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E89 Complete Vehicle

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Complete Vehicle

Model: E89

Production: From Start of Production

OBJECTIVES

After completion of this module you will be able to:

- Identify the changes made between the E85 and E89
- Identify the different variants of the E89
- Identify the components of the Retractable Hardtop
- Explain the operation of the Retractable Hardtop
- Identify the suspension components
- Explain the operation of the Parallel EPS system
- Explain the operation of the EMF system
- Explain the operation of the new Capacitance Seat Occupancy sensor

Introduction

The new Z4, successor to the E85 Z4 Roadster and E86 Z4 Coupe, is the first BMW Roadster to have a retractable hardtop. With its long engine compartment lid, large wheel apertures, long wheelbase and squat overhang it features all typical elements of a BMW Roadster. The vehicle's manufacturing has been moved from Spartanburg, South Carolina to the Regensburg, Germany plant.

These features are further enhanced by the flat front section, the pronounced shoulder line and rear end. In addition, the engine compartment lid that extends over the wheel arches, the large BMW radiator grill, the side gills, the black A-pillar, the contoured roof and rear lights with innovative light technology further cement the characteristic accents.

The two-piece, electrohydraulically operated retractable hardtop made of lightweight aluminum panels takes approximately 20 seconds to open or close fully automatically. The compact stowage of the roof elements in the luggage compartment allows for a flat, Roadster-characteristic rear design and a luggage compartment volume between 180 and 310 liters (6.3 and 10.9 cubic feet). Large window areas together with the heated glass rear window provide an optimum all-round field of view.

All models are equipped with Efficient Dynamics measures and thus no compromise has been made in terms of acceleration, performance and fuel economy. At launch in May 2009, the E89 is offered as tow model variants.

Z4 sDrive35i - N54B30O0 (300 hp / 300 lb-ft)

Z4 sDrive30i - N52B30O1 (255 hp / 220 lb-ft)

Both model variants come standard with a manual 6 speed transmission but if the automatic transmission option is desired, two transmissions are available. For the Z4 sDrive30i , there is the familiar GA6HP19Z (TU) transmission. For the Z4 sDrive35i, the sports automatic with double clutch (DCT) GS7D36SG transmission that was first utilized in the fourth generation M3 is available.

The new BMW Z4 is equipped with a three level dynamic driving control as standard. This allows the driver to change the accelerator pedal characteristics, gearshift program and shift speed of the optional automatic gearbox, DSC response and the optional adaptive M running gear with the touch of a button.

Head and elbow clearance as well as ease of entry have been greatly improved compared to the predecessor model. The low seat position near the rear axle creates the typical ride experience of a BMW Roadster.

Changes when compared to the E85:

- Improved interior and comfort
- Retractable hardtop
- Bi-xenon as standard (fog lights discontinued)
- Through-loading facility
- Wheelbase increased by +146 mm (5.75”)
- Standard ” wheels optional 19” wheels
- Optional adaptive M running gear
- Optional sports automatic transmission with double clutch (only on Z4 sDrive35i)
- Cruise control with brake intervention
- Dynamic driving control
- CIC (with navigation)

Body

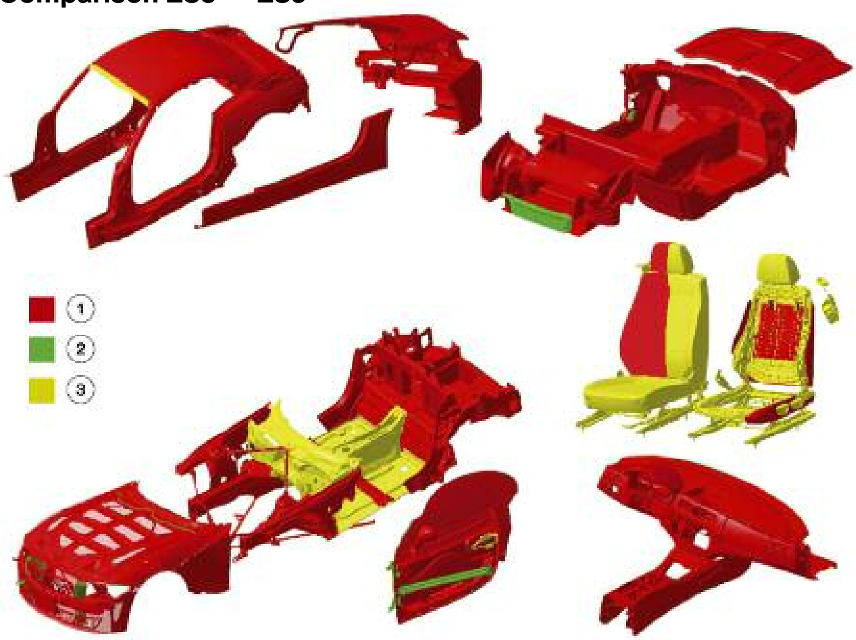
The following are some important design objectives in the development of the E89 body:

- Harmonious overall impression with extended proportions, coupe-inspired roof line and flat rear end
- Remote controlled, fully automatic retractable hardtop with load help function
- Through-loading capability for carrying skies or a golf bag regardless of top position
- More and easier-to-use storage compartments in the vehicle interior as well as a rear storage area behind the seats
- Greatly improved all-round vision (rear side windows) and a larger rear window
- Compelling impression (driver-orientated), top-quality appearance and functionality of the interior
- Distinctly reduced noise level at higher speeds

Comparison of Body Components

The new Z4 has been designed with very few components actually used from the previous model. The illustration below identifies the components used in both generation Z4.

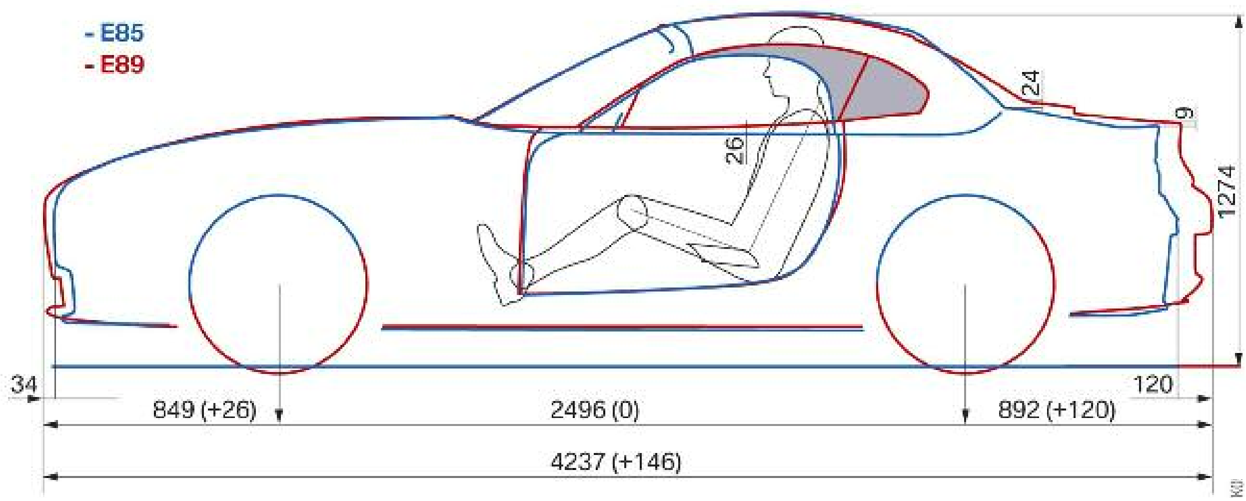
Comparison E85 — E89



Index	Explanation
1	New components (newly developed)
2	Common parts
3	Modified components (developed with minimum expenditure)

Dimensions

The E89 has grown compared to the E85. The width is now 1790 mm (+9 mm).

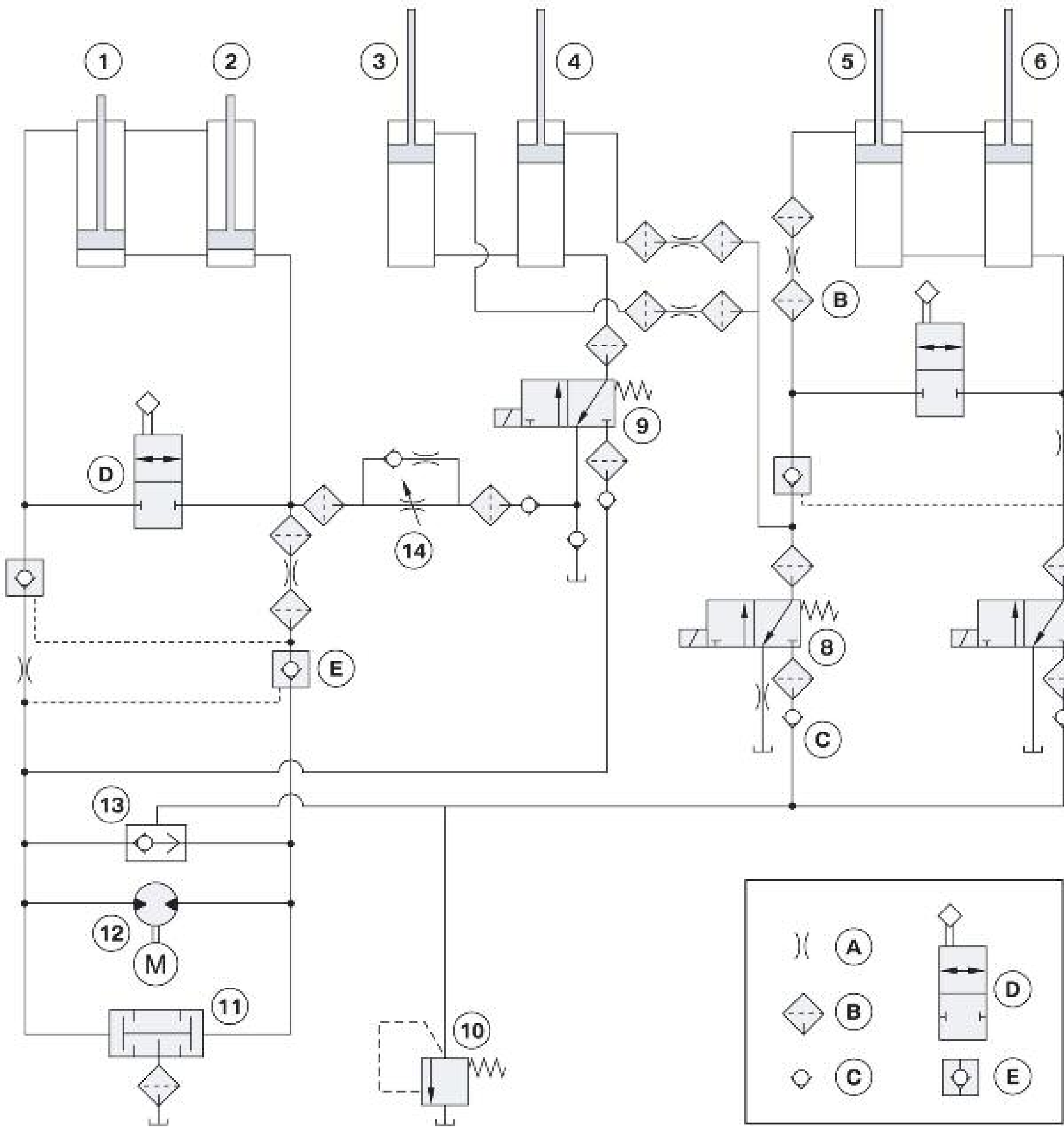


Garage dimensions E85/E89

Retractable Hardtop

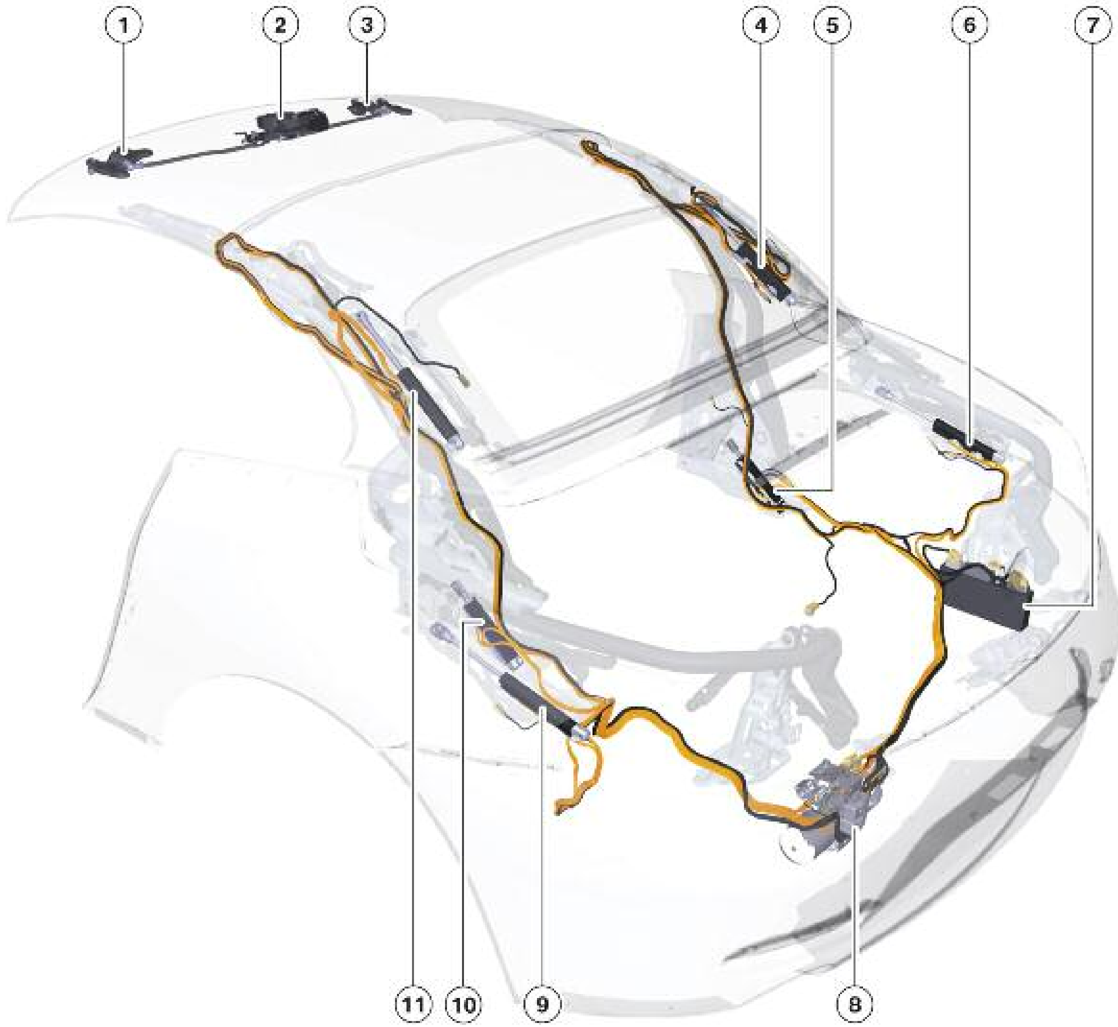
The retractable hardtop consists of two aluminum roof panels. They are operated by means of an internal linkage. The retractable hardtop and the rear module are driven hydraulically. The hydraulic system consists of 6 hydraulic cylinders that are supplied with pressure by the hydraulic unit via the hydraulic lines. The cylinders are always actuated in pairs. The retractable hardtop is equipped with a headliner without tensioning cables.

Hydraulic System Circuit Schematic



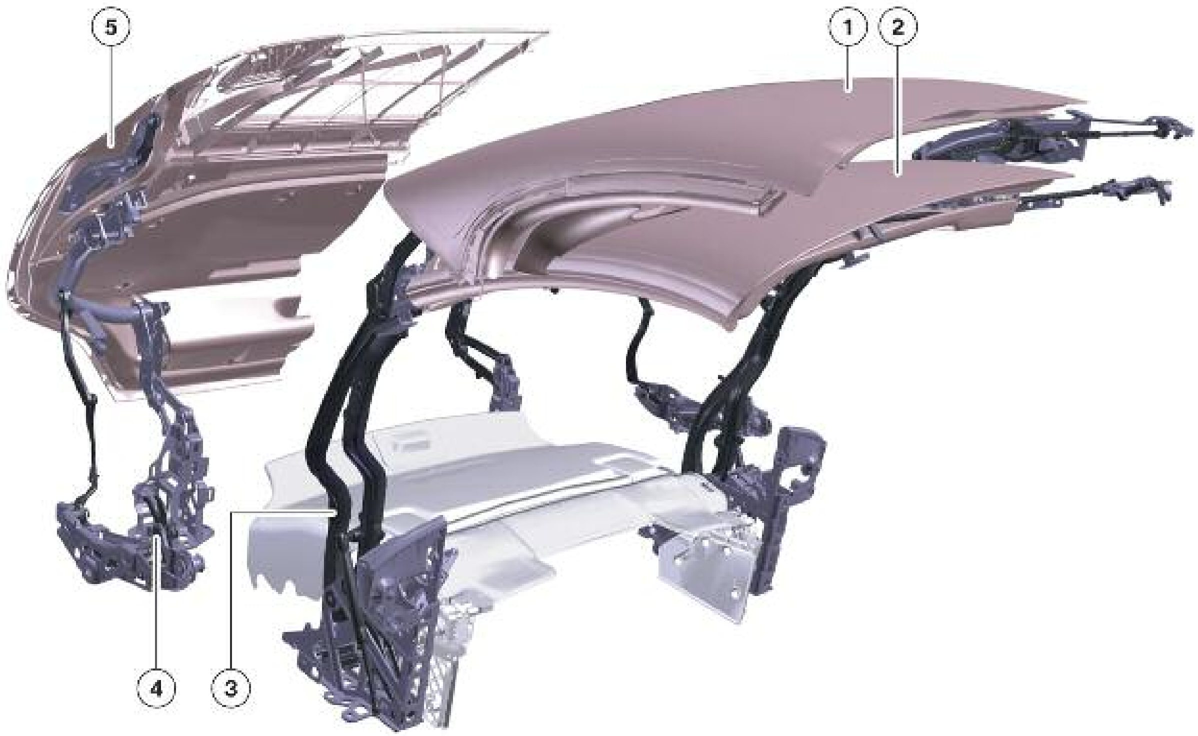
Index	Explanation
A	Throttle
B	Filter
C	Non-return valve
D	Emergency operating valve
E	Pilot-controlled non-return valve
1	LH hydraulic cylinder, main pillar
2	RH hydraulic cylinder, main pillar
3	LH hydraulic cylinder, roof panel
4	RH hydraulic cylinder, roof panel
5	LH hydraulic cylinder, rear module
6	RH hydraulic cylinder, rear module
7	Valve for rear module
8	Valve for roof panel and rear module
9	Valve for main cylinder and roof panel
10	Pressure relief valve
11	Changeover valve
12	Hydraulic pump
13	Changeover valve
14	Two-way flow control valve

Hydraulics and Locking Mechanism



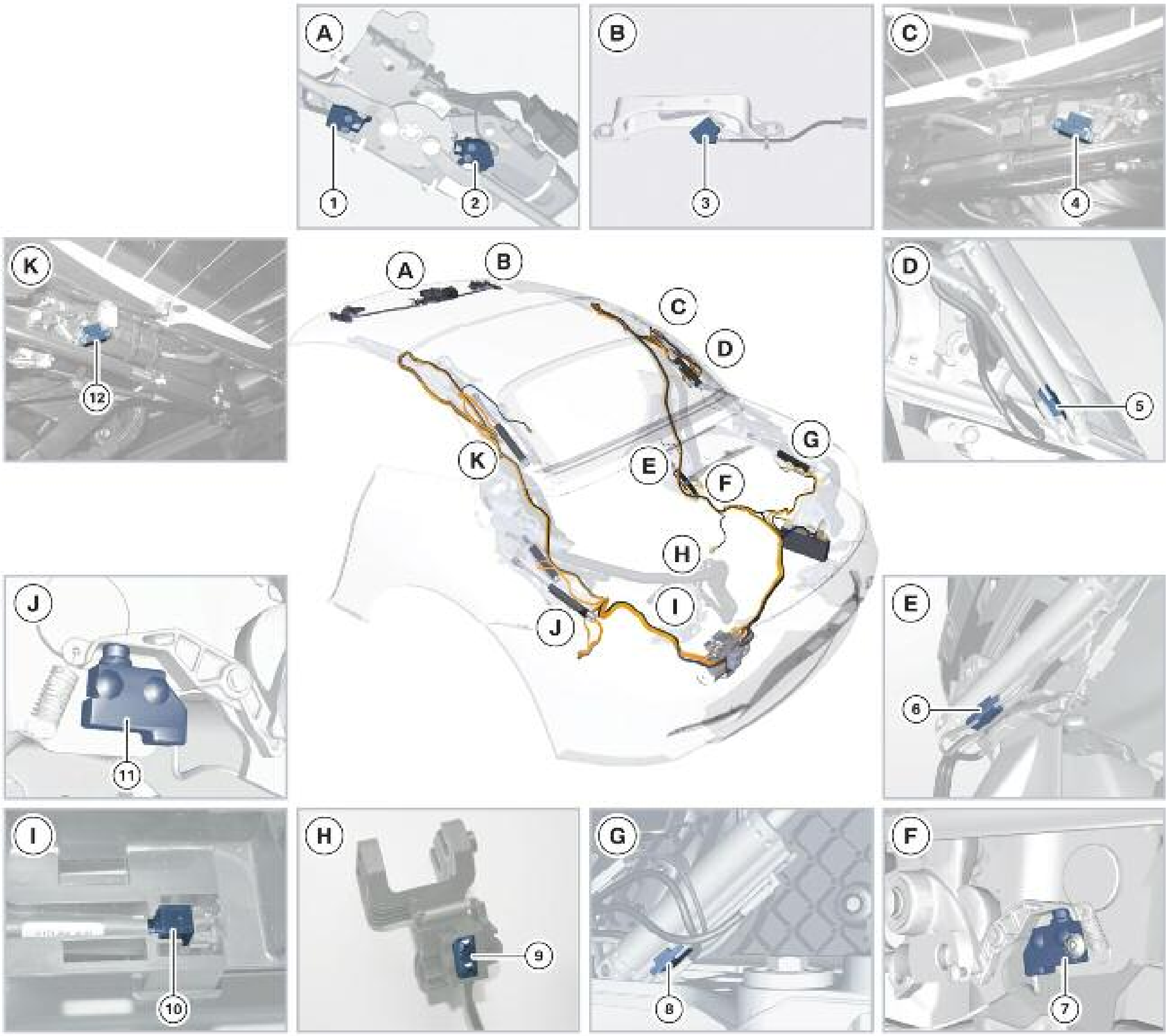
Index	Explanation
1	LH latch, windscreen cowl panel
2	Drive for locking retractable hardtop
3	RH latch, windscreen cowl panel
4	RH hydraulic cylinder, roof panel
5	RH hydraulic cylinder, main pillar
6	RH hydraulic cylinder, rear module
7	Convertible top module
8	Hydraulic unit
9	LH hydraulic cylinder, rear module
10	LH hydraulic cylinder, main pillar
11	LH hydraulic cylinder, roof panel

Mechanical System Overview



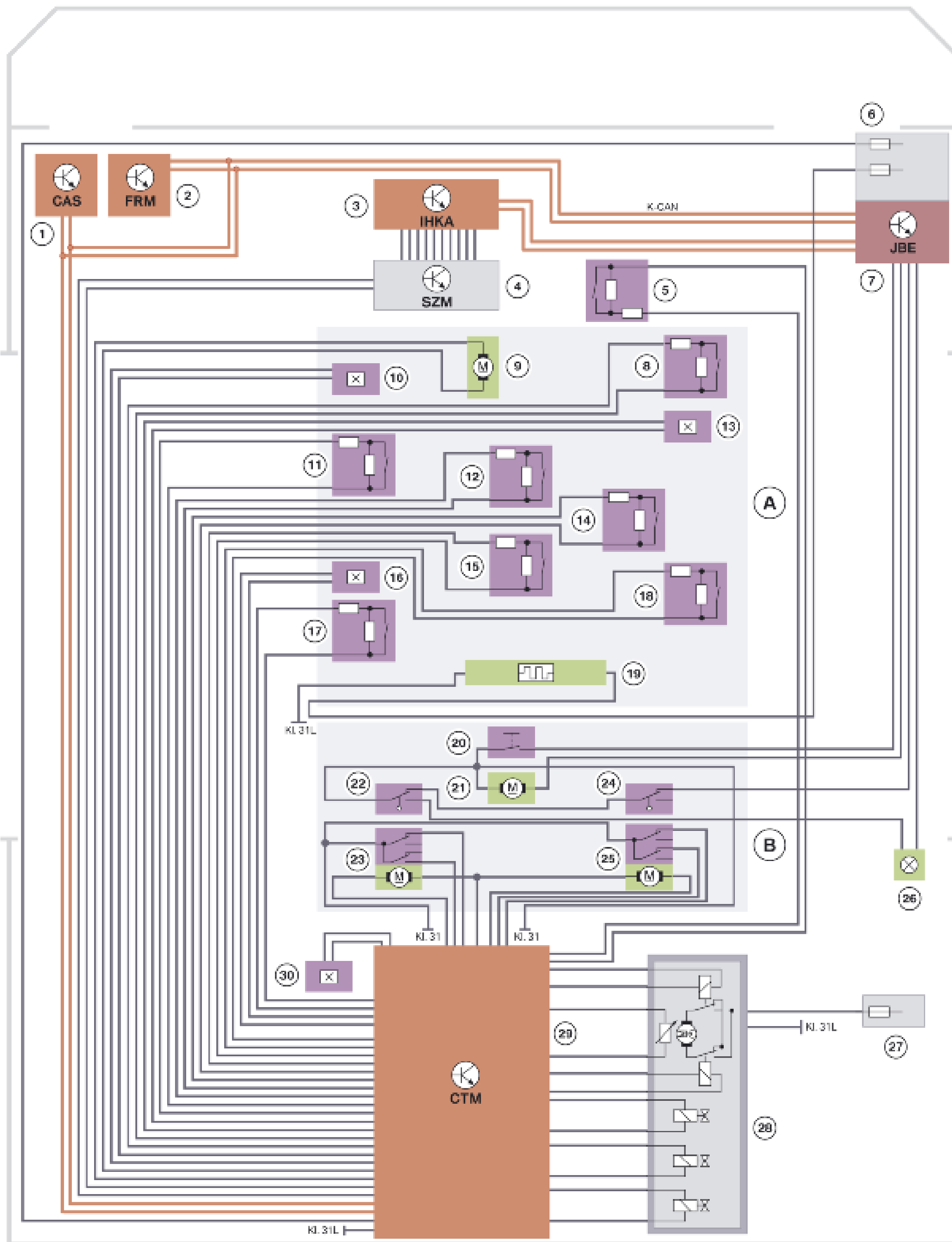
Index	Explanation
1	Roof panel 2
2	Roof panel 1
3	Main pillar mechanism
4	Rear module mechanism
5	Rear module

Sensors



Index	Explanation
A - K	Locations
1	Microswitch, cowl panel unlocked
2	Microswitch, cowl panel locked
3	Microswitch, cowl panel reached
4	RH microswitch, roof panel closed
5	Hall sensor, roof panel packed
6	Hall sensor, roof panel opened
7	RH microswitch, rear module closed
8	Hall sensor, roof package extended
9	Microswitch, roof module compartment locked
10	Hall sensor, luggage compartment partition
11	LH microswitch, rear module closed
12	LH microswitch, roof panel closed

Circuit Diagram - Convertible Top Module



Index	Explanation	Index	Explanation
A	Roof module	15	Microswitch, roof module compartment locked
B	Rear module	16	Hall sensor, rear module opened
1	Car Access System (CAS)	17	LH microswitch, rear module closed
2	Footwell module (FRM)	18	RH microswitch, rear module closed
3	Integrated automatic climate control (IHKA)	19	Heated rear window
4	Center console control panel (SZM)	20	Rear lid button
5	”Cowl panel reached” microswitch	21	Release drive
6	Front power distribution box	22	Rear lid lock switch
7	Junction box electronics (JBE)	23	LH automatic soft close drive
8	RH microswitch, roof panel closed	24	Rear lid lock switch
9	Drive for locking retractable hardtop	25	RH automatic soft close drive
10	Hall sensor, roof package extended	26	Luggage compartment light
11	LH microswitch, roof panel closed	27	Battery power distribution box
12	Microswitch, cowl panel unlocked	28	Hydraulic unit
13	Hall sensor, roof panel packed	29	Convertible top module (CTM)
14	Microswitch, cowl panel locked	30	Hall sensor, luggage compartment partition

System Components

Microswitches and Hall Sensors

The various positions of the retractable hardtop and of the rear module are detected by 8 microswitches and 4 Hall sensors and signalled to the convertible top module CTM. All microswitches and Hall sensors receive their voltage supply from the convertible top module and have diagnostic capabilities.

After loss of terminal 30 or after emergency operation, the retractable hardtop can still be operated without the need for re-initialization. The microswitches and Hall sensors ensure the convertible top module reliably detects the position of the retractable hardtop.

Buttons for Operating the Hardtop

Two buttons are provided in the center console for the purpose of operating the retractable hardtop. These buttons are wired to the convertible top module. When a button is pressed, the convertible top module receives the information and executes the corresponding command. Movement of the retractable hardtop or side windows stops if the button is released while the hardtop is moving. Operation is indicated by a red LED in one button and a green LED in the other. The convertible top module actuates the LEDs via the K-CAN.

The green LED in the button lights up during the opening/closing operation. The red LED signals an operating error or incorrect conditions (e.g. luggage compartment partition not in lower position). The red LED flashes as soon as the retractable hardtop is in an intermediate position and not operated. The LED flashing does not indicate a fault. The flashing LED draws attention to the fact that the vehicle cannot be driven in this situation.

A fault code that cannot be read out is stored under following conditions:

- Terminal R On while the button is pressed
- When the button is pressed for longer than 20 seconds after roof operation has concluded.

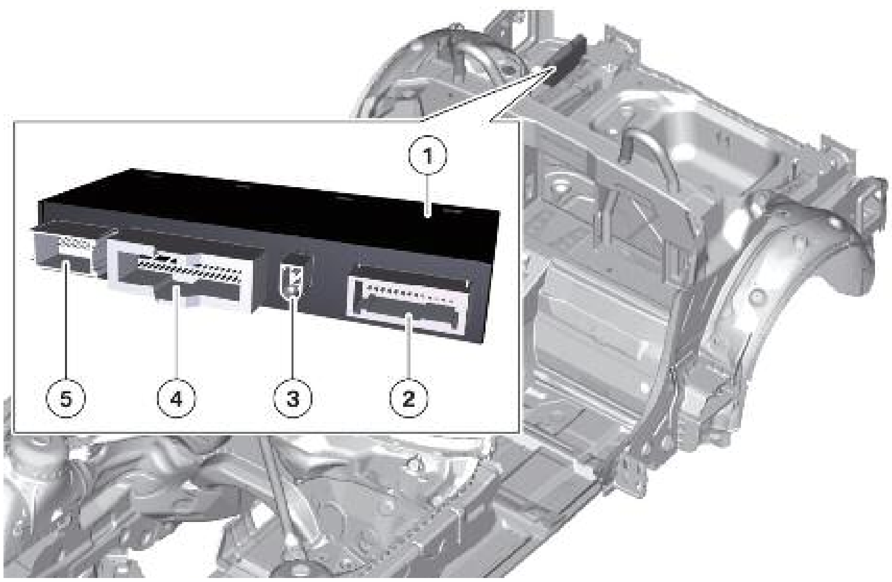
The retractable hardtop is then temporarily inoperative. The retractable hardtop can be operated again after pressing the Open button once.

Convertible Top Module

The Convertible top module (CTM) is the central electronic control unit for all functions of the retractable hardtop. The convertible top module is installed on the right in the luggage compartment. The convertible top module controls the retractable hardtop, the rear module, the automatic soft close system and the drive unit for locking the hardtop.

The CTM also controls the hydraulic pump and the six hydraulic cylinders by way of the three valves in the hydraulic unit. The K-CAN connects the convertible top module to other control units. Information on outside temperature, driving speed and rear lid status etc., is received via the K-CAN. The convertible top module ends a signal to the car access system (CAS) when the retractable hardtop is opened or closed. The car access system is the master for the power windows. In certain situations, the convertible top module outputs information in the form of check control messages in the instrument cluster.

Convertible Top Module - Location and Connections



Index	Explanation
1	Convertible top module
2	26-pin connector for Hall sensors and microswitches
3	2-pin connector to drive unit for locking retractable hardtop
4	41-pin connector for voltage supply, automatic soft close system, and K-CAN
5	18-pin connector for actuating hydraulic unit

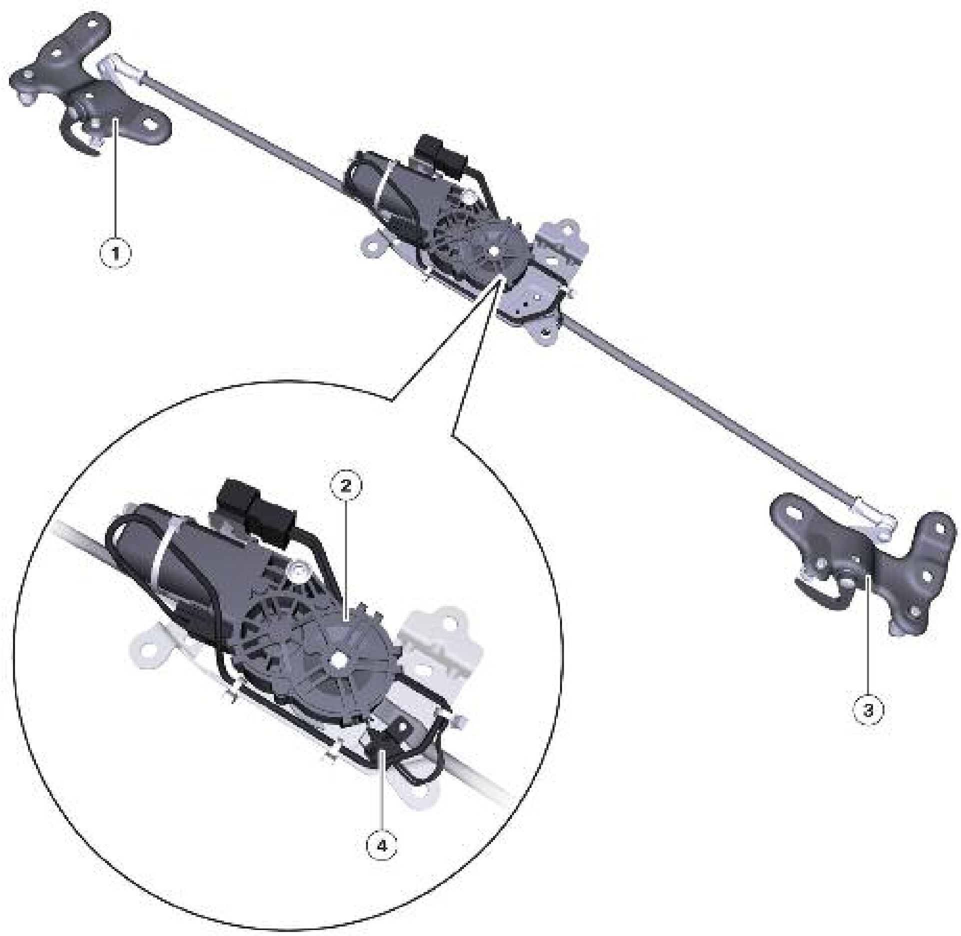
Note: ISTA-P must be used to encoded the new module after replacement.

Drive for Locking the Retractable Hardtop

The drive unit, consisting of an electric motor with gear mechanism, locks and unlocks the retractable hardtop with the cowl panel at the upper windscreen frame. The convertible top module actuates the electric motor. The drive unit is arranged in the middle. The retaining hooks on the right and left are moved by a rotary plate and push rods. The two Hall sensors ’cowl panel locked and unlocked’ monitor the locking procedure.

When the retractable hardtop is opened, the drive unit locks the hardtop on the base plate in the rear module. This is a crash-lock function, which prevents the retracted hardtop from folding forward in the event of a crash.

Drive for locking the retractable hardtop



Index	Explanation
1	Retaining hook, left
2	Drive for locking retractable hardtop
3	Retaining hook, right
4	’Cowl panel unlocked’ microswitch and ’cowl panel locked’ microswitch

Hydraulic Unit
The hydraulic unit is located in a pan in the luggage compartment floor. The movement direction of the retractable hardtop and rear module are determined by corresponding valve positions and the direction of rotation of the hydraulic pump. The direction of rotation of the hydraulic pump is controlled by two relays.

The hydraulic pump generates an operating pressure from 150 to 200 bar.

The temperature in the hydraulic pump is measured to avoid the pump overheating during frequent use of the retractable hardtop. Two cables connect the temperature sensor ground-free to the convertible top module. A line break (open circuit) results in a fault code being entered in the fault code memory. At from a temperature of 90°C, hardtop closing movement already started is continued up to the secure end position. The movement of the retractable hardtop is stopped immediately at a temperature of 105°C.

The movement can be continued after the temperature has dropped below 90°C.
The hydraulic unit is protected by a 50 amp slow-blow fuse.

Other than topping the hydraulic system off, the hydraulic fluid does not require any servicing. Add only the approved hydraulic fluid to the mark on the reservoir.

Hydraulic Unit Location

Note: Excessive noise during top operation may be due to aerated hydraulic lines. If excessive operating noise is heard during operation, the retractable hardtop should be opened and closed several times in order to automatically bleed the hydraulic system via the fluid reservoir.

Instrument Cluster - KOMBI
The instrument cluster provides the outside temperature (bus signal). The instrument cluster uses the check control symbol to show check control messages relating to the retractable hardtop.

Footwell Module - FRM
The footwell module FRM actuates the front power window regulators. The side windows must be lowered in order to open the retractable hardtop (bus signal to convertible top module).

Junction Box Electronics - JBE
The junction box electronics JBE actuates the rear power window regulators. The side windows must be lowered in order to open the retractable hardtop (bus signal to convertible top module). The junction box electronics provides the signal indicating whether the rear lid is closed (bus signal).

The power distribution box in the junction box supplies terminal 30g to the convertible top module. The convertible top module additionally receives terminal 15 from the car access system. This still enables adequate communication with the BMW diagnosis system when, for example, the voltage supply from the junction box is interrupted.

Car Access System - CAS
The car access system is the master control unit for the power window regulators. On request of the convertible top module, the car access system lowers or raises the side windows. In addition, the car access system prevents the rear lid from being opened and movement of the power windows when the retractable hardtop is in an intermediate position. The car access system controls the auto-remote opening function for the retractable hardtop. The signals from the remote control are received by the remote control receiver and sent to the car access system.

Antenna Diversity
The convertible top module sends a corresponding signal to the antenna diversity module depending on whether the retractable hardtop is closed or open. The antenna diversity function then correspondingly switches over the antennas.

Principles of Operation

The following options are available for operating the hardtop:

- Using the button (close and open)
- Using the key in the lock cylinder in the driver's door handle (close and open)
- Using the remote control (open only)
- Using the ID transmitter with Comfort Access option (close, as long as the ID transmitter is within range of the comfort access antennas and open as with the remote control).

Operating Pre-Conditions
The retractable hardtop can be opened and closed using the button in the center console only if the following conditions are met:

- Terminal R ON
- Outside temperature above -12°C
- Boot lid closed
- Vehicle stationary (driving speed < 0.7 km/h)
- Luggage compartment partition in lowest position
- Lateral inclination of vehicle < 11°
- Power windows initialized
- Battery voltage > 11.5 V
- Less than five successive opening/closing operations
- Hydraulic fluid temperature for opening < 90°C and for closing < 105°C
- Electrical system check successful
- Production, transport and workshop mode (FeTraWe) not set.

It is not possible to open and close the retractable hardtop while driving. Due to the high current consumption of the retractable hardtop of up to 40 amps, the hardtop should only be operated when the battery charger is connected or the engine is running.

Note: The rear power window regulators do not have an anti-trap system. There is also no one-touch function for closing the rear windows.

Opening the Retractable Hardtop

The retractable hardtop is normally operated by pressing the open or close button in the center console. The hardtop moves for as long as the button is pressed. The green LED in the button lights up while the retractable hardtop is moving. Movement of the retractable hardtop, rear module or side windows is stopped immediately if the button is released while the retractable hardtop is moving. The red LED then flashes in the button.

Movement of the hardtop can be resumed by pressing the button again. Movement of the side windows can be resumed within 10 seconds. If one of the conditions is not met, the red LED will light continuously.

The convertible top module checks the conditions for opening the retractable hardtop when the Open button in the center console is pressed. If the check is successful, the hardtop is opened as follows:

- Lower side windows (if closed or in intermediate position)
- Release hardtop at cowl panel
- Switch off heated rear window (takes place via junction box electronics)
- Unlock and open rear module
- Roof panel 2 is released and packed over roof panel 1
- Stow roof panel package in rear module and lock
- Close and lock rear module
- Close side windows.

The hardtop is closed automatically in the reverse order.

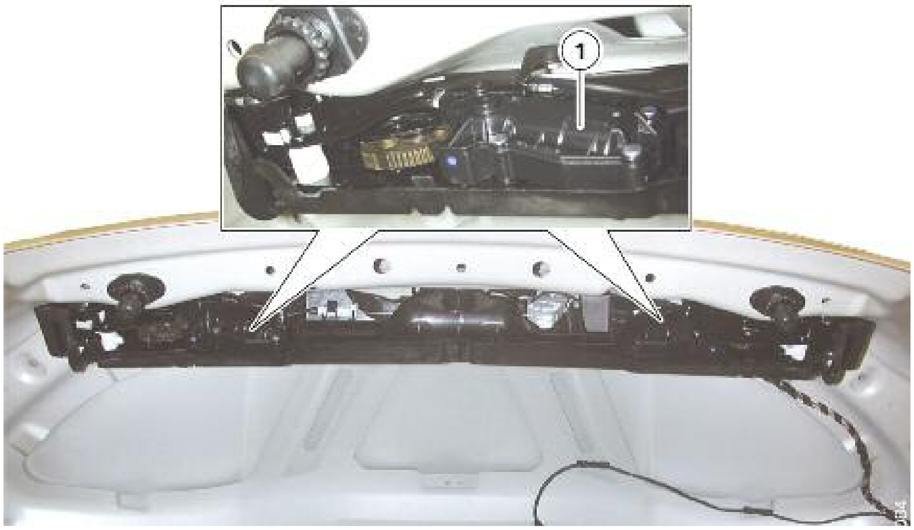
Operating Conditions with Comfort Access

The following functions can be performed only when the ID transmitter is less than 4 m away:

- Open
- Close
- Easy Load feature

Automatic Soft Close System

The automatic soft close function is installed as standard to conveniently close the rear [trunk] lid. The automatic soft close system consists of two drive units. The drive units lock the rear lid on the left and right on the rear module carrier. This increases the stability of the rear end.



Automatic soft close drive (1)

Each trunk lid latch assembly has a microswitch. These two microswitches are operated when the rear lid locks on the left and right have reached the lock strikers. The signals are hard wired to the junction box electronics which then makes the signal available to the convertible top module via the K-CAN-bus. The convertible top module then actuates the two drive units of the automatic soft close system until the rear lid is locked.

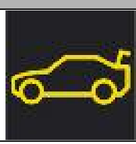
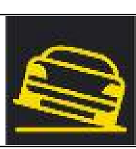
Manually shutting the rear lid would make closing via the automatic soft close system unnecessary. For safety reasons, steps must be taken to ensure that the rear lid is completely closed. For this reason, the drive units of the automatic soft close system are still actuated.

Both drive units feature a repeat interlock to avoid overheating. The repeat interlock allows the automatic soft close system to be actuated up to 20 times (counter up to 20 increments). The automatic soft close system is then inhibited electrically for approximately 2 minutes.

Check Control Messages

It is not possible to open or close the retractable hardtop in certain situations. In such cases, corresponding messages are shown in the instrument cluster in the form of check control messages.

A short message and additional information are shown on vehicles equipped with a central information display (CID). The check control messages provide explanatory information relating to the red LED in the button that lights up in the case of fault. An active check control message is shown every 5 seconds.

Check Control Symbol	Check Control Message	Additional Information
	Luggage compartment open!	-
	Roof malfunction!	No roof movement possible. If the retractable hardtop does not lock, contact the nearest BMW dealer.
	Roof operation!	Roof movement not completed. Check whether roof movement is blocked. Then press button again.
	Roof control failed!	Roof position and roof locking are not detected. Trip can be continued if roof is locked securely. See Owner's Handbook for information on checking the roof lock.
	Roof not locked!	Roof not locked. First open or close roof completely before continuing trip.
	Luggage compartment partition!	No roof movement possible. Move luggage compartment partition into required position; see Owner's Handbook.
	Roof drive overheated!	Roof drive overheated.
	Roof operation not possible!	Roof operation only possible when vehicle is stationary.
	Vehicle not parked on level ground!	Vehicle not parked on level ground. No roof movement possible.

Sensor Status

	Retractable hardtop open	Intermediate position1	Intermediate position2	Retractable hardtop closed
"Roof package stowed" Hall sensor	● On	O Off	O Off	O Off
LH microswitch, roof panel closed	O Off	O Off	O Off	● On
RH microswitch, roof panel closed	O Off	O Off	O Off	● On
Hall sensor, roof panel packed	● On	● On		O Off
Microswitch, cowl panel locked	● On	O Off	● On	● On
Microswitch, cowl panel unlocked	O Off	● On	O Off	O Off
LH microswitch, rear module closed	● On	O Off	● On	● On
"Rear module open" Hall sensor	O Off	● On	O Off	O Off
RH microswitch, rear module closed	● On	O Off	● On	● On
Microswitch, roof module compartment locked	● On	O Off	O Off	O Off
"Cowl panel reached" microswitch	O Off	O Off	● On	● On
"Luggage compartment divider" Hall sensor	● On	● On	● On	● On

Convenient Loading Function of Rear Lid
The retractable hardtop can be opened and closed using the ID transmitter on vehicles equipped with the Comfort Access option.

The new auto-remote function for loading and unloading provides fast access to the luggage compartment when the retractable hardtop is down. This function makes it easier to load larger items of luggage for instance. The auto-remote function is activated as follows:

- Briefly press the rear lid button on the remote control
- Then, press and hold the rear lid button on the remote control (no more than one second may pass between releasing and pressing the rear lid button).

Initially, the rear module is unlocked and fully opened. The roof package is swivelled out of the luggage compartment. The rear module is then closed and locked. The rear lid is unlocked by the automatic soft close system. The boot lid opens a little. The auto-remote functions via the remote control conform to national market specifications.

Emergency Opening of Rear Lid
As there is no lock cylinder and Bowden cable assembly, the rear lid cannot be released in the event of the rear lid lock being defective. At the same time, movement of the retractable hardtop is inhibited by the unknown status of the rear lid.

The lid can be opened if the Bowden cable (emergency glow in the dark) handle can be reached from the through load compartment.

The rear lid can also be forced to open by using the diagnostic tester. The rear lid activation via the JBE component activation function. This activation request ignores all status that would typically inhibit rear lid operation such as top position.

Emergency Actuation of the Retractable Hardtop
An emergency actuation facility for releasing the retractable hardtop by the customer is not possible. Emergency actuation is, however, possible in the service workshop. The emergency actuation procedure is described in detail in the repair instructions.

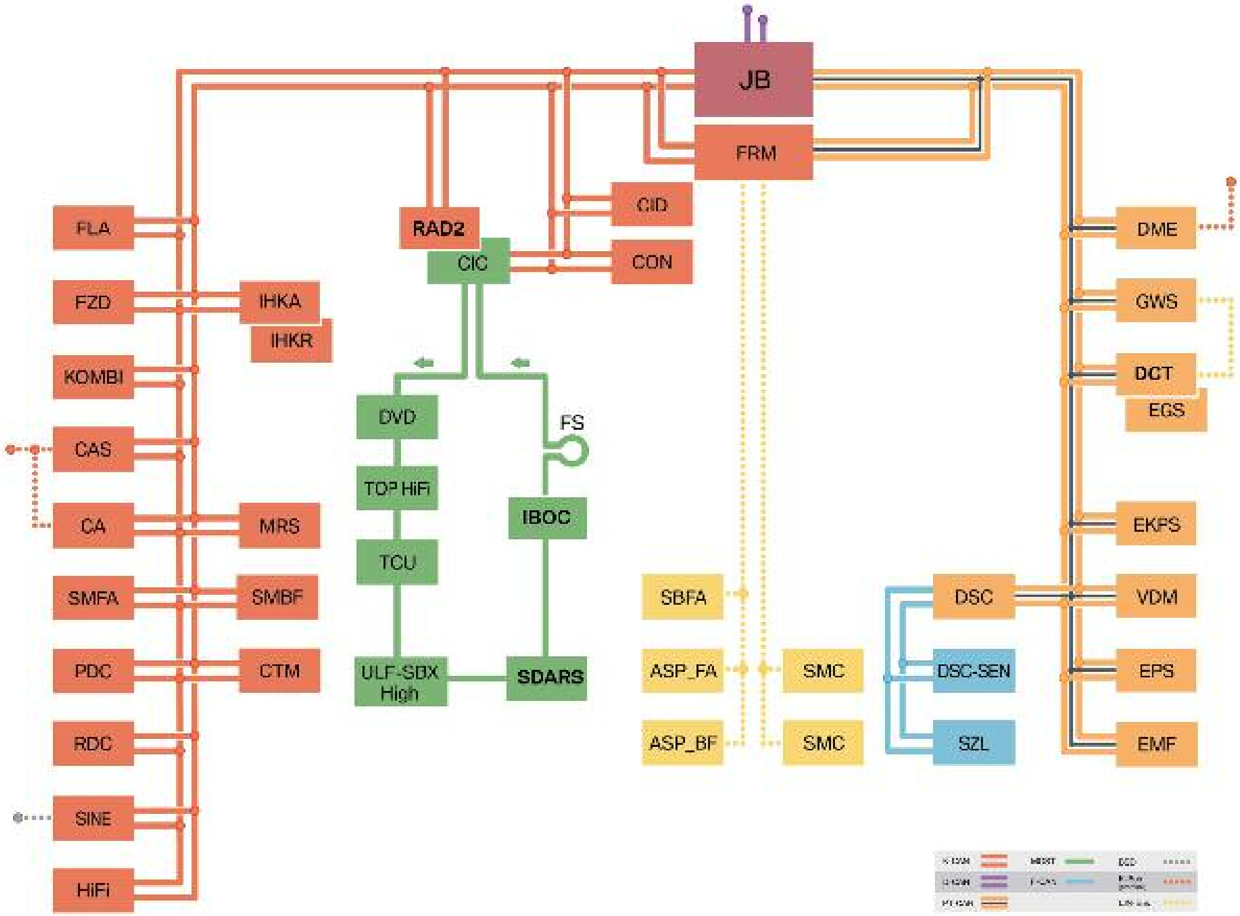
Electrical System

The electrical system of the E89 - Z4 Roadster is based on the BMW 1 Series and 3 Series. The electrical system therefore includes the junction box electronics, footwell module and the roof functions module with the known functions.

The E89 has no fog lights. The following points are new features or changes on the E89:

- Steering wheel heating
- MOST direct access port
- Overview of head units
- Antenna systems

E89 Bus Diagram



Index	Explanation	Index	Explanation
ASP	Exterior mirrors	IBOC	Digital tuner US (only installed without CIC)
CA	Comfort access	IHKA	Automatic climate control
CAS	Car access system	IHKR	Integrated heating/air conditioning control
CIC	Car information computer	JB	Junction box
CID	Central information display	KOMBI	Instrument cluster
CTM	Convertible top module	MRS	Multiple restraint system
CON	Controller	PDC	Park distance control
DCT	Double clutch transmission/gearbox	RAD2	Radio BMW Professional
DME	Digital motor electronics	RDC	Tire pressure monitor
DSC	Dynamic stability control	SBFA	Switch cluster, driver's side
DSC SEN	DSC Sensor	SDARS	Satellite tuner (US)
DVD	DVD changer	SINE	Siren with tilt alarm sensor
EGS	Electronic transmission control	SMFA	Driver's seat module
EKPS	Electronic fuel pump control	SMBF	Passenger's seat module
EMF	Electromechanical parking brake	SMC	Stepper motor controller
EPS	Electromechanical power steering	SZL	Steering column switch cluster
FLA	High beam assist	TCU	Telematics control unit
FRM	Footwell module	TOP HiFi	Top-HiFi amplifier
FZD	Roof functions module	ULF-SBX	Interface box High (USB/audio interface)
GWS	Gear selector	VDM	Vertical dynamics management
HiFi	HiFi amplifier		

MOST Direct Access Port

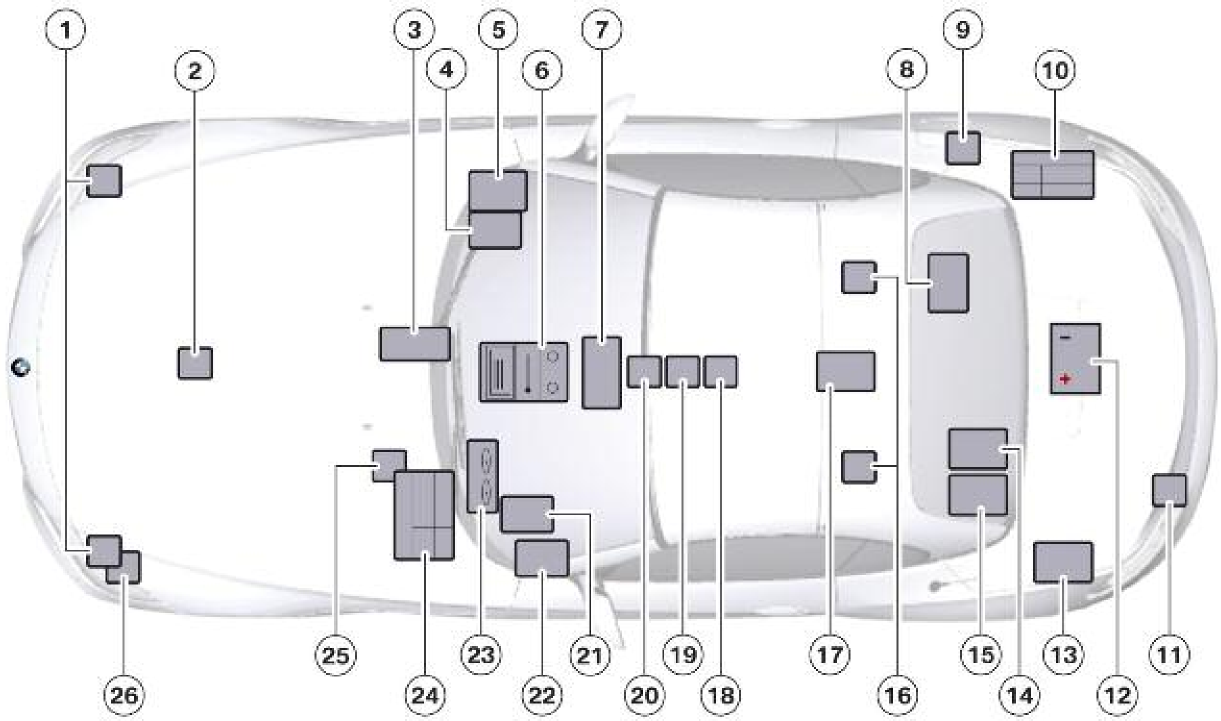
Because the vehicle is based on a 2000BN vehicle and is equipped with a MOST-bus, MOST direct access port is also installed in the E89. The MOST direct access port is located on the left in the footwell.

The two connected plugs must be taken from the common connector (A). The two plugs are then connected together (B). The integrated communication optical module ICOM can now be connected in the usual way to the joined plug.

E89 MOST Bus Connection

Index	Explanation
1	MOST plug connector
2	MOST-bus disconnected and plug connector joined
3	ICOM connected with MOST direct access port

Control Units Location



Index	Explanation	Index	Explanation
1	Adaptive headlight (AHL)	14	Side airbag, front left
2	Electromechanical power steering (EPS)	15	Door satellite, front left (STVL)
3	EGS/DCT Control Unit	16	Belt force limiter, right
4	CD changer (CDC) and DVD changer (MMC)	17	Belt force limiter, left
5	Junction box (JB)	18	B-pillar satellite, left (SBSL)
6	IHKA/IHKR, RAD2/CIC, SZM	19	B-pillar satellite, right (SBSR)
7	FZD and FLA	20	Electric fuel pump
8	Top-HiFi amplifier (TOP HiFi)/HiFi amplifier (HiFi)	21	Telephone (TCU)
9	Electronic fuel pump control (EKPS)	22	Safety battery terminal (BST)
10	CTM, PDC, CA, EMF, RDC	23	Side airbag, rear left
11	Diversity module	24	Vehicle center satellite (SFZ)
12	Battery	25	Side airbag, rear right
13	SDARS	26	Seat occupancy detection, rear left

Audio System

Two head units are available on the E89; BMW Professional RAD2 and car information computer CIC.

The available speaker systems include both the stereo system as well as the HiFi and TOP HiFi system.

All of the same features available to the E90 are also avaliable to the E89 such as SBX High (USB), multimedia changer, SIRIUS satellite radio and IBOC (HD radio).

If a vehicle is ordered with a CIC, the iboc tuner is located inside the CIC. If the vehicle is equipped with a RAD2, the IBOC control unit is mounted in a separate location.

Antenna Locations

The antenna system on the E89 consists of 3 FM, 1 AM, 1 GPS, 2 Telephone and an SDARS antenna. Their locations are illustrated below:

Overview of Antennas

Index	Explanation	Index	Explanation
1	Satellite tuner antenna SDARS antenna	5	Not for U.S.
2	Not for U.S.	6	FM antenna 2
3	FM 3	7	FM antenna 1, AM antenna, telephone antenna 1
4	Telephone antenna 2		

Multiple Restraint System 7

The 7th generation multiple restraint system MRS is a consistent further development of the multiple restraint systems fitted in BMW vehicles.

The multiple restraint system detects an accident situation that is critical for the occupants and activates the necessary restraint systems. The restraint system is activated selectively depending on the severity and type of accident.

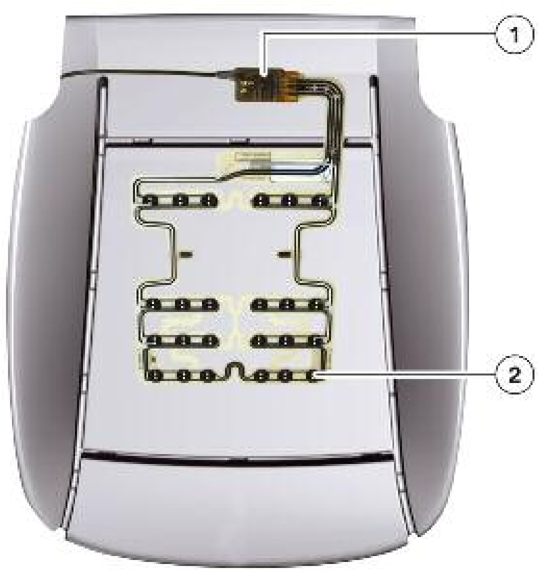
Passenger Seat Occupancy Detection

The new passenger seat occupancy detection system introduced on the E89 consists of a seat occupancy pad with integrated capacitor plate. The previous generation occupancy (OC3) detection was realized via the use of pressure sensors attached to the seat cushion.

In the new capacitive sensing passenger occupancy detection system, an electrical field is generated across the capacitor plate and vehicle ground. The seat occupancy mat is connected to an electronic evaluator. The occupancy status is classified based on the evaluation of the electrical field.

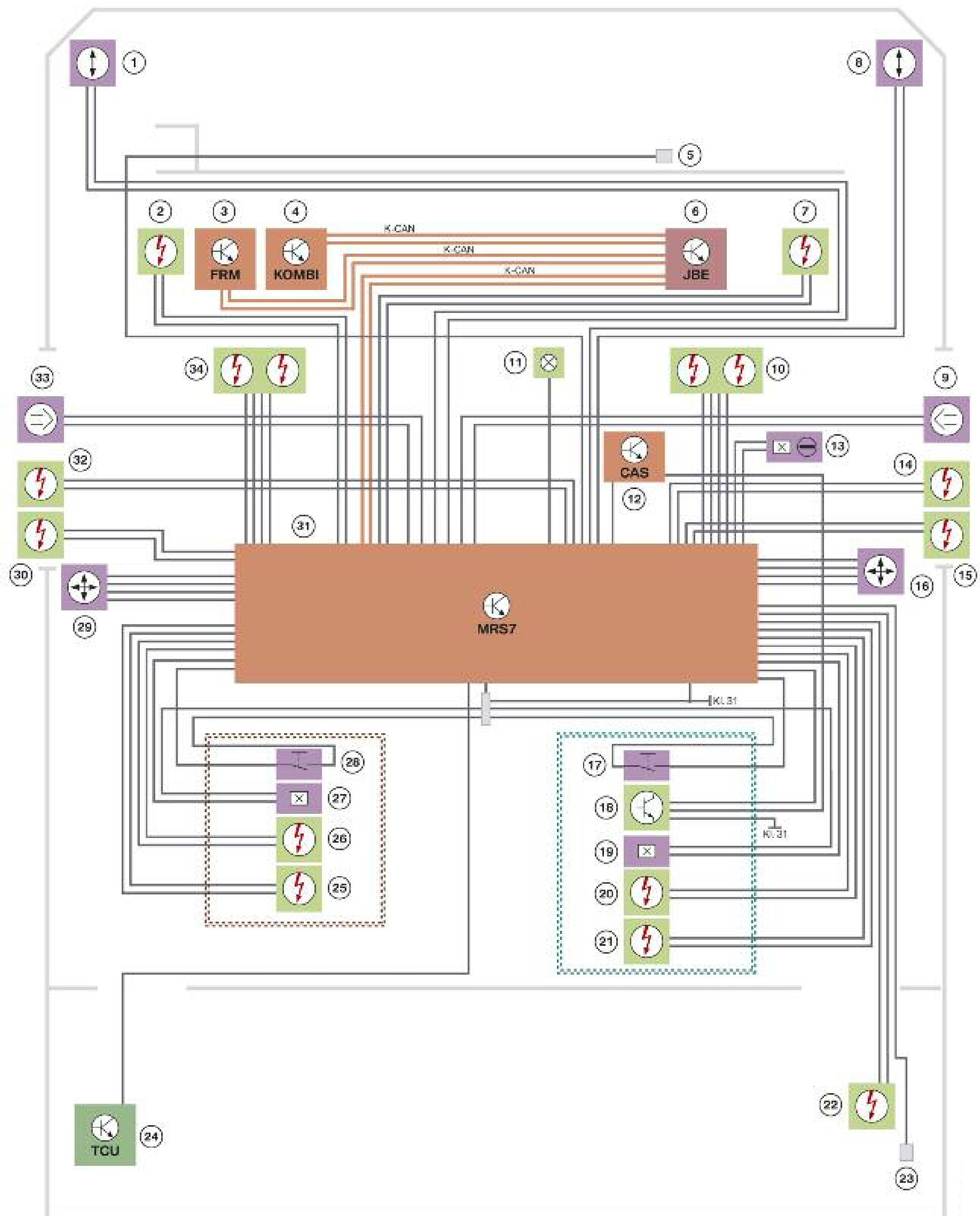
A person sitting down on the seat changes the electrical field. The change is registered by the electronic evaluator and the corresponding status is determined. The electronic evaluator sends the status information cyclically to the MRS control unit. Data exchange takes place by means of a hardware link. The seat occupancy detection function monitors the inputs and outputs. Possible fault statuses are stored in the fault code memory of the MRS control unit.

Capacitive Seat Occupancy Sensor



Index	Explanation
1	Electronic Evaluator
2	Seat Occupancy Pad

MRS 7 Circuit Schematic



Index	Explanation	Index	Explanation
1	Airbag front sensor, left	18	Seat occupancy pad, front passenger
2	Driver's knee airbag	19	Seat belt buckle contact, front passenger
3	Footwell module (FRM)	20	Side airbag, front passenger
4	Instrument cluster (KOMBI)	21	Seat belt pretensioner, front passenger
5	Plug connection, battery monitoring line, front	22	Safety battery terminal
6	Junction box electronics (JBE)	23	Plug connection, battery monitoring line, rear
7	Knee airbag, front passenger	24	Telematics control unit (TCU)
8	Airbag front sensor, right	25	Seat belt pretensioner, driver
9	Airbag sensor, front right door	26	Side airbag, driver
10	Front airbag, passenger's side	27	Seat belt buckle contact, driver
11	Indicator lamp for front passenger airbag deactivation	28	Seat occupancy switch, driver
12	Car access system (CAS)	29	Seat occupancy pad, driver
13	Switch for front passenger airbag deactivation	30	Retractor tensioner, driver
14	Seat belt force limiter, front passenger	31	MRS control unit
15	Retractor tensioner, front passenger	32	Seat belt force limiter, driver
16	Airbag sensor, front left door	33	Airbag sensor, driver's door
17	Seat occupancy switch, front passenger	34	Steering wheel airbag

E89 Chassis and Suspension

The handling and agility of the E89 are outstanding in this vehicle class. This is achieved by the rear wheel drive, an optimum steering response and outstanding traction in all load situations. It has been possible to optimally match the front axle kinematics and steering as no allowances had to be made for drive influences. An axle load distribution between 50:50 and 44:56 has been achieved in all load situations.

Index	Explanation
1	New components (newly developed)
2	Modified components (developed with minimum expenditure)
3	Common parts E87 and E90

Double-joint Spring Strut Front Axle

A modified version of the double-joint spring strut front axle known from the E8x and E9x series vehicles is used in the E89. Adaptations were necessary due to the available space and the modified suspension geometry.

The graphic uses colors to show an overview of the common parts, modified components and new components in the E89 compared to the E85 and compared to the E9x and E8x models for the front axle.

Some components have been fully adopted, others have been adapted and optimized to the changed conditions while other components are a complete new development. In the same way as the E8x and E9x models, the E89 is based on the well-known principle of the double--joint spring strut front axle. The well-proven principle of the central link rear axle from the E85 is retained for the rear axle.

Dynamic Driving Systems

Differentiation

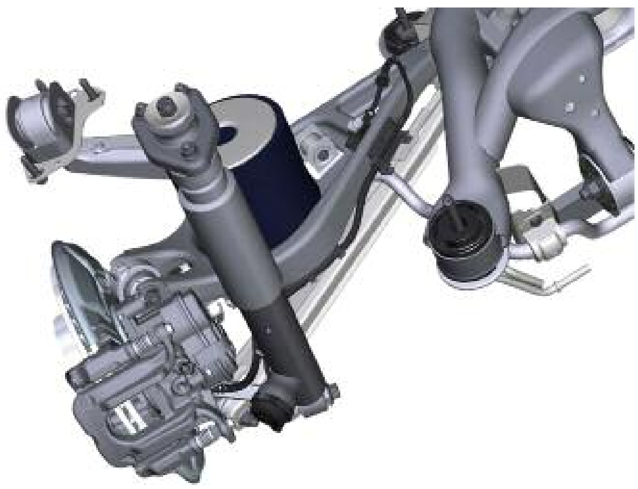
The dynamic driving systems are differentiated in three directions of action and are assigned to the individual dynamic systems corresponding to their main direction of action:

- Longitudinal dynamics systems
  – Dynamic stability control (DSC)
  – Electromechanical parking brake (EMF)
- Transverse dynamics systems
  – Electromechanical power steering (electronic power steering EPS)
- Vertical dynamics systems
  – Adaptive M chassis and suspension

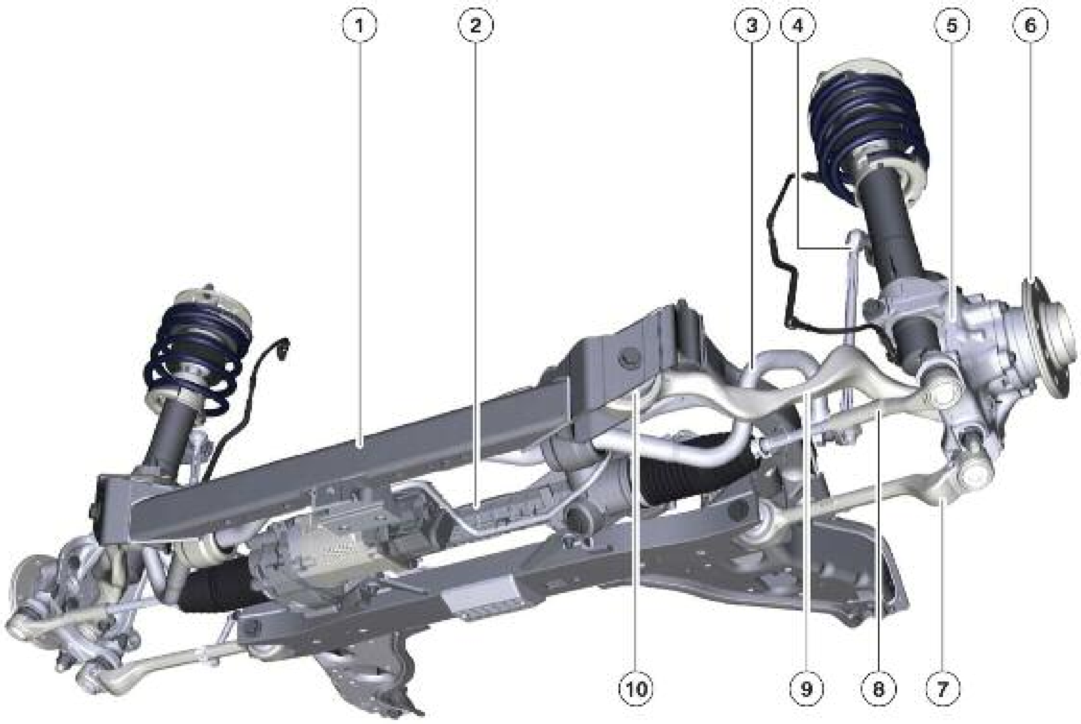
Changes and New Features

The parking brake on the E89 is designed as an electromechanical parking brake EMF. The EMF on the E89 differs from the known EMF systems in that it is integrated in the brake calliper. Competitors are already using this system in series production.

E89 Brake calliper with EMF actuator



E89 Front Axle



Index	Explanation
1	Front axle carrier
2	Electromechanical power steering
3	Stabilizer bar
4	Stabilizer link
5	Spindle
6	Wheel hub
7	Control arm
8	Tie rod
9	Tension strut
10	Hydraulic mount/Bushing

The E85 was equipped with a single-joint spring strut front axle. To optimize the suspension properties, the E89 is equipped with a double-joint spring strut front axle. The reasons are explained in the following.

Kingpin Offset

The kingpin offset (scrub radius) of the E89 is greater compared to that of the E85. The reason for this is that the front axle has been adopted from production line 2 (1 Series and 3 Series).

On the single-joint spring strut front axle of the E85 the position of the wheel control joint largely determines the size of the kingpin offset. Since the kingpin offset should be as small as possible, the wheel control joint must be located as far towards the outside as possible. This however results in problems concerning the package space for the brake disc and brake calliper. On the double-joint spring strut front axle the position of the control arm and tension strut with respect to each other determines the size of the kingpin offset.

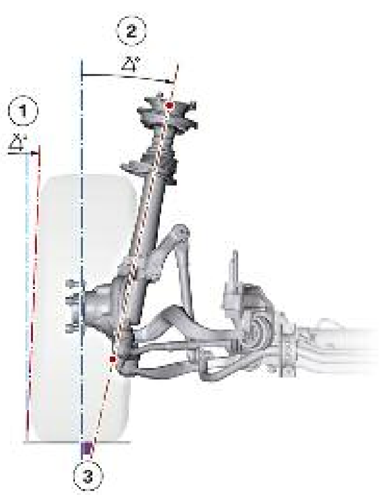
Determining the lower pivot point

The pivot points of the control arm or wishbone and tension strut at the swivel bearing can therefore be selected such that no space problems are encountered for the brake system.

While these aspects still retain their validity, a larger kingpin offset than on the single-joint spring strut front axle is now used. The reason for this is that common parts from production line 2 are used as far as possible but the track width has increased compared to the 1 Series and 3 Series. Among other measures, this was achieved by changing the rim offset, thus, of course, also increasing the kingpin offset.

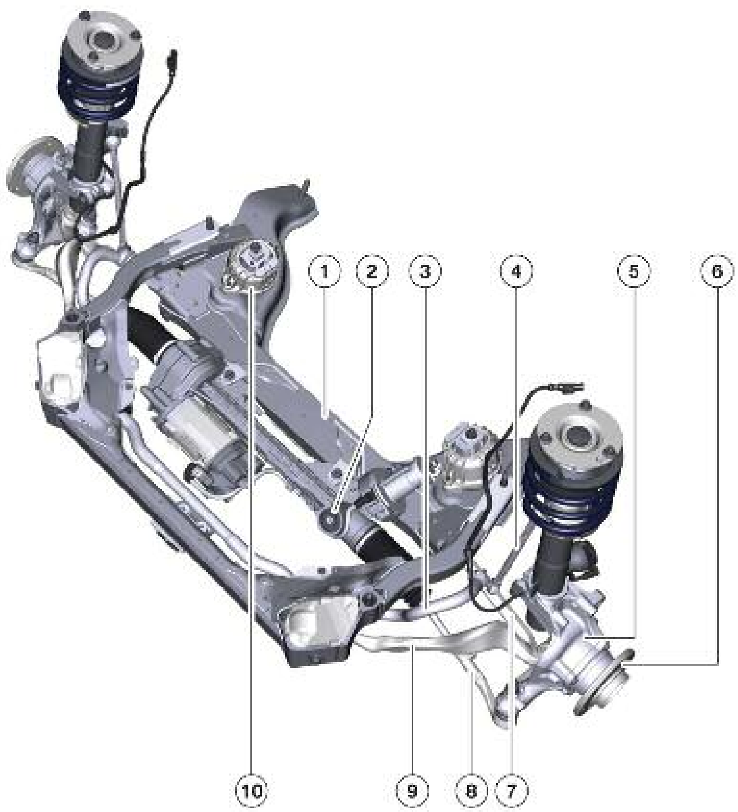
The effects of increased susceptibility to interference caused by a larger kingpin offset were eliminated by an optimized and modified elastokinematics system and tuned to such an extent that an improvement was achieved compared to the E85. As a result, the response of the E89 to steering movements is slightly more indirect at high speeds and very direct at speeds up to 100 km/h. The vehicle handling is very balanced up to the limit range and therefore has outstanding control properties.

Positive Kingpin Offset



Index	Explanation
1	Camber
2	Kingpin inclination
3	Kingpin offset

E89 Front Axle



Index	Explanation
1	Front axle carrier
2	Electromechanical power steering
3	Stabilizer bar
4	Stabilizer link
5	Swivel bearing
6	Wheel hub
7	Control arm
8	Track rod
9	Tension strut
10	Engine mount

Both tension struts are mounted with hydraulic bushings on the front axle carrier. In addition, the distance of the tension strut and control arm pivot points at the swivel bearing largely determines the vertical force lever arm. The further the joints of the tension strut and control arm are from each other at the swivel bearing, the greater the recovery force initiated by the vehicle weight.

On the single-joint spring strut front axle, the distance is zero as the two joints of this axle have merged to form one. The resulting advantage of the double-joint spring strut front axle is improved directional stability in the high speed range and a lower tendency to steering instability in the lower speed range (less susceptible to torsional vibration in the steering wheel).

Compared to that of the control arm, the ball joint (guide joint) of the tension strut is raised at the swivel bearing, thus providing effective anti-dive control. A further advantage of this arrangement is that this tension strut mount on the axle carrier can be arranged at approximately the same level with respect to the mounting at the swivel bearing and does not have to be lowered. This is of particular benefit to a large overhang angle. In addition, it is possible to lower the control arm mount on the axle carrier side, thus enabling a lower roll center.

The single-joint axle features only one type of cross brace as the axle carrier. The double-joint spring strut front axle on the other hand features a frame which additionally provides significant stiffening of the front end.

Technical data

Description	E85	E89
Total toe-in	14.4’	14.0’
Track width	1473.3 mm	1511.1 mm
Camber	-34.8’	-23.3’
Kingpin inclination	15.7	14.3
Castor angle	5.9	7.2
Castor offset	17.7 mm	20.7 mm
Kingpin offset	4.7 mm	9.6 mm
Steering angle, inner	43.1	37.7
Steering angle, outer	35.3	31.2
Rim offset ET/IS	47 mm	29 mm
Tire size	225/50 R16 225/45 R17 225/40 R18	225/45 R17 225/40 R18 225/35 R19

Central-link Rear Axle

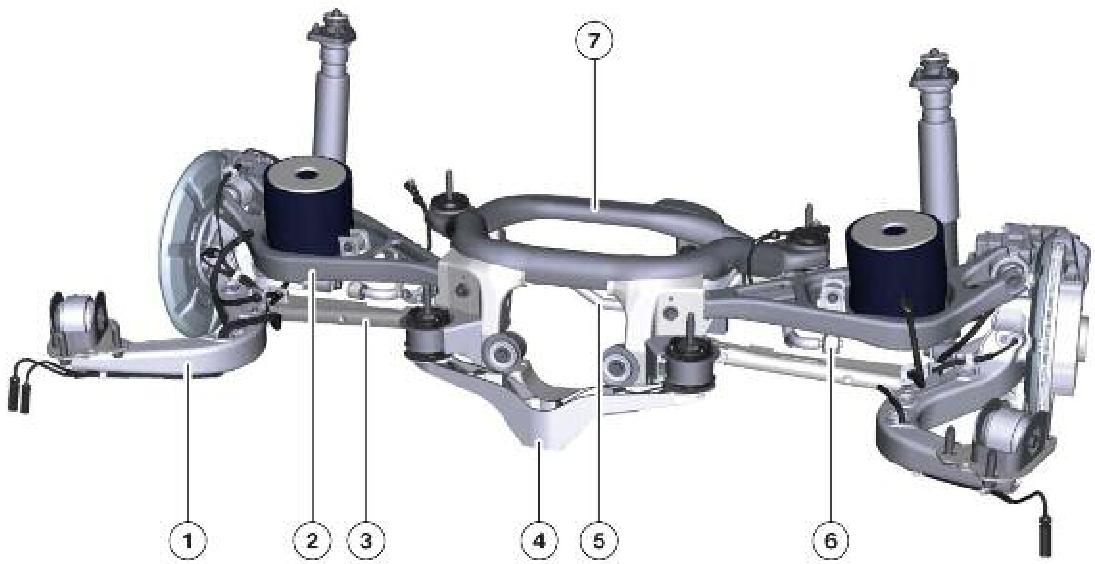
An adapted version of the rear axle known from the E85 with the development designation HA 3 is fitted in the E89.

The central link rear axle is an intricately constructed, weight and space saving, multi-link rear axle. The wheels are controlled by two control arms and one semi-trailing arm that is mounted at the central point on the body. The precise interaction between the semi-trailing arm and control arm ensures that the wheels remain in the best possible position with respect to the road surface, thus providing outstanding directional stability. The flexible link bearings ensure exceptional driving stability while cornering, providing the vehicle with excellent rolling and acoustic comfort.

The designation HA 3 does not refer to the three links but rather is a continuation of the development designation at BMW. The central link rear axle optimizes the following properties:

- Directional stability
- Alternating load response
- Self-steering response
- Lane change stability
- Transition response from cornering to straight ahead
- Rolling comfort.

E89 Central Link Rear Axle



Index	Explanation
1	Semi-trailing arm
2	Transverse control arm, top
3	Transverse control arm, bottom
4	Thrust strut
5	Stabilizer bar
6	Stabilizer link
7	Rear axle carrier

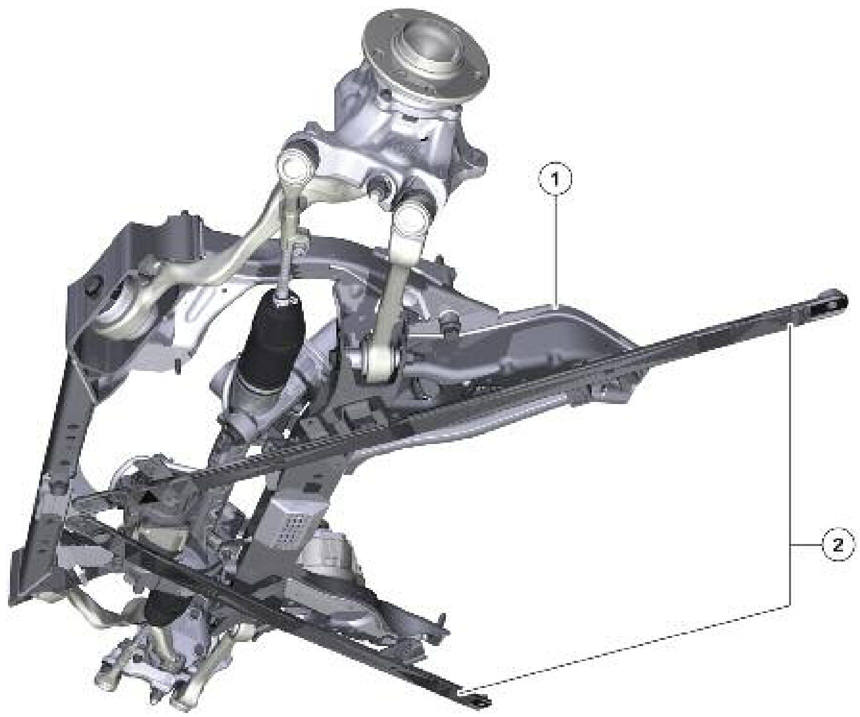
Technical Data

Description	E85	E89
Total toe-in (angle)	22’	18’
Track width	1521 mm	1562 mm
Camber	-2 15’	-2 20’
Wheelbase	2495 mm	2496 mm
Rim offset ET/IS	47 mm (50 mm*)	29 mm (40 mm*)
Tire size	225/50 R16 225/45 R17 255/40 R17* 255/35 R18*	225/45 R17 255/40 R17* 255/35 R18* 255/30 R19*
*Mixed tires		

Suspension Reinforcement Devices

Support brackets are fitted on the front axle and rear axle as well as a thrust panel additionally on the rear axle to increase the body rigidity and to optimize the transfer of forces into the body. These components distribute the force input into the body over the largest possible area.

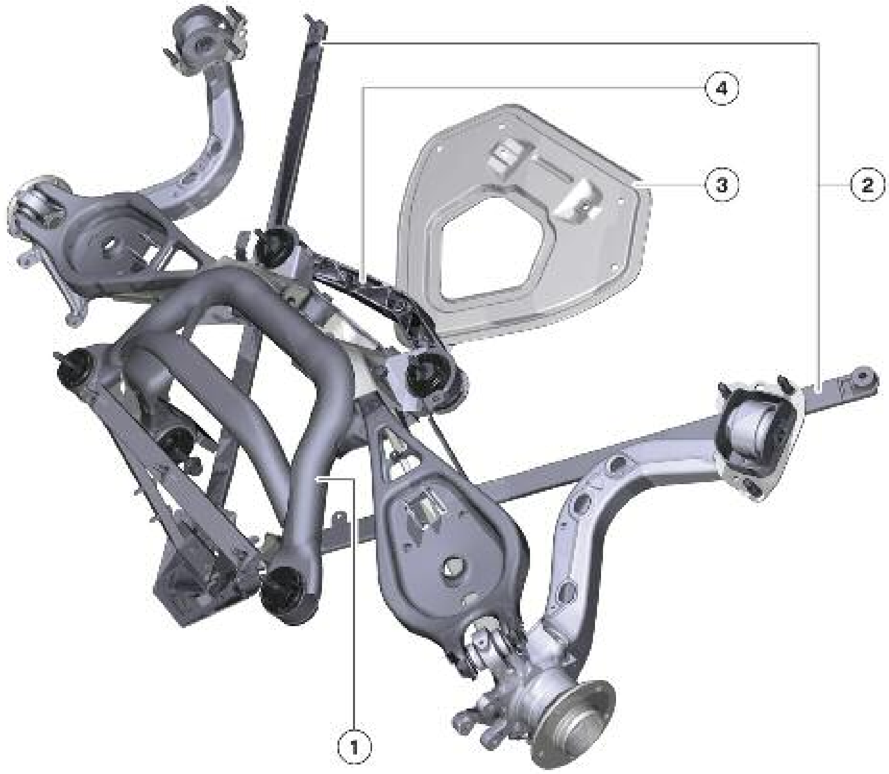
Front Axle



E89 Front axle carrier with struts

Index	Explanation
1	Front axle carrier
2	Support brackets

Rear Axle



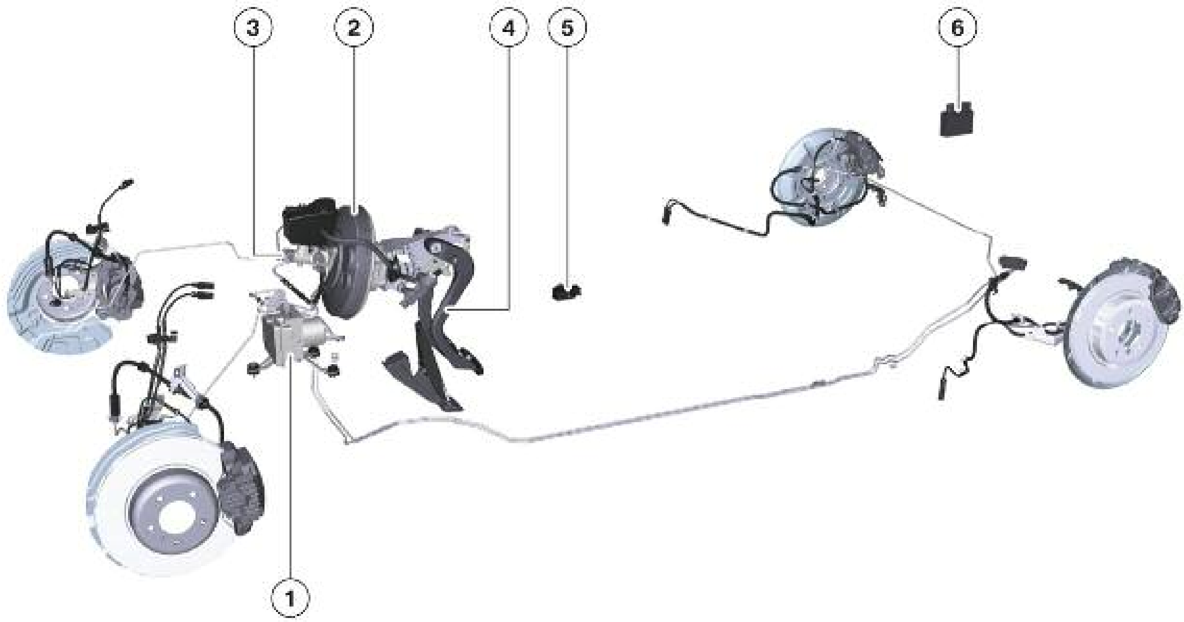
E89 Rear axle carrier with tension struts and thrust panel

Index	Explanation
1	Rear axle carrier
2	Tension support brackets (struts)
3	Thrust panel
4	Thrust strut

Brakes

The function and weight of the service brake have been improved. Aluminum floating calliper brakes and aluminum frame calliper brakes are fitted on the front axle. Lightweight brake discs are used on the front axle of both top models. Outstanding stability was achieved by the corresponding dimensioning. The brake pad control principle as well as the brake callipers and brake discs secure the long-term properties in terms of surface protection, corrosion protection and unsusceptibility to soiling.

E89 Service brake



Index	Explanation
1	DSC unit
2	Brake booster
3	Master brake cylinder
4	Brake pedal
5	DSC sensor
6	EMF control unit

Technical Data

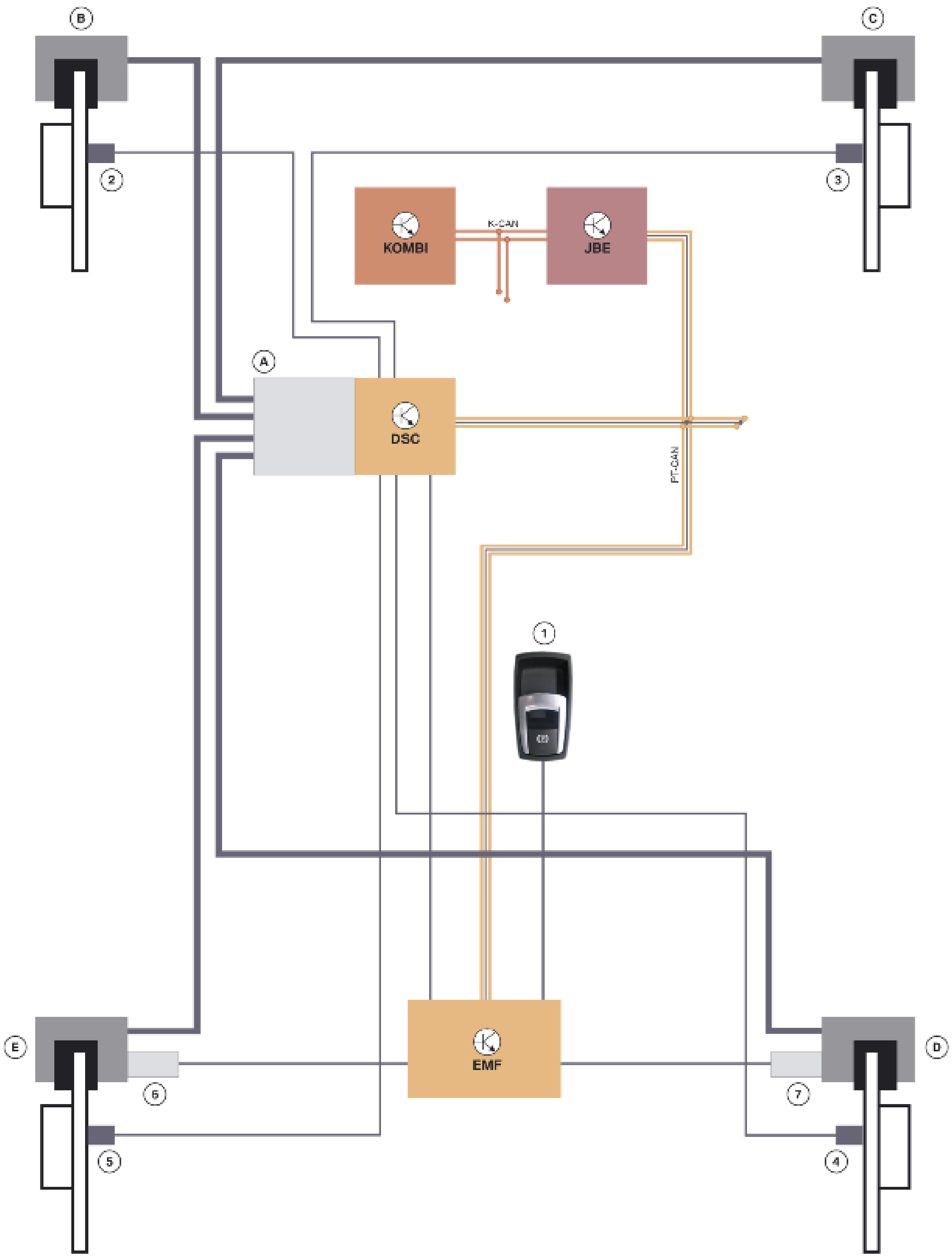
Model	Type	Front brake disc in mm x thickness in mm	Rear brake disc in mm x thickness in mm
E85	Z4 2.5i Z4 3.0si	286 x 22* 325 x 25*	280 x 10 294 x 19*
E89	Z4 sDrive30i Z4 sDrive35i	330 x 24* 348 x 30*	300 x 20* 324 x 20*
*Internally ventilated brake disc			

Parking Brake

For the first time at BMW, the E89 is equipped with an electromechanical parking brake integrated in the brake calliper. The use of the electromechanical parking brake offers the following advantages:

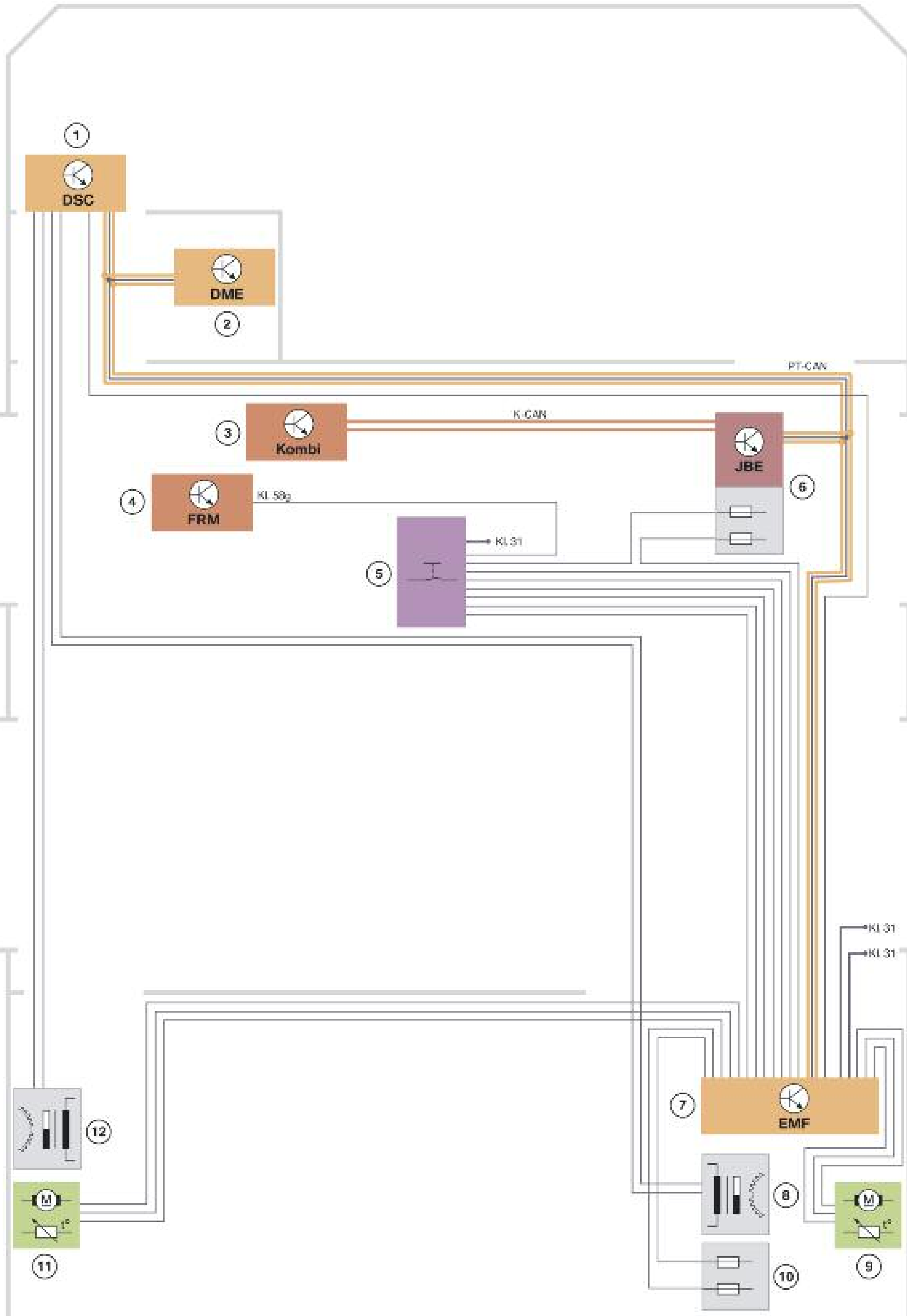
- Operation by means of a button ergonomically positioned in the center console
- Reliable application and release of the electromechanical parking brake (EMF) under all conditions
- Dynamic emergency braking function also at low friction ensured by the control systems (ABS)
- No parking brake lever means additional storage space in the area of the center console.

System Overview - Electromechanical Parking Brake (EMF)



Index	Explanation
A	DSC unit
B	Brake calliper, front left
C	Brake calliper, front right
D	Brake calliper, rear right
E	Brake calliper, rear left
1	EMF button
2	Wheel speed sensor, front left (not used for EMF)
3	Wheel speed sensor, front right (not used for EMF)
4	Wheel speed sensor, rear right
5	Wheel speed sensor, rear left
6	EMF actuator, rear left
7	EMF actuator, rear right
EMF	Electromechanical parking brake
DSC	Dynamic stability control
JBE	Junction box electronics
KOMBI	Instrument cluster
PT-CAN	Powertrain-Controller Area Network

System Circuit Diagram - Electromechanical Parking Brake (EMF)

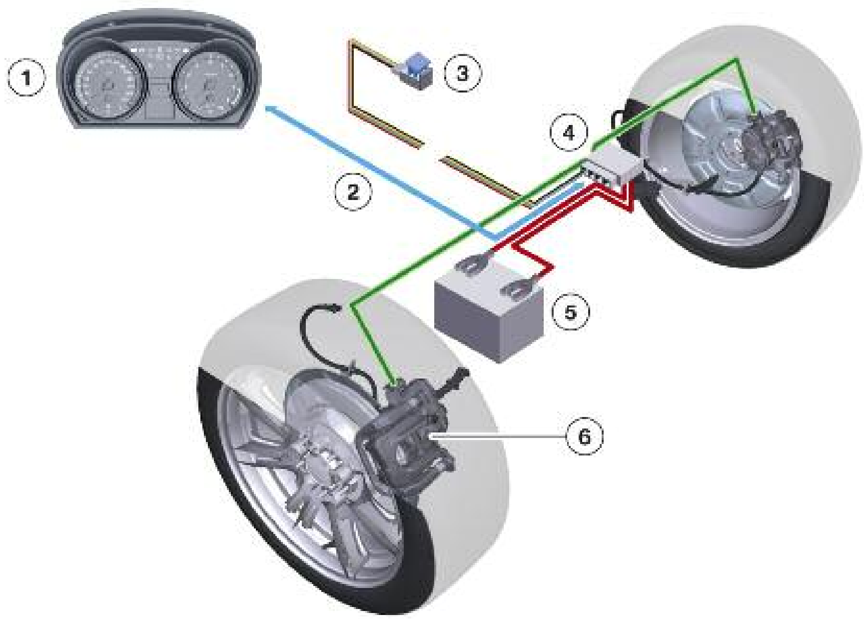


Index	Explanation
1	DSC (Dynamic stability control)
2	DME (Digital motor electronics)
3	KOMBI (Instrument cluster)
4	FRM (Footwell module)
5	EMF button
6	JBE (Junction box electronics)
7	EMF (Electromechanical parking brake)
8	Wheel speed sensor, rear right
9	EMF actuator, rear right
10	Fuses
11	EMF actuator, rear left
12	Wheel speed sensor, rear left

Principles of Operation

The EMF control unit receives the driver's choice to apply the parking brake from the EMF button on the center console. The vehicle status is determined via the link to the electrical system and the bus systems and the control unit decides whether all conditions for applying the brake are met. If this is the case, the two EMF actuators on the rear brake callipers are actuated.

E89 EMF System Overview



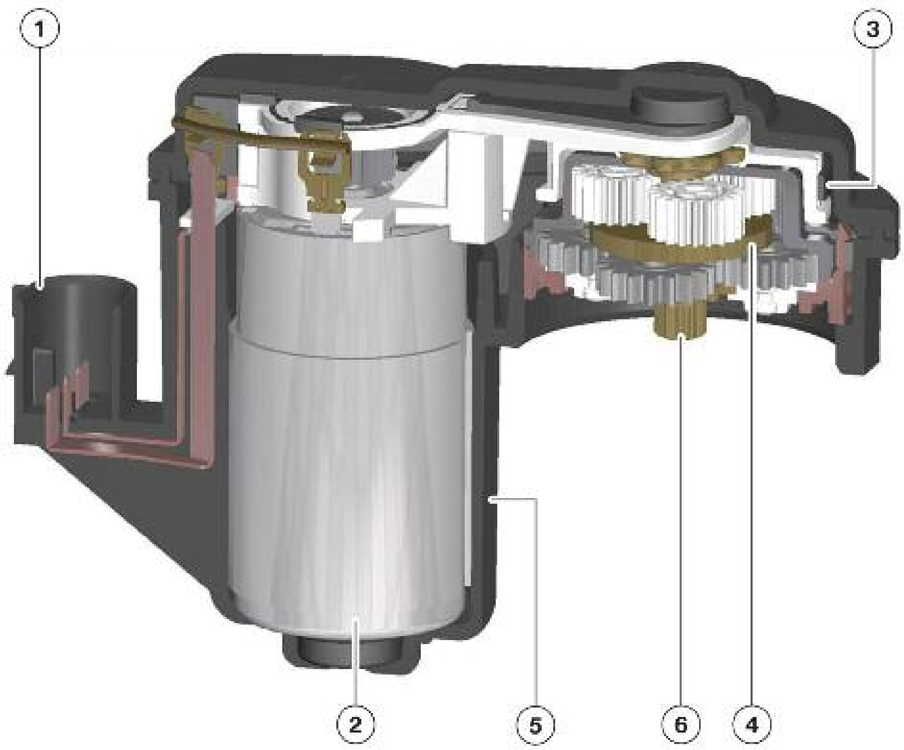
Index	Explanation
1	Instrument cluster
2	Information flow
3	EMF button
4	EMF control unit
5	Battery
6	EMF actuator

Due to the self-locking characteristics of the spindle, the tension is retained even when no power is applied, thus firmly holding the vehicle. On reaching the required force, the applied brake status is indicated by a red indicator lamp in the instrument cluster and an additional red LED in the EMF button.

Function of the EMF Actuator

The EMF actuator is mounted on the brake calliper and pushes directly on the back of the “normally” hydraulically operated brake piston.

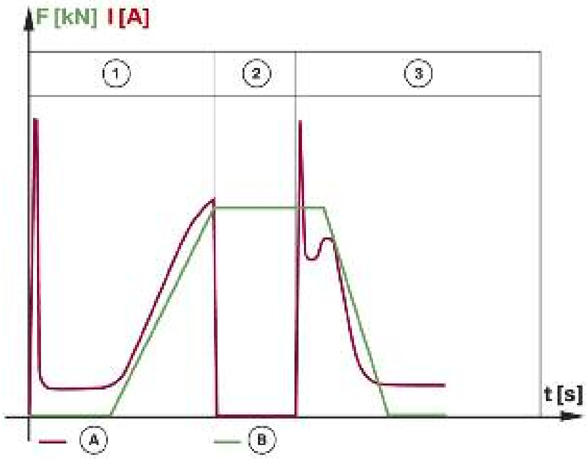
Design of EMF actuator



Index	Explanation
1	Plug connection
2	Electric motor
3	Drive belt
4	Planetary gear
5	Housing
6	Connection to spindle

The force is transmitted via electric motor (2) and drive belt (3) to a two-stage planetary gear train (4). Spindle (4) shown in the following graphic is driven by spindle connection (6). Spindle (4) in the spindle nut with anti-twist lock (2) in brake piston (3) provides the self-locking effect. The force is transmitted via the spindle and spindle nut with anti-twist lock to brake piston (3). As in hydraulically operated systems, the brake piston acts on the brake pads that are forced against the brake disc. Due to the self-locking effect of the spindle in the spindle nut with anti-twist lock, the tension is retained and the vehicle is held firmly even when no power is applied.

E89 EMF voltage and force curve

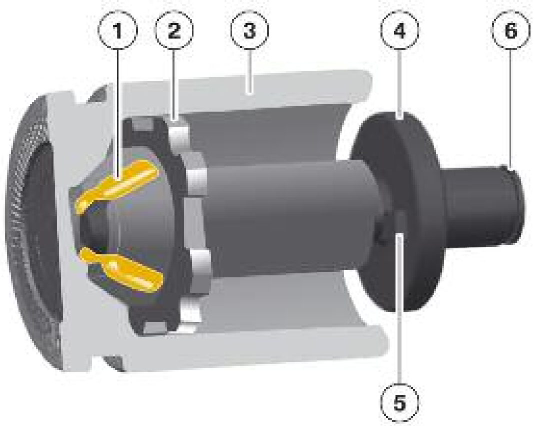


Index	Explanation
A	Force curve
B	Voltage curve
1	Applying EMF
2	EMF applied
3	Releasing EMF

Brake Piston

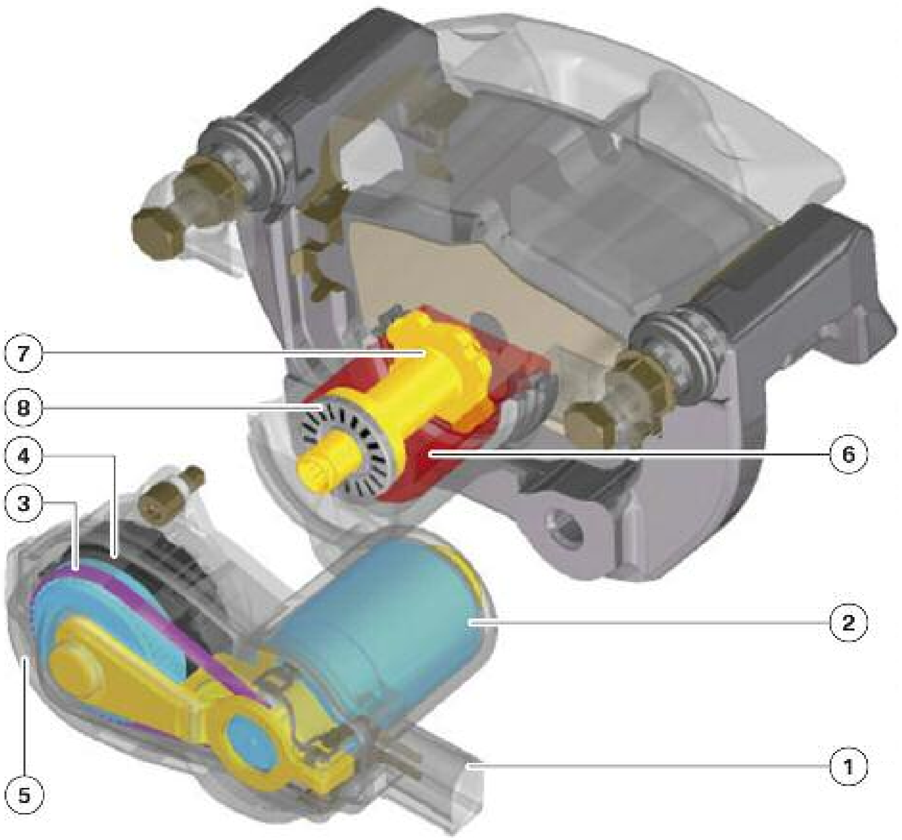
The brake fluid can flow via grooves (1) past the spindle nut to ensure the brake system is completely bled. The screw-in travel is limited by spindle stop (5). This therefore prevents tightening and blocking when in open state.

E89 Spindle and spindle nut in brake piston



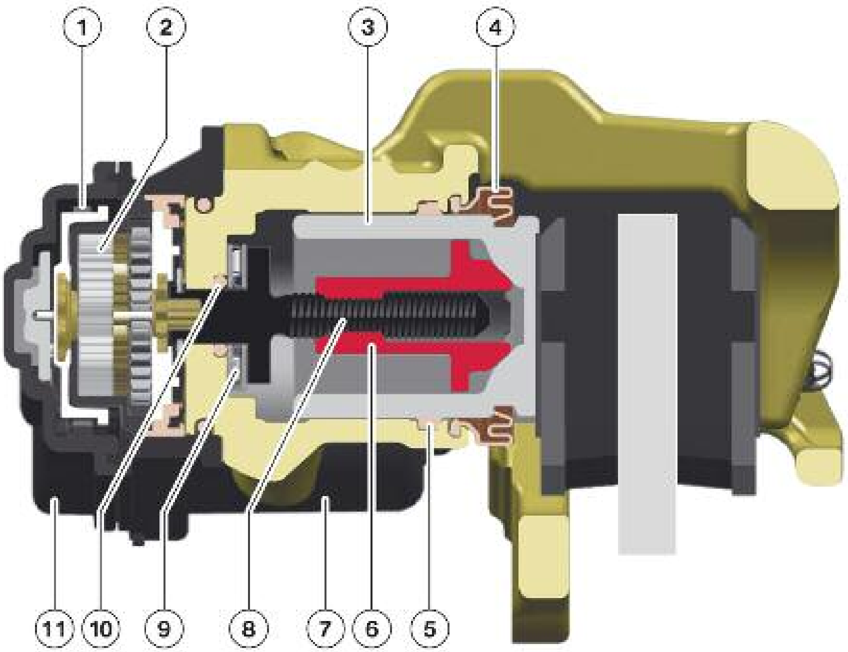
Index	Explanation
1	Groove
2	Spindle nut with anti-twist lock
3	Brake piston
4	Spindle
5	Spindle stop
6	Connection to planetary gear

Overview of EMF actuator with brake calliper



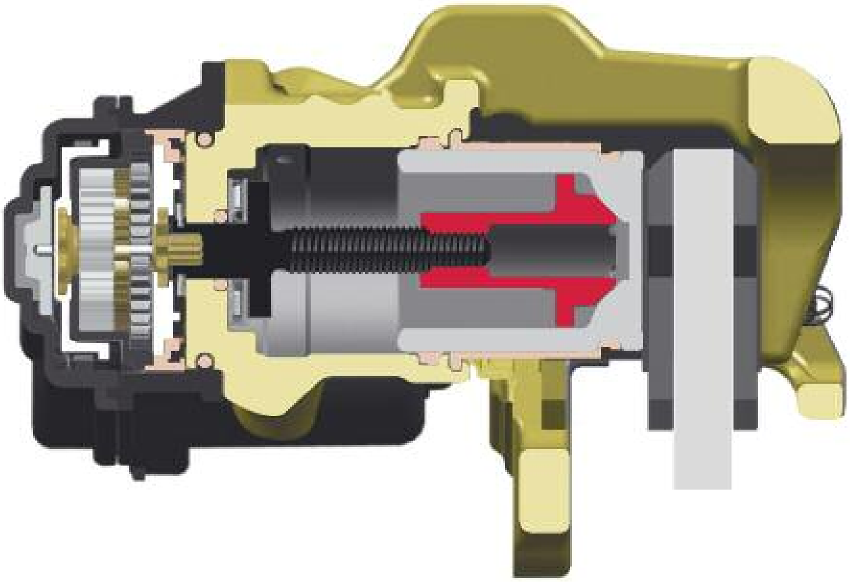
Index	Explanation
1	Plug connection
2	Electric motor
3	Drive belt
4	Planetary gear
5	Housing
6	Brake piston
7	Spindle with spindle nut
8	Roller bearing

E89 Parking brake applied with new brake pads

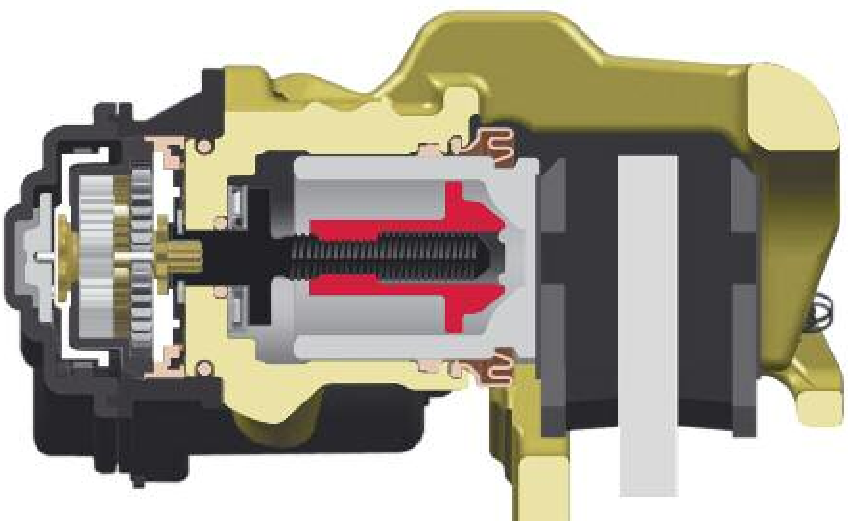


Index	Explanation
1	Drive belt
2	Planetary gear
3	Brake piston
4	Dust sleeve
5	Seal
6	Spindle nut
7	Electric motor
8	Spindle
9	Roller bearing
10	Seal
11	Housing

E89 Parking brake applied with worn brake pads



E89 Parking brake released with new brake pads



Applying the Parking Brake

The driver can apply the parking brake by pulling the EMF button. The operating direction is the same as that of the mechanical handbrake lever.

The signal from the EMF button is read by the EMF control unit. The EMF control unit individually activates the EMF actuators at the wheel brake.

The parking brake can be applied in any logical terminal status. Applying the parking brake at terminal 0 is made possible by connecting terminal 30 to the EMF control unit. The EMF control unit is woken up when the driver operates the EMF button at terminal 0. In turn, the EMF control unit wakes the other control units in the vehicle. Only then does the EMF control unit receive the important information on the stationary status of the vehicle. In addition, the change status of the parking brake can be indicated after waking the control unit.

The parking brake applied status is indicated by a red LED in the EMF button and by the EMF indicator lamp in the instrument cluster. If the parking brake is already applied, pulling the EMF button again will have no effect.

E89 Indicator lamp, parking brake applied

Rolling Monitor with Parking Brake Applied

This monitoring function is designed to prevent the vehicle from rolling with the parking brake applied. The rolling monitor is always activated when the status of the parking brake changes from released to applied and ends after a defined period of time after this status change.

The function ends:

- when a fault occurs that prevents mechanical retensioning
- when the vehicle assumes sleep mode, the control unit is switched off or reset.

The DSC uses a signal as the input variable for rolling detection. The tension at the EMF actuators is immediately increased as soon as this signal indicates that the vehicle is starting to roll during rolling monitoring. During the retensioning phase, the tensioning force is increased until the vehicle no longer rolls or a maximum tensioning force is reached.

Temperature Monitoring

The task of the temperature monitoring function is to compensate for the loss of force that occurs when the hot brake disc cools down. Temperature monitoring is activated when the temperature exceeds a defined value as the status of the parking brake changes from released to applied.

The DSC control unit calculates the brake disc temperature at the individual wheels and sends the corresponding value to the EMF control unit. During the status change, the higher temperature of the two brake discs is taken for the temperature monitoring function. A characteristic map contains the corresponding temperature ranges with the associated retensioning times.

The corresponding retensioning times in the characteristic map are activated depending on the temperature during the status change. The tension is increased once when the first retensioning time is reached. The tension is then increased again after the second retensioning time has elapsed and increased yet again after the third. The characteristic map may also contain the value 0 for one or several retensioning times. In these cases, the corresponding increase in tension does not take place. The function ends under following conditions:

- Occurrence of a fault that prevents retensioning
- The control unit is switched off or reset
- The last retensioning step has already been executed.

Releasing the Parking Brake

The EMF button is pushed down to release the parking brake. For the parking brake to actually release terminal 15 must additionally be on and at least one of the following conditions must apply:

- Brake pedal pressed or
- Parking lock of automatic gearbox engaged or clutch pedal pressed (only vehicle with manual gearbox).

This prevents the vehicle from inadvertently rolling if, for example, the EMF button is pressed by another occupant instead of the driver. The LED in the EMF button and the EMF indicator in the instrument cluster go out when the parking brake is released.

Activation of the EMF actuator causes the spindle to rotate. The rotation of the spindle causes the spindle nut to move a short defined distance from the brake piston.

Dynamic Emergency Braking

Two operating units for the brake are required by law. Besides the brake pedal, the second operating unit in the E89 is the EMF button in the center console. Pulling the EMF button while driving triggers dynamic emergency braking with a defined sequence via the DSC system. This function is intended for emergencies when the driver can no longer slow down the vehicle using the brake pedal. Other occupants can also stop the vehicle in this way should, for example, the driver suddenly become unconscious.

During dynamic emergency braking, hydraulic braking pressure is built up at all four wheel brakes. The DSC functions are fully active and the brake lights come on. This is an important advantage compared to a manual parking brake.

Dynamic emergency braking takes place only for as long as the driver is pulling the EMF button. The deceleration initiated by the DSC is increased in ramps. The EMF indicator lamp in the instrument cluster is activated during dynamic emergency braking. In addition, a check control message is given together with an acoustic signal in order to warn the driver of this adverse situation.

The DSC control unit prioritizes if the driver attempts to slow down the vehicle by simultaneously pressing the brake pedal and pulling the EMF button. The higher deceleration request is implemented. If dynamic emergency braking is continued until the vehicle comes to a stop, the parking brake will remain applied even after the EMF button is released. The EMF indicator lamp in the instrument cluster remains active. The driver can then release the parking brake (see Releasing the Parking Brake).

Parking Brake Fault

The EMF indicator lamp in the instrument cluster lights yellow to indicate a fault in the parking brake. A check control message is also output.

E89 Indicator lamp, parking brake fault

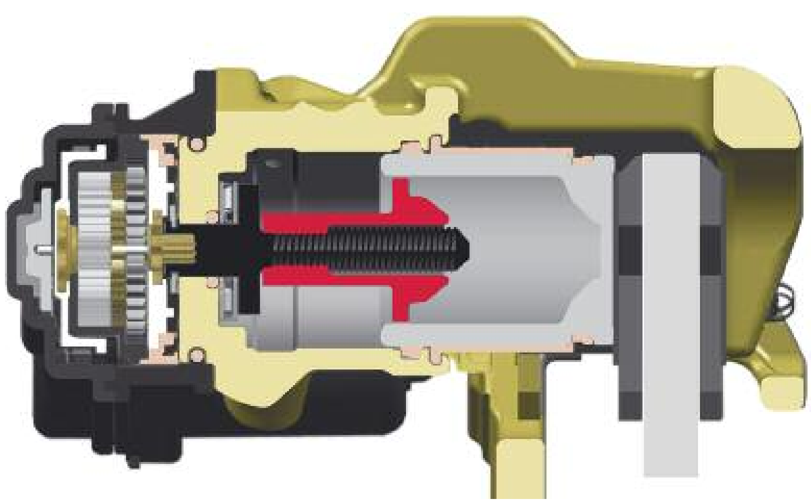
Emergency Release

No parking brake emergency release function is provided for the customer. The parking brake can be released using the BMW diagnosis system or the EMF actuators are removed and the spindle is turned back manually.

Changing Brake Pads

To change the brake pads, the EMF actuator must be in the fully opened position so that the brake piston can be pushed back. The BMW diagnosis system can be used to actuate the EMF actuators and assume the fully opened position. This position is necessary to change the brake pads. Installation mode is set automatically on reaching the installation position.

E89 Parking brake with spindle nut in installation position for changing brake pads



For safety reasons, the parking brake cannot be activated for as long as the EMF control unit is in installation mode. If the EMF button is pulled, the EMF indicator lamp in the instrument cluster will flash yellow.

Installation mode can be cancelled in two ways:

- By carrying out the service function Reset Installation Mode with the aid of ISTA
- By driving the vehicle and exceeding a programmed minimum speed.

After being changed, the brake pads must be bedded-in. This is necessary to ensure the brake pad and brake disc pairing assumes the specified friction parameters. Only then will the required braking force be reached.

The exact procedure for bedding-in the service brakes is described in the Repair Instructions. The instructions must be followed exactly.

Brake Test Rig Recognition

The EMF control unit recognizes the brake test rig based on a plausibility check (wheel speed comparison) and assumes brake test rig mode. The following target positions are assumed in succession by pulling the EMF button several times:

- Brake pads applied
- Force 1 for brake test rig
- Force 2 for brake test rig
- Target force.

The EMF indicator lamp flashes slowly when brake test rig mode is activated and the EMF actuators are released.

The EMF indicator lamp begins to flash fast when brake test rig mode is activated and EMF actuators are partially applied.

The EMF indicator lamp lights permanently when brake test rig mode is activated and EMF actuators are fully applied.

The parking brake can be released on the brake test rig without pressing the brake pedal or clutch pedal.

Brake test rig mode is automatically cancelled on exiting the brake test rig. The mode is also deactivated by pressing the EMF button or if a fault occurs.

Description	Check control message	Central information display	General brake indicator lamp	Parking brake indicator lamp	Check control symbol
For safety reasons, the parking brake can only be released with the service brake pedal depressed	Additionally press foot brake Manual gearbox: Additionally press foot brake or clutch	-	-	-	
The driver must immediately be made aware of a fault in the EMF button	-	-	-		-
Parking brake applied mechanically	-	-	-		-
Redundant EMF button fault, workshop visit required as soon as possible	Parking brake fault!	Parking brake fault. Have checked by BMW Service dealer	-		
Mechanical application of parking brake no longer possible, dynamic emergency braking (emergency brake function) still available	Parking brake fault!	Parking brake fault. Not operative when vehicle stationary. Emergency braking function still possible. Have checked by nearest BMW Service dealer.	-		

Description	Check control message	Central information display	General brake indicator lamp	Parking brake indicator lamp	Check control symbol
Dynamic emergency braking (emergency brake function) no longer possible, mechanical brake application still possible	Parking brake fault!	Parking brake fault. No emergency braking function. Parking brake can be applied with vehicle stationary. Have checked by your BMW Service dealer.	-		
Parking brake completely failed, mechanical parking brake cannot be applied, no emergency braking function	Parking brake failed!	Parking brake failed. Secure vehicle to prevent it rolling away. Have checked by nearest BMW Service dealer.			
Warning when driving off - parking brake or dynamic emergency braking applied	Release parking brake	-	-		
Installation mode (only with EMF button operated)	-	-	-		-

Suspension and Damping

Basic Suspension Setup

The spring struts on the front axle are made of steel and are connected in a clamp arrangement to the aluminum wheel carrier. Two-tube gas-pressurized dampers are used. The piston rods on the front axle are hollow. The piston in the shock absorbers are coated with PTFE (colloquially also known as Teflon).

The coil springs on the front and rear axle have been are optimized in terms of their tension and weight. To ensure a constant ride height is achieved depending on the engine and vehicle equipment, as on all BMW vehicles, different springs are used that are adapted to the specific vehicle weight.

Stabilizer bars are used on the front and rear axles. For weight reasons, the stabilizer bar on the front axle is of a tubular/hollow design.

Adaptive M Chassis and Suspension

The adaptive M suspension setup is lower by 10 mm. Four continuously adjustable shock absorbers in the optional Adaptive M chassis and suspension achieve variable damping forces to suit the driving situation by means of coupled tension/compression stage adjustment (continuous electronic damper control EDC-K). The shock absorbers are automatically set harder (more dynamic/sporty) or softer (more comfortable) corresponding to the driving situation.

In contrast to the E70/E71 and F01/F02 a bus system is not used in the E89 for data transfer. The VDM control unit is responsible for controlling the vertical movements. On the E89, the EDC-K function is integrated in the VDM control unit. The E89 does not feature any other vertical dynamics systems.

The EDC-K system on the E70/E71 and F01/F02 is known as vertical dynamics control. The designation was changed because the actuator units for the dampers are controlled by satellites on the shock absorbers and data transmission from the VDM control unit to the satellites takes place via FlexRay.

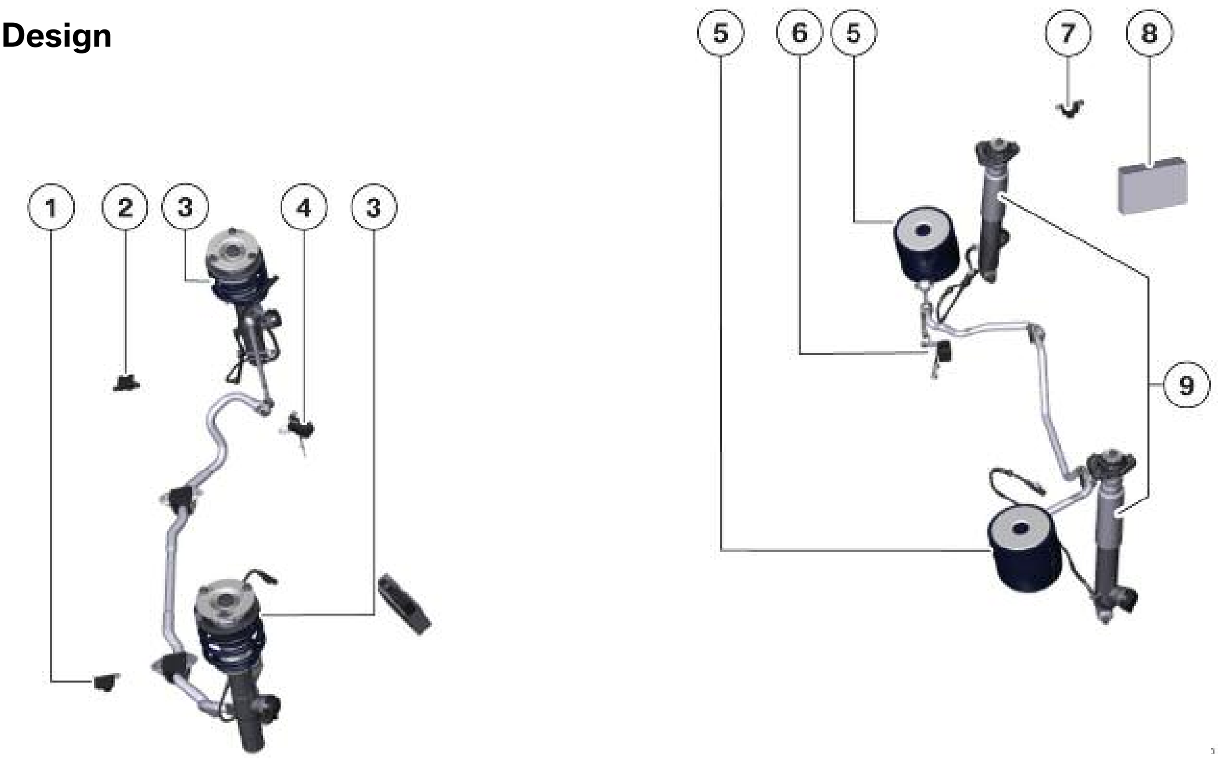
Also on the E89, the damper control can be influenced by means of the dynamic driving control switch on the center console. Two characteristic curves are used, which, in addition to a comfortable characteristic (normal) additionally enable another distinctly sports-orientated characteristic (sport).

History of Electronic Damping

	EDC M3	EDCI	EDCII	EDCIII	EDC-K	VDCI	VDCII	EDC
Model	E30	E32, E34	E24	E31, E32, E34, M5, E38, E39	E65, E66	E70, E71	F01, F02	E89
Introduction	1987	1987	1989	1990	2001	2006	2008	2009
Operation	Rotary switch	Rocker switch	Push-button	Rocker switch	Controller	Dynamic driving switch	Dynamic driving switch	Dynamic driving switch
Damper levels	Comfort, Normal, Sport	Comfort, Sport	Comfort, Sport	Comfort, Sport	Contin-uous	Contin-uous	Contin-uous	Contin-uous
Selection via control	Comfort, Normal, Sport	Comfort, Sport	Comfort, Sport	Comfort, Sport	Comfort, Sport	COM-FORT, Sport	COM-FORT, NORMAL, SPORT, SPORT+	NORMAL, SPORT, SPORT+
Additional sensors	None	None	1x Vertical*, Steering angle	2x Vertical*, 1x Longitudinal*, 1x Steering angle	3x Vertical*	4x EDC satellites, x Ride-height sensors	4x EDC satellites, 4x Ride-height sensors	3x Vertical* 2x Ride height sensors
Gas pres-surized shock absorber	Two-tube	Two-tube	Two-tube	Two-tube	Two-tube	Two-tube	Two-tube	Two-tube
Diagnostic capabilities	No	No	Yes	Yes	Yes	Yes	Yes	Yes
*Acceleration sensor								

Note: In order to simplify the description of the system, the continuous electronic damper control on the E89 is simply referred to as EDC.

Design



E89 Adaptive M chassis and suspension

Index	Explanation
1	Acceleration sensor, front left
2	Acceleration sensor, front right
3	Spring strut, front
4	Ride-height sensor, front
5	Springs, rear
6	Ride-height sensor, rear
7	Acceleration sensor, rear right
8	VDM control unit
9	Shock absorber, rear

Function

The input parameters such as road condition, vehicle load and driving style are registered directly by the system and used to activate the corresponding characteristic map as required. This results in improved damping over a broad range with distinct comfort and safety advantages.

The aim of EDC is to clearly increase vibration comfort (vehicle movement) without compromising on driving characteristics (wheel-related movement) and safety. Three acceleration sensors register the driving dynamics of the vehicle and send the data each over a separate data line to the VDM control unit. Sensors register the following values:

- Vehicle speed
- Vertical acceleration
- Longitudinal acceleration and deceleration
- Steering angle
- Ride height.

The EDC valves are set to the hard position when no power is applied (failsafe position). The EDC valves are actuated by the VDM control unit and are set towards soft. The VDM control unit contains adaptive controllers with four output stages and converts the signals corresponding to a defined characteristic map. For this purpose, the four EDC valves on the shock absorbers are actuated independently (wheel-individual).

An EDC valve externally mounted on each shock absorber is responsible for controlling the oil flow in the tension and compression stages (damping). The shock absorbers are automatically set harder (increases dynamics) or softer (increased comfort) corresponding to the driving situation. In the event of the VDM control unit failing, the power supply to the EDC valves is disconnected and they are closed mechanically by springs, thus fixing the EDV valves in the hard position.

The dynamic driving switch makes it possible to additionally influence the control system.

Sensors
Additional sensors and information from existing systems are required to ensure the EDC operates correctly.

For instance, the EDC receives information on the vertical acceleration as the springs compress and recoil from the three additionally installed acceleration sensors. The acceleration sensors are fitted on the front left, front right and rear right. The acceleration sensors on the front and rear axles make it possible to register the movement of the vehicle body with respect to the road surface.

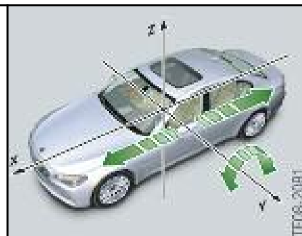
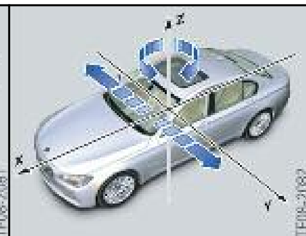
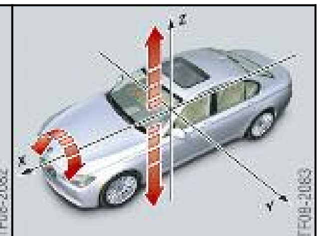
The steering column switch cluster makes available the rate of change in the steering angle in the form of a signal on the PT-CAN. The signal for the front left and front right wheel speed is also made available on the PT-CAN. The signal is provided by the DSC control unit.

The DSC sensor makes available the longitudinal acceleration signal on the PT-CAN. The ride-height values are registered by a ride-height sensor on the front axle and on the rear axle and are also made available.

Dynamic Driving Systems

Overview

Fundamentally, the dynamic driving systems can be divided into three acceleration axes. The X-axis denotes the longitudinal dynamics, the Y-axis the transverse dynamics and the Z-axis the vertical dynamics. All dynamic driving systems act on one or several axes. The following overview shows the dynamic driving systems available for the E89 together with the effective axes.

Effective direction			
DSC	✓	✓	
EPS		✓	
VDM			✓
DCC	✓		

Dynamic Stability Control DSC

The following table shows an overview of the subfunctions combined in the DSC.

Function	Subfunction	Description
ABS		Anti-lock brake system
	EBV	Electronic braking force distribution
	CBC	Cornering brake control (counteracts oversteer)
	DBC	Dynamic brake control
ASC		Automatic stability control
	MMR	Engine torque control
	MSR	Engine drag torque control
	BMR	Braking torque control
DSC		Dynamic stability control
	GMR	Yaw moment control
	SDR	Thrust differential control
	DTC	Dynamic traction control

Vertical Dynamics Management VDM
Electronic damper control EDC is used as the vertical dynamic system in the E89. The EDC function is integrated in the VDM control unit. The sales designation for the E89 is Adaptive M suspension.

Dynamic Cruise Control DCC
The option SA544 Cruise Control with Brake Function (also known as also known as Dynamic Cruise Control) is available for the E89.

Dynamic Driving Control in the E89
Compared to the E85/E86, the new dynamic control in the E89 has two new features:

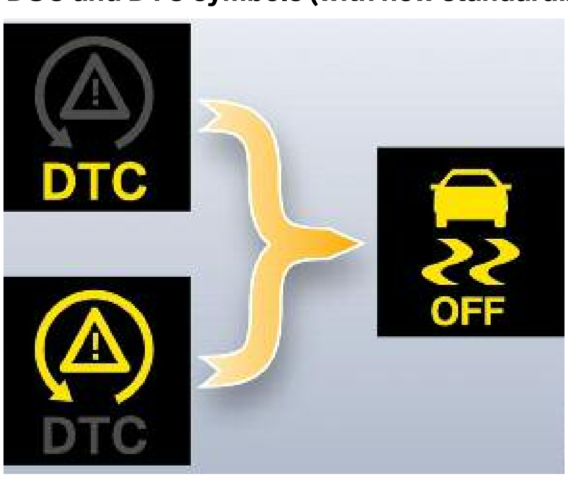
- All dynamic driving systems available in the vehicle are influenced in full.
- Three levels are available. The status of the dynamic stability control is also taken into account thus making two further levels possible.

Dynamic Driving Switch
The E85/E86 was equipped with a SPORT button that influences several systems. The SPORT button switched the steering, automatic transmission and accelerator pedal between a standard mode and a sports mode. This made it possible to match these three systems more effectively in the two available modes. As a result, the customer experienced a vehicle trimmed to a sports driving style without compromise in sports mode.

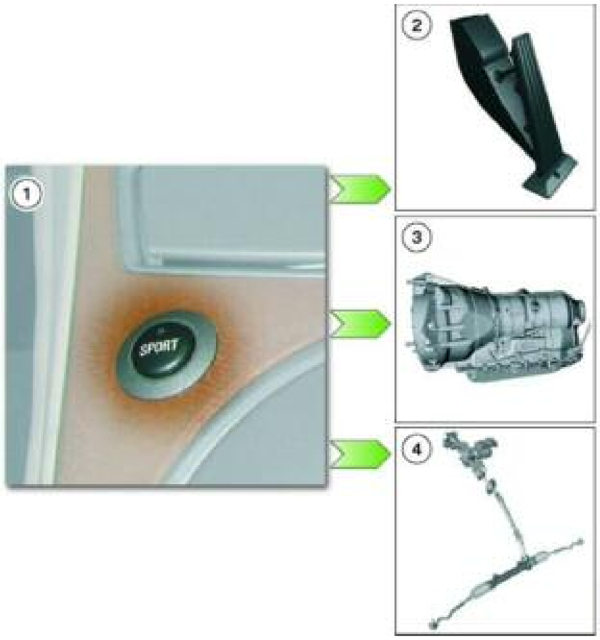
Dynamic driving control is activated by a new dynamic driving switch and the DTC button arranged directly in front of it. Dynamic driving control combines the activation of many vehicle drive and dynamic driving functions.

The overall vehicle then assumes the characteristics that the driver expects in the selected drive range. With this bundling of functions, the vehicle characteristic can be set considerably more pronounced and less compromising. In response, the large number of, in part, unfeasible individual combinations is avoided (for example: sports steering and comfort-orientated damping).

DSC and DTC symbols (with new standardized symbols)



SPORT button in the E85/E86



Index	Explanation
1	SPORT button
2	Accelerator pedal
3	Automatic gearbox
4	Steering

DTC button and dynamic driving switch

Index	Explanation
1	DTC button
2	Dynamic driving switch

Central Information Display CID
In addition to the indicator in the instrument cluster, an assistance window also appears in the CID when the DTC button or dynamic driving switch is pressed. The newly selected mode is shown here and explained by an additional text.

Modes and Their Effects
The entire vehicle has a coherent response due to the fact that the individual systems are switched jointly and in a co-ordinated manner. This configuration avoids unfeasible combinations. For instance, this configuration rules out a sports accelerator pedal characteristic together with an extremely comfort-orientated shift program of the automatic transmission. The following table shows the possible combinations and the five available modes.

	Dynamic driving switch									DTC button					
Mode	NORMAL			Sport			SPORT+			TRACTION			DSC OFF		
Vehicle setup	Comfort			Sport			Sport			Comfort			Comfort		
Drive systems															
Accelerator pedal characteristic	Comfort			Sport			Sport			Comfort			Comfort		
Mode, automatic gearbox	D	DS	M	D	DS	M	D	DS	M	D	DS	M	D	DS	M
Gearshift program, automatic gearbox *1	XE	S	M	S	S	M	S	S	M	XE	S	M	XE	S	M
Gearshift speed, automatic gearbox *2	N	S	S	S	S	S+	S	S	S+	N	S	S	N	S	S
Vehicle Chassis, suspension and dynamic driving systems															
Power steering	Basic			Sport			Sport			Basic			Basic		
DSC	DSC ON			DSC ON			DTC			DTC			DSC OFF		
Vertical dynamics management	Basic			Sport			Sport			Basic			Basic		
*1XE = Extremely economical gearshift program; S = Sports gearshift program; M = Manual gearshift program *2N = Normal shift speed, S = Fast shift speed, S+ = Very fast shift speed															

The modes (D, DS, M) of the automatic gearbox are selected via the selector switch and shift paddles.

As before, DS mode is engaged by shifting the selector lever to the left. The selector lever locks in this position. The sports program can only be engaged from D. The manual gearshift program M is selected by shifting the selector lever forward or back in the sports program. The manual gearshift program M is also selected by pressing the shift paddles in D or DS mode.

Electric Power Steering (EPS)

The main difference between hydraulic and electric power steering systems is in the method of generating the power assistance force that reduces the amount of force that the driver has to apply to the steering wheel.

Hydraulic power steering systems feature a pump that is driven either by a belt running off the engine or by an electric motor. The pump is part of a hydraulic system which generates the fluid pressure/flow that is used to produce the power assistance for steering.

Electric power steering systems produce the power assistance force directly by means of an electric motor that transmits its torque either to the steering column or the steering gear. Therefore, such systems generally require extra gearing to connect the electric motor to the existing steering system components.

Otherwise, the basic design of the steering system is the same (e.g. rack-and-pinion steering gear for both hydraulic and electric power steering systems).

The steering characteristics, e.g. amount of steering force required, progression of steering force, feedback from the roadwheels, are subject to strict development specifications that have resulted in continual optimization of the hydraulic power steering systems so far used. The new electric power steering systems have to match up to the outstanding steering characteristics of BMW vehicles BMW owners have come to experience.

Versions of Electric Power Steering

The table below categorizes EPS systems on the basis of the mounting position of the servo unit consisting of electric motor and reduction gearing. With the advent of EPS, the method of generating the power assistance for steering changes from hydraulic to electrical means.

Index	EPS with APA	C-EPS
Vehicles	Z4 (E89)	Z4 (E85, E86)
Manufacturer	ZF	ZF
Type of Motor	Brushless Motor	Brushless Asynchronous Motor
Location of Motor and Reduction Mechanism	Parallel to Steering Rack	Upper Part of Steering Column Inside Passenger Compartment
Design of Reduction Mechanism	Belt and Ball Screw Drive	Worm Shaft and Gear

Distinction from Active Steering

The electric motor of an EPS system is capable of superimposing additional force in addition to the force applied by the driver. The EPS is able to determine the level and timing of that force independently of such factors as the engine speed.

The rigid link between the steering wheel and the front wheels remains unchanged with electric power steering. The gear ratio of the rack is fixed, so the position of the steering wheel is always directly related to the position of the front wheels.

The electric motor in an active steering system, by contrast, is capable of superimposing a steering angle (which changes the ratio between steering wheel and front wheels) but not a steering force.

The steering train of an active steering system is split by a double planetary gear. This enables the active steering to alter the steering angle of the roadwheels without it being felt by the driver through the steering wheel.

In order for the wheels to adopt the total steering angle produced by the steering wheel position plus the superimposed adjustment, a bracing force is required: the driver has to hold the steering wheel firmly. A pump unit is also required. This can only be of the hydraulic type on active steering systems. Only hydraulic pump units are currently capable of providing the combination of high positioning force and positioning speed.

Features

The use of electric power steering provides many advantages for the BMW customer, the environment and the BMW Group.

Interacting with the well-proven suspension concepts, a unique combination of driving comfort and dynamics is achieved. The steering properties (e.g. the level of steering torque assistance and damping) can be finely tuned by correspondingly programming the electrical system while ensuring optimum adaptation to the different vehicle philosophies.

Thus, despite the use of identical mechanical components, the system will be capable of perfect adaptation to future BMW models.

Where more precise steering and better handling characteristics are desired for a more sports-style model, it can be achieved by reducing the amount of power assistance.

Although the driver then has to apply slightly more force to the steering wheel, the feedback from the roadwheels gives the more "direct" feel desired.

By contrast, a greater degree of power assistance can be programmed for models whose steering characteristics are to be more comfort-orientated.

With the disappearance of the hydraulic system (consisting of pump, hoses, cooler, fluid, etc.), assembly of the steering on the production line is more efficient for the manufacturer. The EPS steering system is supplied as a pre-assembled unit and fitted to the vehicle as such. In addition, the EPS also eliminates the environmental hazard of hydraulic fluid leakage.

Because the electric motor is activated only when required (when steering but not when driving straight ahead) fuel consumption is reduced and the effective power output of the combustion engine increased when compared to a conventional hydraulic power steering system.

The example figures below illustrate the difference in power consumption between the two steering systems.

Power Consumption	Electric Power Steering	Hydraulic Power Steering
Minimum Demand	10 Watts	300 - 400
Maximum Demand	1,000 Watts	2,000

Features of Electric Power Steering

Improved Handling Dynamics

- Steering characteristics perfectly adapted to vehicle model
- Active return to center
- Linear dynamics benefits of up to 2 kW

Greater Driving Comfort

- Steering train isolated from suspension vibration while still transmitting the important road feedback (different road surface conditions) to the driver
- Improved isolation of interference from the road surface (less steering judder)
- Electronically controlled, speed-dependent power-assistance (e.g. greater when parking)

Greater Driving Safety

- Servotronic function: EPS assists the driver to hold the correct line, particularly at high speeds, by providing a lower level of power assistance than at low speeds.
- Steering wheel backlash is reduced by active speed-dependent damping. This function also reduces the vehicle's tendency to slew in response to abrupt steering wheel movements made by the driver.

Better Environmental Credentials

- Fuel saving of approx. 0.2 l per 100 km
- No possibility of leakage from the hydraulic system

Simplifications for the Vehicle Manufacturer

- Reduced assembly and inspection complexity at the production plant as the system is supplied as a complete unit
- Reduced range of variants compared to hydraulic systems (pumps, hoses, steering wheels)
- Easier tuning of power steering assistance by programming
- High future potential: integration between vehicle systems (dynamic driving systems, driver assistance systems)

System Overview

Mechanical Design

The electric power steering is an absolutely identical fit with the previously used hydraulic power steering as far as the connections between it and the vehicle are concerned.

For comparison, a hydraulic power steering system and the new EPS with parallel mounted motor are illustrated below.

Index	Explanation
1	Hydraulic-fluid reservoir
2	Steering column
3	Torsion bar and valve actuator
4	Track rod
5	Hydraulic power steering pump
6	Steering rack

Hydraulic power steering (typical installation configuration)

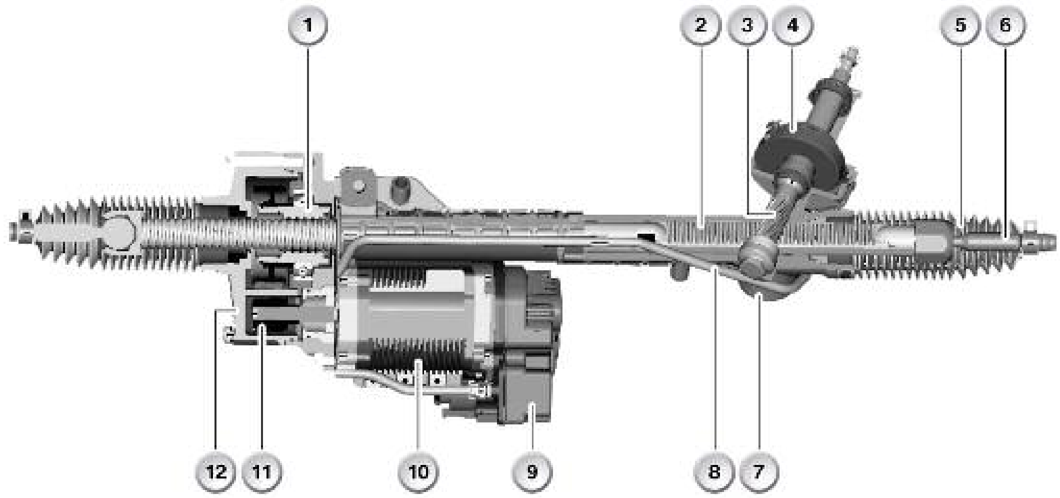
Index	Explanation
1	Steering rack
2	Steering torque sensor
3	Steering column
4	Track rod
5	EPS control unit
6	Electric motor with position sensor
7	Reduction gear

Electric power steering with parallel-mounted motor

The EPS system essentially consists of the following components:

- Steering torque sensor
- EPS control unit
- Electric motor with position sensor
- Reduction gear
- Steering rack

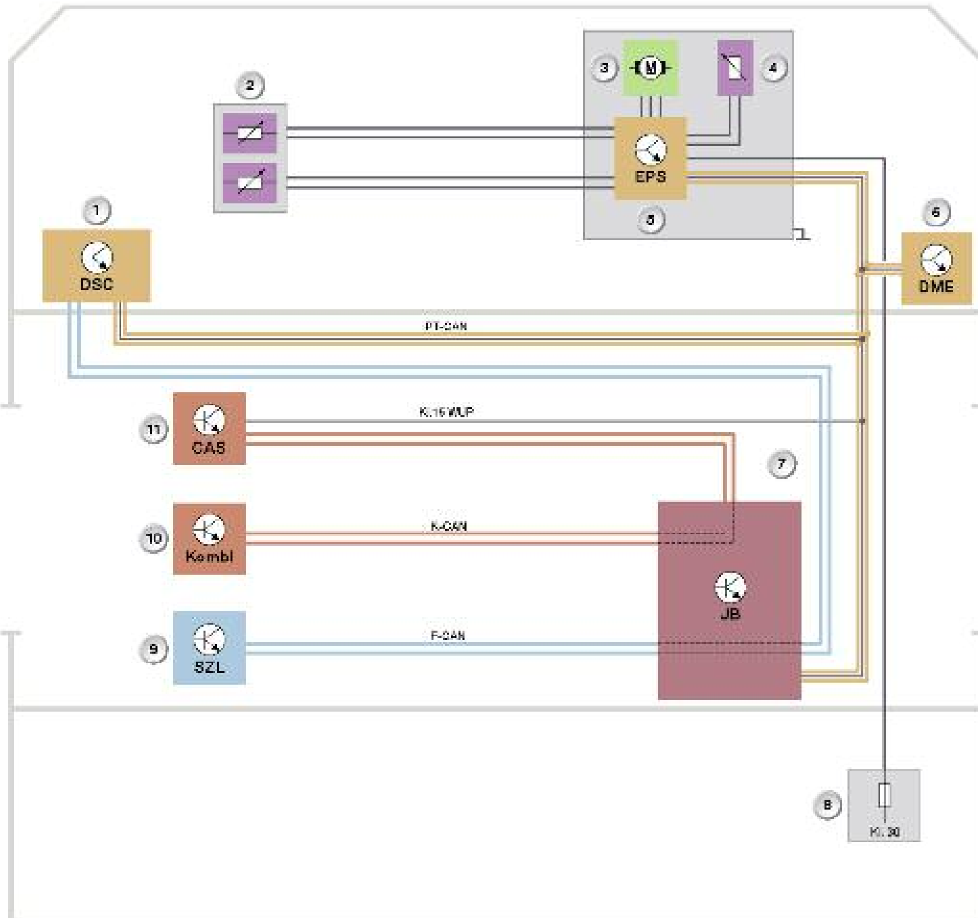
EPS rack-and-pinion steering box with parallel-mounted electric motor



Index	Explanation	Index	Explanation
1	Ball-screw drive (part of reduction gearing)	7	Thrust piece
2	Rack	8	Signal and power lead for steering torque sensor
3	Pinion	9	EPS control unit
4	Steering torque sensor	10	Electric motor
5	Gaiter	11	Toothed-belt drive (part of reduction gearing)
6	Track rod	12	Reduction-gear housing

Note: These components form a preassembled unit (often referred to as "EPS steering rack assembly") that can only be replaced as a complete unit. To do so, the unit has to be disconnected from the tie rods and the lower end of the steering column.

EPS System Circuit Diagram



Index	Explanation
1	DSC control module
2	Steering torque sensor with redundant back-up
3	Electric motor
4	Motor position sensor
5	EPS control unit
6	DME control unit
7	Junction box
8	Fuse in boot (power supply for EPS)
9	Steering column switch cluster with steering-angle sensor
10	Instrument cluster
11	CAS control unit

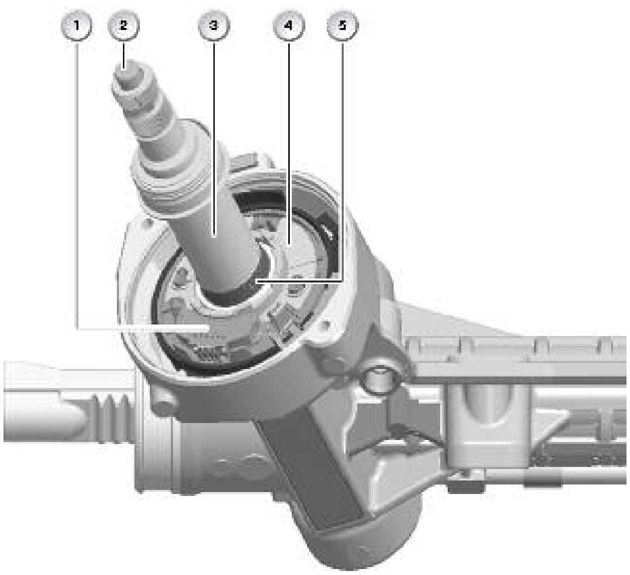
System Components

The main components of the EPS system are the:

- Steering torque sensor
- EPS control unit
- Electric motor with position sensor
- Reduction gear
- Steering rack

Steering Torque Sensor

The steering torque sensor provides the EPS control unit with information about the steering torque applied by the driver in the form of an input signal. The EPS control unit uses that signal and other input signals to calculate the power assistance torque and operates the electric motor accordingly. The torque produced by the electric motor is added by way of the reduction gear to the steering torque applied by the driver. The total torque is converted by the steering rack into steering force at the front wheels.



Index	Explanation
1	Sensor unit with analyzer circuitry
2	Torsion bar (top end) 5 Ring magnet
3	Input shaft
4	Coil spring
5	Ring magnet

Rotation of the input shaft (3) and ring magnet (5) is detected and electronically analysed by the sensor unit (1). The fundamental sensing principle applied is called the Hall effect.

As the rigidity of the torsion bar (2) inside the input shaft is known, the electronic circuitry can calculate the amount of torque applied from the degree of twist.

The steering torque is then digitally transmitted to the EPS control unit via a direct cable connection.

The sensor signal is provided with redundant back-up (a second identical sensor) so that system availability in the event of sensor failure is improved. If an unacceptable degree of divergence between the two sensors is detected during operation, the system continues to operate on the basis of the more plausible of the two signals and full EPS functionality is maintained.

If the fault status remains present at the end of the driving cycle, a fault memory entry is generated and the EPS does not operate when the next driving cycle starts.

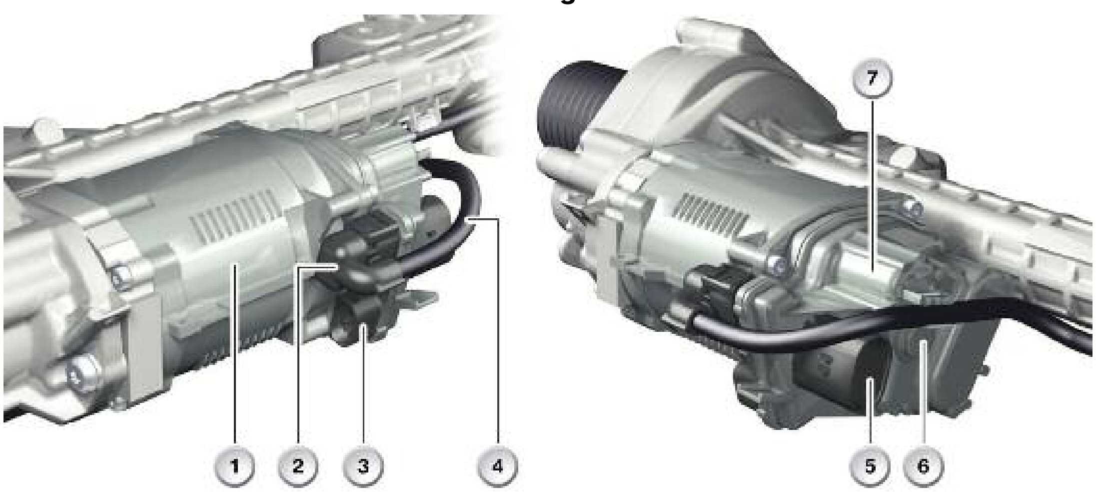
EPS Control Unit

As well as the control circuitry, the EPS control unit also contains the power electronics for operating the electric motor.

The power electronics includes a multiple output relay that turns off the power supply to the motor windings in the event of a fault. Breaking the circuit allows the motor shaft to rotate freely. Fault conditions in which the motor would electrically lock up are avoided.

There is a temperature sensor integrated in the control unit that is required for detecting overload situations.

EPS control unit and electric motor housing



Index	Explanation
1	Electric motor housing
2	Steering torque sensor lead connection
3	Bus connection
4	Cable to steering torque sensor
5	Power supply connection
6	Diaphragm made of Goretex
7	EPS control unit housing

The housing of the EPS control unit (and the electric motor) is located in a position exposed to large temperature fluctuations and high external moisture levels. Therefore, there is a diaphragm made of Goretex on the housing that equalizes the pressure difference between the inside and outside of the housing but still prevents moisture intrusion at that point.

On the EPS control unit and electric motor housing there are also the following EPS electrical connections:

- Power supply for the EPS
- Bus connection (PT-CAN inc. wake-up line)
- Power supply and signal line for steering torque sensor

Electric Motor with Position Sensor

The essential function of the electric motor is to generate the required torque calculated by the EPS control unit.

The type of electric motor used is a brushless DC motor (made by Siemens).

Although it is powered by direct current, its method of operation is based on that of an AC synchronous motor. The power electronics in the EPS control unit convert the power supply voltage (DC voltage) into phase voltages so as to produce a rotating field at the phase windings.

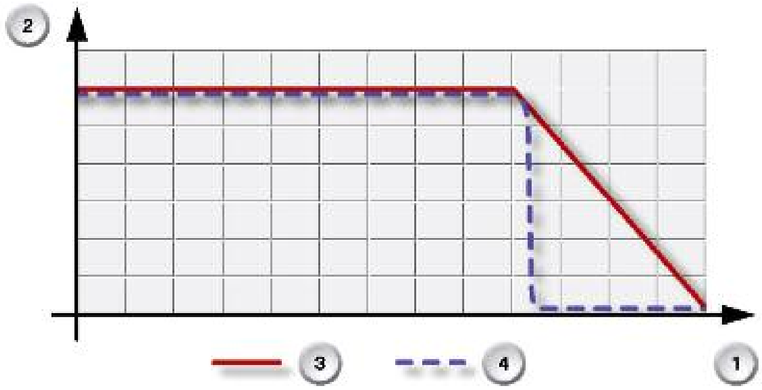
Only this type of motor combines the following characteristics that are decisive for use in an EPS system:

- High efficiency
- Long service life
- Small external dimensions
- Low wear
- High thermal load capacity
- Constantly high torque over a wide speed range

The electric motor is almost exclusively operated in the speed range throughout which its torque is constant. Only in rare cases involving extremely high rates of steering angle change applied by the driver does the speed briefly reach the point at which the torque curve falls away with increasing motor speed. Very aware drivers may perceive this as reduction of power steering assistance. In contrast with hydraulic power steering, where the drop is noticeable as an abrupt stiffening, the change is progressive with EPS, which is generally perceived as more pleasant.

The maximum power consumption (transient) is 85 A so that at a rated voltage of 12 V a peak output of approximately 1 kW results. The fuse in the trunk that protects the power circuit against shorting has an appropriately high rating for that high current draw.

Available torque versus rate of change of steering angle (EPS vs. Hydraulic Power Steering)



Index	Explanation
1	Speed of electric motor, equates to rate of change of steering angle
2	Torque
3	EPS electric motor - relationship of torque to motor speed
4	Hydraulic power steering pump - relationship of torque to steering angle rate of change

In contrast with the peak output, the average output required for delivery of EPS functions is very low. It is only between approx. 20 W and 40 W (depending on driving profile) because the electric motor is only supplied with power on demand, e.g. when cornering but not when travelling in a straight line (without having to use the steering).

Demand-based operation of the electric motor is the main reason why the fuel consumption of vehicles with EPS is around 0.2 l / 100 km less than that of vehicles with hydraulic power steering. And on the other hand, the power that would otherwise be required to constantly drive the power steering pump is now almost entirely available as additional motive power for the vehicle. Depending on the situation, there can be a linear dynamics gain of up to 2 kW.

A second important component is actually on the circuit board of the EPS control unit but is located directly adjacent to the electric motor shaft: the motor position sensor. In that way the motor position sensor can directly signal the electric motor's rotor position to the EPS control unit. As the electric motor is rigidly connected to the steering rack by means of the reduction gearing, the EPS control unit can deduce the position of the roadwheels and the steering angle from the rotor position.

After first calibrating the straight-ahead position with the aid of the signal from the steering angle sensor, the motor position sensor signal is subsequently used for the EPS functions (e.g. "active steering-wheel return"). The reason for this is the higher resolution of the motor position sensor signal.

The sensing principle applied by the motor position sensor is identical with that used by the steering torque sensor. Both consist of Hall-effect sensor units adjacent to which there is a rotating magnet. The steering torque sensor is designed to detect small degrees of twist, while the motor position sensor must detect large amounts of rotation (a complete revolution must be measurable). The motor position sensor is also duplicated, though in this case the duplicate unit has a different resolution in order to be able to pick up both fast and slow movements effectively.

Reduction Gear

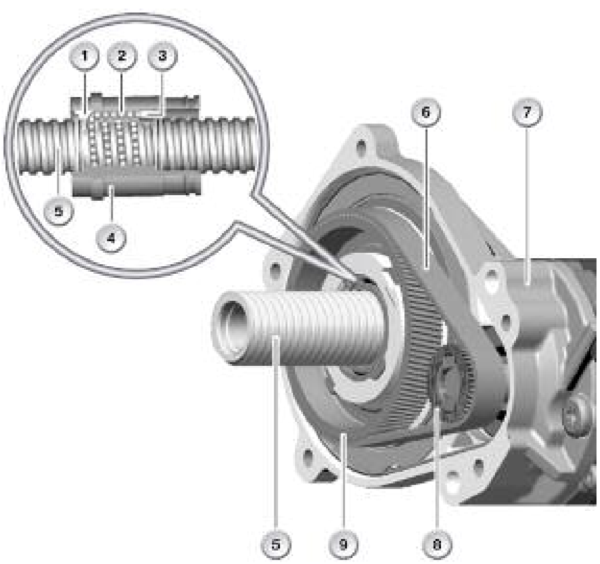
The reduction gearing transmits the torque generated by the electric motor to the steering rack, thereby applying steering force to the front wheels.

The overall transmission ratio is approximately 20 revolutions of the electric motor to one revolution of the steering wheel. That low gearing ratio combined with the high torque of the electric motor makes it possible to generate the required steering rack forces.

The low ratio combined with the rotating mass of the electric motor also has a damping effect on feedback from the road and roadwheels (as described in the section "Active damping").

The reduction gearing consists of the belt drive and reciprocating ball (screw) drive.

Reduction gearing for EPS with APA



Index	Explanation	Index	Explanation
1	Ball bearing outfeed mechanism	6	Toothed drive belt
2	Ball bearing return channel	7	Reduction-gear housing
3	Ball bearing infeed mechanism	8	Small gear wheel
4	Nut of ball screw drive	9	Large gear wheel
5	Ball screw thread on steering rack		

The electric motor shaft drives the small gear wheel (8) of the belt drive directly. Via the toothed drive belt (6) and the large gear wheel (9), the nut (4) of the ball screw drive is made to rotate.

That nut contains a return channel (2) and mechanisms at either end of the bearing race for feeding the ball bearings into (3) and out of (1) the ball screw thread of the steering rack (5). Thus, the ball bearings circulate within a "closed system".

As the nut cannot move along the steering rack, the ball bearings moving along the ball screw thread exert an axial force on the steering rack.

The reduction gearing is inseparably attached to the electric motor. Repairs or adjustments to it as a separate component are not possible.

The reduction gearing and its components (including the drive belt) are designed to last for the life of the vehicle.

If the gaiter at the end of the steering rack is damaged, water can get into the reduction gear housing and therefore into the steering gear as well. That water will cause corrosion and, over time, loud noises when steering.

Nevertheless, power steering assistance from the EPS continues to be provided even in such cases.

In order that large amounts of water do not remain in the steering gear (e.g. after driving through deep water), a water drain valve has been fitted at the lowest point of the reduction gear.

Note: If a defective bellows (boot) is discovered, it should be replaced so as to prevent water entering the steering gear. At the same time as replacing the gaiter, the water drain valve at the lowest point of the reduction gear should also be replaced and is included in the repair kit.

Steering Rack

The steering rack of the EPS system has the same function as that of a hydraulic power steering system.

It converts the steering force applied by the driver combined with the power steering assistance provided by the EPS into a force applied to the track rods. Ultimately, that results in steering movements by the front wheels.

The design and dimensions of the steering rack are such that the design of the other vehicle components only required marginal adjustments in order to enable the use of electric power steering.

In particular, the points of attachment to the wheels by way of the track rods and with the steering column are absolutely identical with those used up to now with the hydraulic power steering.

The track rod also has the same gearing ratio.

Accordingly, the gearing ratio of the steering system as a whole is identical regardless of the power assistance method used.

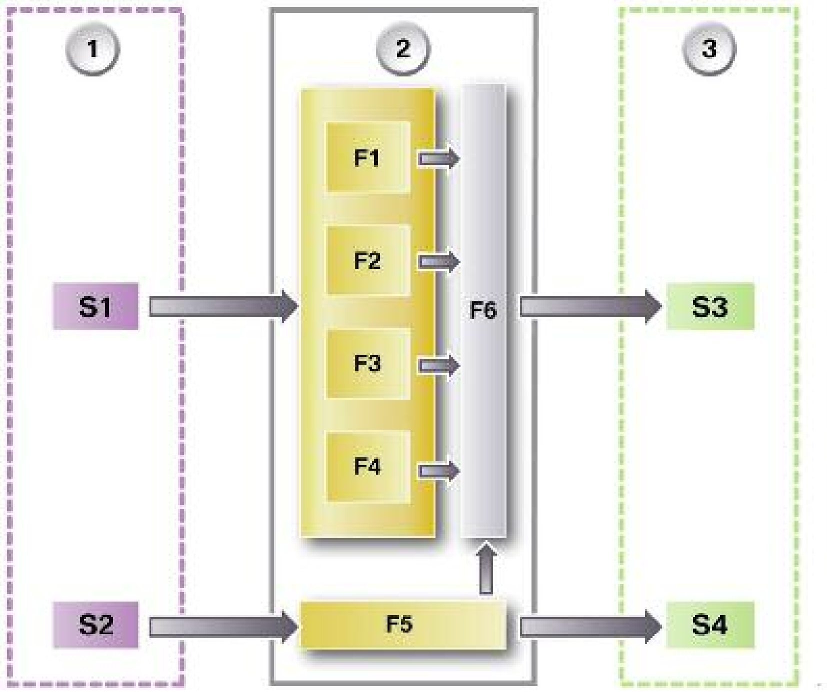
As with hydraulic power steering systems, there is a thrust piece at the point where the pinion engages in the rack. It guides the rack and also serves as a means of adjusting the entire unit at the factory.

The thrust piece in this EPS system acts purely as a spring mechanism without a hydraulic bearing.

Note: Adjustment of the steering rack and pinion using the thrust piece is a once-only operation carried out during production. That adjustment cannot and must not be performed at a dealership!

Principles of Operation

Overview of EPS functions



Index	Explanation
1	Input
2	EPS control unit
3	Output
S1	Input signals for EPS control and modulation functions - Steering force applied by driver - Road speed and other variables that describe the driving situation - Steering angle, steering angle rate of change
S2	Input signals for EPS status control - Terminal 15 on/off - Engine running/not running
F1	"Speed-dependent power steering assistance" function
F2	"Active steering wheel return" function
F3	"Active damping" function
F4	"Active roadwheel feedback" function
F5	"Status control" function
F6	"Co-ordination of specified settings" function
S3	Output signal of EPS control and modulation functions: control of electric motor
S4	Output signal of EPS status control: - Demand for higher cooling capacity - Control of warning and indicator lamps

EPS Input Variables

Steering Column Switch Cluster (SZL)	
Transmitter	Steering column switch cluster with steering-angle sensor
Signal	Steering angle set by driver
Transmitted via	PT-CAN
Receiver	EPS control unit
Function	Active steering-wheel return

Dynamic Stability Control (DSC)	
Transmitter	Dynamic stability control with DSC sensor
Signal	Road speed and other variables that describe the driving situation
Transmitted via	PT-CAN
Receiver	EPS control unit
Function	Steering power assistance, active roadwheel feedback

Digital Motor Electronics (DME)	
Transmitter	Digital motor electronics
Signal	Engine running
Transmitted via	PT-CAN
Receiver	EPS control unit
Function	Status control

Car Access System (CAS)	
Transmitter	Car Access System
Signal	Terminal 15 status
Transmitted via	PT-CAN
Receiver	EPS control unit
Function	Status control

EPS Output Variables

Digital Motor Electronics (DME)	
Transmitter	EPS control unit
Signal	Demand for greater cooling capacity
Transmitted via	PT-CAN
Receiver	Digital motor electronics
Function	Control of electric fan

Instrument Cluster (Kombi)	
Transmitter	EPS control unit
Signal	Request for failure message
Transmitted via	PT-CAN
Receiver	Instrument cluster
Function	Control of warning and indicator lamps

DME Functions Used by EPS

Intelligent Alternator Control

With the advent of "intelligent alternator control" (IGR) on the DME as an additional means of CO2 reduction, the alternator voltage is adjusted according to the driving situation and battery charge level. Therefore, there will be periods in which the electrical system voltage is at the level that has been normal up to now (approximately 13.8 V). However, there will also be situations in which the voltage drops to around or just below 12 V.

The EPS components, and in particular the electric motor, are rated for a power supply of 12 V. At that level, the requirements in terms of maximum steering power assistance and speed are satisfied.

If the maximum EPS output were demanded at an alternator voltage of 12 V, the high current draw by the electric motor would produce a voltage drop on the EPS power supply line. The consequence would be an EPS input voltage of substantially below 12 V and, therefore, a reduced level of steering power assistance.

In order to prevent such an undesirable situation occurring, there is an additional IGR function for the EPS that is implemented without additional exchange of signals with the EPS and comprises the following features:

- Observation of whether an operating status exists in which high EPS output is required.
  - The bus signals indicating steering angle rate of change and road speed are monitored for that purpose. A high level of EPS output is identified when the steering angle rate of change is high at the same time as the road speed is low.
- Action: Increase of alternator output and temporary increase of electrical system voltage when high EPS output is detected.

This function ensures that the power supply at the EPS input terminals always provides at least the rated voltage of 12 V regardless, to a great extent, of other variables.

Note: Detecting statuses involving high EPS output and raising the electrical system voltage constitute a control cycle that is completed within 2 seconds at most. As it is also an infrequent situation, it is unlikely that it will be the subject of customer complaints. If a particularly observant customer complains of momentarily reduced power steering assistance, this control cycle may possibly be the cause. If there are repeated complaints, performing a diagnosis on the power supply is advisable.

Speed-dependent Power Steering Assistance

The Servotronic function that is only achievable by means of additional system complexity on hydraulic steering systems is implemented in the form of software on the electric power steering system and is therefore available with EPS.

The customer expects the lightest and smoothest steering movement possible when maneuvering or parking into spaces. Less sensitive steering setup is required when driving at high speed so that the vehicle can be kept on course more effectively.

Based on the sensor signals indicating the vehicle's road speed and the steering torque applied by the driver, the EPS provides a high level of power steering assistance at low speeds and when stationary (maximum convenience).

At high speeds on the other hand, the EPS demands greater steering force from the driver by reducing the level of power steering assistance. This helps the driver to hold a constant line.

As can be seen from the graph, the level of power assistance is computed on the basis not only of vehicle speed but also of the steering torque applied by the driver. If the driver applies a small amount of turning force to the steering wheel, the assistance from the EPS also initially remains at a relatively low level. This produces excellent self-centering characteristics, i.e. the steering does not react over-sensitively from the straight-ahead position.

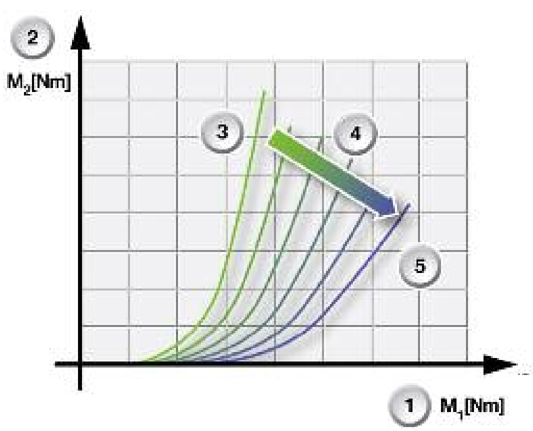
If the driver applies greater force to the steering wheel, there is a smooth transition to a steeper curve gradient. As a result, the driver obtains the expected high degree of assistance when making abrupt steering movements or tight maneuvers.

The characteristics described here have been adopted by the EPS from the familiar hydraulic steering systems.

The transition between the curves is not abrupt but progressive. The EPS calculates appropriate transitional levels where necessary.

The steering characteristics of the EPS is influenced by the driver as in other vehicles by pressing the driving dynamics button.

EPS speed-dependent power steering assistance



Index	Explanation
1	Steering torque applied by driver
2	Power assistance torque provided by EPS
3	Vehicle road speed equal to zero
4	Vehicle road speed increases
5	Vehicle road speed at maximum

Active Steering-wheel Return
In addition to the natural self-centering characteristics inherent in the steering and suspension systems, this function assists steering-wheel return by appropriate operation of the electric motor.

The following signals are required for this purpose:

- Road speed
- Steering torque applied by driver
- Steering angle and
- Steering angle rate of change

However, the steering angle signal is only required for calibration with the electric-motor position sensor in order to determine the target position for steering-wheel return (steering angle equal to zero). Thereafter, the active steering-wheel return function uses the electric-motor position sensor signal as it has a higher resolution than the steering angle sensor signal and thus enables more precise control.

If the steering-angle sensor signal is not available, e.g. due to a fault on the SZL, the active steering-wheel return function cannot operate. The other EPS functions remain active. Customers may possibly describe the resulting vehicle behavior as "pulling to one side" because the steering wheel does not return to the straight-ahead position as precisely as usual.

The necessity for activation of the active steering-wheel return function arises when, for example, the driver allows the steering wheel to slip when exiting a corner. The signal values reflecting that situation which the EPS uses to detect the situation are:

- Steering angle clearly not equal to zero and
- Steering torque applied by driver approximately equal to zero

The electric motor is then operated by the EPS so as to generate a return force that produces smooth return of the steering wheel to a position close to the straight-ahead position.

Note: If a customer complains of the car "pulling to one side" the possible causes to be considered include not only a mechanical problem with the suspension/steering but also a signal or communication fault between the EPS and the steering column switch cluster/steering-angle sensor. In such a situation, the EPS is unable to provide the active steering wheel return function and this may be perceived by the customer as the vehicle "pulling to one side".

Therefore, before checking the wheel alignment, the EPS fault memory should be checked and, if necessary, the stored testing sequence followed in order to make certain the signal from the steering-angle sensor is present.

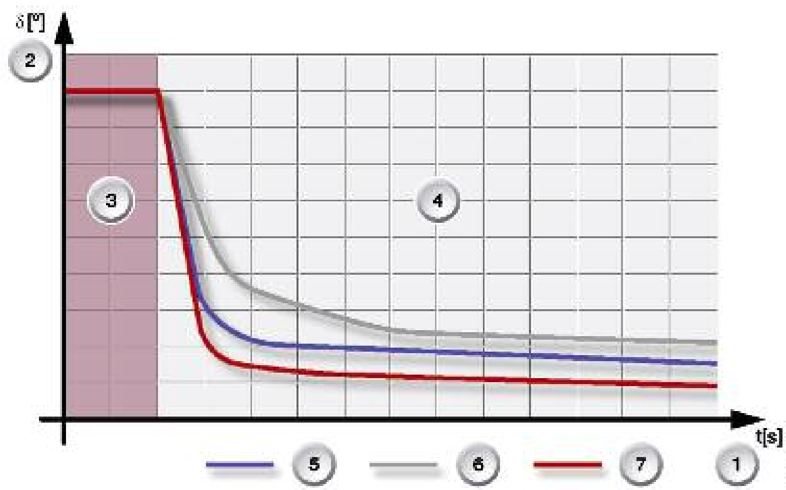
The clearly perceptible improvement compared with the self-centering characteristics of hydraulic power steering systems is evident from the graph below.

The electric power steering returns to the center position more dynamically and precisely. This applies to all electric power steering systems used by BMW because they all incorporate the active steering-wheel return function.

The self-centering characteristics of an EPS system without active steering wheel return shown on the graph are for comparison purposes only. They reveal themselves to be inferior to those of a hydraulic power steering system. This is due to the greater inertia of the electric motor and reduction gearing.

However, all EPS systems used by BMW incorporate active steering-wheel return and therefore offer the benefits described above.

Self-centering characteristics of various steering systems



Index	Explanation
1	Time
2	Steering wheel angle
3	Driver holds steering at a constant lock (cornering)
4	Driver lets steering wheel slip (exiting corner)
5	Self-centering characteristics of a hydraulic power steering system
6	Theoretical self-centering characteristics of EPS without active steering-wheel return
7	Self-centering characteristics of EPS with active steering-wheel return

Active Damping

The undesirable steering-wheel movements to be damped can be produced either by inadvertent steering input by the driver or feedback from the road/roadwheels.

Damping Roadwheel Feedback

The design of the front suspension (double link Macpherson strut suspension) on its own ensures that vertical wheel movements produce very little lateral force on the track rods.

Due to the low ratio of the reduction gear by which the electric motor is connected to the steering rack, the inertia of the electric motor also has a damping effect on the forces and movements transmitted from the roadwheels to the steering wheel. Those mechanical damping effects are supplemented by an electronic damping function on the part of the EPS. It analyses the movements of the steering rack (using the signals from the electric-motor position sensor) and operates the electric motor accordingly in response.

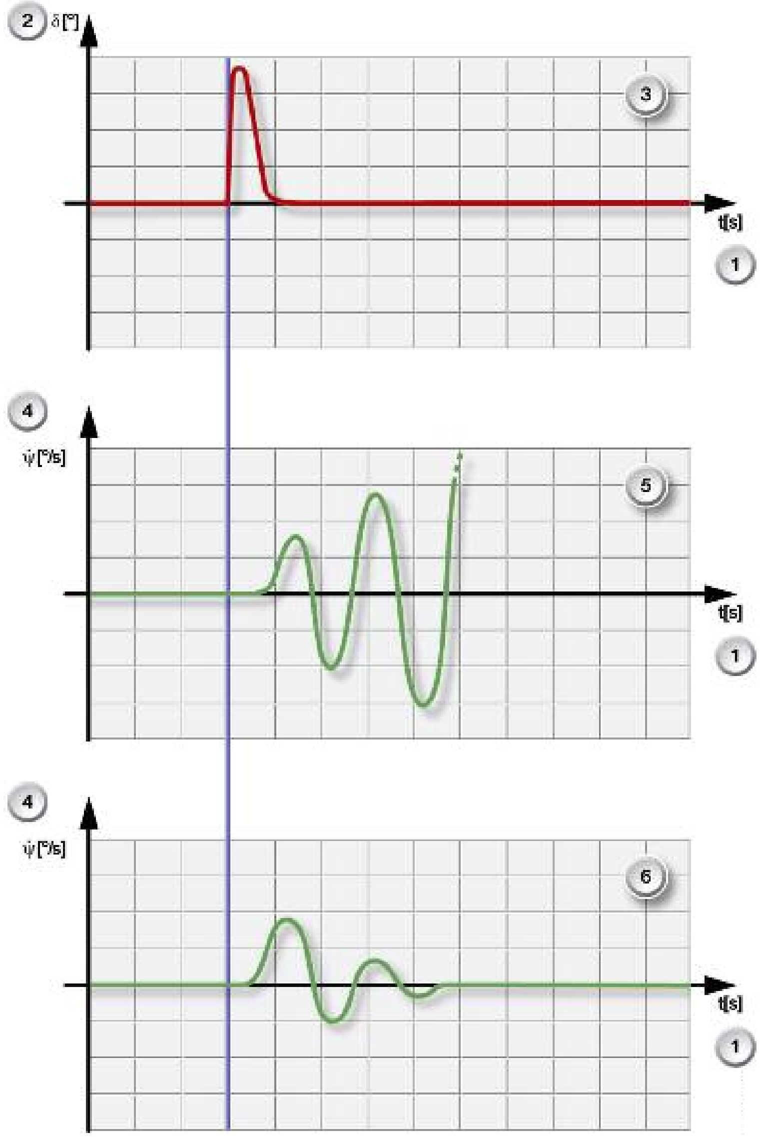
This means that feedback from external forces is transmitted in controlled amounts to the steering wheel so that, on the one hand, the driver obtains sufficient information about the nature of the road surface, but on the other, undesirably extreme steering wheel back-lash is prevented.

Damping Steering Input from Driver

Particularly at high speeds, unintentional jerky movements of the steering wheel by the driver have a negative effect on vehicle handling stability. So-called "snatching" of the steering wheel can, under certain circumstances, cause the vehicle to start rocking, which can lead to snaking and the driver ultimately losing control of the vehicle if corrective action is not taken quickly enough.

The EPS detects such steering input and operates the electric motor so as to substantially damp the movements, particularly at high speeds. As a result, vehicle rocking is prevented.

Damping of Steering Input by EPS



Index	Explanation
1	Time
2	Steering wheel angle
3	Steering angle progression (steering input by driver, "snatching" the steering wheel)
4	Yaw rate
5	Theoretical vehicle response without active damping: the turning action following the steering input is progressively amplified at high vehicle speed.
6	Desirable vehicle response with active damping: the turning action is heavily damped even at high vehicle speeds.

Active Roadwheel Feedback

Partly due to the damping effect of the inertia of the electric motor, an EPS system can inherently not provide as direct feedback about the nature of the road surface as a hydraulic power steering system.

In order to obtain virtually identical roadwheel feedback characteristics on vehicles with EPS, the EPS analyses information that describes the vehicle's dynamic handling situation. From that information, the EPS computes additional "EPS road surface data". As a result, the driver obtains better roadwheel feedback characteristics which are very similar to those of a hydraulic power steering system.

Control

The EPS status control function makes the overriding decision as to whether operation of the electric motor is permissible or not. It produces a clearance signal that is sent to the EPS function that is co-ordinating the subordinate specified settings of the control and modulation functions.

The conditions for allowing operation are the following:

- Ignition must be switched on
- Engine must be running
- There must be no EPS input signal faults or EPS internal faults present

The response to detected faults described below represents an exception.

Status Shutdown in the Event of Faults

A primary aim in the development of the EPS was to ensure that vehicle response in the event of faults would remain manageable by the driver. Therefore, under no circumstances must a sudden high steering force in either direction be allowed to occur. For that reason, the EPS has numerous monitoring functions for detecting faults on the sensors, actuators and associated systems that are involved in EPS operation.

All fault statuses in which reliable and correct control of the electric motor is not possible result in the disabling of motor operation and, therefore, shutdown of the EPS functions.

The consequence of that is that the driver no longer benefits from the convenience of power-assisted steering. More importantly, however, incorrect control of the electric motor is prevented.

Note: The loss of power steering assistance in the event of faults constitutes an intended system response on the part of the EPS.
Although such a response may be slightly unnerving for the driver, the vehicle remains fully steerable with greater physical effort.

Loss of power steering assistance in the event of faults occurs both with electric and hydraulic power steering. The two systems thus also behave in a similar manner in response to faults.

In such a fault situation, a yellow warning lamp lights up on the instrument cluster. The driver is also notified of the fact that power steering assistance from the EPS is no longer available by display of the appropriate Check Control symbol together with the explanatory message on the Central Information Display.

Co-ordination of Specified Settings

The specified settings for the control and modulation functions for operating the electric motor are co-ordinated at a central point by the EPS software. If a clearance signal from the status control function is present, the individual specified settings are normally added together and signalled as a total value.

In certain transitional situations the specified settings are filtered before they are signalled.

The following are examples of such cases:

- The EPS goes into operation after the engine is started. The power assistance torque is increased progressively until the desired level is reached.
- The EPS reduces the power steering assistance for function-related reasons (see also the section "Supplementary functions").

In the event of a fault the control signal for the electric motor is abruptly cancelled instead of being filtered in order to prevent incorrect operation as quickly as possible.

Supplementary Functions

The functions described below are encountered only rarely in special operating situations. The information given here can help to distinguish those special operating statuses, which do not require repairs, from genuine faults when handling complaints from customers.

Protection Against Overload

The EPS reduces the degree of power steering assistance if the temperature of EPS components becomes too high. By limiting motor operation, the amount of heat generated by the EPS itself is also limited, thereby protecting the components against excessive thermal stress.

This action starts to come into effect from a temperature of approximately 100°C and escalates to the point where power steering assistance is reduced to zero at a temperature of 115°C.

Upwards of a certain degree of function restriction, the warning light on the instrument cluster is switched on (see the section "Shutdown in the event of faults") and a fault registered in the fault memory.

In addition to reducing power steering assistance, the EPS also requests higher electric fan output from the DME in order to produce a greater cooling effect.

This type of overload can occur at high ambient temperatures combined with simultaneous high degrees of steering activity, especially when stationary.

Another overload situation can occur if an attempt is made to turn the front wheels against a solid obstacle (e.g. a kerbstone). If this situation occurs repeatedly at short intervals, the degree of power steering assistance is similarly reduced. This firstly protects the EPS components against excessive mechanical stresses, and secondly signals to the driver that there is a solid object preventing the wheels turning.

The EPS detects such situations by comparing the control signals to the electric motor with the motion of the motor.

Note: The EPS reduces the power steering assistance in overload situations. If customer complaints are received, the customer should be questioned as to the situation in which the symptoms occurred before commencing any repair work.

If necessary enlighten the customer as to the way in which these protective functions operate.

End Stop as Software Function

Although the EPS steering gear also incorporates mechanical end stops, there is afunction that steeply reduces the level of power assistance shortly before the mechanical end stops are reached. Although the driver will perceive this as increased steering resistance, it makes turning the wheels to full lock much smoother overall.

In addition, this function reduces the stresses on mechanical and electrical components of the steering system and thus contributes to the achievement of long service life combined with reliable operation.

Service Information

Brakes

For safety reasons, the parking brake cannot be activated for as long as the EMF control unit is in installation mode. If the EMF button is pulled, the EMF indicator lamp in the instrument cluster will flash yellow.

The exact procedure for bedding-in the service brakes is described in the Repair Instructions. The instructions must be followed exactly.

Adaptive M Chassis and Suspension

For standardization reasons, the continuous electronic damper control on the E89 is simply referred to as EDC.

A detailed functional description of the EDC van be found in Background Material E65 Dynamic Driving Systems from April 2001.

Dynamic Driving Systems

Cruise control with brake function is described in detail in the Participant's Manual E90 Dynamic Driving Systems.

Dynamic driving switch
The yellow DSC indicator and warning lamp and the DTC button have new symbols. Beginning with the F01/F02, these new DSC symbols will replace those previously used.

Replacing an EPS System

The EPS components consisting of steering torque sensor, EPS control module unit, electric motor with position sensor, reduction gear and steering rack form a single unit (often referred to as "EPS steering rack assembly") that can only be replaced as a complete unit. To do so, the unit has to be disconnected from the track rods and the lower end of the steering column.

After a new EPS steering rack is fitted, a front wheel and tracking alignment check is required. The commissioning sequence involves coding the EPS to match the vehicle model and the diagnosis function for learning the end-stop positions.

Intelligent Alternator Control and EPS

Detecting statuses involving high EPS output and raising the electrical system voltage constitute a control cycle that is completed within 2 seconds at most. As it is also an infrequent situation, it is unlikely that it will be the subject of customer complaints.

If a particularly observant customer complains of momentarily reduced power steering assistance, this control cycle may possibly be the cause. If there are repeated complaints, performing a diagnosis on the power supply is advisable.

Active Steering Wheel Reset

If a customer complains of the car "pulling to one side" the possible causes to be considered include not only a mechanical problem with the suspension/steering but also a signal or communication fault between the EPS and the steering column switch cluster/steering-angle sensor. In such a situation, the EPS is unable to provide the active steering wheel return function and this may be perceived by the customer as the vehicle "pulling to one side".

Therefore, before checking the wheel alignment, the EPS fault memory should be checked and, if necessary, the stored testing sequence followed in order to make certain the signal from the steering-angle sensor is present.

Protection Against Overload

The EPS reduces the power steering assistance in overload situations. If customer complaints are received, the customer should be questioned as to the situation in which the symptoms occurred before commencing any repair work.

If necessary enlighten the customer as to the way in which these protective functions operate.

Shutdown in the Event of Faults

The loss of power steering assistance in the event of faults constitutes an intended system response on the part of the EPS.

Although such a response may be slightly unnerving for the driver, the vehicle remains fully steerable with greater physical effort.

Electrical Connections

If the EPS steering rack assembly has to be replaced, only the power supply and bus connection have to be disconnected and not the connection for the steering torque sensor.

If a customer complains of inadequate power steering assistance, it can be due to a voltage drop across the power supply connection.

Therefore, in such cases the power supply connection should be checked for corrosion.

Step-down Gear

If a defective gaiter is discovered, it should be replaced so as to prevent water entering the steering gear. At the same time as replacing the gaiter, the water drain valve at the lowest point of the reduction gear should also be replaced and is included in the repair kit.

Corrosion on the moving parts of the steering gear does not normally result in heavy steering. Instead, corrosion is frequently a cause of noises from the steering mechanism.

If customers complain of loud steering noises and if they are definitely attributable to the EPS steering rack, the complete EPS steering rack assembly must be replaced.

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