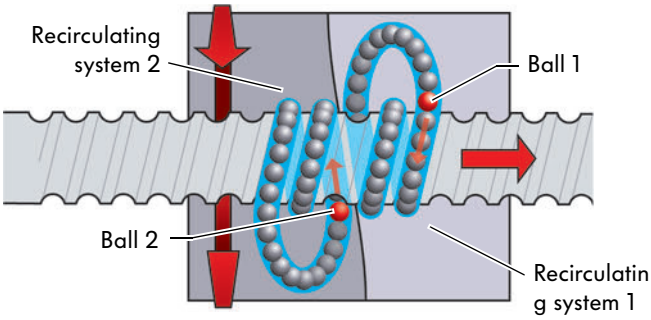
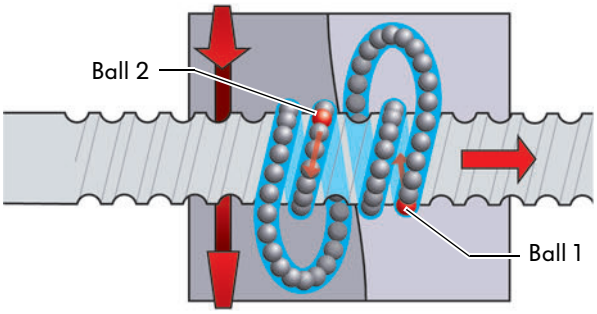


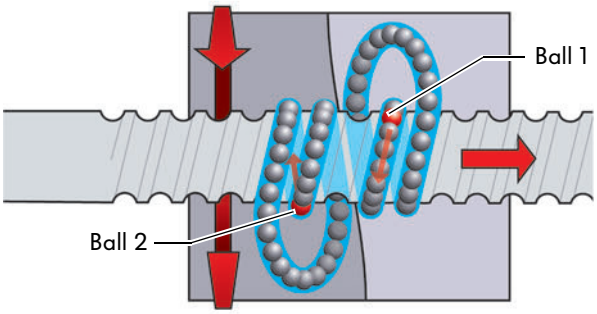
Situation 1

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).



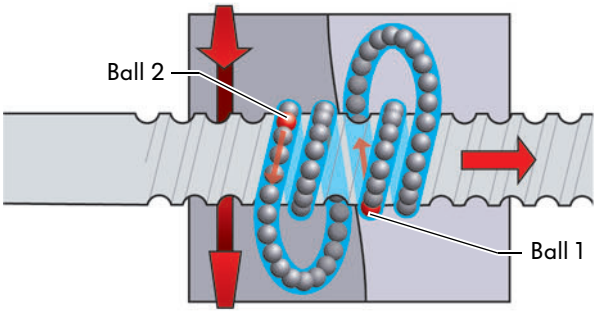
Situation 2

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



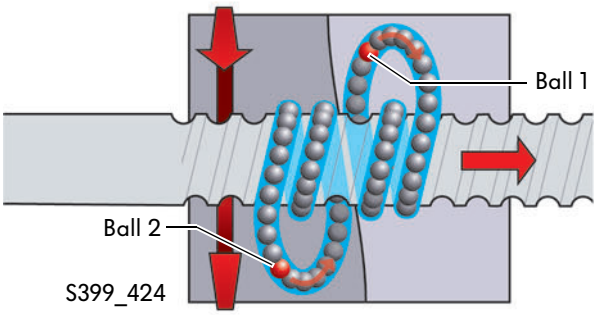
Situation 3

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



Situation 4

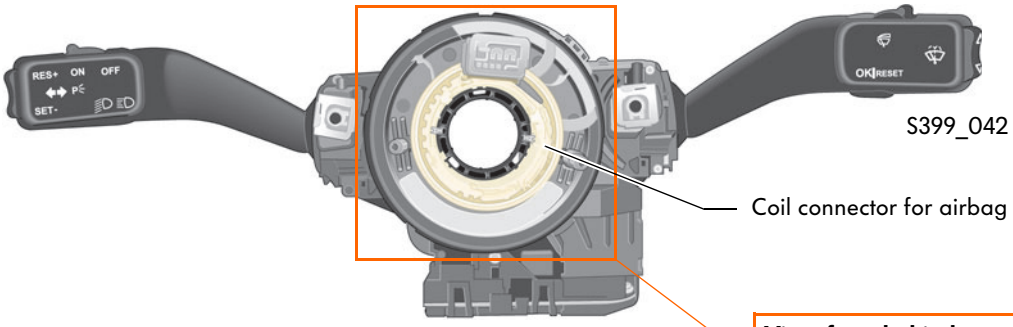
Ball 1 moves upwards in the spindle groove (the hidden, rear section in the diagram).
Ball 2 moves downwards in the spindle groove.



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.

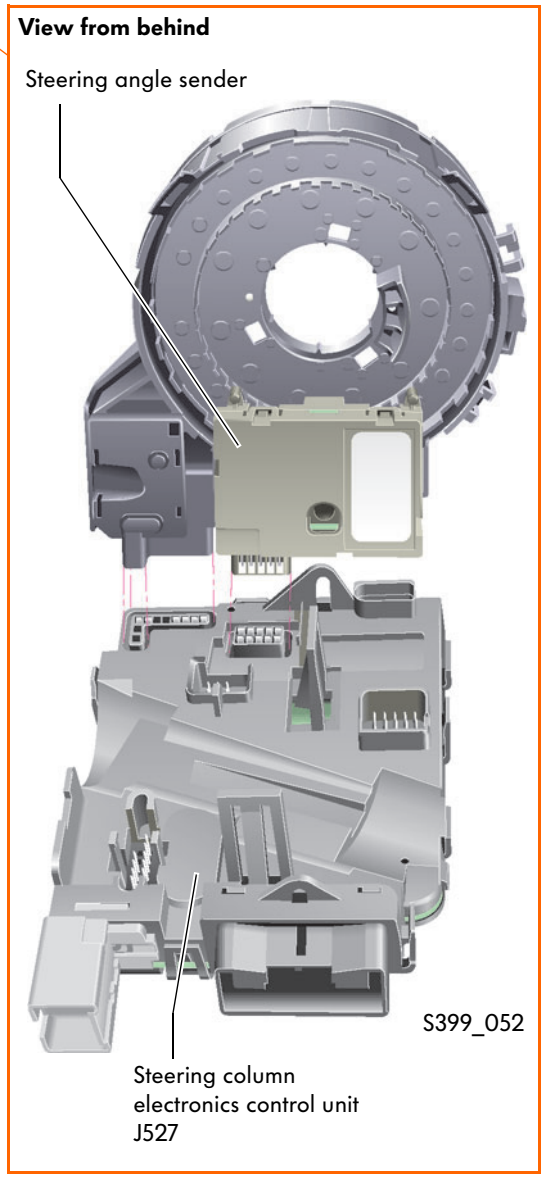
Steering angle sender G85



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.

View from behind

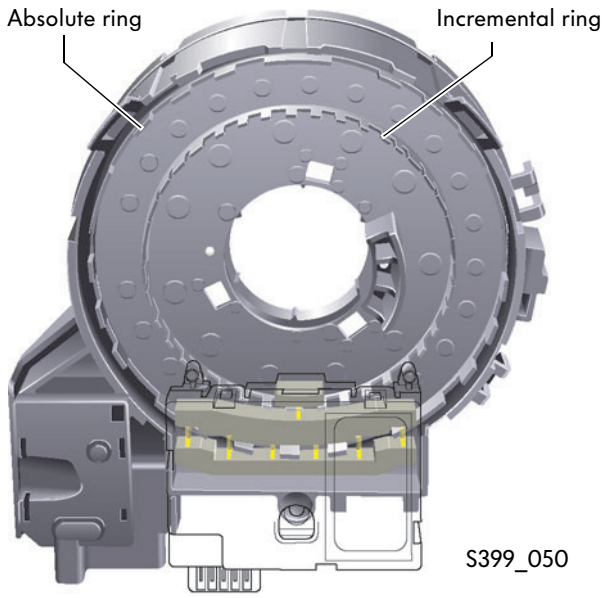


Effects upon failure

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

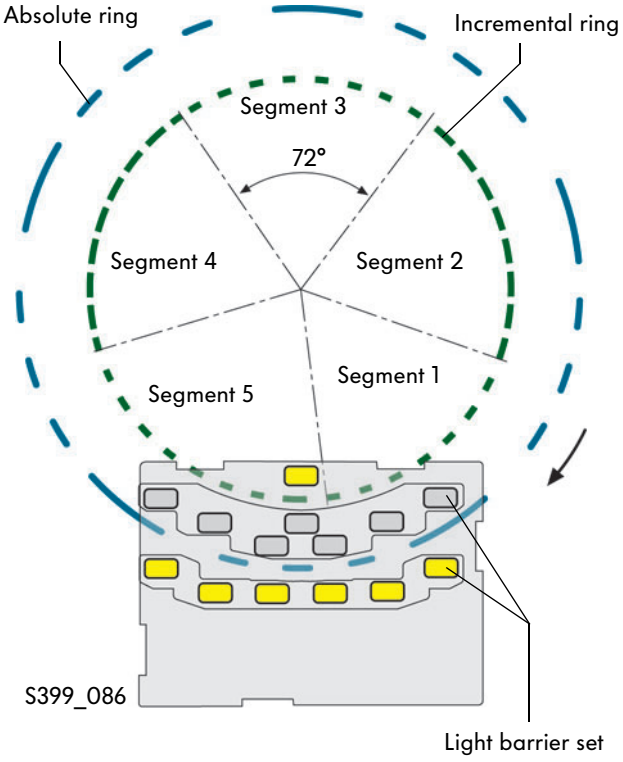
Functional principle



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.



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.

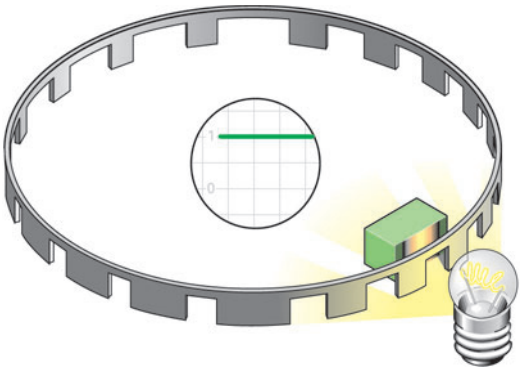
The steering angle sender can recognise a 1044° steering angle. It adds up the angle degrees. It thus recognises when the 360° point is exceeded that one turn of the steering wheel has been completed.

The steering angle sender is designed to allow 2.76 turns of the steering wheel.

Steering Electrics

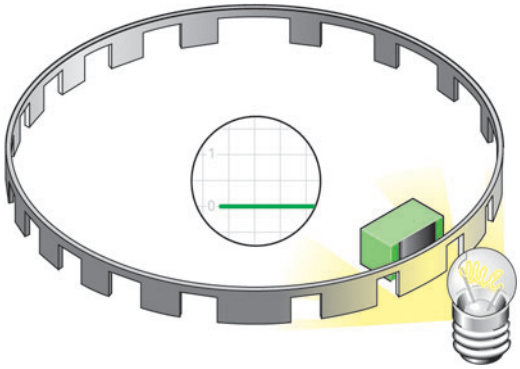
The angle is measured using light barriers.

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.



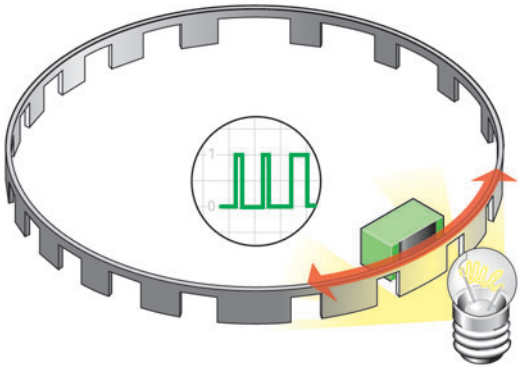
S399_114

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.

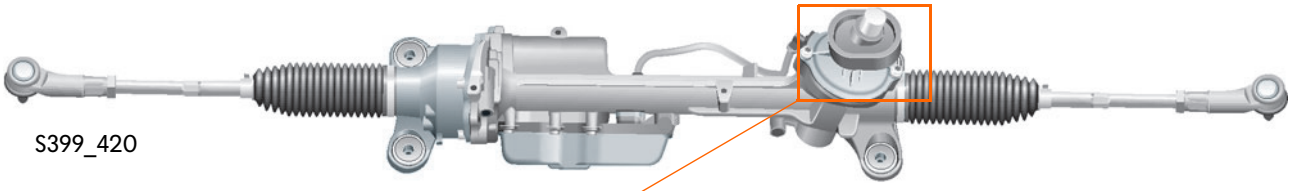


S399_118

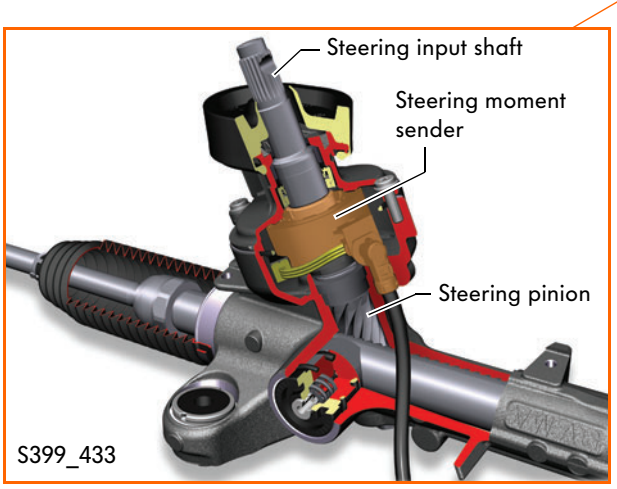
In the same way, a sequence of signal voltages is created by each light barrier set for the absolute ring. All sequences of signal voltages are processed in the steering column electronics control unit.

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

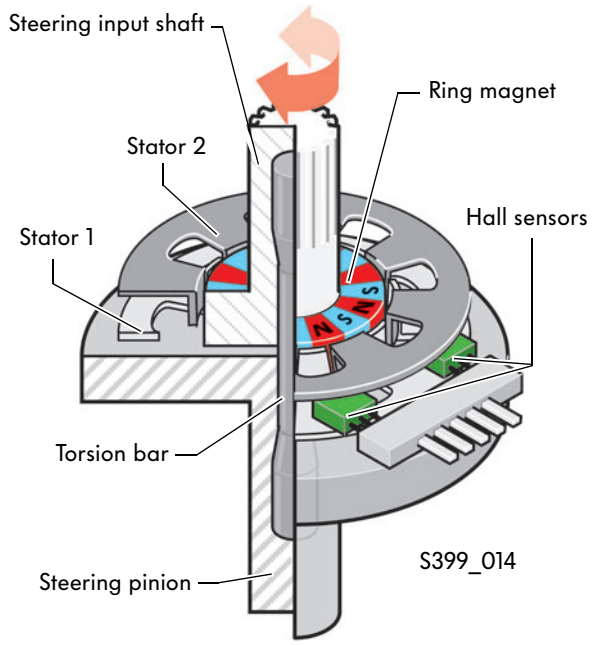


S399_420



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.



S399_014

Design

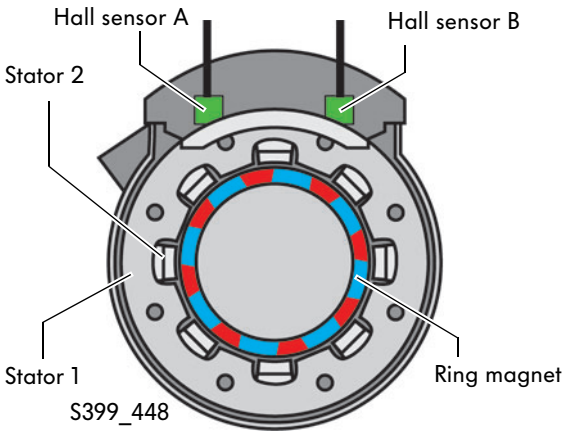
The steering input shaft and the steering pinion are connected to each other on the torque sensor via a torsion bar. The torsion bar has a defined torsional stiffness.

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.

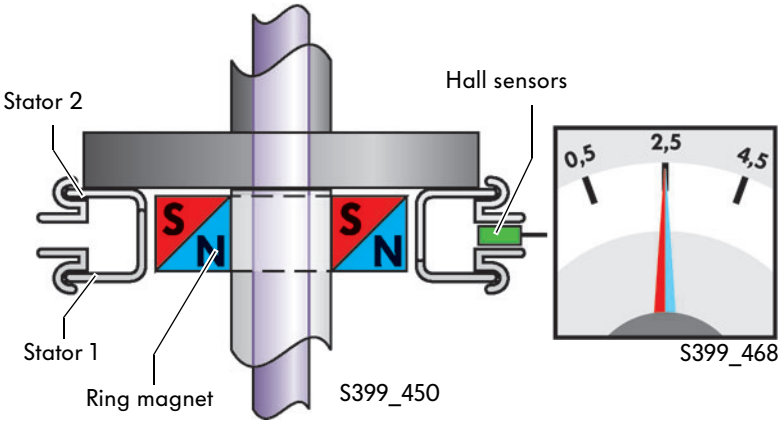
How it works

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



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.

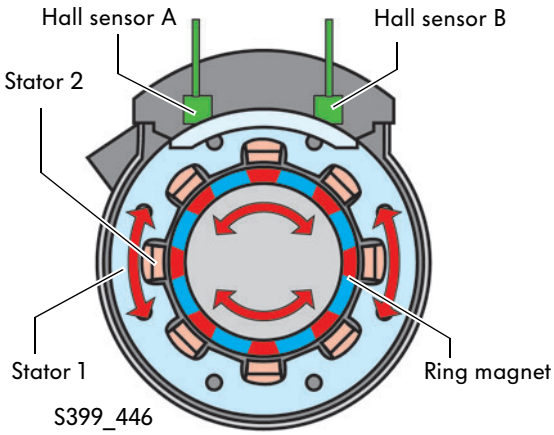


Therefore neither stator 1 nor stator 2 has a north or south alignment. A magnetic field cannot form between the two stators.

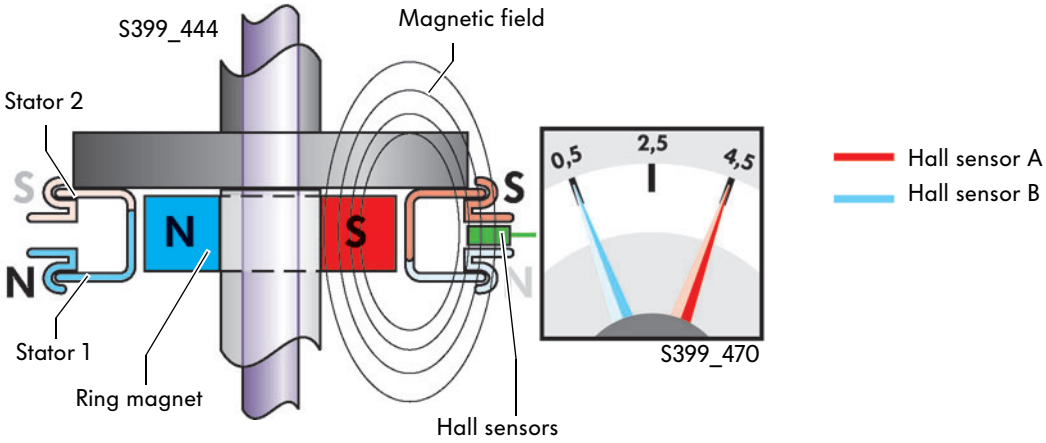
The Hall sensors are supplied with an input voltage of 5V. As no magnetic field has formed between the two stators, the Hall sensors issue a signal for the zero moment of 2.5V.

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.



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.



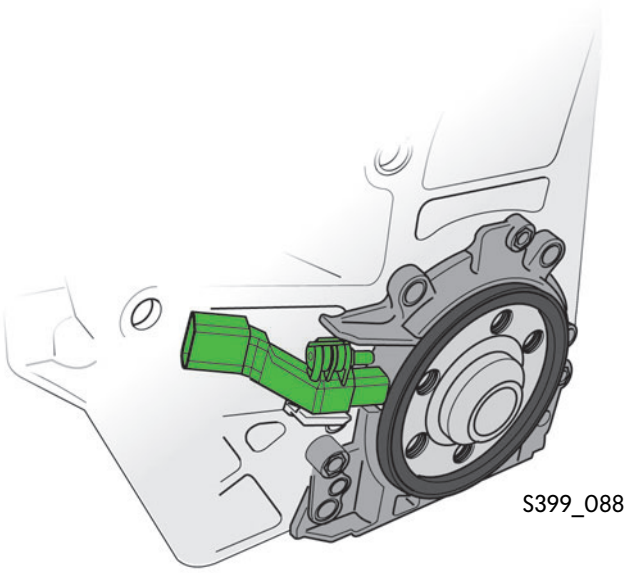
Effects upon failure

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.

Engine speed sender G28

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



S399_088

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.

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”.

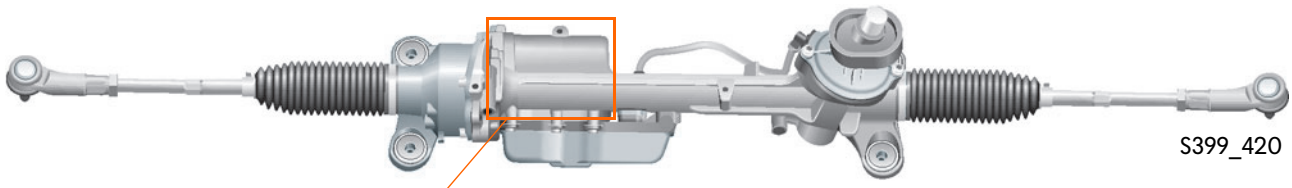
Vehicle speed

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

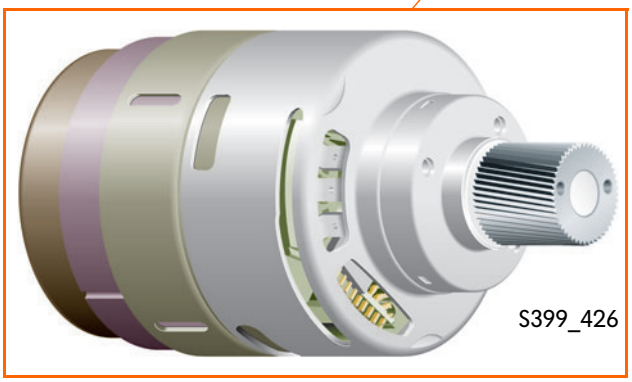
Effects upon failure

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

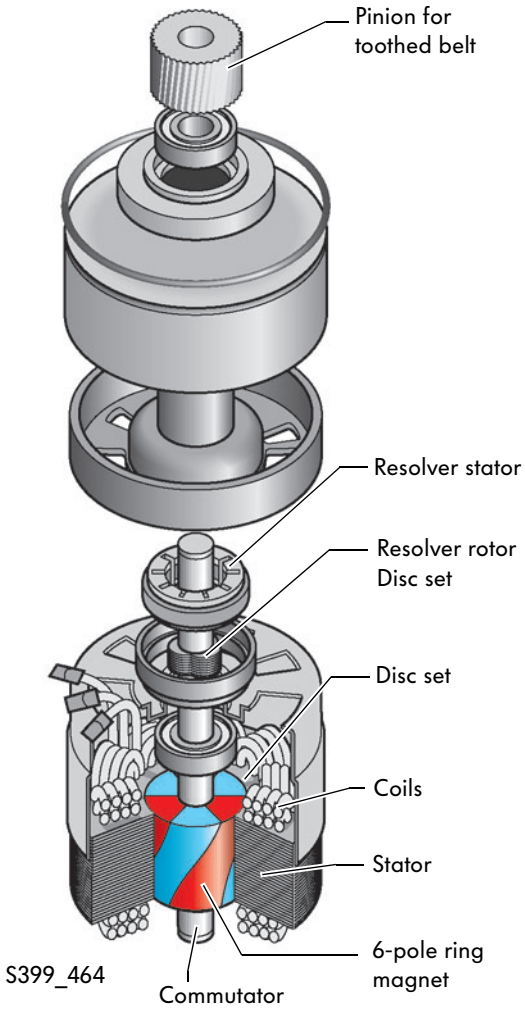
There is no steering assistance if the motor fails.

Steering Electrics

Design

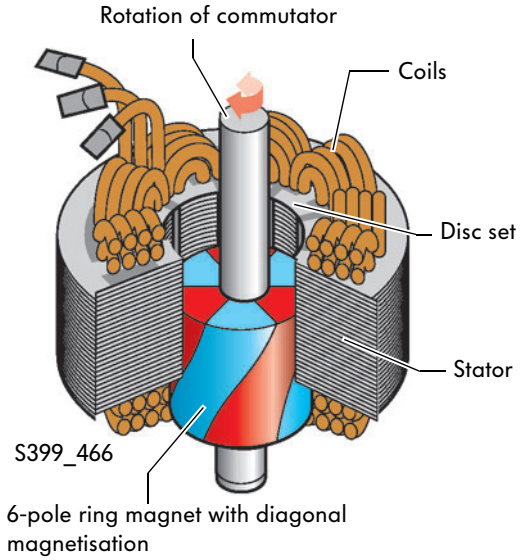
The motor for the electromechanical power steering consists among other things of a rotor and a stator. The rotor is a 6-pole ring magnet made from rare-earth magnets. Rare-earth magnets allow very high magnetic field strengths in conjunction with minimum design dimensions.

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.



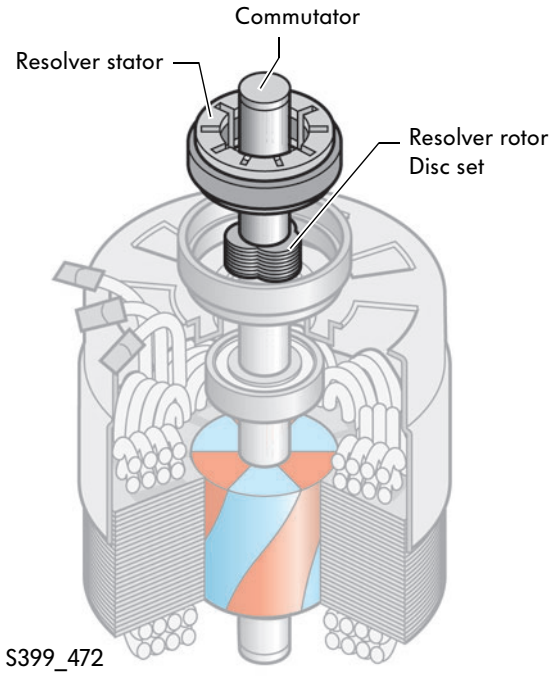
How it works

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.



Sender for motor position

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



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.

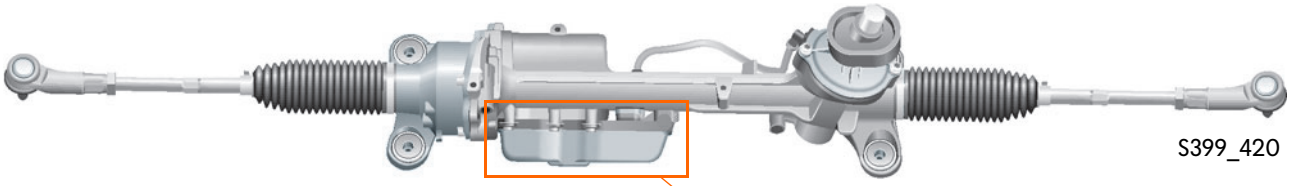
Therefore it measures the exact position of the electromechanical power steering motor V187 that is required for precise control of the motor.

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.

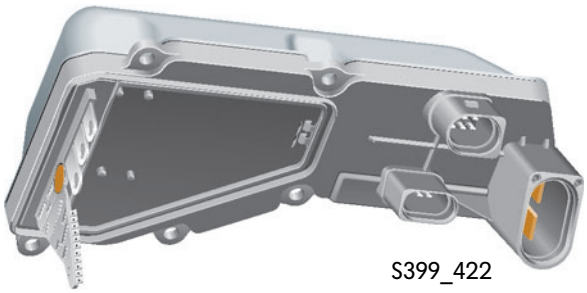
Steering Electrics

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.

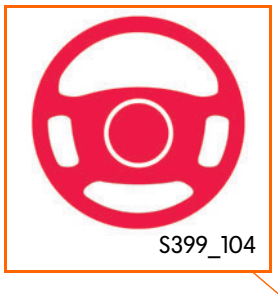
If the steering assistance falls below a value of 60%, the electromechanical power steering warning lamp K161 will illuminate yellow.

If the control unit is faulty, the steering will need to be replaced completely.

Electromechanical power steering warning lamp K161

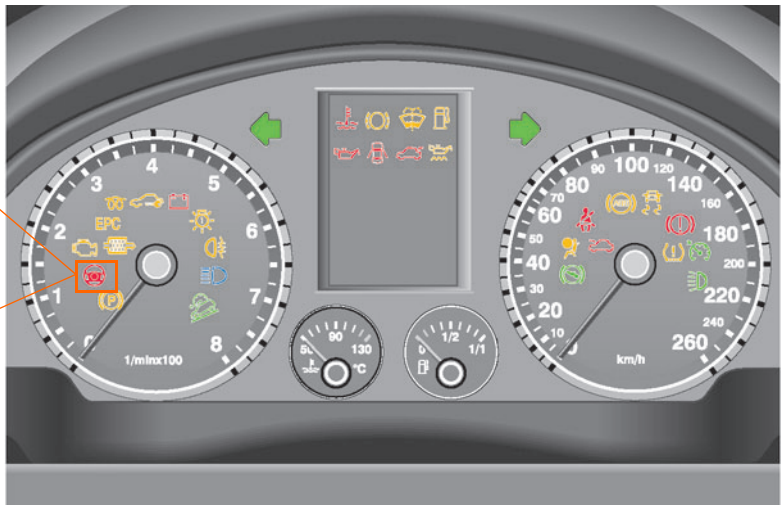
The electromechanical power steering warning lamp is in the display in the dash panel insert.
It is used to display malfunctions or faults in the electromechanical power steering.

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.

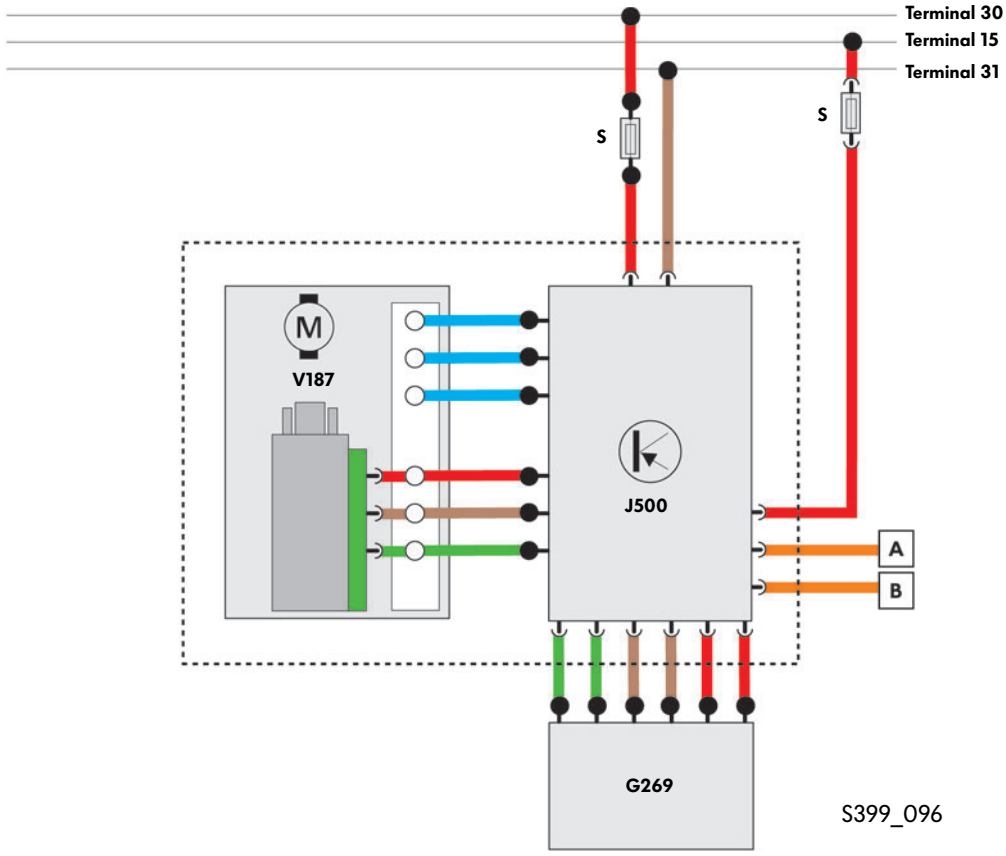
Flat batteries

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



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.

Answers

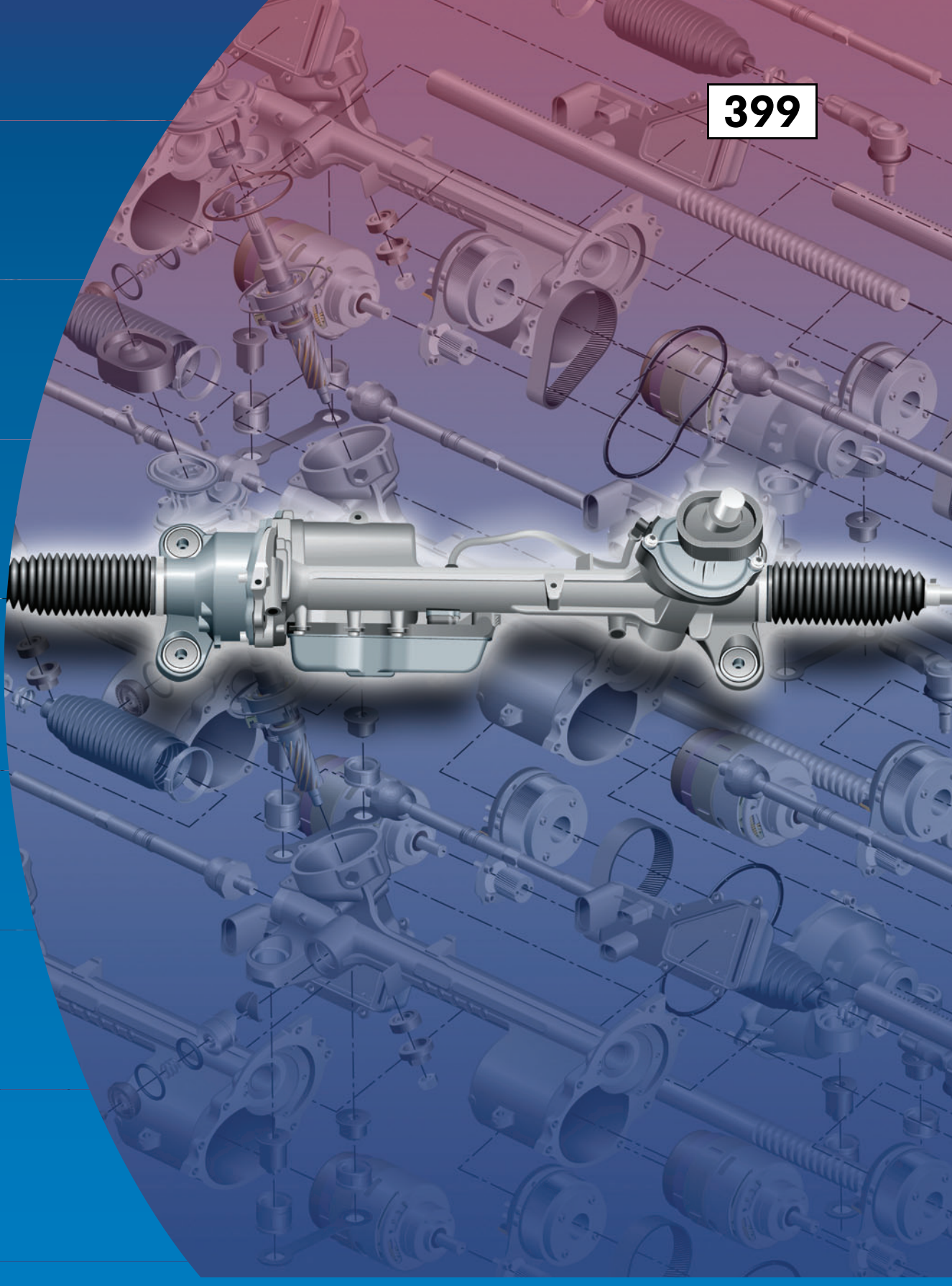
1.) b

2.) a

3.) b

4.) b

5.) c



000.2812.01.20 Technical status 11.2007

Volkswagen AG
Service Training VSQ-1
Brieffach 1995
38436 Wolfsburg