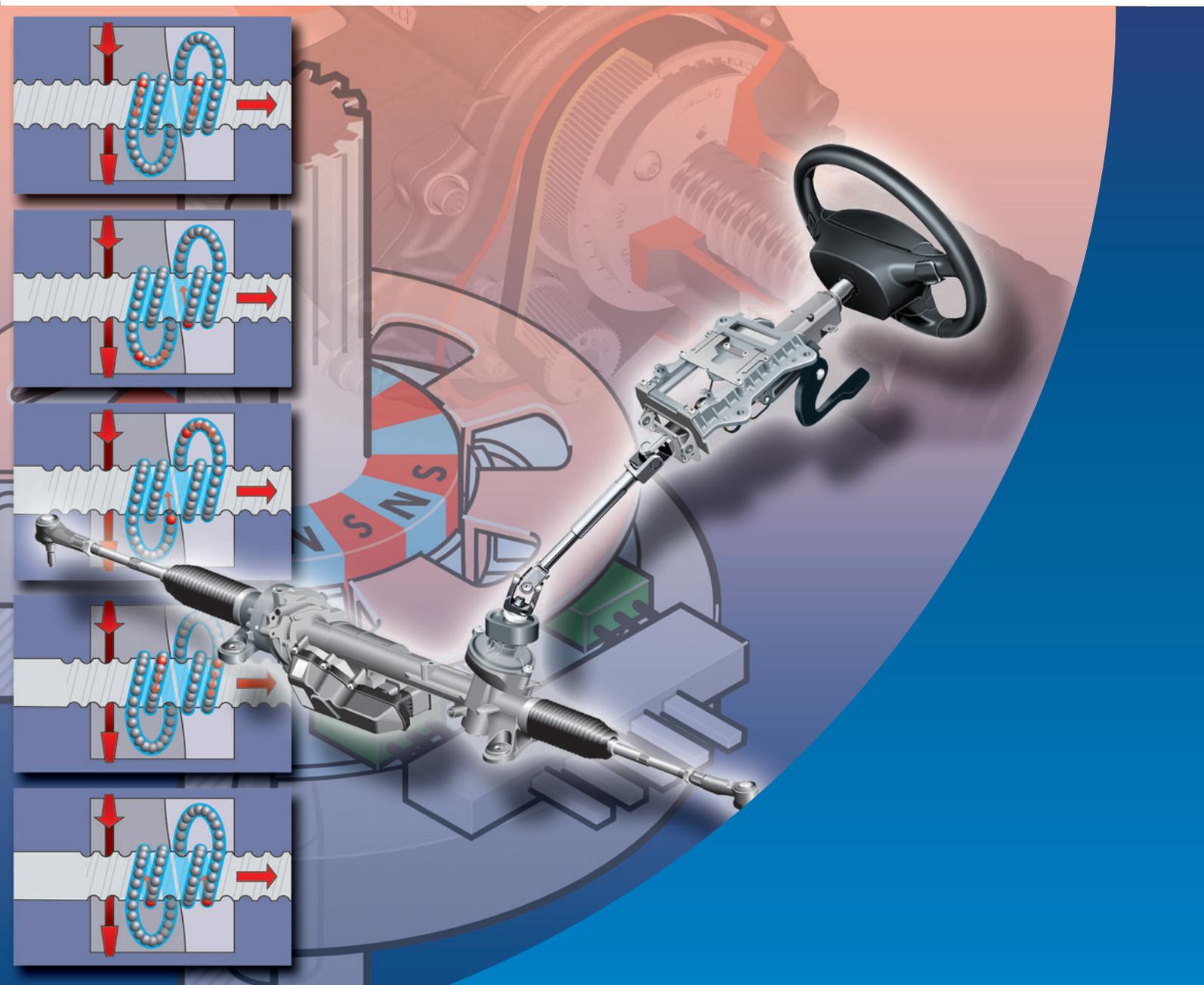Self-study Programme 399

Electromechanical Steering with Parallel-axis Drive
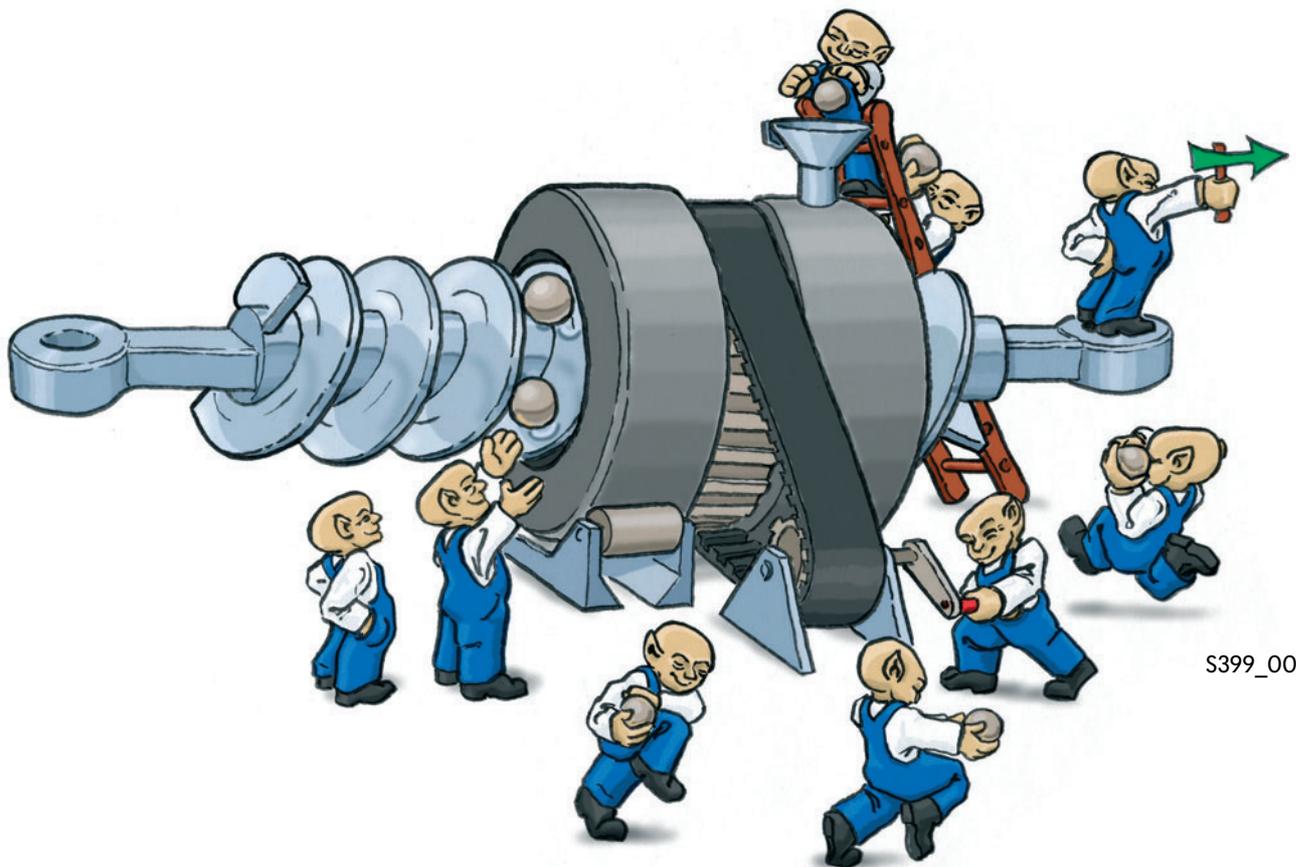
Design and Function

The electromechanical power steering has many advantages compared with a hydraulic steering system.
It assists the driver and relieves the physical and mental burden for him. It works on demand, i.e. only when the driver requires steering assistance.
The steering assistance depends on the vehicle speed, the steering movement and the steering angle.

The parallel-axis power steering is part of the latest generation of electromechanical steering systems. This steering system uses a combination of tried and tested components and innovative new features.
It is currently only used in left-hand-drive vehicles.

The electromechanical steering with parallel-axis drive is a VW development from the Braunschweig development team. It is also produced at the Braunschweig site.

This self-study programme explains how this electromechanical power steering with parallel-axis drive works in detail.

S399_001

NEW

Warning
Note

Contents

Introduction

Overview of electromechanical steering with parallel-axis drive

The steering comprises the following components:

- Steering wheel
- Steering column switch with steering angle sender G85
- Steering column
- Steering moment sender G269
- Steering box (recirculating-ball gearbox)
- Electromechanical power steering motor V187 (synchronous motor)
- Power steering control unit J500
- Universal joint shaft

Steering wheel

Steering column

Electromechanical power steering motor V187

Universal joint shaft

Steering box

Steering moment sender G269

Power steering control unit J500
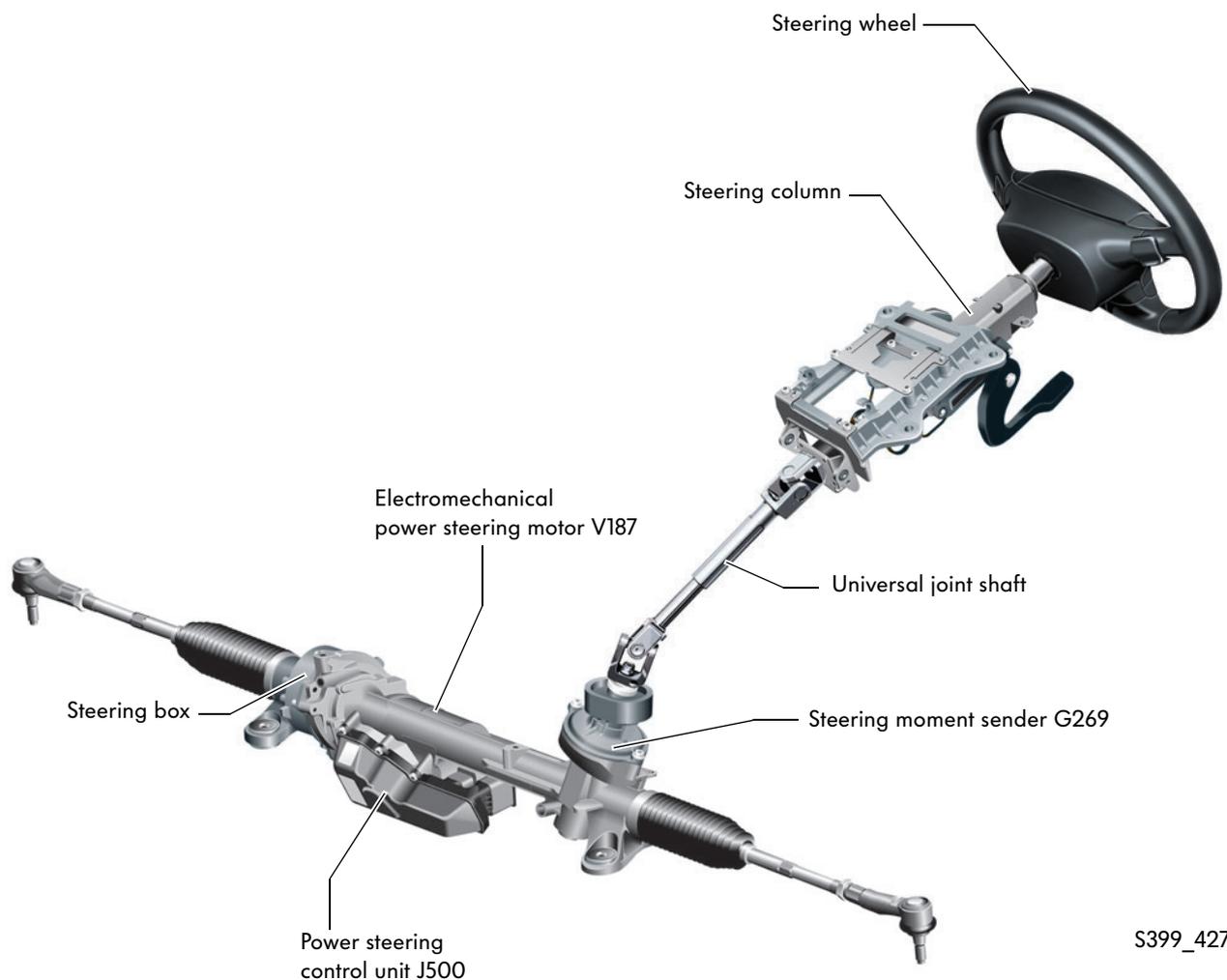
S399_427

What you should know about the electromechanical power steering:

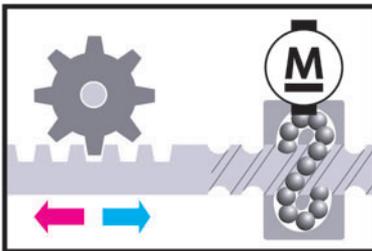The electromechanical power steering does not require a hydraulic system for steering assistance. This steering system makes an important contribution to environmental protection since no hydraulic fluid is used.
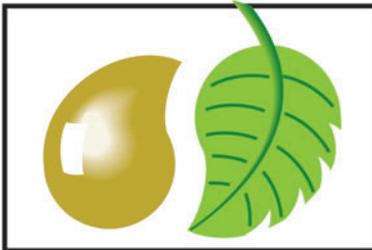
S399_106

The electromechanical power steering is a steering system with parallel-axis drive. It features a newly developed steering box with a belt-driven recirculating-ball gearbox that provides the steering assistance.

S399_108
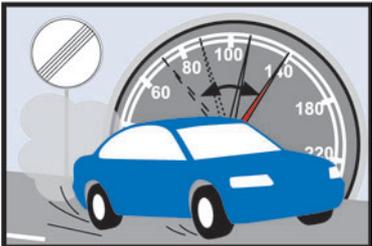
The electric motor is activated on demand to provide steering assistance.
The system provides the driver with steering assistance related to the driving conditions (Servotronic).
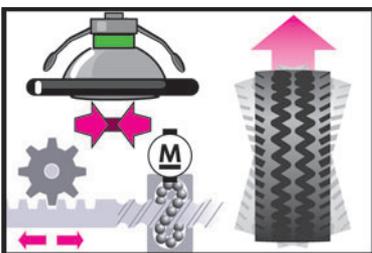
S399_110

The steering is returned to the straight ahead position by the "active return" function with assistance from the electromechanical power steering.
This results in an acceptable return of the steering wheel after cornering as well as more stable straight-running.

S399_111

The straight-ahead driving correction provides steering assistance to relieve the driver on straight roads when there are constant cross-winds or the road has excessive camber.

S399_112

Introduction

The different lengths of the drive shafts for the left-hand and right-hand front wheels resulting from the front-wheel drive and transverse engine layout often cause the vehicle to be pulled to one side while accelerating. The uneven tracking compensation system recognises this and counteracts it by counter-steering.
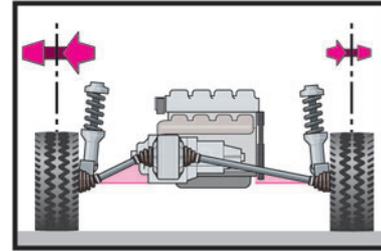
S399_442

The counter-steer assistance applies appropriate steering forces via the power steering system to help the driver counter-steer (e.g. when braking on road surfaces with varied grip or during manoeuvres with transverse-dynamic loading).
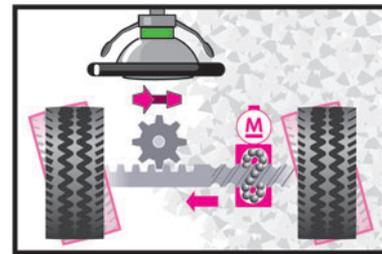
S399_418

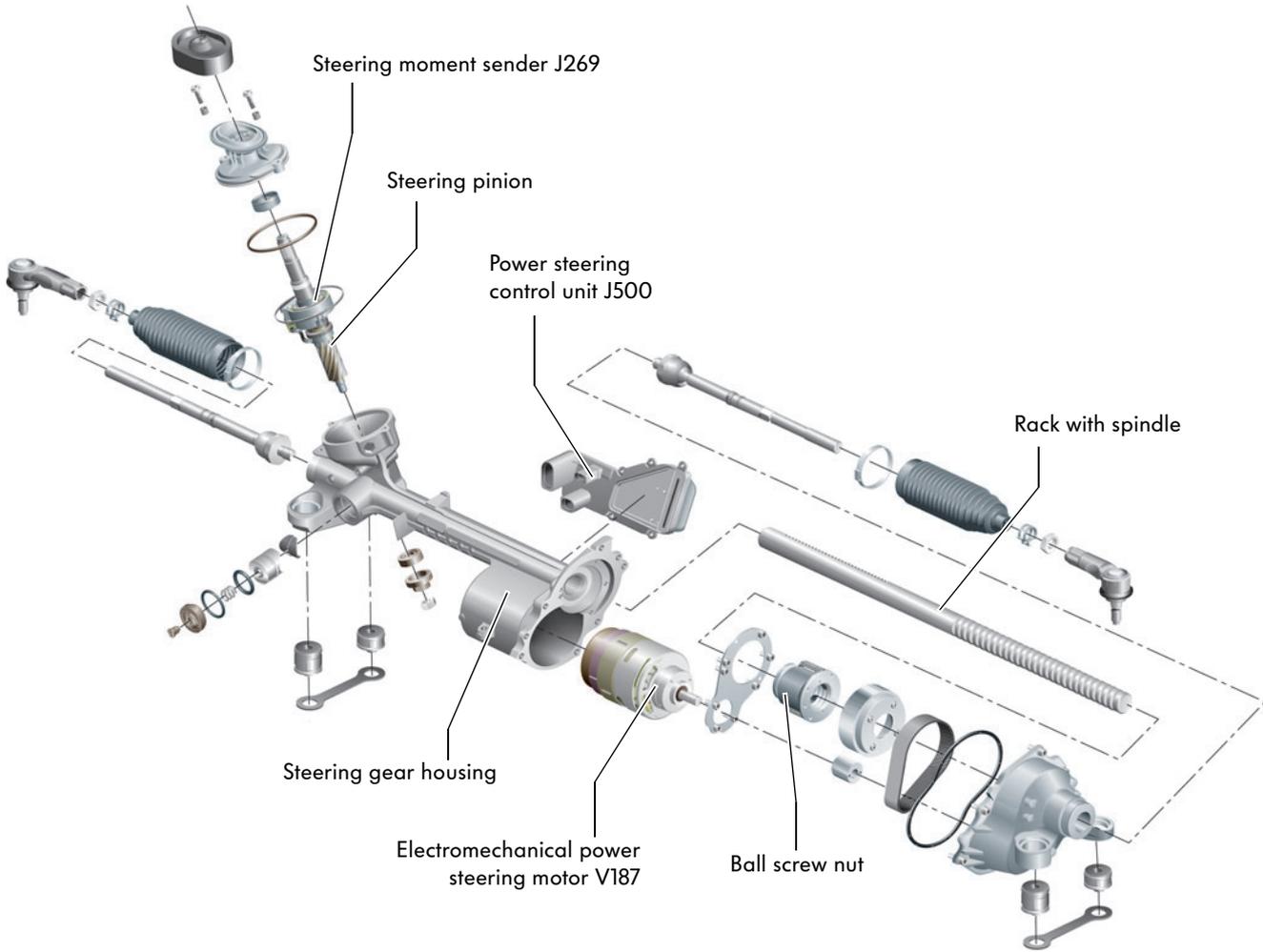## The advantages of the electromechanical power steering

One advantage of the electromechanical power steering compared with hydraulic steering systems is that there is no need for a hydraulic system.
The components that assist steering are mounted on and act directly on the steering box.

Furthermore a considerable saving in energy is achieved. Unlike the hydraulic steering that requires a constant volume flow, the electromechanical power steering only consumes energy when the steering is actually used. The fuel consumption is reduced due to this on-demand power consumption.

The electromechanical steering with parallel-axis drive and recirculating-ball gearbox is currently one of the most effective steering systems. The special design of the servo unit and its low internal friction allows this steering system to give a high-precision, extremely smooth steering feel.
Bumps from the road are filtered out completely due to the slow mass of the recirculating-ball gearbox and the electric motor. The low internal friction of the recirculating-ball gearbox allows the driver to feel the changes at the wheel that are important for driving feel.

The electromechanical power steering and its components

Steering moment sender J269

Steering pinion

Power steering control unit J500

Rack with spindle

Steering gear housing

Electromechanical power steering motor V187

Ball screw nut

S399_100

The fuel saving compared with a hydraulic power steering system is up to 0.2 litres every 100 kilometres.

The recirculating-ball gearbox is driven via a toothed belt by an electric motor that is arranged parallel to the rack. As the force or drive moment does not need to be re-directed, it is called a steering system with parallel-axis drive.

Overview of the system

Overview of the system

J104 ABS control unit

G44 - G47 Speed sensor (speed signal)

G28 Engine speed sender

Engine control unit

J533 Data bus diagnostic interface

J285 Control unit with display in dash panel insert

J527 Steering column electronics control unit

Terminal 15

Powertrain CAN

G85 Steering angle sender

K161 Electromechanical power steering warning lamp

G269 Steering moment sender

V187 Electromechanical power steering motor

S399_018

J500 Power steering control unit

## Map and characteristic curves

The steering assistance is regulated according to speed using a map in the permanent program memory of the control unit. The map is not programmed into the control unit until the final phase of vehicle production at the factory due to the vehicle weight and equipment.

The map can, however, also be programmed in customer services following repair work (e.g. if the steering is replaced) with the vehicle diagnosis, measurement and information systems using the "Guided Fault Finding" or "Guided Functions" with special software. The corresponding map can be imported using a vehicle-specific PR number that is given on the vehicle data sticker at Volkswagen manufacturers.

S399_452

Heavy vehicle
Light vehicle
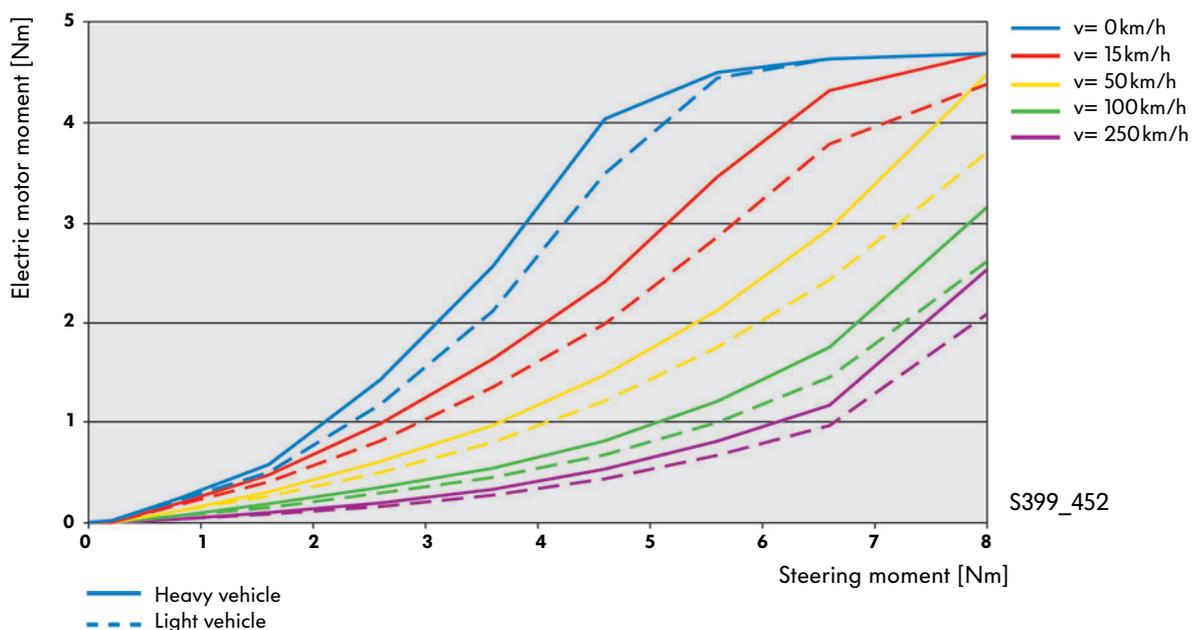
A map for a heavy vehicle (continuous line) and map for a light vehicle (broken line) for the Tiguan have been chosen as examples from the 5 maps available.
A map contains five different characteristic lines for different vehicle speeds.
(e.g. 0 km/h, 15 km/h, 50 km/h, 100 km/h and 250 km/h). A map defines at which steering wheel moment, how much steering assistance is provided for your speed by the drive torque of the electric motor. Furthermore a map can be programmed for the mobility aid.

Function

Steering procedure


S399_030

Torque at steering wheel

Steering assistance

Effective steering force
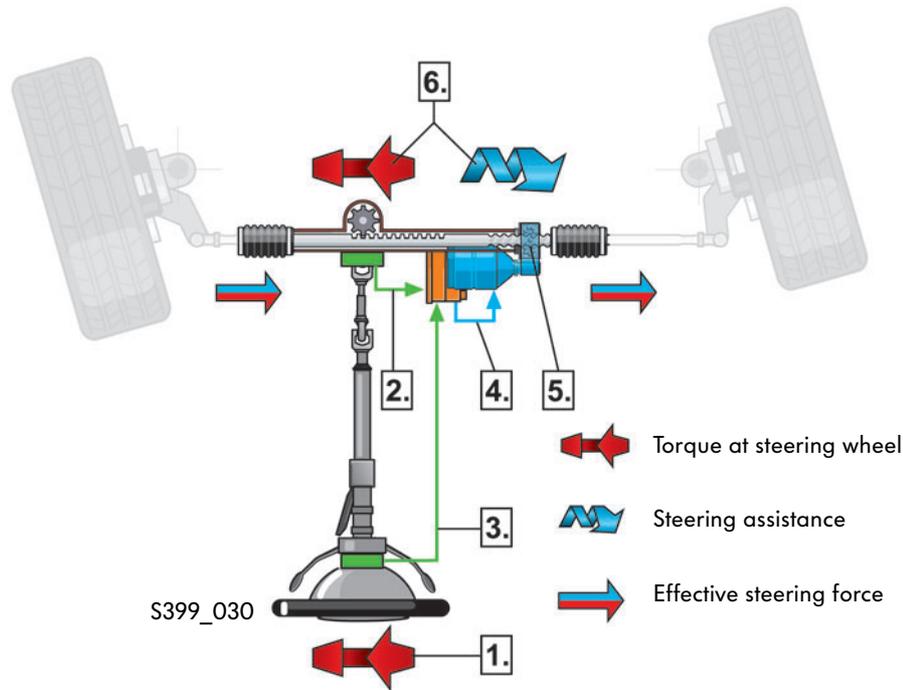
1. The steering assistance procedure starts with the driver turning the steering wheel.

2. The torque at the steering wheel twists a torsion bar on the steering pinion.
   The steering moment sender G269 detects the twisting and transmits the measured steering moment to the control unit J500.

3. The steering angle sender G85 transmits the current steering angle.

4. The control unit determines the required steering assistance and activates the electric motor on the basis of the steering moment, vehicle speed, engine speed and the characteristic curve stored in the control unit.
   The information on the steering angle and steering speed is used for functions like, straight-ahead driving correction.

5. The steering support is provided via a belt-driven recirculating-ball gearbox. The spindle nut is driven by the electric motor via a toothed belt.

6. The sum of the force of the torque at the steering wheel and the force of the assistance moment from the electric motor gives the effective steering force on the rack.

Steering procedure when parking

S399_032

v=0km/h

Torque at steering wheel

Steering assistance

Effective steering force
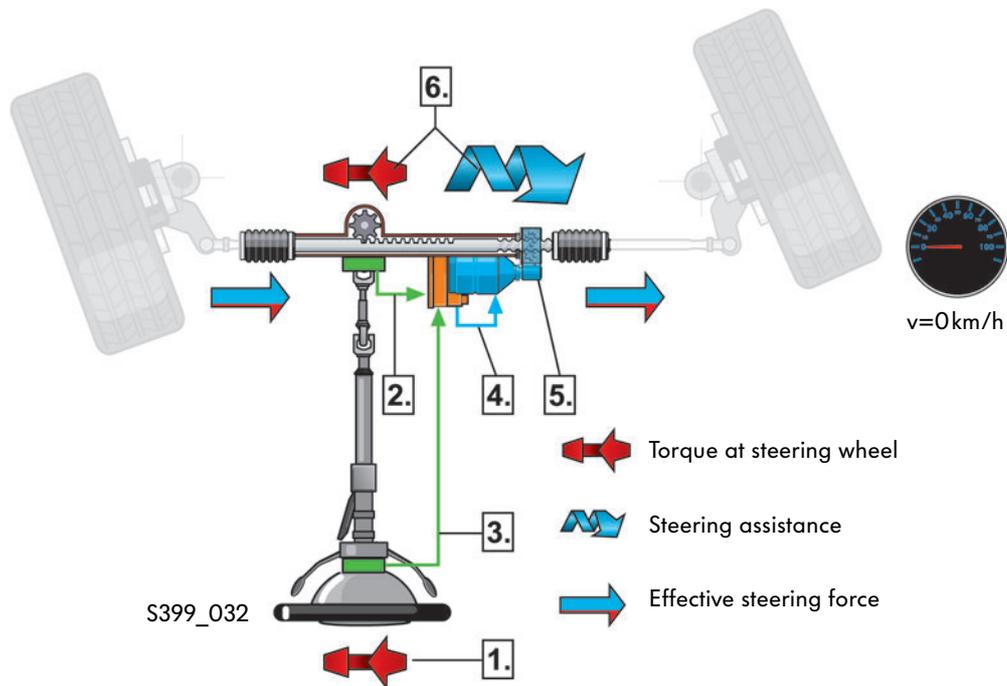
1. When manoeuvring into a parking space, the driver turns the steering wheel to full lock.

2. The torsion bar is twisted. The steering moment sender G269 measures the twisting and signals to the control unit J500 that a large steering moment is being applied to the steering wheel.

3. The steering angle sender G85 transmits a large steering angle.

4. The control unit determines that high steering assistance is required and regulates the electric motor accordingly on the basis of the high steering moment, the vehicle speed of 0km/h, the engine speed (>500rpm), the large steering angle, the steering speed and the characteristic curve stored in the control unit for v=0km/h.

5. Maximum steering assistance is therefore provided for the parking manoeuvre.

6. The sum of the force of the torque at the steering wheel and the force of the maximum steering assistance from the electric motor gives the effective steering force on the rack.

Function

Steering during city driving

S399_034

- Torque at steering wheel
- Steering assistance
- Effective steering force

v=50 km/h
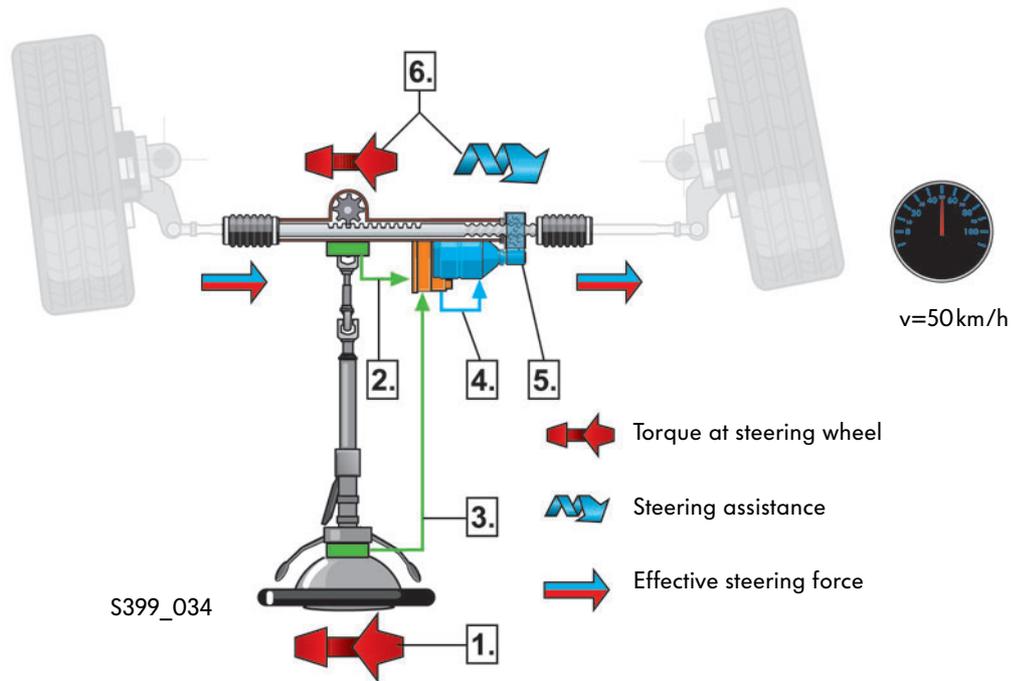
1. When cornering in city traffic, the driver turns the steering wheel.

2. The torsion bar is twisted. The steering moment sender G269 measures the twisting and signals to the control unit J500 that a medium steering moment is being applied to the steering wheel.

3. The steering angle sender G85 transmits a medium steering angle.

4. The control unit determines that medium steering assistance is required on the basis of a medium steering moment, the vehicle speed of 50 km/h, a medium steering angle, the steering speed and the characteristic curve for v=50 km/h stored in the control unit and regulates the electric motor accordingly.

5. Therefore on corners there is medium steering assistance via a belt-driven recirculating-ball gearbox.

6. The sum of the force of the torque at the steering wheel and the force of medium steering assistance from the electric motor gives the effective steering force on the rack when cornering in city traffic.
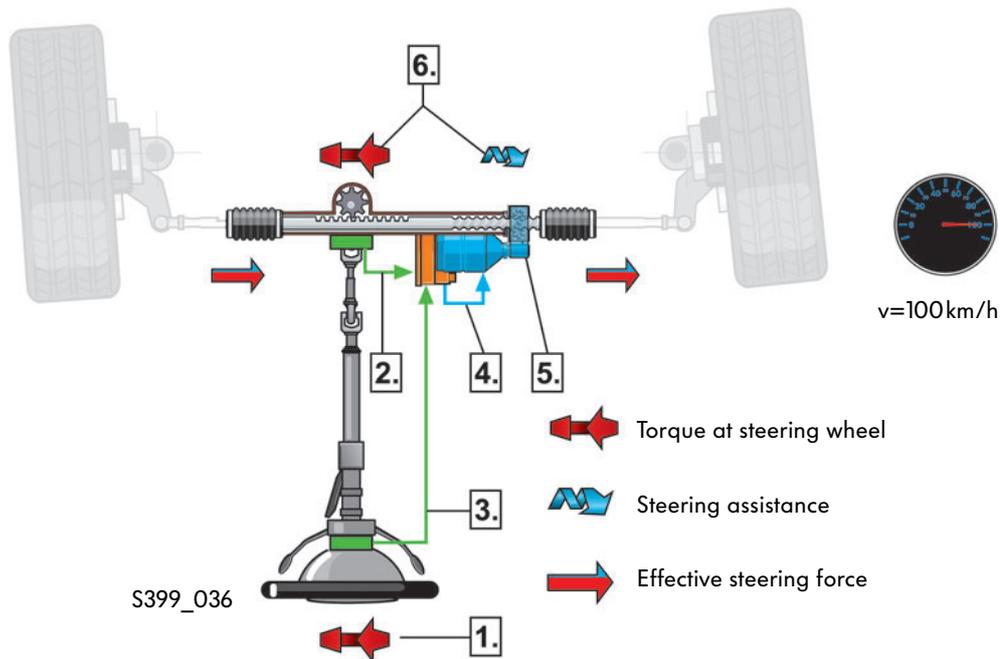
Steering on motorways

S399_036

v=100 km/h

Torque at steering wheel

Steering assistance

Effective steering force

1. When changing lanes, the driver turns the steering wheel slightly.

2. The torsion bar is twisted. The steering moment sender G269 measures the twisting and signals to the control unit J500 that a light steering moment is being applied to the steering wheel.

3. The steering angle sender G85 transmits a small steering angle.

4. The control unit determines that low or no steering assistance is required on the basis of a low steering moment, the vehicle speed of 100 km/h, a low steering angle, the steering speed and the characteristic curve for v=100 km/h stored in the control unit and regulates the electric motor accordingly.

5. There is therefore low or no steering assistance via the belt-driven recirculating-ball gearbox when steering on the motorway.

6. The sum of the force of the torque at the steering wheel and the force of minimum steering assistance from the electric motor gives the effective steering force on the rack when changing lanes.

Function

Active return

S399_038

← Return force	
∿ Steering assistance	
⬅ Effective steering force	
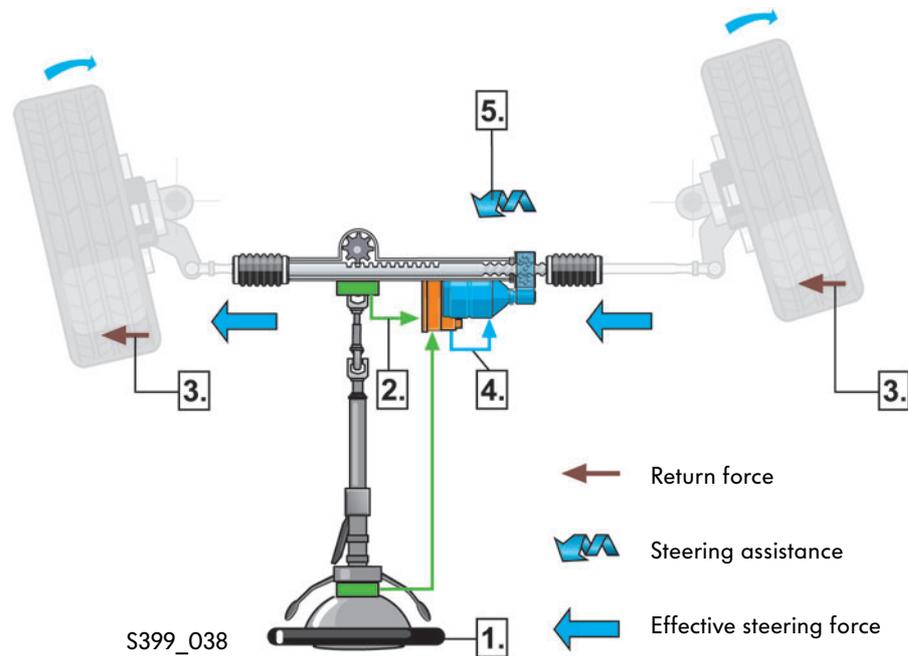
1. If the driver reduces the steering moment when cornering, the torsion bar will be relieved.

2. In conjunction with the reduction of steering moment, the inclusion of the steering angle and the steering speed, a target return speed is calculated. This is compared with steering angle speed. This gives us the return moment.

3. Due to the axle geometry, return forces are generated at the turned wheels.
Due to the friction in the steering system and in the axle, the return forces are often too small to move the wheels back to the straight ahead position.

4. By evaluating the steering moment, vehicle speed, engine speed, steering angle, steering speed and characteristic curves stored in the control unit, the control unit calculates the torque required from the electric motor to return the wheels.

5. The motor is activated and steering assistance is provided to return the wheels to the straight-ahead position.

Straight-ahead driving correction

The straight-ahead driving correction is a function that is derived from the active return. Steering assistance is provided to return a vehicle to moment-free, straight-ahead driving. A long-term and a short-term algorithm are explained here.

Long-term algorithm

The long-term algorithm has the task of compensating, long-term deviations from straight-ahead driving that, could be caused by switching from worn-in (used) winter tyres to summer tyres.

Short-term algorithm

The short-term algorithm corrects short-term deviations. This relieves the burden on the driver, who, for example, may have to constantly steer against a constant side wind.

S399_084

 Return forces

 Steering assistance

 Effective steering force
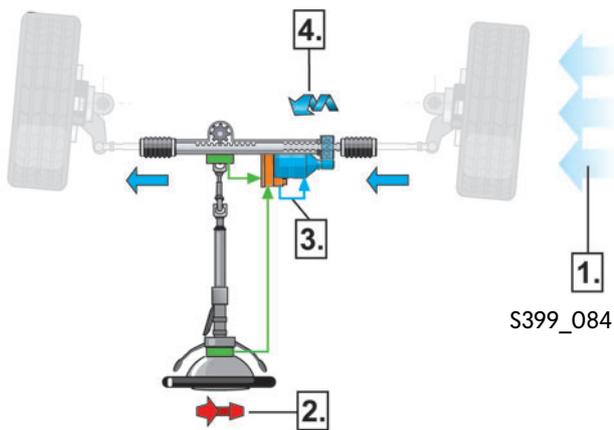
1. A constant side force, for example, a side wind is acting on the vehicle.

2. The driver turns the steering wheel to hold the vehicle on a straight-ahead track.

3. By evaluating the steering moment, vehicle speed, engine speed, steering angle, steering speed and characteristic curves stored in the control unit, the control unit calculates the torque required from the electric motor to correct the straight-ahead running.

4. The motor is activated. The vehicle is set to straight-ahead driving.
   The driver no longer has to "counter-steer".

Function

Uneven tracking compensation system

The uneven tracking compensation system (also known as torque steer compensation) is a new function in the electromechanical power steering for front-wheel drive vehicles. It prevents uneven tracking when vehicles with powerful engines and different drive shaft lengths accelerate.

S399_428

Steering assistance

Effective steering force
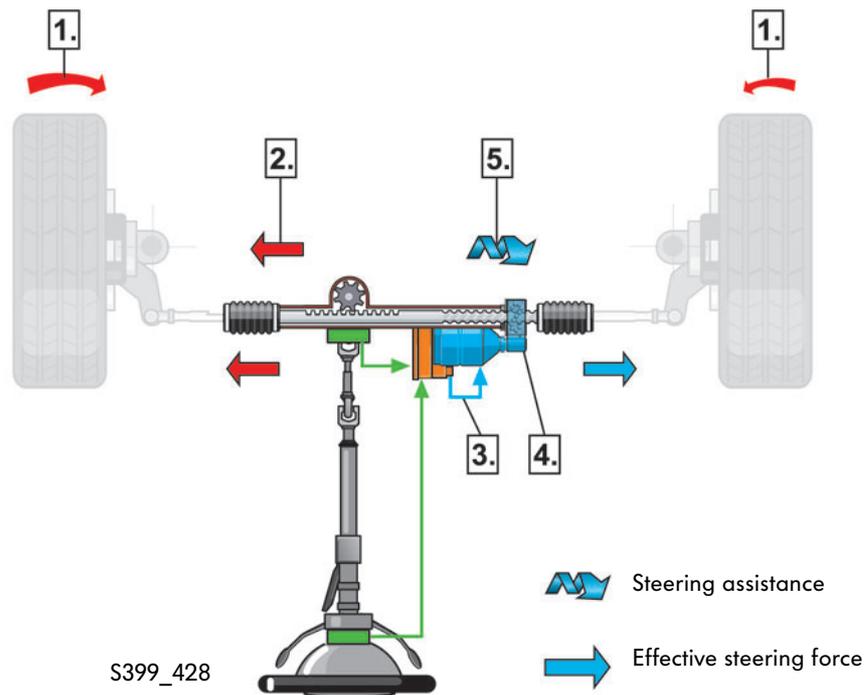
1. The different length drive shafts that are normally used with transverse engines and front-wheel drive have different working angles which cause different moments around the vertical axis of the wheels during acceleration.
These moments can cause uneven tracking.

2. There is a force in the direction of the larger moment around the vertical axis.

3. The power steering control unit calculates the required steering assistance to compensate the uneven tracking and activates the electric motor.

4. The necessary steering assistance is transferred to the rack via the steering box with belt-driven recirculating-ball gearbox.

5. The effective force is exclusively created by the steering assistance.

Further information can be found on the uneven tracking compensation system in self-study programme no. 404 "The 2008 Tiguan".

Counter-steer support

The counter-steer support is a supplementary safety function in the ESP system. This assistance system helps the driver stabilise the vehicle in critical situations (e.g. when braking on road surfaces with varied grip or during manoeuvres with transverse-dynamic loading).

S399_430

Torque at steering wheel

Steering assistance

Effective steering force
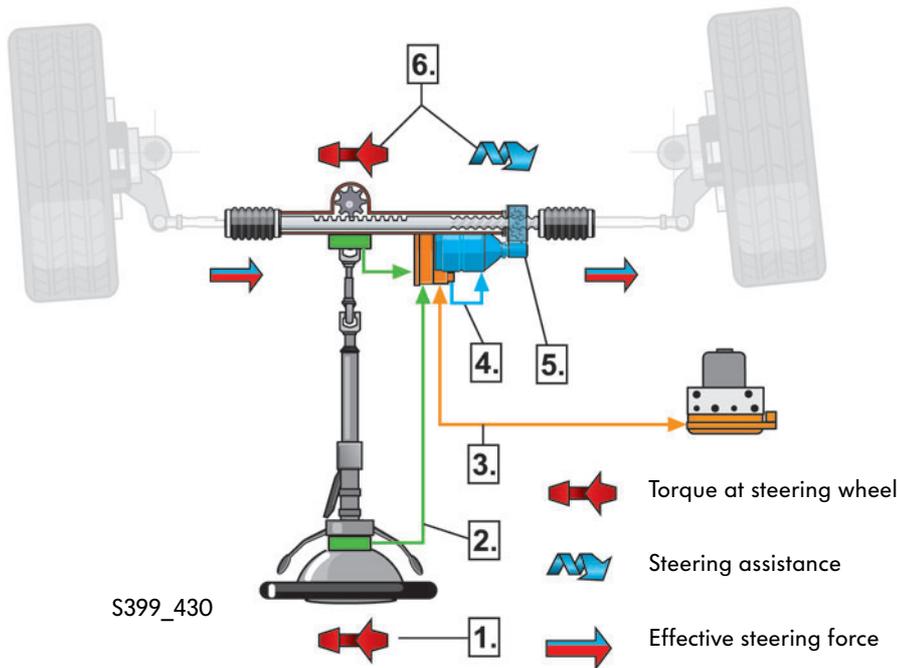
1. The varied grip on the road surface causes lateral forces and rotary rates that need to be compensated by counter-steering. The driver steers against them.

2. The steering angle sender measures the extent of the driver's steering movement.

3. These signals are forwarded to the ESP control unit via the CAN data bus that has recognised a critical driving situation with the aid of its sensors. It calculates the necessary steering assistance to help the driver counter-steer and forwards this data to the power steering control unit.

4. The power steering control unit activates the electric motor.

5. The necessary steering assistance is transferred to the rack via the steering box with belt-driven recirculating-ball gearbox.

6. The effective steering force results from the sum of the torque at the steering wheel and the steering assistance.
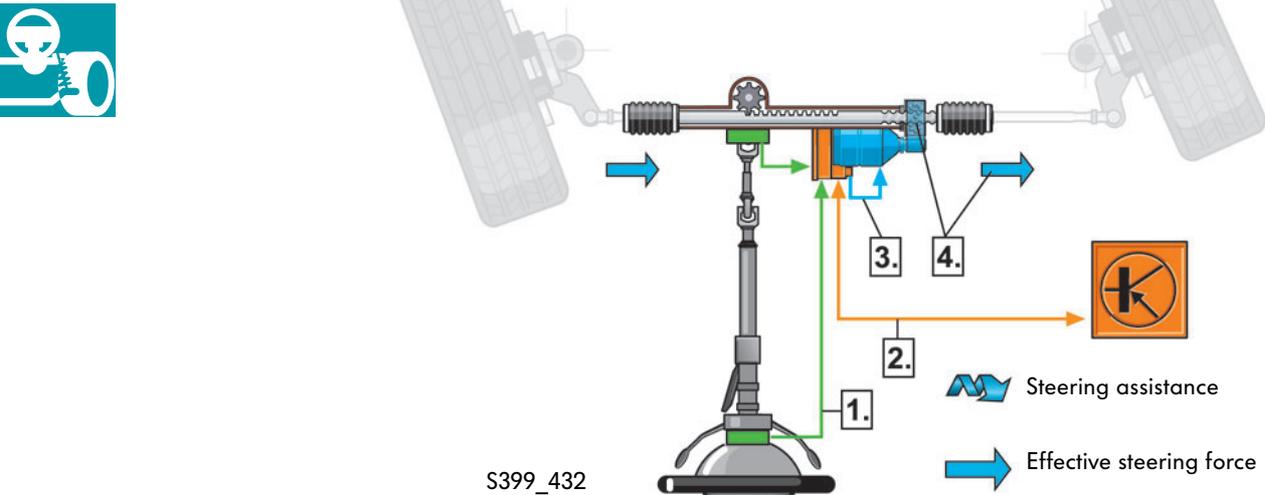
You will find further information on counter-steer support in self-study programme 374 "Traction Control and Assist Systems".

Function

ParkAssist

The ParkAssist system is an active helper when you reverse into parking spaces.

S399_432

Steering assistance

Effective steering force

1. When the driver starts the automatic parking procedure by selecting reverse gear while the vehicle is stationary, pressing the accelerator and releasing the brake pedal, he may not apply steering moment to the steering wheel.

2. The control unit for parallel parking assist, which has recognised the parking situation by means of its sensors, signals the steering requirement and activates the power steering control unit.

3. The power steering control unit activates the electric motor.

4. The necessary steering angle is set on the rack via the steering box with belt-driven recirculating-ball gearbox.
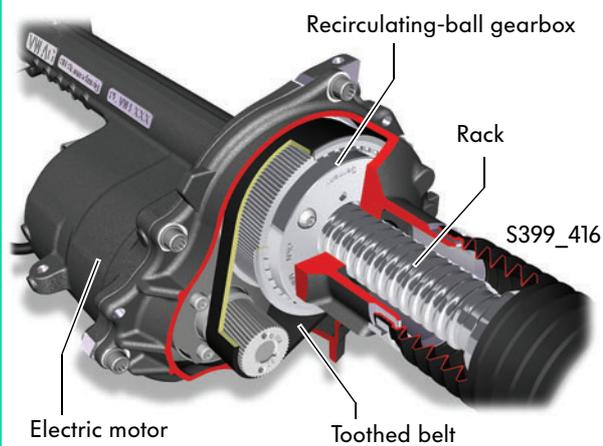
Further information can be found on the uneven tracking compensation system in self-study programme no. 389 "ParkAssist".

Steering Mechanics
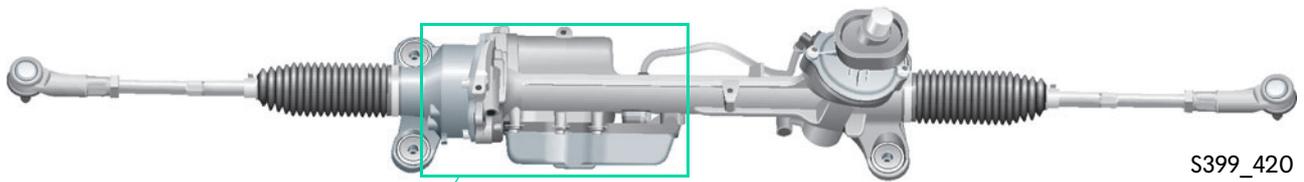
Steering box

S399_420

Steering-assistance gearbox

Recirculating-ball gearbox

Rack

S399_416

Electric motor

Toothed belt

The electromechanical power steering with parallel-axis drive applies the necessary steering force to the rack using the steering-assistance gearbox.
The steering-assistance gearbox consists of the electromechanical power steering motor V187, the recirculating-ball gearbox and the power steering control unit J500.

An all-new gearbox is used in this power-steering system. The rotary movement of the electric motor is converted into a longitudinal movement and is transmitted to the rack.

Recirculating balls

Ball screw nut

Return channel

Rack

Return channel

Gear

S399_438
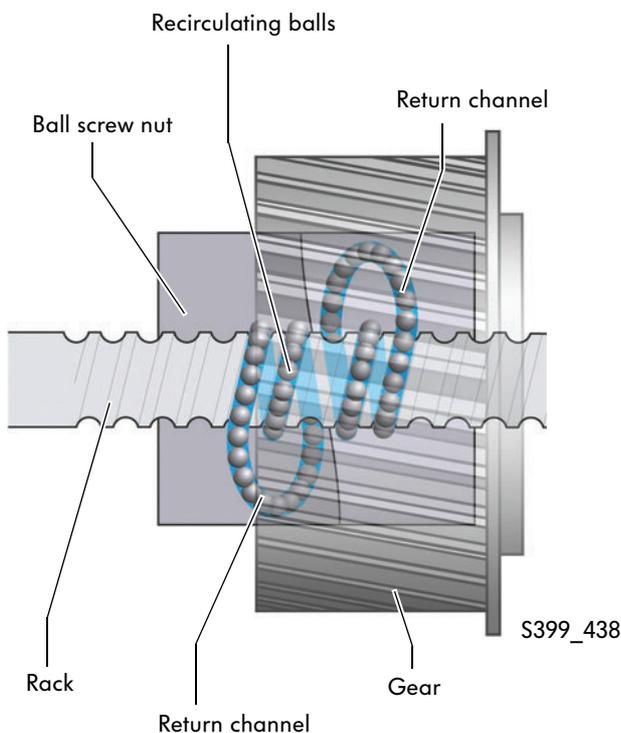
Design

The rotary movement of the electric motor mounted parallel to the rack is transferred to the recirculating-ball gearbox via a toothed belt.

The centrepiece of the steering box is the ball screw nut that is fixed in the case and encloses the rack that takes the form of a spindle in this area.

One special constructive feature of the recirculating-ball gearbox is the return channels of the balls in the ball screw nut.

Steering Mechanics

How it works

The ball screw nut is turned clockwise or anti-clockwise depending on the desired steering direction. As the rack takes the form of a spindle in this area, rotary movement of the ball screw nut pushes the rack in the desired direction.

Steering vehicle to left

Rotary movement of ball screw nut

Balls

Return channel

Longitudinal movement of the rack

S399_434
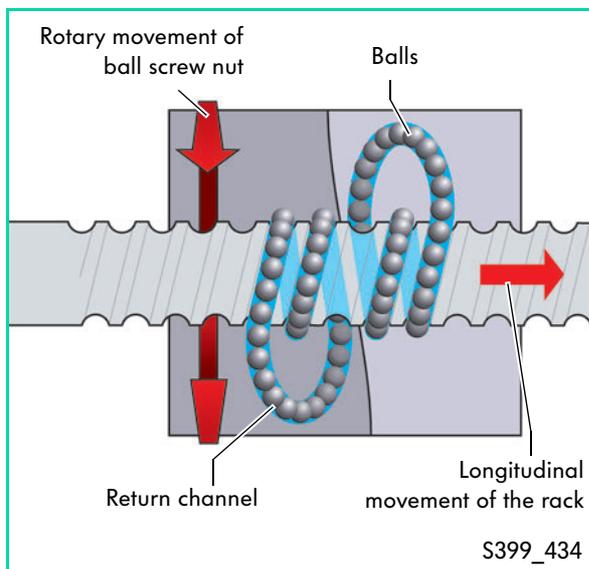
The ball screw nut is turned clockwise.
The rack moves to the right.

Steering vehicle to right

Rotary movement of ball screw nut

Spindle grooves

Longitudinal movement of the rack

S399_436
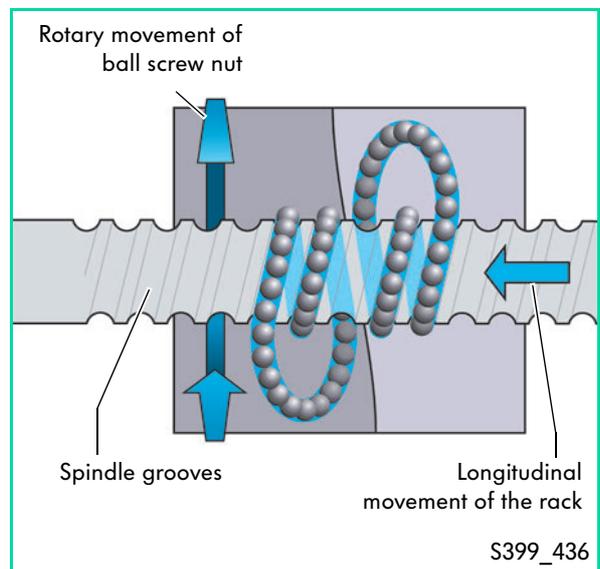
The ball screw nut is turned anti-clockwise.
 The rack moves to the left.

The balls run with the movement of the ball screw nut in the spindle grooves of the rack. While the ball screw nut rotates, the balls are fed back to the starting position via the return channels. Using five situations at different times and using the clockwise rotary movement of the ball screw nut, the path of the balls can be looked at more closely using two balls as an example. The ball screw nut has two independent recirculating systems with balls and return channels. The two systems are mirrored. The return channels are required because the balls would otherwise run against the end point and thus lock the steering.
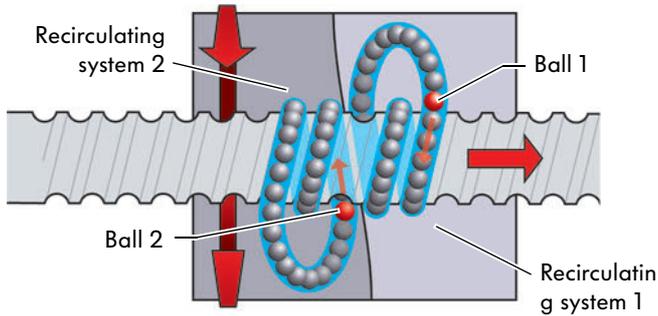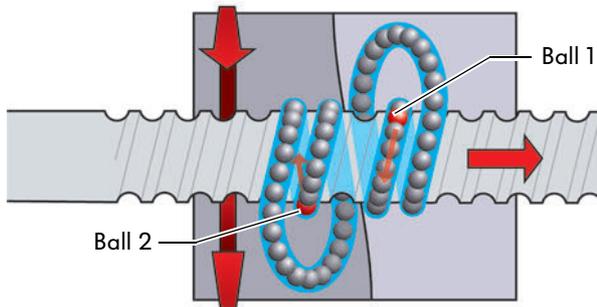
Situation 1

Ball 1 comes out of the return channel and moves downwards in the spindle groove.
Ball 2 comes out of the return channel and moves upwards in the spindle groove (the hidden, rear section in the diagram).
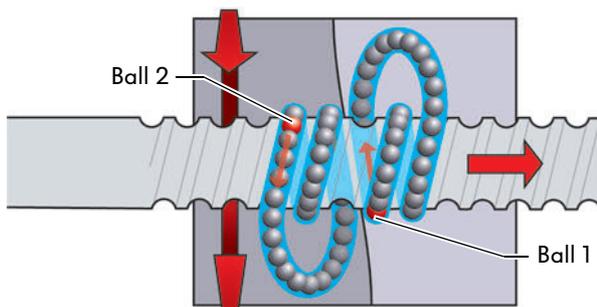
Recirculating system 2

Ball 1

Ball 2

Recirculating system 1
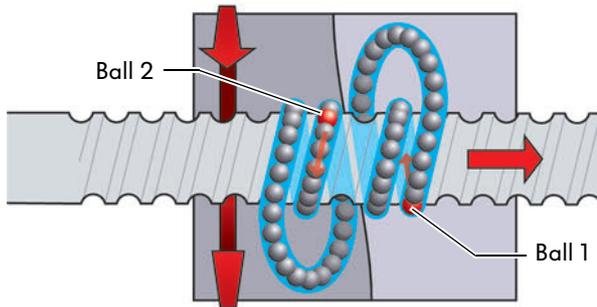
Situation 2

Ball 1 moves upwards in the spindle groove (the hidden, rear section in the diagram).
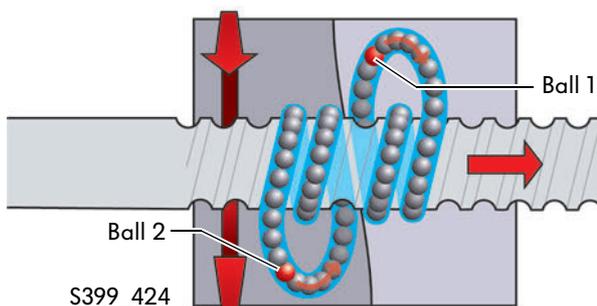Ball 2 moves downwards in the spindle groove.

Ball 2

Ball 1

Situation 3

Ball 1 moves downwards in the spindle groove.
Ball 2 moves upwards in the spindle groove (the hidden, rear section in the diagram).

Ball 1

Ball 2

Situation 4

Ball 1 moves upwards in the spindle groove (the hidden, rear section in the diagram).
Ball 2 moves downwards in the spindle groove.
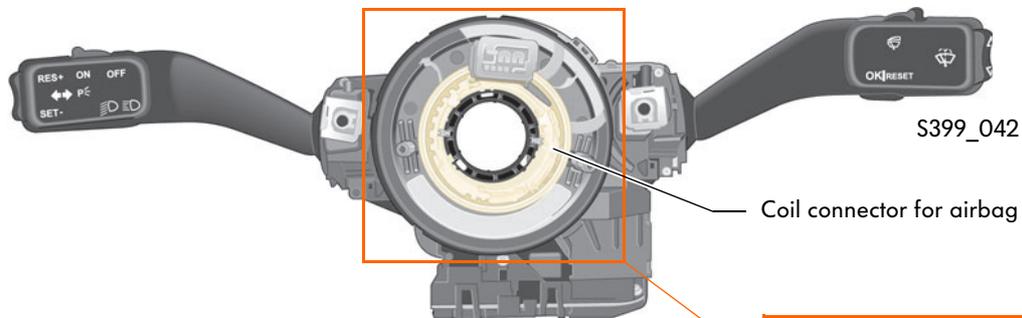
Ball 2

Ball 1

Situation 5

Both balls are fed to the starting position of the respective recirculating system via the return channels. The ball screw nut can thus rotate on a ball groove and the spindle is moved over large distances.

Ball 1

Ball 2

S399_424

21

Steering Electrics

Steering angle sender G85

S399_042

Coil connector for airbag

The steering angle sender G85 is located behind the return ring with the airbag slip ring. It is mounted on the steering column between the steering column ECU and steering wheel.

The steering angle sender supplies the steering angle signal to the steering column electronics control unit J527 via the CAN data bus.
The steering column electronics control unit contains the electronics for evaluating the signals.

Effects upon failure

If the sensor fails, a back-up program is used.
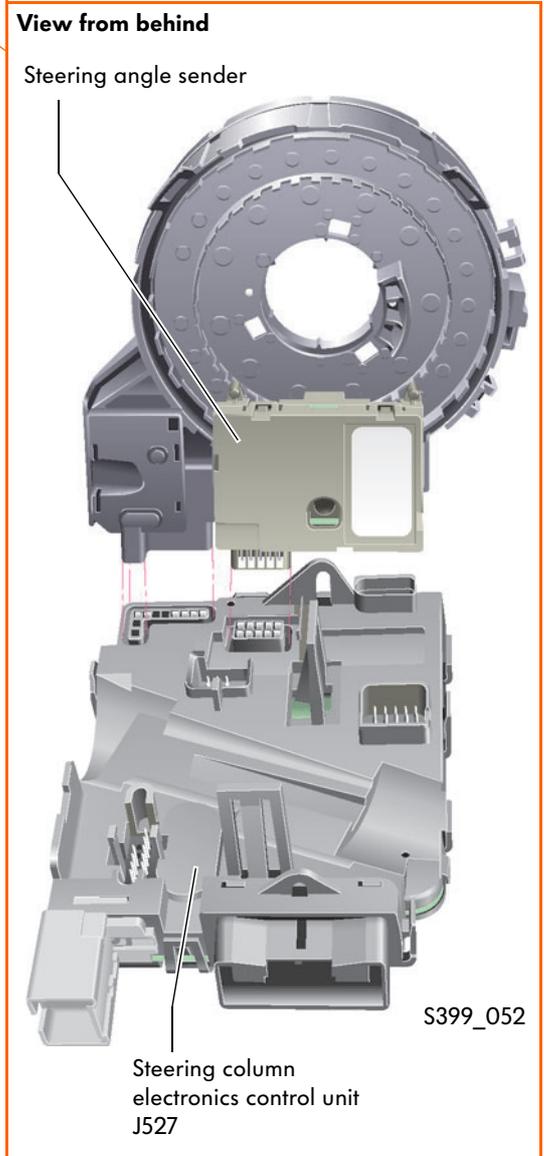The missing signal is set to a substitute value.
The steering assistance is maintained completely.
The fault is indicated by the electromechanical power steering warning lamp K161.
The following functions are switched off, for example:

- Active return
- Software end positions
- Straight-ahead driving correction

View from behind

Steering angle sender

S399_052

Steering column electronics control unit J527

Functional principle

Absolute ring   Incremental ring

S399_050
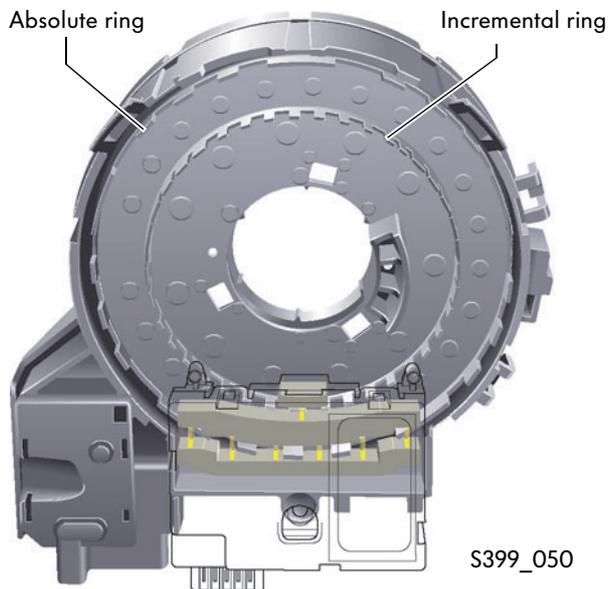
The basic components of the steering angle sender are:

- A coding disc with two code rings
- Light barrier sets each with a light source and an optical sensor

The coding disc consists of two rings, the outside absolute ring and the inside incremental ring.

Absolute ring   Incremental ring

Segment 3

72°

Segment 4   Segment 2

Segment 5   Segment 1

S399_086
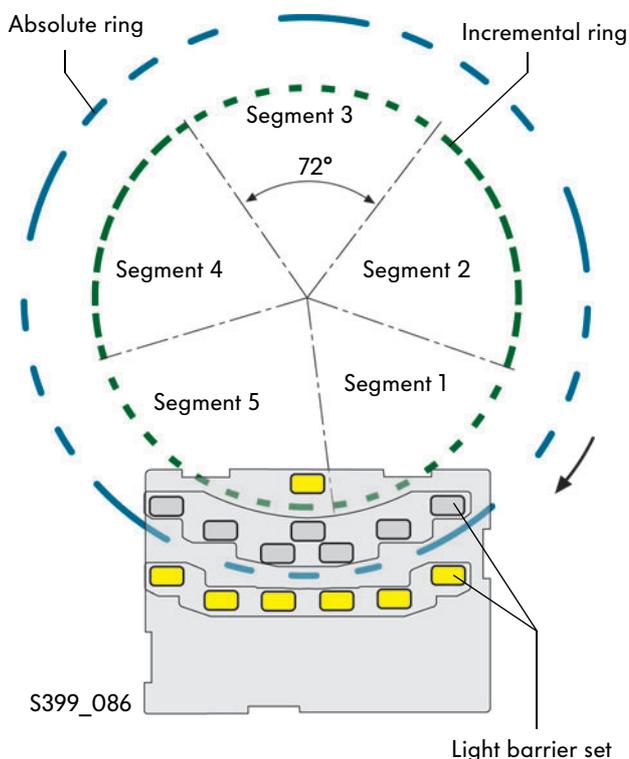
Light barrier set

The incremental ring is divided into 5 segments each with 72° and is read by a light barrier set. The ring is broken inside the segment. The sequence of the openings is the same within a segment, but different between the segments. This results in the coding of the segments.

The absolute ring determines the angle. It is read by 6 light barrier sets.

The steering angle sender can recognise a 1044° steering angle. It adds up the angle degrees. It thus recognises when the 360° point is exceeded that one turn of the steering wheel has been completed.
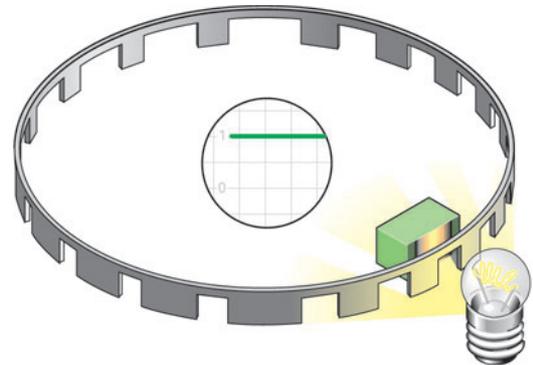
The steering angle sender is designed to allow 2.76 turns of the steering wheel.

Steering Electrics

The angle is measured using light barriers.

If only the incremental ring is observed to simplify matters, the light source is on one side of the segment ring and the optical sensor is on the other side.

S399_114

When light falls onto the sensor through a gap, a signal voltage is created. If the light source is covered, the voltage will be dropped again.
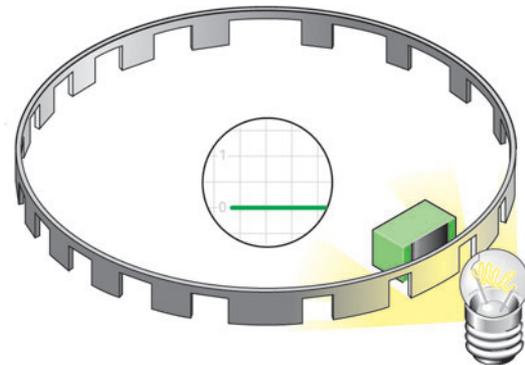
S399_116

If you now move the incremental ring, there is a sequence of signal voltages.
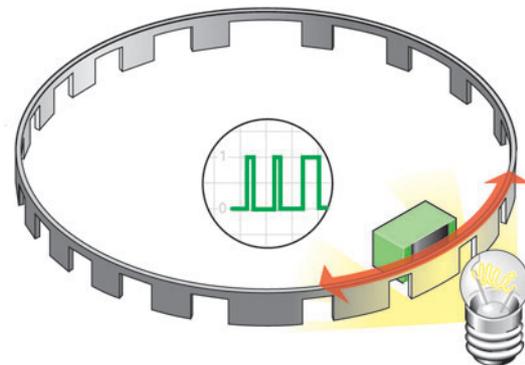
S399_118

In the same way, a sequence of signal voltages is created by each light barrier set for the absolute ring. All sequences of signal voltages are processed in the steering column electronics control unit.

By comparing the signals, the system can calculate how far the rings have been moved. The starting point of the movement is determined by the absolute ring part.

Steering moment sender G269

S399_420

Steering input shaft

Steering moment sender
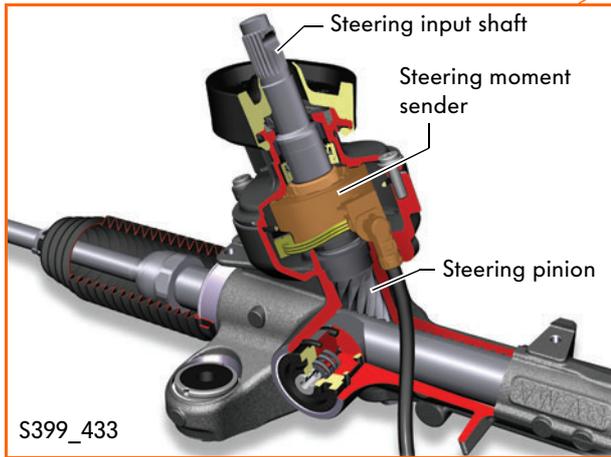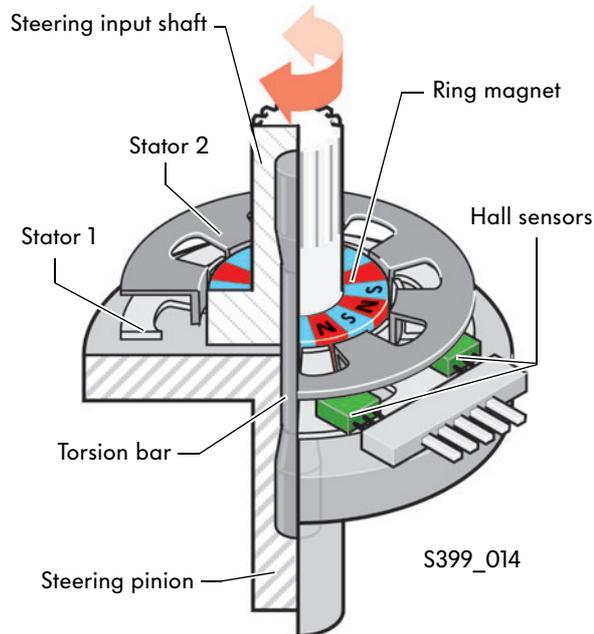
Steering pinion

S399_433

The steering moment applied to the steering wheel by the driver is the basis for calculating the assistance power that is provided by the steering system. The steering moment is measured at the steering pinion with the aid of the steering moment sender G269. The relative rotation of the steering input shaft is compared with the steering pinion and converted to an analogue electrical output signal.

Design

The steering input shaft and the steering pinion are connected to each other on the torque sensor via a torsion bar. The torsion bar has a defined torsional stiffness.

A sixteen-pole ring magnet (eight pole pairs) is on the steering input shaft and rotates with the shaft.
Two stators each with eight teeth are on the steering pinion and rotate with it. In rest position, the stator teeth are exactly in the middle between the respective south poles and north poles of the ring magnet.
The Hall sensors are fixed on the housing and do not rotate.

Steering input shaft

Ring magnet

Stator 2

Stator 1

Hall sensors

Torsion bar

Steering pinion

S399_014

Steering Electrics

How it works

The sensor works contact-free according to the magnetoresistive principle. The height and alignment of the magnetic flow between stator 1 and stator 2 is a direct measurement of steering moment and is measured by two linear Hall sensors (redundant configuration). Depending on the steering moment applied and thus the torsion angle, the signal from a Hall sensor moves between zero position and maximum position.
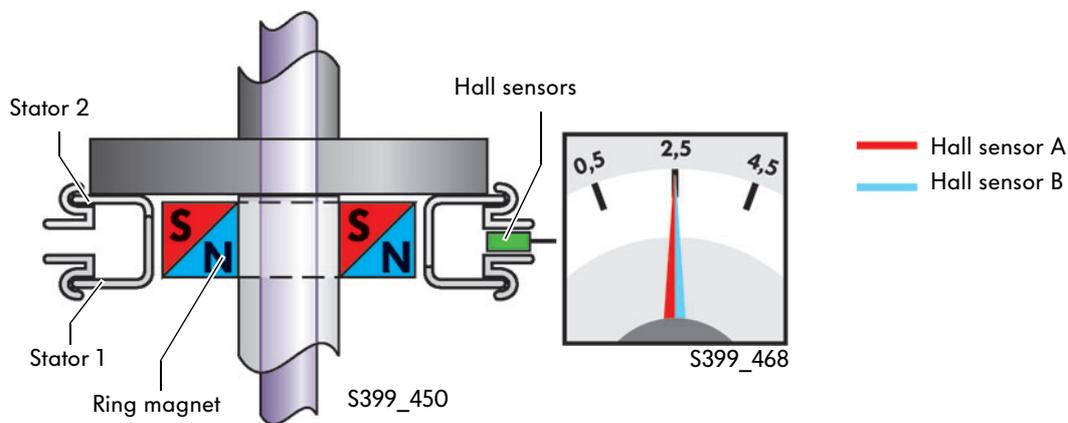
Zero position

Hall sensor A   Hall sensor B

Stator 2

Stator 1   Ring magnet

S399_448
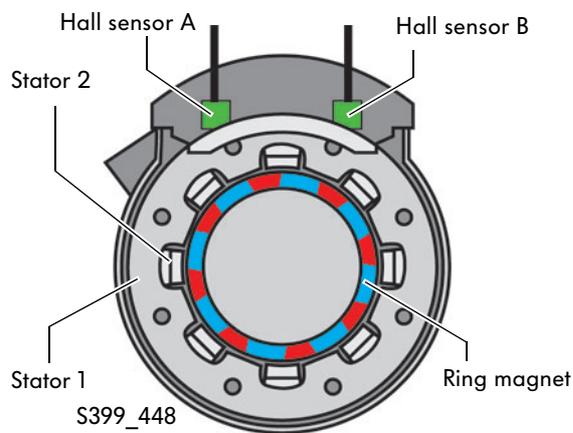
When the torque sensor is in zero position, the teeth of stator 1 and stator 2 are exactly in the middle between two magnetic poles.

Stator 2   Hall sensors

S   S
N   N

Stator 1

Ring magnet   S399_450

0,5   2,5   4,5

S399_468
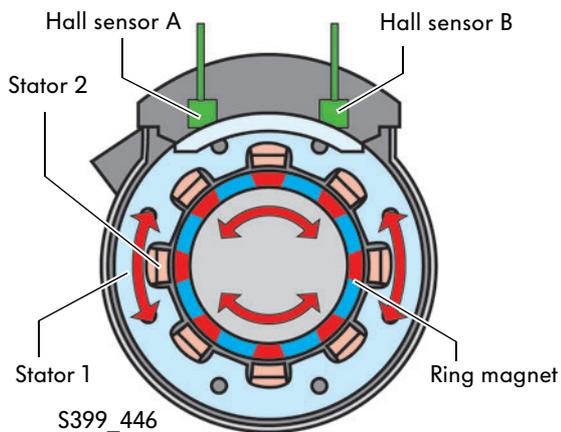
Hall sensor A
Hall sensor B

Therefore neither stator 1 nor stator 2 has a north or south alignment. A magnetic field cannot form between the two stators.
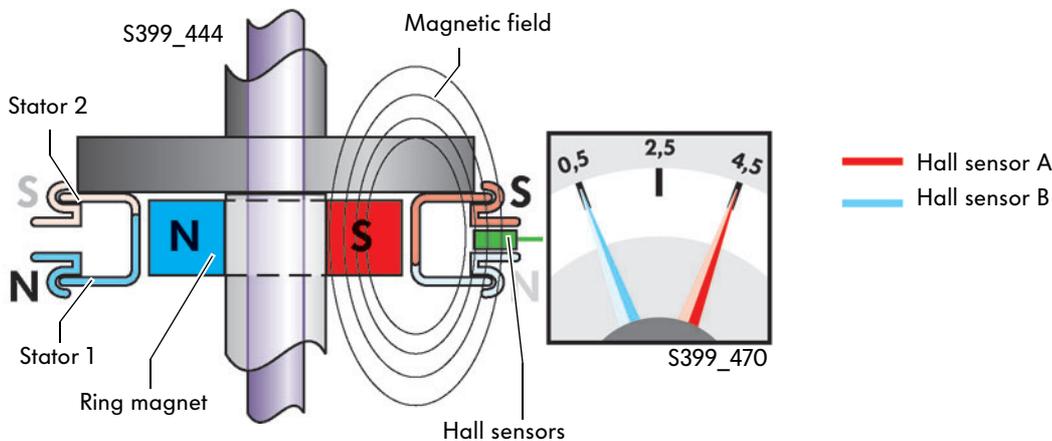
The Hall sensors are supplied with an input voltage of 5V. As no magnetic field has formed between the two stators, the Hall sensors issue a signal for the zero moment of 2.5V.

Maximum position

If the driver turns the steering wheel, a torsion angle between the steering input shaft and the steering pinion results. The ring magnet turns compared with stator 1 and 2. When the eight teeth on stator 1 set are precisely on the north poles and the eight teeth of stator 2 precisely on the south poles of the ring magnet, the sensor has reached maximum position. This means that stator 1 has, for example, a north alignment and stator 2 has a south alignment.

Hall sensor A

Hall sensor B

Stator 2

Stator 1

Ring magnet

S399_446

A magnetic field forms between the two stators. This field is measured by the Hall sensors and is converted into an electrical signal. If Hall sensor A has the maximum voltage of 4.5V, Hall sensor B issues an minimum voltage of 0.5V.
In the opposite steering direction, Hall sensor A has a voltage of 0.5V and Hall sensor B a voltage of 4.5V.

S399_444

Magnetic field

Stator 2

S

N

Stator 1

Ring magnet

Hall sensors

0,5   2,5   4,5

S399_470

Hall sensor A
Hall sensor B

Effects upon failure

If the steering moment sender is faulty, the steering box will need to be replaced. The steering assistance will be deactivated if a fault is recognised. It is not suddenly deactivated, but "softly".

To obtain this "soft" deactivation, a steering moment substitute signal is calculated from the steering and rotor angle of the electric motor. The fault is indicated by the electromechanical power steering warning lamp K161 being illuminated red.
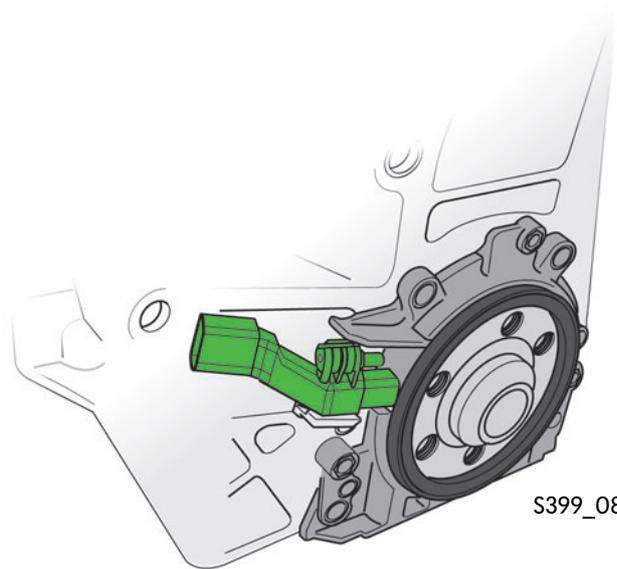
Steering Electrics

Engine speed sender G28

The engine speed sender is a Hall sender. It is
screwed into the crankshaft sealing flange housing.

Signal use

The engine speed and the precise position of the
crankshaft are calculated by the engine control
unit using the signal from the engine speed sender.

S399_088

Effects upon failure

If the engine speed sender fails, the steering is
operated with terminal 15. The fault is not indicated by
the electromechanical power steering warning lamp
K161 illuminating.

You will find further information on the
engine speed sender G28 in SSP 316
"The 2.0 l TDI Engine".

Vehicle speed

The signal for the vehicle speed is supplied by the ABS control unit.

Effects upon failure

If the signal for the vehicle speed fails, an emergency-running program is started. The driver has full steering
assistance, but no Servotronic function. The fault is indicated by the electromechanical power steering warning
lamp K161 illuminating yellow.

Electromechanical power steering motor V187

S399_420

S399_426

The electromechanical power steering motor V187 is mounted parallel to the rack in the steering gear housing. It transfers the steering-assistance force to the recirculating-ball gearbox via a toothed belt.

The electric motor delivers a maximum torque of 4.5Nm to assist steering.

The electromechanical power steering motor V187 is a 3-phase synchronous motor. In synchronous motors, the rotor rotates in sync with the stator current field.

Compared with an asynchronous motor, this synchronous motor has the following advantages.

- It is lighter.
- It is wear-free because it does not use brushes.
- The rotor is a permanent magnet.
- It does not need pre-excitation.
- It is energy-saving and reacts faster.

The synchronous motor has a good electrical efficiency as there is no current-drawing magnetic pre-excitation as with an asynchronous motor.
It has therefore been possible to reduce the active power consumption compared with similar steering systems.

Effects upon failure

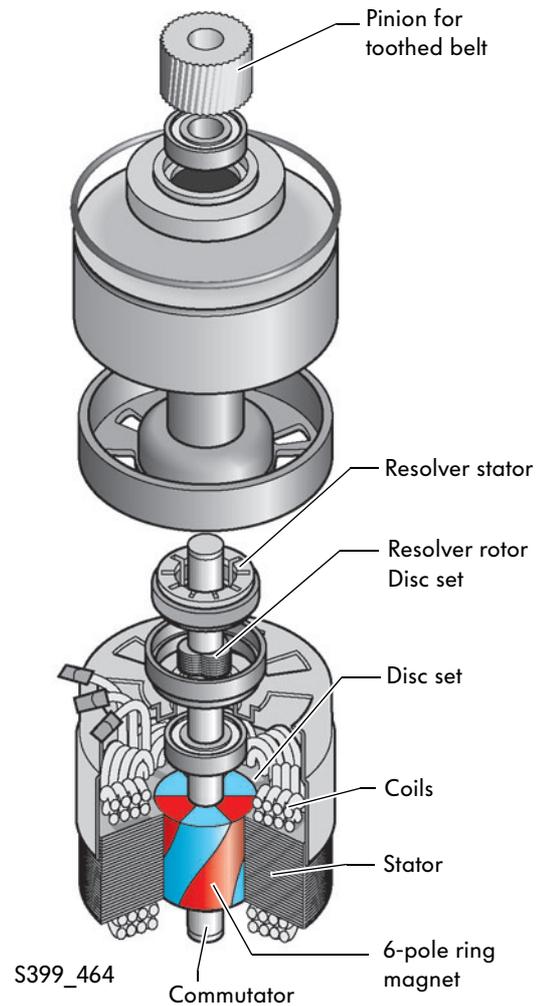There is no steering assistance if the motor fails.

29

Steering Electrics

Design

The motor for the electromechanical power steering consists among other things of a rotor and a stator. The rotor is a 6-pole ring magnet made from rare-earth magnets. Rare-earth magnets allow very high magnetic field strengths in conjunction with minimum design dimensions.

The stator consists of 9 coils and 9 disc sets. This number results in an unpaired arrangement. The coils are powered using a successively offset sinus curve so that one magnetic field results from all three magnet fields and pulls the rotor behind it. The magnetisation of the 6-pole ring magnet is diagonal to make the motor quieter.

Pinion for toothed belt

Resolver stator

Resolver rotor
Disc set

Disc set

Coils

Stator

6-pole ring magnet

S399_464

Commutator

How it works

A rotating magnetic field is generated in the stator when the coils are powered. The commutator magnet adjusts itself depending on the direction of the rotating field generated by the coils like a compass needle in the magnetic field of the earth. The speed and direction of rotation is determined by the current. The unpaired number of the 9 coils and the 6 magnetic poles of the commutator cause it to spontaneously rotate. No pre-excitement is necessary. The commutator rotates in sync with the stator current field. The motor is also called a synchronous motor for this reason.

Rotation of commutator

Coils

Disc set

Stator

S399_466

6-pole ring magnet with diagonal magnetisation
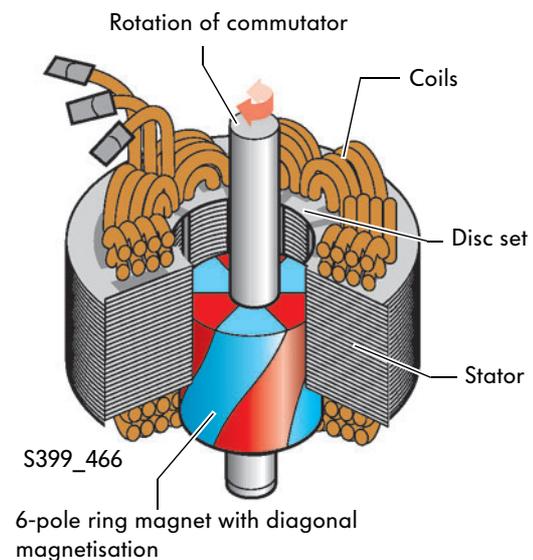
Sender for motor position

The motor position sender is part of the electromechanical power steering motor V187.
It cannot be accessed from the outside.

Commutator

Resolver stator

Resolver rotor
Disc set

S399_472
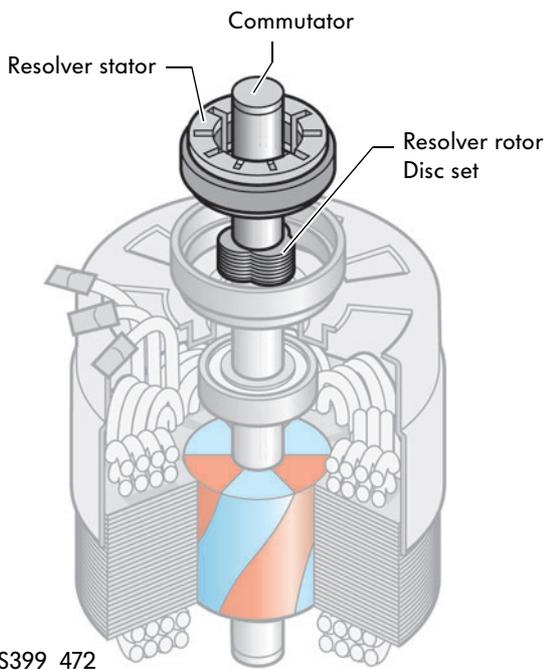
Design

The motor position sender is at one end of the shaft. The motor position sender is based on the resolver principle. It consists of the resolver stator with 10 coils and the resolver rotor. The resolver rotor is made from a set of iron discs.

Signal use

The motor position sender is used to determine the absolute position of the commutator within one revolution. The rotor speed and direction of rotation is also determined from the signal.

Therefore it measures the exact position of the electromechanical power steering motor V187 that is required for precise control of the motor.

Effects upon failure

If the sensor fails, the steering assistance is safely deactivated. The fault is indicated by the electromechanical power steering warning lamp K161 being illuminated red.

Steering Electrics

Power steering control unit J500

S399_420

The control unit is cemented and screwed to the steering box. The control unit contacts are welded to the electric motor and can therefore not be separated. By using the steering box casing for thermal dissipation, there is no temperature-related reduction in the steering assistance even when a very high level of heat develops in the control unit.

S399_422
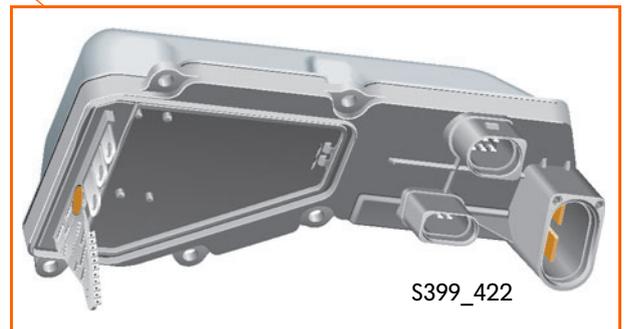
The control unit uses input signals like:

- the steering angle signal from the steering angle sender G85,
- the engine speed from the engine speed sender G28,
- the steering moment and the rotor speed of the electric motor as well as
- the vehicle speed signal

to determine the current steering assistance requirement. The current strength and direction of the stator current is calculated and the motor V187 is activated.

Effects upon failure

A temperature sensor is integrated into the control unit to measure the temperature of the steering system.
If the temperature rises above 100° C, the steering assistance is constantly reduced.

If the steering assistance falls below a value of 60%, the electromechanical power steering warning lamp K161 will illuminate yellow.
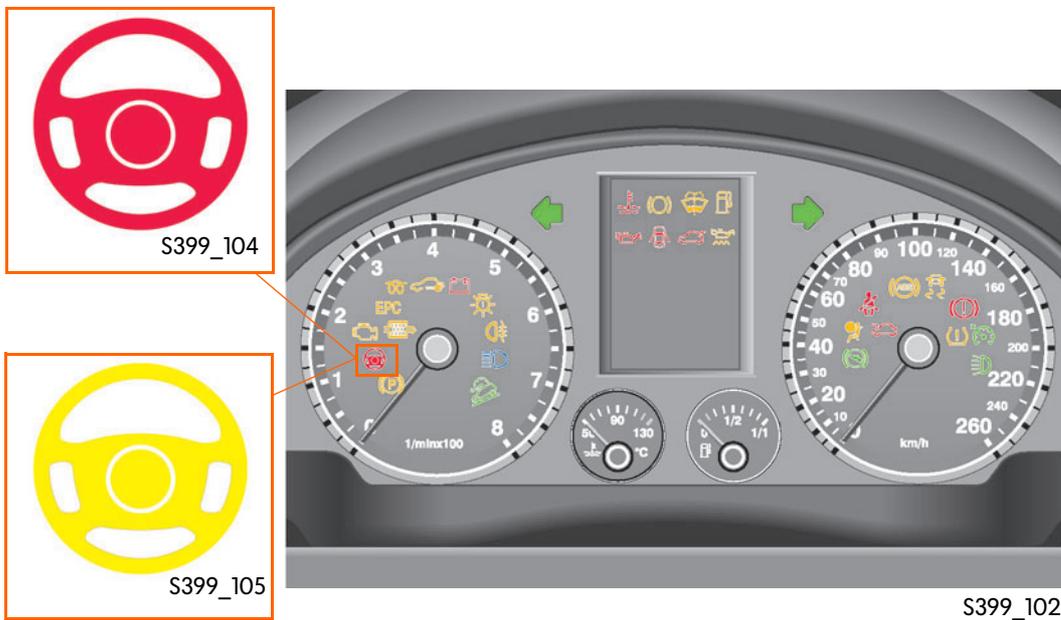
If the control unit is faulty, the steering will need to be replaced completely.

Electromechanical power steering warning lamp K161

The electromechanical power steering warning lamp is in the display in the dash panel insert.
It is used to display malfunctions or faults in the electromechanical power steering.

The warning lamp illuminates in two colours when there are malfunctions. Yellow means a simple warning. If the electromechanical power steering warning lamp turns red, you should find a workshop immediately. If the warning lamp is red, a triple gong will sound as an acoustic warning signal.

S399_104

S399_105

S399_102

When you turn the ignition on, the electromechanical power steering warning lamp turns red as the electromechanical power steering system carries out a self-check.

The warning lamp only extinguishes once the power steering control unit transmits the signal that the system is working properly.
This self-check takes approx. two seconds. The warning lamp extinguishes immediately when the engine is started.

Steering Electrics

Special features

Towing

Under the conditions that

- the speed is greater than 7km/h and
- the ignition is on,

steering assistance is also provided when the vehicle is towed.

Flat batteries

The steering system recognises and reacts to undervoltage. If the battery voltage falls to 9 volt, the steering assistance is reduced initially and the electromechanical power steering warning lamp illuminates yellow.

If the battery voltage falls below 9 volt, the steering assistance is switched off and the electromechanical power steering warning lamp illuminates red.

If there are brief voltage dips below 9 volt, the electromechanical power steering warning lamp illuminates yellow.

Functional diagram

Terminal 30
Terminal 15
Terminal 31

S

S

V187

J500

A

B

G269

S399_096
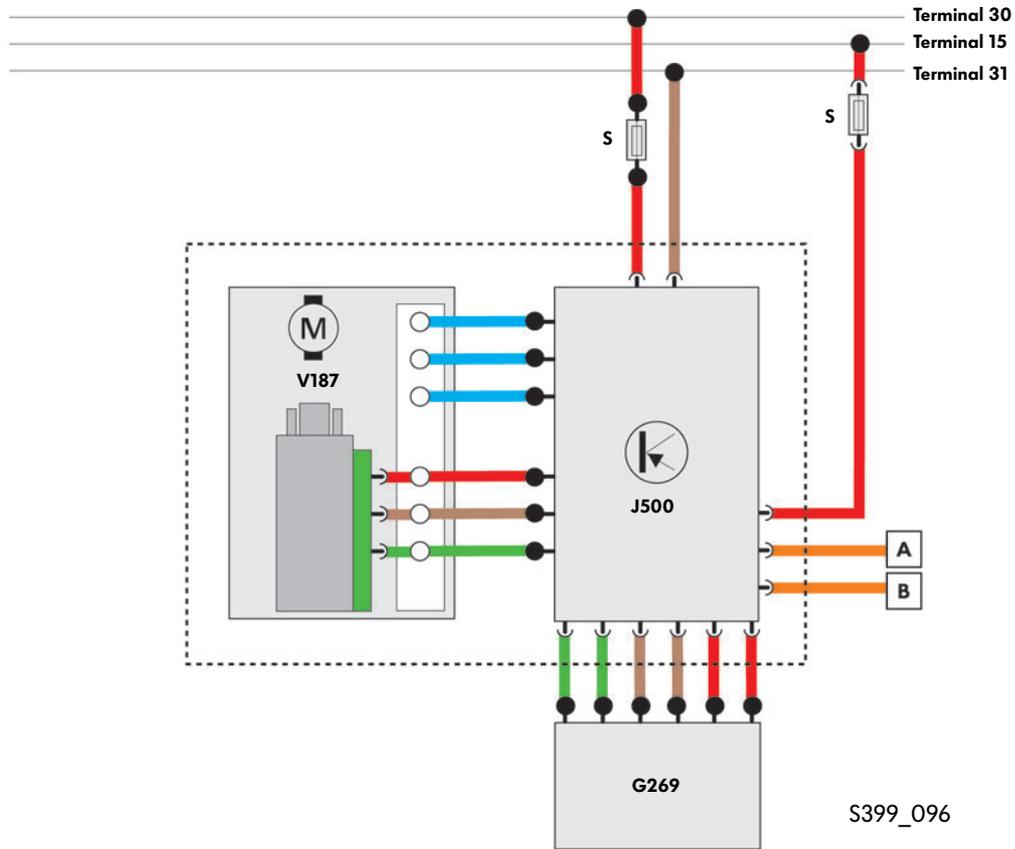
A   - CAN low
B   - CAN high
G269 - Steering moment sender
J500 - Power steering control unit
S   - Fuse
V187 - Electromechanical power steering
         motor

Colour code/legend

Input signal
Output signal
Positive
Earth
CAN data bus

Service

Diagnosis

The system components in the electromechanical power steering are self-diagnosis capable.

Steering stop teach-in

A limit is applied by the software to avoid a hard mechanical steering stop.
The "software stop" and thus the damping is activated at approx. 5° steering angle before the mechanical stop.

The steering assistance is reduced in relation to the steering angle and steering speed and even a counter-force is generated.
In the "Basic Setting" function, the angle positions for the stops need to be deleted with one of the vehicle diagnosis, measuring and information systems. To set the steering stops, use the detailed information in the current repair guide and in the "Guided Fault Finding" or in "Guided Functions".

Notes

Test Yourself

1. **Where is the motor position sender installed in an "electromechanical steering system with parallel-axis drive"?**

   ☐ a) The motor position sender is mounted directly on the steering pinion.

   ☐ b) The motor position sender is part of the electric motor V187.

   ☐ c) The motor position sender is between the steering column and steering column switch.

2. **What kind of electric motor is used for the "electromechanical steering with parallel-axis drive"?**

   ☐ a) a 3-phase synchronous motor

   ☐ b) a 3-phase asynchronous motor

   ☐ c) a 2-phase synchronous motor

3. **How is power transmitted between the electric motor and rack in the "electromechanical steering with parallel-axis drive"?**

   ☐ a) a planetary gearbox

   ☐ b) a recirculating-ball gearbox

   ☐ c) a worm gear

4. **How are the signals from the "steering moment sender" transmitted?**

   ☐ a) via a coil connector and two rotating Hall sensors

   ☐ b) via two Hall sensors that are fixed to the housing and do not rotate

   ☐ c) via a Hall sensor outside the revolving parts

5. What function do the return channels in the ball screw nut have?

☐ a) They collect the balls.

☐ b) They guide the balls past the ball screw nut.

☐ c) They return the balls to their starting position.

399

�֎ This paper was manufactured from pulp that was bleached without the use of chlorine.