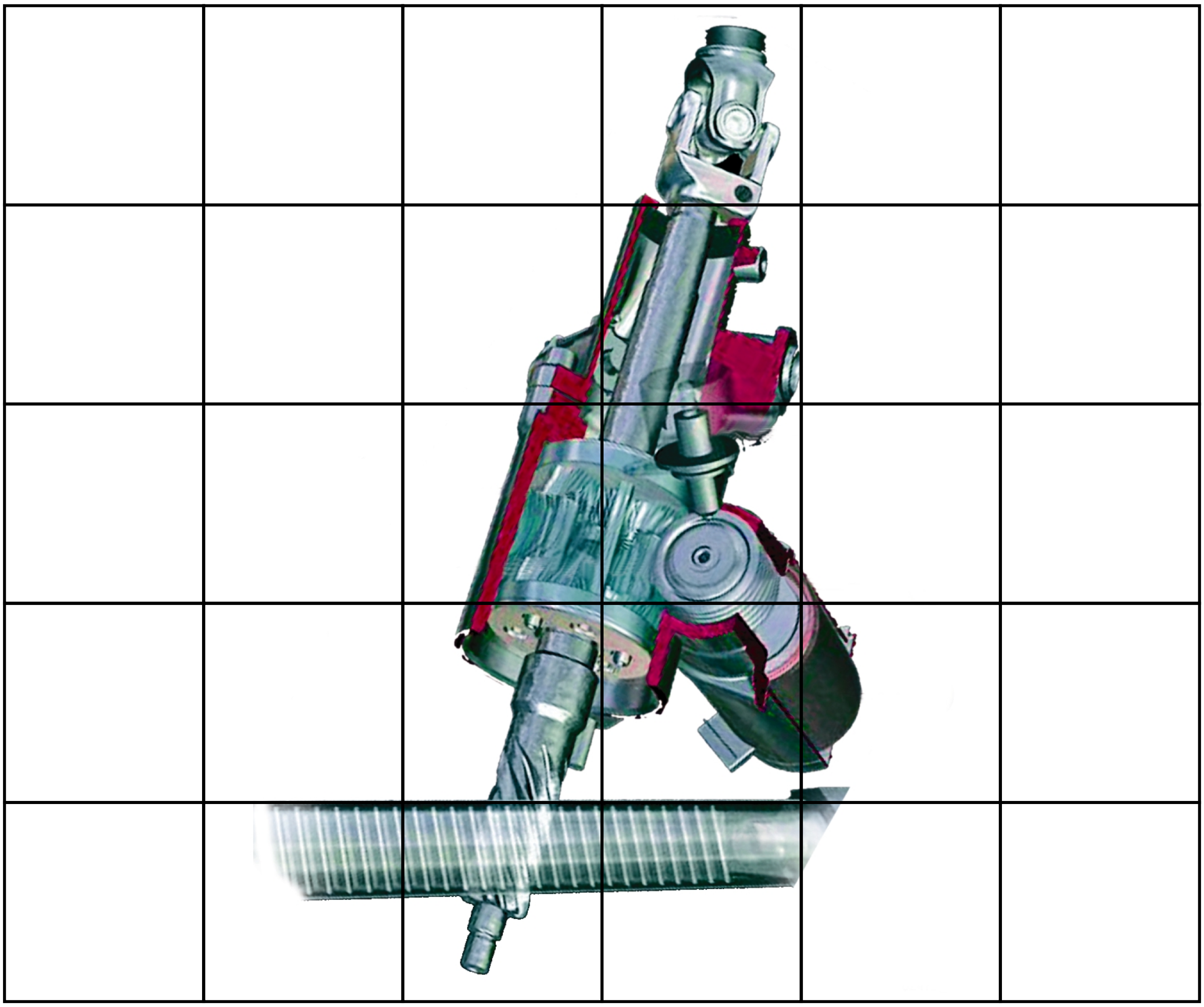
BMW Group
Aftersales Training

E60 Chassis
Participant Manual



NOTE
The information contained in this training course manual is intended solely for participants of the BMW Service Training course.
Refer to the relevant "Technical Service" information for any changes/ supplements to the Technical Data.

VS-42 MFP-HGK-BRK-0400

Contents

E60 Chassis

Basic principles of chassis and suspension engineering and terms used in chassis and suspension geometry will be explained using the E60 chassis and suspension as an example.

A wheel-alignment check which has been precisely carried out is essential in ensuring optimum driving performance, driving comfort, driving safety and trouble-free operation of the complex in-car systems. DynamicDrive, Dynamic Stability Control and Active Front Steering are just some examples of systems which rely on signal inputs which are dependent on the chassis and suspension setting.
It is important to stress the importance of an exact steering-angle offset after repairs to the chassis and suspension. The steering-angle offset is carried out on the wheel-alignment analyzer with the BMW Kinematics Diagnosis System (KDS).

An exemplary wheel-alignment check is carried out with the KDS. Reference is made within the framework of this description to the fault sources which can occur during a wheel-alignment check.

The following areas are discussed on an E60-specific basis:

- Active Front Steering
- Front axle
- Rear axle
- Suspension and damping
- Brakes
- Wheels and tyres, tyre defect indicator

Wheel-alignment check

- Chassis-and-suspension-specific terms

Geometrical axis

The geometrical axis is the angle bisector of the total toe-in angle of the rear axle.

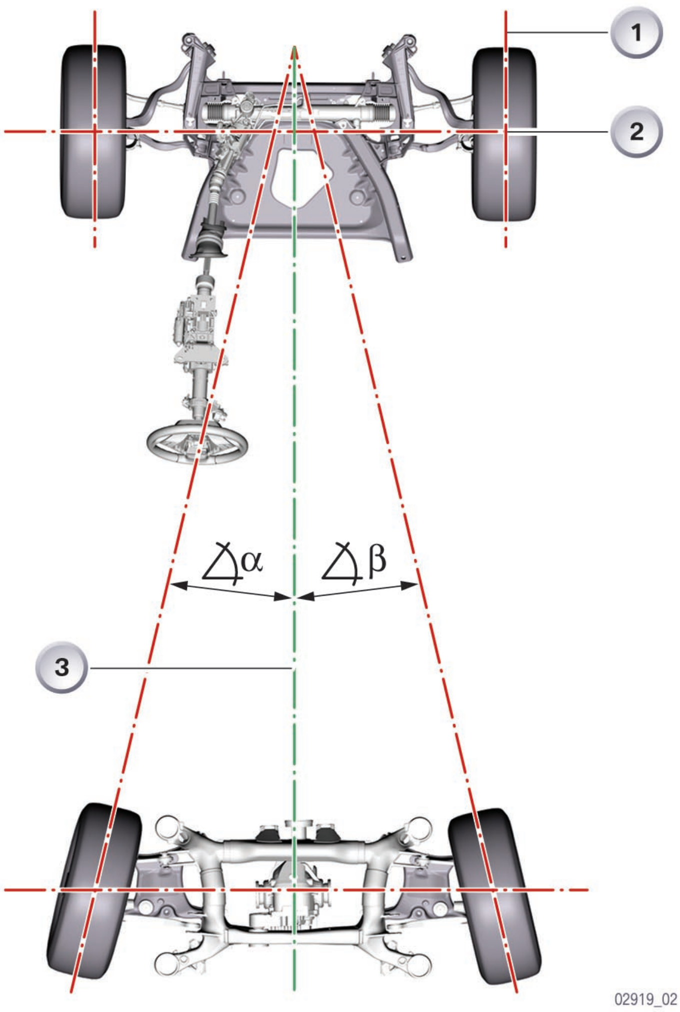


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Fig. 1: Geometrical axis

Index	Explanation	Index	Explanation
1	Wheel centre plane	3	Geometrical axis
2	Wheel contact point		

Longitudinal centre plane of vehicle

The longitudinal centre plane of the vehicle is a plane which is perpendicular to the road surface and passes through the middle of the track width of the front and rear axles.

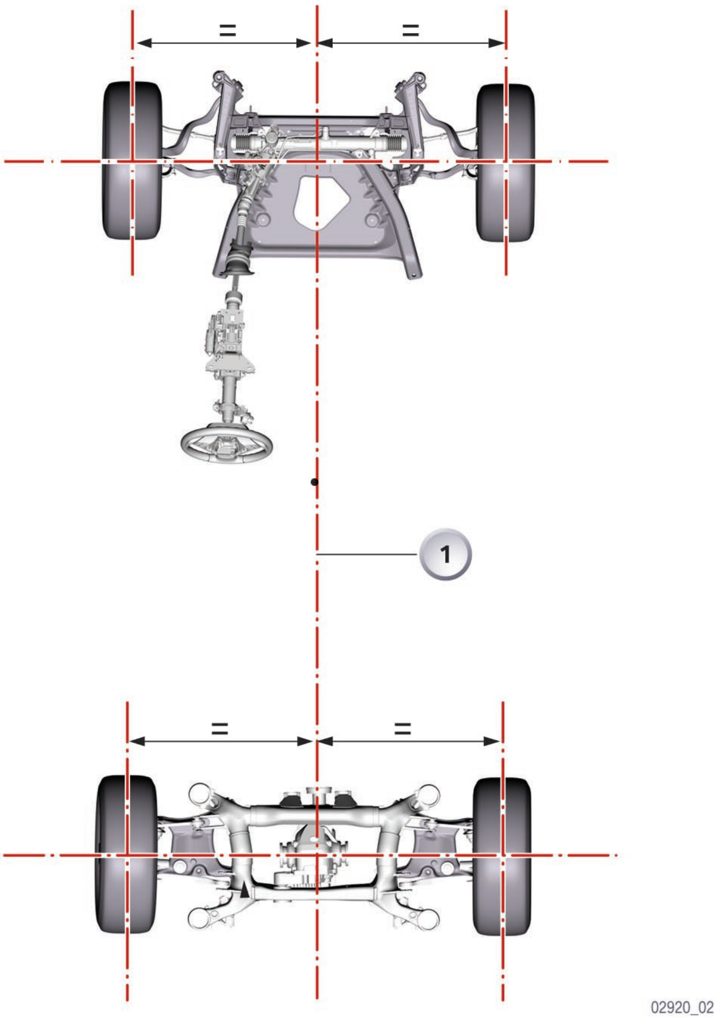

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Fig. 2: Longitudinal centre plane of vehicle

Index	Explanation
1	Longitudinal centre plane of vehicle

Wheel axle angle

The wheel axle angle is the angle between the longitudinal centre plane of the vehicle and the angle bisector of the total toe-in angle of the rear axle.
It is positive when the angle bisector points to front left. It is negative when the angle bisector points to front right. The wheel axle angle is produced from the toe, lateral offset and inclination of the rear axle. The vehicle drives straight ahead on this axle.

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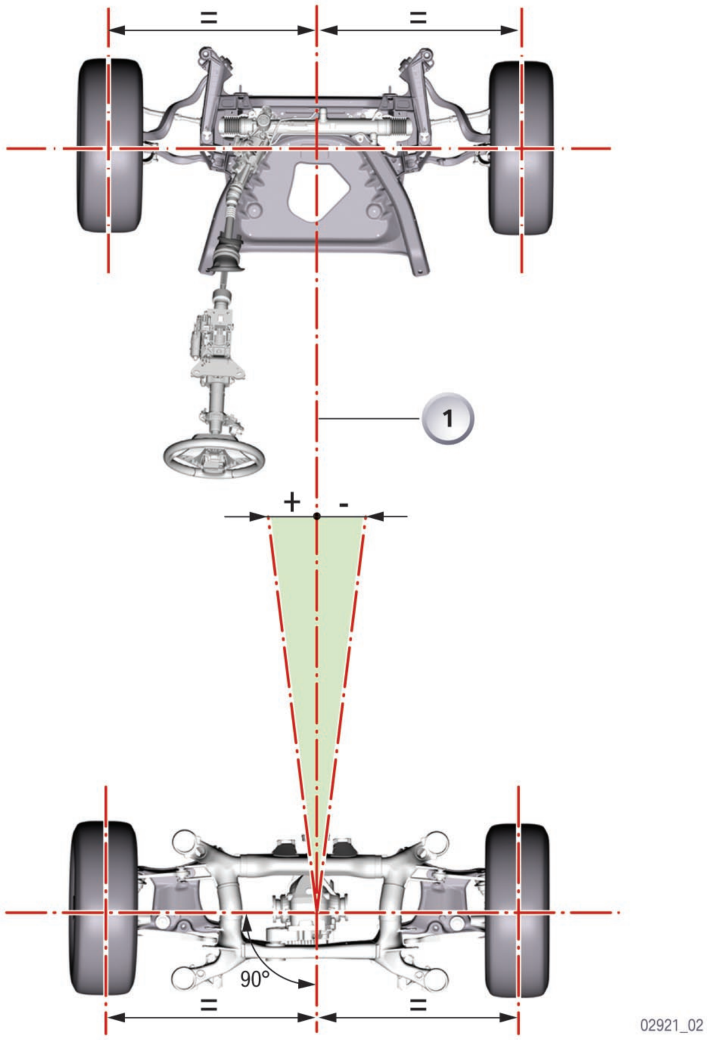

Fig. 3: Wheel axle angle

Index	Explanation
1	Longitudinal centre plane of vehicle

Track width

The track width is the distance from rim centre to rim centre on an axle.

The track width has a significant influence on the vehicle's cornering ability. A greater track width allows the vehicle to take corners at higher speeds.

In the case of independent wheel suspension, with control or semi-trailing arms, a change in track width occurs during wheel compression and rebound. This change in track width increase rolling resistance and tyre wear.

Toe

The total toe of an axle is calculated from the difference in distance between the wheels on an axle at front and rear. The measurements are taken at the rim flanges.

The individual toe on the front axle designates the angle of an individual wheel in relation to the geometrical axis.

The individual toe on the rear axle designates the angle of an individual wheel in relation to the longitudinal centre plane of the vehicle.

Toe errors do not result in constant vehicle "pulling."

Camber

The camber is the inclination angle of the wheel to the perpendicular. It is positive when the wheel is leaning outwards at the top. It is negative when the wheel is leaning inwards at the top.

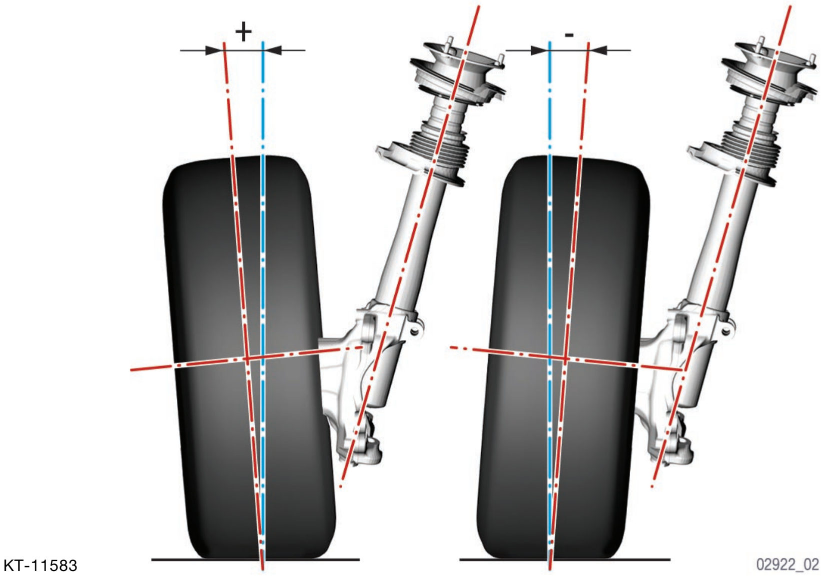

Fig. 4: Camber

Camber errors do result in constant vehicle "pulling." A negative camber on the front axle causes the vehicle to oversteer. A positive camber on the front axle causes the vehicle to understeer.

Kingpin inclination

The kingpin inclination is the inclination of the swivel axis (spring-strut rotation axis) in the vehicle transversal direction to a perpendicular to the road surface.

Kingpin inclination and camber together on the MacPherson strut form an angle (included angle) which remains constant during wheel compression and rebound.

The kingpin inclination raises the vehicle during a steer angle. It also generates self-aligning forces which return the wheels and steering wheel to the straight-ahead position after driving through a bend.

Kingpin-inclination errors do result in vehicle "pulling."

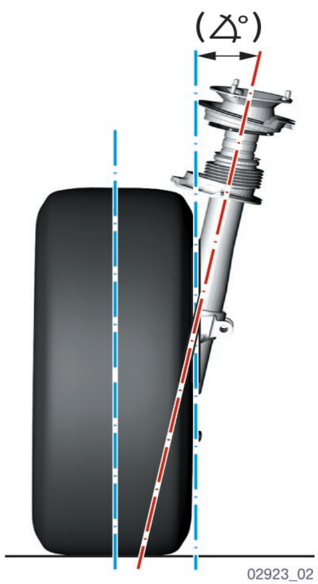

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Fig. 5: Kingpin inclination

Kingpin offset

The kingpin offset, or steering offset, is the distance between the wheel centre plane at the wheel contact point and the point at which the extended spring-strut rotation axis intersects the road surface.

The kingpin offset can be positive, negative and zero.

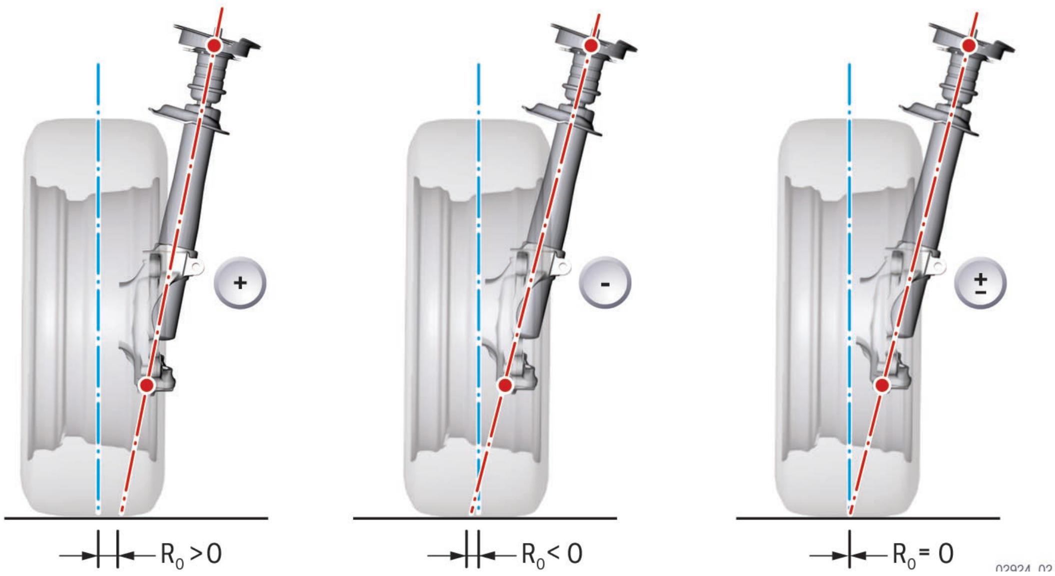

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Fig. 6: Kingpin offset

Index	Explanation
R_0	Kingpin offset

In the event of a large positive kingpin offset, the steered wheels are heavily affected by rolling resistance. In the case of alternating road grip or different wheel loads, it is the stronger wheel which assumes the control function. This gives rise to bumpy straight-ahead driving. Today's car designers aim to keep the kingpin offset as small as possible (E65 = 0, E60 = 2 mm).

Caster

The caster is the inclination of the swivel axis in the direction of the longitudinal vehicle axis from the perpendicular to the road surface through the wheel centre.
The caster offset is the distance between the points of intersection of the swivel axis and the perpendicular through the wheel centre, measured at the road surface.

When the caster is positive, the wheel contact point follows the contact point of the swivel axis (the wheels are pulled). Positive caster gives rise to directional stabilization.

When the caster is negative, the wheel contact point precedes the contact point of the swivel axis (the wheels are pushed). Negative caster gives rise to light steering movement.

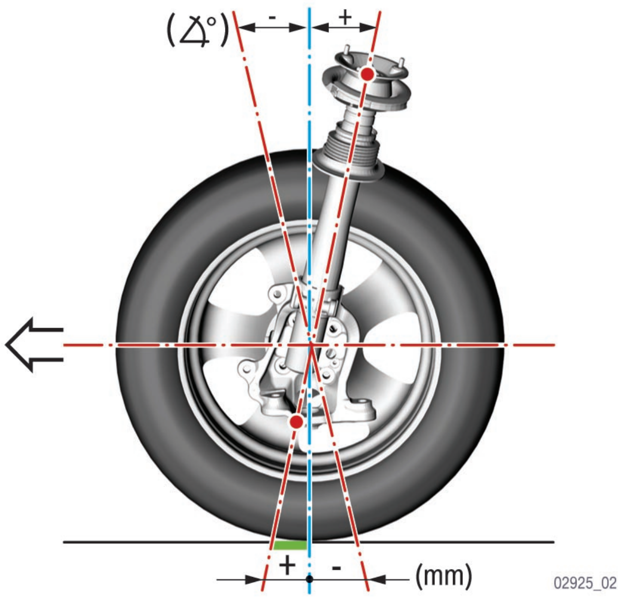

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Fig. 7: Caster angle and caster offset (green)

Positive caster supports the straight-ahead position of the wheels.

Caster errors do result in vehicle "pulling."

Toe difference angle

The toe difference angle is the angle difference δ between the inner wheel and the outer wheel as the vehicle is cornering. The steering is designed in such a way that the angular position of the wheels to each other changes as the steering angle increases. The toe difference angle is measured with the inner wheel at a steering angle of 20°. The measuring sequences takes into account the toe-in.

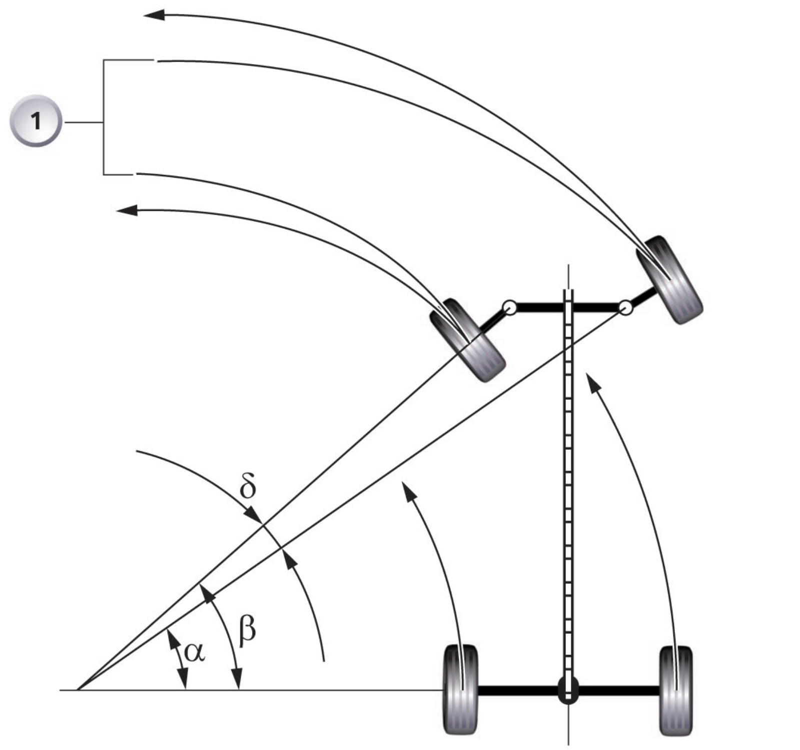

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Fig. 8: Toe difference angle

Index	Explanation
1	Natural path with equal steering angle

Maximum steering angle

The maximum steering angle is the angle of the centre plane of the inner and outer wheels with the steering wheel at full left- and right-hand lock in relation to the longitudinal centre plane of the vehicle.

- Test bay requirements

The test bay should be positioned in the workshop/garage in such a way that the vehicles to be measured/aligned can be driven on straight. It is essential for the test bay to have been aligned and set to the required levels of precision with levelling instruments.
Make sure the power supply cable is safely routed in order to avoid interference with the wheel-alignment system. A power socket should be available directly at the measuring platform so as to rule out potential differences between the platform running rails and the computer power supply.

- The wheel contact points must be situated at the same height. The contact surfaces of the rotary and slide-in plates must not exceed height differences on one axle (right/left) of 0.5 mm or between front/rear and diagonally of 1 mm. Otherwise the camber, toe and caster values will be distorted.
  A rotary-plate height difference of 2 mm between left and right will result in a camber measuring error of 4.8°.
- The rotary and slide-in plates must be pinned to the lifting platform. This prevents them from shifting when the vehicle is driven on.
- The rotary and slide-in plates must demonstrate ease of movement. This eliminates the risk of distortion in the chassis and suspension. Distortion in the wheel suspension will result in erroneous readings for toe and camber.

- The rotary and slide-in plates are aligned to the track width and wheelbase. It is important to ensure that the plates of the rotary underlays cannot run against the radial limit stops during the steering routine. This would cause distortion in the wheel suspension and thus result in measuring errors.
- Quick-action clamping units and sensor pins of the measuring-instrument holders must be handled correctly. Excessive abrasion in the take-up sleeves or worn sensor pins will result in toe and camber measuring errors.

- Vehicle preparation

The vehicle must be prepared before the alignment check is started:

- Check the vehicle to ensure that the rim and tyre sizes are the same. Check to ensure sufficient tread depth and correct tyre inflation pressure in order to avoid camber measuring errors.
- Check play in the steering and at the wheel bearings.
- Check the condition of the suspension and damping.
- Make sure the bores in the rims and the locating points in the wheel hubs (for subsequent accommodation of the sensor pins of the measuring-instrument holders) are clean. Dirt or sensor pins of varying degrees of wear will result in significant toe and camber measuring errors.
- Drive the vehicle centrally onto the rotary plates.
- Secure the vehicle against rolling back.

These vehicle preparations are carried out to safeguard the basic requirements for wheel alignment and for the elimination of simple fault sources.

- Vehicle conditioning

- Remove the locking pins from the rotary or slide-in plates on one side of the vehicle in order to prevent chassis distortion during loading. Locking the rotary and slide-in plates on one side of the vehicle prevents the vehicle from shifting.
- Select the vehicle equipment in the vehicle setpoint data memory mask of the KDS. Enter the vehicle type and the rim size.
  Notes on differentiating between standard or special chassis appear in the KDS after the setpoint data have been selected for the vehicle type via the red question mark in the mask.
- Load the vehicle in accordance with KDS specifications in order to determine the condition of the support springs. Observe the tank capacity.
- Loading of the vehicle is no longer necessary for wheel-alignment checks on E46, E65 and E85 vehicles and on future models.
- The actual ride levels are measures and entered in the KDS. If the ride levels are outside the tolerances of ±10 mm, then the support springs are old and stiff, the wrong support springs are fitted or the wrong chassis has been selected.
  If the actual ride levels are within the tolerance range and do not deviate too markedly from one another, then the KDS makes the setpoint data available for the wheel-alignment check.
  If the actual ride levels on those vehicles which do not require loading are outside the tolerances or the values differ too much from each other, the wheel-alignment check is carried out with loading.

- If the support springs are checked, the vehicle is brought into the design position by further loading/reloading (±2 mm). The setpoint data for the wheel-alignment check are only applicable to the ride level of the design position.
- Attach measuring-instrument holders to all the wheels. Make sure the handles of the clamping levers are parallel to the tyres or point inwards to the tyres. This is the only way of ensuring that the tensioning springs of the measuring-instrument holders have sufficient pretension.
- Remove the handles of the clamping levers from the front measuring-instrument holders.
- Insert the pickups in the measuring-instrument holders.
- Once the pickups have been fitted, the measuring-instrument holders can be correctly seated by uniformly turning the sensor pins. The sensor pins must show the same turning resistance. If the sensor pins cannot be turned or are too loose, either there is dirt in the take-up sleeves or the sensor pins are worn.
- Align the pickups using the integrated spirit levels.
- Carry out positioning of the pickups by entering the numbers 1 to 4 at the pickups .
- Switch on the wheel-alignment system or start a new alignment check. All previous values are deleted. The positioning of the 4 pickups is read in.
- The vehicle setpoint data are called up from the data memory by means of menu prompting.
- Block the service brake by inserting the brake tensioner. Inserting the brake tensioner ensures that the wheels do not roll during the steering routine, thus eliminating the risk of errors in measurement of the kingpin-inclination angle.

- The vehicle setpoint data are called up from the data memory by means of menu prompting.
- Remove the locking pins for the rotary or slide-in plates on the second side of the vehicle.

Vehicle loading (e.g. 3 x 68 kg on the seats + 21 kg in the luggage compartment) is used to check the support springs. If this proves to be in order within the permitted tolerances, the exact ride level is set with the subsequent reloading operation. The vehicle is now in the design (standard) position. The setpoint values stored in the KDS relate to this ride level only.

- Incoming wheel-alignment check

The incoming wheel-alignment check, the adjustment tasks and the concluding outgoing wheel-alignment check can be carried out as a program-prompted check or as a check with random access.

In the case of the program-prompted alignment check, the order of the chassis measuring points to be called up is specified by the system software and controlled by the software. For each measuring point, the corresponding chassis graphic is displayed together with the current measurement data in a setpoint/actual-value comparison. Work through the complete measuring process by selecting the "Program step forwards" and "Program step back" buttons.

In the case of the alignment check with random access, the order of the measuring points can be freely selected. The desired measuring point can be selected by touching the relevant graphic on the screen with the touch pin. In spite of this free selectability, some points must be observed in the order of measurements in order to obtain correct results. This wheel-alignment check with random access is intended for workshop/garage personnel with appropriate previous knowledge and sufficient experience.

Procedure for incoming wheel-alignment check

- Set "Driving straight ahead" for correct recording of the toe and camber values for the rear axle.
- Carry out the steering routine with 20° steering angles on both sides to determine caster, kingpin inclination and toe difference angle.
- When the vehicle is touched in order to carry out the steering routine, the infrared transmission path from the pickups to the KDS is interrupted. Only when there is a turning movement at the steering wheel does the KDS switch over to the rotary-plate signals.
- Set the steering centre point. Record toe and camber for the front axle.
- Carry out the steering routine in order to measure the maximum left/ right steering angle.
- Check the measured-value summary with setpoint/actual-value comparison of all the measured values.

If all the measured values are within the permitted tolerance, a test record can be printed out and the wheel-alignment check terminated on this vehicle.

If actual values are outside the tolerance, replace damaged parts and/ or perform adjustment tasks.

Adjustment tasks

- Perform "Driving straight ahead" in accordance with the operator prompting in the monitor display.
- Adjust the rear axle. Adjust camber and toe separately. The camber is adjusted before the toe. The associated adjustment pictures and texts of the repair instructions can be displayed at the touch of buttons before the measured values are corrected in the permanent setpoint/ actual-value comparison with simultaneous display of all the rear-axle values.
- There is a special adjustment mask for the chassis of the legendary M1: a 3-part display of caster, camber and toe can be called up for the relevant front wheel. The ongoing change to the values is shown in a setpoint/actual-value comparison in this display. This results in reciprocal influencing of the adjustment. The adjustment order of caster, camber, individual toe has therefore proven itself.
- On BMW chassis with the option of camber adjustment, this can also be performed with the axle raised. To do so, select the orange arrow in the KDS screen mask.
- In the case of a wheel-alignment check with random access, the camber adjustment of the front wheels can be shown in an image.
- Adjust the front axle. In the final adjustment of the individual toe values, it is important first to envisage the steering centre point on the steering gear. A check is now conducted as to whether the steering wheel is straight. Only then is it locked with the steering-wheel arrester. The correct toe-in value can now be adjusted by turning the steering tie rods.
- Adjust the maximum steering angle. By repeating the steering routine, it is possible to determine with the monitor display whether the specified setpoint value has been achieved with the corrections made.

Outgoing wheel-alignment check

- Recording of front-axle toe and camber with the monitor instruction to adjust the steering centre point beforehand. Recording of toe and camber can be omitted if at the end of the previous adjustment tasks the toe and camber were adjusted and valid values were stored.
- Set "Driving straight ahead" for correct recording of the toe and camber values for the rear axle.
- Carry out the steering routine with 20° steering angles on both sides to determine caster, kingpin inclination and toe difference angle.
- Carry out the steering routine in order to measure the maximum left/right steering angle.
- Check the measured-value summary with setpoint/actual-value comparison of all the measured values. If all the measured values of the outgoing check are within the permitted tolerances, a test record can be printed out and the wheel-alignment check terminated for this vehicle.

Active Front Steering

Conventional rack-and-pinion power steering is used in the E60. Two items of options (SA) are also available:

- Servotronic (SA 216)
- The active front steering system (SA 217)

The active front steering option is only available in conjunction with the Servotronic option.

The design and operating principle of the Servotronic option have remained the same.

The driving-dynamic active front steering system is used for the first time at BMW.
The electronic controlled steering system assists the driver beyond the torque support of the power steering with a variable steering ratio. The core element of the steering system is the so-called superimposing gear. The superimposing gear is a planetary gear which is integrated in the split steering column.
An electric motor engages the planetary gear via a worm-gear drive as a function of the vehicle speed. In this way, the steering system generates according to the driving situation an additional or reduced front-wheel angle by modifying the steering spindle/pinion gear ratio.

In critical situations, the steering system can specifically modify the wheel angle engaged by the driver and thereby stabilize the vehicle more quickly than the driver.

The active front steering system is integrated in the vehicle electrical system via the Powertrain CAN (PT-CAN) and the new Chassis CAN (F-CAN).

The active front steering system is very closely linked to the Dynamic Stability Control (DSC) drive-control system. Sensors and signals used by DSC are also used by the active front steering control unit.

- New system features

The flow rate supplied by the hydraulic pump is adjusted by means of an electrically controllable valve, known as an Electrically Controlled Orifice (ECO). It is controlled as a function of engine speed, road speed and steering-wheel angle.

- Advantages of system

The active front steering system assists the driver in steering movements and actively introduces additional steering angles into the steering as a function of driving-dynamic variables.

When the vehicle is being parked, only minimal steering-wheel movements are needed to deliver large steering angles. Less than 2 turns are needed to move the steering wheel from one lock to the other.

At high speeds, on motorways for instance, the steering gear ratio becomes increasingly more indirect right up to the level of conventional steering and even beyond.
The simultaneously increasing steering-wheel torque level prevents unintentional steering movements and the driver can feel the improvement in directional stability.

Unintentional vehicle motion, e.g. oversteering, is compensated by the active front steering system without the driver having to take corrective action to maintain the desired course.

- Mechanical system overview

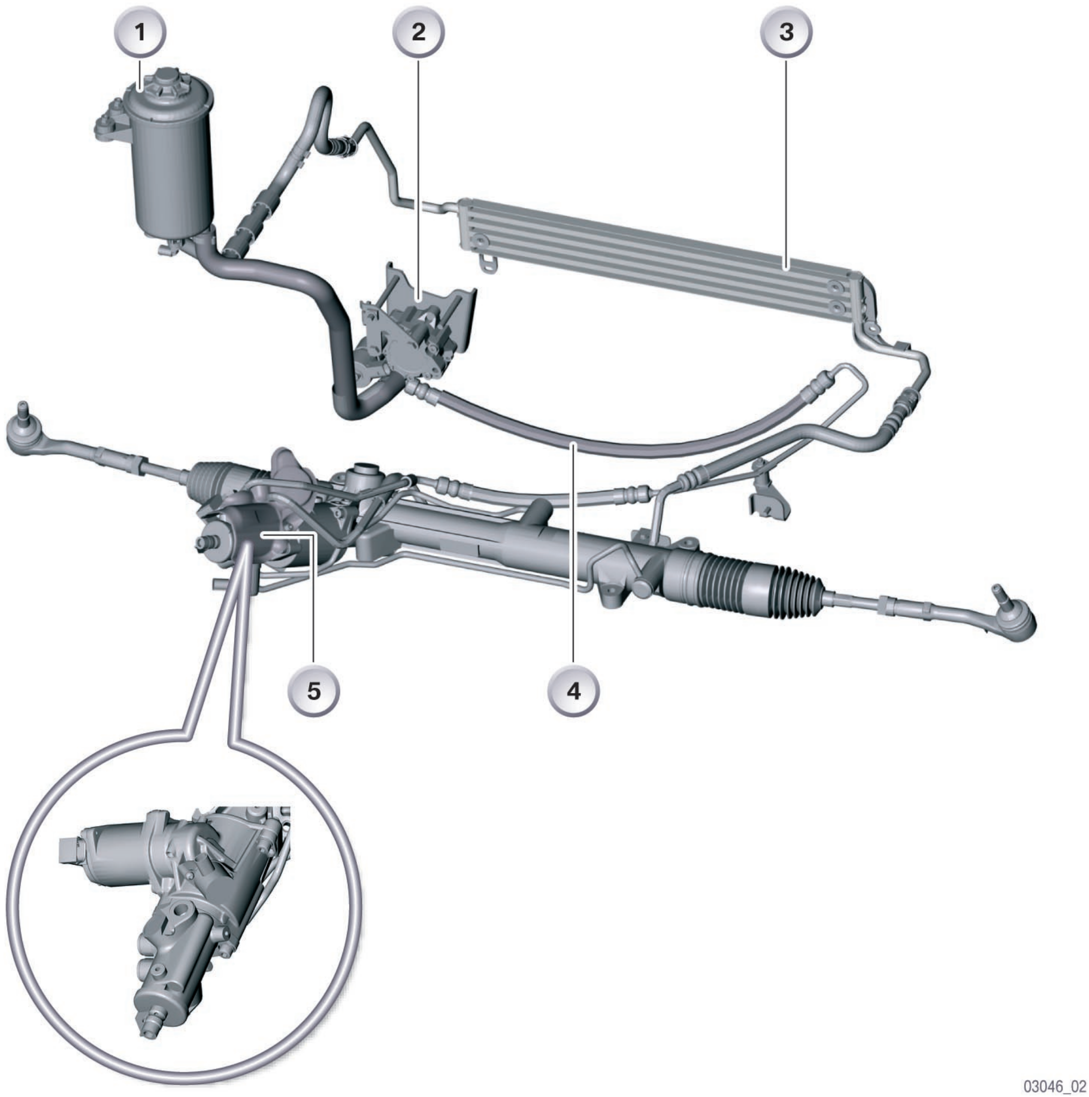

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Fig. 9: System overview of mechanical active front steering components

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

- Inputs/outputs

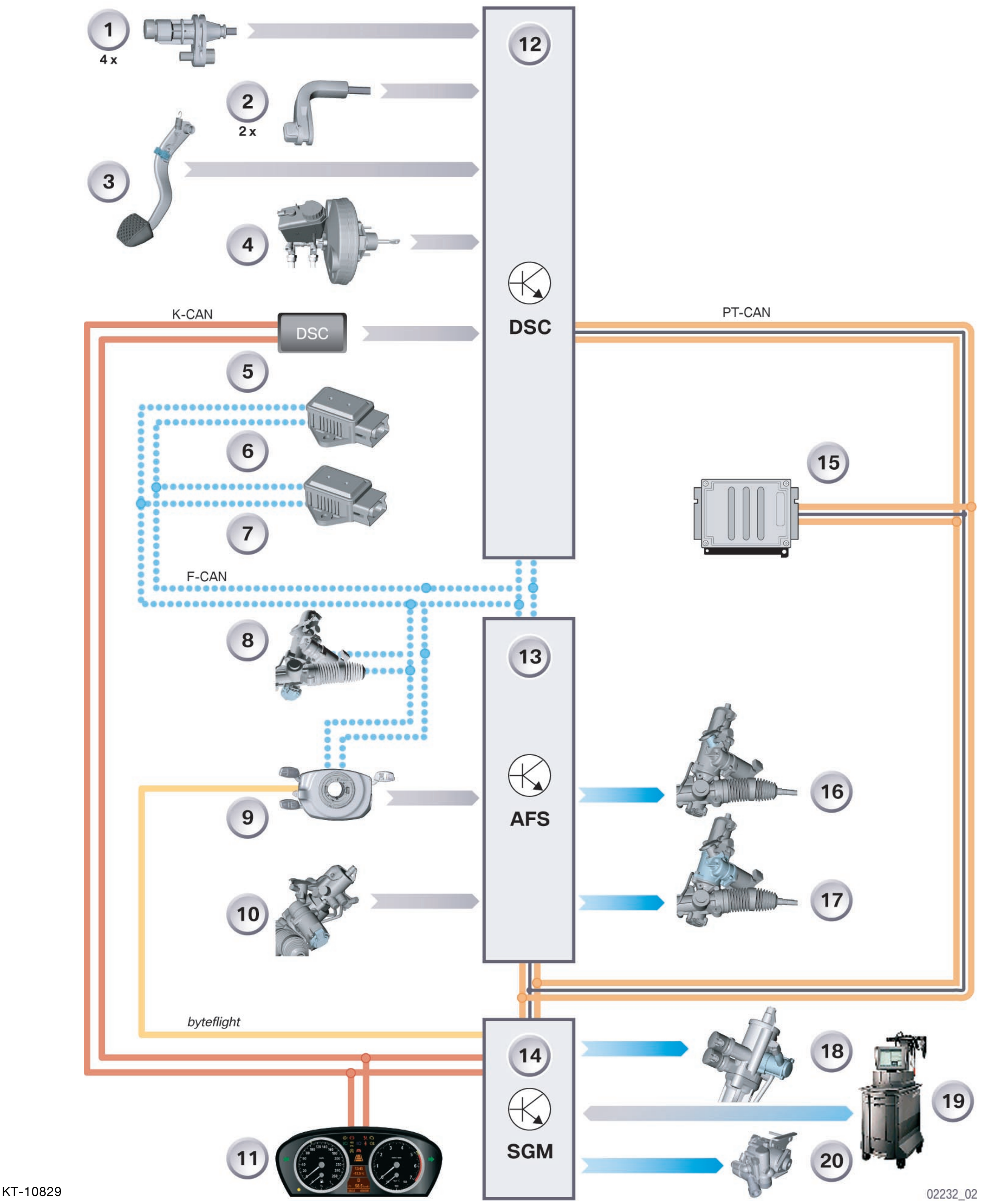

Fig. 10: System overview of active front steering

Index	Explanation	Index	Explanation
1	Wheel-speed sensors	13	AFS active front steering control unit
2	Brake-pad wear sensors	14	SGM control unit
3	Brake-light switch	15	DME control unit
4	Brake-fluid level switch	16	Lock, actuating unit
5	DSC button	17	Active front steering actuating unit
6	DSC sensor 1	18	Servotronic valve
7	DSC sensor 2	19	BMW diagnostic system
8	Summation steering-angle sensor	20	Hydraulic pump with ECO valve
9	Steering-angle sensor	PT-CAN	Powertrain CAN
10	Motor position sensor, actuating unit	F-CAN	Chassis CAN
11	Instrument cluster	*byteflight*	*byteflight*
12	DSC control unit	K-CAN	Body CAN

Note: The SGM is the Safety and Gateway Module.

- System schematic

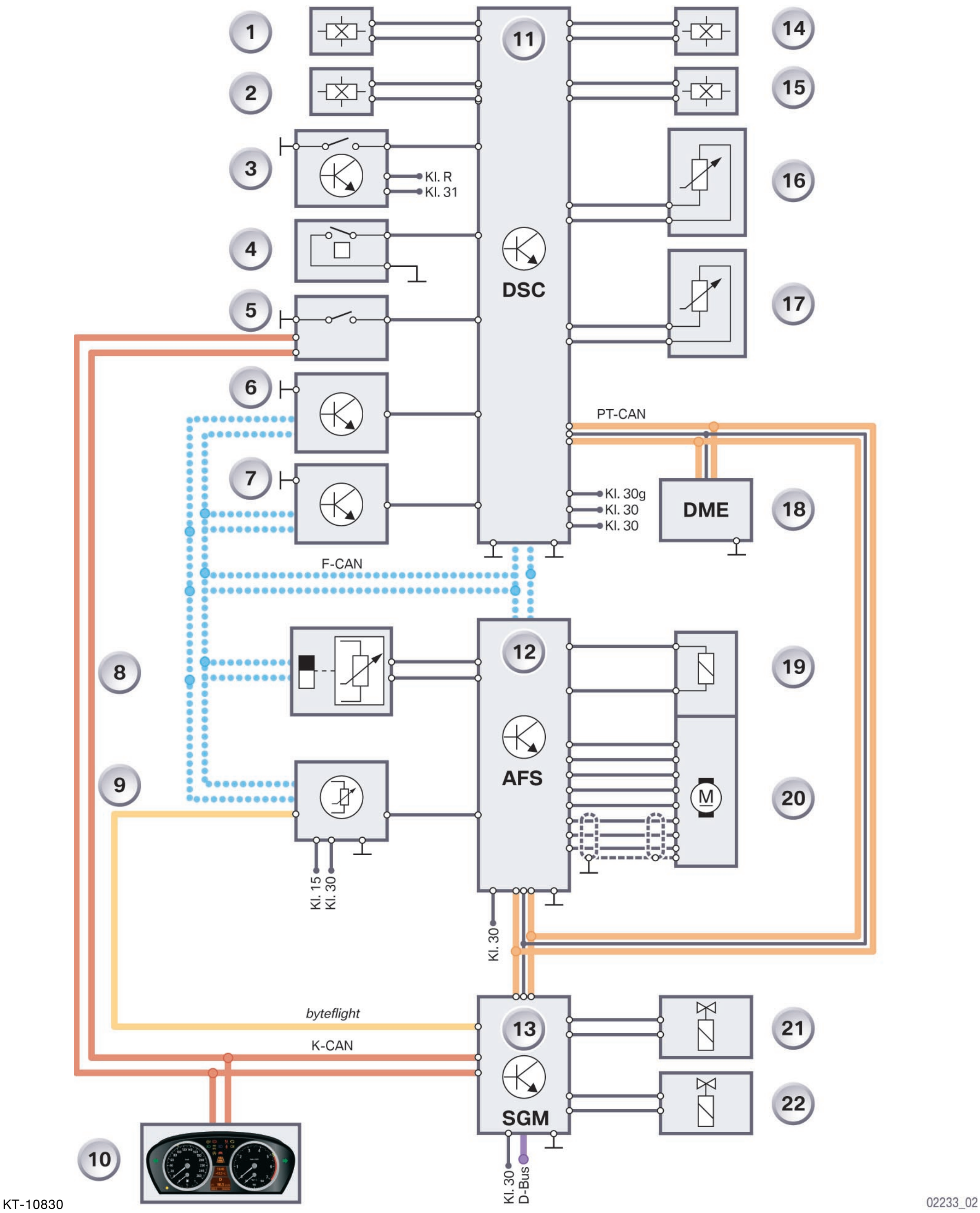

Fig. 11: System schematic, active front steering

Index	Explanation	Index	Explanation
1	Wheel-speed sensor, front left	16	Brake-pad wear sensor
2	Wheel-speed sensor, rear left	17	Brake-pad wear sensor
3	Brake-light switch	18	DME control unit
4	Brake-fluid level switch	19	Lock, actuating unit
5	DSC button	20	Electric motor, actuating unit
6	DSC sensor 1	21	Servotronic valve
7	DSC sensor 2	22	ECO valve, hydraulic pump
8	Summation steering-angle sensor	Kl.15	Terminal 15
9	Steering-angle sensor	Kl. 30	Terminal 30
10	Instrument cluster	Kl. R	Radio terminal
11	DSC control unit	Kl. 31	Terminal 31
12	AFS active front steering control unit	F-CAN	Chassis CAN
13	SGM control unit	PT-CAN	Powertrain CAN
14	Wheel-speed sensor, front right	K-CAN	Body CAN
15	Wheel-speed sensor, rear right	D-Bus	Diagnosis bus

- DSC sensor

The lateral-acceleration and yaw-rate sensors are combined in a single housing and designated the DSC sensor. The active front steering system is also provided with a second DSC sensor in addition to the DSC sensor fitted as standard.

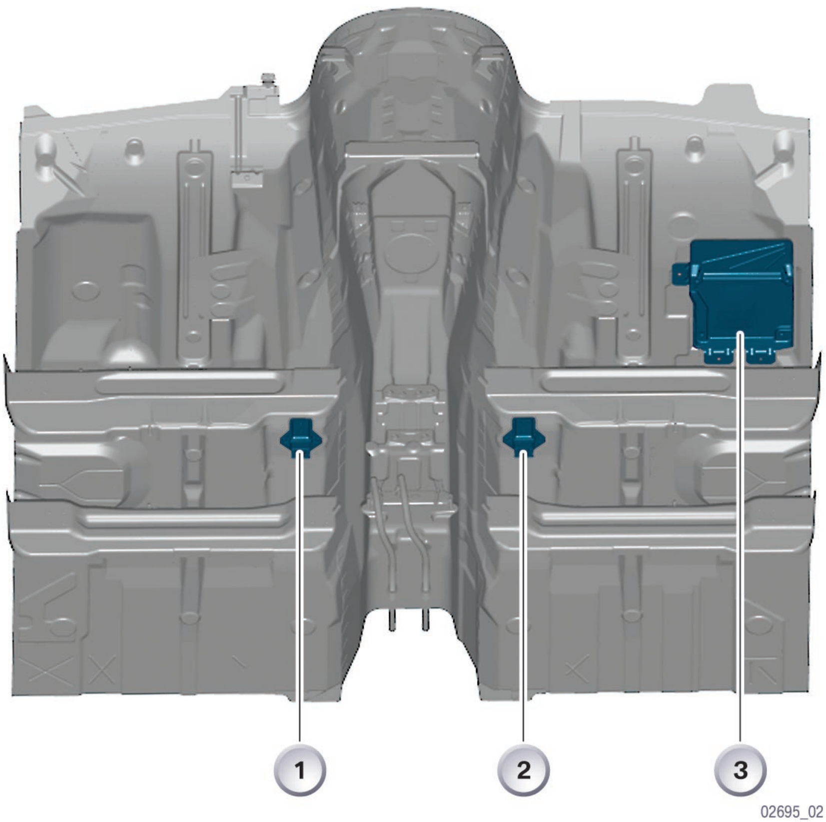

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Fig. 12: Installation locations of DSC sensors and active front steering control unit

Index	Explanation	Index	Explanation
1	DSC sensor for active front steering	3	Active front steering control unit
2	DSC sensor for brake system		

The DSC sensor fitted as standard is located under the right front seat.

The second DSC sensor is located under the left front seat

The two DSC sensors are technically identical but coded by means of the software so that they cannot be mixed up.

The second DSC sensor is used for redundant signal acquisition of yaw rate and lateral acceleration.

Both sensors supply yaw-rate and lateral-acceleration signals.

The use of two DSC sensors makes it possible to perform the plausibility check.

- Summation steering-angle sensor

The summation steering-angle sensor is only fitted in the vehicle if the active front steering system is fitted.

The summation steering-angle sensor records the rotation angle of the steering pinion and thus the wheel deflection (or steering angle) of the vehicle.

The summation steering-angle sensor is flanged-mounted at the bottom of the steering gear.

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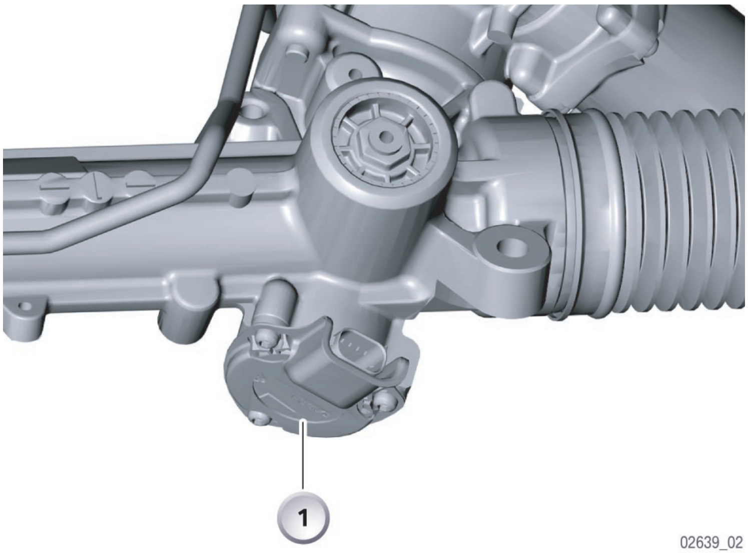

Fig. 13: Summation steering-angle sensor

Index	Explanation
1	Summation steering-angle sensor

- Motor position sensor of actuating unit

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

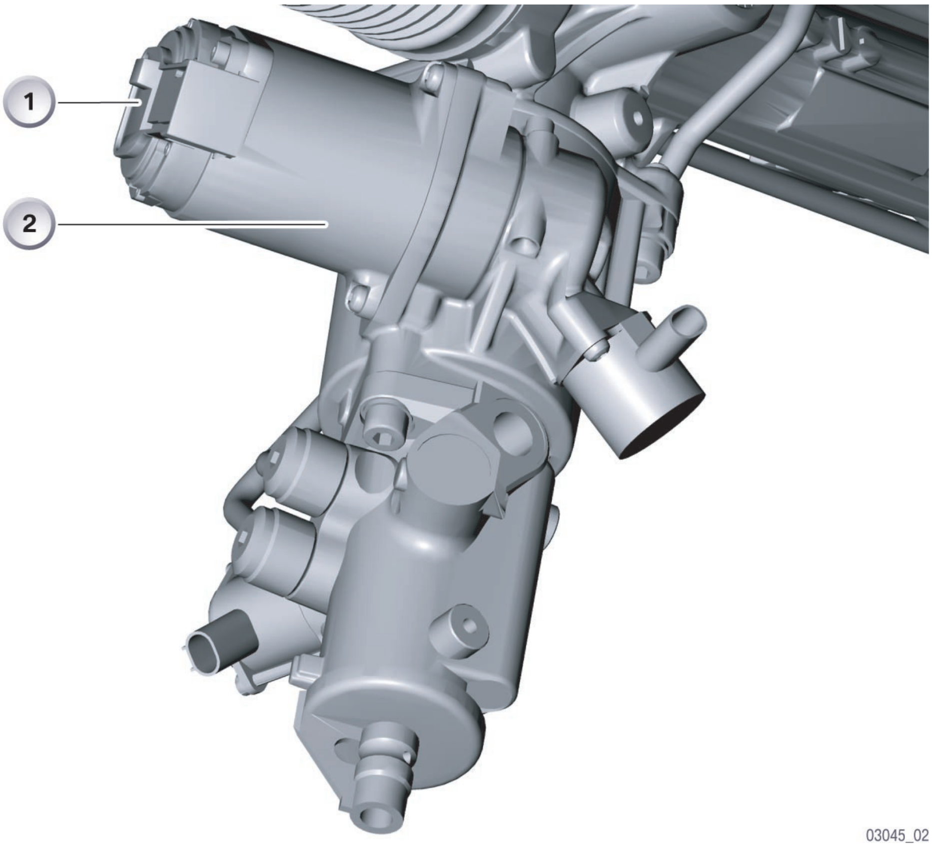

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Fig. 14: Actuating unit

Index	Explanation	Index	Explanation
1	Motor position sensor	2	Electric motor

- Steering-angle sensor

The steering-angle message is directed from the steering column switch cluster (SZL) to the active front steering control unit via a serial interface and via the F-CAN.

The SZL incorporates a second processor for redundant steering-angle calculation. This second processor is only fitted if the active front steering system is fitted and serves to monitor the plausibility of the signal.

The steering-angle sensor is integrated in the steering column switch cluster.

- Active front steering control unit

The active front steering control unit is located in the right footwell and screwed down to the floorpan.

The control unit is protected by a kickplate housing.

The kickplate housing incorporates a pin for connecting the shielding for the 3 phases of the active front steering actuating unit.

The control unit is integrated in the vehicle electrical system via the PT-CAN and the F-CAN.

The active front steering control unit calculates the signals for activating the active front steering actuating unit from the various input signals.

Input signals

- DSC signals (wheel speeds, yaw rate and lateral acceleration)
- Steering angle
- Summation steering angle
- Position of electric servomotor of actuating unit

The active front steering control unit is initialized when the ignition is turned on.
The active front steering actuating unit cannot be activated during the initialization procedure. The sensor signals are checked and if necessary calibrated.

If faults are detected, either the "Error" fault status is adopted or yaw-rate control is deactivated. In the case of the "Error" fault status, it is not possible to activate the actuating unit.

The "Drive" status is adopted after successful initialization.

The active front steering control unit sends the current message corresponding to the required flow rate to the SGM via the PT-CAN.

- Safety and Gateway Module (SGM)

The SGM consists of a combination of the Central Gateway Module (ZGM) known from the E65 and the Safety and Information Module (SIM).

The SGM is located in the equipment carrier behind the glovebox.

The SGM receives from the active front steering control unit the specified setpoint current for activating the Servotronic valve and the ECO. The SGM activates the Servotronic valve and the ECO in pulse-width-modulated form.

In vehicles without active front steering, the software for activating the Servotronic valve and the ECO is implemented in the SGM.

- Hydraulic pump

The hydraulic pump is a vane pump and is equipped with an electrically controllable valve for regulating the flow rate of the hydraulic fluid. This valve is called the Electrically Controlled Orifice (ECO).

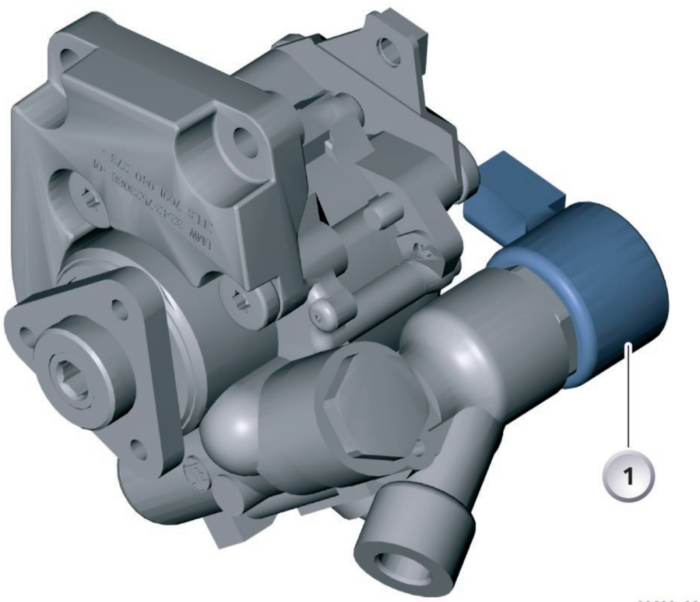

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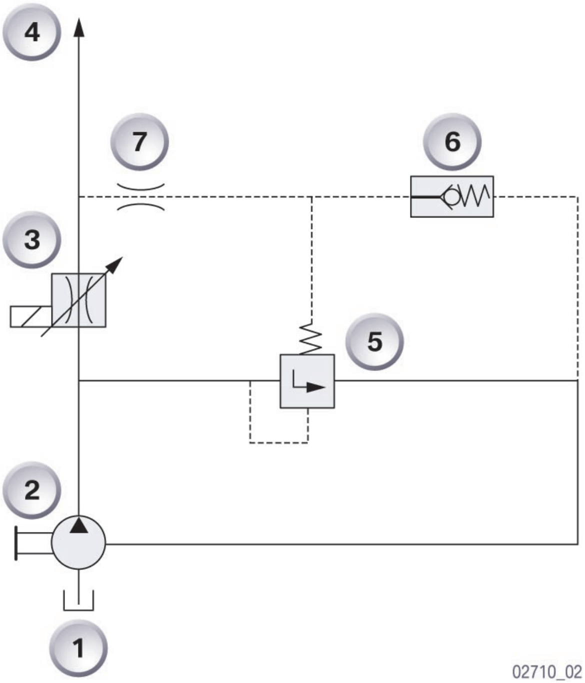
Fig. 15: Hydraulic valve with ECO

Index	Explanation
1	Electrically Controlled Orifice (ECO)

The active front steering system can generate higher wheel-angle speeds compared with conventional rack-and-pinion power steering systems. High hydraulic power levels must be maintained in the hydraulic system for the high wheel-angle speeds. A conventional vane pump of sufficient dimensions would generate a high power loss. This would give rise to an unnecessary increase in fuel consumption. An improvement can be achieved by using a controllable hydraulic pump.

The hydraulic pump with the ECO regulates the flow rate according to requirements and reduces the dynamic pressure in the steering system.



KT-11337

Fig. 16: Hydraulic schematic with ECO valve

Index	Explanation	Index	Explanation
1	Hydraulic reservoir	5	Pressure control valve
2	Hydraulic pump	6	Pressure limiting valve
3	ECO valve	7	Restrictor orifice
4	Rack-and-pinion power steering		

The low power consumption of the hydraulic pump helps to reduce vehicle fuel consumption and thus CO_2 emissions.

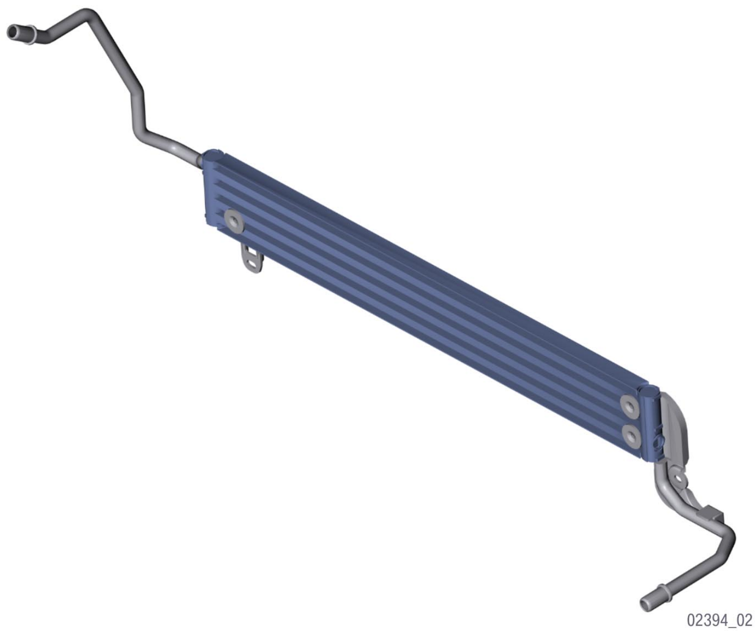
When the ECO is fully energized, the hydraulic pump delivers a maximum flow rate of 15 l/min as a function of engine speed.

When deactivated and de-energized, the hydraulic pump makes available a reduced flow rate of approx. 7 l/min for steering-effort support.

- Power-steering cooler

The power-steering cooler is located on the engine-cooling module.

This cooler consists of 4 tubes of rectangular cross-section and soldered fins.



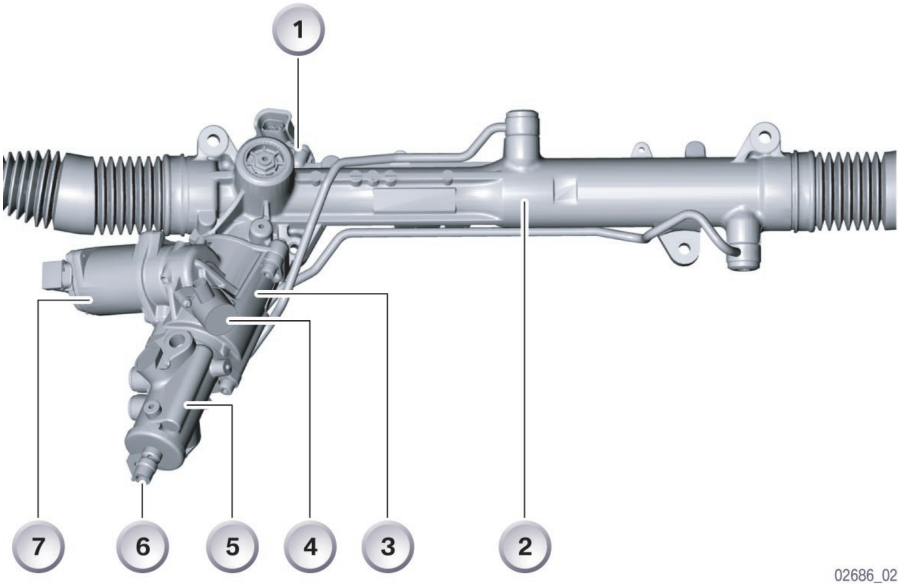
KT-10855

Fig. 17: Power-steering cooler

- Active front steering actuating unit

The active front steering actuating unit is located on the steering gear. It is integrated in the split steering column between the Servotronic valve and the rack.

This actuating unit comprises a brushless synchronous DC motor and a planetary gear.



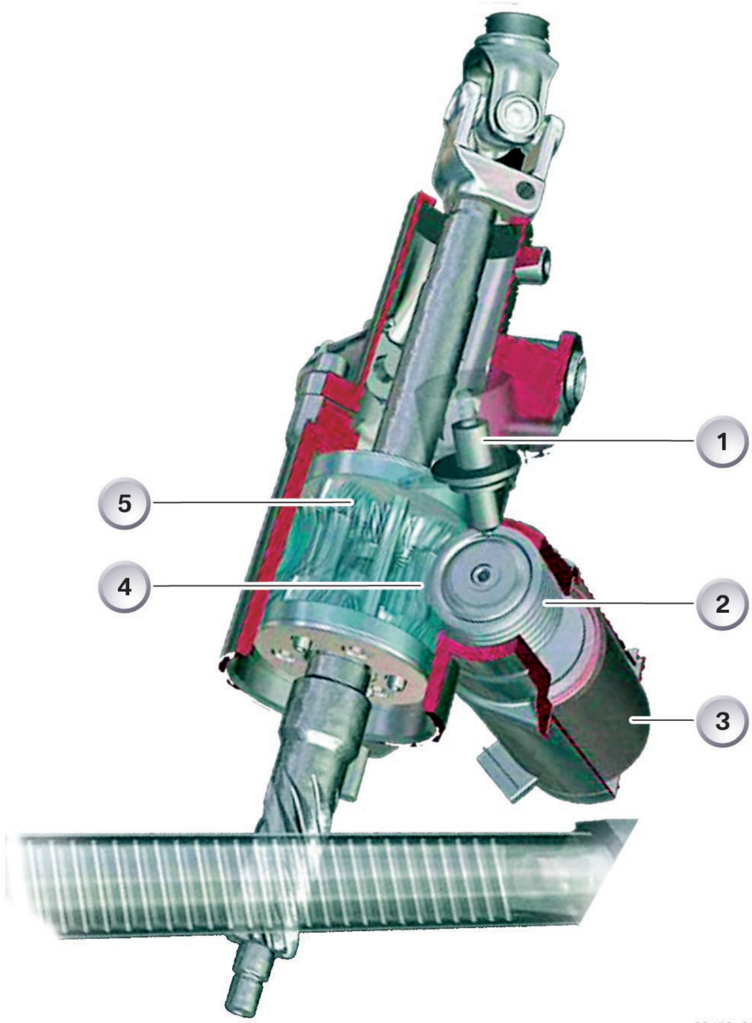
KT-11318

Fig. 18: Actuating unit and rack

Index	Explanation	Index	Explanation
1	Summation steering-angle sensor	5	Servotronic valve
2	Rack	6	Steering spindle
3	Planetary-gear housing	7	Electric motor
4	Magnetic lock		

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

One input shaft is connected via the Servotronic valve to the lower steering spindle. The second input shaft is driven by the electric motor via a self-locking worm-gear drive as a step-down stage. The worm-gear drive drives a worm gear which superimposes the steering angle of the front wheels specified by the driver.

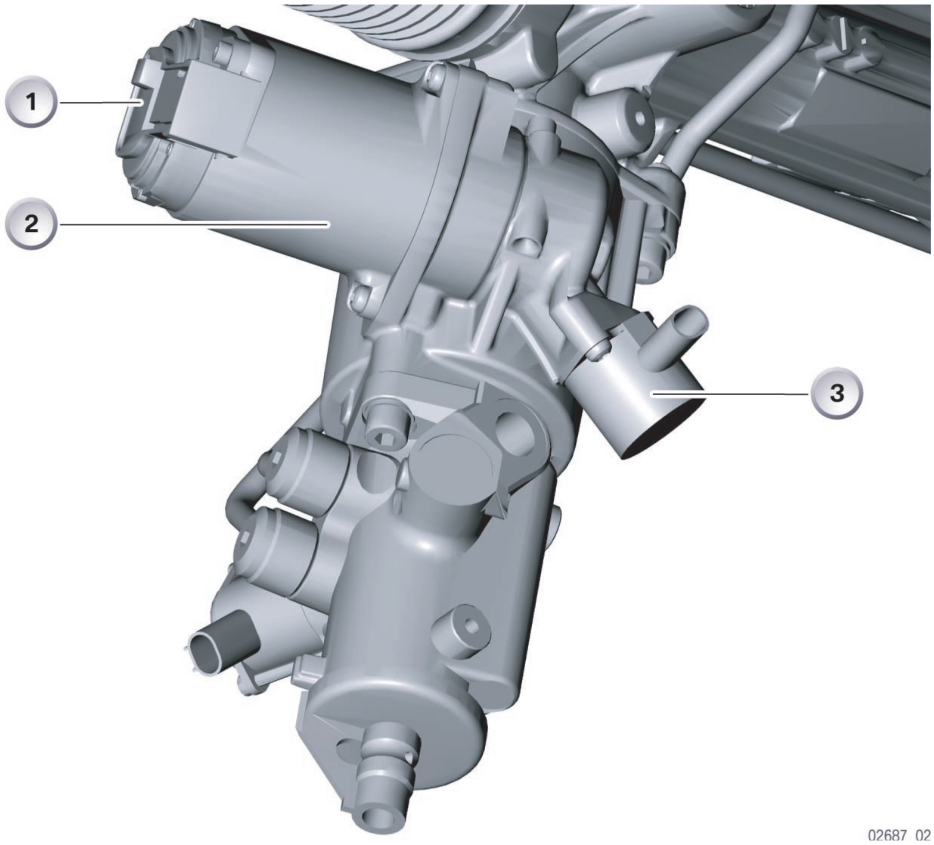


KT-11107

Fig. 19: Design of active front steering actuating unit

Index	Explanation	Index	Explanation
1	Lock	4	Worm gear
2	Worm-gear drive	5	Planetary gear
3	Electric motor		

An electromagnetically controlled safety interlock is fitted. The safety interlock engages under spring load the interlock toothing (last tooth of the worm-gear drive) of the worm-gear drive when there is no voltage applied.
The safety interlock is released at a current of approx. 1.8 A.



KT-11319

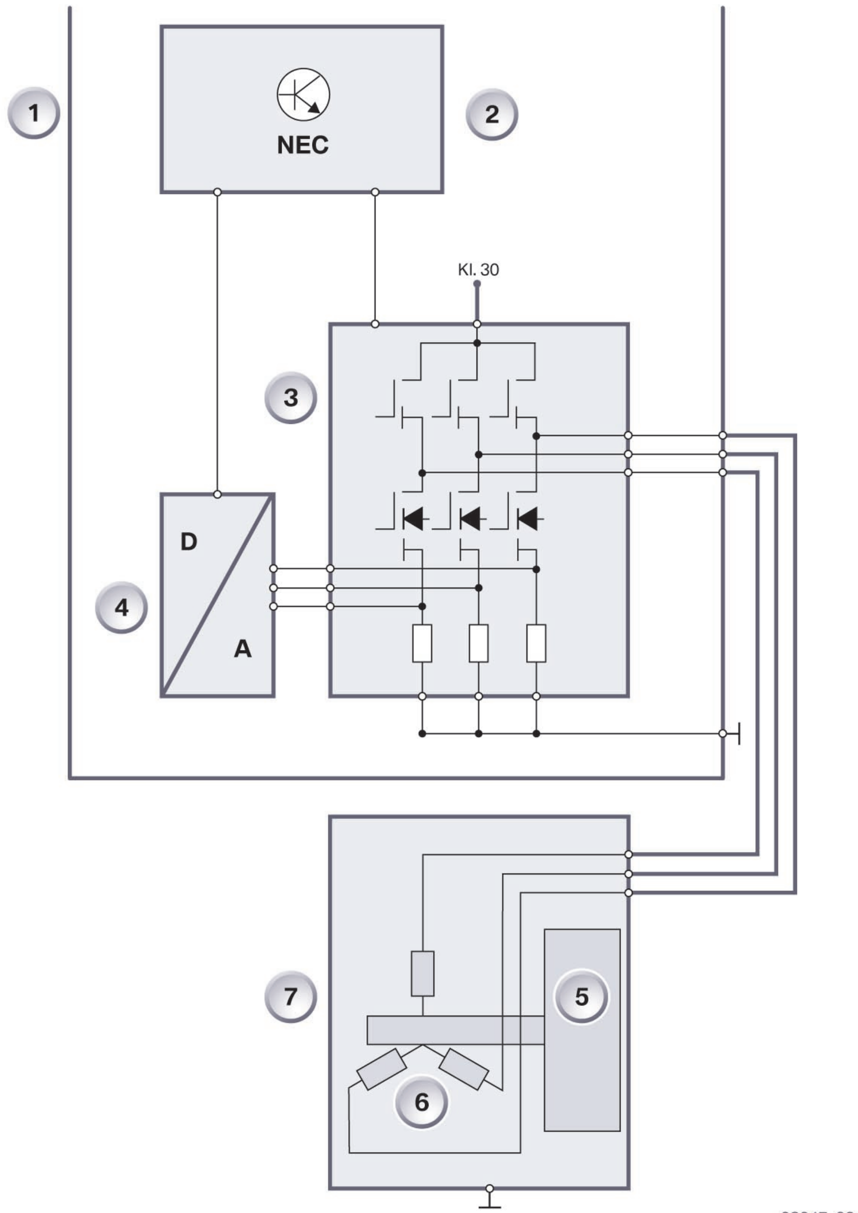
Fig. 20: Actuating unit

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

The rotor position of the electric motor is recorded by the motor position sensor on the motor itself.

The electric motor is powered by way of 3 phases. The 3 phases are energized alternately by the electronics of the active front steering control unit.

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



KT-11764

Fig. 21: Activation of electric motor

Index	Explanation	Index	Explanation
1	Active front steering control unit	5	Motor stator
2	Processor	6	Motor windings
3	Circuit in control unit	7	Electric motor
4	Analog/digital converter		

However, the actuating forces for the steering angle are not applied by the electric motor but rather as in conventional steering by the separate power-steering support.

- Functions of active front steering

Active front steering, which specifically changes the steering angle of the front wheels specified by the driver, sets new standards in terms of agility, comfort and safety.

The system comprises the following functions:

- Variable steering gear ratio
- Yaw-rate control (support of DSC)
- Power-steering support

Variable steering gear ratio

The variable steering gear ratio adapts the steering gear ratio to the road speed and the steering angle requested by the driver. The steering is designed to be indirect at high speeds and direct at low speeds.

Vehicle manoeuvrability is significantly increased at slow speeds or when parking by the active front steering actuating unit. The driver no longer needs to grip the steering wheel excessively. When the vehicle is stationary, 2 turns are enough to move the steering wheel from one lock to the other.

At high speeds (> 120 km/h), active steering allows a more indirect steering gear ratio than do conventional steering systems. The servo-motor operates in the opposite direction to the steering-wheel angle at high speeds.
Unintentional steering movements are prevented in conjunction with the increased steering-torque level (Servotronic).

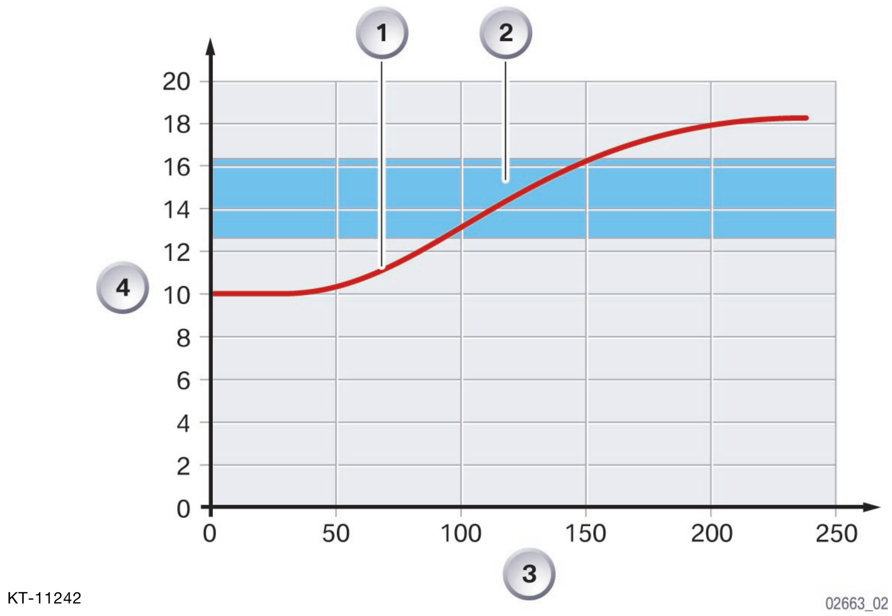


Fig. 22: Steering gear ratio as a function of road speed

Index	Explanation	Index	Explanation
1	Active front steering	3	Road speed
2	Conventional steering	4	Gear ratio

Yaw-rate control

The active front steering system supports the vehicle-stabilizing function of DSC.

In dynamic critical situations, active front steering system can specifically modify the steering angle of the front wheels specified by the driver and stabilize the vehicle much more quickly than the driver.

The intervention thresholds of DSC are much higher than those of active front steering. If vehicle oversteering is detected, the active front steering system intervenes first in order to stabilize the vehicle. DSC intervenes only if the steering system is not enough to stabilize the vehicle.

Power-steering support

Power-steering support is implemented by a conventional rack-and-pinion power steering system. Servotronic is available as an option.

The electronics and the software for Servotronic are incorporated in the SGM if active front steering is not fitted.

For the active front steering system, the software for power-steering support is incorporated in the active front steering control unit. The output stage for activating the Servotronic valve and the valve in the hydraulic pump (ECO) is located in the SGM. The ECO regulates the hydraulic flow rate in the hydraulic pump in order to provide only the flow rate currently required for the power steering.

- System safety

Unintentional system self-steering is classified as safety-critical behaviour by the active front steering system.

The safe system status (failsafe) is the lowest-energy status of the actuating-unit servomotor. Regardless of whether the safe status is brought about by a power loss or by intentional deactivation by the system, it is essential to ensure that the actuating unit does not engage the steering system. The actuating unit is blocked by a lock, which engages the unit's worm-gear drive. The lock is preloaded by a spring and held against the preload by the voltage supply. An interruption of the voltage supply will thus cause the lock to engage the worm-gear drive of the actuating unit.

The locked superimposing gear ensures that manual steering by the driver via the steering column is still possible. The steering then responds like conventional steering. The purely mechanical gear ratio between the steering wheel and the front wheels is maintained.

The electric motor of the active front steering actuating unit is connected with 3 phases. A short circuit to ground thus prevents the electric motor from completing a full rotation as the motor can only rotate a maximum of 120° (360° : 3).

The Servotronic valve switches at zero current to the fast-driving curve.
Power-steering support is reduced accordingly.
When the ECO is at zero current, the flow rate is 7 l/min.

If the active front steering control unit does not send a valid message on the PT-CAN, the SGM operates after 100 ms with a roadspeed-dependent substitute curve. The substitute curve ensures sufficient steering properties for the passive active front steering system.

The driver is alerted to system fault states by way of a warning lamp, a variable warning lamp and Check Control messages in the instrument cluster.

KT-9981

Fig. 23: Warning lamp and variable warning lamp

The Check Control message runs as follows:
AFS failure! Steer with care.

The following information appears in the control display:
Steering behaviour altered! Possible to continue the journey. Steering wheel may be at angle. Have the problem checked by the nearest BMW Service.

- Switch-on conditions

The switch-on conditions for the active front steering system are terminal 15 On and a running engine.

When the engine is started, the system performs a synchronization of the steering-wheel position and the steering angle. This ensures that steering-wheel position and steering angle match up after steering-wheel movements when the system is deactivated (passive status). Steering-wheel movements or movements by the wheels can be discerned.

- Service information

Steering-angle adjustment

A steering-angle adjustment (offset) must be carried out if the SZL or the steering gear together with the rack is replaced. This must be carried out on the KDS.

The summation steering-angle sensor on the steering gear is calibrated to the middle of the rack at the steering-gear manufacturer.

Interference in radio reception

Interference in radio reception can be caused by there being no connection of the shielding of the 3 phases of the actuating unit to the housing of the active front steering control unit.

- Diagnosis, coding

Servotronic

Servotronic is activated in diagnosis as an independent control unit, the output stage for Servotronic is located in the SGM.

Only the vehicle-specific configuration is entered by way of coding.

Front axle

The double-joint spring strut axle with tension struts is essentially the same as the front axle of the E65.
The complete front axle is made from aluminium. It has been possible to save on weight and space compared with the E39 thanks to the use of the reinforcement plate. The reinforcement plate ensures a high degree of transversal vehicle rigidity.

Technical data

Wheels	**7x16; 7.5x17; 8x17; 8x18**
Caster angle	7°51'
Caster offset (mm)	28
Camber	-0.2°
Total toe-in	10'±8'
Toe difference angle	1.66° at 20° steer angle facing into the bend
Kingpin inclination	14°32'
Rim offset (mm)	20
Kingpin offset (mm)	+2
Track width (mm)	1558
Maximum steering angle	inner 43°22' outer 34°1'

Axle alignment is performed at the tie rods.

If necessary, the camber is corrected by removing the pin on the upper support bearing.

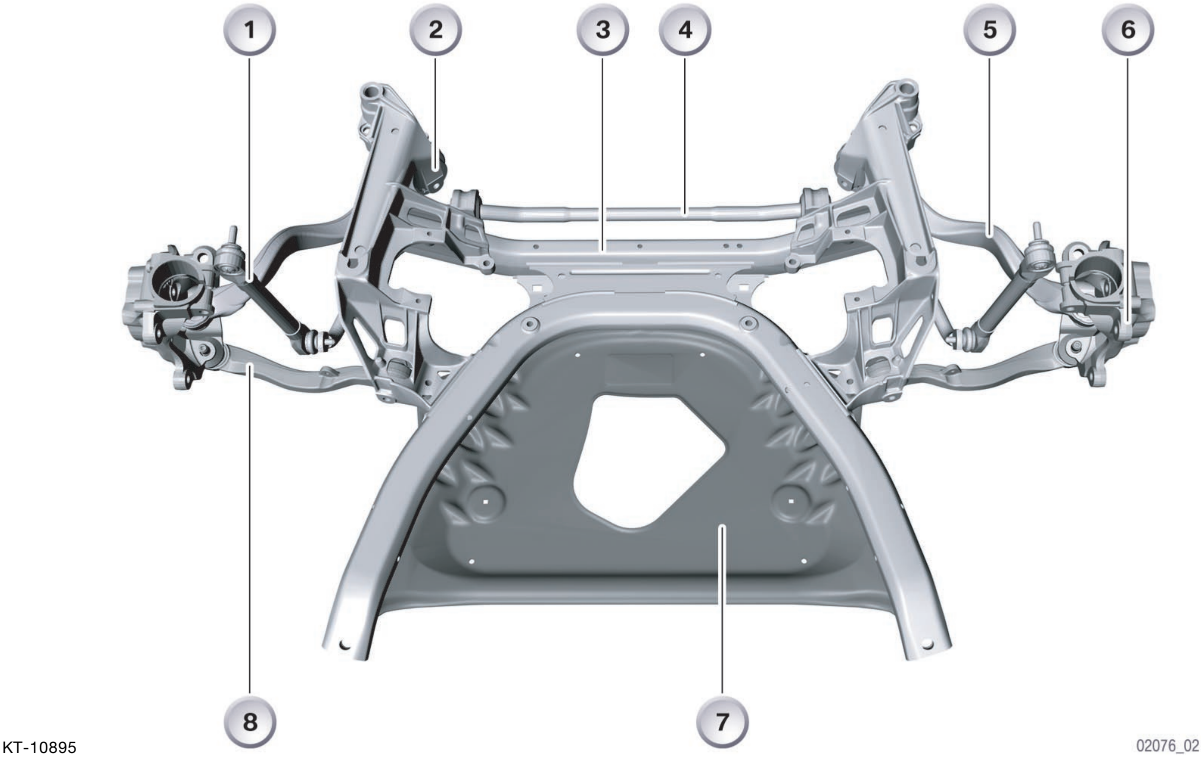


Fig. 24: Front axle

Index	Explanation	Index	Explanation
1	Stabilizer link	5	Tension strut
2	Hydro-mount	6	Swivel bearing
3	Front axle carrier	7	Reinforcement plate
4	Stabilizer bar	8	Control arm

The car must not be driven without the reinforcement plate in place! The reinforcement plate ensures the transversal rigidity of the car and contributes in conjunction with the front axle carrier to the strength of the front axle.

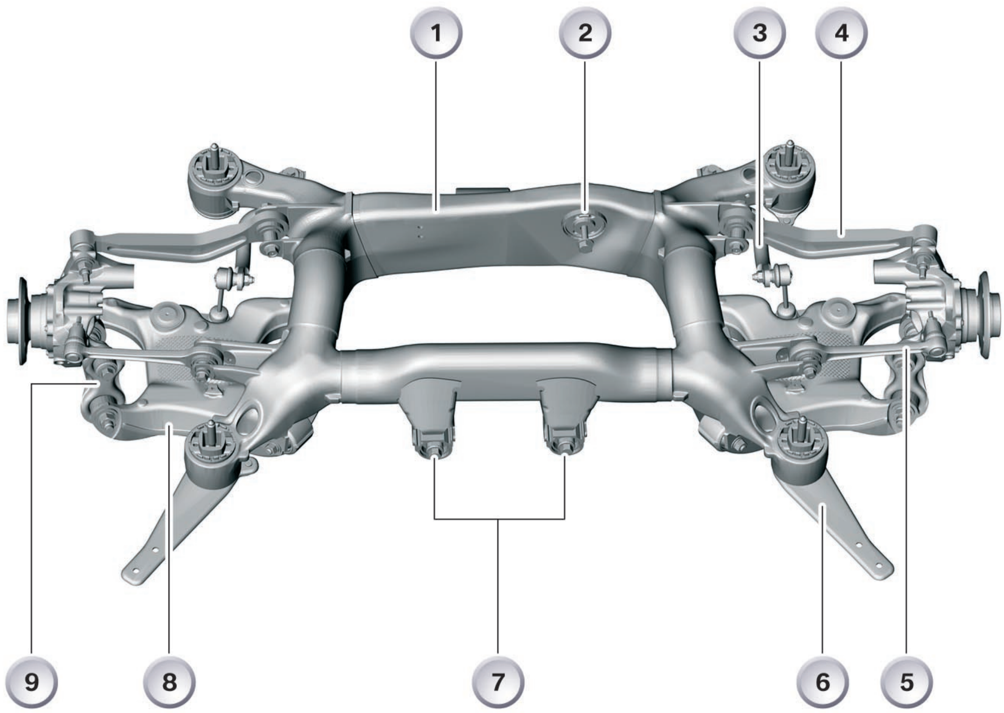
Rear axle

The rear axle carrier, the control arms and the swinging arms are made of aluminium. The concept is that of the Integral 4 rear axle.

All the bearings used on the rear axle are rubber bearings. Tension struts serve to increase body rigidity.

The stabilizer bar is fitted behind the rear axle carrier.

The ride level sensors have been moved forward.



KT-10896

Fig. 25: Rear axle

Index	Explanation	Index	Explanation
1	Axle carrier	6	Thrust rod
2	Rear axle differential bearing, rear	7	Rear axle differential bearing, front
3	Stabilizer bar	8	Swinging arm
4	Control arm	9	Integral link
5	Traction strut		

Suspension and damping

Spring struts with coil springs and twin-tube gas-pressure dampers are used on the front and rear axles.

The sports suspension available as an option is 15 mm lower at the front and rear axles compared with the standard suspension. The sports suspension has been equipped with harder springs, sportier damper tuning and stiffer stabilizer bars.

For BMW Russia, Eastern Europe, Egypt, Caribbean, Africa and South America, the SA 815 Rough road package with raised suspension is approved for LHD models. The rough road package consists of:

- New spring strut dampers at front and rear
- Adapters for front and rear
- Underbody protection with mounting materials

The following options are not permitted in conjunction with the rough road package:

- Tyres with aspect ratios of less than 50%
- Sporty chassis tuning

Brakes

The E60 has a hydraulic dual-circuit brake system with "front/rear split". The electric precharging pump for the DSC function has been omitted.

Model/engine	Brake caliper/disc, front axle	Brake caliper/disc, rear axle
520i, 520d	FN-Al 60 / dia. 310 x 24 mm	FN-Al 42 / dia. 320 x 20 mm
530i, 530d	FNR-Al 60 / dia. 324 x 30 mm	FN-Al 42 / dia. 320 x 20 mm

For cars with small engines (520i, 520d), conventional floating calipers are used on the front and rear axles.
Cars with higher-performance engines (530i, 530d,) are fitted with floating calipers with frames on the front axle and conventional floating calipers on the rear axle.

The housings of the brake calipers are made of aluminium.

All brake discs are coated with geomet.

M12 studs are used to bolt the wheel.

Pedals

The pedal bracket is a glass-fibre-reinforced moulded plastic part. The brake and clutch pedals are mounted on axle shafts, which are also made of glass-fibre-reinforced plastic. These axle shafts are secured by retaining lugs in the axial direction in the bracket.

Notes for Service:

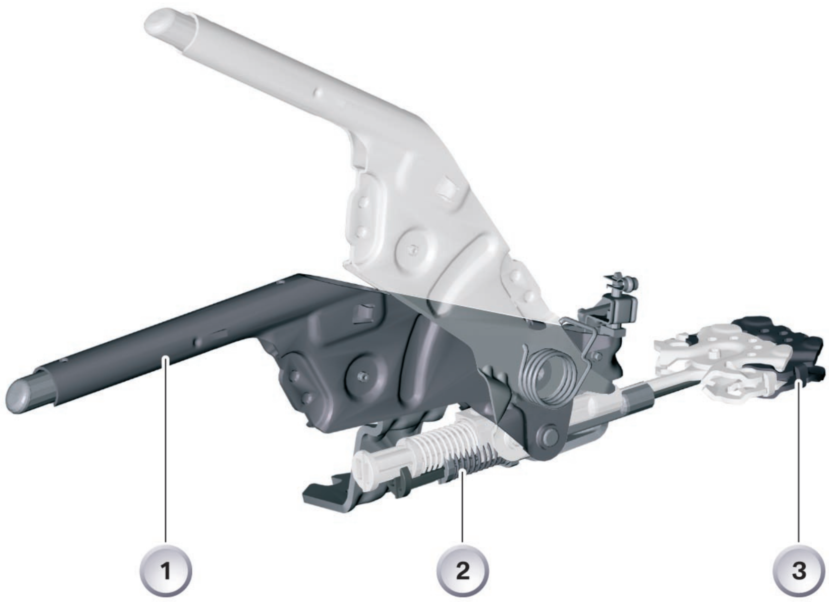
Because it is not always possible to remove axle shafts without damaging them, they must not be reused once they have been removed.

Because the pedal bracket/brake pedal connection is particularly critical to safety, the brake pedal is not to be removed on its own. The entire component must be replaced instead.

Parking brake

The parking brake is actuated by means of a conventional handbrake lever. The handbrake lever is located on the centre console and bolted to the floor pan.

The parking brake is equipped with an automatic cable adjuster (ASZE) and a compensating element.



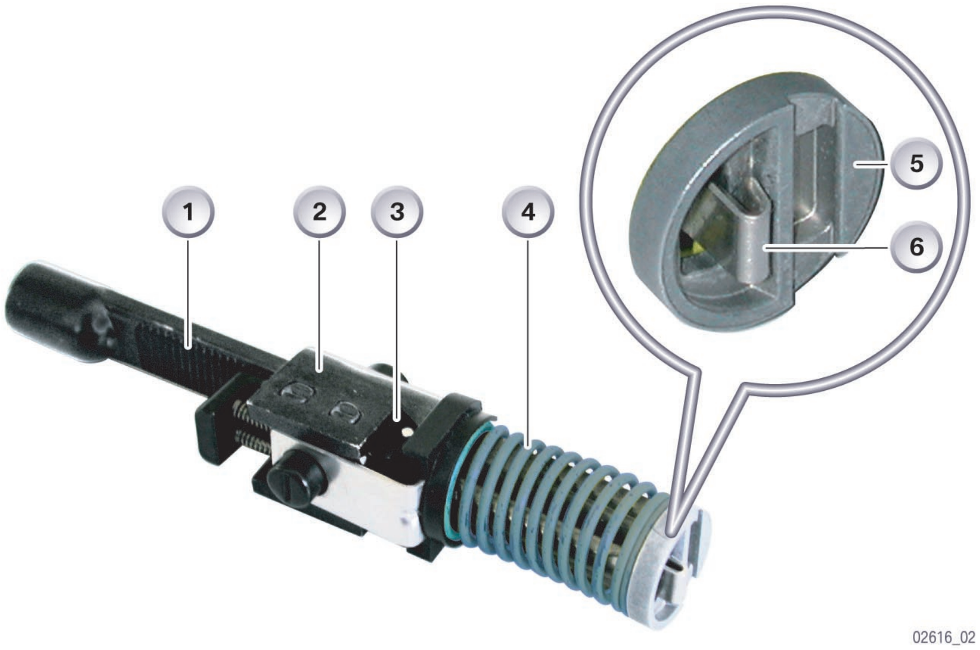
KT-10906

Fig. 26: Parking-brake actuating unit

Index	Explanation
1	Parking-brake lever
2	Automatic cable adjuster
3	Compensating element with mounting clip

The mounting clip locks the cables in the compensating element.

The duo-servo brakes correspond to the duo-servo brakes of the E65 (dia. 185 x 30 mm).



KT-11225

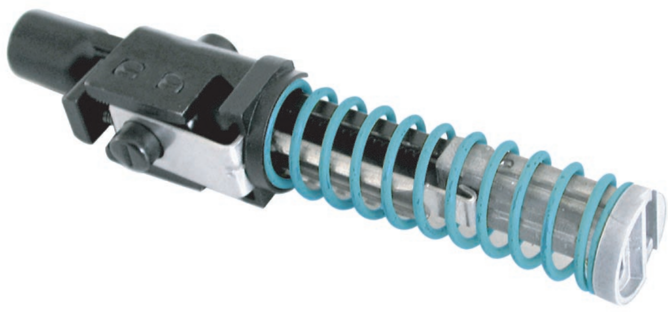
Fig. 27: ASZE in assembly position

Index	Explanation	Index	Explanation
1	Rack	4	Tensioning spring
2	ASZE housing	5	Locking clip
3	Clamping jaw	6	Locking hook

The function of the ASZE is to adjust the handbrake cables and compensate longitudinal variations and settling. It does not however adjust the wear on the duo-servo brake. This must, as before, be adjusted at the expander lock in the brake. The function of the compensating element is to distribute the actuating force uniformly to both handbrake cables.

Notes for Service:

If there is a cable break, the automatic cable adjuster is in the most untensioned position.



KT-11226

Fig. 28: Position of ASZE in event of a cable break

Removing the cables:

To replace the cables, it is necessary to remove the centre console and the rear-compartment ventilation ducts.

For the cables to be removed, the parking-brake lever must be in the released position.

For the cables or the duo-servo brakes shoes to be changed, the ASZE unit must be deactivated.

Deactivating the ASZE unit:

A screwdriver must be used to press back the locking clip of the tensioning spring until the locking hook engages the locking clip of the tensioning spring.

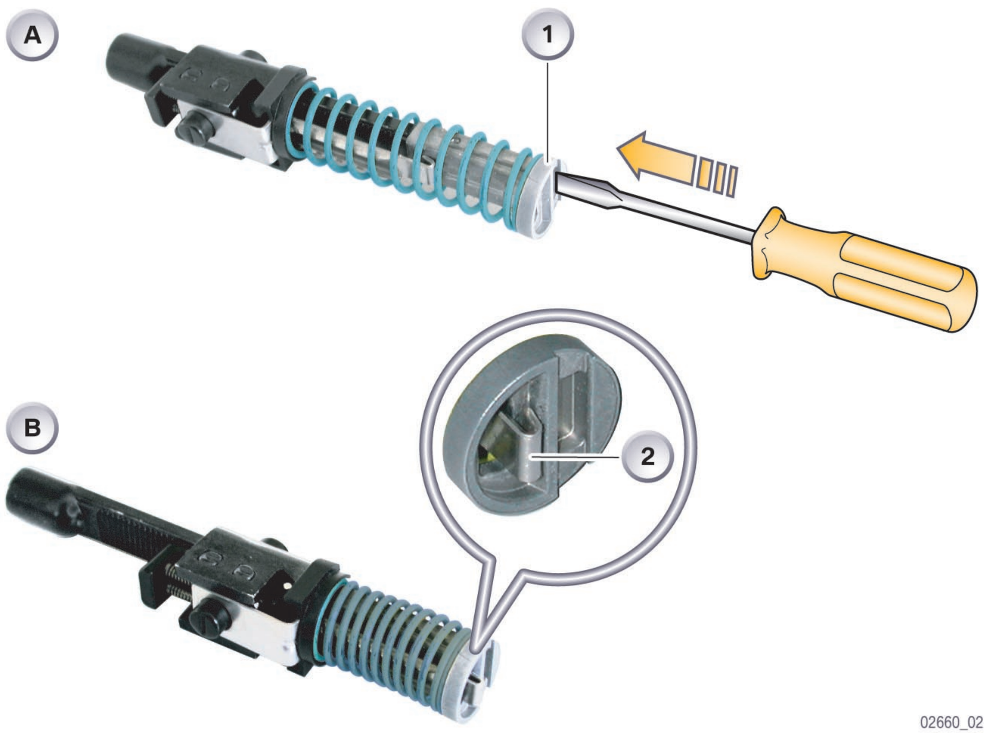
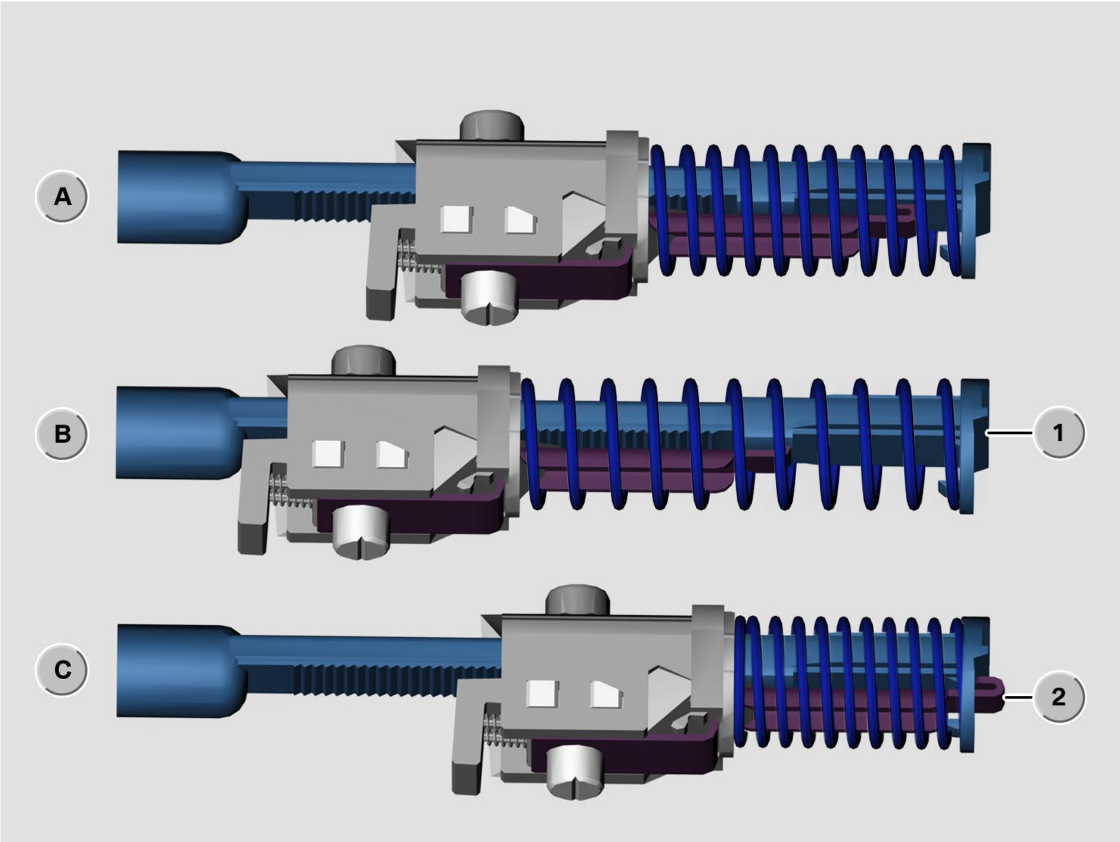


Fig. 29: Deactivating the ASZE unit

Index	Explanation	Index	Explanation
A	Cable break position; the ASZE is in the operating position when the tensioning spring is less untensioned	1	Locking clip
B	Assembly position	2	Locking hook

The cables can now be disconnected from the duo-servo brakes.

To be able to disconnect the cables, it is necessary to remove the mounting clip.



KT-9890

Fig. 30: Possible positions of ASZE unit

Index	Explanation	Index	Explanation
A	Operating position	1	Locking clip
B	Position in case of a cable break	2	Locking hook
C	Assembly position		

Installing the cables:

For the cables to be installed, the parking-brake lever must be in the "released" position. The cables do not automatically feed themselves into the compensating element on insertion but rather must be guided with a screwdriver into the correct position.

To secure the cables in the compensating element, it is necessary to attach the mounting clip.

The cables are connected to the duo-servo brakes.

The ASZE can be reactivated by levering the locking hook out of the locking clip.

Adjusting the duo-servo brakes:

The basic clearance of the duo-servo brake is adjusted at the adjusting screw of the duo-servo brake shoes.
The parking brake is automatically adjusted when the ASZE unit is activated.

Wheels and tyres, tyre defect indicator

8 different wheel stylings are available.

2 16-inch wheel sets and 2 17-inch wheel sets are offered as standard wheels.

16-inch, 17-inch and 18-inch wheel sets are offered as option (SA).

Runflat tyres are not available for the 16-inch wheel sets.
All other option sets have runflat tyres.

An anti-theft wheel stud similar to the E39 is planned for the 17-inch wheels and the SA rims.

The tyre defect indicator (RPA) is a standard feature. The RPA function is integrated in the DSC control unit.

A compact wheel is also supplied as standard. The compact wheel has the designation T-135/80-17 (the T stands for Temporary Spare).
Important: The pressure of compact wheel is 4.2 bar!

The following wheel/tyre combinations are available as standard:

Model	Wheels/tyres	Styling number	Styling (standard)
520i	7Jx16 H2 IS20 Tyre 205/60 R16 Aluminium band wheel with wheel trim		 KT-10865
525i, 530i, 530d SA 520i	7Jx16 H2 IS20 Tyre 225/55 R16 Lightweight forged wheel	134	 KT-10866
535i SA 520i, 525i, 530i	7.5Jx17 EH2 IS20 Tyre 225/50 R17 Cast-aluminium wheel SA Runflat tyres	138	 KT-10867
545i	7.5Jx17 EH2 IS20 Tyre 225/50 R17 Cast-aluminium wheel SA Runflat tyres	116	 KT-10868

The following options are available:

Model	Wheels/tyres	Styling number	Styling (SA)
SA 588	7Jx16 H2 IS20 Tyre 225/55 R16 Cast-aluminium wheel	KT115	 KT-10869
SA 589	8Jx17 EH2 IS20 Tyre 245/45 R17 Cast-aluminium wheel Runflat tyres	122	 KT-10870
SA 590	8Jx18 EH2 IS20 Tyre 245/40 R18 Cast-aluminium wheel Runflat tyres	123	 KT-10871
SA 591	Front: 8Jx18 EH2 IS20 Tyre 245/40 R18 Rear: 9Jx18 EH2 IS32 Tyre 275/35 R18 Cast-aluminium wheel Runflat tyres	124	 KT-10872

- Tyre defect indicator (RPA)

The RPA function is integrated in the DSC control unit.
The system compares by way of the wheel speeds the tyre-tread circumferences of the 4 wheels.

The RPA system does not monitor the uniform diffusion loss over all 4 tyres. If the same pressure loss occurs in the 4 tyres, the wheel speeds change to the same extent and the pressure loss is not detected. The customers must regularly monitor inflation pressures themselves.

The system must be reinitialized when tyre inflation pressures are changed or when the tyres are changed. The RPA is initialized by means of the controller at terminal 15 ON. The system switches to the "Learning phase" status. This status is shown in a status line in the Central Information Display (CID).
After a brief driving time, the system learns the new wheel speeds as reference values.

For the RPA there are 2 variable warning lamps with 2 associated Check Control messages (CC messages) which are displayed in the instrument cluster:

- "Tyre puncture!" signals a loss of pressure of more than 30% in a tyre. This is accompanied by a gong sound.
- "Run Flat Indicator failure!" signals that the system is inactive due to a fault and cannot detect any tyre failures.

Explanatory notes pertaining to the relevant CC messages appear in the CID.

Variable warning lamp	Notes in CID
 KT-9982 Fig. 31: Tyre puncture!	Stop vehicle carefully and change wheel, see Owner's Handbook. Safety tyres: Possible to continue at max. speed of 80 km/h (50 mph). Distance limit, see Owner's Handbook. Have the problem checked by the nearest BMW Service.
 KT-10014 Fig. 32: Run Flat Indicator failure!	Tyre punctures are not identified. Have fault checked by BMW Service as soon as possible.

The RPA submenu in the CID also features a status line which indicates the current RPA status.

- "Learning phase," i.e. the system is standardized. The learning phase is indicated until RPA is ready for operation the first time after the start of standardization.
- "Inactive" because there is a fault in the system and thus no tyre failure can be detected.
- "Active" when the system can detect a tyre failure.

- Diagnosis

Diagnosis of the RPA function is performed by way of the DSC control unit.

- Programming, coding

The RPA is automatically programmed/coded with the DSC software.