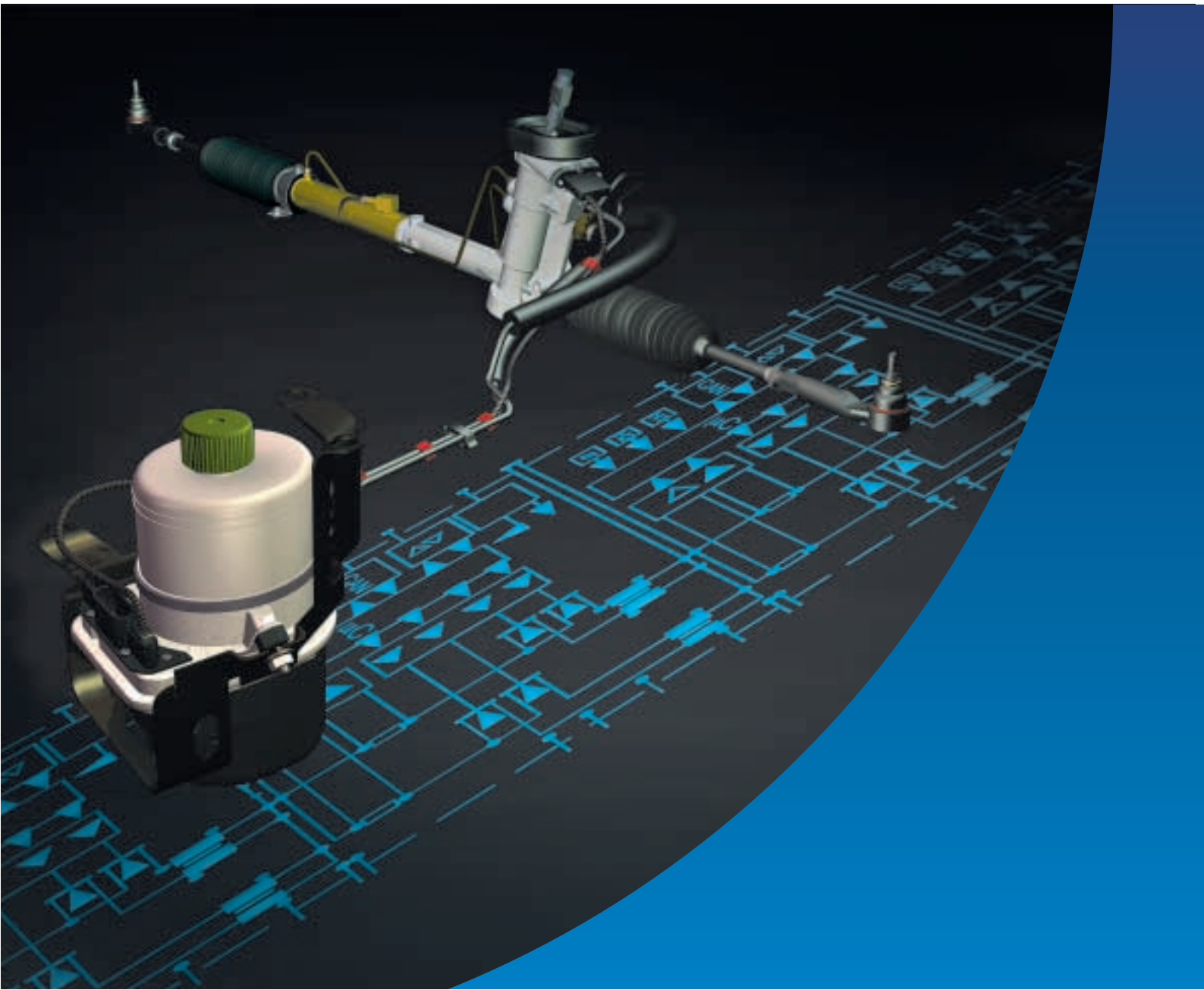
Service.

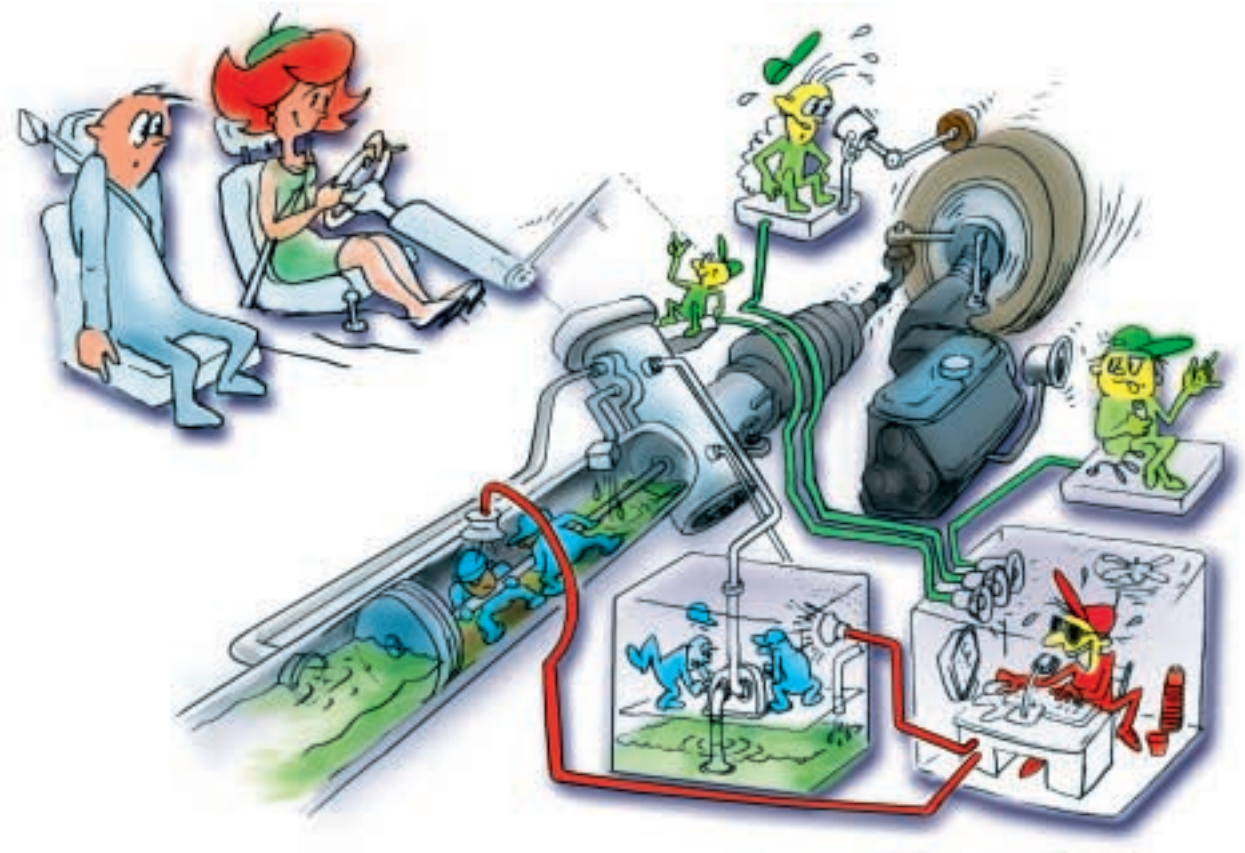
Self-Study Programme 259

EPHS – Electrically Powered Hydraulic Steering

Design and Function



EPHS – Electrically Powered Hydraulic Steering



259_033

The EPHS = Electrically Powered Hydraulic Steering is familiar from the Lupo FSI.
This system is supplied by TRW and by KOYO.

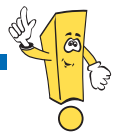
The new steering system offers a wide range of advantages while at the same time retaining the excellent steering properties of the conventional hydraulic power-assisted steering.

Advantages of the EPHS:

Improvement in comfort,
easy to operate when parking,
but steering firm at high speeds
(safety factor).

Fuel savings,
as the energy consumption is based on demand – irrespective of the operating state of the internal combustion engine.

NEW



Important Note

The Self-Study Programme describes the design and function of new developments! The contents are not updated.

Please always refer to the relevant service-literature for up-to-date inspection, adjustment and repair instructions.

At a Glance

Introduction

The pressure required for the steering servo assistance, is produced by a hydraulic pump.

This pump is driven directly by the vehicle engine, as in the conventional, familiar power-assisted steering system.

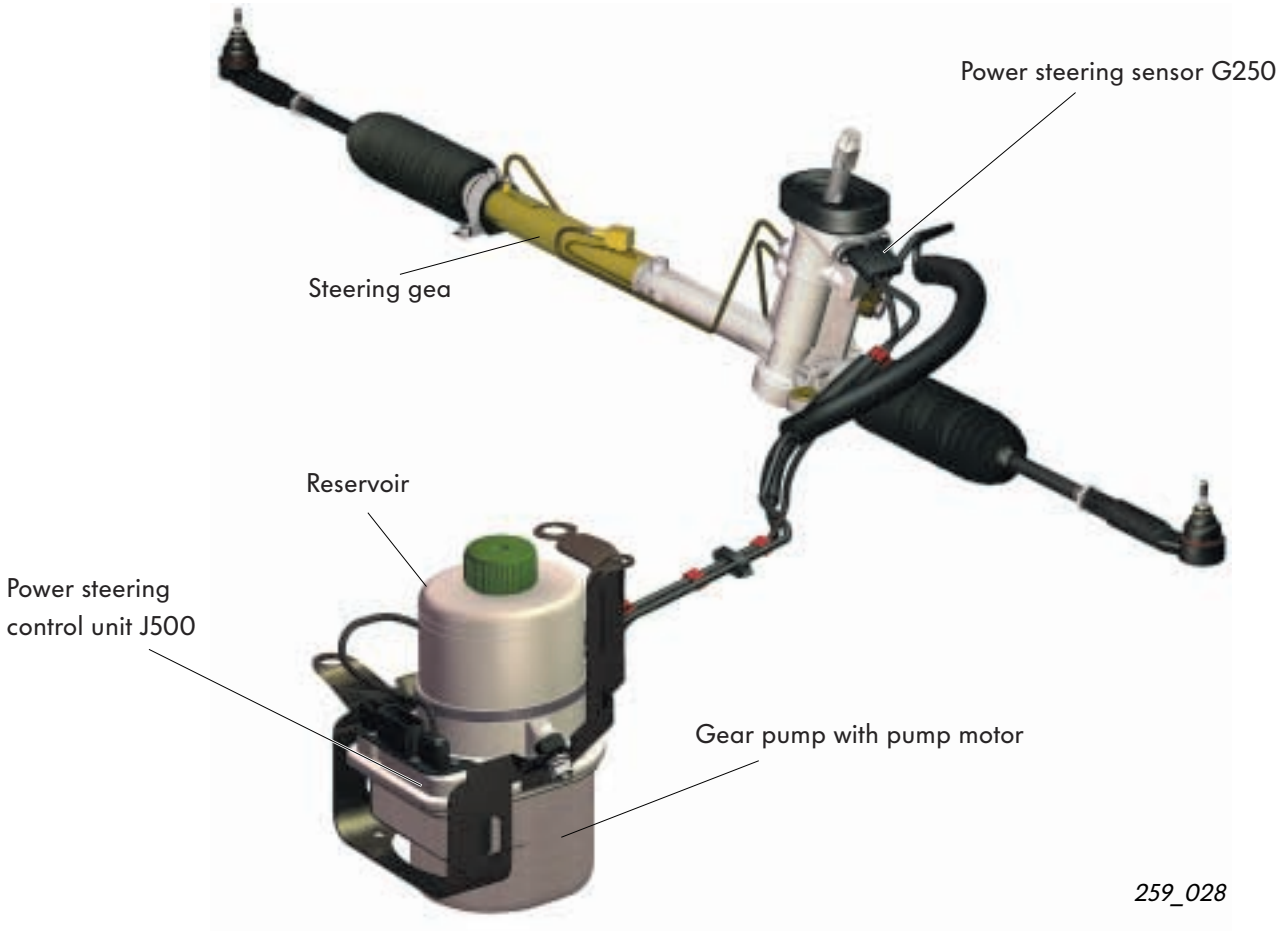
In other words, part of the engine power output is required for driving the pump.

At the moment at which the greatest steering servo assistance is required – mainly when parking – engine speed is at its lowest.
The pump capacity is designed for such a case.
The faster the steering rate, the higher is the pump speed and thus the volume flow.
Pump capacity which is not required at higher engine speeds, is dumped via a bypass.

In the new steering system, although the hydraulics likewise assist human steering effort, the hydraulic pump – a gear pump – is driven in this case by an electric motor and is mechanically independent of the vehicle engine.
The hydraulic control is of identical design.
A new feature is the steering servo assistance based on the steering angle rate and vehicle speed.

A steering angle sensor is additionally integrated for this purpose in the housing of the rotary disc valve (refer to Fig. below), which transmits the steering angle rate to the electronic control.
The steering angle information flows along a sensor cable directly to the control unit.

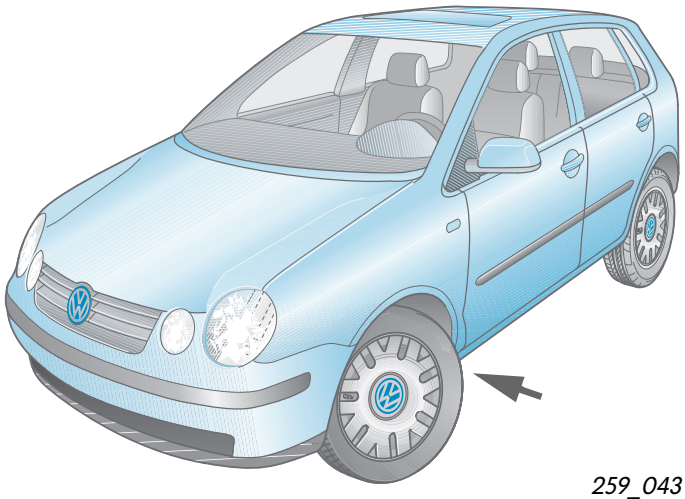
In addition, the vehicle speed is detected in the control unit during the analysis.
This information is supplied over the CAN data-bus.



The steering system fitted to Volkswagen models is supplied by TRW and by KOYO.

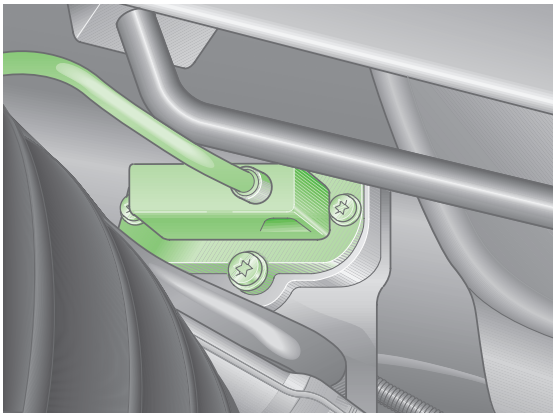
The operating principle of both steering systems is identical. The steering systems differ in how they determine the steering angle rate. This is already recognizable from the external shape of the steering angle sensors.

In order to be able to see the power steering sensor in the vehicle, it is necessary to raise the vehicle and to turn the steering to full right lock (see arrow in Fig. on right for direction of viewing).



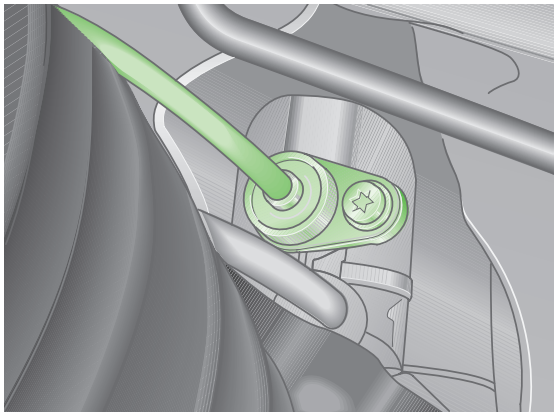
259_043

The middle illustration opposite shows a TRW steering fitted in the vehicle. It is recognizable from the power steering sensor which is flat and wide in design (more detailed description from page 13 on).



259_002

The lower illustration shows a KOYO steering installed in the vehicle. Its power steering sensor is cylindrical in shape (more detailed description from page 15 on).



259_001

Certain components of the two steering systems differ from each other and cannot be interchanged. This applies both to electrical/electronic, as well as to purely mechanical components, such as track rods and track rod ends.

Introduction

Overview of the system with its components

The Servotronic warning lamp K92

After the ignition is switched on, the Servotronic warning lamp K92 lights up. An internal test cycle takes place during this time.

If the warning lamp does not go out after the engine is started and after the test cycle is completed, faults may be stored in this case.

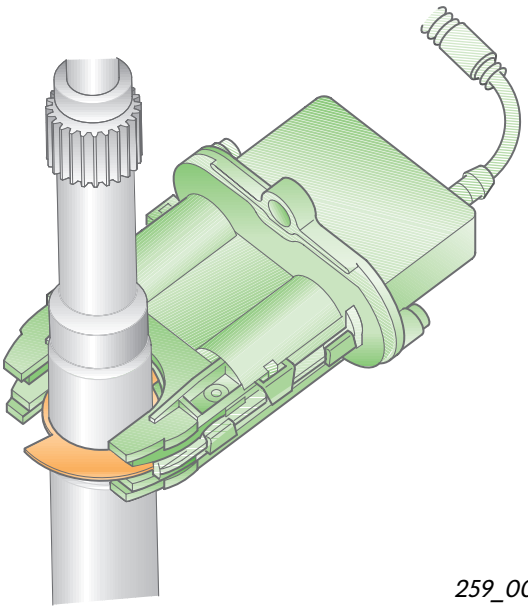
259_042

Power steering sensor G250

The sensor is integrated in the housing of the rotary disc valve of the power steering gear. It detects the steering angle and calculates the steering angle rate.
If the sensor fails, the steering function is nevertheless assured.

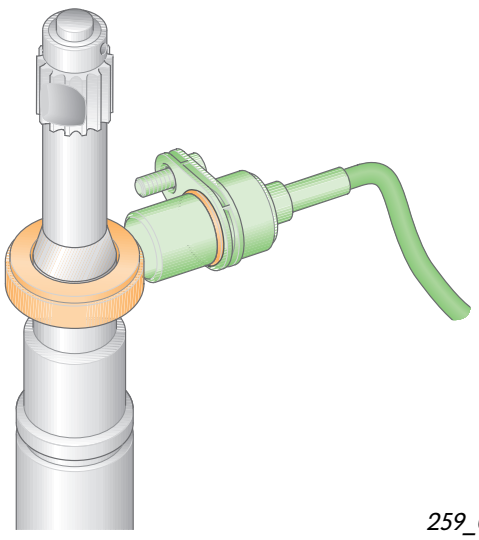
The power steering switches over in this case to a programmed emergency running mode. The steering forces required are greater. Malfunctions are stored in the power steering control unit J500.

The illustration opposite shows the power steering sensor of the TRW steering system.



259_005

This illustration provides you with a view of the power steering sensor of the KOYO steering system.

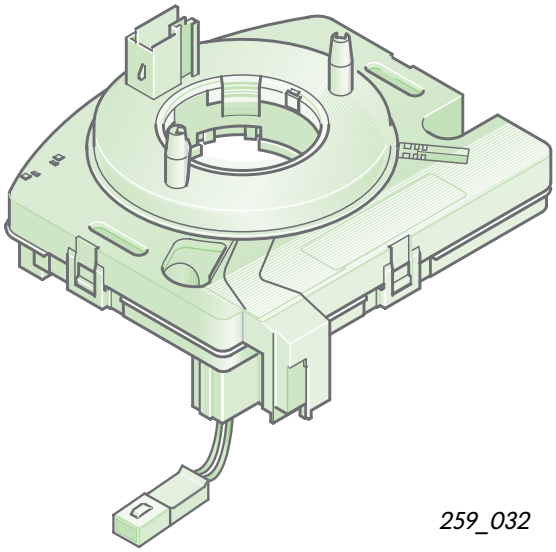


259_027

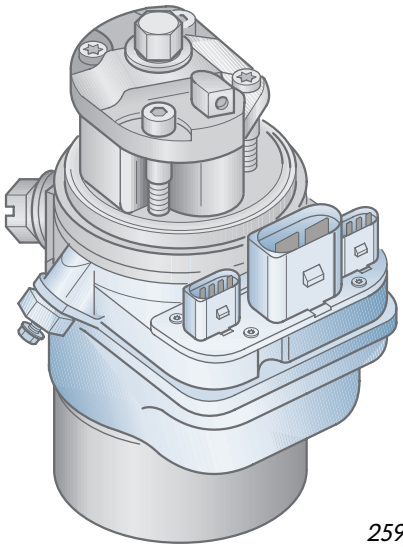
The steering angle sender G85

The steering angle sender is located on the steering column between steering column switch and steering wheel. This sensor is used on vehicle models which are available only with the electronic stability programme (ESP). In this case, the power steering sensor G250 is not fitted.

The ABS control unit J104 and the power steering control unit J500 both make use of the signal supplied by the steering angle sender transmitted over the CAN databus, for detecting the angle by which the steering wheel is turned.



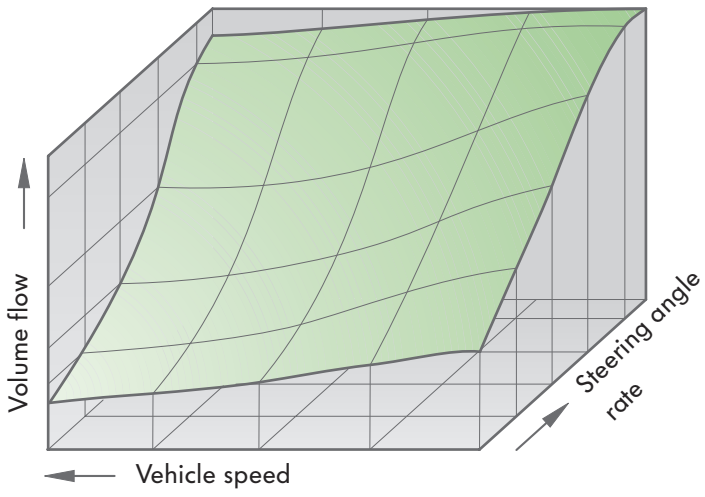
259_032



259_010

The power steering control unit J500

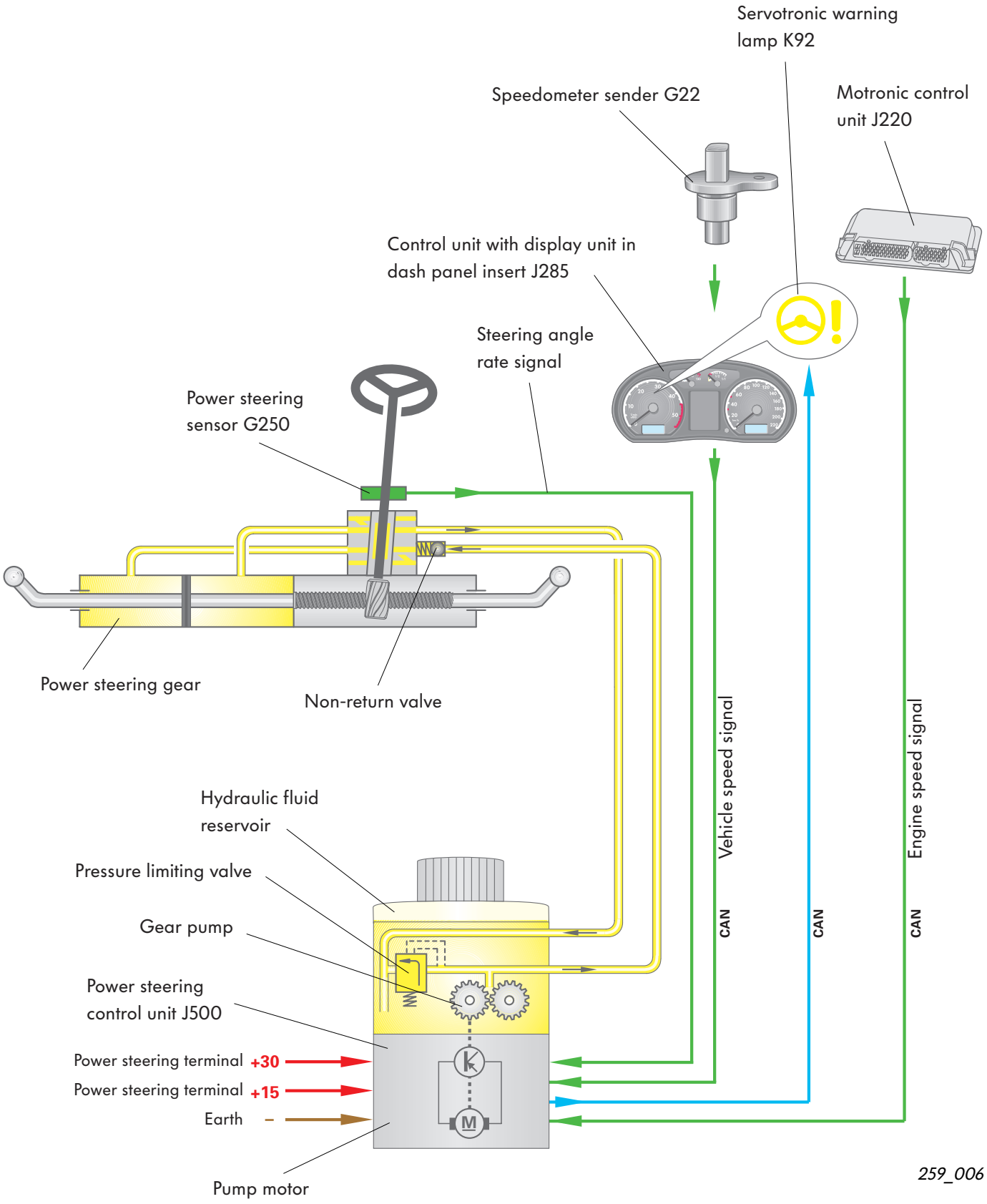
The control unit is integrated in the engine pump assembly.
It converts the signals for driving the gear pump in line with the steering angle rate and the vehicle speed.
The delivery required at a particular moment is obtained from a map stored in the control unit.
The control unit detects and stores faults which occur during operation.
A restart protection and temperature protection are integrated in the control unit.



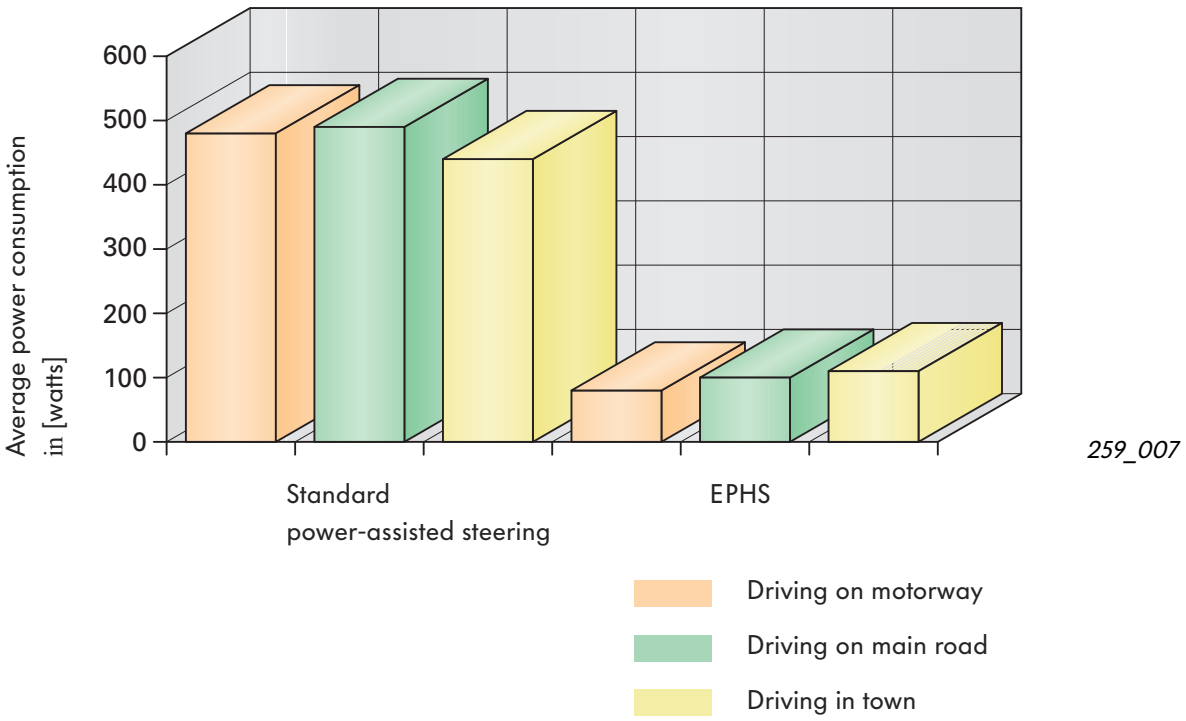
259_004

System Overview

System overview – schematic diagram



Advantages of the EPHS – Electrically Powered Hydraulic Steering



259_007

In comparison to the traditional, conventional power-assisted steering system the newly developed EPHS Electrically Powered Hydraulic Steering offers a multitude of advantages:

- Energy savings of as much as 85 %
- More environmentally friendly system as a result of lower energy demand and reduced energy use, as well as smaller quantity of fluid in hydraulic system.
- Taking realistic driving cycles as a comparison, fuel savings of about 0.2 l/100 km are achievable.
- Improvement in active safety as the steering is easy to operate when parking, but is firm at high speeds.

When driving solely on motorways, there is a high power loss at the bypass valve in a conventional power-assisted steering system as a result of the high engine speed, in other words at low steering angle rates and high engine speed, the power steering pump supplies an excess volume flow.

The new electrically powered hydraulic steering achieves its maximum economy from the low steering angle rate when driving on motorways and from the volume flow which is matched to the vehicle speed.

Even when driving in towns, the savings are still clearly perceptible (refer also to chart).

Design and Function

General

The EPHS Electrically Powered Hydraulic Steering is a power-assisted steering system which operates in line with the steering angle rate and vehicle speed.

The steering hydraulics pump V119 consists of a gear pump and the electric motor.

This steering system makes use of a gear pump integrated in the engine pump assembly in place of the hydraulic pump (vane pump) with which you are familiar from previous power-assisted steering systems.

This gear pump is driven not directly by the internal combustion engine of the vehicle, but by an electric motor integrated in the engine pump assembly.

The electric motor runs only when the ignition is switched on and the internal combustion engine is also running.

Signals relating to the steering angle rate, vehicle speed and engine speed are transmitted to the control unit. This control unit regulates the speed of the electric motor as well as the gear pump, and thus the delivery and volume flow of the hydraulic fluid.

Restart protection

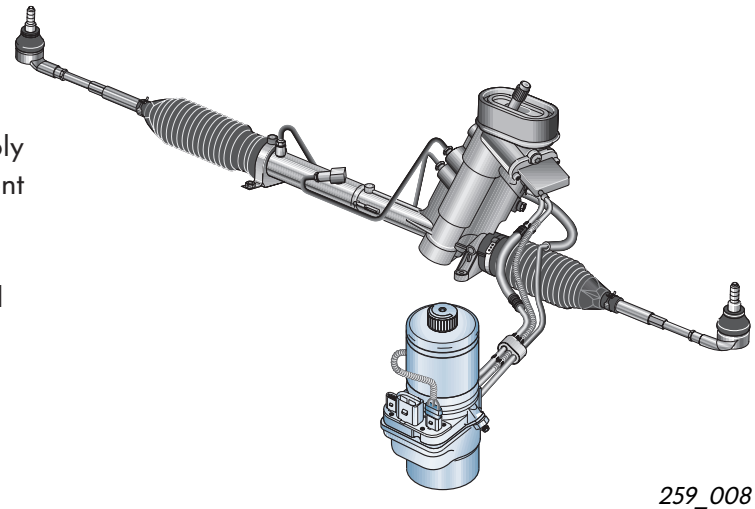
The EPHS Electrically Powered Hydraulic Steering features a restart protection after a fault, failure or crash. The restart protection, if activated because of a crash, can only be deactivated with a diagnostic tool.

If other faults exist, the restart protection can be cancelled by switching the ignition off and starting the engine again. It may be necessary to wait about 15 minutes in order to allow the engine pump assembly to cool down after having overheated. If, after this waiting period, it is still not possible to override the restart protection by starting the engine, this indicates there is a fault in the vehicle electrical system or the engine pump assembly is faulty. In such cases, it is necessary to conduct a self-diagnosis and, if the engine pump assembly is faulty, to replace it.

The engine pump assembly

The engine pump assembly is a self-contained component.

A special bracket for the engine pump assembly is attached in the left to the engine compartment to the longitudinal member, between bumper and wheelhouse.
The engine pump assembly is flexibly mounted in rubber bushings at the bracket.



259_008

The engine pump assembly combines the following components:

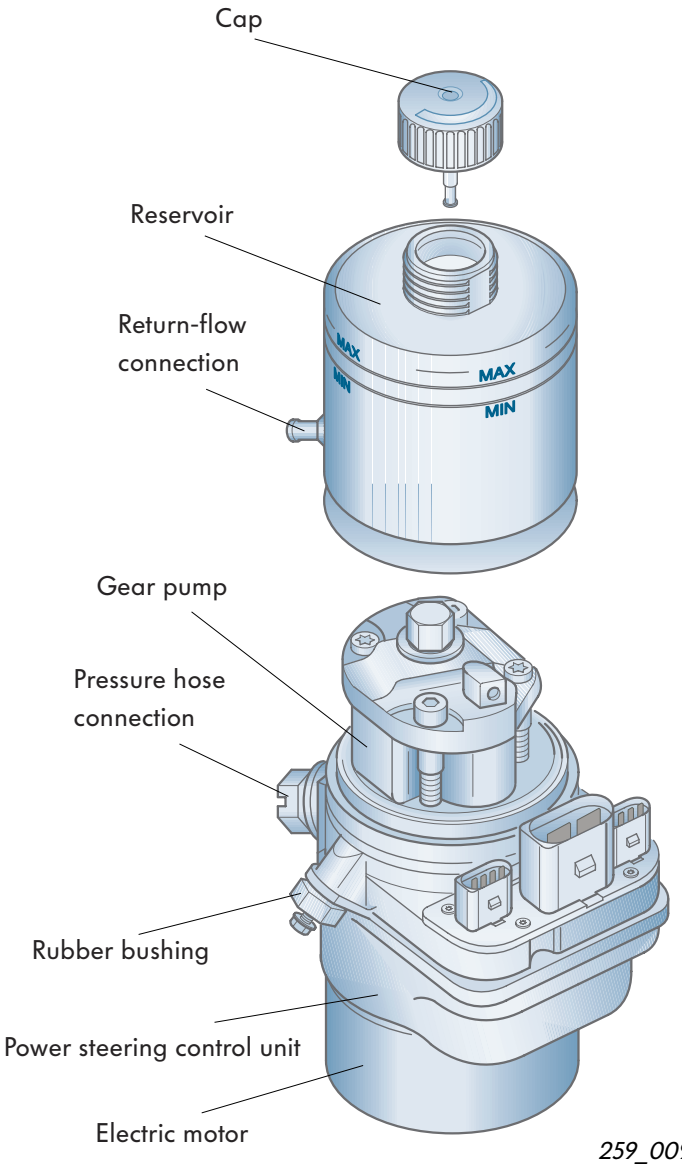
- the hydraulic unit with gear pump, pressure limiting valve and electric motor,
- the hydraulic fluid reservoir,
- the power steering control unit.

The engine pump assembly does not require any maintenance. It is lubricated internally by the hydraulic fluid.

It cannot be disassembled, and no provision is made for repairs.

A pressure line links the pump to the power steering gear.

The return-flow line of the hydraulic fluid merges into the reservoir.

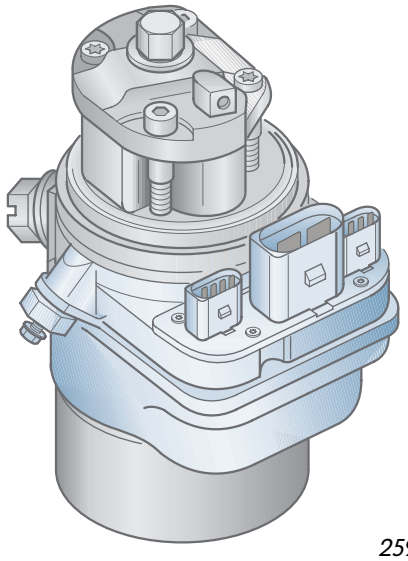


259_009

Design and Function

The power steering control unit J500

is an integral part of the engine pump assembly.



259_010

Incoming signals

- Engine speed (internal combustion engine)
- Vehicle speed
- Steering angle rate

Task

The control unit converts the signals for driving the gear pump in line with the steering angle rate and vehicle speed.

Extended functions

- Temperature protection for power steering
- Restart protection after faults

Self-diagnosis

The control unit detects faults during operation and stores them in a permanent memory.

Pump function

Ignition	Vehicle engine	Pump	Steering servo assistance
on	running	running	available
off	off, vehicle speed = 0	not running	none

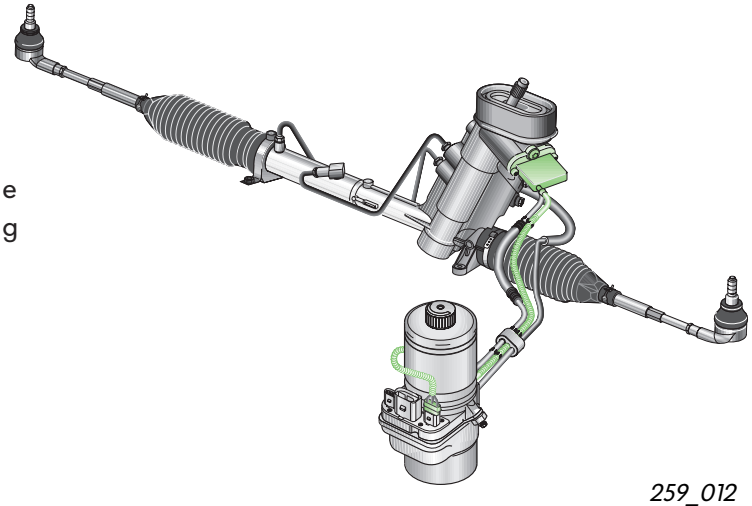
Steering servo assistance

Vehicle speed	Steering angle rate	Delivery	Steering servo assistance
low, e.g. parking	large	high	high (easy to operate)
large, e.g. motorway	small	low	low (firm steering)

The power steering sensor G250

Task

The power steering sensor G250 is installed at the top of the steering gear and embraces the input shaft of the steering gear. It determines the steering wheel angles and calculates the steering angle rate. It is not an absolute angle sensor (steering wheel angle in proportion to steering wheel turns)!

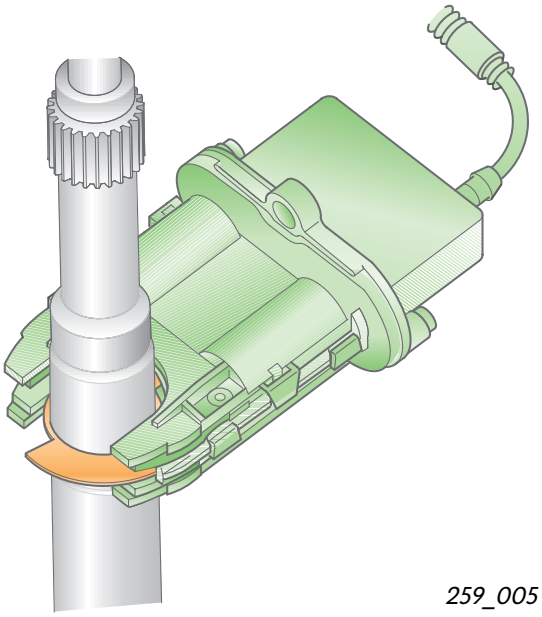


259_012

Analysis of signal

The signal is required in the power steering control unit in order to detect the movements of the steering.

The larger the steering angle rate, the greater is the pump speed and thus the volume flow (ignoring vehicle speed).



259_005

Substitute function

If the sensor fails, the power steering switches into a programme to emergency running mode.

The steering function remains assured, although greater steering forces are required.

Self-diagnosis

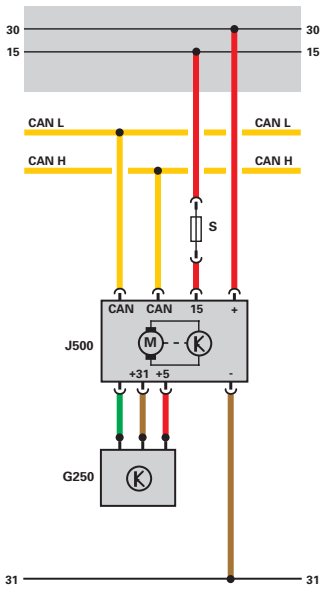
The sensor is integrated in the self-diagnosis.

The power steering control unit stores any mal-functions of the sensor.

In function 02 - Interrogating fault memory - it is possible to detect

- short circuit to earth
- open circuit/short circuit to positive
- faults.

Electric circuit



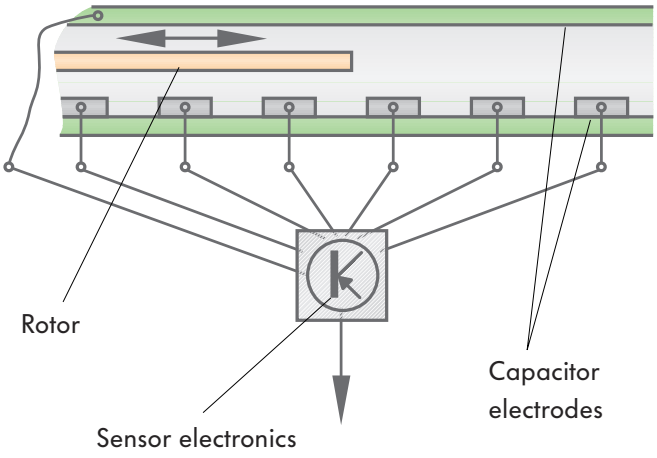
259_013

G250 Power steering sensor
J500 Power steering control unit

The capacitive sensor

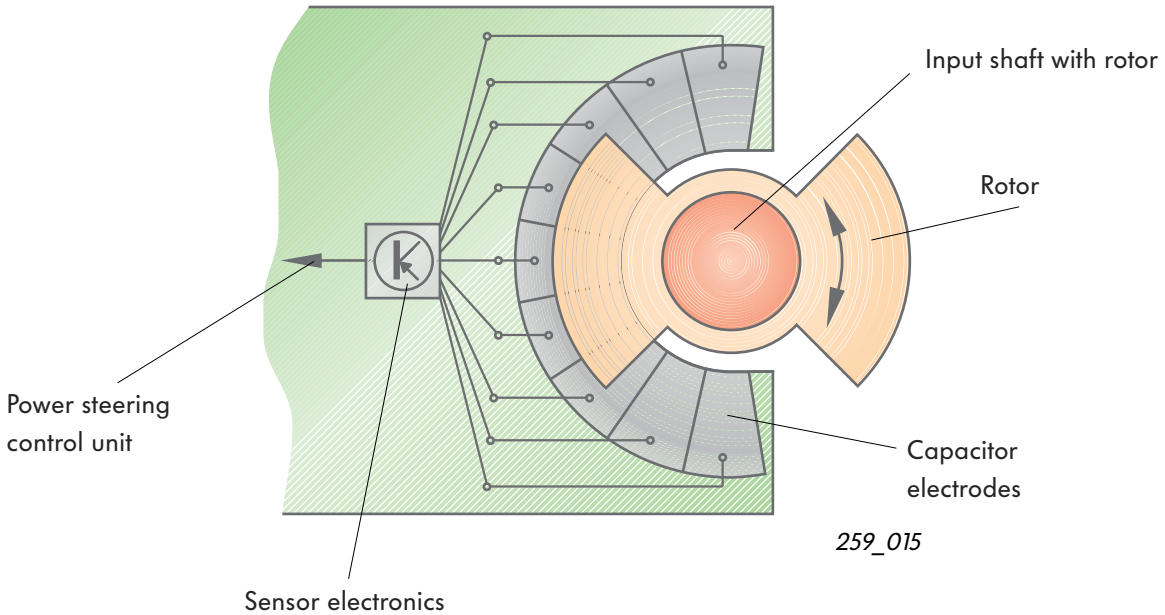
A rotor mounted on the input shaft, rotates between nine small plate-type capacitors. This distorts the capacitance of the plate-type capacitors.
The sensor electronics calculates the signals (steering angle and steering angle rate) for the power steering control unit from this change in capacitance.

Basic diagram of distortion of capacitance



259_014

Plan view

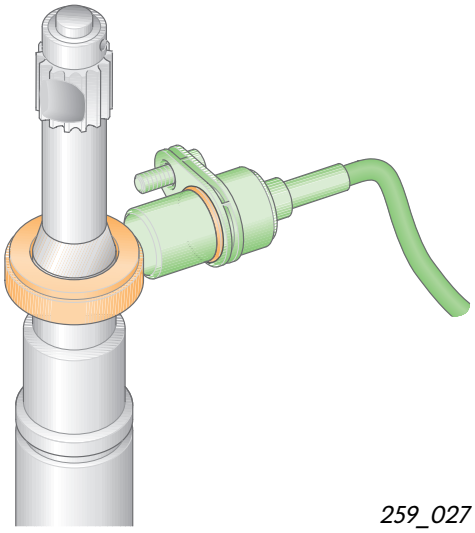


259_015

The power steering sensor G250

Task

The power steering sensor G250 is installed at the top of the input shaft of the steering gear. It determines the steering wheel angles and calculates the steering angle rate. It is not an absolute angle sensor (steering wheel angle in proportion to steering wheel turns)!



259_027

Analysis of signal

The signal is required in the power steering control unit in order to detect the movements of the steering.

The larger the steering angle rate, the greater is the pump speed and thus the volume flow (ignoring vehicle speed).

Substitute function

If the sensor fails, the power steering switches into a programmed emergency running mode.

The steering function remains assured, although greater steering forces are required.

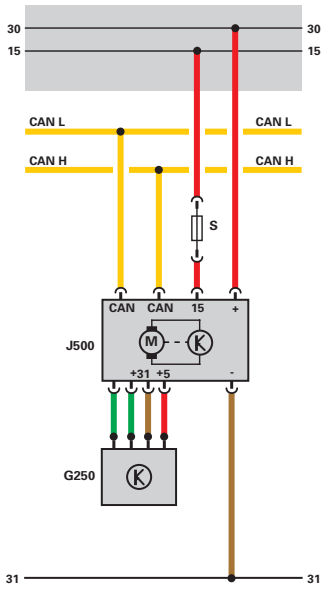
Self-diagnosis

The sensor is integrated in the self-diagnosis.

The power steering control unit stores any mal-functions of the sensor.

In function 02 - Interrogating fault memory - it is possible to detect

- short circuit to earth
- open circuit/short circuit to positive
- faults.



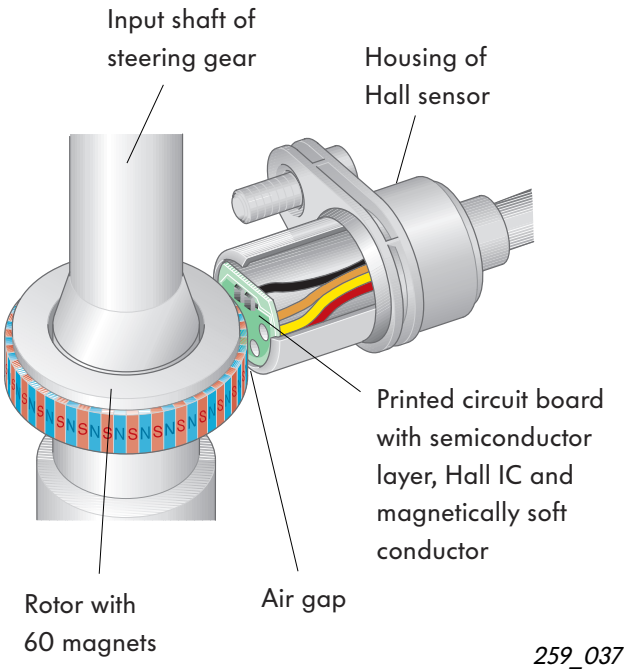
259_029

Electric circuit

G250 Power steering sensor
J500 Power steering control unit

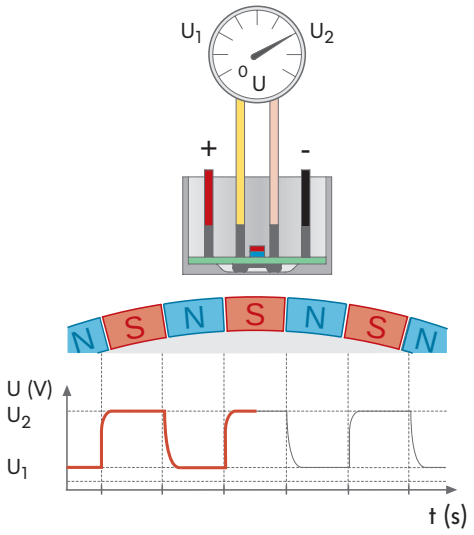
Hall sensor principle

The Hall sensor is an electronic control switch. It consists of a rotor (magnetic ring with 60 magnets) and an integrated semiconductor circuit in the sensor, the Hall IC.
A supply current flows through a semiconductor layer in the Hall IC. The rotor rotates in an air gap. As a result of the high number of magnets in the rotor, it is possible to detect the steering angle with a very high accuracy.



259_037

If a magnet of the rotor is directly within the range of the Hall IC, this position is known as a magnetic barrier. A Hall voltage is generated in this state within the Hall IC at the semiconductor layer.
The magnitude of the Hall voltage depends on the intensity of the magnetic field between the permanent magnets.



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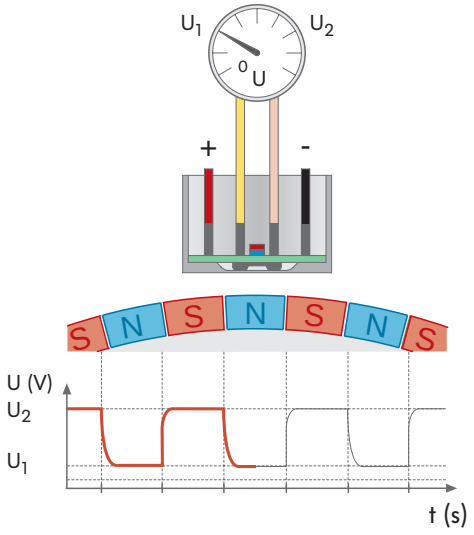
As soon as the relevant magnet of the rotor rotates further and leaves the magnetic barrier, the magnetic field is deflected by the Hall IC. The Hall voltage in the Hall IC drops and the Hall IC switches off.

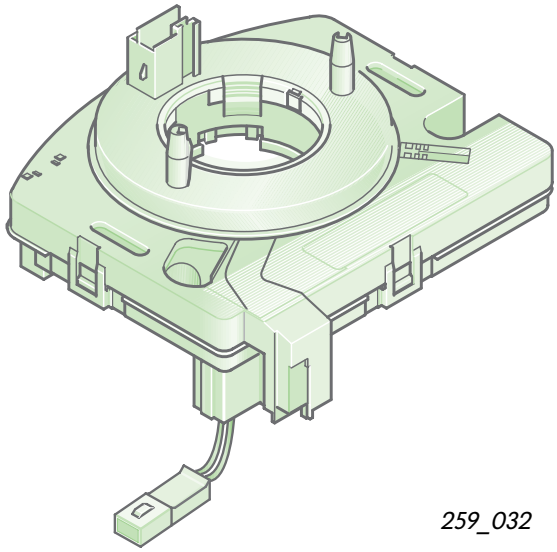


259_038

The steering angle sender G85

Task

The steering angle sender G85 transmits the angle by which the steering wheel is turned to the left or right by the driver, to the ABS control unit J104 and steering angle control unit J500 over the CAN databus.
Design and function are explained in SSP 204 - Electronic Stability Programme, page 19.



259_032

Analysis of signal

The signal, in addition to the vehicle speed and engine speed, is used by the power steering control unit J500 for determining the pump speed and thus the volume flow.

Substitute function

If the sensor fails, the power steering moves into a programmed emergency running mode.

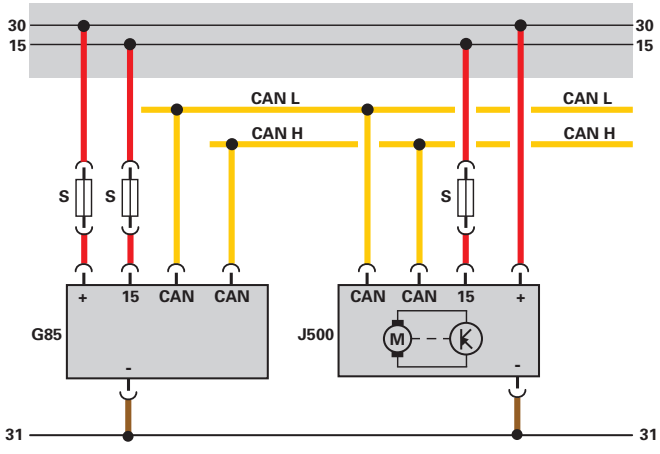
The steering function remains assured, the greater forces are required for steering.

Self-diagnosis

After the control unit or the sensor has been replaced, it is necessary to re-calibrate the zero position.
The sensor is integrated in the self-diagnosis. The power steering control unit stores any mal-functions of the sensor.

In function 02 - Interrogating fault memory - it is possible to detect

- no communication from steering angle sender,
- incorrect setting,
- mechanical fault,
- defective,
- implausible signal.



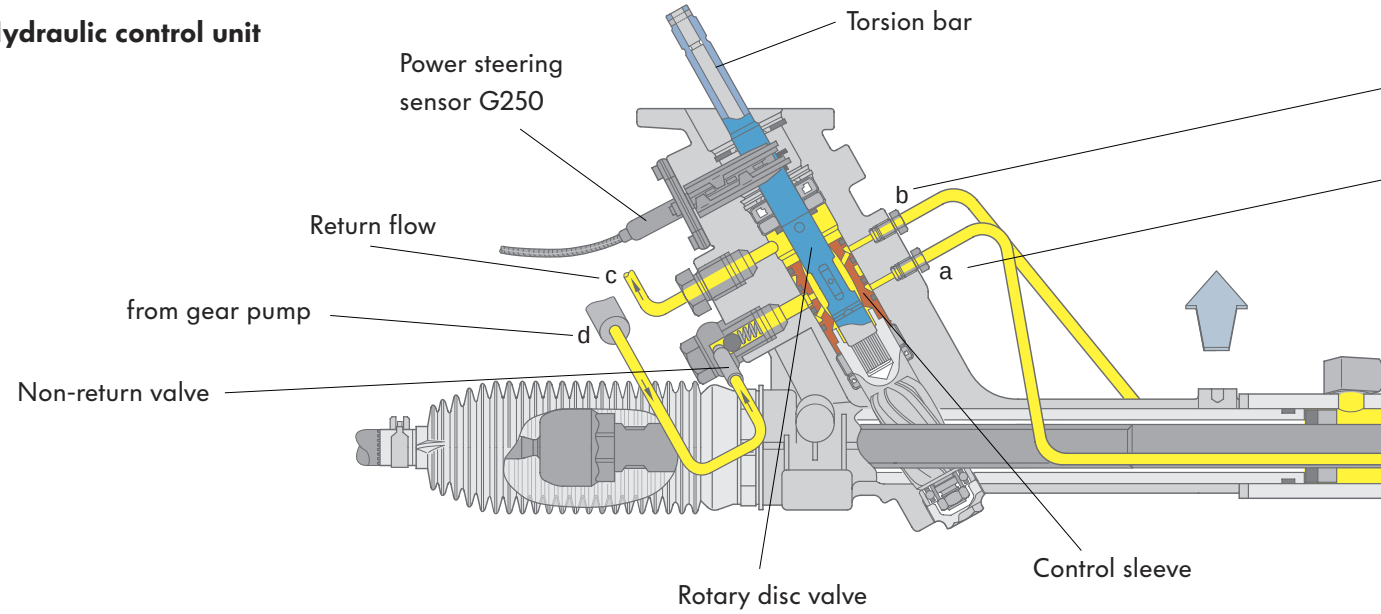
259_034

Electric circuit

G85 Steering angle sender
G250 Power steering sensor

Design and Function

Hydraulic control unit



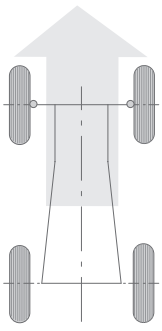
In the same way as on the familiar power-assisted steering, the hydraulic control unit contains a torsion bar which is connected on the one side to the rotary disc valve and on the other side to the drive pinion and the control sleeve.

Driving straightahead

When driving straightahead, the torsion bar holds the rotary disc valve and control sleeve in the neutral position. The power steering sensor does not detect any steering angle rate.

The hydraulic fluid flows back practically pressureless through the hydraulic control unit along the return-flow line to the reservoir.

The control slots of the rotary disc valve and control sleeve in the neutral position are set in such a way to each other that the hydraulic fluid is able to flow into both sides of the working cylinder and to flow off accordingly through the return-flow slots of the control sleeve to the reservoir.



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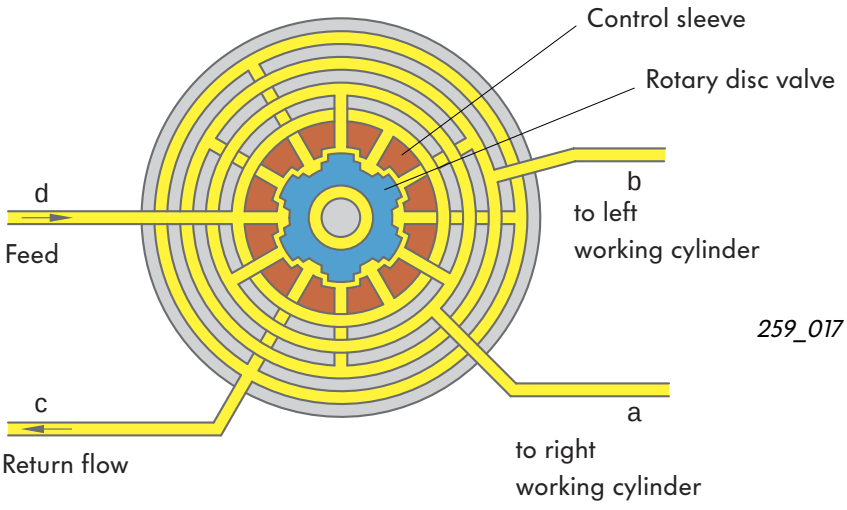
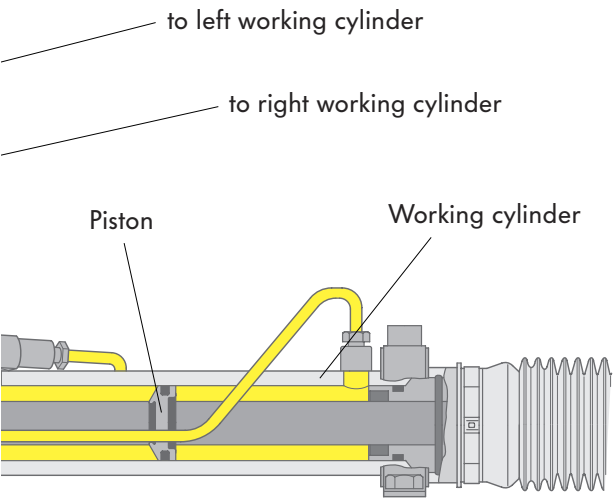




259_016

The function positions of „right full lock“ and „left full lock“ are, in hydraulic terms, similar to those of the familiar power-assisted steering.

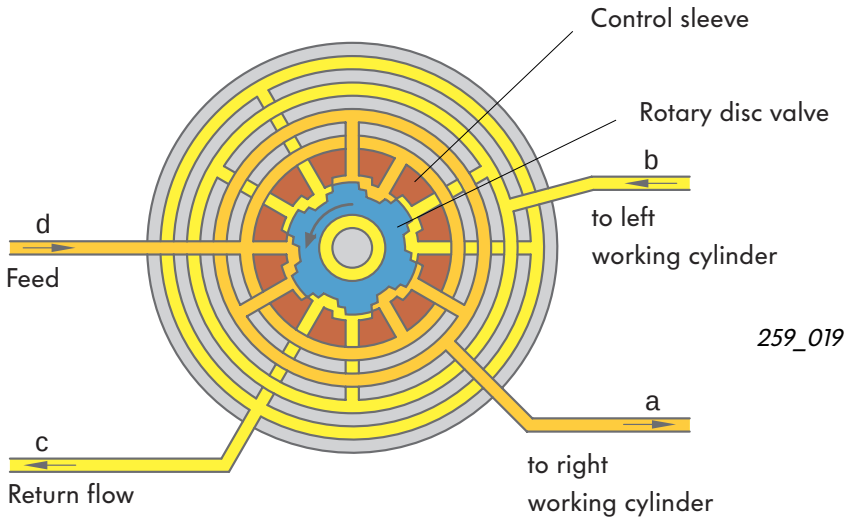
Left full lock

As the torsion bar twists, the rotary disc valve is turned against the control sleeve. The control slots of the rotary disc valve allow the pressurized oil to flow to the right side of the working cylinder.

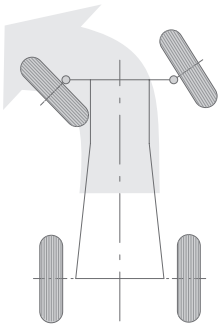
The pressurized oil flows into the working cylinder and assists the steering movement.
At the same time, the rotary disc valve shuts off the feed to the left side and opens the return flow out of the left side of the working cylinder.

The pressure on the right side forces the oil out of the left side of the working cylinder into the return flow.

As soon as the steering action is completed, the torsion bar ensures that the rotary disc valve and the control sleeve spring back into the neutral position.



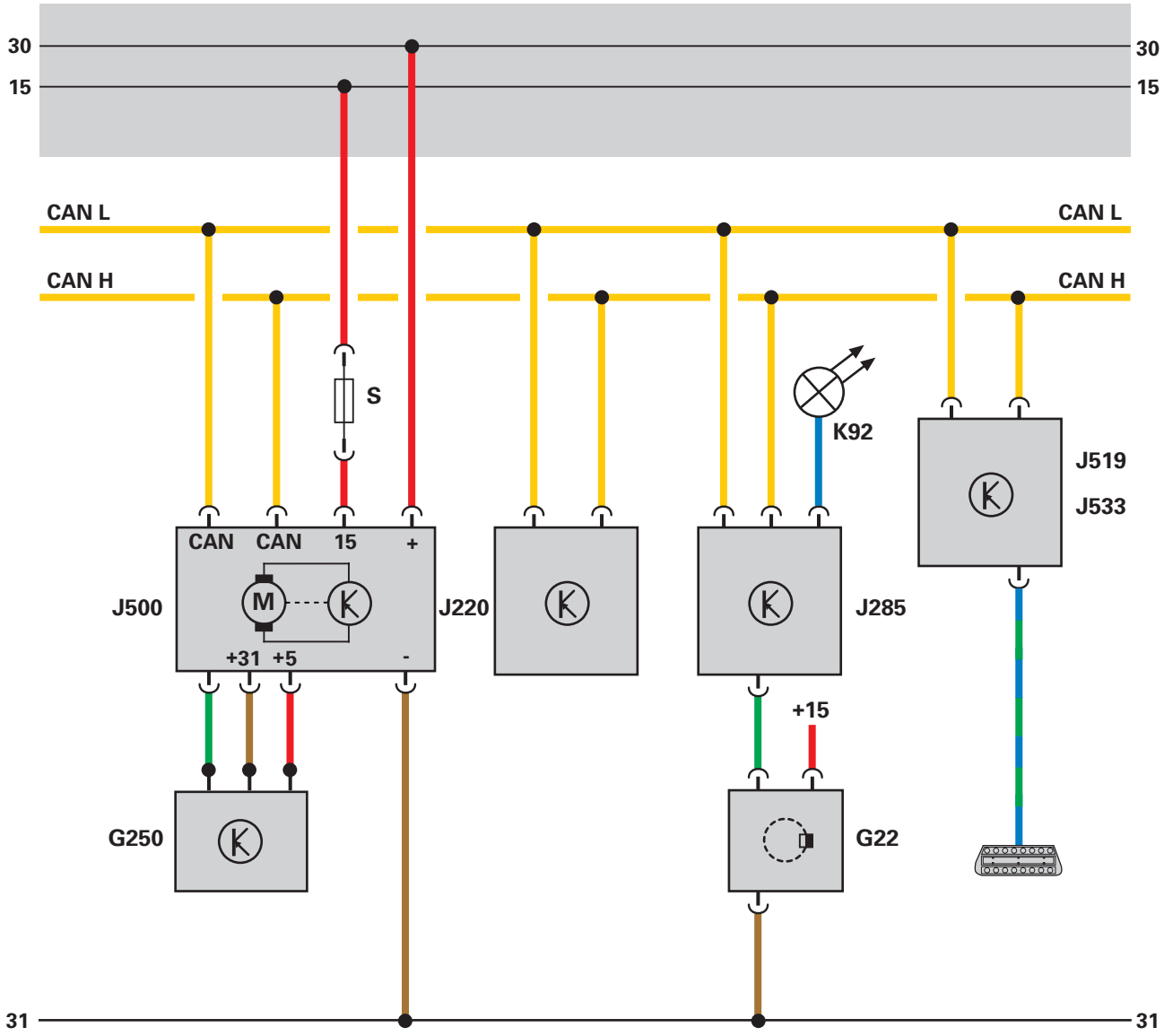
259_019



259_020

Function Diagram

Example: TRW steering system without Electronic Stability Programme (ESP)



259_022

Legend

G22	Speedometer sender
G250	Power steering sensor
J220	Motronic control unit
J285	Control unit in dash panel insert
J500	Power steering control unit
J519	Electrical system control unit
J533	Databus diagnostic interface
K92	Servotronic warning lamp
S	Fuse

Input signal

Output signal

Positive

Earth

CAN (output and input signal)

bidirectional

The funcktion diagram is not a current flow diagram.

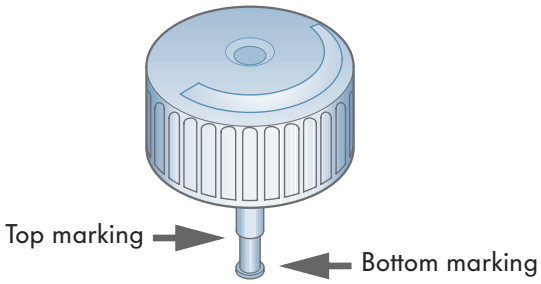
Inspecting hydraulic fluid level

TRW

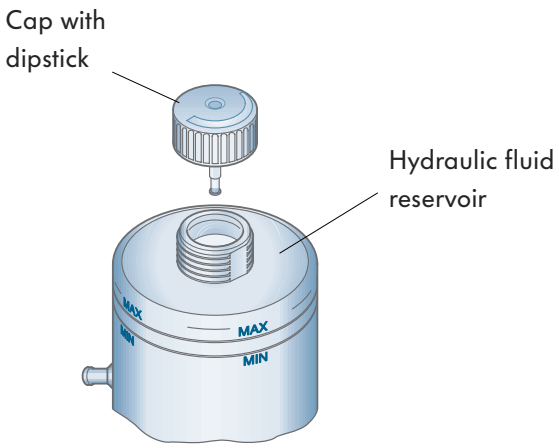
The hydraulic fluid level is inspected with the aid of the dipstick attached to the screw cap of the reservoir.

– hydraulic fluid cold:
  in the area of the bottom marking

– hydraulic fluid warm
  (from engine temperature of about 50 °C):
  about midway between bottom and top markings



259_023

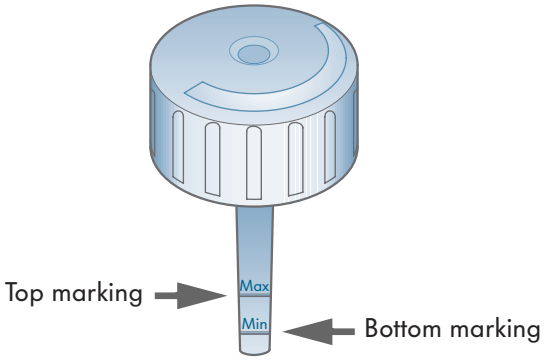


259_024

KOYO

On the KOYO steering system as well the hydraulic fluid level is checked with the aid of a dipstick attached to the screw cap of the reservoir.

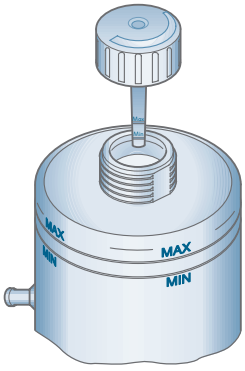
The conditions for inspecting the fluid level are identical to those of the TRW steering system. The dipstick of the KOYO steering system, however, is designed as a flat dipstick.



259_025

The fluid level is checked as follows:

1. Unscrew cap
2. Clean dipstick with cloth
3. Screw in cap hand-tight
4. Remove cap again and read off fluid level on dipstick



259_026

Servotronic warning lamp K92

After the ignition is switched on , the Servotronic warning lamp K92 lights up. An internal test cycle takes place during this time.

If the warning lamp does not go out after the engine is started and after completion of the test cycle, this is an indication that faults may be stored.

Faults may be defect in the electrical system.

259_042

Self-diagnosis

Diagnosis communication is performed over the CAN. The gateway transmits the signals from the CAN over the K wire.

Self-diagnosis relates to the electrical/electronic part of the power steering. The control unit detects faults during operation and stores them in the permanent memory. This information is retained even if the battery voltage is interrupted.
Sporadic faults are not stored in the permanent memory.

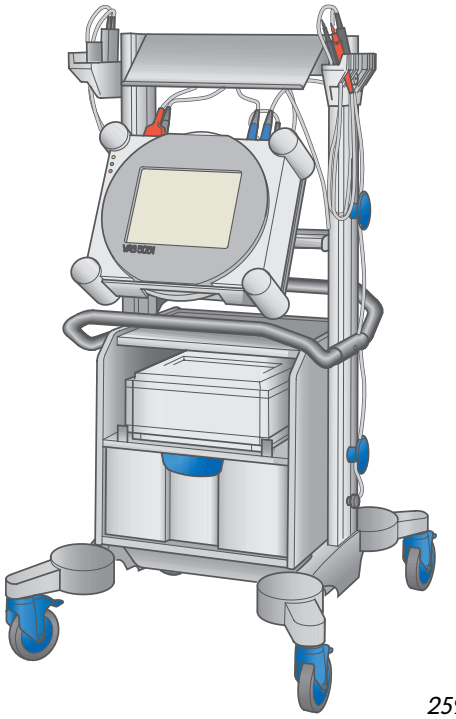
The ignition must be switched on first before initiating self-diagnosis.

Self-diagnosis can be performed with
the vehicle system tester V.A.G 1552,
the fault reader V.A.G 1551 or
with the vehicle diagnostic, testing and information system VAS 5051.

Self-diagnosis is initiated with the address word **44 - Power steering**.

Functions available:

01 - Interrogate control unit version
02 - Interrogate fault memory
05 - Erase fault memory
06 - End output
07 - Code control unit
08 - Read measured value block

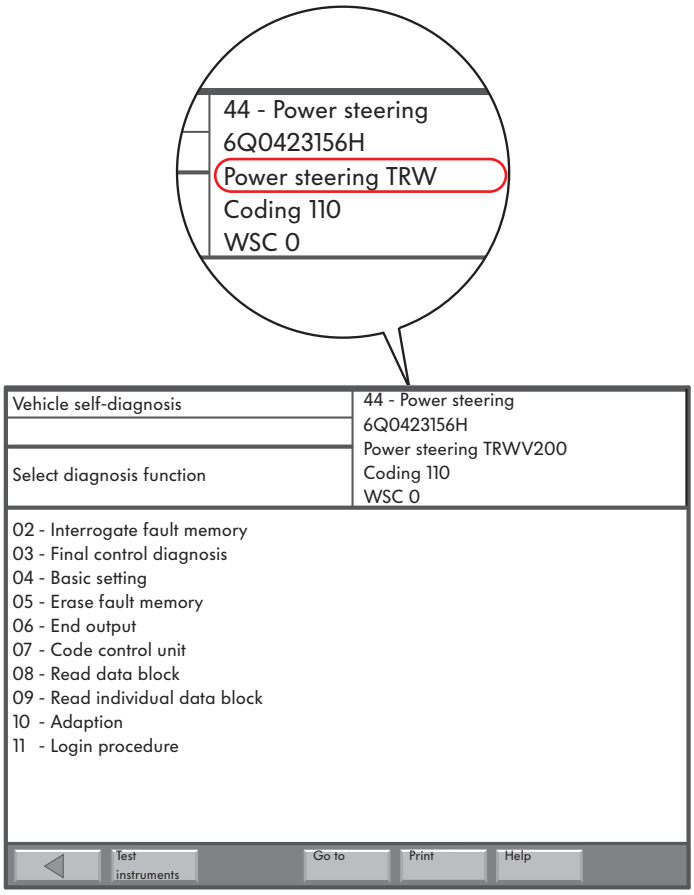


259_021

Recognition features of the steering systems

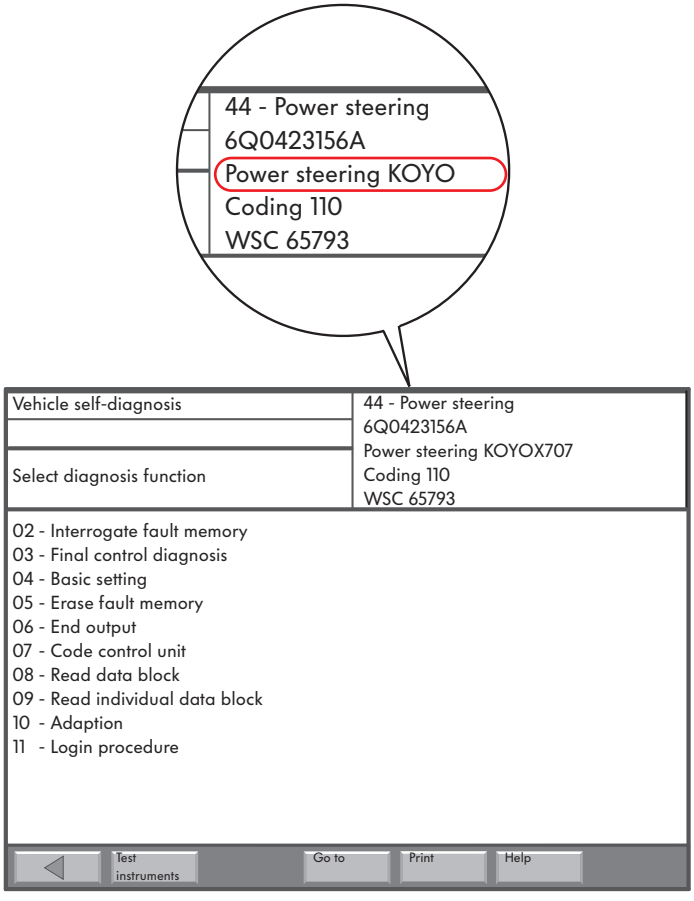
The Diagnostic and Information Systems VAS 5051 and VAS 5052 can be used to recognize the version of the steering system fitted in the function „Vehicle self-diagnosis“. This is done by selecting address word „44 - Power steering“ in the function „Vehicle self-diagnosis“.
After this entry is made, the version of the steering system appears in the screen in the top right window, together with other information.

The illustration opposite shows the screen for a vehicle fitted with the TRW steering system.



259_035

This illustration shows the screen for a vehicle fitted with the KOYO steering system.



259_036

Test Your Knowledge

Which answers are correct?
Sometimes only one.
But perhaps also more than one – or all of them!

1. How is the hydraulic pressure required for the steering servo assistance produced on the Electrically Powered Hydraulic Steering?

   A. by means of a hydraulic pump (vane pump) driven by the vehicle engine
   B. by means of a gear pump driven by an electric motor
   C. by means of an oil pump of the vehicle engine

2. Which input parameters are required by the Electrically Powered Hydraulic Steering?

   A. vehicle speed
   B. steering angle rate
   C. engine speed

3. In what way does the TRW steering system differ from the KOYO steering system?

   A. in how the steering angle rate is determined
   B. in the number of turns of the steering wheel
   C. in the differences in the operating principle of the hydraulic sector

4. When does the Servotronic warning lamp K92 in the dash panel insert light up?

   A. The warning lamp lights up if the Electrically Powered Hydraulic Steering is operated.
   B. The warning lamp lights up after the ignition is switched on. During this time an internal test cycle takes place in the power steering control unit J500.
   C. The warning lamp lights up if a fault is stored in the power steering control unit J500 (for example failure of the power steering sensor G250 or a fault in the power steering control unit).

5. What are the advantages which the Electrically Powered Hydraulic Steering offers?

   A. improvement in active safety as the steering is easy to operate when parking, but is stiff when driving at high speeds
   B. fuel savings of about 0.2 l/100 km in comparison to a conventional power-assisted steering
   C. more environmentally friendly because of reduction in the quantity of fluid in hydraulic system and the reduced energy demand

6. If a crash occurs, how is it possible to deactivate the restart protection of the Electrically Powered Hydraulic Steering?

   A. by switching off the engine and starting it again
   B. only by using a diagnostic tool in a Volkswagen Service Dealership
   C. The restart protection can only be deactivated after other types of faults, as for example if the pump has overheated.

7. What is the operating principle on which the power steering sensor G250 is based in the KOYO steering system?

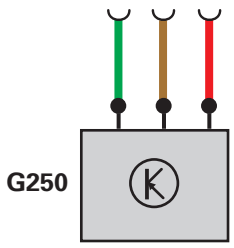
   A. based on the principle of capacitor mistuning
   B. based on the induction principle
   C. based on the Hall sensor principle

8. To which side of the working cylinder does the pressurized oil flow when the steering is turned to the left?

   A. to the right side of the working cylinder
   B. to the left side of the working cylinder

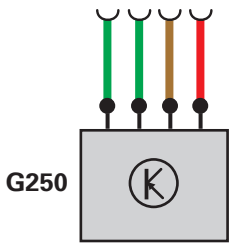
9. Which system diagram shows the power steering sensor G250 of the TRW steering system?

Fig. A



259_040

Fig. B



259_041

Subject Index

Map

as a general rule represents the functional interactions of characteristic parameters, in other words the operating characteristic (power outputs, pressures, temperatures, engine speeds, vehicle speeds or voltage signals from the steering angle sensor). The map is stored in a microprocessor in a control unit and is used there for determining the signals which are transmitted to the actuators.

Calibration

means determining the zero point or the straight-ahead position of a parameter to be detected. This „learning process“ is used or required during initial operation or after a component has been replaced.

Capacitor

a capacitor consists of two or several metal coatings (capacitor plates) separated from each other by a dielectric. If the dielectric (magnetic field) is altered, the capacitance of the capacitor changes. This change can be used as an input signal for control systems.

Capacitance

is the capacity for electric charges. It depends on the geometric arrangement of the conductors and on the dielectric constance of the material in which the conductors are located.

Semiconductor

Semiconductor is a name given to a crystalline solid body, the conductivity of which is between the electric and the non-electric conductors.
The most common types of semiconductors are: silicone, germanium, selenium.

CAN databus

(Controller Area Network) provides a very rapid transfer between several equal-priority control units. The participating control units are interlinked by means of a linear line structure.
If one user fails, the bus structure remains fully available for all the other users (exception: failure of engine control unit).

Gateway

The gateway is located in the vehicle electrical system control unit and ensures data exchange between the as many as three CAN databus subsystems.
Direct communication between these subsystems is not possible because of the different transmission rates.

Hall effect

This term refers to changes in the electrical flow through a conductor which are caused by a magnetic field.
There are 12 such effects. One of the most familiar is the Hall effect.

Notes

Answers to „Test Your Knowledge“

1. B.; 2. A, B, C,; 3. A.; 4. B, C.; 5. A., B., C.; 6. B.; 7. C.; 8. A.; 9. A.

Service.

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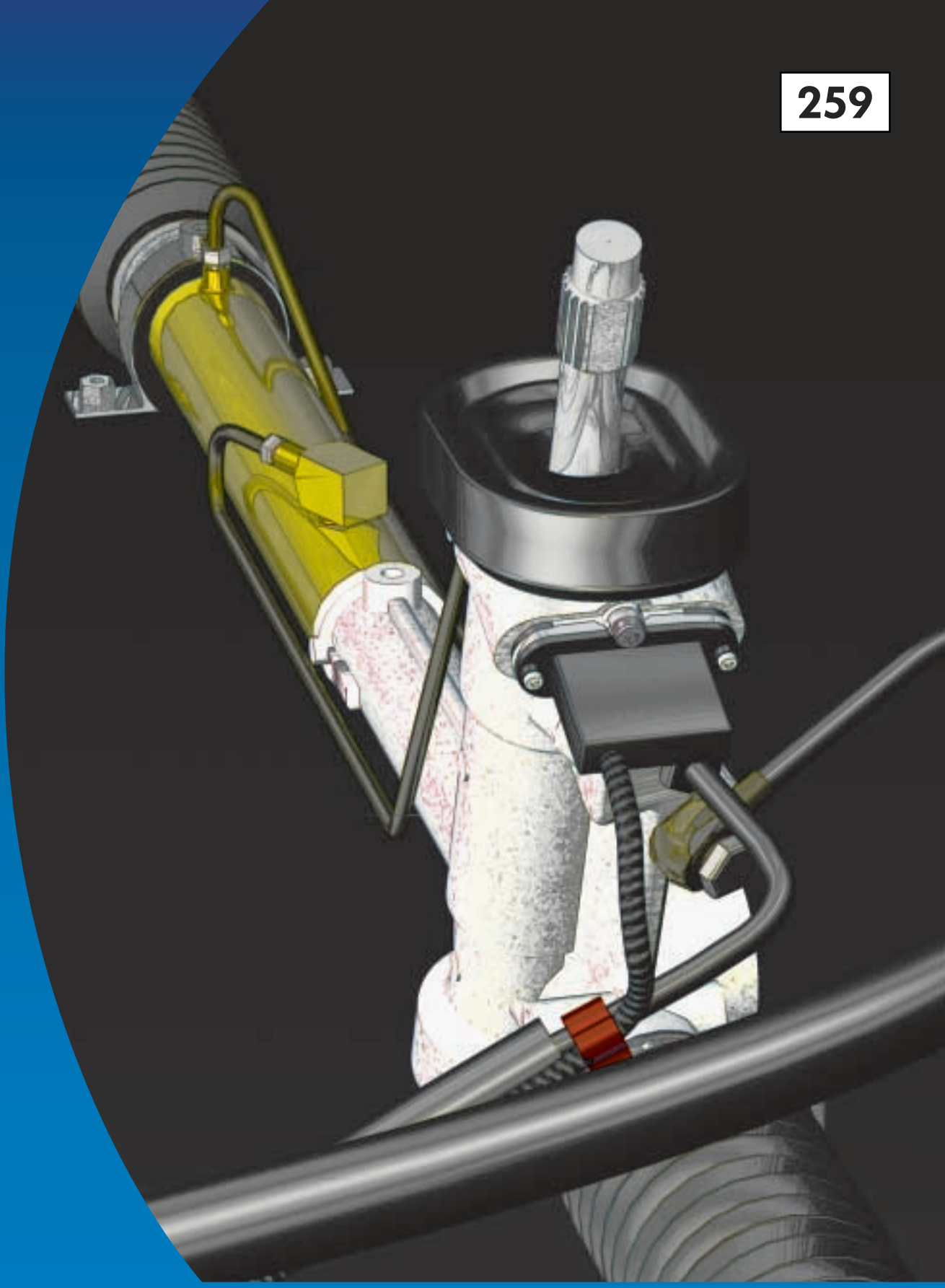

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