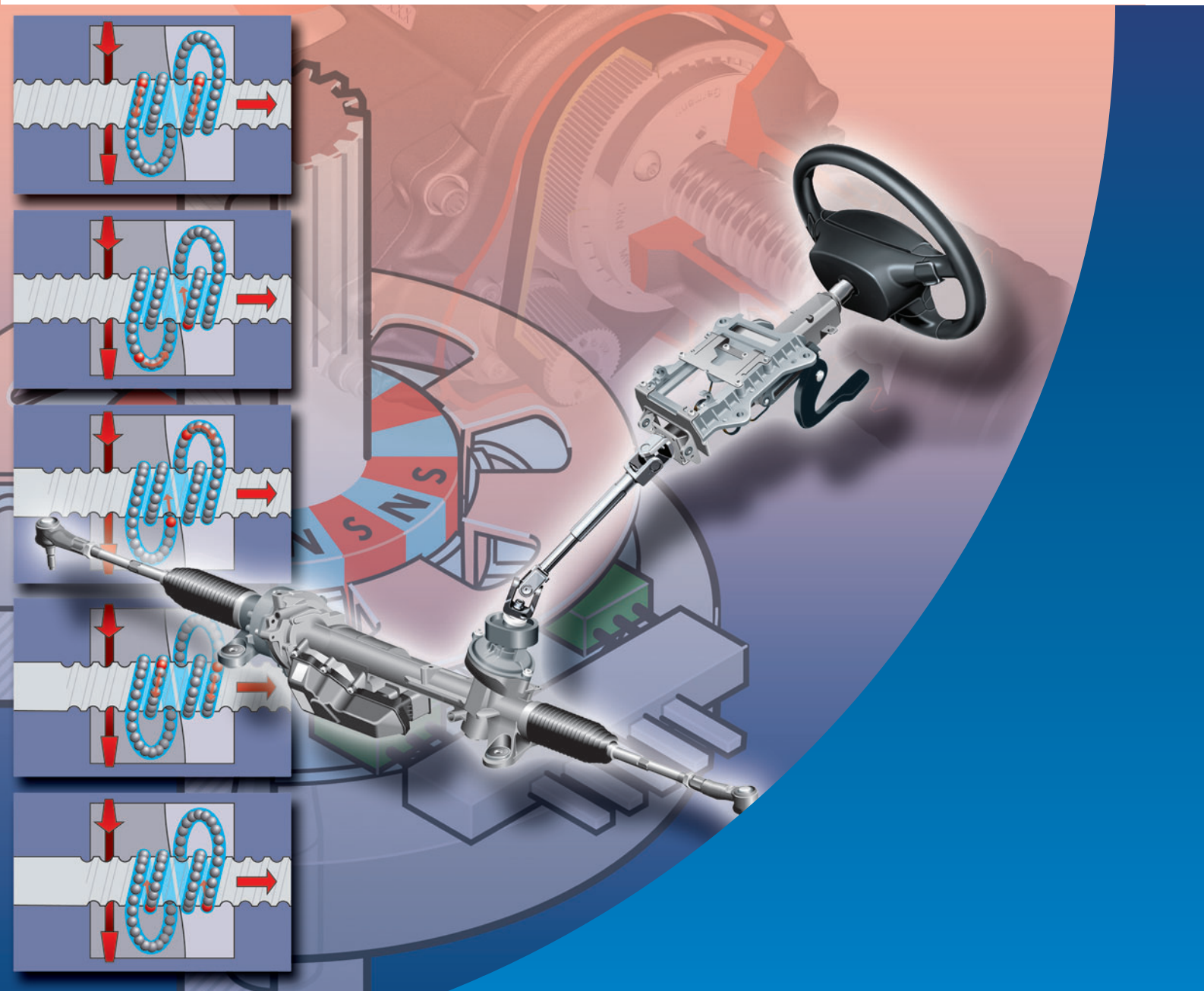




Self-study Programme 399

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.

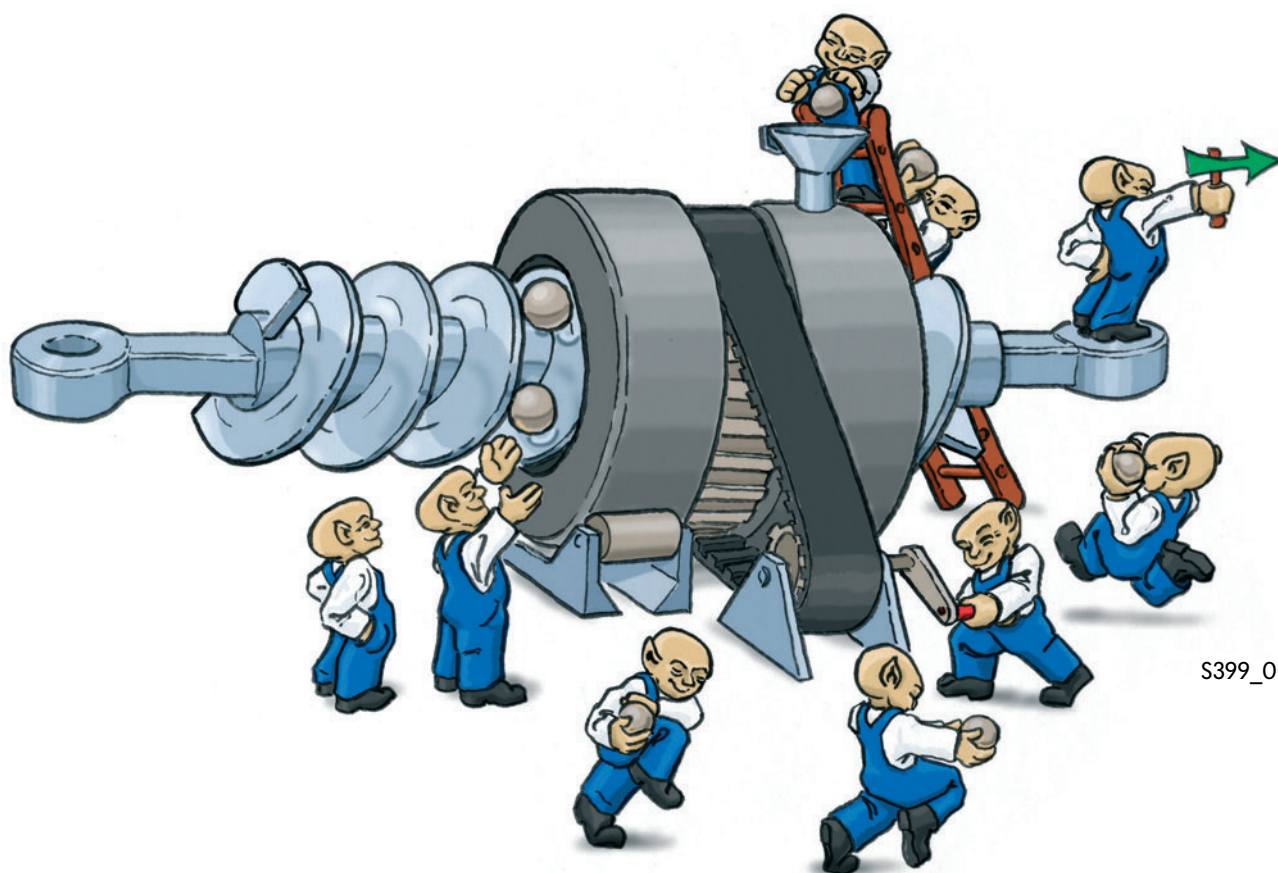
The parallel-axis power steering is part of the latest generation of electromechanical steering systems.

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**

**The self-study programme shows the design and function of new developments.
The contents will not be updated.**

For current testing, adjustment and repair instructions, refer to the relevant service literature.





Introduction	4
System overview	8
Function	9
Steering mechanism	19
Steering electrics	22
Functional diagram	35
Service	36
Test yourself	38



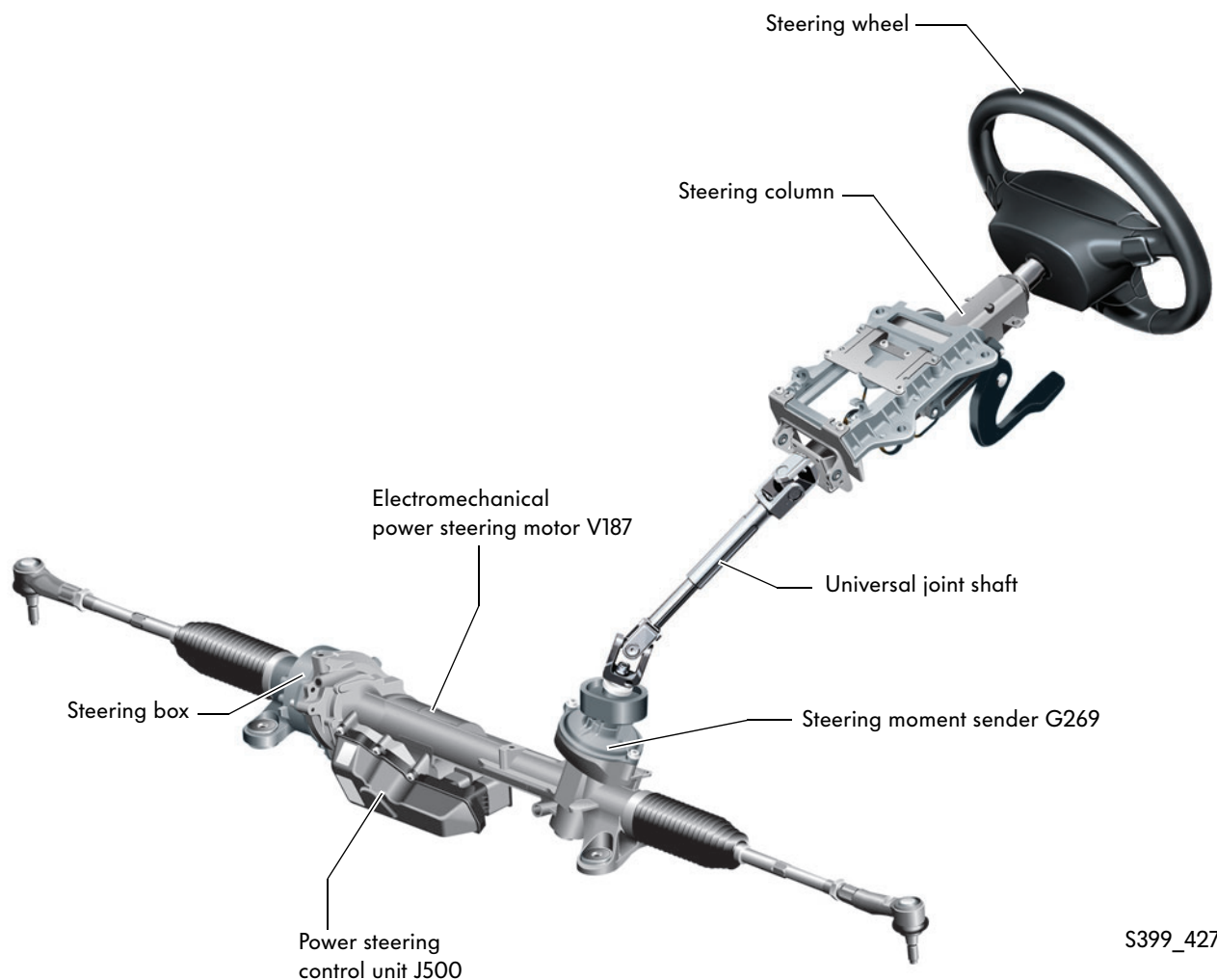
Introduction



Overview of electromechanical steering with parallel-axis drive

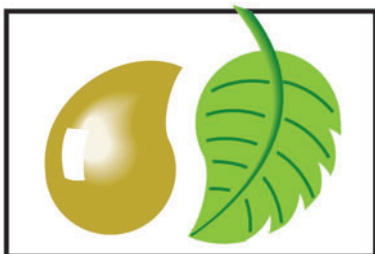
The steering comprises the following components:

- 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



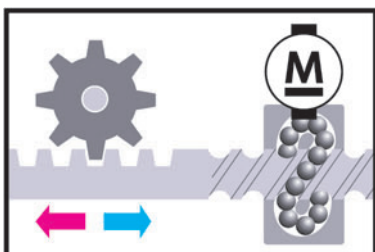
S399_427

What you should know about the electromechanical power steering:



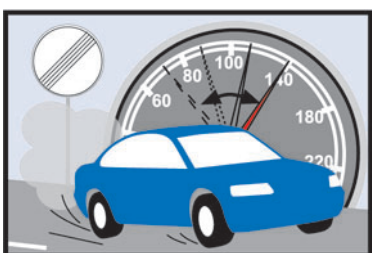
S399_106

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.



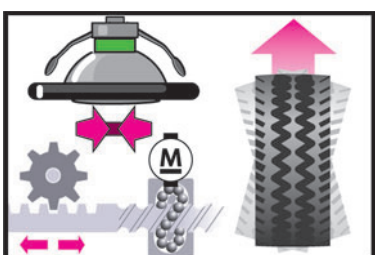
S399_108

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_110

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_111

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.



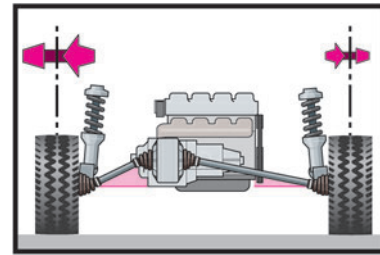
S399_112

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.

Introduction

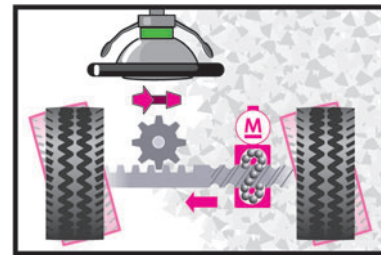


The different lengths of the drive shafts for the left-hand and right-hand front wheels resulting from the front-wheel drive and transverse engine layout often cause the vehicle to be pulled to one side while accelerating. The uneven tracking compensation system recognises this and counteracts it by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

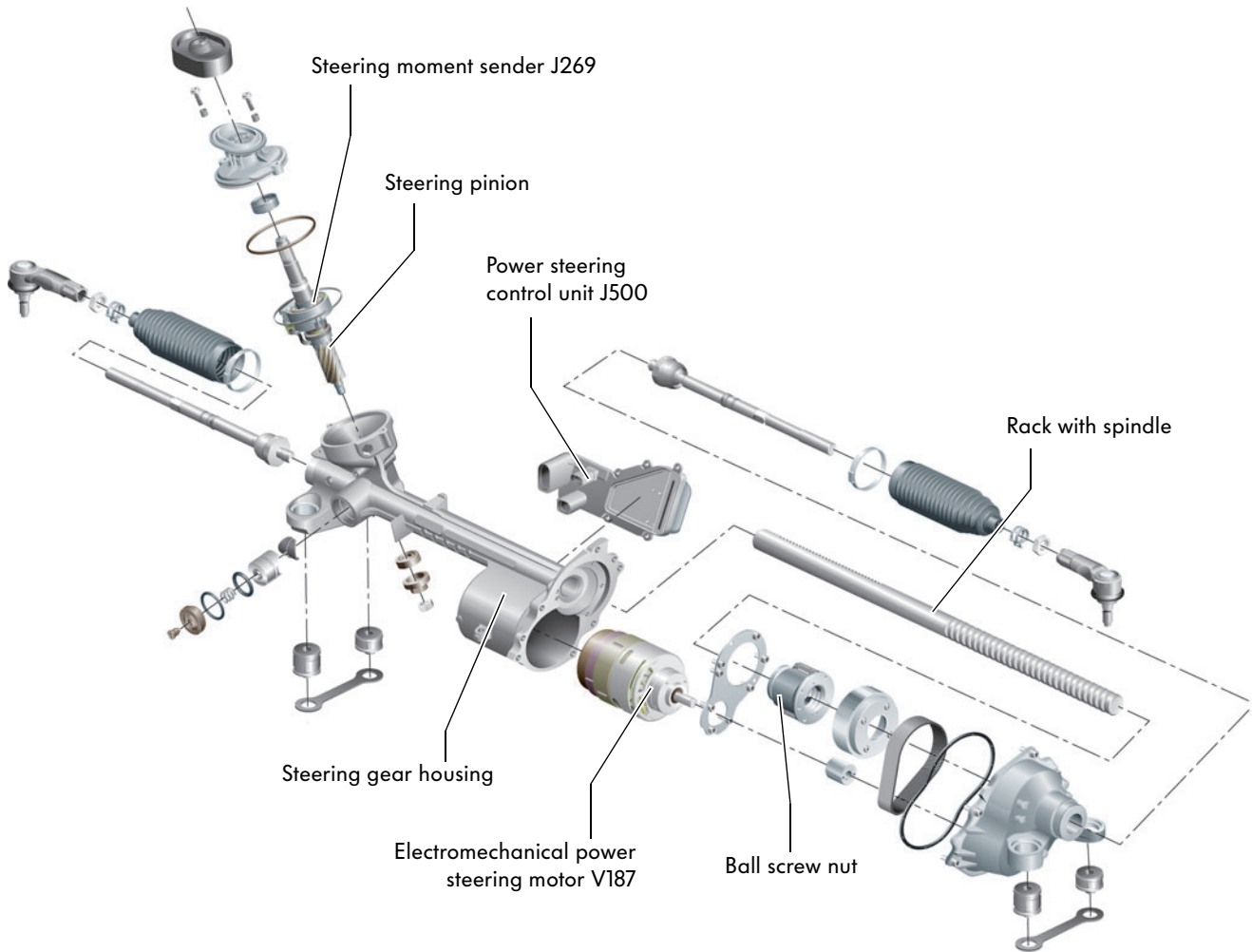
One advantage of the electromechanical power steering compared with hydraulic steering systems is that there is no need for a hydraulic system. The components that assist steering are mounted on and act directly on the steering box.

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



S399_100



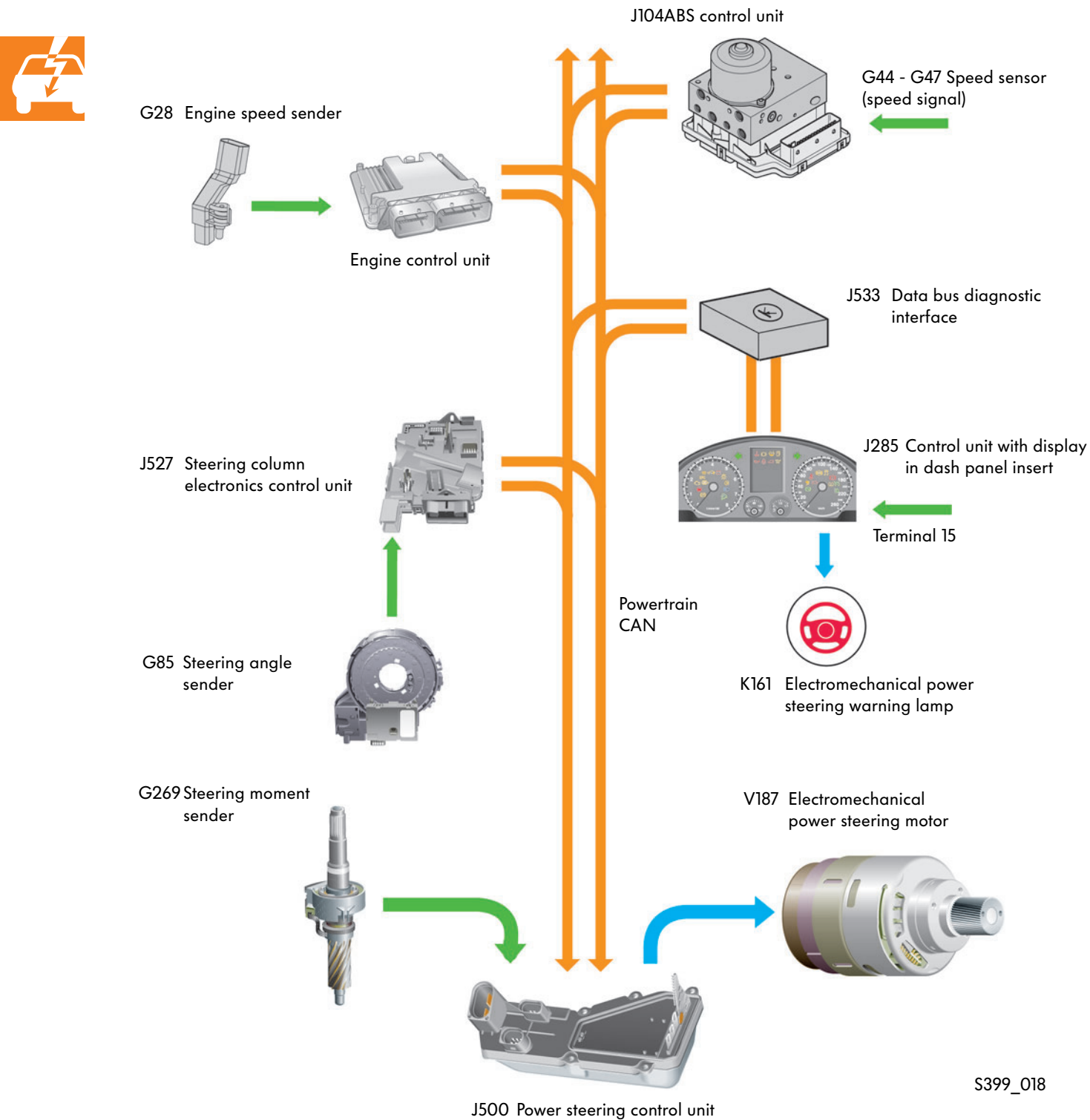
The fuel saving compared with a hydraulic power steering system is up to 0.2 litres every 100 kilometres.



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

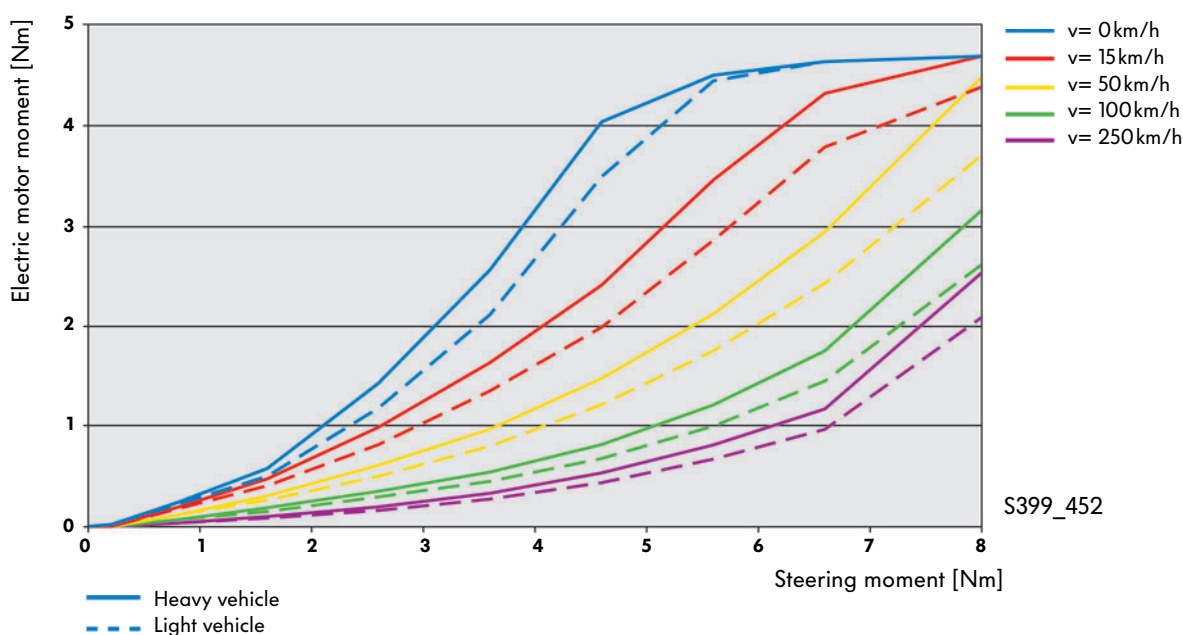


S399_018

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.



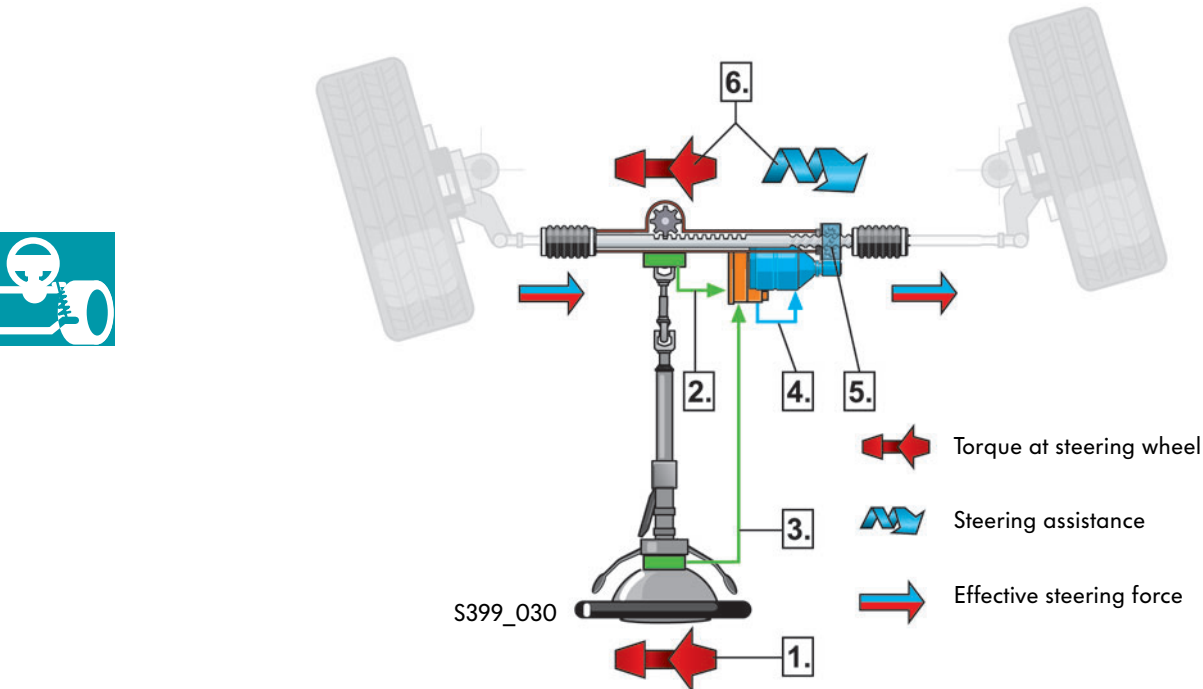
A map for a heavy vehicle (continuous line) and map for a light vehicle (broken line) for the Tiguan have been chosen as examples from the 5 maps available.

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.

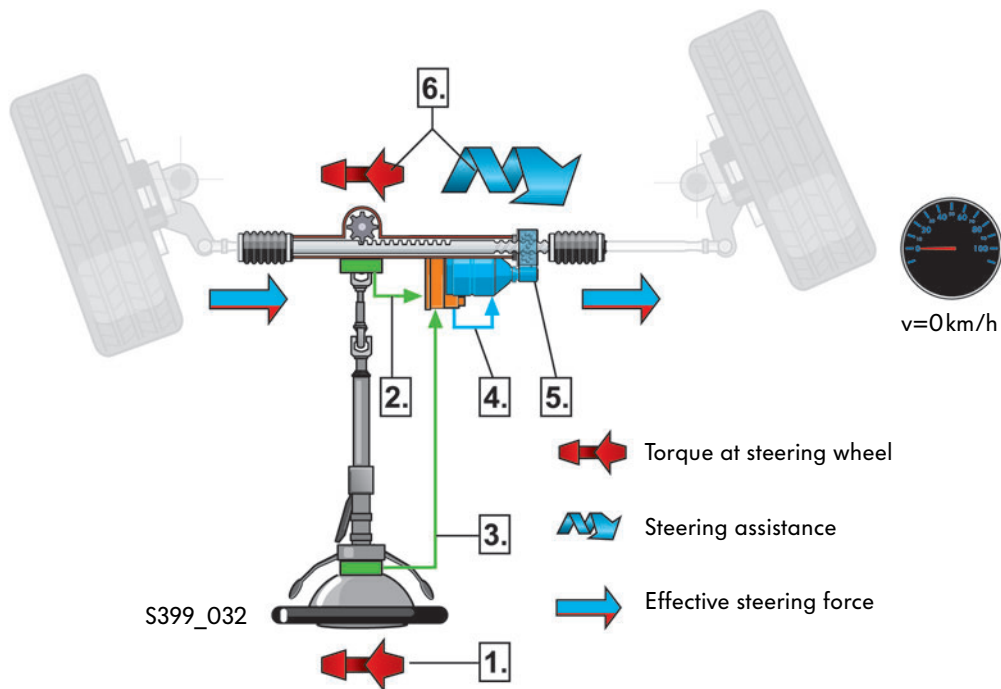
Function

Steering procedure



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

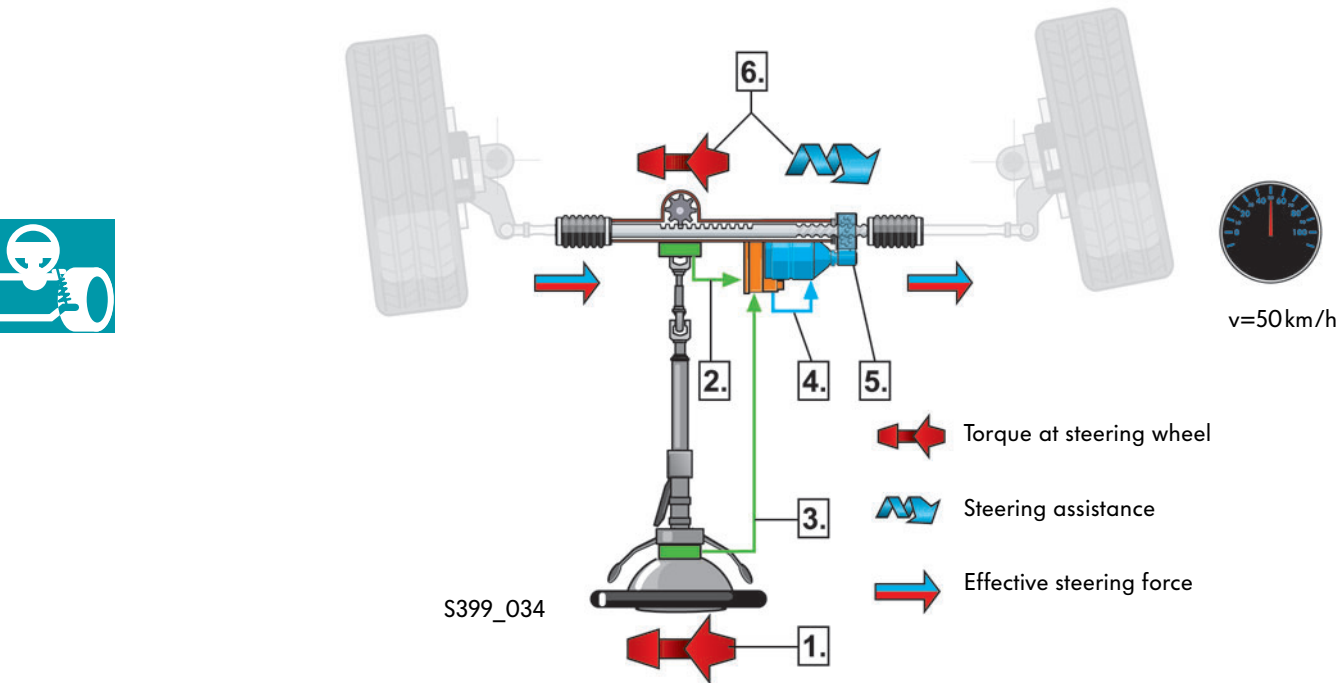


1. When manoeuvring into a parking space, the driver turns the steering wheel to full lock.
2. The torsion bar is twisted. The steering moment sender G269 measures the twisting and signals to the control unit J500 that a large steering moment is being applied to the steering wheel.
3. The steering angle 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 0 km/h , the engine speed ($>500\text{ rpm}$), the large steering angle, the steering speed and the characteristic curve stored in the control unit for $v=0\text{ km/h}$.
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.



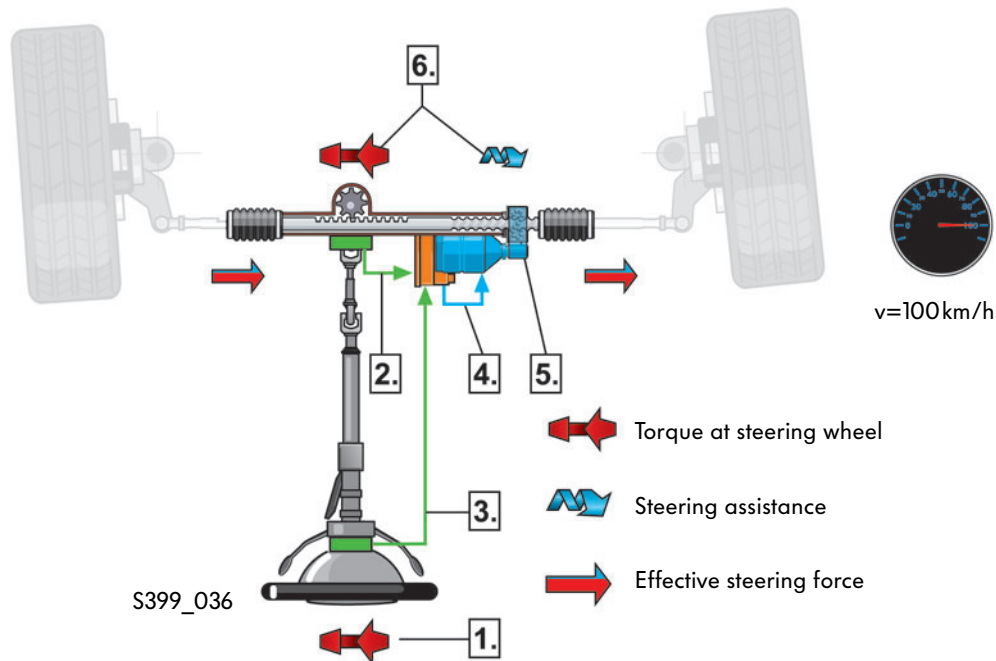
Function

Steering during city driving



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

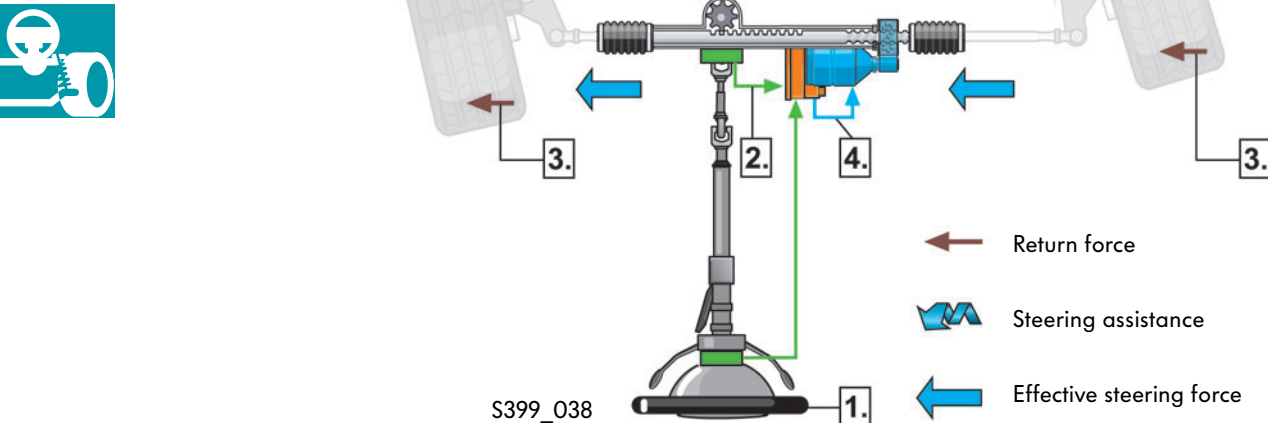


1. When changing lanes, the driver turns the steering wheel slightly.
2. The torsion bar is twisted. The steering moment sender G269 measures the twisting and signals to the control unit J500 that a light steering moment is being applied to the steering wheel.
3. The steering angle sender G85 transmits 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 100km/h, a low steering angle, the steering speed and the characteristic curve for $v=100\text{ km/h}$ 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



Straight-ahead driving correction

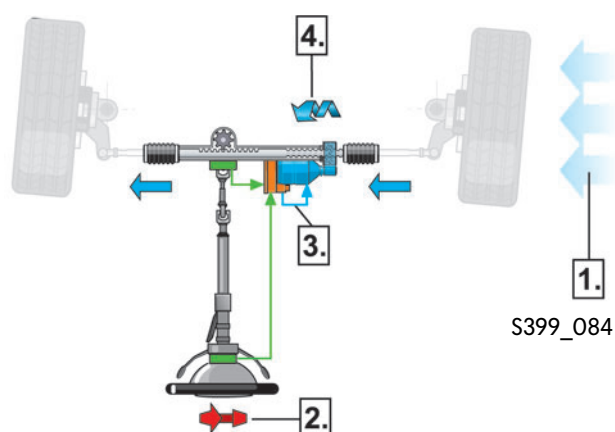
The straight-ahead driving correction is a function that is derived from the active return. Steering assistance is provided to return a vehicle to moment-free, straight-ahead driving. A long-term and a short-term algorithm are explained here.

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.



Return forces



Steering assistance



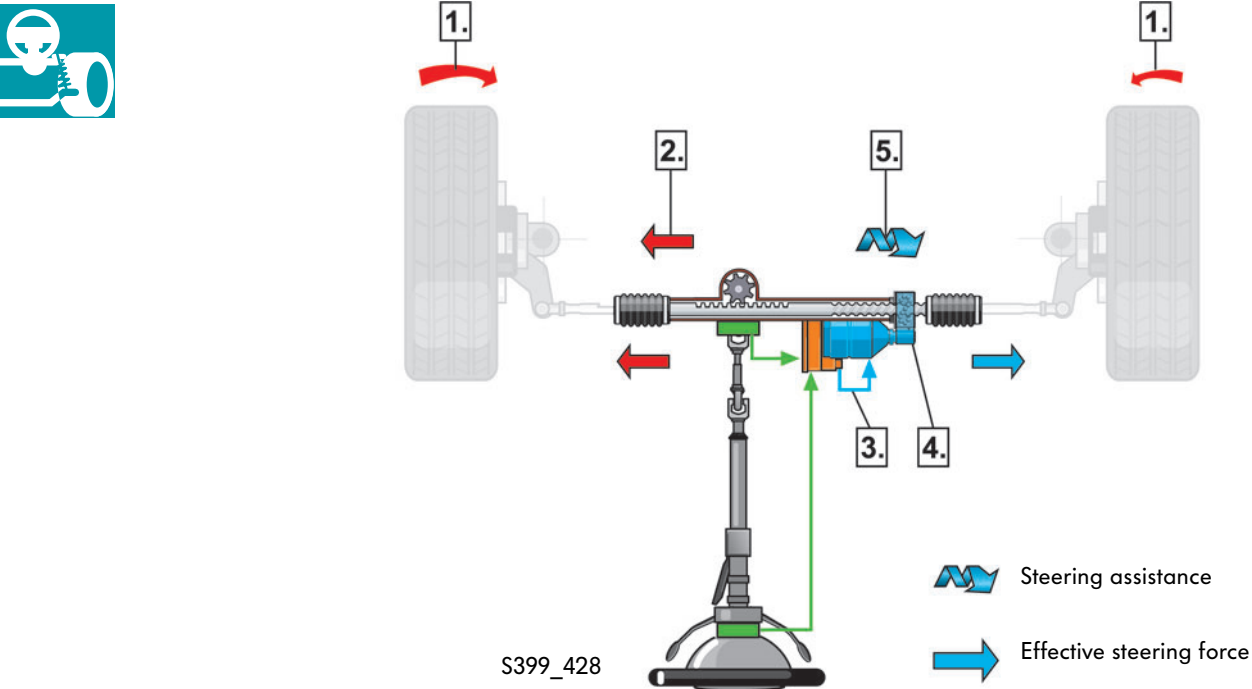
Effective steering force

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.



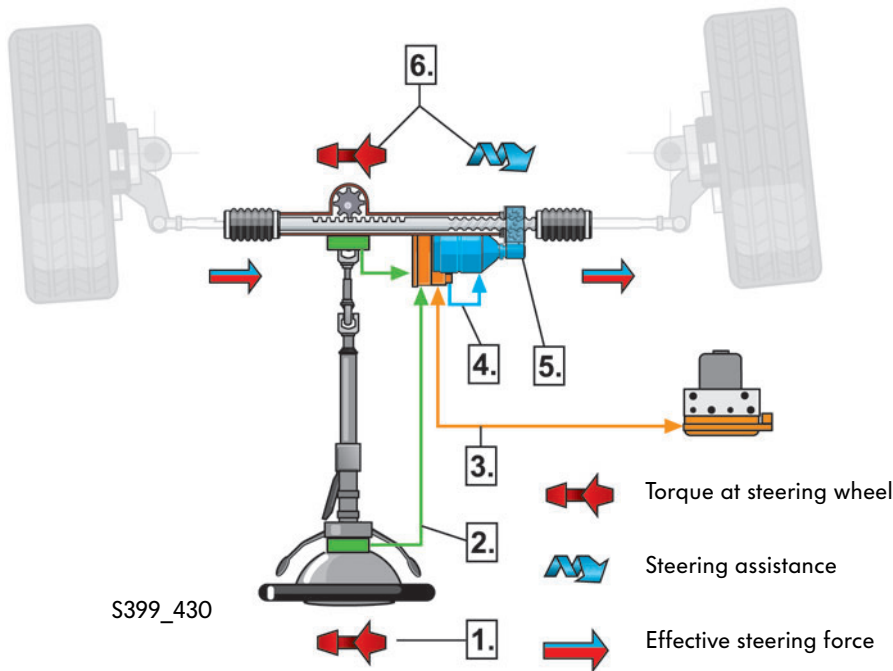
1. The different length drive shafts that are normally used with transverse engines and front-wheel drive have different working angles which cause different moments around the vertical axis of the wheels during acceleration. These moments can cause uneven tracking.
2. There is a force in the direction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



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.



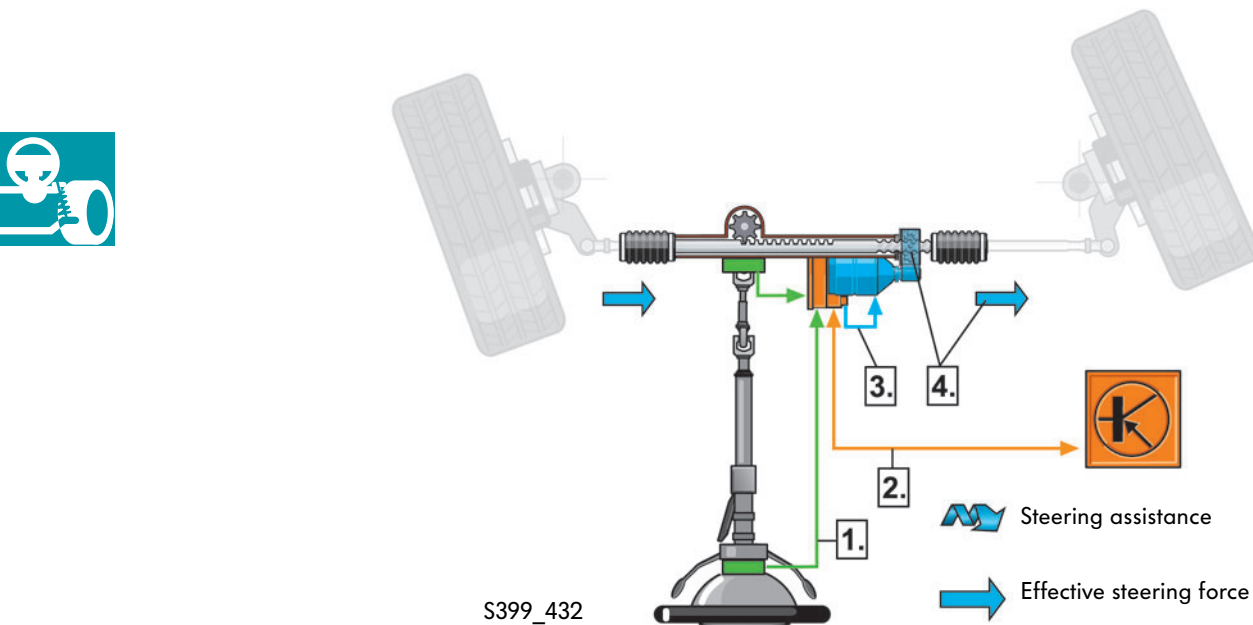
You will find further information on counter-steer support in self-study programme 374 "Traction Control and Assist Systems".



Function

ParkAssist

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

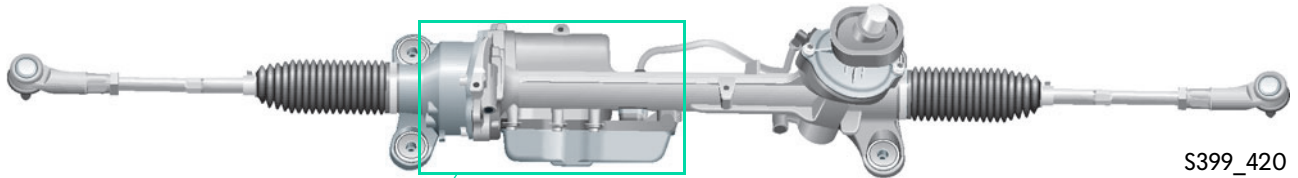


1. When the driver starts the automatic parking procedure by selecting reverse gear while the vehicle is stationary, pressing the accelerator and releasing the brake pedal, he may not apply steering moment to the steering wheel.
2. The control unit for parallel parking assist, which has recognised the 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.

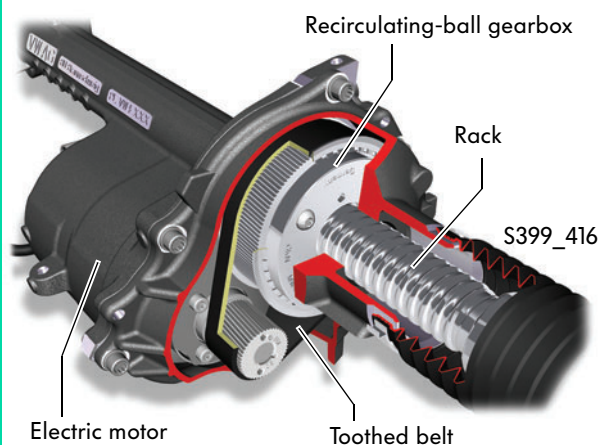


Further information can be found on the uneven tracking compensation system in self-study programme no. 389 "ParkAssist".

Steering box



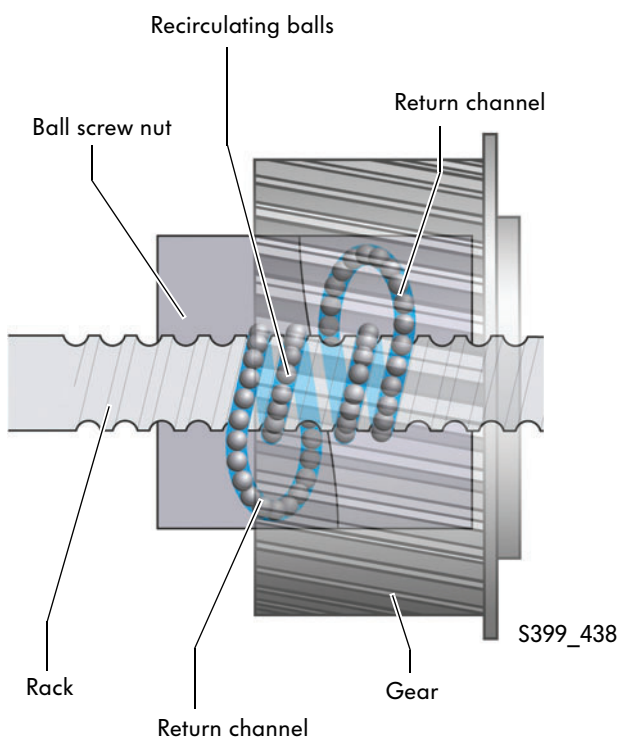
Steering-assistance gearbox



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.



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.

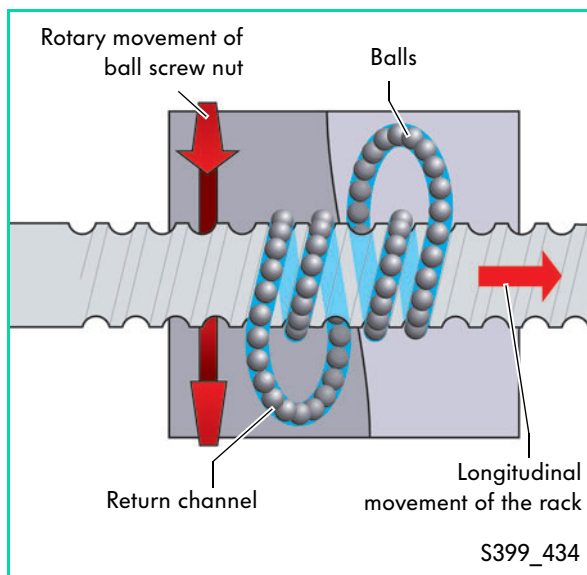
One special constructive feature of the recirculating-ball gearbox is the return channels of the balls in the ball screw nut.

Steering Mechanics

How it works

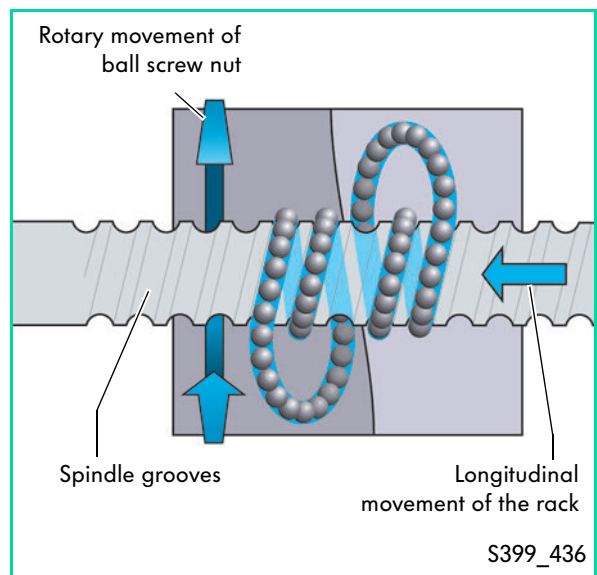
The ball screw nut is turned clockwise or anti-clockwise depending on the desired steering direction. As the rack takes the form of a spindle in this area, rotary movement of the ball screw nut pushes the rack in the desired direction.

Steering vehicle to left



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

Steering vehicle to right



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.