same speed.



12 - Tyre tolerance logic

Index	Explanation
nVA	Wheel speed at the front axle
nHA	Wheel speed at the rear axle
1	Different rolling circumferences at the front axle
2	Same rolling circumference at the front and rear axle
3	Greater rolling circumference at the front axle than at the rear axle
4	Smaller rolling circumference at the front axle than at the rear axle

# Service information

## xDrive four-wheel drive

### Limp-home operation

All-wheel drive is maintained for as long as possible in the event of failure of important signals or of the DSC control unit. A limp-home (emergency operation) controller is integrated in the transfer case control unit for this purpose.

This controller operates in redundancy to the transfer case clutch control in the DSC control unit.

Failed wheel speed signals at the rear axle are calculated from the drive or engine speed.

The values from the rear axle are used if the front wheel speed signals fail.

A substitute value can be derived from the peripheral wheel speeds if no signal is received from the steering angle sensor.

### General information for towing four-wheel-drive vehicles and notes on correct operation on brake dynamometers

#### Important: Towing vehicles with xDrive

Always raise both axles when towing vehicles with xDrive. Do not tow the vehicle with only one axle raised (either the front or rear axle). Not one wheel of a vehicle with xDrive is permitted to make contact with the road during towing. There is no guarantee that the clutch will be fully separated, even if the servomotor is supplied with no power. The vehicle could move out of the towing device. The transfer case would be damaged if the wheels of the raised axle become locked in the towing device as a result of deformation.

Observe the warning plate on the left-hand B-pillar and the note in the Owner's Handbook. Towing vehicles with xDrive is permitted but with certain restrictions. Even towing on all wheels is technically permissible, but with the following restrictions:

- Maximum towing speed of 40 mph (70 km/h)
- Towing distance: maximum of 90 miles (150 km)

Observe the note in the Owner's Handbook.

#### Important: Driving onto brake dynamometers

Hill Descent Control (HDC) must be switched off before the vehicle is driven onto the brake dynamometer and must remain switched off. The HDC indicator lamp must not light up. There is a possibility of the HDC indicator lamp going out or not lighting up even when HDC is active. This is because HDC is temporarily unavailable due to high brake temperatures.

Vehicles with xDrive and automatic transmission

Always carry out the brake test with the selector lever in position "N" (neutral) and do not accelerate when the rollers begin turning. This ensures that the multi-plate clutch in the transfer case remains separated and the vehicle cannot be moved off the dynamometer.

After driving onto the brake test rig, the accelerator must not be pressed in vehicles with xDrive and manual gearbox. The transfer case clutch is also not closed. The vehicle cannot be pushed/pulled out of the brake test rig.

---

## Diagnosis

If tyre tolerance logic is active, an entry to this effect will be stored in the fault code memory.

---



## Programming

The transfer case control unit and the DSC control unit are programmable.

---





## Indicator and warning lamps

The following table shows the assignment of warning lamps and audible signals to the system statuses of xDrive/DSC.

System status	Lamp display in the instrument cluster	Gong
DSC off	 <small>TF04-5732</small>	No
DSC defective (ABS fallback level) or transfer case control unit defective	 <small>TF04-5732</small>	Yes





<b>System status</b>	<b>Lamp display in the instrument cluster</b>	<b>Gong</b>
Total DSC failure or total DSC failure and failure of the transfer case control unit	   	Yes



# Contents

## Active Cruise Control (ACC)

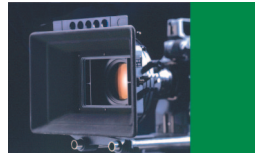


### Introduction

System description

1

1



### Functions

Functional description

3

3



### System components

Components

13

13



### Service information

Notes for service staff

Paintwork repairs on vehicles with active cruise control

17

17

19



# Introduction

## Active cruise control (ACC)

### System description

Active cruise control is a convenience distance and speed control system that operates by automatic engine management and braking interventions.

It is a convenience system for relieving the strain on the driver on country roads and motorways.

A radar sensor detects the distance, speed and angle of objects moving in front of your vehicle.

The driver is able to preselect a desired speed of between 30 km/h and 180 km/h. The desired speed is adjustable. Pressing the steering column lever inwards increases the desired speed in increments of 1 km/h.

There are two different modes of operation:

- **Free driving**

ACC automatically adjusts the speed of the vehicle to the desired speed selected.

- **Traffic flow driving**

The driver is notified that distance-dependent traffic flow mode is in operation by an indicator lamp in the instrument cluster. ACC maintains a specified distance from the vehicle in front.

The speed of the driver's own vehicle is controlled by interventions in the engine management and brake system.

As soon as the road ahead is clear again, the indicator lamp goes out and the desired speed is resumed.

---

### Principle

Active Cruise Control enables the driver to select a desired speed that will automatically be maintained by the vehicle, provided the lane ahead is clear.

Within technically possible limits, the system automatically modifies the speed of the vehicle to match the speed of a slower vehicle in front. There are four levels that may be selected for maintaining the distance from the vehicle ahead. For safety reasons, the distance is speed-dependent. To maintain the distance specified, the system automatically reduces throttle and may even gently apply the brakes. The vehicle accelerates if the vehicle in front begins to pick up speed. As soon as the lane ahead is clear again, the system accelerates the vehicle back up to the desired speed.



# Functions

## Active cruise control (ACC)

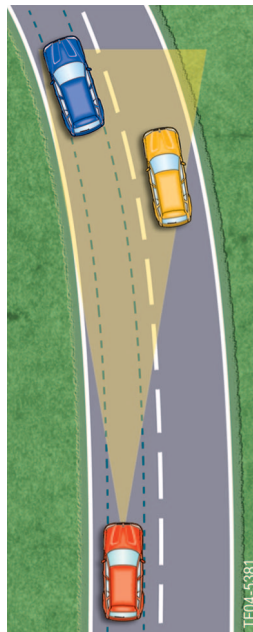
### Functional description

#### Operating principle

After being actuated by the driver, the ACC system processes information from the radar sensor. As a result, the vehicle speed is adapted to the preceding vehicles.

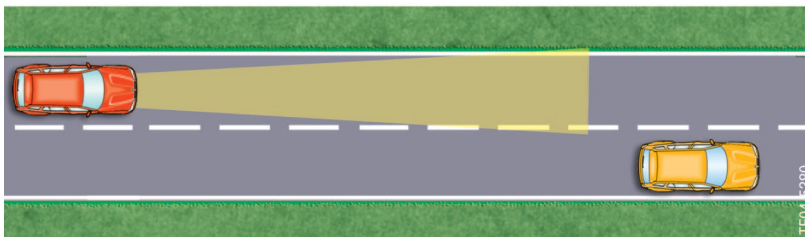
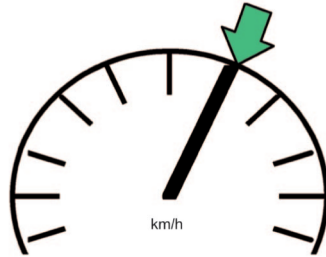
To be able to do this, ACC must be able to support the following:

- Detection of vehicles in front (by the ACC1) up to a distance of approximately 120 m in a range of  $\pm 4^\circ$ .
- Detection of vehicles in front (by the ACC1) up to a distance of approximately 120 m in a range of  $\pm 8^\circ$ .
- Measurement of distance, angle and relative speed
- Prediction of the vehicle's own suspected lane course
- Identification of the relevant object for distance control
- Adjustment of the vehicle's speed to match the speed of the vehicle in front through:
  - Acceleration at a rate of up to  $1.2 \text{ m/s}^2$  with ACC1 or ACC2.
  - Deceleration at a rate of up to  $2.0 \text{ m/s}^2$  with ACC1.
  - Deceleration at a rate of up to  $2.5 \text{ m/s}^2$  with ACC2.
  - Limitation of transverse acceleration to a maximum rate of  $3.0 \text{ m/s}^2$  with ACC1 or ACC2.



1 - Operating principle

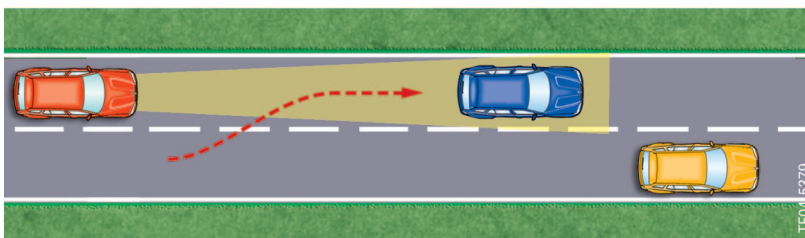
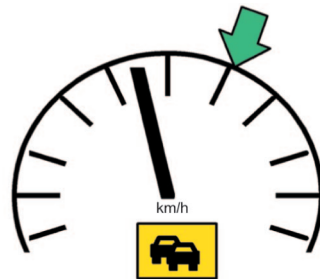
ACC operates in the same way as conventional cruise control when there is no vehicle in front, i.e. **free driving mode**. The speed of the vehicle is controlled to maintain the desired speed set by the driver.



2 - Free driving

ACC lights the "object detected" lamp as soon as a vehicle is detected in the predicted lane. ACC automatically decelerates the vehicle if the vehicle in front is moving at a slower speed. In the majority of cases this is realized smoothly through engine intervention and only rarely through brake intervention.

The switch from **free driving** to **traffic flow mode** takes place without the need for driver intervention.

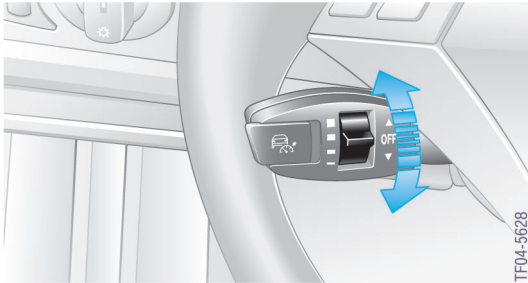


3 - Distance control

In **traffic flow mode**, the ACC vehicle follows the vehicle in front with a predefined time gap in between, and no faster than the desired speed set. The distance to the vehicle ahead changes with the speed of this vehicle.



The driver is able to select one of four different time gaps (1 s, 1.5 s, 2 s and 2.5 s).



4 - ACC selector lever

ACC therefore assists the driver in maintaining the minimum distance specified by law in certain countries. Traffic flow mode avoids distances that may incur fine payments.

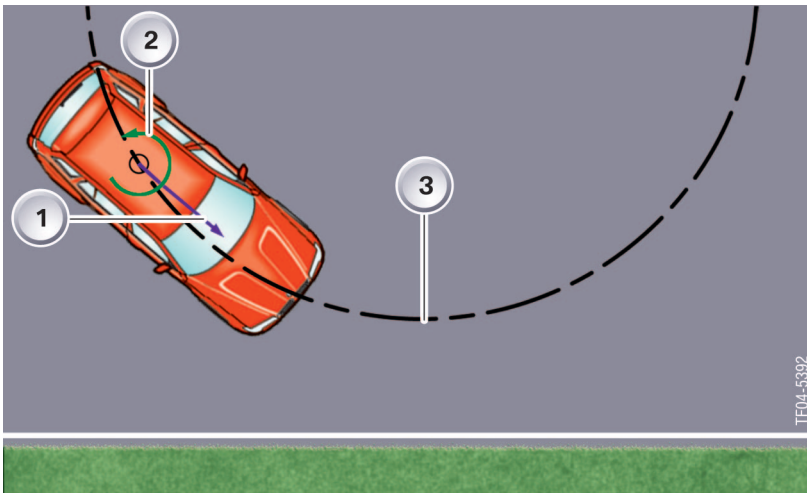
Standard cruise control is resumed automatically as soon as no vehicle is detected in the predicted course of travel.

### Lane prediction

Technicians refer to the task of predetermining the driving line by way of calculation as lane prediction.

To identify the correct object for distance control, ACC must predict the future lane course of the vehicle. Vehicles are then deemed relevant for control interventions if they are moving in the same lane. Lane prediction is advance determination of the course of the ACC vehicle, which is almost always accurate on motorways and major country roads.

The speed (1) and the yaw rate (2) supplied by DSC are used to predict the course of travel (3).



5 - Lane prediction

## Function limits

The following limits are imposed for safe ACC operation:

- ACC operation only possible between 30 km/h and 180 km/h.
- ACC deceleration by brake intervention  
A rate of  $2.0 \text{ m/s}^2$  with ACC1  
A rate of  $2.5 \text{ m/s}^2$  with ACC2
- Maximum ACC acceleration of  $1.2 \text{ m/s}^2$ .
- Maximum transverse acceleration of  $3.0 \text{ m/s}^2$ .

ACC reaches its limits in the following situations:

- The monitoring range of the radar sensor limits detection of vehicles in front and vehicles on a different course, e.g. on tight bends.
- ACC may respond to a vehicle cutting in with a delay. For these reasons, ACC should not be used on winding roads or where frequent lane changing is required.
- It is not possible to compensate for considerable differences in speed, e.g.

approaching a slow moving truck at high speed.

- ACC cannot be used in stop/start traffic because it is not able to brake the vehicle to a halt. The driver is responsible for control of the vehicle by braking in good time.
- Only use ACC in conditions of adequate visibility.
- The time gap between the ACC vehicle and the vehicle in front is no less than 1 second in stationary conditions. This time gap may be temporarily less than 1 second if a vehicle cuts in just in front, for example.

The "object detected" lamp begins to flash if the ACC is no longer able to control the selected distance. An audible signal also sounds. The driver must then take control.

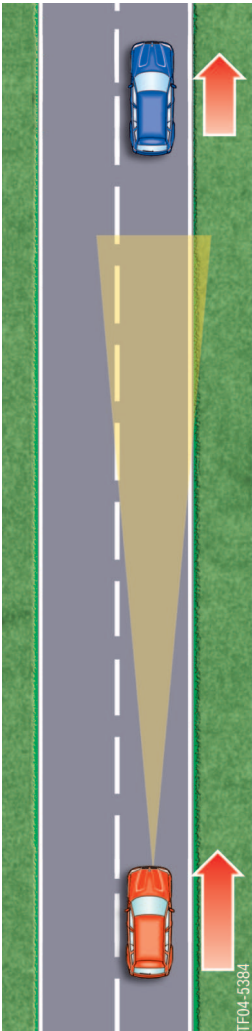
If the system's function limits are reached in ACC mode, the system may behave in a manner that requires further explanation. These situations are described below.

### Limited range and deceleration

The radar sensor has a limited range of approximately 120 m on the one hand, on the other hand DSC only provides ACC with a maximum deceleration rate of  $2.0 \text{ m/s}^2$  or  $2.5 \text{ m/s}^2$ .

ACC is thus only able to fully provide automatic speed control in a limited relative speed range.

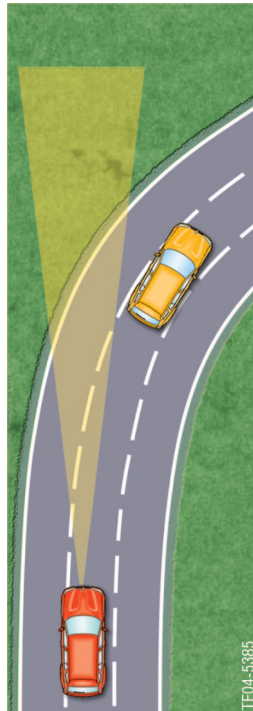
If the system reaches its function limits, the driver is prompted to take control by a flashing "object detected" lamp.



6 - Range

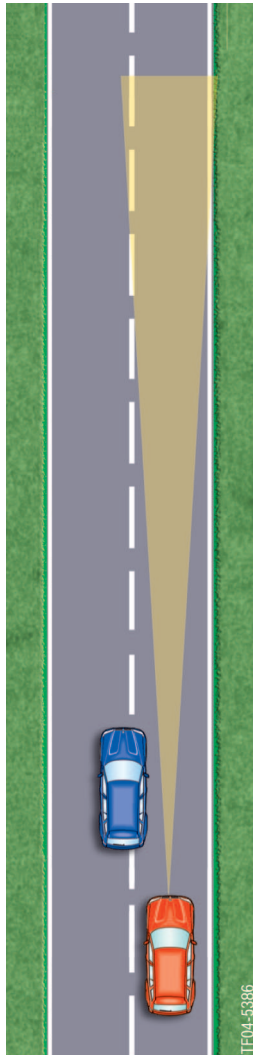
### Lateral field of view

The preceding vehicle can be lost in bends due to the limited lateral field of view. The ACC vehicle is not accelerated to the required speed for approx. 2 s in a bend. This function is designed to ensure the ACC vehicle can on no account drive too close to the preceding vehicle that is briefly out of view.



7 - Lateral detection range 1

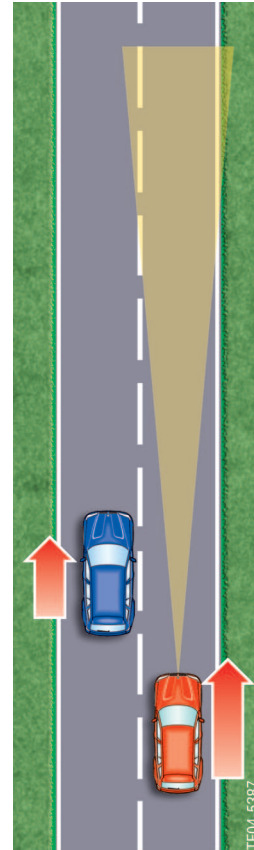
With straight-ahead travel, there may be a delayed response if a vehicle cuts in just in front. This vehicle is only detected when it is clearly moving in the same lane as the ACC vehicle.



8 - Lateral detection range 2

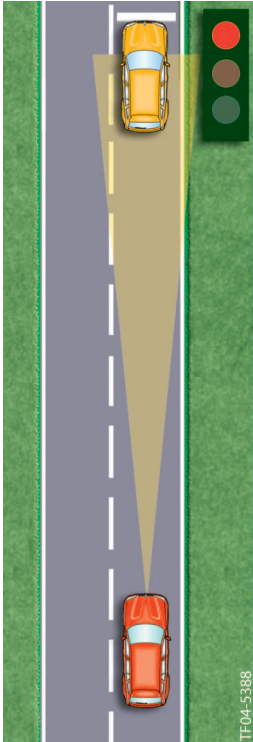
### Unexpected behaviour

- The vehicle on the left is being undertaken by the vehicle on the right (left-hand-drive vehicles) because the desired speed is higher than the speed of the vehicle on the left.



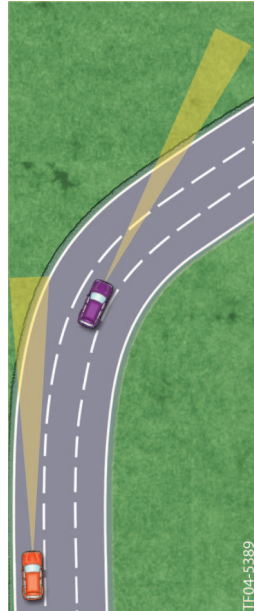
9 - Unexpected behaviour 1

- ACC responds differently if vehicle A is waiting at traffic lights or if it is still moving at low speed.
  - Vehicle stationary
    - No ACC braking intervention, only acceleration inhibition close to vehicle A. The "object detected" lamp does not light up. The driver is not prompted to take control.
  - Vehicle moving slowly
    - The ACC vehicle is braked by DSC down to approximately 40 km/h, there is then a smooth transition to drag torque control. The "object detected" lamp lights up. The driver is prompted to take control.



10 - Vehicle stationary

- On a bend, ACC prevents acceleration to the desired speed if this would increase transverse acceleration to over  $3 \text{ m/s}^2$ .  
ACC accelerates to the desired speed before a bend.



11 - Cornering:

### Special situations

The driver recognizes special situations by the fact that the "object detected" lamp is not on. The vehicle, however, remains below the required speed and is not further accelerated.

- For reasons of comfort, the vehicle controls the speed on tight bends so as to limit transverse acceleration to a maximum of  $3 \text{ m/s}^2$ . This applies in free driving and traffic flow mode.
- The range can be substantially reduced by rain, fog and snow. ACC can no longer be used in extreme cases.
- Driving up hills and down valleys may cause the object to be lost.

## Lens heating

The integrated lens heating reduces the risk of ACC unavailability in wintery conditions. The lens heating is activated by directly switching through the vehicle voltage (terminal 30g on E6x vehicles) from the ACC sensor. The lens heating is controlled by a pulse-width-modulated (PWM) signal from the active cruise control control unit. The heater coil is integrated in the lens of the ACC sensor (the lens is made of plastic.)

The lens heating is only switched on within a specific outside temperature range (approximately +5 °C to -5 °C). At temperatures around freezing the snow is wet. At much lower temperatures the snow is dry. The lens heating is switched off below a specific outside temperature to prevent the snow from thawing on the lens and leaving an artificial lining. The current outside temperature value is supplied by the instrument cluster.

## Switch-on conditions for the lens heating

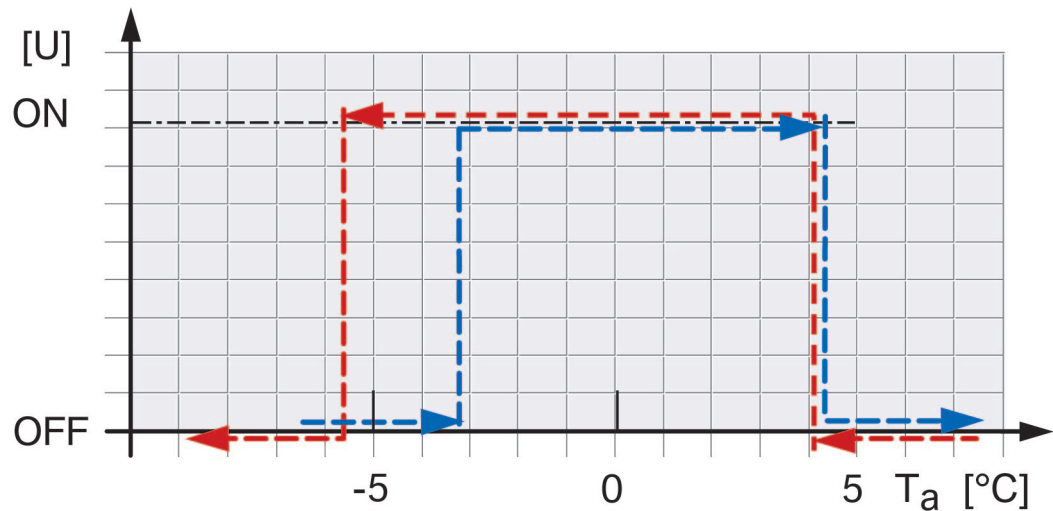
- Engine ON
- ACC ON
- Outside temperature between +5 °C and -5 °C

## Lens heating safety switch-off

- Temperature in the ACC sensor above 50 °C (measured by the internal temperature sensor in the ACC sensor control unit)
- Voltage greater than 16 V. The safety switch-off only deactivates the lens heating. Active cruise control is not deactivated (no entry in fault code memory).

## Monitoring of lens heating

- The lens heating is monitored for open circuit and short circuit of the heater coil.
- If the watchdog responds, active cruise control is deactivated (entry in fault code memory).



12 - Lens heating

TF04-5390



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## **Check control message**

The following check control messages may be displayed in the event of ACC failure or deactivation:

<b>Check control message in the status line of the CID</b>	<b>Additional text</b>
ACC deactivated! Drive carefully	ACC deactivated Active cruise control deactivated due to risk of slipping. Keep your distance and drive carefully! Reactivate ACC if necessary, driving situation permitting.
ACC deactivated! Keep your distance	ACC deactivated Active cruise control deactivated due to a dirty sensor. Keep your distance! Wipe the sensor clean, see Owner's Handbook.
ACC failure! Keep your distance	ACC failure Active cruise control ACC failure. Keep your distance! Have the vehicle checked at the nearest BMW Service centre.
ACC deactivated! Parking brake	ACC deactivated Active cruise control deactivated because parking brake applied. Keep your distance! Reactivate ACC if necessary.
ACC deactivated! Keep your distance	ACC deactivated Active cruise control ACC is deactivated below approx. 30 km/h (20 mph). Keep your distance! Reactivate ACC if necessary.
ACC deactivated! Brake yourself	ACC deactivated Active cruise control deactivated due to long downhill driving. Keep your distance! Reactivate ACC if necessary.
Engine speed! Select a higher gear ACC deactivated Keep your distance	Engine speed too high Select a higher gear, driving situation permitting. ACC deactivated Active cruise control ACC deactivated: selected gear not suitable for driving situation. Change gear and reactivate ACC if necessary.
Engine speed! Change down	Engine speed too low Select a lower gear, driving situation permitting.



# System components

## Active cruise control (ACC)

### Components

#### Radar sensor

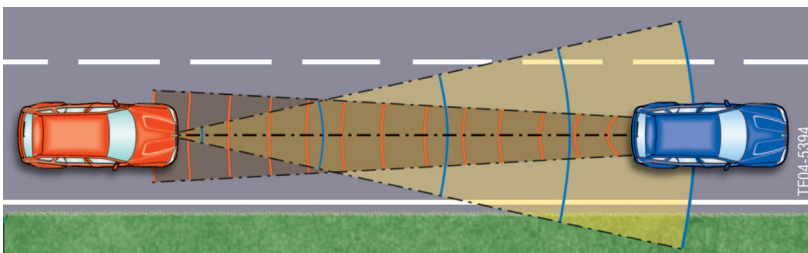


1 - ACC sensor installation location

The radar sensor (transmission frequency 76-77 GHz) detects objects moving in front of the vehicle by transmitting radar waves. The radar pulse is radiated at the speed of light.

The pulses are transmitted for 10 ms every 100 ms.

The aerial detects an echo if the radar beam is interrupted by a radar-reflective object.



2 - Radar beam

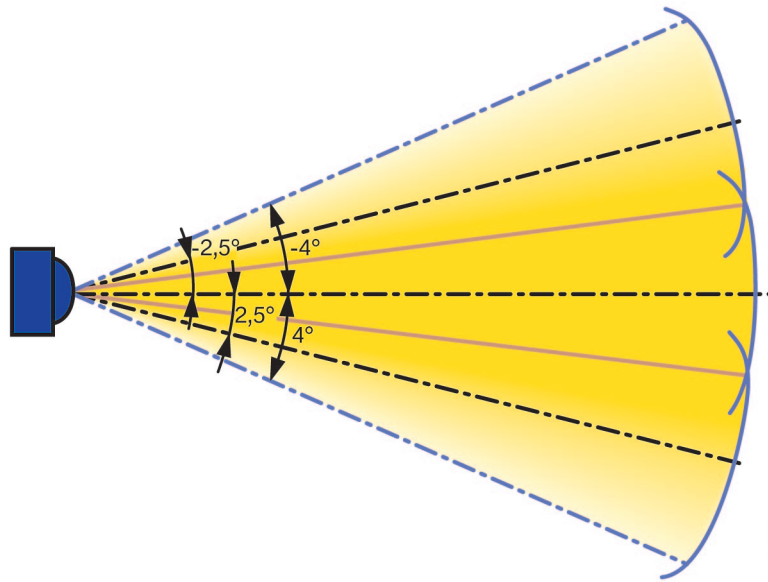
For the period of the signal, ACC is able to determine the **distance** to an object.

The Doppler effect makes it possible to determine the **relative speed** between the ACC vehicle and an object. If the object moves towards the transmitter, the frequency of the reflected waves increases.

If the object moves away from the transmitter, the frequency of the reflected waves diminishes.

To determine the **angle**, the measuring range of the ACC1 is monitored by three radar beams. The middle beam is aimed straight ahead. The other two beams are aimed at an offset of  $2.5^\circ$  in relation to the middle beam. The entire horizontal detection range of the radar sensor is  $\pm 4^\circ$ .

The ACC2 emits 4 radar beams. These have a detection range of  $\pm 8^\circ$ .

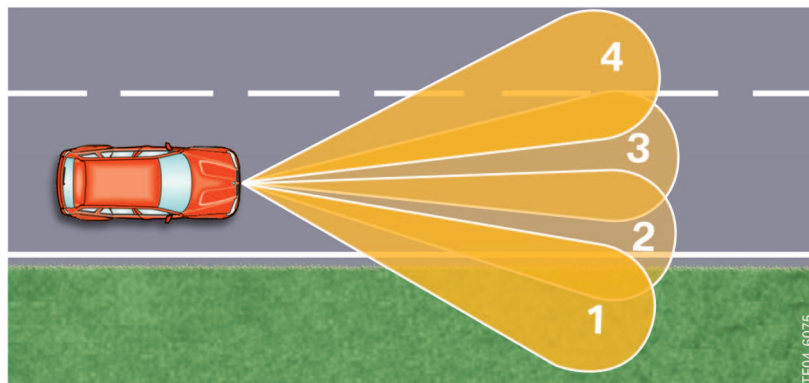


3 - Beam diagram

**How the ACC2 differs:**

- The ACC sensor continuously monitors the detection range in front of the vehicle, extending approx. 2 - 120 metres, using 4 radar beams. The transmission frequency

of the ACC2 is also 76-77 GHz. The detection range is limited laterally and vertically by the aperture angle of the ACC sensor. The horizontal aperture angle is  $\pm 8^\circ$ . The vertical aperture angle is  $\pm 4^\circ$ .



4 - Angle measurement

Each radar beam is emitted by an aerial in the control unit that also receives the reflected radar signal.

## Control unit

The ACC control unit is fitted underneath the bumper at the front of the vehicle. It is secured to a metal bracket by three studs. The control unit can only be coded by variant. The aerial required is integrated in the control unit. It is not possible to repair the control unit.

The ACC control unit in the system network is responsible for controlling the distance, vehicle speed and acceleration as well as CAN communication with the partner systems. The ACC control unit contains all diagnosis and self-test functions.

The ACC control unit is protected against short circuit to positive or earth, polarity reversal and open circuit.

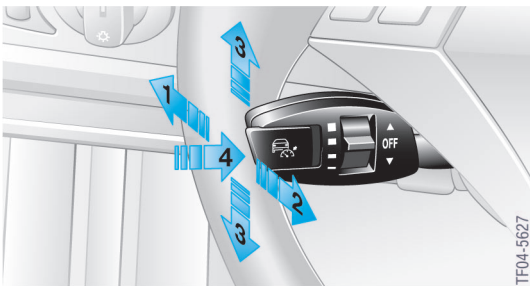
The sensor shuts down if the system voltage drops to  $< 10\text{ V}$  or rises to  $> 17\text{ V}$ . An entry is then stored in the fault code memory.



5 - Control unit on the bracket

TF04-5374

## Steering column lever with the following functions:



6 - ACC selector lever

4. With the system deactivated:  
press briefly to call up the stored speed and distance.

With the system activated:

To increase the desired speed by 1 km/h with each press of the button. The thumb switch on the lever allows the driver to select one of four distances from the vehicle in front.

1. To store and increase the desired speed, the system is activated.
2. To store and reduce the desired speed, the system is activated.
3. To deactivate the system.



# Service information

## Active cruise control (ACC)

### Notes for service staff

#### Deactivation by the driver

There are various ways in which ACC can be deactivated by the driver:

- Pressing the button
- Depressing the brake pedal
- Moving the selector lever to N
- Deactivating DSC using the button

#### Automatic deactivation

The system is deactivated automatically in the following situations and the driver is notified accordingly:

- Subsystem failure --> "ACC inactive"
- Sensor obscured --> "Sensor view"
- The set speed LED goes out if the speed of the vehicle drops below the minimum of 30 km/h.
- ACC is deactivated and the set speed LED goes out in the event of prolonged ASC or DSC interventions.

#### Vehicles with manual transmission

It is possible to use the system, and also change gear, from 2nd gear within the normal engine speed range. Continuous operation at very high or very low engine speeds is not possible. In this event, a gearshift message is displayed or the system is automatically deactivated.

#### Vehicles with SMG

In sequential mode, continuous operation is not possible at very high engine speeds. In this event, a gearshift message is displayed or the system is automatically deactivated.

#### Lens heating

The lens is heated to reduce the risk of ACC unavailability in winter or poor weather conditions. The heater is a resistance heater. The heating coil is integrated in the plastic lens body.

The lens heater is switched on after the engine is started, depending on the outside temperature  $T_a$ .

It may not be possible to prevent sensor "blindness" in all conditions despite the use of a lens heater.

The "Sensor view" message is displayed for approximately 20 seconds and a gong sounds if the lens heating is not sufficient to clear the radar sensor of snow.

To prevent overheating of the lens body, the lens heating is deactivated if the internal component temperature rises to more than 50 °C. This temperature is measured by the internal temperature sensor of the ACC control unit.

The ACC control unit shuts down to protect its processor if the vehicle voltage rises to > 17 V.

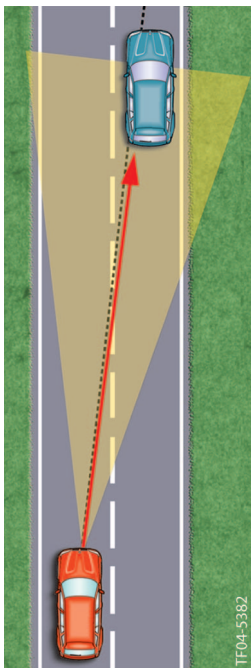
The lens heating is monitored. Any faults cause ACC to be deactivated and an entry is stored in the fault code memory.

## Alignment

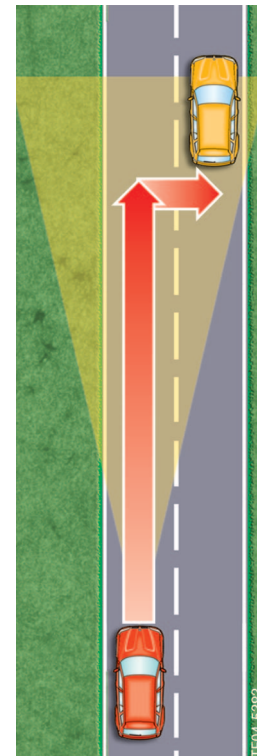
The radar sensor must be adjusted with the vehicle unladen.

Correct adjustment is a prerequisite for reliable system operation.

Horizontal misalignment results in faulty response to vehicles in an adjacent lane as well as in delayed response to vehicle in the own lane.



1 - Alignment 1



2 - Alignment 2

ACC is able to compensate for minor horizontal misalignments of up to  $1^\circ$  by enforcing certain function restrictions. Any greater deviation will cause ACC to be deactivated. The "ACC inactive" message is displayed.

## Paintwork repairs on vehicles with active cruise control

**Important: The radar sensor must be protected from prolonged exposure to heat and to excessive levels of heat during repairs to paintwork.**

The radar sensor is able to withstand exposure to temperatures of approximately 100 °C to approximately 125 °C for a maximum of 1 hour.

The radar sensor must not be active. The radar sensor must be removed for work involving higher temperatures or a longer duration.





# Contents

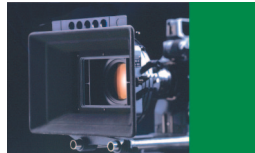
## Electromechanical parking brake



### Introduction

1

What are the special features of the system? 1



### Functions

3

Basic functions 3

EMF components and their functions 4

Gearbox with wrap spring 7

Parking brake button on the E65 8

Indicator lamps on the E65 9



### System components

13

System components on the E65 13



### Service information

15

Emergency release and restoring normal operation 15



### Summary

19



# Introduction

## Electromechanical parking brake

### What are the special features of the system?

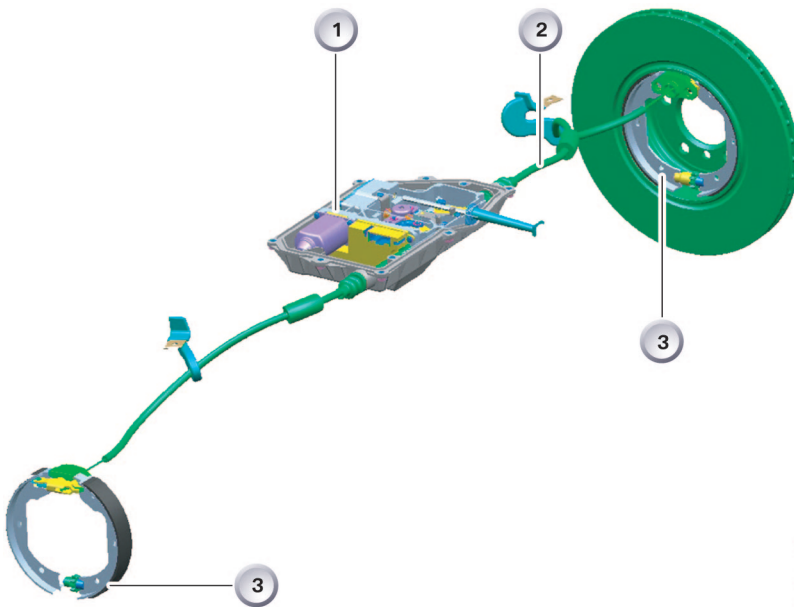
The task of the system is to mechanically hold the vehicle when parked. In addition, the brake system features an additional independent brake system as prescribed by law. The parking brake also offers other convenience and safety functions.

The E65 was the first model to benefit from the electromechanical parking brake (EMF) as standard. The fundamental aim of the parking brake is to prevent a stationary vehicle from moving away. It brakes the parked vehicle securely. The parking brake replaces the previous handbrake and footbrake. This is an

automated, comfort-oriented parking brake system, in which the driver can apply and release the parking brake by the push of a button. This conversion satisfies typical BMW requirements:

- Elimination of all situations that may have a detrimental effect on safety
- Optimum functionality
- Maximum system availability
- Best possible convenience

Components of the parking brake system



TF04-5765

1 - EMF components

Index	Explanation	Index	Explanation
1	EMF actuating unit	3	Drum brake
2	Bowden cable		





# Functions

## Electromechanical parking brake

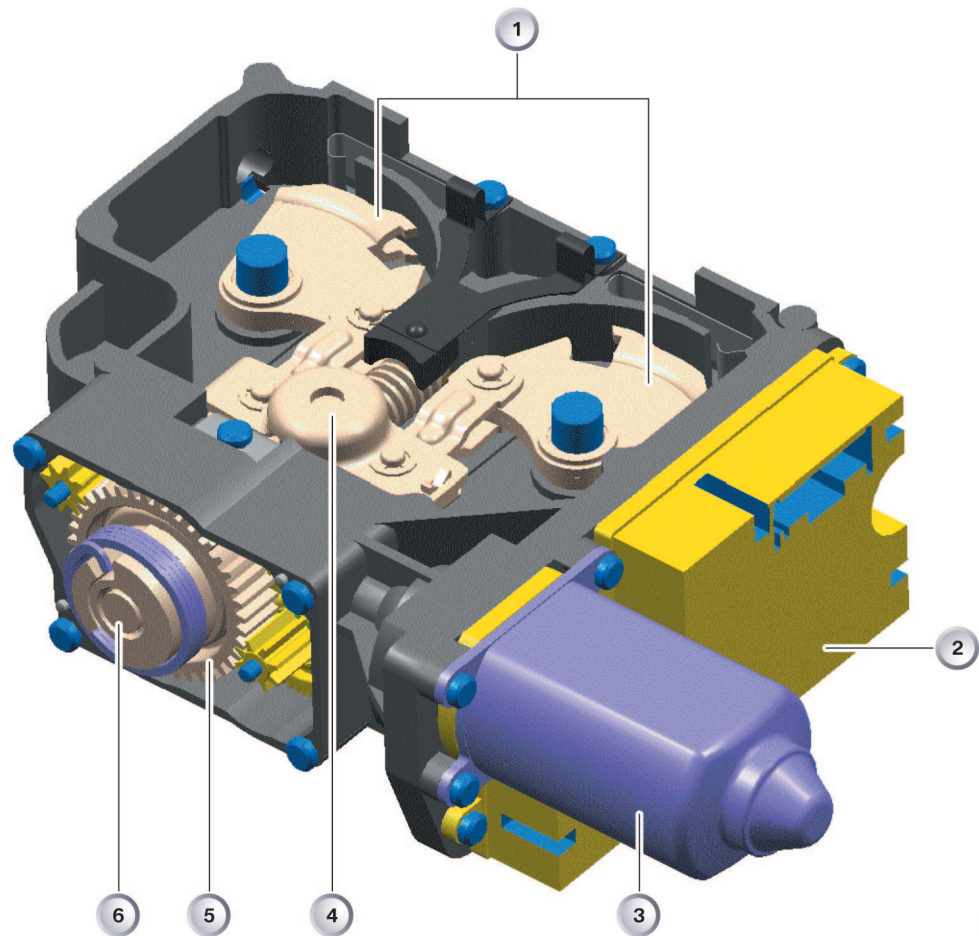
### Basic functions

The parking brake has two different functions, depending on the operating status of the vehicle.

1. Independent stationary braking
  - When the engine is running, the parking brake acts on the disc brakes at the front and rear axle with support from the DSC hydraulics.
  - When the vehicle is stationary and the engine is not running, the parking brake acts on the duo-servo parking brake on the rear axle. This is realized with the aid of the electromechanical actuating unit and bowden cables. The actuating unit, if activated, always applies a braking force defined in the control unit.
2. Dynamic emergency braking
  - Predefined braking interventions are initiated by the DSC system if the parking brake button is pressed when the vehicle is in motion. The braking is monitored by the ABS control function and remains active until the button is released.

## EMF components and their functions

### Electromechanical actuating unit



1 - Assembled EMF components

TF04-5757

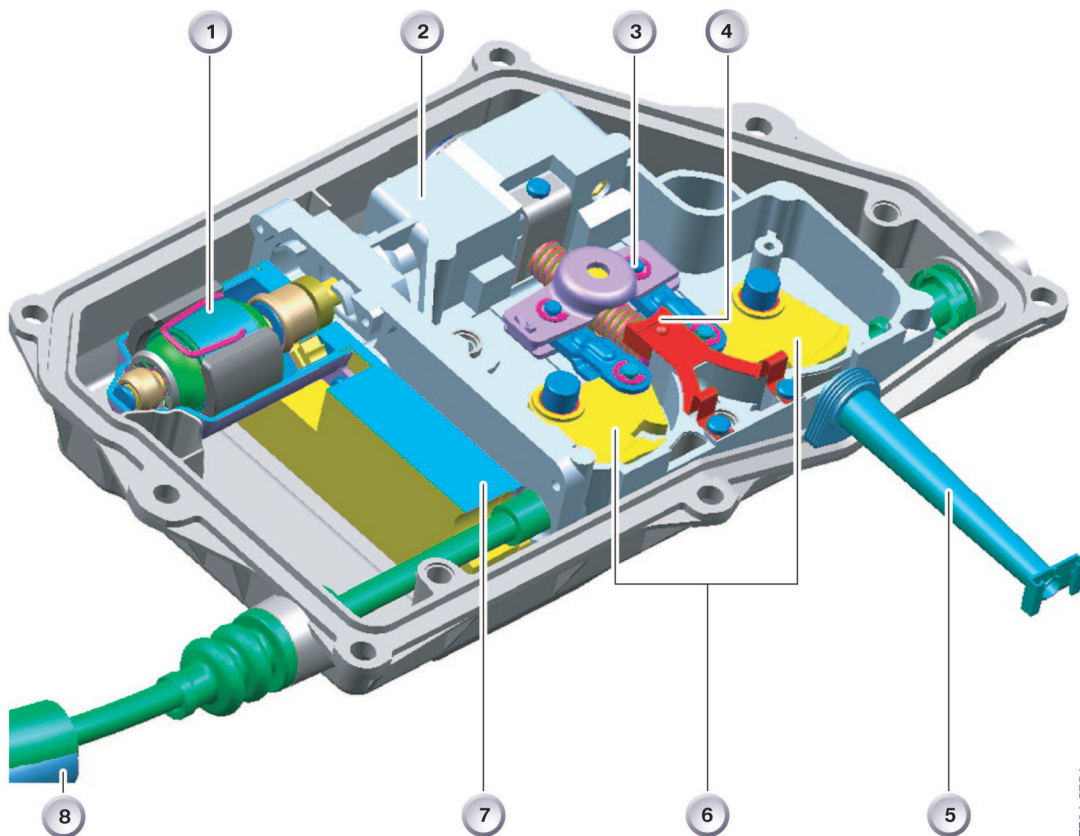
Index		Index	
1	Cable pulleys	4	Balancing arm
2	Attached control unit	5	Gearbox
3	Servomotor	6	Spindle

The motor of the actuating unit drives the gearbox, which then turns the spindle. The spindle moves the balancing arm, which is required for right-left balancing of the Bowden cables. Depending on the direction of spindle rotation, the balancing arm pulls the cable pulleys connected by a lever. The Bowden cables connected to the cable pulleys apply or release the duo-servo parking brake. The

release action is effected by return springs in the duo-servo parking brake.

If the brake is released again, the spindle is driven by the gearbox and takes the end of the wrap spring on the opposite side with it. The spindle is released from the housing by being drawn inwards and around the spindle. The

balancing arm shifts forwards and turns the cable pulleys outwards by means of the connecting lever. This releases the Bowden cables.



TF04-5754

2 - Parking brake limit stop

Index		Index	
1	Servomotor	5	Guide tube for emergency release
2	Gearbox	6	Cable pulley
3	Balancing arm	7	Control unit
4	Limit stop	8	Bowden cable

The holding force of the parking brake is maintained by the wrap spring on the spindle. After the holding position has been reached, the power flow of the spindle has the effect of turning the spindle in the opposite direction due to the tensile force of the tensioned cables. This causes the first windings of the wrap spring to splay outwards. They press against the surrounding housing and hold the spindle in position. The parking brake force is

thus supported by the wrap spring and not the gearbox.

It is also possible to use the gearbox to turn the spindle using the manual emergency release and release the spring tension.



---

## Control unit

The add-on parking brake control unit is integrated in the EMF actuating unit. It is connected to the DSC control unit and the vehicle peripherals (instrument cluster, DME, gearbox) via the CAN.

The ECD interface (electronically controlled deceleration) is used in the DSC control unit for the hydraulic brake control. Pressing the parking brake button while the engine is running requests a fixed amount of brake pressure, which is generated by the hydraulic unit and forwarded to the parking brakes.

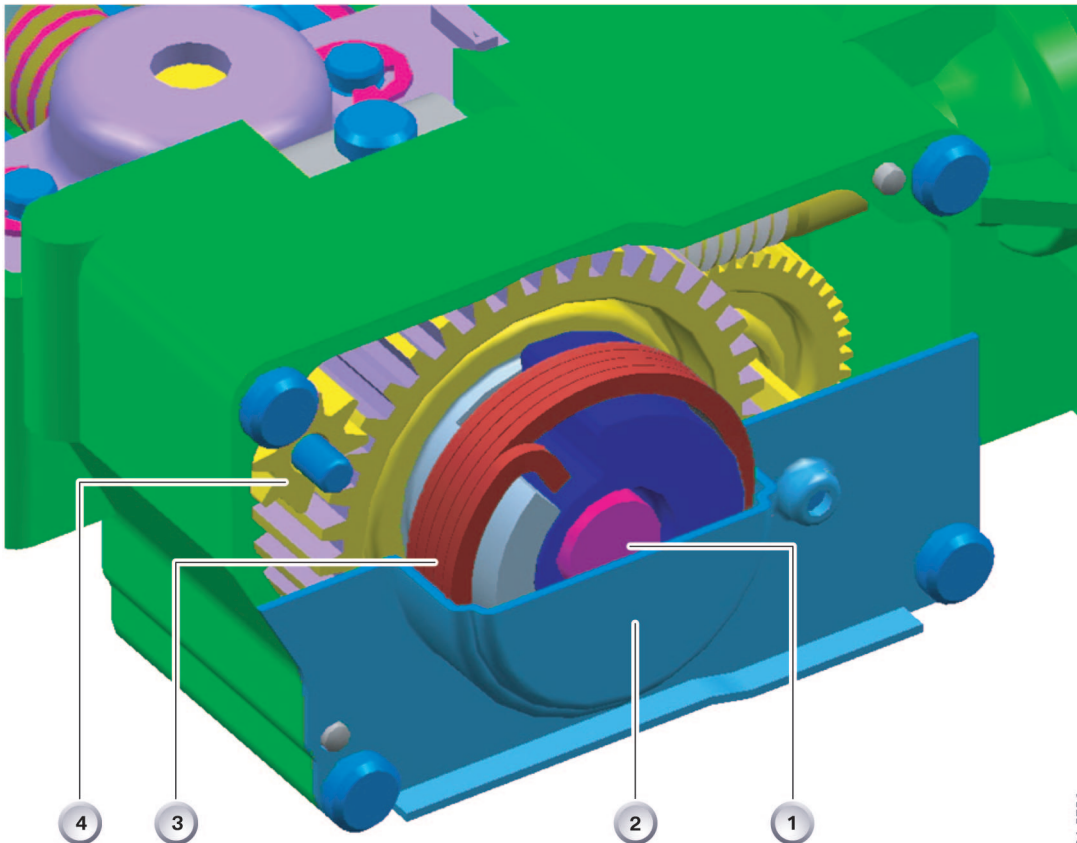
The force acting on the spindle is calculated in the parking brake control unit.

This is realized, on the one hand, by determining the power intake of the motor in connection with the temperature at the motor coil. On the other hand, the actuating force is calculated in connection with the speed drop of the motor. The drop in speed can be derived from the motor speed against torque characteristic curve.

There is also a Hall sensor for detecting the speed and position of the motor.



## Gearbox with wrap spring



TF04-5756

3 - Gearbox and wrap spring

Index	Explanation	Index	Explanation
1	Spindle	3	Wrap spring
2	Wrap spring cover	4	Emergency release drive

The gearbox is a three-stage reduction gear set comprising a worm gear, spur gear and spindle. The gearwheels of the gear mechanism are made from plastic.

For this reason, the entire holding force of the parking brake is supported by the wrap spring in the cover of the spindle housing.

## Parking brake button on the E65

Two separate operating elements are provided for controlling parking brake functions:

- The basic parking brake functions, i.e. Apply/Release with vehicle stationary, are operated by means of a button (1) arranged to the left of the steering wheel on the instrument panel. It operates as an ON/OFF button. In the case of dynamic emergency braking, the brake is applied for as long as the button is pressed, irrespective of the vehicle speed.
- The second operating element is an action field in the menu of the control display. The menu is controlled and activated using the controller. This control allows the driver to select whether the Automatic Hold convenience parking brake function should be activated or deactivated. The activation and deactivation of this convenience function can also be assigned to the individually programmable button on the multifunction steering wheel.



4 - Parking brake button



## Indicator lamps on the E65

The driver is informed at all times of parking brake system status and availability.

This information is in the form of an indicator lamp in the instrument cluster and additional instructions in the control display in the event of a malfunction. The parking brake control unit is connected to the instrument cluster and the control display by CAN. The lamp check is started after the ignition is turned on. Technicians call this the pre-drive check.

### Display in the instrument cluster

Application of the parking brake is indicated by a red indicator lamp with the brake symbol P.

PARK lights up in the indicator lamp for the duration of the actuation process. The P symbol indicates whether the requested status, applied or released, has been achieved.

An audible warning also sounds if the parking brake is operated when the vehicle is in motion (dynamic emergency braking).

### Convenience display (automatic)







The readiness of automatic hold function is displayed by AUTO-P in green in the lamp. The parking brake symbol is also displayed if the Automatic Hold function is active and holding the vehicle.

The parking brake symbol lights up green in this event (the hold function is now controlled by DSC at all 4 wheel brakes).

The green parking brake symbol goes out following automatic release of the brake when driving off. The green readiness indication AUTO-P, however, remains active.

Automatic transition from the hydraulics to the mechanical system takes place when the engine is turned off. The illuminated indicator changes from green to red (additional application of the parking brake and release of DSC).

## Indicator lamp control

System functions	Indicator lamps
Parking brake released	 TF04-5761
Parking brake activated	 TF04-5762
Dynamic emergency braking and gong	 TF04-5760
Automatic Hold ready	 TF04-5748
Automatic Hold active	 TF04-5749
System fault	 TF04-5760

## Check control display

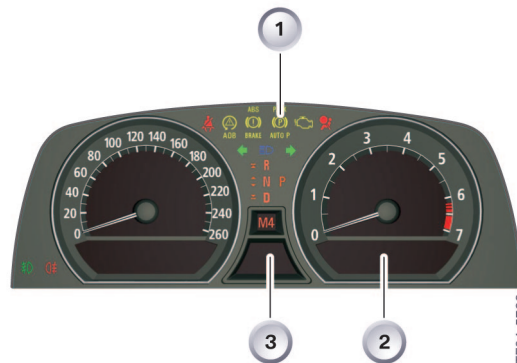
Parking brake malfunctions are indicated by a yellow lamp in the instrument cluster.

The same symbol is also shown by the variable indicator lamp and explained by a brief text message.

In addition to the parking brake, the variable indicator lamp is also available to other control units. Corresponding to a defined priority control, the parking brake control unit can only partially use the indicator lamp. The variable indicator lamp is able to display all symbols and colours of all malfunctions as shown in the instrument cluster.

Malfunction of the parking brake is indicated with the aid of the variable indicator lamp in the instrument cluster. At the same time, the fault

is detailed with supplementary information in the control display.



5 - Instrument cluster

TF04-5766

Index	Explanation	Index	Explanation
1	Parking brake indicator lamp	3	Variable display and warning field
2	Check control display		

## EMF emergency function

The handbrake function is not the only task of the electromechanical parking brake. The EMF additionally conforms to the legal requirement of providing a second operating unit for brake operation.

The electromechanical parking brake is the second operating unit in the E65 in addition to the foot brake.

The vehicle decelerates at a rate of  $3 \text{ m/s}^2$  for 0.8 seconds if the button is pressed when the vehicle is in motion. Braking deceleration is then ramped up to  $5 \text{ m/s}^2$  for the next 2 seconds. This braking deceleration is maintained for as long as the button is pressed.

For safety reasons, the DSC hydraulic system ensures the dynamic braking function by way of the active pressure build-up also when the vehicle is rolling with inclusion of the ABS function. Rolling situations include traffic queues while driving downhill, towing. The brake pressure required is made available as rapidly as possible.

The braking is always monitored by the ABS control function. This ensures vehicle stability under braking. Since all four wheels are braked hydraulically, there is considerably greater

deceleration with a minimum of operating effort (button) by comparison with conventional parking brakes. The controlled brakes is therefore able contribute to improving vehicle safety.

For traffic safety reasons, operation of dynamic emergency braking is indicated to the road users behind by the brake lights coming on.

To avoid accidental operation and misuse, the driver is notified of dynamic emergency braking operation by the "Release parking brake" message and a gong.

The vehicle will remain hydraulically braked if the vehicle is braked to a halt by dynamic emergency braking alone. The red P lamp remains on.

The more effective braking solution is used if the parking brake deceleration request is overlapped by the brake pedal being depressed. Which deceleration request to carry out is decided in the DSC control unit.

This function is intended only for use in an emergency and must never be used as a substitute for normal operation of the service brake.

## When is the emergency function cancelled?

The vehicle will remain hydraulically braked even after the parking brake button has been released if the vehicle is braked to a halt by dynamic braking. There is a transition to the normal DSC hydraulics function. The hydraulic brake is only released when the button is pressed once more.

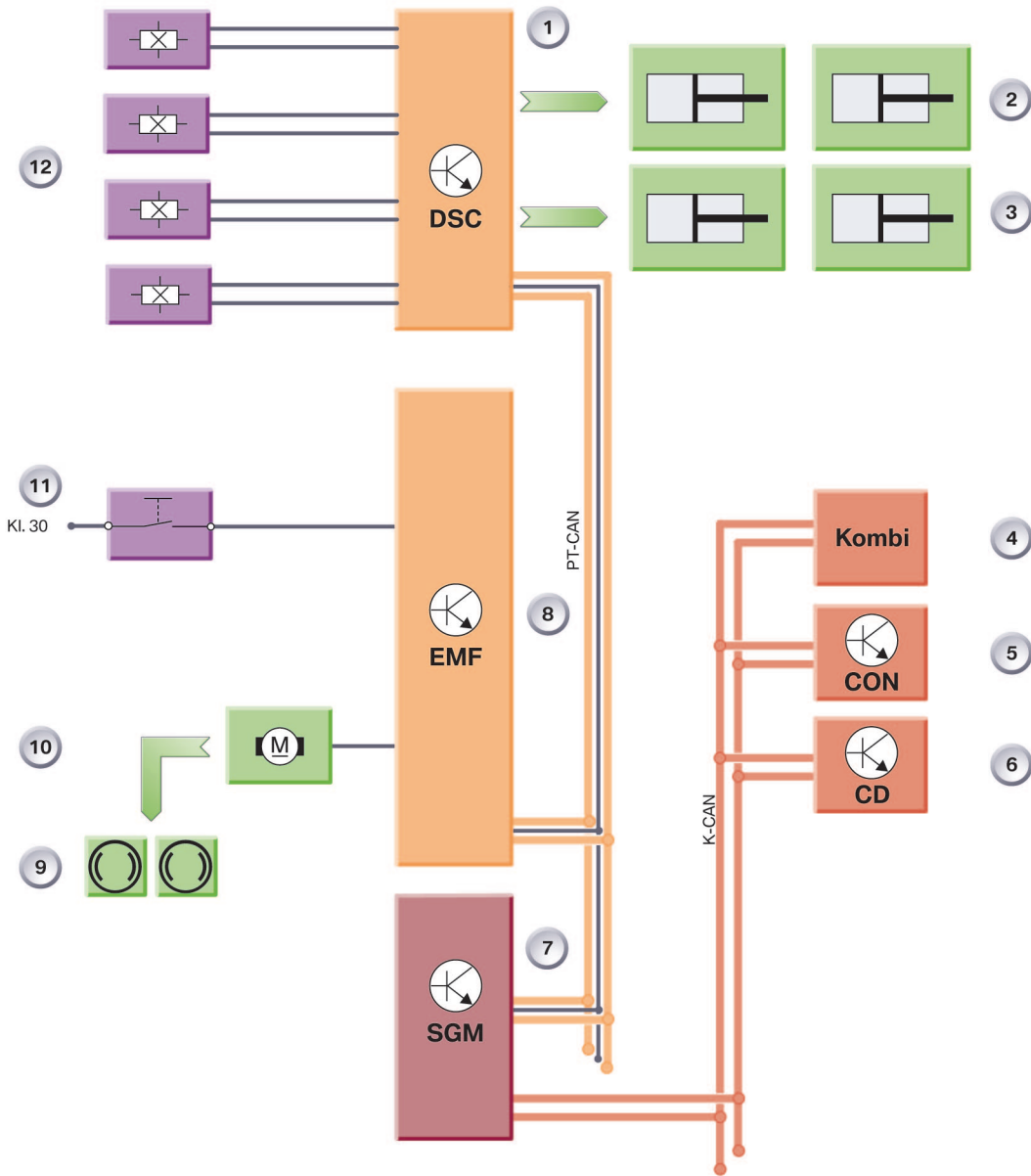
If the driver releases the parking brake button while the vehicle is still in motion, the system level prevailing before the emergency dynamic braking was activated is resumed.

If the parking brake is released and the vehicle is coasting, it is possible to activate emergency dynamic braking in any situation (terminal 15, terminal R, terminal 30) by pressing the button.

# System components

## Electromechanical parking brake

### System components on the E65



TF04-5741

1 - EMF system diagram

Index	Explanation	Index	Explanation
1	DSC module	8	EMF control unit
2	Service brake, front axle	9	Parking brake, rear axle
3	Service brake, rear axle	10	Parking brake servomotor
4	Instrument cluster	11	Parking brake button
5	Controller	12	4 wheel speed sensors
6	Control Display	K-CAN	Body CAN
7	Safety and gateway module SGM	PT-CAN	Powertrain CAN





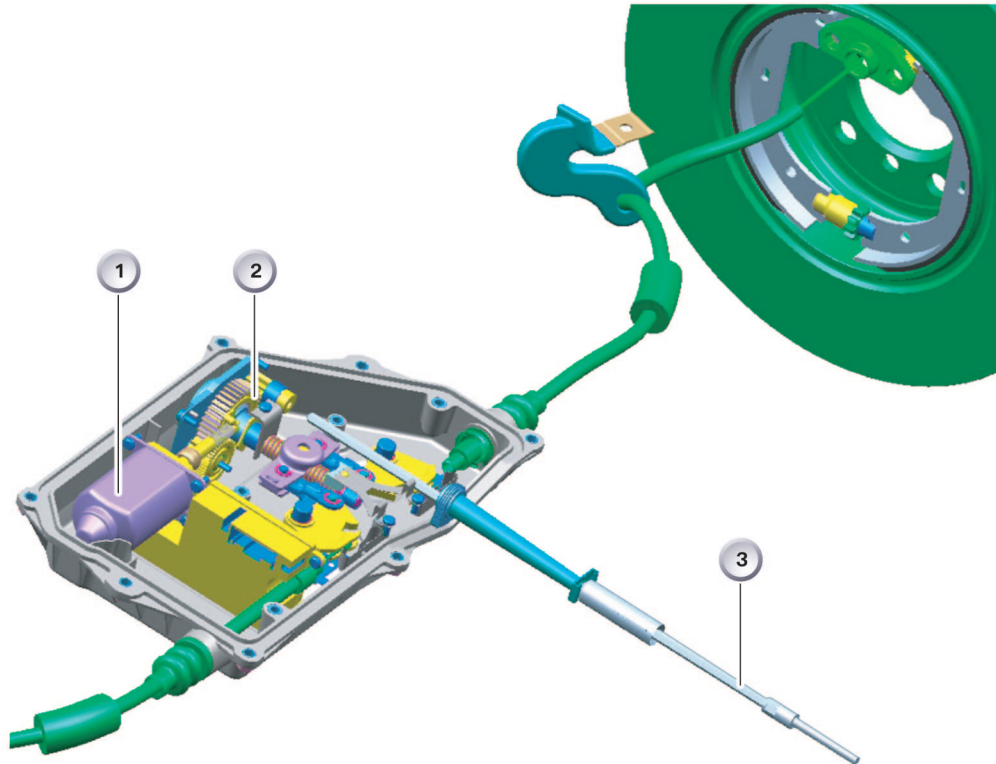
# Service information

## Electromechanical parking brake

### Emergency release and restoring normal operation

The full parking brake effect is released by intervening directly in the gearbox mechanism.

To release the brake in an emergency, an extension rod supplied separately in the vehicle tool kit is inserted through a guide tube and into the emergency release gearwheel.



TF04-5755

1 - Actuating unit

Index	Explanation	Index	Explanation
1	Electric motor	3	Emergency release tool
2	Emergency operation gearwheel		

The insert tool is intended to be inserted through a guide tube on the side of the housing opposite the gearbox.

The turning torque required is achieved using the open-ended spanner and screwdriver handle from the vehicle tool kit.

The brake is released by turning anticlockwise. A release spring in the release tool prevents the tool from turning if accidentally left inside.

**Note:**

After releasing the brake by emergency release, it may still not be possible to move the vehicle if there has been a power failure.

The automatic transmission parking lock may still be engaged.

There is a manual emergency release for the gearbox in the left-hand footwell. Opening a cover reveals a lever that can be folded out by pulling a strap and then engaged. It is then possible to move the vehicle.

The cover in US vehicles is secured by a lock. It can only be opened using the ignition key.

**Restoring normal operation after an emergency release**

If the power supply is restored after the emergency release, the parking brake button must be pressed 3 times.

**1st operation**

The control unit would like to release the brake. The motor cannot turn in reverse as the brake was already released by the emergency release function. The control unit detects an implausible condition.

**2nd operation**

The motor is able to turn forwards. The brake is applied. The control unit detects the situation.

**3rd operation**

The motor is able to turn in reverse. The brake is released again. Normal operating status is restored.

This procedure is also described in the Owner's Handbook.

---

## Brake shoe adjustment

The brake shoes of the parking brake are adjusted as before by turning an adjusting

screw with a screwdriver. A threaded hole is provided in the wheel hub for this purpose.

---

## Removing the Bowden cables

To permit removal of the Bowden cables, it is necessary to raise the end stop using a tool (e.g. a screwdriver). The release tool turns

back the balance arm until the cable pulleys come up against the housing, thus releasing the Bowden cables from the pulleys.

---

## Initializing the parking brake

The parking brake must be initialized following replacement of the drum brake pads. This function can be performed with the aid of the DIS or MoDIC. The process teaches in the

new free play of the brake cables as detected by the Hall sensor in the actuating unit. This makes later detection of cable tearing more reliable.

---

## Bedding-in the duo-servo brake

If the brake shoes of the duo-servo parking brake are replaced as part of repair or maintenance work, it is necessary to bed-in the brake shoes before a sufficient holding effect may be achieved. A special bedding-in routine is stored in the parking brake software that can be called up using DIS.

The readiness of the bedding-in program is indicated to workshop personnel by a flashing red parking brake indicator lamp in the instrument cluster. The bedding-in procedure must be performed within 30 minutes after activating the program. The ignition must not be turned to OFF otherwise the bedding-in program will be terminated. The system will revert to the normal parking brake function.

---

## PBR abbreviation for parking brake

The abbreviation PBR is also used in DIS when referring to the parking brake.



# Summary

## Electromechanical parking brake

### System benefits

- Operating comfort has been enhanced considerably by comparison with the conventional mechanical parking brake.
- Optimum ergonomics have been achieved thanks to its space-saving control (button). Moreover, it has been possible to utilize the room reclaimed in the centre console (stowage compartments, telephone, etc.).
- The automatic braking of the automatic hold function relieves some of the stress of stop and start traffic. It relieves the strain on the driver by reducing the amount of foot operation usually required in creeping traffic.
- Similarly, the automated release of the brake makes pulling away comfortable on uphill gradients without the risk of the vehicle rolling backwards.
- The intervention of the ABS control function during dynamic emergency braking and the deceleration effect boosted by hydraulic four-wheel braking interventions have contributed to raising standards of vehicle safety.
- Yet another safety feature is that it is only possible to release the parking brake when the ignition is ON (child-safety lock, electronic immobilizer).
- The system is diagnostics compatible and benefits from wear compensation. No adjustment work is necessary (Bowden cable adjustment).
- Its diagnostic capabilities inform the driver of system condition and simplify repair and service work.
- A manual emergency release is provided in case of system failure or insufficient power supply.
- There are no distracting brake operation noises.



# Contents

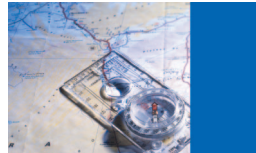
## Transverse dynamics systems



### Objectives

Useful information for the reader

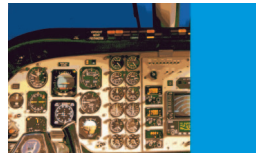
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1



### Introduction

Dynamic Drive

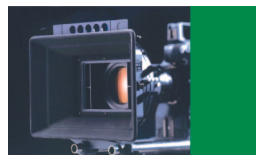
3  
3



### System overview

E60 Mechanical system

5  
5



### Functions

Components and their functions

System functions

Operating states

7  
7  
17  
21



### System components

E60 inputs/outputs

E60 system circuit diagram

25  
25  
27



### Service information

Notes for service staff

29  
29







# Objectives

## Transverse dynamics systems

### Useful information for the reader

Dynamic Drive or active roll stabilization - the BMW transverse dynamics system.

The following pages contain all the information you need to understand the system. You will become acquainted with all system components and their operation, and individual functions will be explained in detail.

You will then be in a position to carry out diagnostics to a professional standard - the basis for high customer satisfaction.





# Introduction

## Transverse dynamics systems

### Dynamic Drive

DynamicDrive is a suspension control system that counteracts rolling forces. DynamicDrive is also known as ARS. This stands for Active Roll Stabilization. DynamicDrive prevents vehicle roll (= turning motion around longitudinal axis during cornering). When a vehicle is cornering, a centrifugal force acts on the centre of gravity which builds up a rolling moment via the vehicle longitudinal axis. This force tilts the vehicle body towards the wheel on the outside of the bend and the vehicle rapidly approaches its dynamic limits. Stabilizer bars are used to counteract the varying forces which act on the wheels as a result of the body angle. During cornering, the wheel suspension on the outside of the bend is compressed and the wheel suspension on the inside of the bend rebounds. This causes the spine of the stabilizer bar to turn. The forces occurring at the mounting points of the

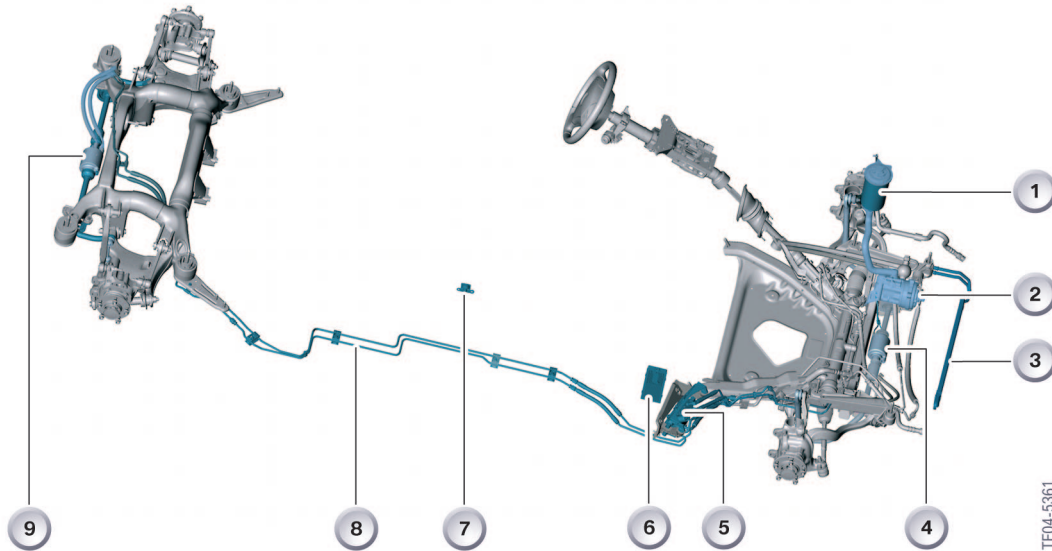
stabilizer bar produce a moment. The moment counteracts the tilt of the body, thus achieving more effective distribution of the load over both wheels. DynamicDrive therefore enhances driving stability. Vertically divided stabilizer bars on both axles are the basic elements of this system. Both halves of the stabilizer bars are connected by a hydraulic oscillating motor which adapts the suspension to the road situation within milliseconds. DynamicDrive also improves driving comfort - especially ride comfort - when travelling straight ahead. If potholes are present on one side of the road, in vehicles with conventional stabilizer bars this has a negative effect on the suspension on the other side. Not so with DynamicDrive.



# System overview

## Transverse dynamics systems

### E60 Mechanical system



TF04-5361

1 - Overview of mechanical system

Index	Explanation	Index	Explanation
1	Fluid reservoir	6	Control unit
2	Tandem pump	7	Transverse acceleration sensor
3	Hydraulic-fluid cooler	8	Hydraulic lines
4	Front oscillating motor	9	Rear oscillating motor
5	Valve block		



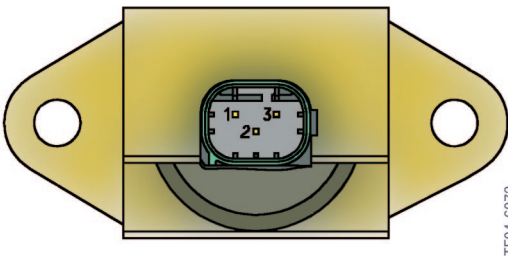
# Functions

## Transverse dynamics systems

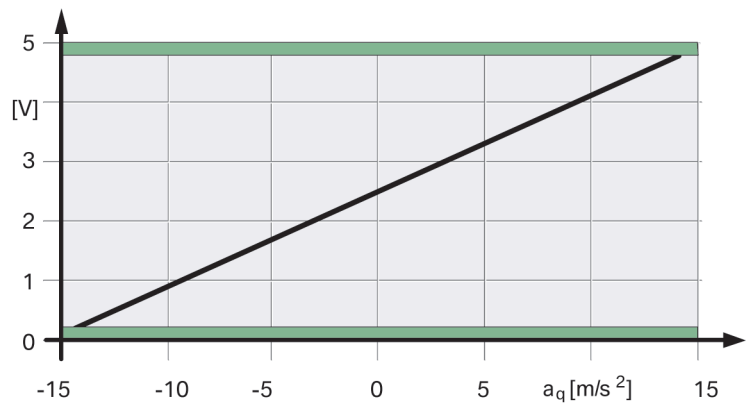
### Components and their functions

#### Transverse acceleration sensor

The transverse acceleration sensor supplies the main sensor signal. It measures the transverse acceleration of the vehicle during cornering up to a measurement range of  $\pm 1.1$  g. The transverse acceleration sensor is installed on the base plate under the right front seat.



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#### Oil level sensor

The oil level sensor detects the fluid supply in the oil reservoir. It is installed on the oil reservoir. Short-circuit/

open circuits cannot be detected by the oil level sensor. A line break is interpreted as a loss of fluid.

#### DynamicDrive control unit

The DynamicDrive control unit is located on the right side of the passenger compartment in the A-pillar area.

The control unit is supplied with power via terminal 30 and is protected by a 10 A fuse.

A vehicle authentication process takes place when the system is started. This compares the vehicle identification number from CAS with the vehicle identification number which is encoded in the DynamicDrive control unit.

Then the control unit's hardware and software is checked.

All the outputs (valve magnets) are subjected to a complex check for short circuits and breaks. If there is a fault, the system switches the actuators into a safe driving condition.

The control unit switches off if there is undervoltage or overvoltage.

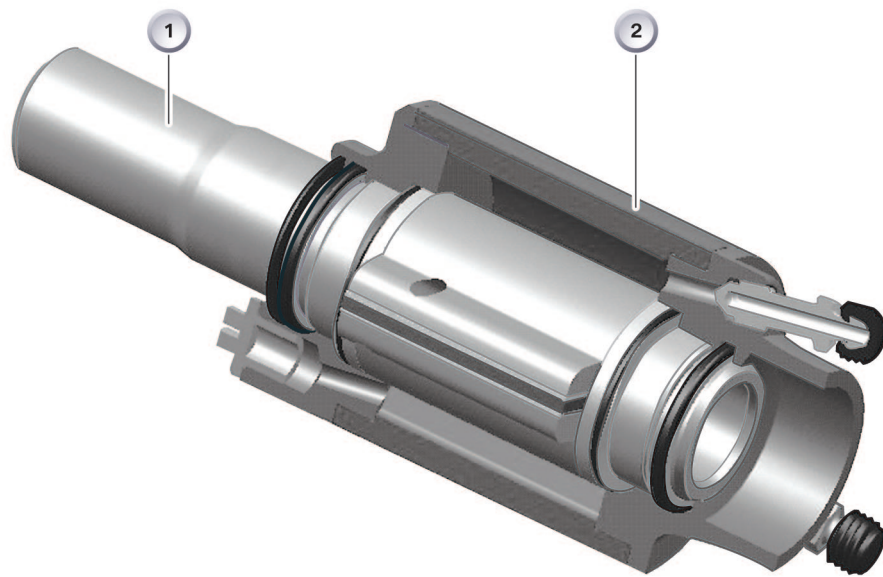
The control unit learns the "offset" for the steering angle and the transverse acceleration during start-up and during driving.

## Active stabilizer bar

The active stabilizer bar consists of the oscillating motor and the halves of the stabilizer bar with press-fitted roller bearings which are mounted on the oscillating motor. The roller bearings provide the connections to the axle carrier. The use of roller bearings

ensures optimum comfort thanks to better response and reduced control forces.

The oscillating motor and the oscillating motor housing are joined by one half of the stabilizer bar.



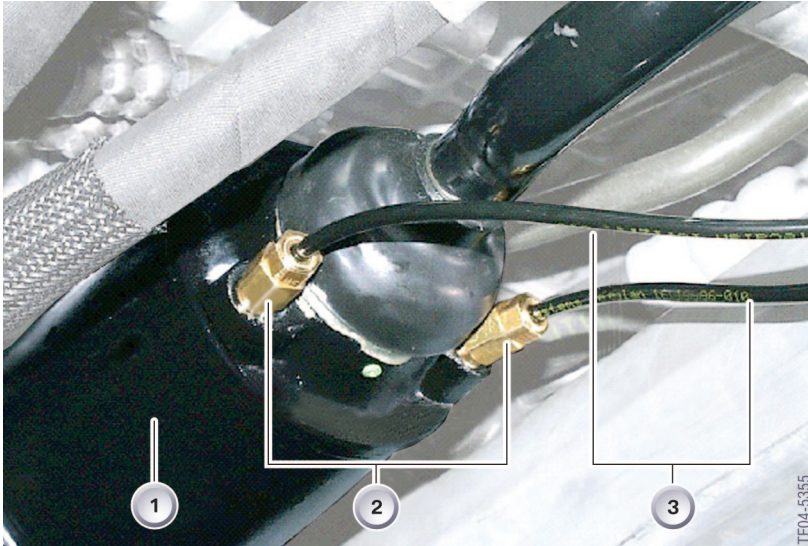
1 - Oscillating motor

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Index	Explanation	Index	Explanation
1	Oscillating motor shaft	2	Oscillating motor housing



The oscillating motor of the front-axle stabilizer bar is fitted with 2 pressure relief valves.

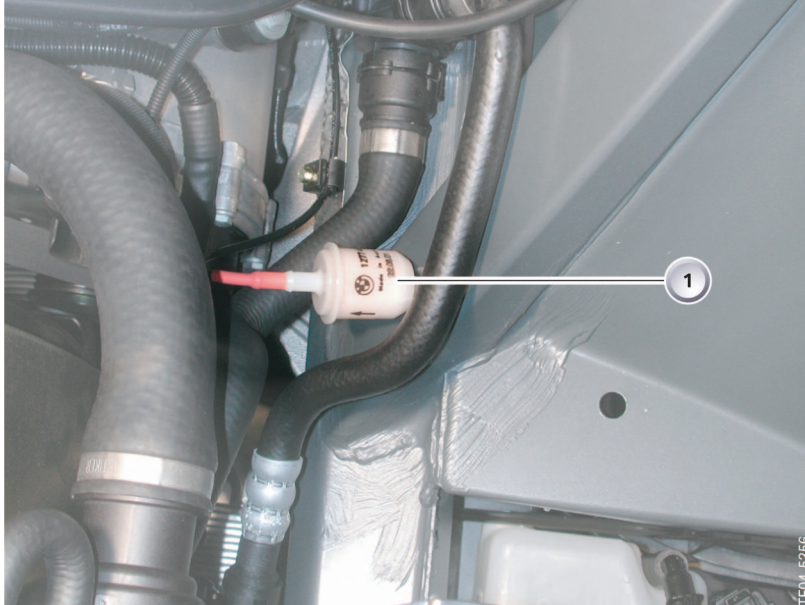


2 - Pressure relief valves

Index	Explanation	Index	Explanation
1	Oscillating motor	3	Pneumatic lines
2	Pressure relief valves		

Pneumatic lines are mounted on the pressure relief valves (venting valves). The pneumatic lines lead to a filter element

(conventional fuel filter) which is inserted in the diagonal strut on the left wheel arch.



3 - Filter element

Index	Explanation
1	Filter element

The filter element is located in different positions in the engine compartment, depending on the mounting position of the various engines.

The positions for the pressure relief valves are fitted with screw plugs on the oscillating motor of the rear-axle stabilizer bar.

### Function of pressure relief valves

When the vehicle is driven on poor road surfaces, the stabilizer bar movements give rise to brief underpressures (cavitation) in the oscillating motors which in turn cause rattling noises.

Pressure relief valves have been fitted on the front oscillating motor in order to eliminate these noises. These pressure relief valves allow filtered air to flow into the oscillating motor through the connected pneumatic lines. This prevents cavitation.

This small quantity of air is absorbed by the hydraulic fluid (Pentosin) to form an emulsion, which is discharged during subsequent activations of the oscillating motor. The air is separated in the expansion tank.

Since no noises can be heard at the rear axle, the pressure relief valves have been omitted from the rear oscillating motor.

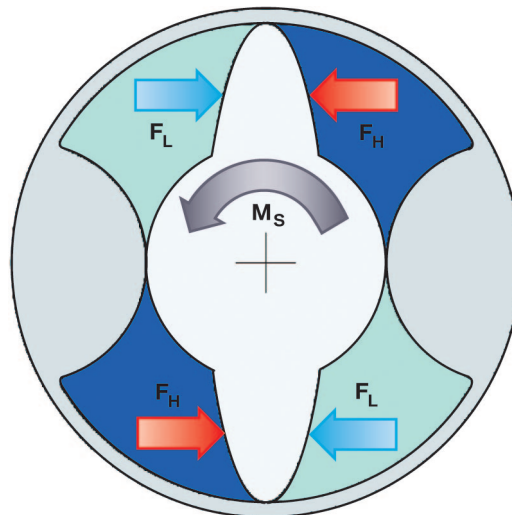
## Operating principle of oscillating motors

The oscillating motor has three functions to perform:

- It guides the torque into the two halves of the stabilizer bar.
- It decouples the two halves of the stabilizer bar.
- In the event of system failure (fail-safe mode), the front axle stabilizer bar creates sufficient damping via the hydraulic fluid of the oscillating motor. It now works like a conventional stabilizer bar.

Exception: If the oscillating motor chambers no longer contain any fluid as a result of a leak, the front axle stabilizer bar can no longer create damping.

The opposing chambers in the oscillating motor are connected to one another. The same pressure exists in both chambers. Two chambers are supplied with high-pressure fluid using one connection. The two other chambers are connected to the tank via the return line. The forces  $F_H$  (High) or  $F_L$  (Low) are created as a result of the differences in pressure. As  $F_H$  is greater than  $F_L$ , a torque  $M_S$  is generated. The shaft turns in the opposite direction to the housing as a result.



4 - Generating torque

Since one half of the stabilizer bar is connected to the shaft, and the other with the housing, the two halves turn in opposite directions.

This torque  $M_S$  at the stabilizer bar connections produces the active moment  $M_A$  about the vehicle longitudinal axis. The active moment counteracts the rolling moment  $M$  while cornering. The body is forced upwards on the outside of a bend, and dragged down on the inside of a bend.

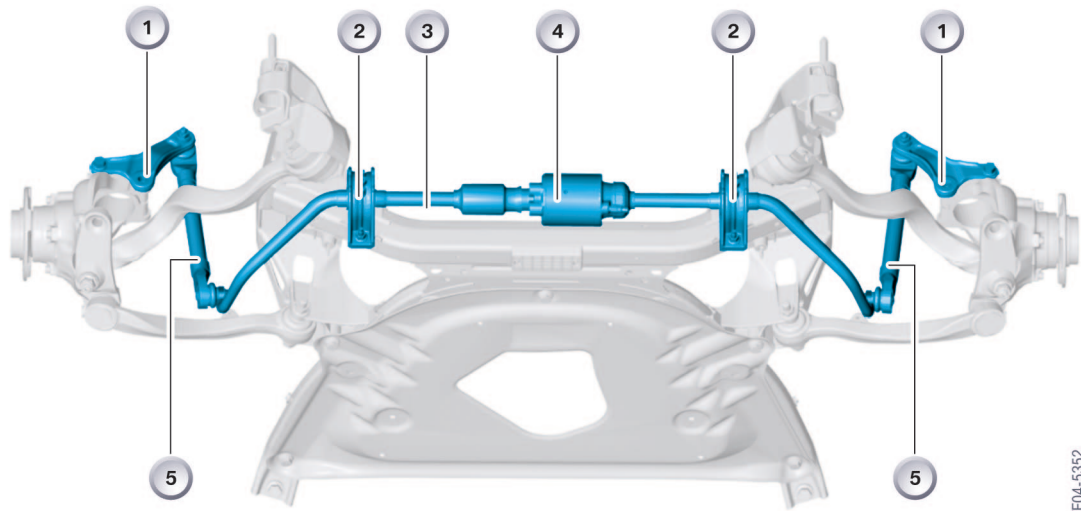
The maximum body torque on the front and rear axle occurs when there is a high degree of transverse acceleration. The system pressure is then 180 bar at the front axle and 170 bar at the rear axle.

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## Front-axle stabilizer bar

The stabilizer bar is mounted on the front-axle carrier.

The stabilizer links are connected to the "goosenecks" of the swivel bearings.



5 - DynamicDrive front axle

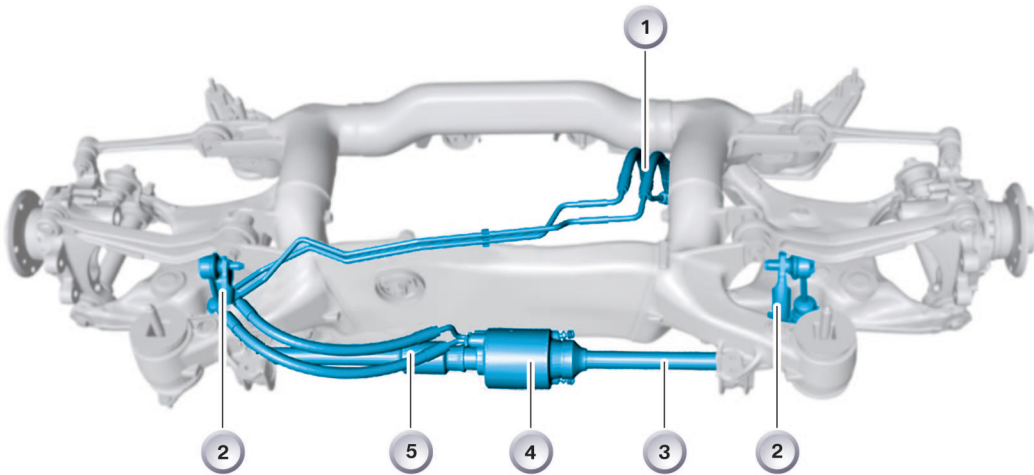
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Index	Explanation	Index	Explanation
1	Anti-roll bar link connection to swivel bearing	4	Oscillating motor
2	Anti-roll bar bracket	5	Anti-roll bar links
3	Anti-roll bar		

## Rear-axle stabilizer bar

The stabilizer bar is mounted behind the rear-axle carrier.

The stabilizer links are connected to the rear-axle swinging arms.



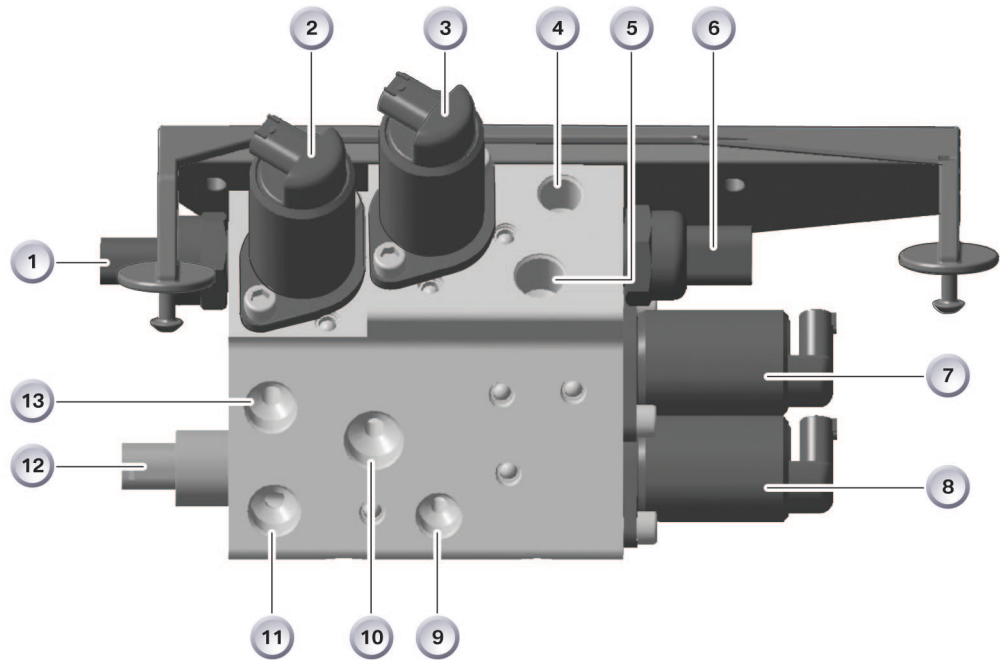
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6 - DynamicDrive rear axle

Index	Explanation	Index	Explanation
1	Hydraulic lines from valve block	4	Oscillating motor
2	Anti-roll bar links	5	Hydraulic lines
3	Anti-roll bar		

## Valve block

The valve block is located on the floor plate behind the front right wheel-arch trim.



7 - Valve block

TF04-5353

Index	Explanation	Index	Explanation
1	Rear-axle pressure sensor	8	Directional valve
2	Rear-axle pressure-limiting valve	9	Line 1, rear-axle oscillating motor
3	Front-axle pressure-limiting valve	10	Line to hydraulic fluid reservoir
4	Line 1, front-axle oscillating motor	11	Line 2, rear-axle oscillating motor
5	Line 2, front-axle oscillating motor	12	Switching position recognition sensor
6	Front-axle pressure sensor	13	Line to tandem pump
7	Fail-safe valve		

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## Pressure control valves

There is a pressure control valve on both the front and rear axles. They both adjust the

actuation pressures for the front- and rear-axle stabilizer bars.

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## Directional valve

The directional valve is electrically actuated. It specifies the direction of the high-pressure

fluid (active pressures) and the reservoir fluid for right-hand and left-hand bends.

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## Fail-safe valve

The fail-safe valve (safety valve) is electrically actuated. The fail-safe valve responds in the event of a power supply failure or if a fault is detected in the system.

When de-energized, the fail-safe valve locks

the oscillating motor for the front axle. Thus the active stabilizer bar behaves like a normal mechanical stabilizer bar and brings about understeering.

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## Switching position recognition sensor

The task of this sensor is to detect the specific position of the directional valve.

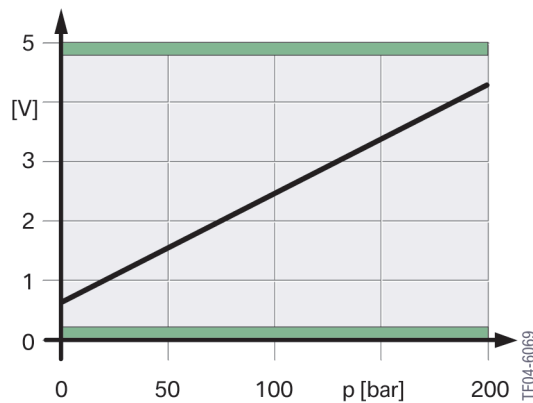
2 positions can be detected:

- Left-hand control
- Right-hand control

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## Front-axle/rear-axle pressure sensors

The pressure sensors are responsible for detecting the front and rear axle stabilizer bar hydraulic pressures. The sensors are mounted on the valve block. The pressure sensor offset values are taught-in by the control unit once, during commissioning.



8 - Pressure sensor characteristic curve

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## Tandem pump

The engine drives the tandem pump via a ribbed V-belt. The tandem pump consists of a radial piston part for DynamicDrive and a vane cell part for the power steering.

When idling, the pump speed is approximately 750 rpm.

The pump's minimum fluid flow rate is 4.5 l/min at approximately 5 bar and 3.3 l/min at 200 bar. This means that sufficient system

dynamics are also guaranteed when the engine is idling.

The maximum fluid flow rate is limited to 7 l/min from a pumping speed of approximately 1165 rpm and upwards.

The DynamicDrive and power steering share a common oil reservoir and power steering cooler.

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## Oil reservoir

The oil reservoir is identical on all vehicles, whether they have the DynamicDrive function or not. The reservoir incorporates a fluid filter.

An oil level sensor is provided for the minimum quantity.

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## Cooler

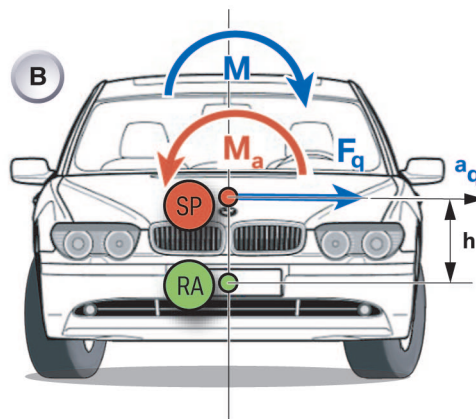
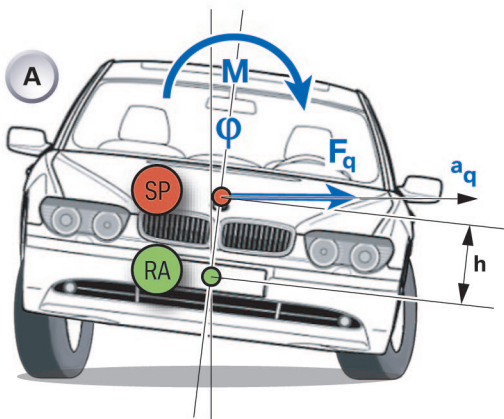
The cooler ensures a long-term fluid temperature of < 120 °C and a short-term fluid temperature of < 135 °C in all hydromechanical components under all conditions.



## System functions

Transverse acceleration  $a_q$  is exerted on the vehicle while cornering. The transverse acceleration is applied at the centre of gravity of the vehicle body. The body rolls about the vehicle longitudinal

axis (rolling axis) RA which is defined by the kinematics of the front and rear axle. The roll angle is formed  $\varphi$  (max.  $5^\circ$ ). This produces a maximum change in level at the wheel arch of 10 cm.



TF04-5449

9 - Rolling

Index	Explanation	Index	Explanation
A	Vehicle without DynamicDrive	Ma	Active body moment
B	Vehicle with DynamicDrive	SP	Centre of gravity
M	Rolling moment	RA	Vehicle longitudinal axis (rolling axis)
$a_q$	Transverse acceleration	$F_q$	Transverse force
$\varphi$	Roll angle	h	Lever arm centre of gravity height

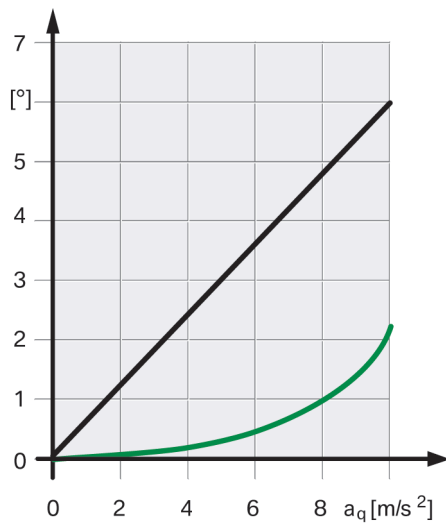
In a passive vehicle with conventional suspension, the rolling moment  $M$  is absorbed by the stabilizer bars and springs. The springs on the outside of the curve are compressed. The springs on the inside of the curve are elongated. In addition, the stabilizer bars rotate. A roll angle between the vertical axis and the body results.

On vehicles with DynamicDrive, the rolling moment  $M$  is compensated up to a transverse acceleration  $a_q$  of approx.  $3 \text{ m/s}^2$  (0.3 g). The active stabilizer bars alone are responsible for this function. A roll angle only builds up once the rolling moment  $M$  has exceeded the moment actively set  $M_a$  by the stabilizer bar. The additional rolling moment  $M$  is then absorbed by the passive springs.

The active body moments  $M_a$  at (the front and rear axle) counter the rolling moment  $M$ . Using this approach, the roll angle is compensated for in accordance with the characteristic curve specified in the control unit. The roll angle is fully compensated for up to a transverse acceleration of approximately  $3 \text{ m/s}^2$  ( $0.3 \text{ g}$ ). A roll angle also builds up with DynamicDrive but only with a high transverse acceleration. The roll angle together with an increasing understeering trend therefore provide the driver with an indication that the vehicle is approaching its limit range.

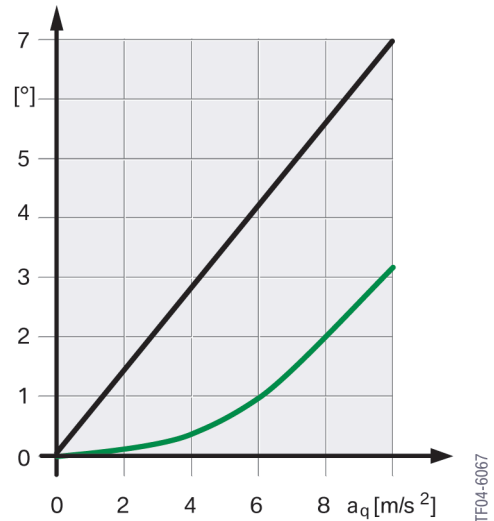
⚠ Note: The tyre suspension created by the rolling moment ( $M$ ) is not compensated for. ◀

### Roll angle diagram



10 - Roll angle diagram 1

The roll angle shown is achieved with an unladen vehicle with the driver in the vehicle.



11 - Roll angle diagram 2

When a vehicle is fully laden, the greater body weight effects a greater transverse force on the vehicle. Depending on the configuration of the vehicle load (in the vehicle or on the roof), this also results in a change to the lever arms  $h$ . The vehicle will in this case form a slightly greater roll angle than specified in the control curve.

By the same token, however, the fully laden passive vehicle also forms higher roll angles.

The distribution of the active body torque between the front and rear axle depends on the road speed.

## Affect of the self-steering behaviour

The self-steering behaviour can be decisively influenced by the distribution of the stabilizing torque on the axles. The greater the stabilizing torque on an axle, the lower the transverse forces transmitted on this axle.

Two cases are described below with different distribution of stabilizing torque on the axles:

### 1. Identical stabilizing torque on both axles

Handling is NEUTRAL.

The front wheels can apply about the same amount of transverse force on the road as the rear wheels without drive torque. The handling conditions are neutral.

The handling of a vehicle with neutral tuning is very agile and precise. The steering response is very direct.

Even an inexperienced driver can control a vehicle which is tuned to neutral handling very well at low speeds.

### 2. Greater stabilizing torque on the front axle

Handling is UNDERSTEERING.

The front axle wheels cannot apply the same amount of transverse force on the road as the rear axle wheels. The vehicle suffers understeer.

A greater steering-wheel angle is required to be able to follow the desired course.

A vehicle with understeer can generally also be controlled well by an inexperienced driver at higher speeds and higher cornering speeds.

This very sensitive handling reduces the vehicle's agility.

DynamicDrive sets different stabilization moments at the front and rear axle. This results in different vehicle response for low and high speeds.

The passive vehicle is configured as slightly understeering irrespective of the speed range.

The active vehicle with DynamicDrive is configured neutrally in the low speed range. Less steering is required by the driver to drive round the same bend. The result is optimum handling and agility.

In the upper speed range, both vehicles behave almost identically with regard to the required steering angle on the same bend.

The hydromechanical concept is designed so that a greater active stabilizing torque cannot occur on the rear axle than on the front axle. This means that mechanically and hydraulically the vehicle with DynamicDrive is safeguarded such that no oversteering and therefore for normal customers no critical handling characteristics can occur under any circumstances.

## Comparison between the conventional stabilizer bar and the active stabilizer bar

Active stabilizer bars introduce fewer comfort-reducing forces into the body than conventional stabilizer bars. In this case a differentiation must be made depending on the frequency with which the forces were introduced.

Road stimulus	Stabilizer bar behaviour
At approximately 1 Hz (body natural frequency)	At smaller strokes the active stabilizer bar is easier to turn than a conventional stabilizer bar. Consequently, the forces applied in the body are lower. The vehicle is more comfortable and body stability is improved.
From 8 Hz (wheel natural frequency)	Both stabilizer bars behave in a similar way. The active stabilizer bar becomes harder because the fluid is not displaced as quickly.

## Operating states

### **Straight-ahead travel:**

When the engine is started, the pump delivers hydraulic fluid to the system and a back pressure builds up. The pressure difference that occurs between the chambers of the actuator motor has no effect on the stabilizer bar. The reason for this is that, at approx. 1 bar, the pressure difference is very low. No power is applied to the high pressure control valves for the front axle stabilizer bar and the rear axle stabilizer bar. The valves are therefore open. The hydraulic fluid can flow back into the tank directly. This condition remains unchanged as long as the vehicle is travelling straight ahead.

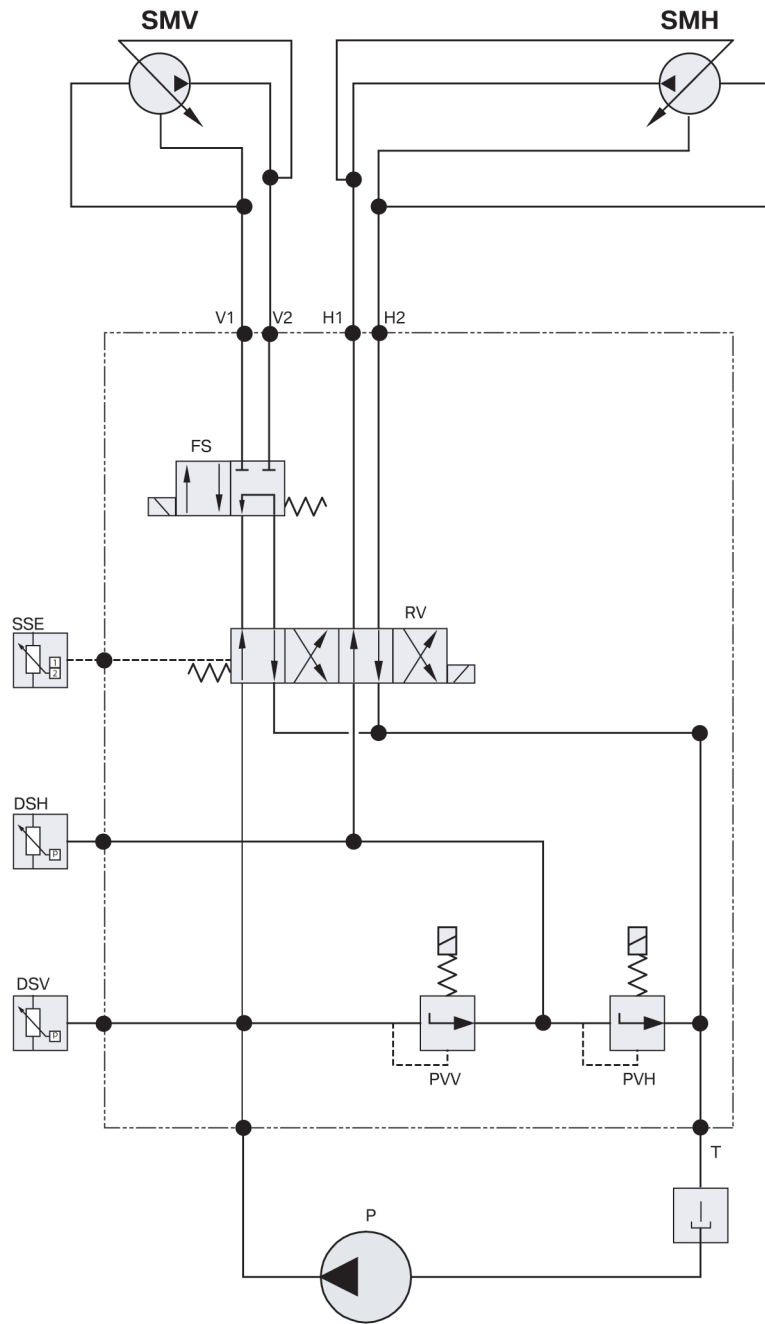
The system function is displayed continuously up to 15 km/h. The full stabilization potential is available from 15 km/h onwards.

### **Cornering:**

When approaching a bend, signals from the transverse acceleration sensor are sent to the DynamicDrive control unit. The control unit now sends a pulse-width-modulated signal (PWM) to the high pressure valves for the front and rear axle stabilizer bars. The stronger the transverse acceleration, the greater the signal will be (current). The higher the power applied to the valves, the more they close. A correspondingly higher pressure is built up in the stabilizer bars. The pressure at the stabilizer bar is registered by the respective pressure sensor on the front axle and on the rear axle and sent to the control unit.

The direction valve (RV) is activated by the control unit to create a pressure build-up which corresponds with the characteristic of the bend (left or right-hand bend). A sensor (SSE) detects the switch position of the direction valve.

The fail-safe valve is also activated with this function.



TF04-5360

12 - Hydraulic schematic

<b>Index</b>	<b>Explanation</b>	<b>Index</b>	<b>Explanation</b>
SMV	Front oscillating motor	RV	Directional valve
SMH	Rear oscillating motor	DSH	Rear-axle pressure sensor
V1	Front-axle hydraulic circuit 1	DSV	Front-axle pressure sensor
V2	Front-axle hydraulic circuit 2	PVV	High-pressure control valve, front axle
H1	Rear-axle hydraulic circuit 1	PVH	High-pressure control valve, rear axle
H2	Rear-axle hydraulic circuit 2	P	Tandem pump
FS	Fail-safe valve	T	Fluid reservoir
SSE	Switching position recognition sensor		

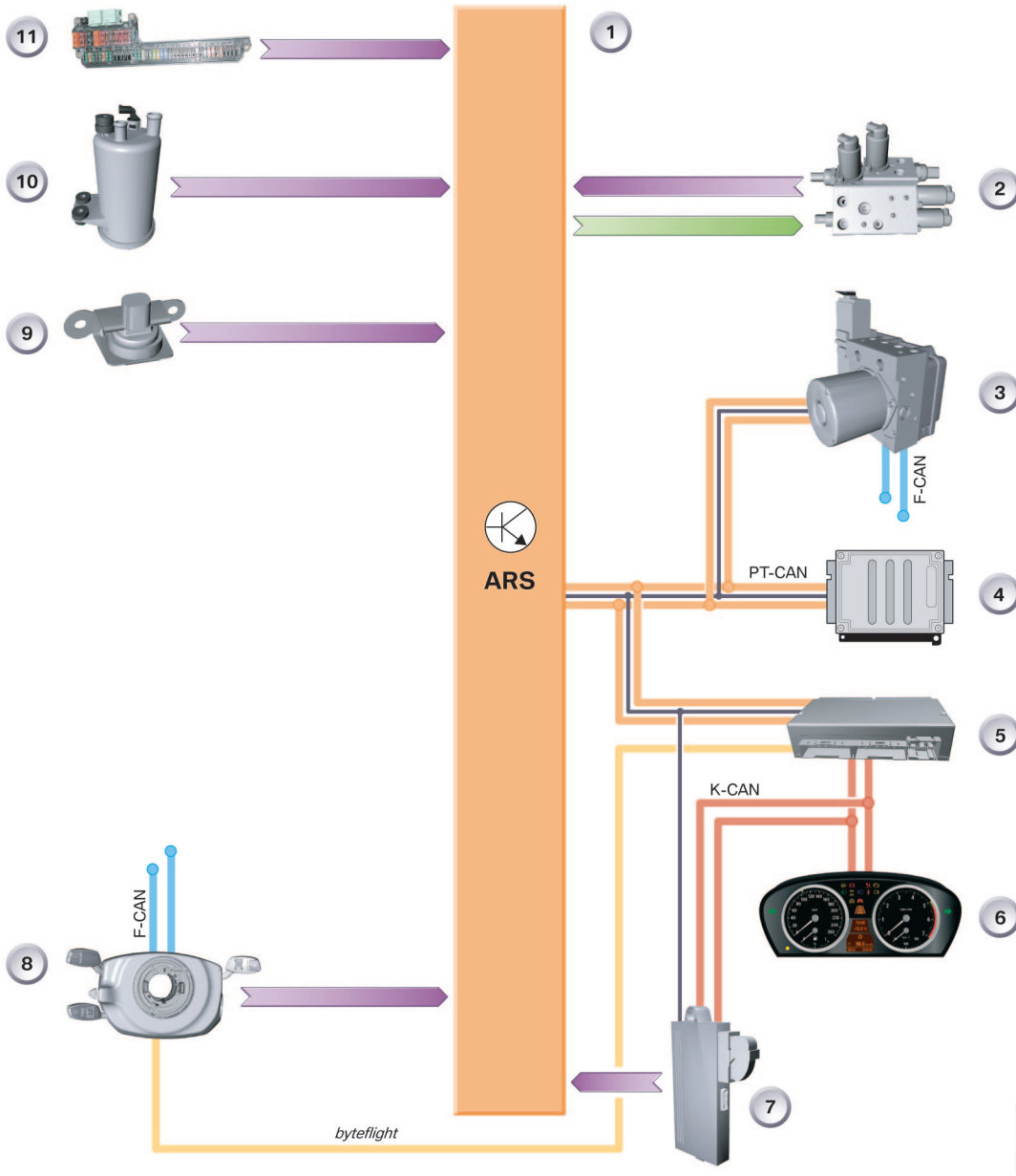




# System components

## Transverse dynamics systems

### E60 inputs/outputs

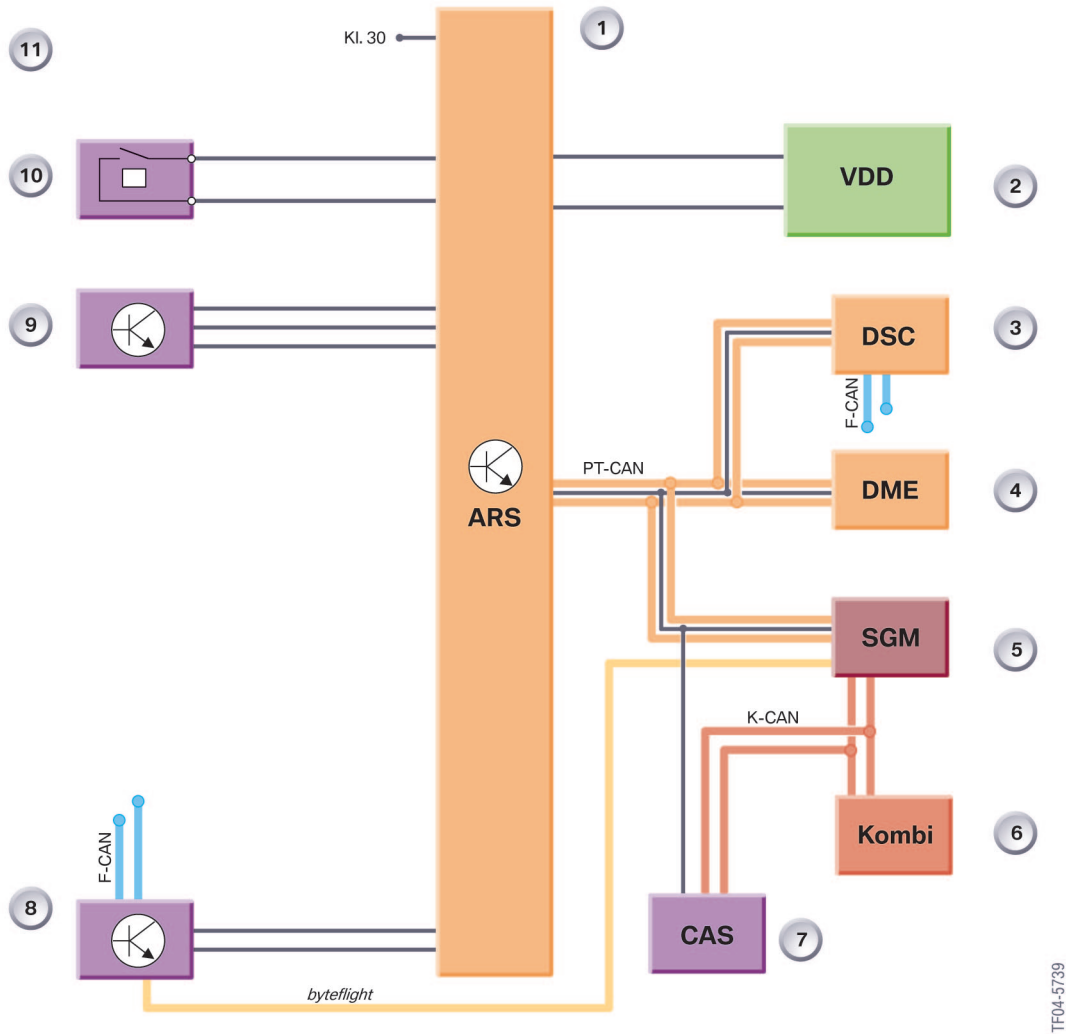


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1 - System overview

<b>Index</b>	<b>Explanation</b>	<b>Index</b>	<b>Explanation</b>
1	DynamicDrive control unit	9	Transverse acceleration sensor
2	Valve block, DynamicDrive	10	Hydraulic reservoir, fluid level sensor
3	DSC module	11	Current distributor, front, power supply
4	Digital motor electronics	<b>bytelight bytelight</b>	
5	Safety and Gateway Module	PT-CAN	Powertrain CAN
6	Instrument cluster	K-CAN	Body CAN
7	Car Access System control unit	F-CAN	Chassis CAN
8	Steering angle sensor		

## E60 system circuit diagram



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2 - DynamicDrive system diagram

Index	Explanation	Index	Explanation
1	DynamicDrive control unit	9	Transverse acceleration sensor
2	Valve block, DynamicDrive	10	Hydraulic reservoir, fluid level sensor
3	DSC module	11	Current distributor, front, power supply
4	Digital motor electronics	<b>bytflight</b>	<b>bytflight</b>
5	Safety and Gateway Module	PT-CAN	Powertrain CAN
6	Instrument cluster	K-CAN	Body CAN
7	Car Access System control unit	F-CAN	Chassis CAN
8	Steering angle sensor		



# Service information

## Transverse dynamics systems

### Notes for service staff

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#### Service information

If the DynamicDrive fails, DSC can no longer be deactivated or if it is already deactivated it does not switch back on automatically.

The connections for all the hydraulic components are designed in different dimensions and lengths so that they cannot be transposed.

A disturbing noise may be heard in the vehicle interior, predominantly caused by assembly and cable connections.

The cables must not make contact. They must not be overtightened or loose in the holders. They are covered by the underbody panelling.

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#### Steering angle sensor adjustment

After work on the steering, it is necessary to adjust the steering angle sensor with the steering column switch cluster (SZL) control unit.

The DynamicDrive system is dependent on the exact zero balance of the steering angle. The maximum deviation tolerance is  $\pm 1^\circ$ . Precise wheel alignment check and adjustment is a prerequisite. The steering angle sensor for ARS 1 must

always be adjusted on a model by model basis in accordance with BMW specifications.

Adaptive tuning is carried out for ARS 2.

The zero position is lost each time the DynamicDrive control unit or the SZL is flash programmed. Steering angle sensor adjustment is then required.

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#### DynamicDrive initialization

The initialization procedure must always be carried out once the system has been opened or a part has been replaced. This also applies after the transverse acceleration sensor has been replaced.

The following conditions must be guaranteed for matching the transverse acceleration sensor and the two pressure sensor offset values:

- The vehicle must stand level on all four wheels
- The vehicle must be unladen
- The engine must be idling

- Rest status (doors closed, persons are not allowed in the vehicle)

No persons may remain within the vicinity of moving chassis parts during the commissioning (both in the works and the workshop). In addition you must ensure that the basic initialization conditions (temperature range, constant engine speed etc.) are observed. The ground clearance must not be restricted. The doors must be closed. The arms of the hoist may no longer be situated beneath the car.

The initialization procedure is split into five stages which follow on from each other automatically:

<b>I: Direction valve test</b> (from 3 to 3.4 s)	First the direction valve is tested by evaluating the signal of the switch-position recognition sensor.
<b>II: Low-pressure test</b> (from 3.4 to 4.3 s)	During this phase, the fail-safe and direction valve are not supplied with current. Checks are then carried out using de-energized and energized pressure control valves at the front and rear axle. This will cause the body to roll. The sides of the vehicle must be clear.
<b>III: High-pressure test front axle</b> (from 4.3 to 9.9 s)	Pressure of 180 bar is applied to the front-axle oscillating motor. Air in the system, internal leaks and a blocked oscillating motor are detected.
<b>IV: High-pressure test rear axle</b> (from 9.9 to 15 s)	Pressure of 170 bar is applied to the rear-axle oscillating motor. Air in the system, internal leaks and a blocked oscillating motor are detected.
<b>V: Pressure control valve test</b> (from 15 to 25 s)	The characteristic curves of the front and rear axle are checked (setpoint/actual value comparison). Faulty pressure control valves are detected.

## Bleeding DynamicDrive

A bleeding routine must be carried out using the BMW diagnostic tester if the DynamicDrive system was opened hydraulically.

The bleeding operation must be performed only using the initialization routine of the BMW diagnosis system. The bleeding operation must not be performed at the pressure relief valves or at the screw plugs of the oscillating motors!

If the test still detects air in the system, a short movement trip should be made if necessary.

The initialization routine must then be repeated after the short trip.

In the event of an extreme leak or suspected partial function of the pressure relief valves (noticeable by rattling noises in the front end), the pressure relief valves and the pneumatic lines must be replaced with new components.

## Diagnosis

The following faults can be detected at the components:

Component	Fault type	Fault detection via:
Control unit	De-energized or faulty	No alive counter in the instrument cluster, VIN not recognized during authentication, software reset
Pump	No pressure	Setpoint/actual-value comparison pressures
Directional valve	Jammed in "energized" position (spring break, swarf)	Directional-valve sensor
	Jammed in "de-energized" position (line break)	Direction valve sensor and current monitoring
Pressure control valve front axle	Open (de-energized, $p = p_{RA}$ )	Setpoint/actual-value comparison, pressure at front axle current measurement
	Closed (mechanical fault) ( $p_{FA} = p_{max}$ )	Setpoint/actual-value comparison, pressure, front axle
Pressure control valve rear axle	Open (de-energized) ( $p = 0$ )	Setpoint/actual-value comparison, pressure, rear axle and current measurement
	Closed (mechanical fault) ( $p_{RA}$ and $p_{FA} = p_{max}$ )	Setpoint/actual-value comparison, pressure, rear axle,
Fail-safe valve	Jammed open	Predrive check
	Jammed closed (line)	Current measurement
Actuator, front/rear axle	Leaking (no torque)	Setpoint/actual-value comparison pressure
	Blocked	Setpoint/actual-value comparison pressure
CAN bus	Total failure (line disconnected)	CAN timeout
Steering angle, $v_{Car}$ , $a_{\phi}$ , $\phi$	Implausible or omitted	Plausibility monitoring and CAN bus signal fault detection

Component	Fault type	Fault detection via:
Sensor a <sub>q</sub>	Total failure (line disconnected)	Voltage monitoring
	Incorrect signal	Check plausibility via CAN messages
Oil level sensor	No signal (line)	
Pressure sensor, front axle	No signal (line)	Voltage monitoring
	Incorrect signal	Setpoint/actual-value comparison, pressure, front axle
Pressure sensor, rear axle	No signal (line)	Voltage monitoring
	Incorrect signal	Setpoint/actual-value comparison, pressure, rear axle,
Sensor, direction valve	no signal	Voltage monitoring
	Incorrect signal	Setpoint/actual-value comparison, direction valve and switch-position recognition sensor

## System shutdown (fail-safe status)

Depending on the fault, the system displays one of the following responses.

The following faults result in system shutdown, i.e. all output stages are de-energized:

- Fault in the front axle stabilizer bar
- Fault at the front-axle pressure sensor
- Fault in the pressure build-up (pump, pressure-limiting valve on the front axle)
- Fault in the control unit
- VIN is not sent via the CAS / absent / incorrect
- Direction-valve position fault, faulty switch-position recognition sensor
- No PT-CAN signal

The de-energized fail-safe valve shuts off the chambers of the active stabilizer bar. Fluid balancing is only carried out through internal leakage of the oscillating motor and valve block.

The check valves in the valve block enable fluid feed to prevent cavitation in the front axle oscillating motor.

The chambers of the rear axle oscillating motor must not be shut off.

The handling corresponds virtually to that of a conventional vehicle. The crossover to the fail-safe status can also be controlled in the event of extreme manoeuvring.





**Warning message**

Cornering stability! Drive slowly around bends



**Instruction**

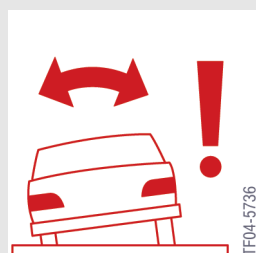
Driving-stability system not functioning, driving stability restricted. No high cornering speeds. Continued driving possible, contact BMW Service immediately.

In the event of a fluid loss in the DynamicDrive hydraulic system or in the steering circuit, the oil level sensor in the oil reservoir responds.

The driver is alerted so that damage to the tandem pump caused by continued driving is avoided.

**Warning message**

Fluid loss! Pull over carefully, switch off engine



**Instruction**

Fluid loss in the chassis and steering systems. Continued driving not possible, contact BMW Service immediately.



## Restricted control comfort

A transverse acceleration is calculated from the road speed and steering wheel angle from the CAN messages. This signal is faster than the actual transverse acceleration and compensates the time delay of the hydromechanical system. In the event of a fault in these two signals, the system responds with a delayed roll compensation. This arises only in the case of extremely quick steering manoeuvres and is barely noticeable in normal cornering manoeuvres.

If a transverse acceleration sensor is defective, the transverse acceleration is calculated. No impairment of function can be detected by the customer.

The customer notices that the vehicle roll is greater if a fault occurs on the rear axle. The agility decreases at road speeds < 120 km/h.

The system also responds if the fault "Fail-safe valve stuck open" is detected in the predrive check.

An electrical fault in the rear-axle pressure sensor may result in minor failures in roll-angle compensation. To be on the safe side, slightly more stabilizing torque is exerted on the front axle than in normal operation. This can be felt by the driver.

<b>Warning message</b>	<b>Instruction</b>
Cornering stability slightly restricted	Chassis stabilization slightly restricted around bends. Continued driving possible, contact BMW Service at next opportunity.

## Restricted system monitoring

DynamicDrive receives the following sensor signals from DSC and SZL via PT-CAN :

- Transverse acceleration
- Yaw velocity
- Road speed
- Steering-wheel angle

These signals are used to check the transverse acceleration sensor.

Drop-out of the engine-speed signal (DME) results in restricted control comfort.

In the event of a fault in the transverse acceleration and yaw velocity CAN messages, the system is lacking two items of redundant information. Since this information is used exclusively for checking the other signals, the DynamicDrive function is preserved with full control comfort.

Although no restriction of the DynamicDrive function exists, the message "Chassis and suspension-control system comfort restricted" is displayed for the driver who is requested to drive to the workshop at the next opportunity.

Warning message	Instruction
Cornering stability slightly restricted	Chassis stabilization slightly restricted around bends. Continued driving possible, contact BMW Service at next opportunity.

A "dynamic" driver will notice the absence of the steering angle sensor signal.

The warning messages must be acknowledged by the driver. Each warning message goes out only after it has been acknowledged.

Once the cause of the fault has been rectified, the control unit can be returned to full function.

There are two reset conditions depending on how fast a fault is to be detected:

- All faults which are no longer present are reset with ignition OFF. It is necessary to wait until the vehicle has entered sleep mode before the ignition is switched ON again.
- Sporadic faults which can mostly be traced back to communication faults in the CAN

bus are then automatically reset while the vehicle is moving straight ahead or stationary provided they have only occurred briefly and rarely. In this case, the customer cannot detect the activation while the vehicle is moving or stationary.

- The associated faults with important additional information are stored in the fault code memory. This additional information contains the kilometre reading/mileage at which the fault occurred, whether the fault is currently present and the frequency with which the fault in question has occurred. Thus, when the vehicle is brought into the garage/workshop, it is possible to carry out a specific analysis of the currently present fault and also an analysis of a sporadic fault.



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## **Programming**

The DynamicDrive control unit is programmed.

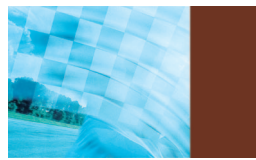
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## **Coding**

The DynamicDrive control unit is encoded.

# Contents

## Level systems



### Objectives

Useful information for the reader

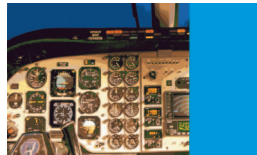
1  
1



### Introduction

History

3  
3



### System overview

System structure

5  
5



### Functions

Functional description (overview)

Functioning principle (normal function)

7  
7  
14



### Service information

Notes for service staff

19  
19





# Objectives

## Ride-height control systems

### Useful information for the reader

The BMW electronic ride height control, EHC for short, is an important component for stability control. This document contains all the important information about the design of this system.

The control strategies described here will help you to understand the function of the EHC and its associated logic systems. This is an important prerequisite for performing diagnostics and troubleshooting on the system successfully and to a professional standard.

You can acquire all the knowledge necessary to do this on the following pages.

Topics relevant to service personnel and inspection conditions which must be adhered to when carrying out a wheel alignment check are also covered.





# Introduction

## Ride-height control systems

### History

BMW introduced level control systems in the 7 Series - E23/E32, 6 Series - E24 and 5 Series - E28 as an option and, in some vehicles, as standard. The entire rear-axle load was supported by air suspension for the first time on the E39. The system was controlled automatically under all operating conditions and without the driver having to make any input.

The single-axle air suspension system on the rear axle of the X5 was transferred from the

E39. The air springs were adapted to the X5. There is a standard and a sports version.

Ride-height control was offered as standard with the M62 engine. It was available as an option with the M57 and M54 engines.

This Participant's Manual deals with the two-axle air suspension system on the X5.

---

### Why is a new system required?

The new two-axle air suspension system has off-roading advantages over the single-axle air suspension.

Lowering the entire body makes it easier to get into and out of the vehicle, as well as to load and unload it.

Off-roading capabilities are improved by the option of increasing the ground clearance of the body.

The driver has the option of setting three different heights using a rocker switch, according to his requirements.

The vehicle still has automatic ride-height control for load compensation and automatic lean compensation.

---

## **Market requirements and customer expectations**

Market requirements and customer expectations regarding comfort and functionality are constantly increasing. Both these aspects have been taken into consideration by giving the driver the option of making settings to the system.

An important comfort feature of off-road vehicles with a large ground clearance is being

able to get into and out of the vehicle and load and unload the vehicle easily.

The functionality of the vehicle is expressed in its off-roading capabilities. This is achieved by the possibility of increasing the ground clearance with the two-axle air suspension.

---

## **Advantages of the new system**

The new system allows active control of the ride-height control by the driver.

The two-axle air suspension allows the vehicle to be lowered at both axles by equal amounts and parallel to each other.

This makes it easier for the occupants to get into and out of the vehicle and to load and unload the vehicle.

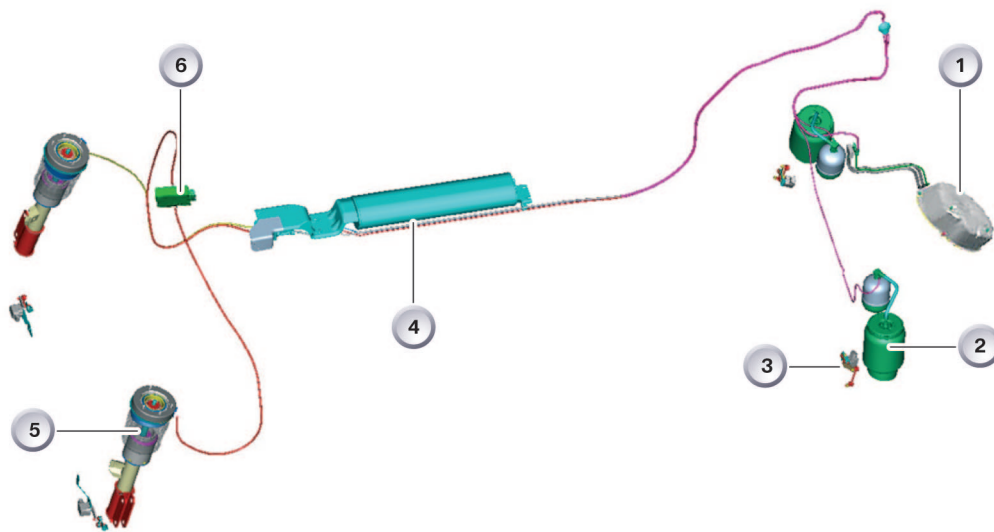
The air suspension system is also fitted in the E61. This is a single-axle air suspension and is basically the same as the one in the E65.

# System overview

## Ride-height control systems

### System structure

#### Overview



TFC04-5685

1 - Air suspension diagram

Index	Explanation	Index	Explanation
1	Air supply unit	4	Pressure accumulator valve unit
2	Rear axle air bellows	5	Front axle air bellows
3	Height sensor	6	Control unit



# Functions

## Ride-height control systems

### Functional description (overview)

In addition to the automatic ride-height control system to compensate for variations in load, the driver has 3 further different options for setting the ride height of the vehicle.

- Off-road (+25 mm), high ground clearance
- Standard (0 mm), normal vehicle height
- Access (-35 mm), for getting in and out, loading and unloading

The different heights are selected using a rocker switch. LEDs show the current height setting.

Lowering the height is only possible when terminal 15 or higher is ON and the doors are closed. The bonnet and tailgate may be open.

The system also has automatic lean control, with which you will be familiar from the single-axle air suspension.



1 - Rocker switch

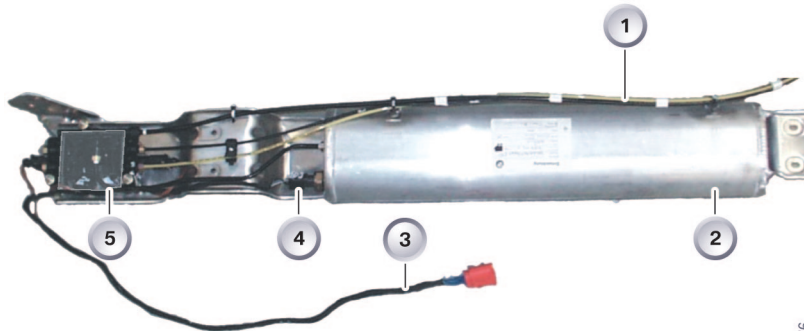
### Pressure accumulator valve unit

The two-axle air suspension system has a pressure accumulator which, together with the valves, forms the pressure accumulator valve

unit. The pressure accumulator valve unit is located under the vehicle floor in the vicinity of the right-hand sill.



2 - Installation location of the air valve unit



TF04-5676

3 - Valve unit

Index	Explanation	Index	Explanation
1	Air lines Yellow = rear right Black = rear left	4	Pressure sensor
2	Pressure accumulator	5	Valve unit
3	Connection line		

## Pressure accumulator

The pressure accumulator allows the very large differences in height to be achieved more quickly than with a compressor system.

The internal pressure is measured by a sensor on the pressure accumulator.

The system pressure is  $15.7 \pm 0.7$  bar.

The minimum pressure is 9 bar.

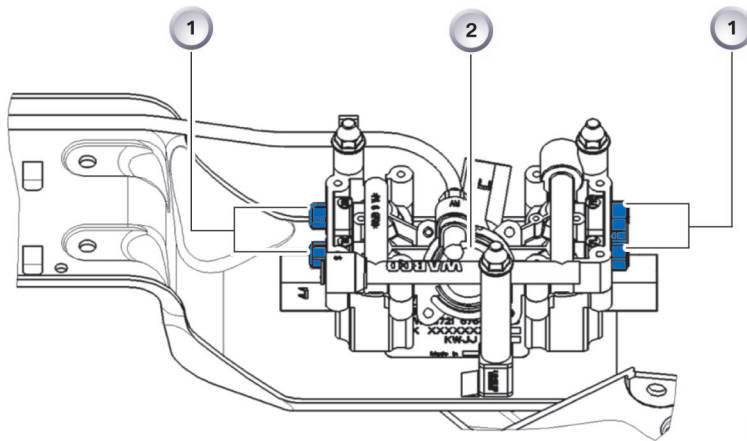
The theoretical filling capacity of the pressure accumulator is sufficient for charging the four spring struts once. This applies from the access to the standard position and for loading the unladen vehicle. However, only up to the permissible gross weight rating at normal temperatures.



## Valve unit

The four bellow valves and the pressure accumulator valve are controlled in the valve unit.

The bellow valves and the pressure accumulator valve are solenoid valves which are closed by spring force when de-energized.



TF04-5683

4 - Sectional view of the valve unit

Index	Explanation	Index	Explanation
1	Air line connections	2	Pressure accumulator valve



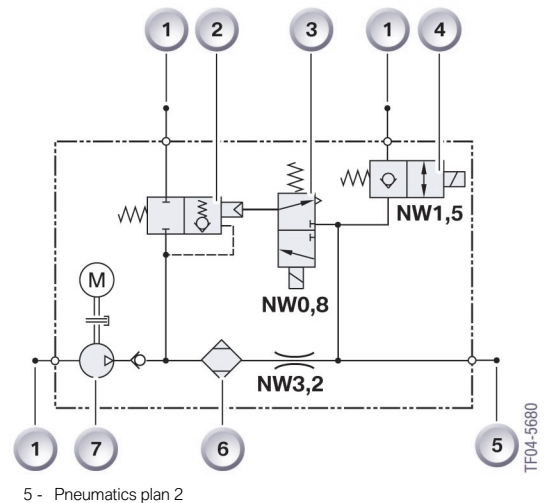
## Air supply unit

The air supply unit is located under the spare wheel in the luggage compartment, the same as in vehicles with single-axle air suspension. The auxiliary reservoir for the rear air-spring bellows is also located in the luggage compartment, as in vehicles with single-axle air suspension.

The air supply unit is designed in a similar way to the single-axle air supply unit for ride-height control, fitted as standard on the E39.

The functions are controlled by actuating a compressor and various valves in the air supply unit and on the pressure accumulator valve unit.

The maximum pressure for the air supply unit is 21 bar.



Index	Explanation	Index	Explanation
1	Sinter filter	5	To the pressure accumulator valve unit
2	Pneumatic bleed valve	6	Air drier
3	Electric pilot valve	7	Compressor
4	High-pressure vent valve	NW	Nominal width in mm

## Pilot valve

The electrically controlled pilot valve acts as a control function for releasing pressure from the system in the normal way.

## Bleed valve

The pneumatically controlled bleed valve serves to actually release the pressure. The small controlled amount of air released from the pilot valve pushes open the main valve as a relay function and large amounts of air can escape quickly.

This combined arrangement of the pilot and bleed valve means that it is not necessary to have a solenoid valve with a high power consumption.

The 21-bar limit valve is integrated in the bleed valve.





## High-pressure vent valve

The high-pressure vent valve acts as a comfort valve. The high-pressure vent valve expels the high pressure from the line after the pressure accumulator valve has closed with

the compressor running. The compressor cannot be stopped without generating noise until this pressure has been released.

## Compressor assembly

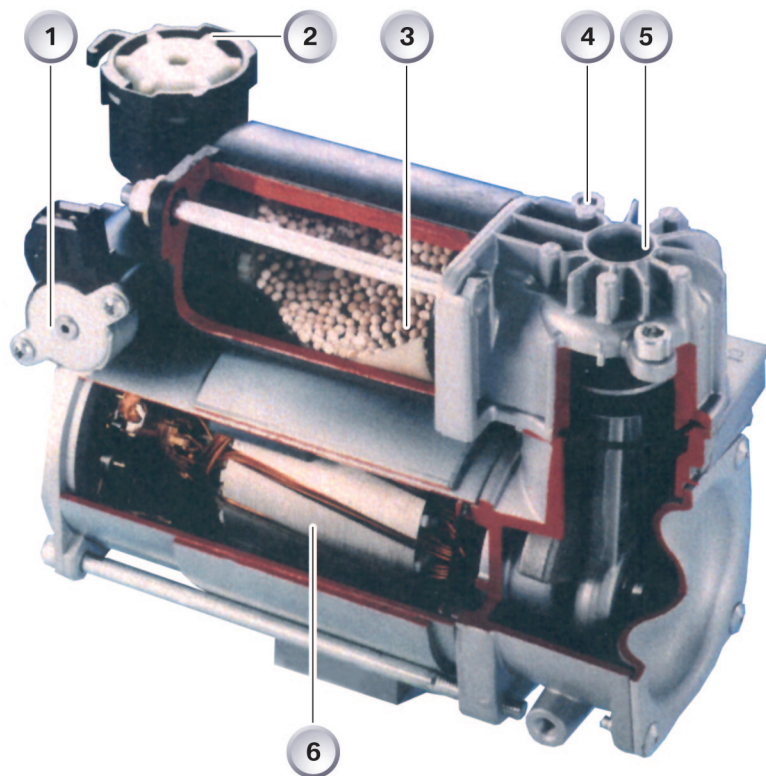
The following technical developments have been implemented:

- Fitting a temperature sensor

A temperature sensor which switches off the compressor at temperatures above 110 °C is located on the cylinder head of the compressor .

- Extension of the compressor on period (180 s)
- New air drier design because of quicker lowering

⚠ The temperature sensor is not located on the compressor itself, but is integrated into the wiring harness. ◀



TF04-5678

6 - Compressor

Index	Explanation	Index	Explanation
1	Pilot valve	4	Installation location of temperature sensor
2	Bleed valve	5	Compressor
3	Air drier	6	Electric motor



## The principles of air drying

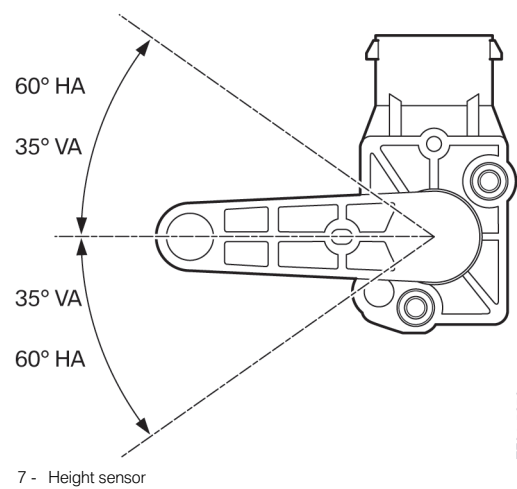
The intake air passes over water-absorbing filter material. The filter material is integrated in the air drier in the form of filter granules and absorbs moisture from the air. As long as the air contains more moisture than the filter material, the moisture will be absorbed into the

individual balls and stored. When it flows back, the air is drier than the filter material. Moisture is therefore drawn back into the air and removed to the outside.

A maximum of 30 g of water can be stored in the filter.

## Height sensor

The height sensor provides information about the height of the vehicle. There is a height sensor for each wheel. You provide information to the control unit for ride-height control.



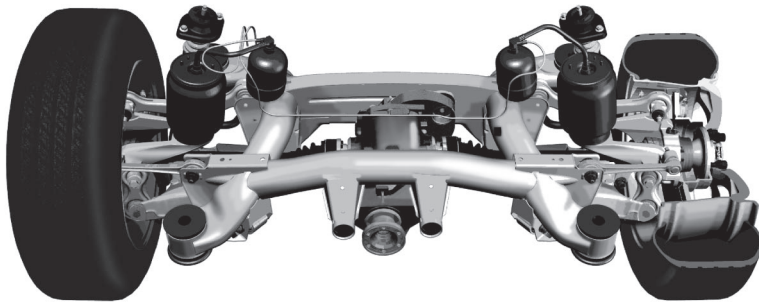
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## Air spring struts

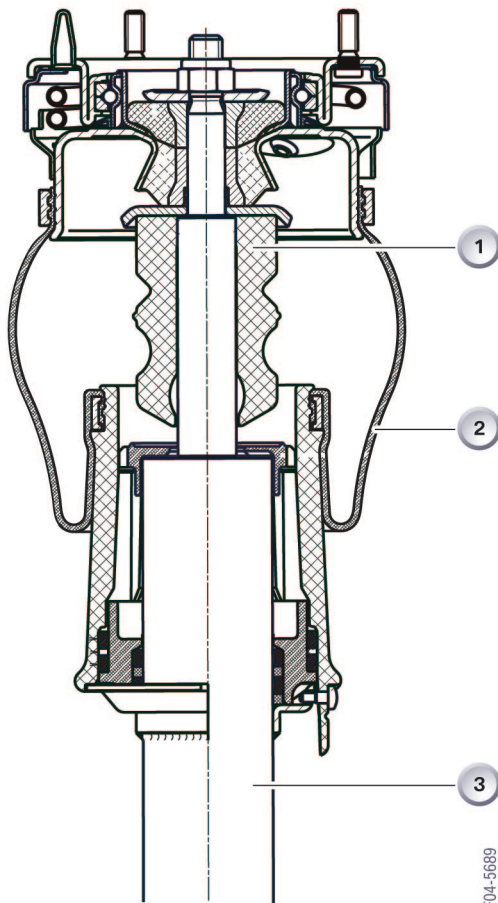
No modifications were made to the rear-axle air springs. The air springs and dampers are separate on the rear axle.

On the front axle, the air spring replaces the steel spring, i.e. the spring bellow is fitted to the damper. The front air spring strut and the shock absorber form a complete unit.



TF04-5673

8 - Air suspension



Index	Explanation
1	Auxiliary spring
2	Air bellows
3	Damper

TF04-5689

9 - Air spring strut



## Functioning principle (normal function)

### Adjusting procedures for the various heights of the E53

The driver can use the rocker switch to set three different heights on the E53.

- Offroad (+25 mm): high ground clearance, up to a maximum speed of 50 km/h
- Standard (0 mm): normal vehicle height
- Access (-35 mm): for getting in and out as well as loading and unloading, up to a maximum speed of 35 km/h. Access may be activated from standard mode from < 25 km/h.

All adjusting procedures are performed without requiring intermediate heights. The vehicle's pneumatics are designed so that virtually parallel lowering is possible however the vehicle is laden. Depending on how the vehicle is laden, either the front axle or the rear axle may be slightly quicker.

A height difference between the two axles is possible in all adjusting procedures due to the different control speeds. If a set threshold is exceeded, the quicker axle is briefly halted.

The different heights can be preselected while the vehicle is in motion. The height of the vehicle will not change until the speed threshold determined in the control unit is reached. The height change is controlled by the control unit.

The LED indicating the current level continues to flash when a new target level is defined and the LED of the target level flashes. The driver defines a new target level by the push of a button or a change is initiated automatically under defined driving conditions. When the new level is reached, the LED of the last level goes out and the LED of the newly reached level lights permanently.

If it is not permissible to select the height, the LED showing the current vehicle height flashes for 3 seconds.

An exception is preselecting the access height while the vehicle is still in motion: the access LED flashes and the LED for the previous height lights up constantly. This does not mean that the vehicle has started to change height. Control will not take place until the vehicle is travelling at or below the appropriate speed threshold for the access height.

The following text messages may appear in the instrument cluster next to the LED display:

- **TRAILER MODE**

A trailer has been detected via the trailer connector. The vehicle height should not be changed, otherwise there is a risk of damage to the trailer and the vehicle. The vehicle is fixed at the standard height. If the trailer is hitched when the vehicle is not at the standard height, the vehicle will not change to standard height until the button is pressed. In any case, the change to standard takes place automatically on reaching the speed threshold. The vehicle will then be fixed at the standard height until the trailer connector is disconnected.

- **RIDE-HEIGHT CONTROL INACTIVE**

There is a fault in the system or a fault in the control unit that can only be detected by the instrument cluster, e.g. control unit disconnected.

- **RIDE-HEIGHT CONTROL INACTIVE + MAX. 60 KM/H**

For safety-critical faults (vehicle is too high or is leaning)

## Adjustment mode

### Sleep mode

The vehicle enters sleep mode 16 minutes after it is switched off. No more height adjustments are made. A watchdog wakes up the control unit every 6 hours for a few minutes (wake-up mode) to rectify any vehicle lean.

### Wake up

In wake-up mode, the control unit is woken up for a certain amount of time to rectify any vehicle lean. The vehicle may lean if there are large variations in temperature or small leaks. This adjustment to the front and rear axles ensures that the vehicle is level. The vehicle is only lowered so that as little power is used as possible. The target level of the lowest wheel acts as the level for all the other wheels. The lowest target level to which the vehicle can be lowered is the access height (-35 mm).

Exception: if the vehicle was already at the access height when it was switched off, it can be lowered to a minimum of -50 mm in wake-up mode. If a leak occurs in the system during longer parking periods, further loss of air will no longer result in a change in the ride-height. In this case, the body is supported by the auxiliary springs and the residual air pressure.

### Pre (lead/run-on mode)

The vehicle is normally woken from sleep mode into lead/run-on mode by the load-cutout signal (VA). Because the engine is not yet running or has already been switched off in this mode, only limited height adjustments can be made in order to protect the battery. The vehicle will only be made level outside a

tolerance range of 20 mm up and 25 mm down, thus counteracting the reduction in control frequency.

All adjustments during the lead and run-on time are made from the accumulator, if this is available. If the accumulator is empty and the engine is switched off, then the adjustment is made directly by the compressor. It is not possible for the user to change the height or for the accumulator to be charged.

### Terminal 15

As soon as the ignition is switched on (terminal 15), the driver can lower the vehicle to the required level.

However, it is not yet possible for the vehicle to be raised or for the accumulator to be charged.

The vehicle will be made level outside a smaller tolerance range of 10 mm up and 10 mm down.

### Normal (engine on)

When the engine is running, the vehicle can be made level, the height can be adjusted up and down and the accumulator can be charged. The compressor starts up when each adjustment is made.

The vehicle will continue to be made level outside the small tolerance range of  $\pm 10$  mm.

As long as the vehicle is stationary, the quickly filtered height signals are used to detect a change in load. This means that the system can react immediately to changes in height.

### **Post (subsequent adjustment)**

Post mode is used to rectify any vehicle lean before it enters sleep mode. It is a mode for subsequent adjustment. Post mode is time-restricted (currently coded to 1 minute). Post mode is only entered if the engine has been running. If the engine has not been running, sleep mode is entered directly from pre mode.

Adjustments are made with a tolerance range of 7 mm. The maximum adjustment made is 5 mm. The quick signal filter is used. The system sets the defined target height levels when the vehicle is leaning (kerb detection).

### **Curve (cornering)**

Rolling motion has a direct influence on the measured ride-height levels. Despite the slow filtering of Drive mode, this would mean undesirable control response would be initiated during longer cornering periods with corresponding rolling angle. This would mean that the vehicle would be leaning once the cornering had been completed and the vehicle level would have to be adjusted again. Curve mode prevents this adjustment by stopping the slow filtering when cornering is detected and cancelling any adjustment that may have been started. Cornering is detected by an incoming transverse acceleration signal of  $> 2 \text{ m/s}^2$ . Curve mode is ended when there is a transverse acceleration signal of  $< 1.5 \text{ m/s}^2$ . The transverse acceleration signal is sent by the yaw rate sensor.

### **Drive**

As soon as the vehicle is in motion, the system switches to the slow filtered height signals. The system now no longer reacts to suspension compression caused by unevenness in the road surface. An average is calculated over a longer period and the load only changes due to the emptying of the fuel tank.

The quick filter is not used again until the vehicle is stationary again and a door or hatch is opened. This is because the vehicle cannot be loaded or unloaded until a door or hatch is opened.

### **Lift (workshop platform)**

If a height threshold is exceeded at all 4 wheels, the control unit assumes that the vehicle is being raised on a workshop platform.

There are three options for resetting the workshop platform recognition:

- The height values become less than the original height settings on all four wheels,
- A selection is made by pressing the switch,
- The system detects a speed of  $> 40 \text{ km/h}$  for 3 seconds.



### **Vehicle jack**

If the system detects that one wheel is lowering, but not at sufficient speed, it recognizes that the vehicle is being raised on a jack. The lowering speed must be less than a given pre-programmed speed threshold. If a jack is detected, the height is stored for the wheel concerned.

The jack recognition is reset when the height falls below the stored height again. In addition, if the vehicle reaches a road speed of 40 km/h for at least 3 seconds, the system will attempt to adjust the vehicle height.

The jack recognition is also reset if the switch is pressed.

### **Kerb (distortion control/off-road)**

The system must not attempt to compensate as soon as there is distortion, e.g. if a wheel is driven over an earth bank. If the vehicle is stationary and the front axle height difference plus the rear axle height difference in the opposite direction is greater than a given threshold, the system recognizes that there is "distortion". This leaning mode is exited when the distortion is smaller than the threshold or the vehicle is moved.

If the distortion is very large, no adjustments are permitted because making adjustments from this level of distortion is not useful, depending on the vehicle.







# Service information

## Ride-height control systems

### Notes for service staff

#### General information

Please be aware that the system is also active in diagnostic mode. Therefore, assembly line mode must be activated before carrying out any work on the system or when making height adjustments.

Assembly line mode:

The heights are fixed; no level adjustments are made. When assembly line mode is set, the function LED is off. The "ride-height control inactive" message appears in the instrument cluster.

Transport mode:

If the vehicle is being transported, the level control is set to transport mode.

To change the vehicle to the height set by the factory, transport mode must be cancelled in Service functions. When transport mode is active, the "Level control inactive" message appears when terminal 15 is switched on.

Transport mode is available again. When the ignition is switched on, the "ride-height control inactive" message appears. Heights are adjusted up or down according to the position of the ignition key. For example, lower when lashed down on a ship or train, higher when "engine on" and travelling on a vehicle transporter.

The correct height from the technical data is set to 5 mm using "control components".

The ride-height level at the right and left of the rear axle are set separately. Then the setting is made on the front axle. Here, the right and left air springs are adjusted together.

The height of the front and rear axles is then stored using the offset function.

The system must be depressurized before any components are exchanged. This is done in diagnosis via control unit functions, control

components, bleed front/rear axle. Repeat this command 6 times.

If the bellows material is visible, they must be replaced.

Once the repair work is completed, the air suspension system of the vehicle on the workshop platform must be recharged with air using diagnostics. The command must also be repeated 6 times. This prevents incorrect folding in the bellows.

The vehicle must not be placed on its wheels when the spring struts are depressurized.

In the same way, a faulty vehicle with a leaking pneumatic system should not be lifted on the workshop platform when the system is "open". The bellows would contract due to the suction and incorrect folds would be formed. These could lead to subsequent malfunctions.

Possible sources of leaks are the O-ring on the piston rod and the sealing element mountings on the piston.

The plug connections for all lines are the same as the connections on the single-axle air suspension. 6-mm lines have been used. The tightening torques in the entire system are 3 + 1 Nm.

When handling air suspension elements, you must be particularly careful with plastic parts which are prone to breaking.

Once the repair work is complete, assembly line mode must be deactivated again via the diagnostics. The function LED in the switch lights up. A text message does not appear in the instrument cluster. The system is OK and operational.

---

## Notes about wheel alignment checks

### 1. Simulate normal conditions for the vehicle

Vehicle and all its equipment for normal driving:

2 x 68 kg on the front seats (seats in central position);  
1 x 68 kg on the rear seat (centre);  
1 x 21 kg in the luggage compartment (centre) and tank full.

### 2. Inspection conditions for the wheel alignment check

- Correct wheels and tyres with an even tyre tread pattern
- Correct tyre pressure (see the information plate on the vehicle)
- Correct wheel bearing play

- EHC in Normal position (see above);  
For ride-height measurement, see Repair instructions 31 33 095 in TIS.  
Attention: if the vehicle is not at the specified height, repair the vehicle.
- The relevant fuse should be removed when you are working on the air supply unit so that no inadvertent adjustments are made. This is purely for the safety of the mechanic. Set the correct height for the measurement = specified value  $\pm$  2 mm by loading or unloading the vehicle.  
The fuse must be replaced in order to set the height.

# Contents

## Damping systems



### Objectives

1

Useful information for the reader

1

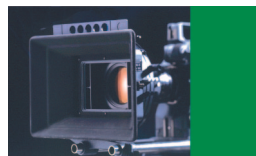


### Introduction

3

Electronic damper control

3



### Functions

5

Functional description

5

System requirements

8

Power supply

10

Vertical acceleration sensor

11

Electronically controlled vibration damper

12

Infinitely adjustable control valve

13

Diagnosis

15



### Service information

17

General information

17





# Objectives

## Damping systems

### Useful information for the reader

The EDC-K continual damping system in BMW vehicles provides the customer with a high degree of comfort.

The following pages contain the most important information about the design and the function of this system.

This will enable you to understand how the system and all its associated components function, so that you can perform diagnostics on the system to a professional standard.



# Introduction

## Damping systems

### Electronic damper control

A modern chassis must offer the driver optimum ride comfort, a high degree of driving safety, good agility and simple handling. Conventional, non-adjustable vibration dampers can only ever provide a compromise of these objectives. Manually adjustable vibration dampers can be set to either sports or comfort damping.

Electronically adjustable damping systems have been developed to provide a solution to these conflicting objectives.

This system is called BMW EDC (Electronic Damper Control).

The first system was the EDC I, which was fitted as standard in the E32 in 1987.

This dual-stage, fully-automatic electronic adjustment system was continually improved and developed. The result was EDC III and later EDC-K.

BMW EDC-K is a fully-automatic system which continually adjusts the damper settings to the current driving situation. The biggest change compared to EDC III was the EDC valves and their control logic system. EDC-K increases ride comfort without impairing safety. If the damper settings are too soft or comfortable on unfavourable road conditions, the vehicle will quickly begin to vibrate. EDC-K

remains in the soft damper setting for as long as possible and only changes immediately to the harder setting when the road situation requires it.

With the EDC-K system, BMW set a benchmark for adjustable damping systems.

Electronic Damping Control (EDC) combines the highest degree of ride comfort with the best possible driving safety. The system also guarantees consistently good vibration characteristics however the vehicle is laden. In addition, all vehicle movements which have an effect on vehicle handling are monitored constantly by sensors. All measurements are analysed by a microprocessor and appropriate control commands are transferred to the shock absorbers. The damping force at the shock absorber is then adjusted to the changing road conditions, load status and handling characteristics by solenoid valves. Pitching under braking or body movements, e.g. when driving over bumps, cornering or accelerating, are significantly reduced. There is also the option of selecting the "Sport" program at the press of a button, thereby setting stiffer damping characteristics.

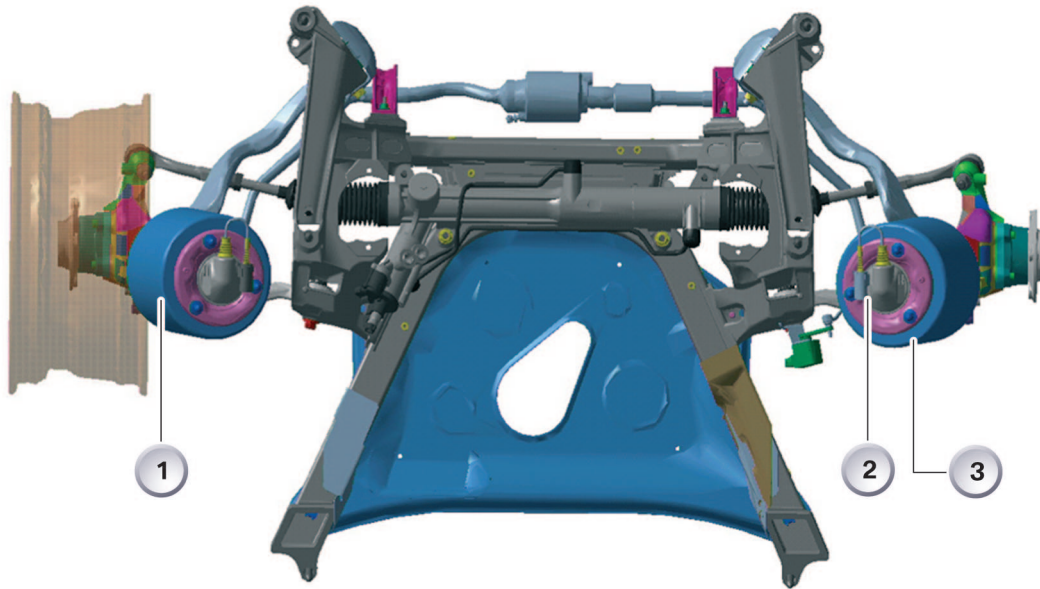




# Functions

## Damping systems

### Functional description



TF04-5444

1 - Front axle

Index	Explanation	Index	Explanation
1	Envelope space coil spring	3	Upper support bearing
2	EDC-K plug connection		

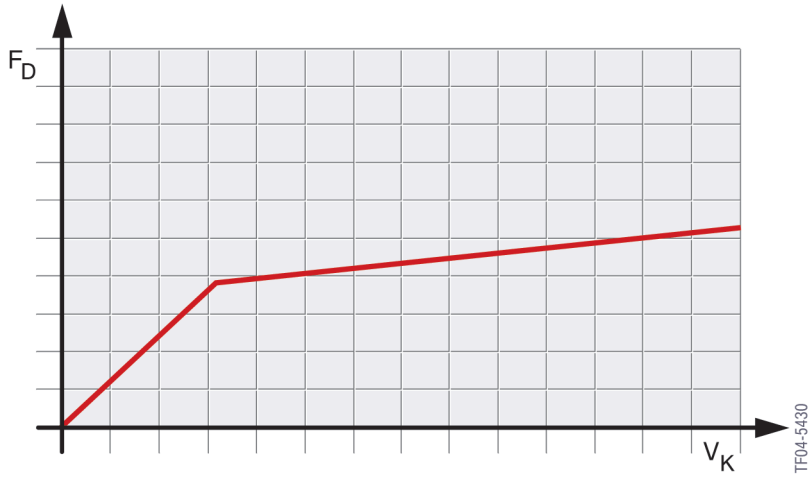
The EDC-K works with an infinitely variable valve in the dampers. The dampers have an infinite number of characteristic curves, thus the term characteristic map damper. This makes it possible to adjust the damping force continually to the low frequency vehicle structure movements.

The result is significantly improved ride comfort and further safety benefits.

The following diagrams illustrate the characteristic curves of the damper settings according to the piston speed in the damper.

The following diagram is the characteristic curve for a standard damper in the rebound phase.

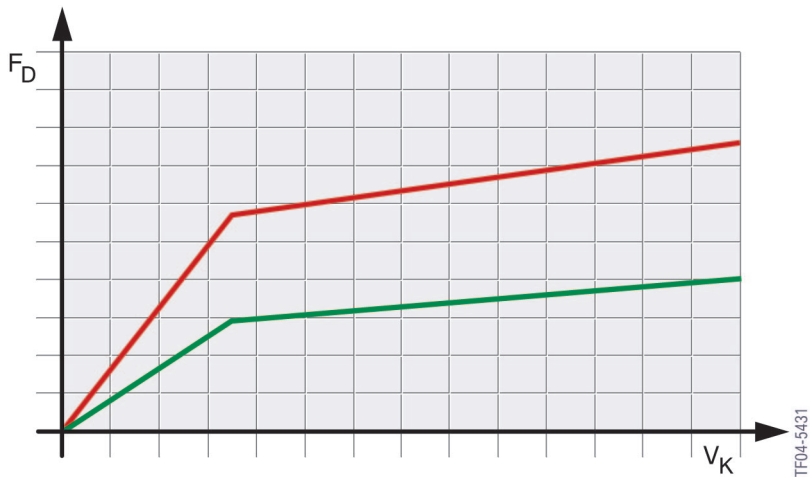
The rebound-phase damper force curve and its damper force  $F_D$  are a function of the piston speed  $v_K$ .



2 - Standard rebound phase characteristic curve

EDC I allowed the driver to manually select the hard, sporty damping or soft, comfortable damping while the vehicle was in motion. The upper characteristic curve represents the hard damping; the lower characteristic curve represents the soft damping.

Neither of the characteristic curves could be too far from the characteristic curve of the standard damper. The vehicle handling would otherwise be too uncomfortable, i.e. hard or unstable, soft.

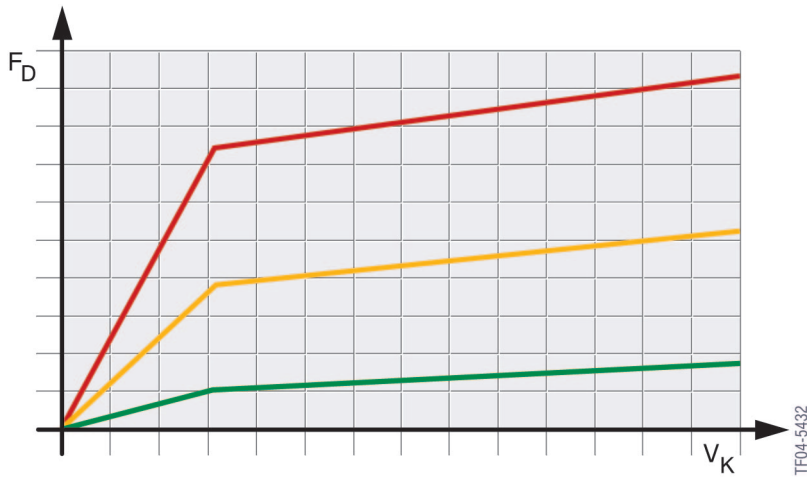


3 - EDC1 rebound phase characteristic curve



EDC III is a fully-automatic adjustment system which adapts to the driving situation. Input parameters, such as road conditions, the load carried in the vehicle and the driving style are all detected by system's sensors. The system

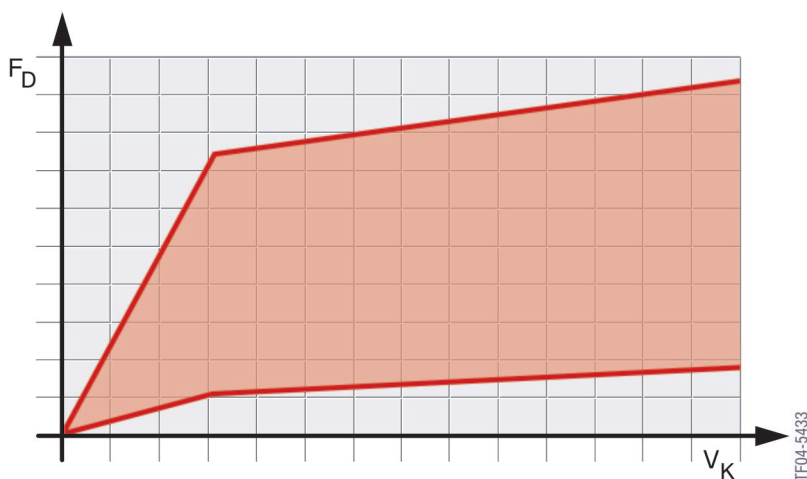
automatically activates one of the three characteristic curves (hard, medium or soft). The driver also has the option of selecting a comfort or sport program.



4 - EDC3 rebound phase characteristic curve

EDC-K enables fully-automatic damper adjustment over the entire characteristic map. The characteristic map is made up of an infinite number of characteristic curves. The dampers are able to adjust continually and to

varying degrees because a damper force  $F_D$  can be set for every piston speed  $V_K$ . The driver also has the option of selecting a comfort or sports setting using the controller.



5 - EDC-K rebound phase characteristic curve



## System requirements

As part of the chassis, the EDC-K is responsible for compensating for dynamic forces acting on the vehicle when it is in motion.

The following forces occur:

- Vertical forces (e.g. through road unevenness)
- Transverse forces (centrifugal forces, crosswind)
- Longitudinal forces (acceleration, braking)

The following vehicle structure movements can occur as a result of these forces:

- About the transverse axis: Pitching
- About the longitudinal axis: Rolling
- About the vertical axis: Yawing

The task of the chassis is to absorb the effects of these forces. The continual adjusting dampers play a large part in this task.

The primary task of the EDC-K is to increase ride comfort while maintaining a high degree of driving safety.

The objective of the EDC-K is for the vehicle to be set to the comfortable, soft damper settings for as long as possible. To increase safety and because the degree of comfort which will now be lost is reduced, a harder damper setting is activated to prevent large vehicle body movements.

The damper hardness is not set to fixed levels, but to many control options via a variable EDC valve.

The EDC-K is a microprocessor-controlled mechatronics adjustment system. The system consists of:

- mechanical,
- hydraulic,
- electrical and
- electronic subsystems

The driving conditions and prevailing road conditions are detected by sensors.

The control unit receives the incoming signals, checks their plausibility and evaluates them dependent on frequency. The control unit then links the various sensor signals and the system logic activates the valves corresponding to defined characteristic maps. Vehicle body and wheel vibrations are damped at required.

The driver can also set a comfort or sport program using the controller if he wishes.

The system is fully compatible with diagnostics.

If the sensors are faulty, the system is made safe by a fixed current feed to the EDC valves. The damping characteristic curve is similar to the curve for a standard damper. If the system should fail (no power), the dampers automatically adjust to the hardest damper setting.



The EDC-K can be divided into 3 functional blocks:

- The control unit
- The sensors and the program selection function
- The actuators, 4 electronically adjustable vibration dampers

The input signals for the system are generated by:

<b>Sensor/switch</b>	<b>Signal</b>	<b>Calculated size</b>	<b>Installation location</b>
Acceleration sensors, front axle and rear axle	Vertical acceleration, front and rear	Vertical speed, compression and rebound travel	Spring strut dome front right, front left, rear right
Steering angle sensor	Steering angle	Steering angle speed	Switch cluster, steering column
Wheel speed sensor, front left/front right	Wheel speed	Road speed, acceleration/braking	Wheel hub front left/ front right
Program selection	Comfort/sport program		Controller



## Power supply

A low current at the valves has the effect of hard damping. A high current results in soft damping.

The specified values for the output voltage are transmitted from the microprocessor in the form of a pulse-width-modulated (PWM) signal.

The current is limited by an excess current cutout in the hardware.

All analogue inputs are protected against positive and negative overvoltage by diodes.

The following analogue signals from the control unit are processed by the microprocessor:

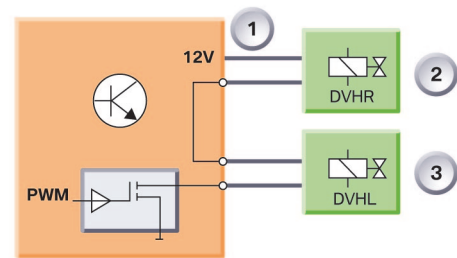
- Power supply from the vehicle
- Output voltage from the switching controller
- Voltage and current to the valves

## Valve control/output stage switching

The actuators are powered by the control unit on the negative side.

The solenoid valves in the dampers have a relatively small ohmic resistance (approximately 2.2 Ohms per valve at room temperature). The current to be set corresponding to the required damping force is in the range from 0 to 2 A. A relatively high current is required at low voltage. The target value must not exceed 2 A otherwise the valve will be damaged. The solenoid valves are connected in series on the axle side. The output current is a direct current.

The adjusting dampers are activated in series on the axle side.



6 - Valve switching, rear axle

TF04-5441

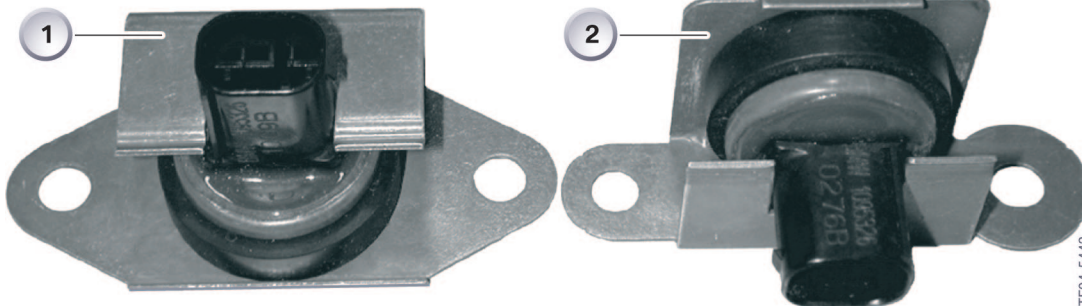
Index	Explanation	Index	Explanation
1	Microcontroller	2	EDC valve, rear right
PWM	Pulse width modulation	3	EDC valve, rear left



## Vertical acceleration sensor

The three vertical acceleration sensors have a measuring range of 2.5 g. They are fitted to the right and left spring strut domes and to the right rear axle dome in the wheel arch. All three sensors are of the same design. They differ only in terms of their mounting arrangement in

the wheel arches. The front two sensors (1) are fitted to the top of the wheel arch; the rear sensor (2) is fitted to the side of the wheel arch. The plug connection to the control unit points downwards on all sensors.



TF04-5443

7 - Vertical acceleration sensor, front axle/rear axle

Index	Explanation	Index	Explanation
1	Acceleration sensor, front	2	Acceleration sensor, rear



## Electronically controlled vibration damper

Twin tube gas-pressure dampers are fitted to the front and rear axles.

These dampers are designed as characteristic map dampers. This means there are no fixed settings as in the EDC III.

A controllable proportional valve is integrated into the piston of each valve. Alternate sides of this valve are supplied with shock absorber fluid during compression and rebound travel.

The control valve generates a lower pressure above and below the piston depending on the volume of fluid which enters.

The electric supply line for the integrated control valve is routed through the hollow piston rod.

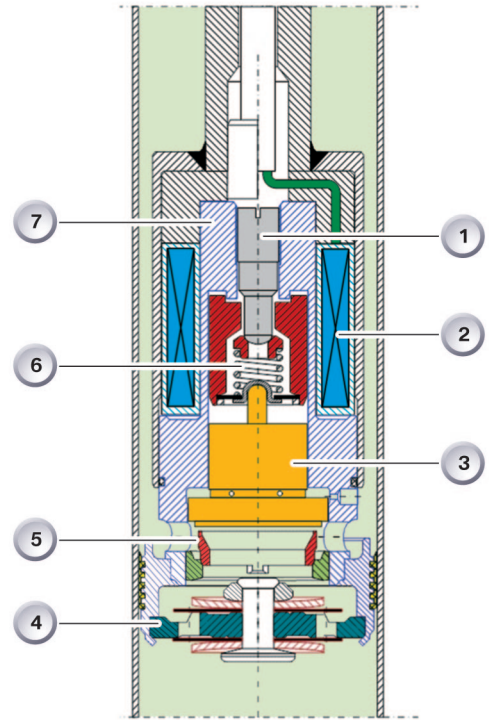
A base valve is connected axially in parallel next to the control valve. Its primary task is to guarantee the minimum pressure level of the characteristic curve.

The minimum rebound phase characteristic curve is generated primarily by a conventional piston valve connected in series to the control valve.

The two valves are controlled separately to ensure that there are optimum vehicle body vibration characteristics in all driving situations.

If the control unit fails and when the ignition is off, the valves are not powered. The dampers are automatically set to the hardest damper setting.

There are differences in the valve configuration at the spring struts of the front and rear axles on vehicles with DynamicDrive.



8 - Cross section of a damper

TF04-5435

Index	Explanation	Index	Explanation
1	Screw	5	Floating valve seat ring
2	Solenoid coil	6	Valve spring
3	Main damper valve	7	Armature
4	Auxiliary valve		



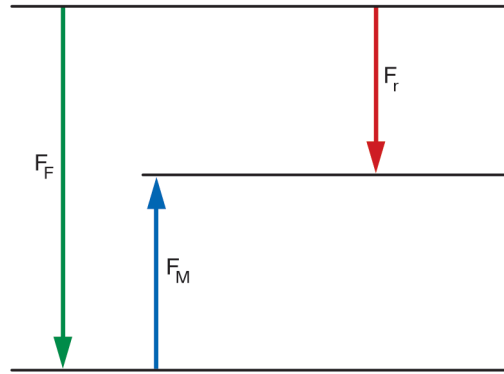


## Infinitely adjustable control valve

When the system is without power, the highest hydraulic resistance is set by the manufacturer. This is achieved by screw (1) which pretensions valve spring (6). This is the hardest damper setting - also known as the safety setting.

The valve spring pushes on armature (7) with maximum force, which in turn pushes on main damper valve (3). The main damper valve pushes on the floating valve seat ring (5), which then rests on the housing and creates a resistance to the flow of fluid.

When power is supplied to solenoid valve (2), the armature moves upwards against the valve spring pretension ( $F_F$ ). Supplying power to the solenoid coil counteracts the valve spring tension ( $F_M$ ), so that the armature exerts less pressure on the main damper valve ( $F_r$ ). The smaller  $F_r$ , the more loosely the floating valve seat ring fits against the housing. The volumetric flow of oil increases. Damping becomes softer. The maximum power of 2 A supplied to the solenoid coil results in the loosest fit of the valve seat ring and the most comfortable damping setting.



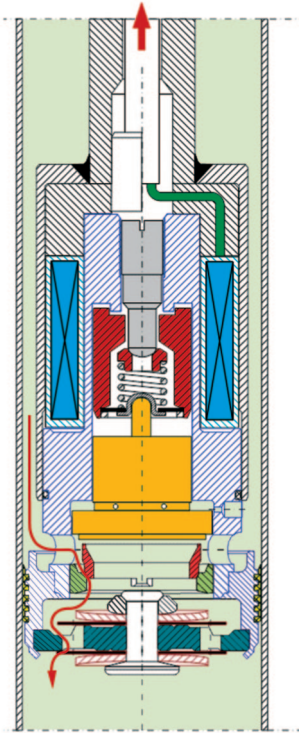
9 - Forces in the valve

TF04-5437

Auxiliary valve (4) generates the softest pressure damping together with the base valve (not illustrated).



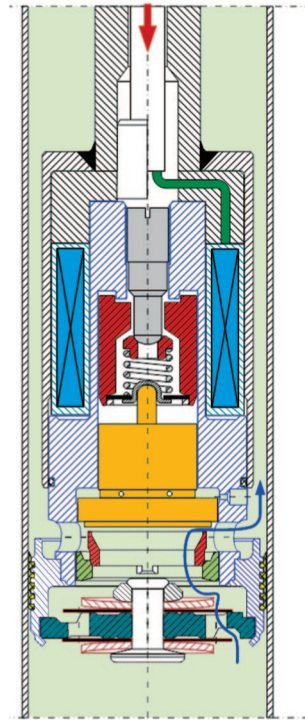
## Rebound phase operating principle



10 - Oil flow in rebound phase

The piston is pulled upwards. The oil flows in the direction indicated by the arrows. The floating valve seat ring pushes the main damper valve upwards due to the hydraulic ratios.

## Compression phase operating principle



TF04-5438

11 - Oil flow in compression phase

The piston rod is pushed downwards. The oil flows in the direction indicated by the arrow. The main damper valve is pushed upwards due to the hydraulic ratios. The floating valve seat ring sits on the bottom.

TF04-5436



## Diagnosis

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### System monitoring and plausibility

For safety reasons, faults in one valve cause the power to be cut to all valves immediately. Faults are detected for each axle separately. The DIS is used for the purpose of locating a fault in a defective valve. Alternatively, the

resistance of the individual valves is measured and compared. An operational valve will have a resistance of 2.2 Ohms  $\pm 10\%$  at room temperature (20 °C). The measured resistance is dependent on temperature.

---

### Acceleration sensors

The EDC-K control unit does not differentiate between faulty behaviour and real operating conditions.

The three sensors are connected in parallel in the control unit without isolation. A short circuit in the power supply of one of these consumers will therefore also affect the power supply to the other sensors.

A maximum of seven different faults can be stored.





# Service information

## Damping systems

### General information

After removing the steering angle sensor, it is necessary to manually reset the steering wheel in the straight ahead position. This position must be reinitialized in the control unit. The steering angle sensor is in the steering column switch cluster.

The straight-ahead position (zero balance) is reset for the first time on the assembly line (steering wheel in the straight-ahead position). The control unit has a learning feature for the straight-ahead position.

While the vehicle is in motion, the steering-wheel straight-ahead position is constantly monitored and corrected if necessary.



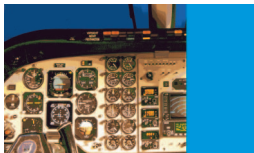



The EDC diagnostics recognize electronic damper faults for each axle. A mechanical check of individual dampers can be carried out on the shock-absorber tester.

The dampers will become weaker over time due to mechanical wear during use. A running-time memory is used to offset the damper characteristic curves with a harder setting. Faulty dampers are usually only replaced on one axle at a time. If a replacement has been made, running-time memory must be reset for the front or rear axle using the DIS (life time reset).



# Contents

## Tyre failure indicator

	<h3>Objectives</h3> <p>Useful information for the reader</p>	1 1
	<h3>Introduction</h3>	3
	<h3>System overview</h3> <p>Different control units for the tyre failure indicator</p>	5 5
	<h3>Functions</h3> <p>Components</p>	7 7
	<h3>System components</h3> <p>Input/outputs, RPA with RPA control unit</p> <p>System circuit diagram for RPA with RPA control unit</p> <p>System circuit diagram for DSC control unit with additional</p> <p>System circuit diagram for RPA with Chassis Integration</p>	11 11 12 13 14
	<h3>Service information</h3> <p>General information</p> <p>Special information on the RPA for E60 models</p>	15 15 17







# Objectives

## Tyre failure indicator

### Useful information for the reader

The tyre failure indicator (RPA) offers the customer a considerable improvement in driving safety.

This document provides a comprehensive overview of this system, and how it is integrated in BMW vehicles.

This documentation provides important information on the design and function of the system. Once you have read this document, you will be able to understand how the system operates, and identify the differences between this and the familiar tyre pressure control system (RDC).

You will be able to perform diagnostics on the tyre failure indicator to a professional standard.





# Introduction

## Tyre failure indicator

### Introduction to the tyre failure indicator (RPA) and tyre pressure control (RDC)

From a purely statistical point of view, a driver suffers a puncture once in every five to seven years, or 100,000 to 150,000 kilometres into their service life. Approximately 80% of all tyre defects are caused by small holes (e.g. caused by nails). These holes lead to a gradual loss of tyre air pressure. Many "tyre blow-outs" can be traced back to preliminary damage from a slow loss in tyre air pressure.

The actual event can be most inconvenient for the individual driver, quite apart from having to stop by the side of the road at night, in rain or in the cold. Driving safety is also no longer guaranteed, as a loss of air pressure in the tyre causes a risk of skidding, or the vehicle may become difficult to steer. The BMW Group offers a warning system that notifies the driver of loss of air pressure in a tyre at an early stage. The RPA (tyre failure indicator) has been in use since 2001. RDC was still available to order until model year 2004.

The RDC system monitors tyre pressure both when the vehicle is in motion, and when stationary. An electronic module mounted inside the tyre measures the tyre pressure and temperature at regular intervals. The measured values are sent to a central control unit.

These components are discontinued in the RPA. In contrast, the RPA identifies a loss of air pressure based on an increased number of revolutions of the wheel. Air escaping from a tyre alters the tyre circumference and the rolling radius of the tyre. The peripheral wheel speed therefore increases. The wheel speeds are monitored continuously with the aid of wheel speed sensors. The system compares the wheels aligned diagonally to each other, and their average number of revolutions. The RPA detects whether the wheel speed has fallen below the initial value by approximately 30 %  $\pm$  10 %, and informs the driver. The system provides information after only a short distance, usually within a few minutes or after the driver reaches a certain minimum speed.



# System overview

## Tyre failure indicator

### Different control units for the tyre failure indicator

Series	E ...	Date of introduction of RPA	RPA design	Initialized by:	
				RPA button	CID and controller
3 Series	E46	SA as from 09/0	RPA integrated in DSC	X	---
	E46 Four wheel drive	SA as from 09/01	RPA control unit	X	---
5 Series	E60	Standard	RPA integrated in the DSC	---	X
	E61	Standard	RPA integrated in the DSC	---	X
6 Series	E63	Standard	RPA integrated in the DSC	---	X
	E64	Standard	RPA integrated in the DSC	---	X
7 Series	E65	SA from 09/02 to 12/03, Standard as from 12/03	RPA integrated in CIM	---	X
	E66	SA from 09/02 to 12/03, Standard as from 12/03	RPA integrated in CIM	---	X
Z-models	E85	Standard	RPA integrated in the DSC	X	---
X-models	E53	Standard as from 04/04	RPA integrated in the DSC	X	---
	E83	Standard	RPA integrated in the DSC	X	---

CID = Central Information Display  
 CIM = Chassis Integration Module  
 DSC = Dynamic Stability Control  
 RPA = Tyre failure indicator  
 SA = Option  
 E = Development series



# Functions

## Tyre failure indicator

### Components

#### Functional description

The systems consist of the following major components:

##### 4 wheel speed sensors

The wheel speed sensors of the Dynamic Stability Control system (DSC) detect the rotation speeds of the individual wheels.

##### RPA button (E46, E85, E83, E53 from 04/04)

The RPA button is only required for initialization. In vehicles without an RPA button, the system is initialized via the Central Information Display (CID) using the controller.

Depending on the series, the software for the RPA is contained in the following control units:

##### DSC control unit with additional software for tyre failure indicator (E85, E83, E53 from 04/04, E60, E61, E63, E64)

In connection with the DSC Mk60 and the DSC 8, the RPA is integrated by way of additional software in the DSC control unit.  
or

##### Chassis Integration Module 2 (E65, E66)

The chassis integration module (CIM) controls Servotronic, steering column adjustment and the tyre failure indicator (RPA).  
As of 12/03, the software for the RPA is now integrated in the CIM (a separate processor in the CIM is no longer required).  
or

##### RPA control unit (E46 four-wheel drive)

The E46 four-wheel drive has a separate RPA control unit. The wheel speeds are detected by the 4 wheel speed sensors. The DSC control unit sends the signals to the RPA control unit by four direct leads.

The following control units participate in the functions of the tyre failure indicator:

##### Safety and Gateway Module (from model 03/04 e.g. E60/61 E65/66)

The safety and gateway module (SGM) forms the connection between the body controller area network (K-CAN) and the powertrain controller area network (PT-CAN).

##### Central gateway module (up to model 02/04 e.g. E65/66)

The central gateway module (ZGM) forms the connection between K-CAN and PT-CAN.

##### Car access system

The CAS control unit informs the RPA of the terminal status (e.g. terminal 15 ON).

##### Multi-Audiosystem Controller or Car Communication Computer

The multi-audio system controller (M-ASK) or the car communication computer (CCC) emits an audible warning if the tyre pressure has dropped.

### **Indicator and warning lamps and the central information display**

A fault in the RPA or a loss of tyre pressure is displayed by the permanent RPA indicator and warning lamp in the instrument cluster. At the same time, a check control message is displayed with a variable check control symbol (only on LC display that shows variable check control symbol).

A fault status in the RPA is displayed by the RPA indicator and warning lamp as follows:

- The indicator and warning lamp can have the following status:
    - Red and audible signal:  
Loss of tyre pressure of more than approximately 30 %  $\pm$ 10 %, and driving safety is no longer guaranteed.
    - Yellow:  
The RPA is malfunctioning defective.
- The detailed text of the Check Control message can be called up in the Central Information Display (E65, E66, E60, E61, E63, E64).

---

## **System functions**

The tyre failure indicator (RPA) includes the following functions:

- Self-test
- Initialization
- Measure loss in tyre air pressure
- Visual and audible warning

### **Self-test**

The RPA performs a self-test at terminal 15 ON. Any fault in the system is displayed by the RPA indicator and warning lamp and a check control message.

### **Initialization**

Initialization is a fully automatic learning process.

The RPA is calibrated or initialized to the specific set of tyres with the current tyre pressure.

Once the journey has started, the control unit begins the adaptation phase. This means that the tyre circumference of the individual wheels is measured and evaluated. During the adaptation phase, the system warns of large losses in tyre pressure.

After approximately 10 minutes, losses in tyre pressure of around 50% of the initial value can be detected.

The end of the adaptation phase is not indicated. As initialization continues, the detection of a loss in tyre pressure increases incrementally to 30%  $\pm$  10%.

In order to take into account changes in tyre circumference at different road speeds, the system uses different road speed ranges. These road speed ranges each need to be initialized individually. The driving time required for initialization depends on the model. Below a certain minimum speed, no warning is issued by the system.



Example:

Road speed ranges	Driving time in road speed range / model-dependent
0 km/h to specific minimum speed (e.g. 25 km/h)	---
25 km/h to 110 km/h	15 minutes
110 km/h to 140 km/h	10 minutes
140 km/h to 170 km/h	5 minutes
170 km/h to 200 km/h	5 minutes
Over 200 km/h	5 minutes

Each of these road speed ranges has its own warning threshold value. The warning threshold value is only reached after a specific driving time within this road speed range, after initialization.

This driving time is not a fixed length of time. The driving time depends greatly on the driving style and the driving conditions. The driving time is reached when, for example, a total of 15 or 5 minutes' worth of useful wheel rotation speed signals is available. When accelerating or braking sharply, or when driving around bends, the wheel speed signal cannot be used.

For example, a vehicle is travelling in the road speed range 110 km/h to 140 km/h for at least 10 minutes. If there is a loss in tyre pressure within this range, a warning is issued.

The RPA detects the wheel speed via the wheel speed sensors of the dynamic stability control system (DSC). The RPA compares the individual wheels with each other and calculates the average speed for the purpose of detecting a loss in tyre pressure.

#### Visual and audible warning

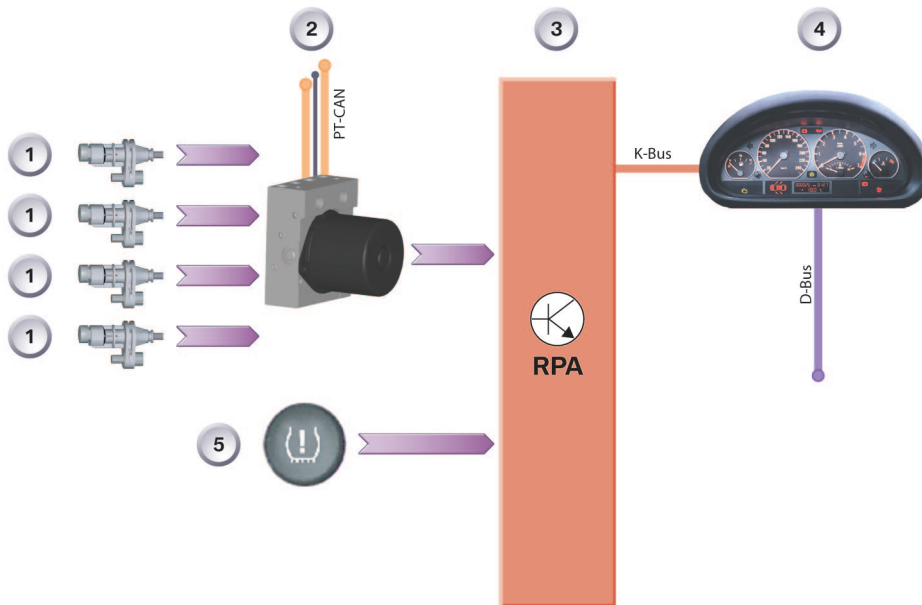
A drop in air pressure in a tyre of approximately 30%  $\pm$  10% of the initial value is indicated by the RPA indicator and warning lamps. An audible signal additionally sounds. The signal output depends on the specific model. Either via the instrument cluster or the multi-audio system controller (M-ASK) or car communication computer (CCC).



# System components

## Tyre failure indicator

### Input/outputs, RPA with RPA control unit



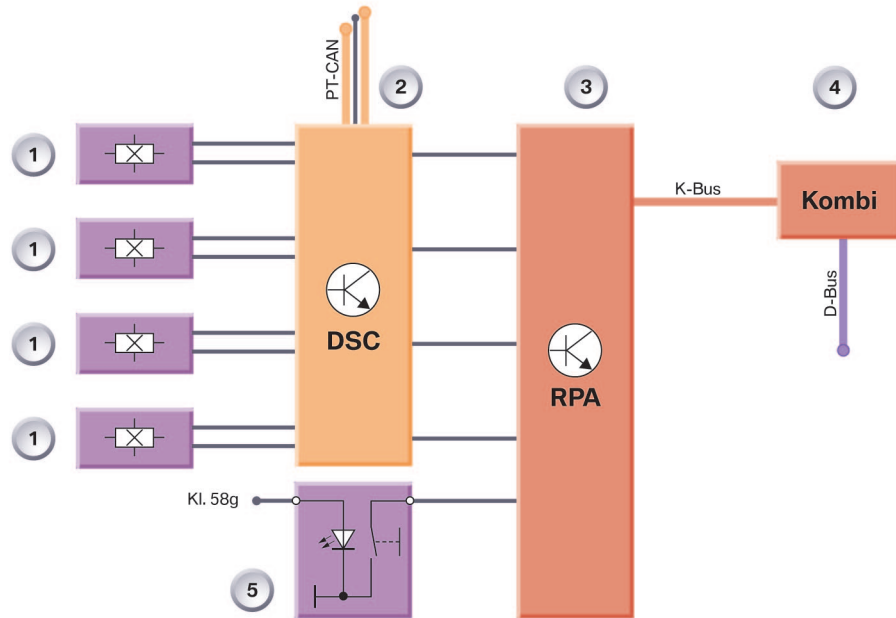
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1 - Four-wheel drive inputs/outputs

Example: E46 four-wheel drive

Index	Explanation	Index	Explanation
1	Wheel speed sensors	5	RPA button
2	DSC control unit (Dynamic stability control)	D-Bus	Diagnosis cable
3	RPA control unit (tyre failure indicator)	K-Bus	Body bus
4	Instrument cluster	PT-CAN	Powertrain CAN (Powertrain Controller Area Network)

## System circuit diagram for RPA with RPA control unit



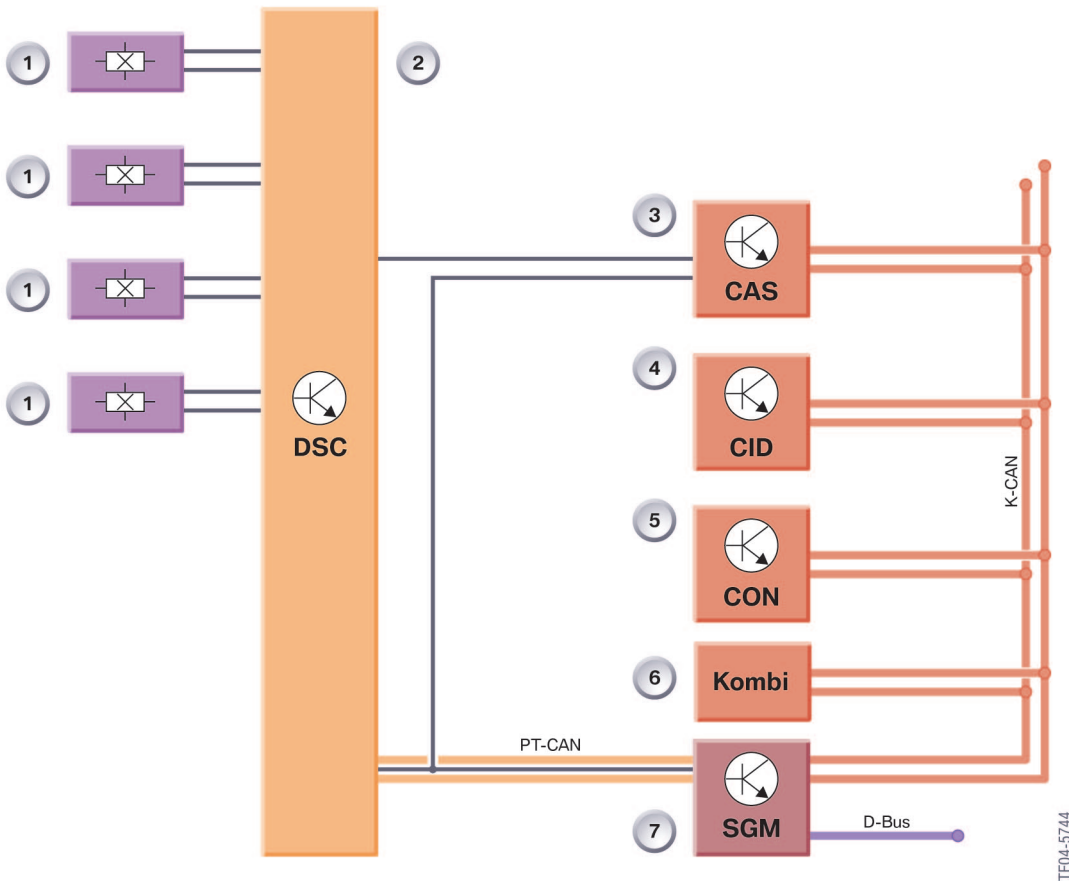
2 - System circuit diagram

Example: E46 four-wheel drive

Index	Explanation	Index	Explanation
1	Wheel speed sensors	D-bus	Diagnosis cable
2	DSC control unit (Dynamic stability control)	K-bus	Body bus
3	RPA control unit (tyre failure indicator)	Terminal 58g	Locator lamp of the RPA button
4	Instrument cluster	PT-CAN	Powertrain-CAN (Powertrain Controller area network)
5	RPA button		

TF04-5726

## System circuit diagram for DSC control unit with additional software for the RPA

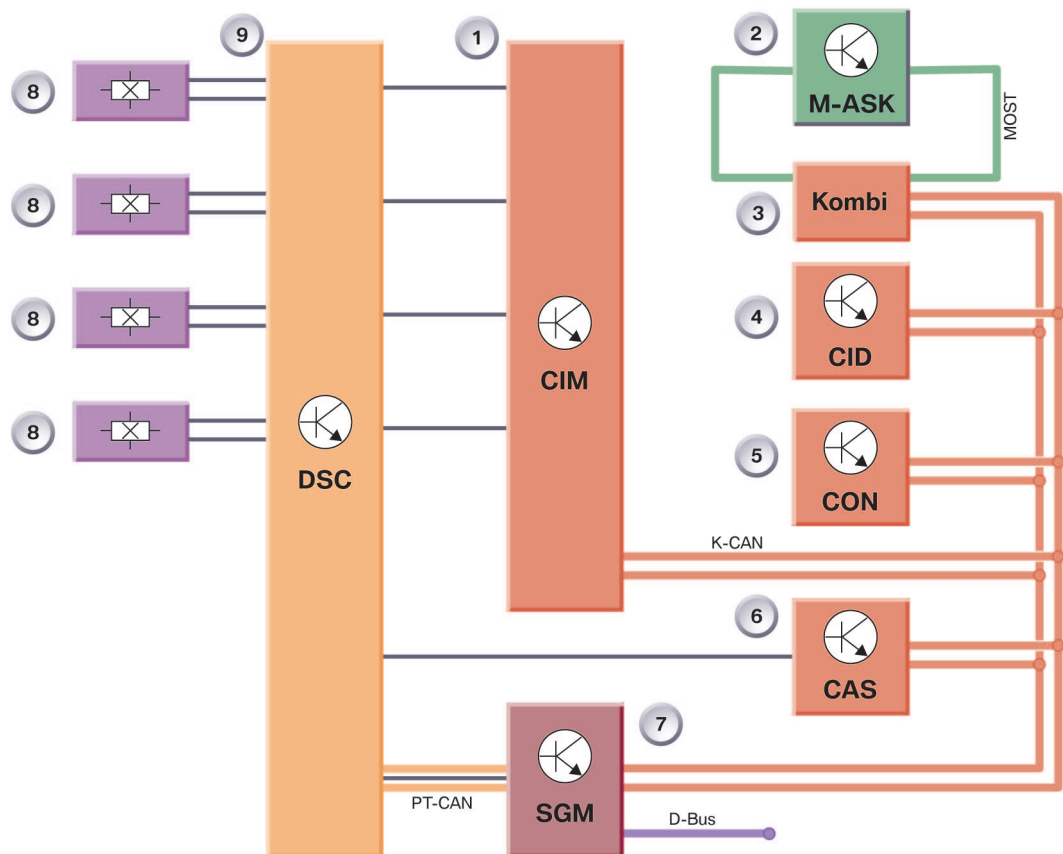


3 - System circuit diagram for E60 tyre failure indicator

Example: E60

Index	Explanation	Index	Explanation
1	Wheel speed sensors	6	Instrument cluster
2	DSC control unit (Dynamic stability control)	7	Safety and gateway module (SGM)
3	Car access system (CAS)	D-bus	Diagnosis cable
4	Central information display (CID)	K-CAN	Body CAN (body controller area network)
5	Controller (CON)	PT-CAN	Powertrain CAN (Powertrain Controller Area Network)

## System circuit diagram for RPA with Chassis Integration Module (CIM)



4 - System circuit diagram E65

Example: E65

Index	Explanation	Index	Explanation
1	Chassis Integration Module (CIM)	8	Wheel speed sensors
2	Multi-Audiosystem Controller (M-ASK)	9	DSC control unit (Dynamic stability control)
3	Instrument cluster	D-bus	Diagnosis cable
4	Central information display (CID)	K-CAN	Body CAN (body controller area network)
5	Controller (CON)	MOST	MOST bus (Media Oriented System Transport Bus)
6	Car access system (CAS)	PT-CAN	Powertrain CAN (Powertrain Controller Area Network)
7	Safety and gateway module (SGM)		

# Service information

## Tyre failure indicator

### General information

#### The following general information is provided for servicing the RPA:

##### Wheel speed sensor failure

If a signal is not received from one of the wheel speed sensors, the RPA assumes the status "inactive" after approximately 2 minutes. The RPA indicator and warning lamp turns yellow. The fault is also displayed in a Check Control message. A fault is entered in the fault code memory.

When the signal returns, the RPA is reactivated after approximately 30 minutes of driving time, and the fault remains recorded in the fault code memory.

##### Driver's responsibility

Check the tyre pressure regularly (at least twice a month), and always before starting a long journey. The set tyre pressure is adopted as the output value.

The RPA does not monitor the natural escape of air (diffusion) in all 4 tyres.

If all 4 tyres have the same loss in tyre pressure, all the wheel speeds change at an equal rate. The RPA cannot detect an equal loss of tyre pressure.

#### Problematic factors for system function

The following driving conditions can lead to a delayed or incorrect warning of a loss in tyre pressure:

- Sharp braking
- Powerful acceleration
- High transverse acceleration
- Driving around a narrow bend radius
- Driving below a minimum speed (the RPA only responds above a certain minimum speed)
- Large differences in slip (axle and/or vehicle side)
- Incomplete initialization in the current road speed range (see Operation)
- Winter driving conditions

The following operating conditions can lead to a delayed warning of a loss in tyre pressure:

- Use of snow chains  
The RPA cannot be guaranteed to function accurately when snow chains are used.

**⚠** If using snow chains, do not perform initialization.

The system should not be initialized when using snow chains, because this leads to incorrect adaptation values.

After the snow chains are removed, the system function returns to normal after a few minutes driving time. ◀

- Towing  
If towing a trailer load of more than approximately 300 kg, re-initialization is necessary.  
After unhooking or unloading the trailer, perform initialization once more.
- Old/new tyres  
Avoid fitting tyres with large differences in tread depth (more than approx. 2 mm) on one axle.

The system does not issue a warning, despite a loss of tyre pressure, in the following cases:

- If two or more tyres lose air pressure to the same extent
- Loss of tyre pressure caused by natural diffusion and that affects all 4 tyres equally
- Tyre damage with immediate great loss of tyre pressure (tyre blow-out, the warning is too late)

## Operation

The tyre failure indicator (RPA) is initialized using the following operating elements:

- RPA button
- With iDrive, in the central information display (CID) using the controller

**⚠** Always perform initialization immediately after correcting the tyre pressure, changing or interchanging tyres. Always set the tyre pressure for cold tyres.

The correct tyre pressure must be set before initialization. During initialization, the set tyre pressure is used as the initial value for the current set of tyres.

The tyre pressures must always be set as for cold tyres to avoid erroneous values caused by changes in temperature. ◀

### **The tyre failure indicator cannot be guaranteed to function correctly if using an emergency wheel.**

When an emergency wheel is used, the software of the RPA can no longer compensate for the different wheel diameters. Initialization cannot be completed.

Initialization must be performed:

- when changing the tyre pressure (tyre pressure is corrected or a new pressure is set)
- if the position of the wheels is altered, even if the tyre pressure has not been changed
- when changing or interchanging tyres (e.g. when changing old tyres for new tyres, summer tyres for winter tyres, etc.)

To perform initialization, proceed as follows:

- Terminal 15 ON
- Vehicles with an RPA button
  - Hold the RPA down until the RPA indicator and warning lamp is lit up in yellow for a few seconds
- Vehicles without RPA button  
Initialization is performed via the Central Information Display (CID) using the controller
  - Select "RPA" in the "Settings" menu, and confirm
  - Select "Set", and confirm
- Start driving

The end of the adaptation phase is not indicated.

## Activation conditions

The tyre pressure indicator (RPA) is automatically activated when terminal 15 is ON. The RPA cannot be switched off manually.



## Special information on the RPA for E60 models

The following illustration shows the variable check control symbol.  
(Example of E60 instrument cluster)



1 - Instrument cluster



T404-5728

Index	Explanation	Index	Explanation
1	Variable check control symbol together with a check control message (yellow or red indicator lamp)	3	Check control message in the central information display
2	"BMW Service" menu in the central information display		

There are two variable check control symbols for the RPA, with 2 corresponding check control messages, which are displayed in the instrument cluster:

- "Flat tyre!" reports a loss of pressure in a tyre of more than 30%. This is accompanied by a gong.
- "Tyre failure indicator failure!" reports that the system is inactive due to a fault and cannot detect a flat tyre.

Additional information for each check control message is displayed in the CID.

Variable check control symbols	Information in the CID
 <p data-bbox="627 651 724 685">Flat tyre</p>	<p data-bbox="895 611 1428 781">Reduce speed, see the Owner's Handbook. Safety tyres: Maximum possible driving speed is 80 km/h. Distance is limited, see the Owner's Handbook. Have the problem checked by the nearest BMW Service.</p>
 <p data-bbox="627 916 868 972">Tyre failure indicator failure</p>	<p data-bbox="895 875 1428 958">Flat tyres are not indicated. Have the problem checked as soon as possible by the nearest BMW Service.</p>

The RPA submenu in the CID also contains a status line that indicates the current status of the RPA.

- 'Adaptation phase': The system is being calibrated. The adaptation phase is

displayed until the RPA first becomes ready for operation after the start of calibration.

- "Inactive": There is a fault in the system and therefore no flat tyres can be detected.
- "Active": The system is capable of detecting a puncture.

## Diagnosis

The diagnosis for the RPA function is performed in the DSC control unit.

### Fault codes

There is a range of different fault codes. If a fault code is displayed, the RPA assumes "inactive" status.

- If there are errors in the coding data: The system needs to be recoded. If faults

recur regularly in the vehicle, the control unit needs to be replaced.

- If there are errors in the standardization data: The system needs to be restandardized. If faults recur regularly in the vehicle, the control unit needs to be replaced.
- Failure of a wheel speed sensor is stored in the fault code memory by the DSC function.

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## Programming

The RPA is automatically flash programmed using the DSC software.

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## Coding

The RPA is encoded by means of a coding description file. This enters different parameters into the control unit that take into account the differences between the different vehicle models.

### **Note for the E60**

Depending on the equipment specification, a space-saver wheel may be supplied. This wheel has the designation T-135/80-17 (the T stands for: "Temporary spare").  
Important: The space-saver spare wheel has a pressure of 4.2 bar!



# Abbreviations

ABS	Anti-lock braking system
ACC	Active cruise control
AHM	Trailer module
AL	Low beam
	Active steering
ARS	Dynamic drive
ASC	Automatic stability control
CAN	Controller area network
CAS	Car access system
CBC	Cornering brake control
CCC	Car communication computer
CDC	CD changer
CID	Central information display
CIM	Chassis integration module
CON	Controller
CVM	Convertible top module
DBC	Dynamic braking control
DDE	Digital diesel electronics
DME	Digital motor electronics
DSC	Dynamic stability control
DSC-SEN	Dynamic stability control - sensor
DWA	Antitheft alarm system
EBV	Electronic brake power distribution
ECD	Electronically controlled deceleration
ECO	Electronically controlled orifice
EDC	Electronic damper control
EGS	Electronic transmission control
EHC	Electronic ride-height control (level control)
EKP	Electric fuel pump
EMF	Electromechanical parking brake
EPS	Electromechanical power steering
EWS	Electronic immobilizer
F-CAN	Chassis CAN
FLR	Driving performance control
GM	Base module
IHKA	Integrated automatic heating/air conditioning
K-CAN	Body Controller Area Network
KBM	Body basic module
LED	Light-emitting diode

LM	Light module
LSZ	Light switch cluster
LWS	Steering angle sensor
M-ASK	Multi-audio system controller
MDS	Panoramic glass roof
MRS	Multiple restraint system
MSR	Engine drag torque control
NAV	Navigation
PDC	Park distance control
PT-CAN	Power Train Controller Area Network
PWM	Pulse width modulation
RLS	Rain/driving light sensor
RPA	Tyre puncture warning
SA	Option
SBSL	B-pillar satellite, left
SBSR	B-pillar satellite, right
SDARS	Satellite Digital Audio Radio Service
SDR	Short distance radar
	Overrun differential control
SES	Voice recognition system
SFZ	Vehicle centre satellite
SH	Auxiliary heating
SHD	Slide/tilt sunroof
SIM	Safety and information module
	Subscriber identification module
SM	Seat module
SMBF	Passenger's seat module
SMFA	Driver's seat module
SMG	Sequential manual transmission
	Sequential M transmission
SZL	Steering column switch cluster
SZM	Centre console switch cluster
VM	Video module
ZGM	Central gateway module



