

Electro-mechanical Power Steering

Design and Function



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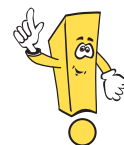
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New!



The Self-Study Program provides you with information regarding designs and functions.

Important/Note!

The Self-Study Program is not a Repair Manual!

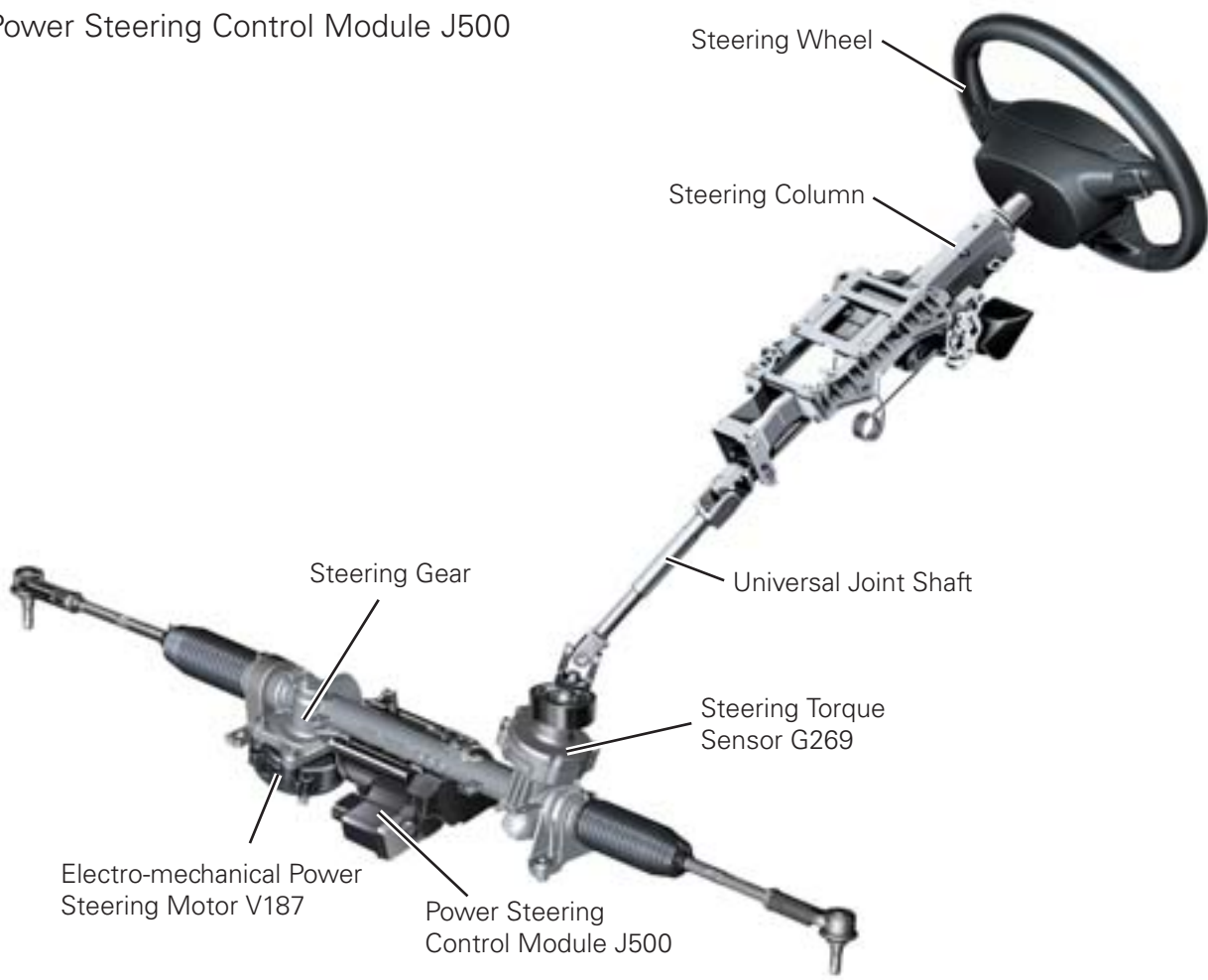
For maintenance and repair work, always refer to the current technical literature.



Electro-mechanical Power Steering with Dual Pinion

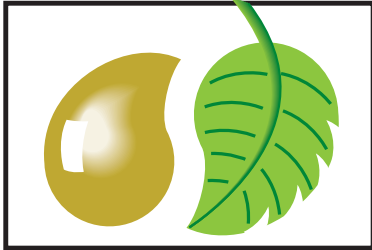
The steering system components are:

- Steering wheel
- Steering Angle Sensor G85
- Steering column
- Steering Torque Sensor G269
- Steering gear
- Electro-mechanical Power Steering Motor V187
- Power Steering Control Module J500

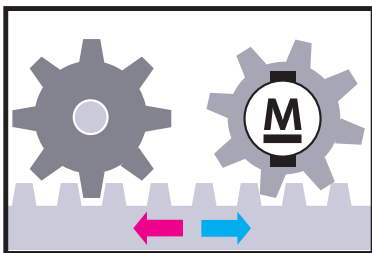


Introduction

What You Should Know About the Electro-mechanical Power Steering System:



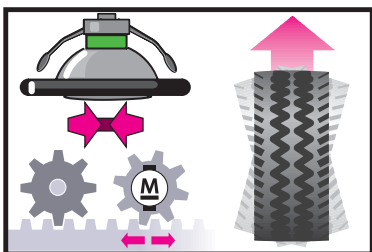
With electro-mechanical power steering, there is no requirement for hydraulic assistance to support the steering. Eliminating hydraulic oil from the steering system helps to protect the environment.



The electro-mechanical power steering system is a dual pinion type. This is characterized by two pinions (steering and drive pinions), which enable the necessary steering force to be transmitted to the steering rack.



To assist the steering, an electric motor is actuated based on input response. The system provides the driver with assistance depending on the driving conditions (servotronic).



The electro-mechanical power steering supports return of the steering wheel back to the center position via the "active return" function. This results in a well-balanced feeling and extremely accurate straight-line stability in every driving situation.



With the straight-line stability function, a force is generated and applied to make it easier for the driver to steer the vehicle in a straight line when the vehicle is being affected constantly by side winds or driven up or down hills.

The Advantages of Electro-mechanical Power Steering

The electro-mechanical power steering system offers the following advantages over a traditional hydraulic system:

- no hydraulic components, for example power steering oil pump, hoses, oil tank, filter
- no hydraulic fluid
- space savings
- reduction in noise
- energy savings
- no complex hose and wiring system

The electric motor and control module are located directly on the steering gear.

This results in a notable energy savings. Unlike hydraulically assisted steering, which requires a permanent circuit flow, the electro-mechanical power steering only draws energy when steering force is necessary. This input response performance leads to a reduction in fuel consumption.

The driver has an optimal driving feeling in every situation thanks to:

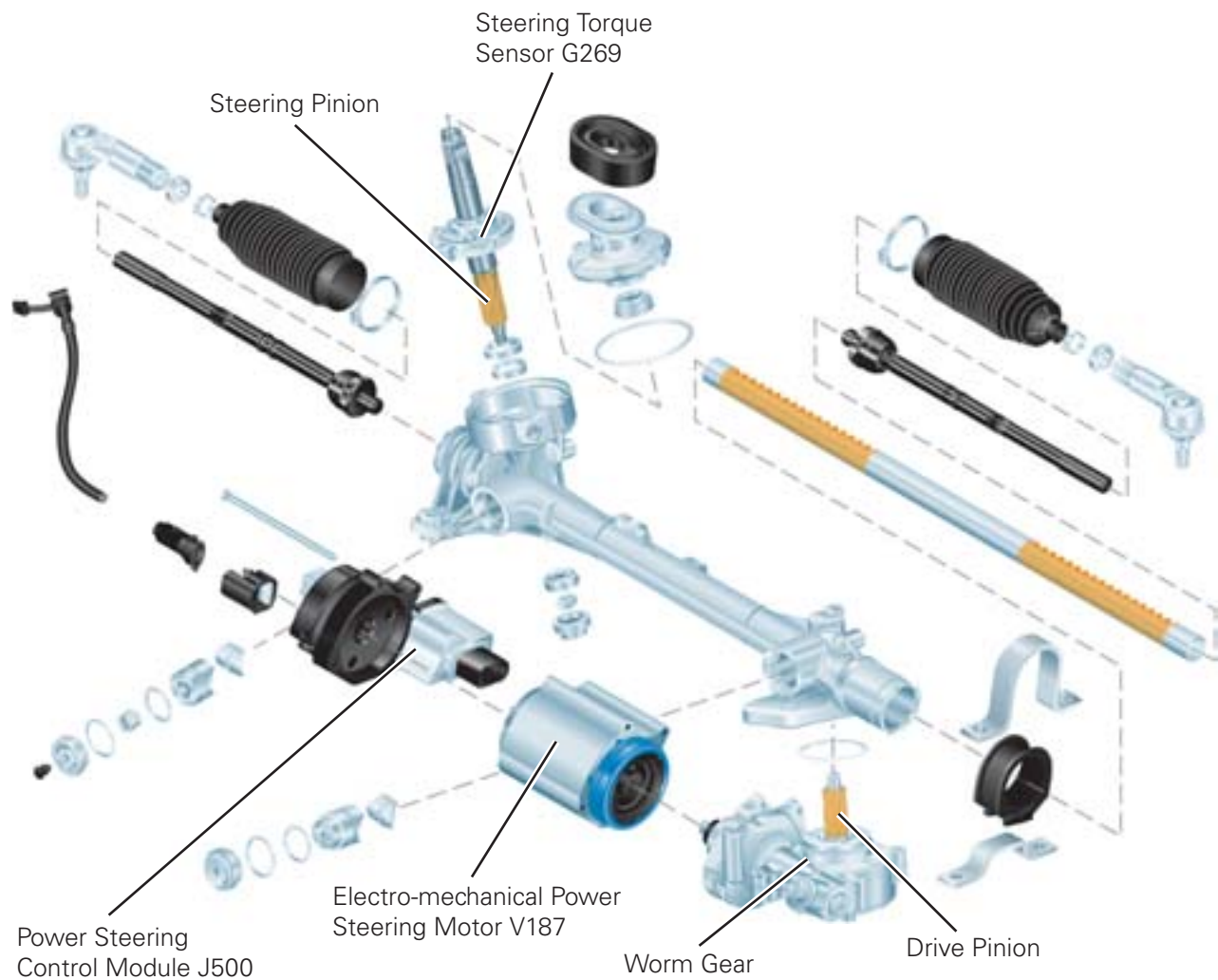
- good straight-line stability (return of the steering wheel to the center position is actively supported by the electro-mechanical power steering system)
- direct but soft application of the steering input
- no uncomfortable steering reactions over uneven driving surfaces



The fuel consumption savings over 620 miles (1000 km) is approximately 0.5 gallons (2.0 liters).

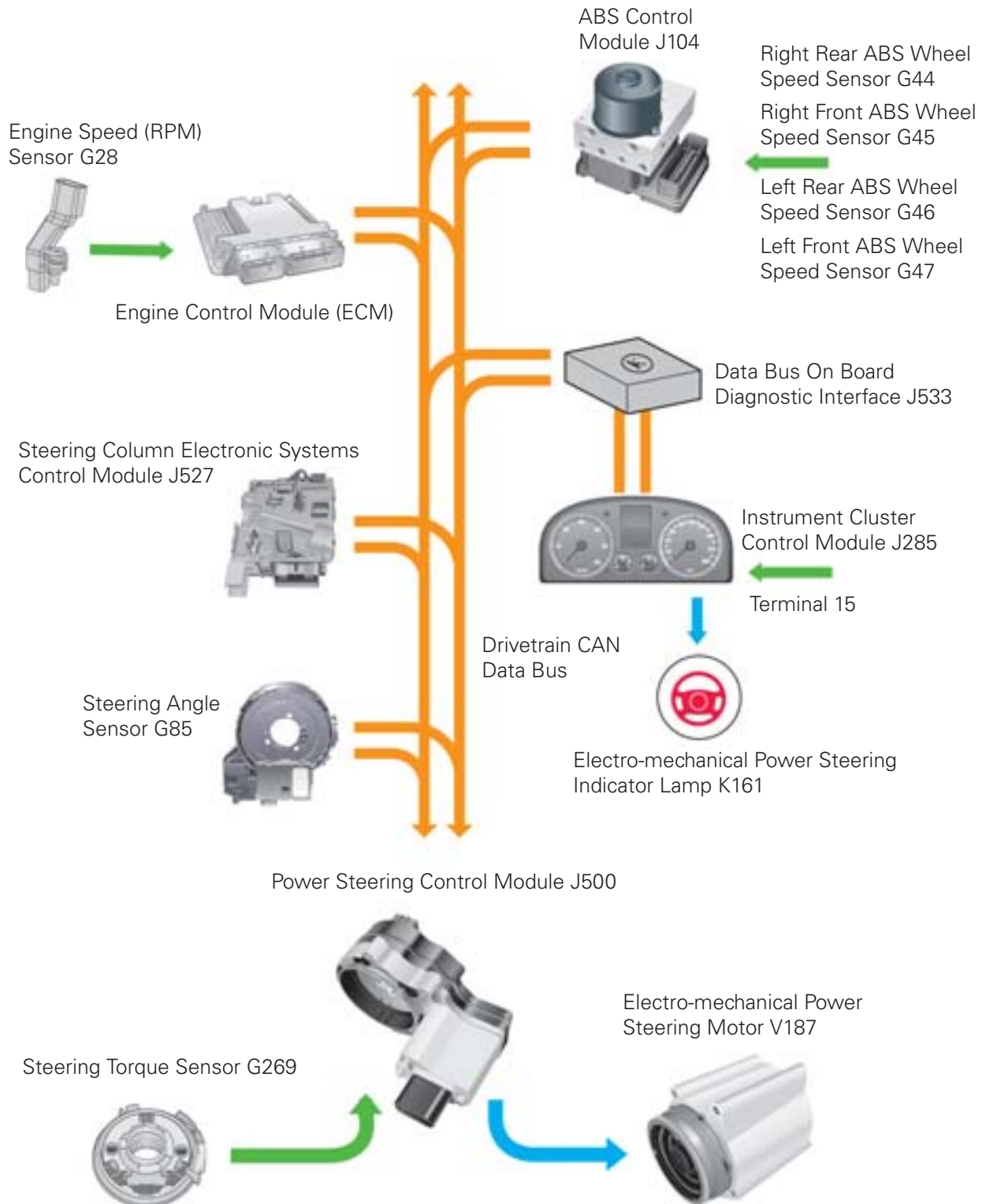
Introduction

Electro-mechanical Power Steering Components



System Overview

System Overview

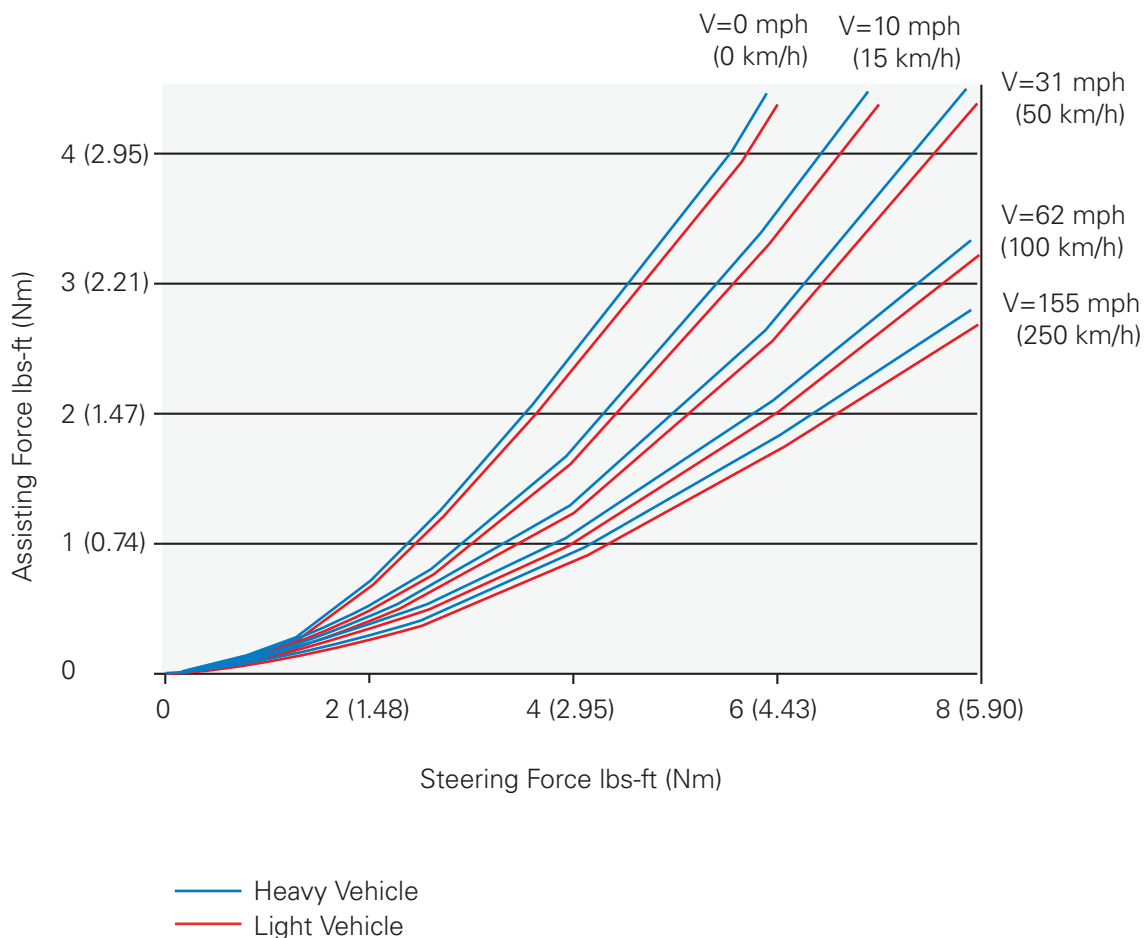


Function

Control Map Characteristics

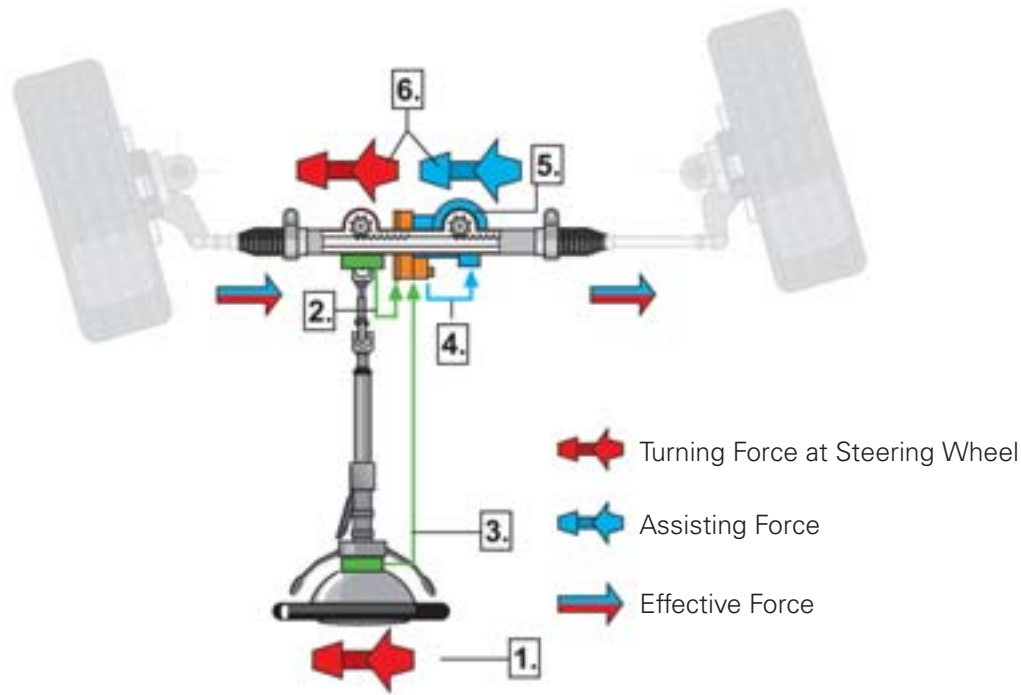
Steering assistance is controlled via a map, which is stored permanently in the program memory of Power Steering Control Module J500. The memory has a capacity for up to 16 different maps. Maps are activated in the factory depending on requirements (e.g. vehicle weight).

However, maps can also be activated with the scan tool if the Power Steering Control Module J500 or steering system were to be serviced or replaced.



For any given vehicle, both a heavy and a light map are selected. Each map has five different characteristics that are calculated using vehicle speed. These maps determine the amount of steering assistance available to the driver.

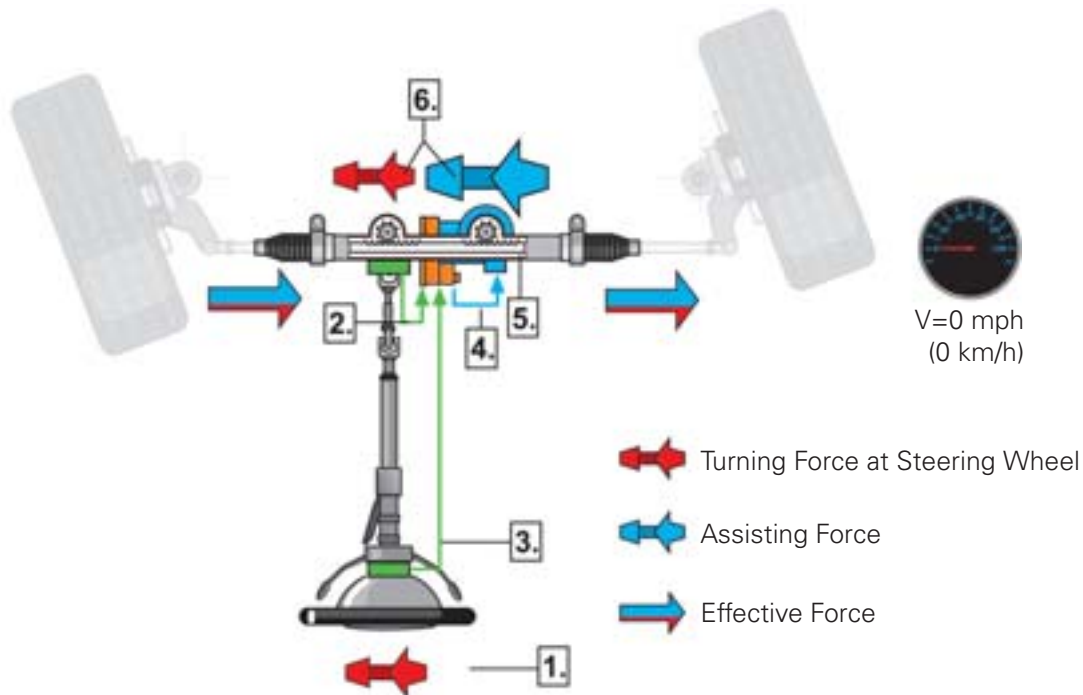
The Steering Function



1. The power steering assistance starts when the driver uses force to turn the steering wheel.
2. The force on the steering wheel causes a torsion bar in the steering gear to turn. The Steering Torque Sensor G269 detects the rotation and sends the calculated steering force figure to the Power Steering Control Module J500.
3. The Steering Angle Sensor G85 reports the current steering angle and steering speed.
4. Depending on the steering force, road speed, engine speed, steering angle, steering speed and maps stored in Power Steering Control Module J500, it calculates the necessary assisting force and actuates Electro-mechanical Power Steering Motor V187.
5. The steering assistance comes from a second pinion, which applies its energy in parallel on the steering rack. This pinion is driven by Electro-mechanical Power Steering Motor V187. The motor engages in the steering rack via a worm gear and drive pinion, which transmits the force required for steering assistance.
6. The sum of the turning force on the steering wheel and the assisting force is the effective force applied on the steering gear to move the rack.

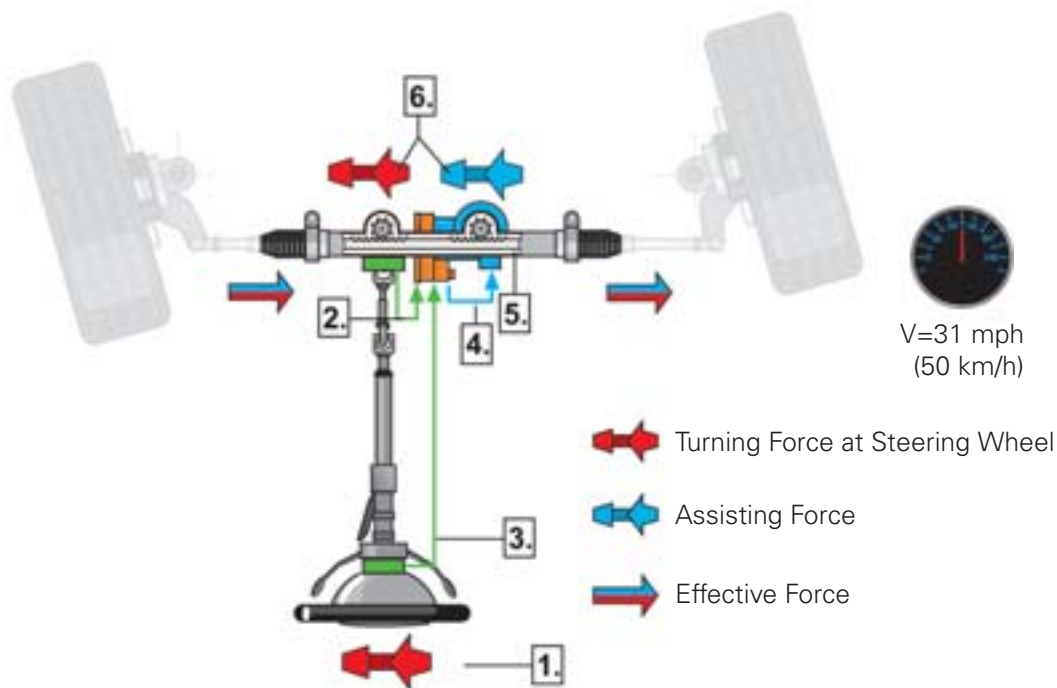
Function

The Steering Function for Parking Maneuvers



1. When parking the vehicle, the driver turns the steering wheel rapidly.
2. The torsion bar is turned. The Steering Torque Sensor G269 picks up the rotation and sends a signal to the Power Steering Control Module J500, indicating that a large amount of force has been placed on the steering wheel.
3. The Steering Angle Sensor G85 reports the current steering angle and steering speed.
4. Based on the large amount of steering force, the road speed of 0 mph (0 km/h), the engine speed, the large steering angle, the steering speed and the maps stored in it for $V=0$ mph (0 km/h), Power Steering Control Module J500 detects that a large amount of assisting force is required and actuates Electro-mechanical Power Steering Motor V187.
5. In this way, the largest amount of steering assistance is applied on the steering rack via the second pinion for parking maneuvers.
6. The sum of the turning force on the steering wheel and the maximum assisting force is the effective force applied on the steering gear for movement of the rack during parking maneuvers.

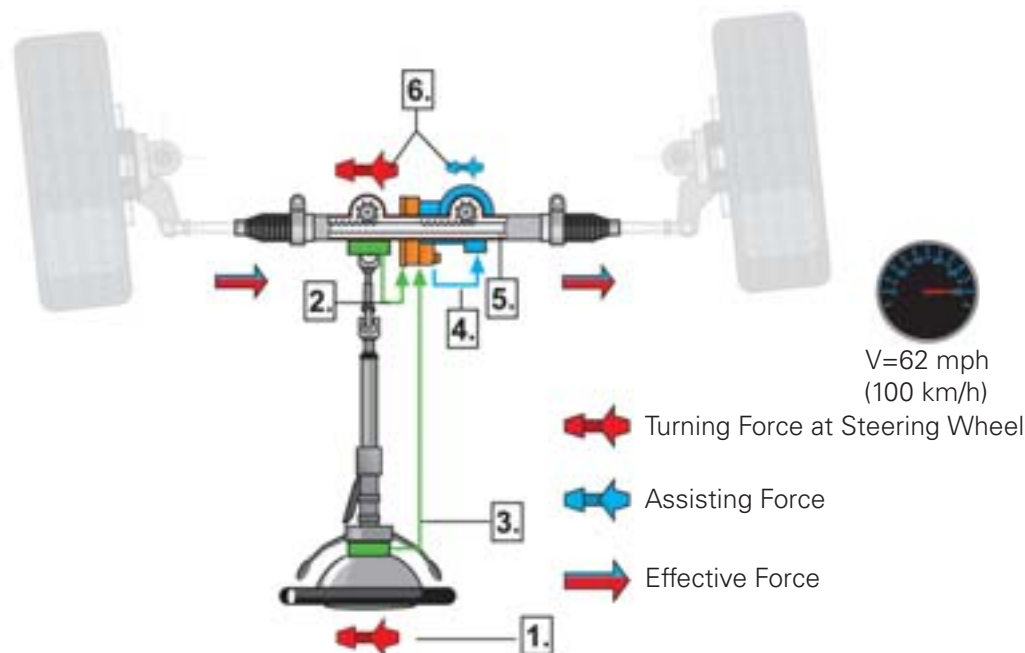
The Steering Function in Urban Areas



1. When cornering in urban areas, the driver uses force to turn the steering wheel.
2. The torsion bar is turned. The Steering Torque Sensor G269 picks up the rotation and sends a signal to the Power Steering Control Module J500, indicating that a medium amount of force has been placed on the steering wheel.
3. The Steering Angle Sensor G85 reports the current steering angle and steering speed.
4. Based on the medium amount of steering force, the road speed of 31 mph (50 km/h), the engine speed, the medium steering angle, the steering speed and the maps stored in it for V=31 mph (50 km/h), Power Steering Control Module J500 detects that a medium amount of assisting force is required and actuates Electro-mechanical Power Steering Motor V187.
5. In this way, a medium amount of steering assistance is applied on the steering rack via the second pinion during cornering.
6. The sum of the turning force on the steering wheel and the medium assisting force is the effective force applied on the steering gear for movement of the rack during cornering in urban areas.

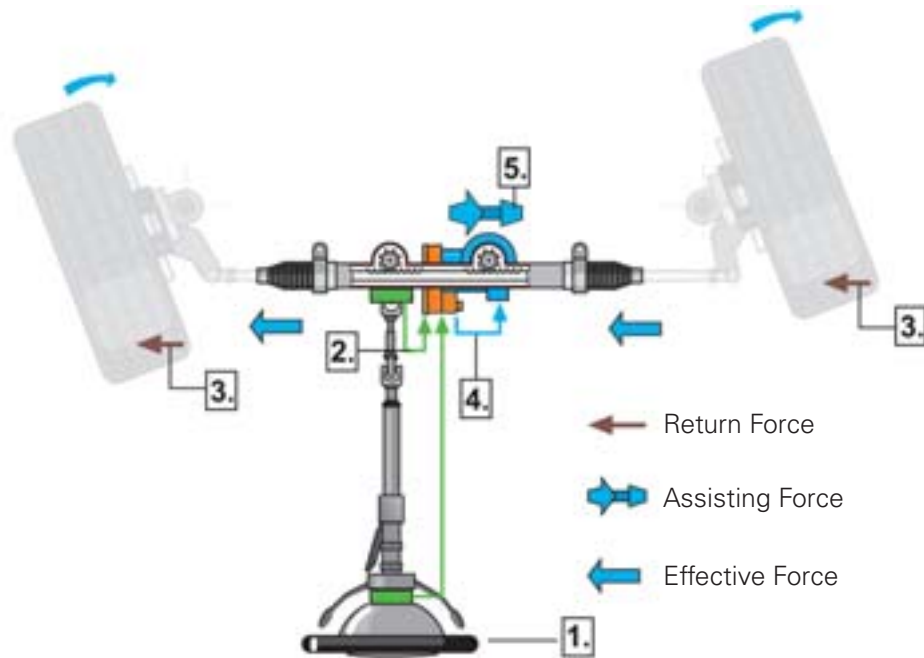
Function

The Steering Function on Highways



1. To change lanes, the driver imparts light force on the steering wheel.
2. The torsion bar is turned. The Steering Torque Sensor G269 picks up the rotation and sends a signal to the Power Steering Control Module J500, indicating that a small amount of force has been placed on the steering wheel.
3. The Steering Angle Sensor G85 reports the current steering angle and steering speed.
4. Based on the small amount of steering force, the road speed of 62 mph (100 km/h), the engine speed, the small steering angle, the steering speed and the maps stored in Power Steering Control Module J500 for V=62 mph (100 km/h), it detects that a small amount of assisting force is required and actuates Electro-mechanical Power Steering Motor V187.
5. In this way, a small amount of steering assistance is applied on the steering rack via the second pinion during lane change maneuvers on the highway, or no assistance at all.
6. The sum of the turning force on the steering wheel and the minimum assisting force is the effective force applied on the steering gear to move the steering rack during lane changing maneuvers.

The Active Return Function



1. If the driver reduces the force on the steering wheel during cornering, torsion bar tension is relieved.
2. In conjunction with the reduced steering force, inclusion of the steering angle and the steering speed, a return speed specification is calculated. This is compared with the steering angle speed. The result of this is the returning force required.
3. Return forces are applied on the steering wheels as a result of the running gear layout. The return forces are often too weak, due to friction in the steering system and in the axle (suspension), to bring the wheels back to the center position.
4. Power Steering Control Module J500 calculates the necessary return force required from Electro-mechanical Power Steering Motor V187 by evaluating the steering force, road speed, engine speed, steering angle, steering speed and the map characteristics stored in Power Steering Control Module J500.
5. Electro-mechanical Power Steering Motor V187 is actuated and the wheels are returned to the straight-ahead position.

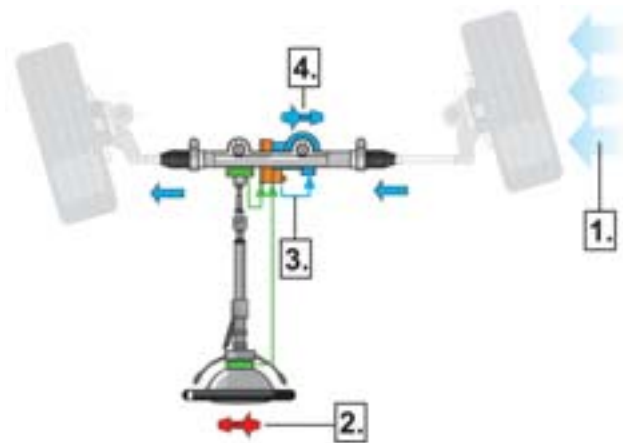
Function

Straight-Line Stability

Straight-line stability is an extension of the active return function. An assisting force is generated to bring the wheels of the vehicle in the center position, when no force is applied. To do this, a difference is made between a short period algorithm and a long period algorithm.

Long Period Algorithm

The long period algorithm has the task of balancing deviations either side of the center position that occur over a long period of time. For example, deviations that could be caused when summer tires are changed for winter tires (used or with different diameter).



-  Return Forces
-  Assisting Force
-  Effective Force

Short Period Algorithm

The short period algorithm is responsible for correcting deviations that occur briefly. This makes driving easier for the driver when, for example, permanent side winds make it necessary to steer against a resistance.

1. A constant side force is applied on the vehicle, e.g. side wind.
2. The driver applies force on the steering wheel to keep the vehicle in a straight line.
3. Power Steering Control Module J500 calculates the necessary force required from Electro-mechanical Power Steering Motor V187 to maintain the straight ahead position by evaluating the steering force, road speed, engine speed, steering angle, steering speed and the map characteristics stored in Power Steering Control Module J500.
4. Electro-mechanical Power Steering Motor V187 is actuated. The vehicle is brought into the straight-ahead position. The driver no longer has to steer against the resistance.

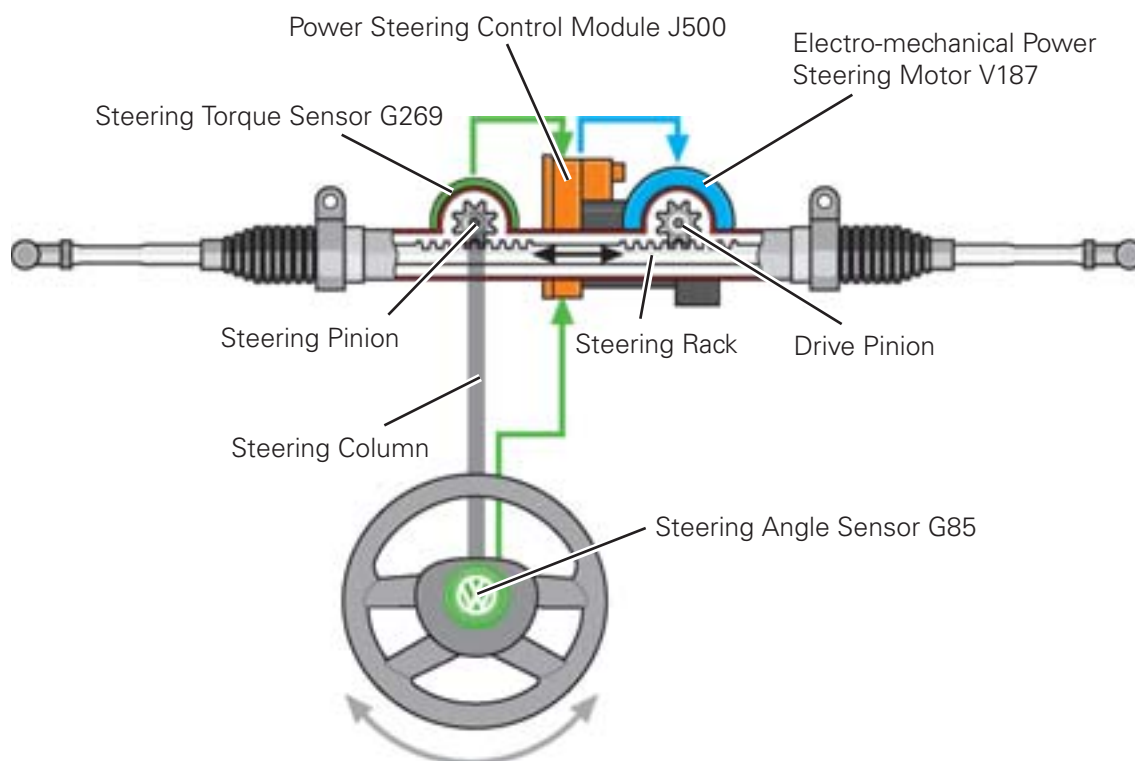
Steering Mechanics

The Steering Gear

The steering gear consists of Steering Torque Sensor G269, a torsion bar, a steering and drive pinion, a worm gear, Electro-mechanical Power Steering Motor V187, and Power Steering Control Module J500. The core of the electro-mechanical power steering is a steering rack with two teeth engaged in the steering gear.

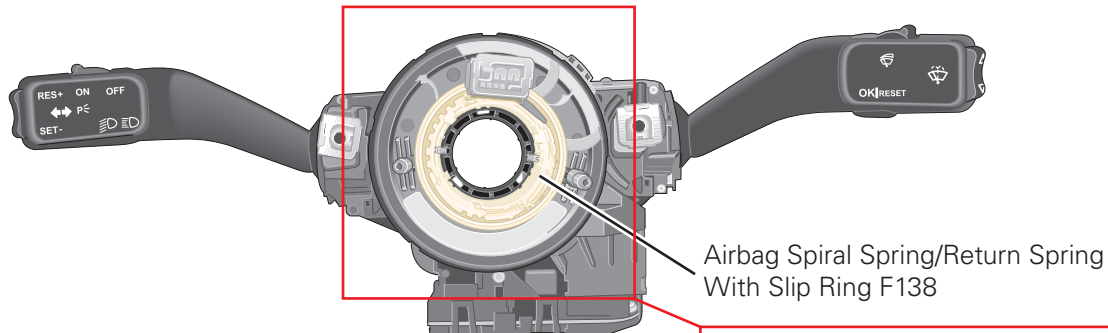
On the electro-mechanical power steering with dual pinion, the steering force required is transferred via the steering pinion and the drive pinion to the steering rack. The steering pinion transfers the steering force applied by the driver and the drive pinion transfers the assisting force from Electro-mechanical Power Steering Motor V187 via a worm gear.

Electro-mechanical Power Steering Motor V187, Power Steering Control Module J500 and steering assistance sensors can be found on the second pinion. This design means that there is a mechanical connection between the steering wheel and steering rack. In this way, the vehicle can still be steered mechanically in the event of failure of Electro-mechanical Power Steering Motor V187.



Steering Electrics

Steering Angle Sensor G85

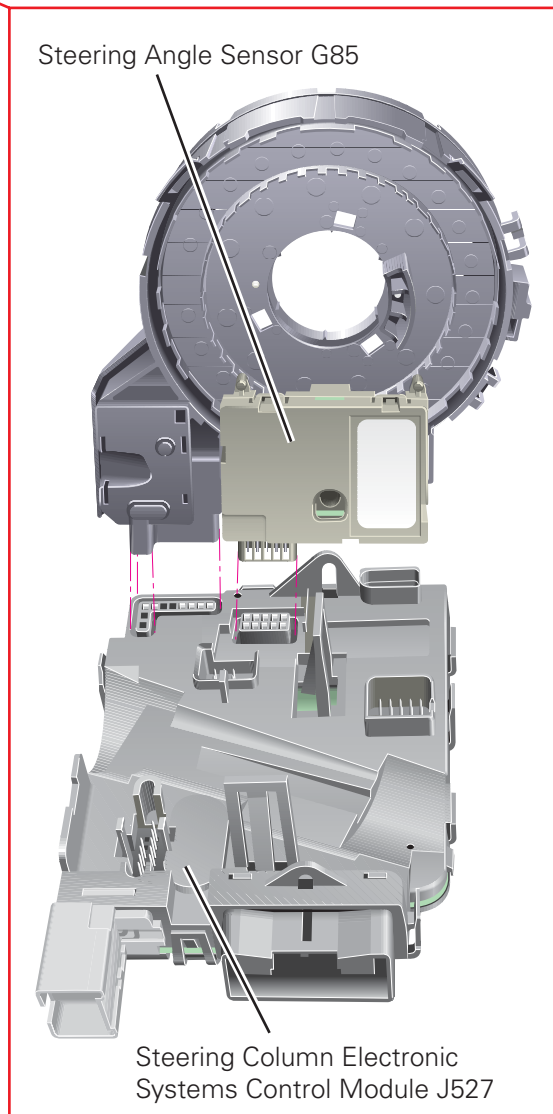


The Steering Angle Sensor G85 can be found behind Airbag Spiral Spring/Return Spring With Slip Ring F138. It is located on the steering column between the steering column switch and the steering wheel.

It sends the signal for steering angle analysis to Steering Column Electronic Systems Control Module J527 via the CAN data bus. The electronic system for analysis of the signals is located in Steering Column Electronic Systems Control Module J527.

Effects of Failure

In the event of signal failure, an emergency running mode is started. The missing signal is replaced by a substitute figure. Power steering assistance remains intact. Electro-mechanical Power Steering Indicator Lamp K161 will light up to indicate the fault.



Steering Electrics

Principles of Operation

Basic components of Steering Angle Sensor G85 are:

- Absolute and increment ring with two codes
- Photoelectric beam pairs, each with one Light-Emitting Diode (LED) and one optical sensor.

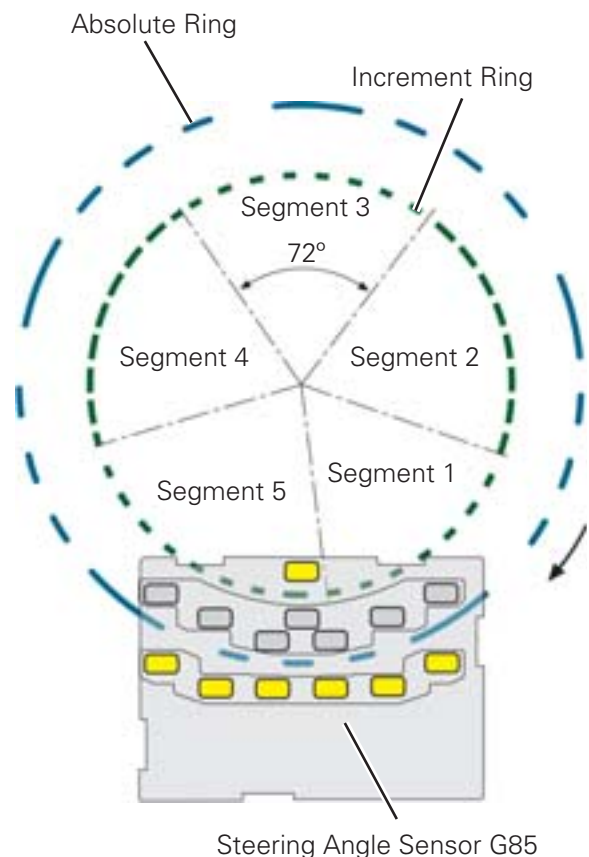
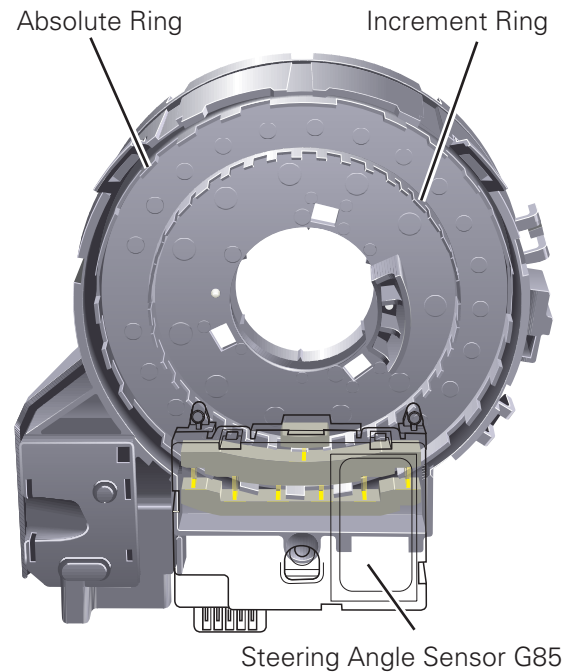
The code plate consists of two rings, an outer absolute ring and an inner increment ring.

The increment ring is separated into five segments, each is 72° , and is read by a photoelectric beam pair. Within each segment the ring is split. The gap of the split is equal within the segments but different between the segments. This provides the code for the segments.

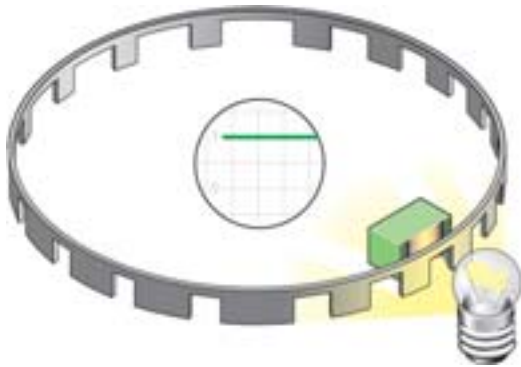
The absolute ring determines the angle. It is read by six photoelectric beam pairs.

Steering Angle Sensor G85 can detect a steering angle of up to 1044° . It accumulates the degrees after each turn of the steering wheel. In this way, it can detect that a full steering circle is complete when the 360° mark is exceeded.

The design of the steering gear allows 2.76 turns of the steering wheel.

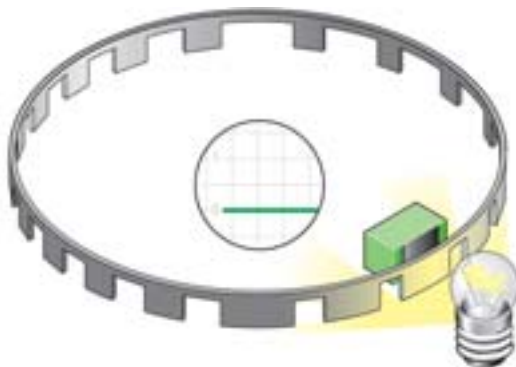


Steering Electrics

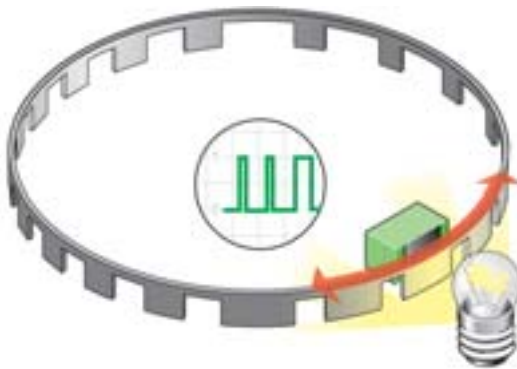


Angle measurement is by means of the photoelectric beam principle.

If, for purposes of simplification, the increment ring is used as an example, the light source is on one side of the segment ring and the optical sensor is on the other.



When light shines through a gap onto a sensor, signal voltage is generated. When the light source is covered, voltage is interrupted.

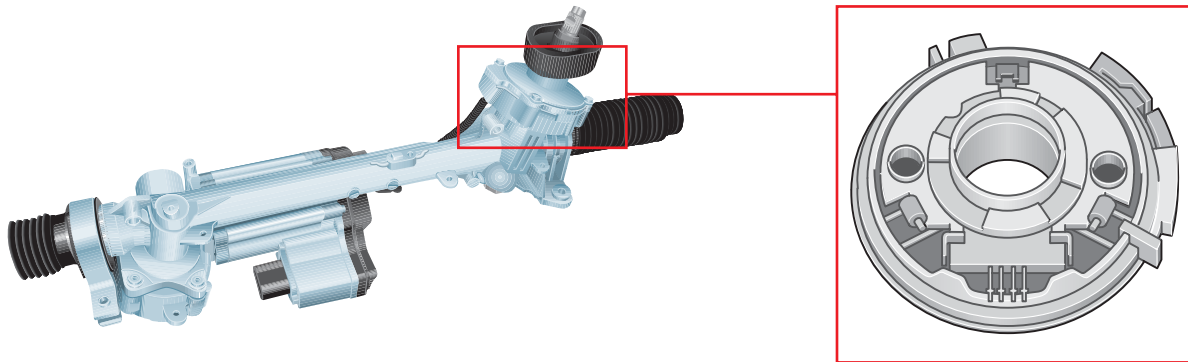


If the increment ring is moved, a sequence of signal voltages is given.

This is precisely how the sequence of signal voltages occurs on each photoelectric beam pair of the absolute ring. All signal voltage sequences are processed by the Steering Column Electronic Systems Control Module J527.

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

Steering Torque Sensor G269



The steering force is calculated directly at the steering pinion with help from the Steering Torque Sensor G269. The sensor works on the principle of magnetic resistance. It is a twin (redundant) sensor, which assures a high level of safety.

The steering column and steering gear are joined together at Steering Torque Sensor G269 via a torsion bar. The connecting piece at the steering column features a magnetic rotor, which turns about 24 areas of different magnetic polarity. For current evaluation, two terminals are used.

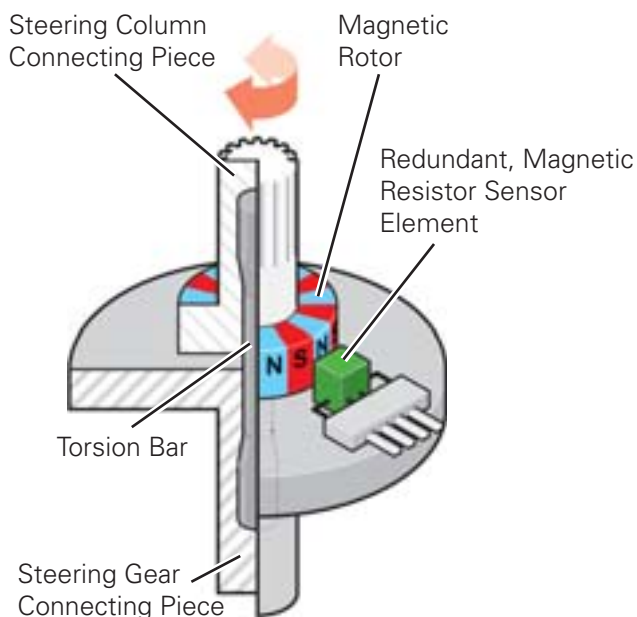
The counterpart is a magnetic resistor sensor element, which is attached to the steering gear connecting piece.

If the steering wheel is turned, both connecting pieces move against each other, depending on the amount of force that is applied. The magnetic rotor also moves against the sensor element during this period, which means that the steering force can be measured and sent to Power Steering Control Module J500 as a signal.

Effects of Failure

The Steering Torque Sensor G269 is integrated into the steering gear assembly and cannot be replaced separately.

If a fault is detected, the power steering assistance is shut down. This shut down is a soft and gradual process, rather than sudden. To achieve a soft and gradual shutdown, a substitute steering force signal is calculated in Power Steering Control Module J500 using the steering and rotor angle of Electro-mechanical Power Steering Motor V187. Faults are indicated by the Electro-mechanical Power Steering Indicator Lamp K161.



Rotor Speed Sender

The rotor speed sender is integral to Electro-mechanical Power Steering Motor V187, and cannot be replaced separately.

Signal Application

The rotor speed sender operates on the principle of magnetic resistance and is similar in design to the Steering Torque Sensor G269. It registers the rotor speed of the Electro-mechanical Power Steering Motor V187. This speed signal is necessary for precise motor actuation.

Effects of Failure

In the event of failure of the sensor, the steering angle speed is used as a substitute figure. To avoid a sudden loss, power steering assistance is shut down gradually. Faults are indicated by Electro-mechanical Power Steering Indicator Lamp K161 lighting up red.

Road Speed

The signal for the road speed is supplied by ABS Control Module J104.

Effects of Failure

In the event of failure of the road speed signal, an emergency running program is started. The driver has full power steering assistance but there is no servotronic variable assistance function. The fault is shown by Electro-mechanical Power Steering Indicator Lamp K161 lighting up yellow.

Engine Speed (RPM) Sensor G28

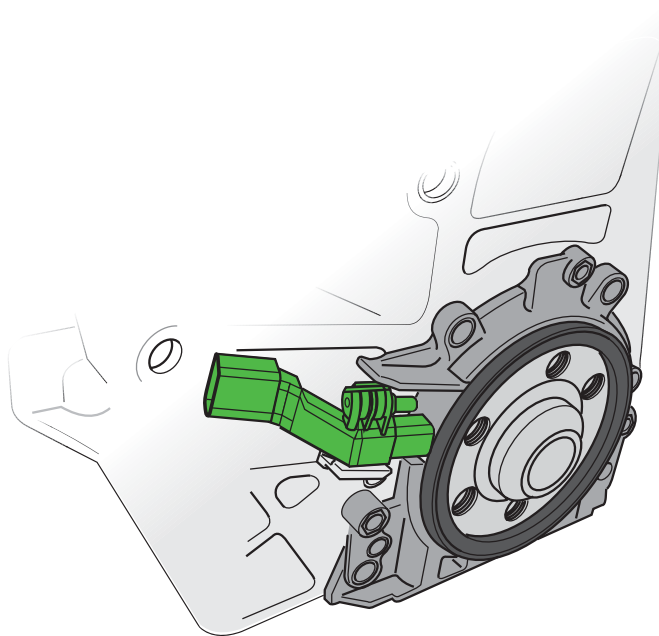
The Engine Speed (RPM) Sensor G28 is a Hall sender. It is attached inside the crankshaft sealing flange housing.

Signal Application

The Engine Speed (RPM) Sensor G28 signal provides the speed of the engine and the exact position of the crankshaft to the engine control module.

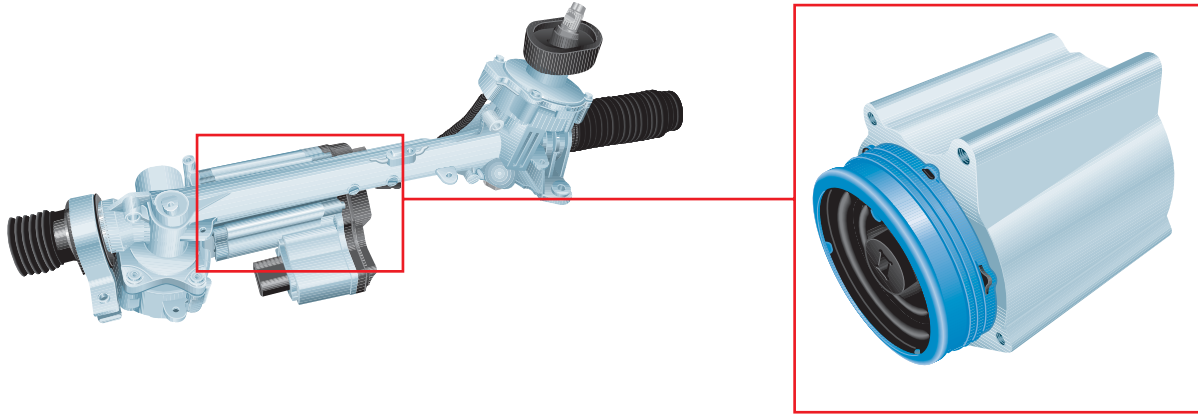
Effects of Failure

In the event of Engine Speed (RPM) Sensor G28 failure, the steering is actuated via terminal 15. The fault is not shown by Electro-mechanical Power Steering Indicator Lamp K161.



Steering Electrics

Electro-mechanical Power Steering Motor V187



Electro-mechanical Power Steering Motor V187 is a brushless asynchronous motor. It develops a maximum torque of 3.02 lbs-ft (4.1 Nm) to assist the steering.

Asynchronous motors do not feature a permanent magnetic field or an electrical exciter. Asynchronous motors get their name from the difference between the frequency of the voltage applied and the rotational frequency of the motor. Both frequencies are different, hence the term asynchronous.

Asynchronous motors are simple in construction (without brushes) and have a high level of operational efficiency.

They feature a short response time and are suitable for quick steering wheel movements.

Electro-mechanical Power Steering Motor V187 is installed in an aluminum housing. It engages in the steering rack via a worm gear and drive pinion and transmits the force required for steering assistance.

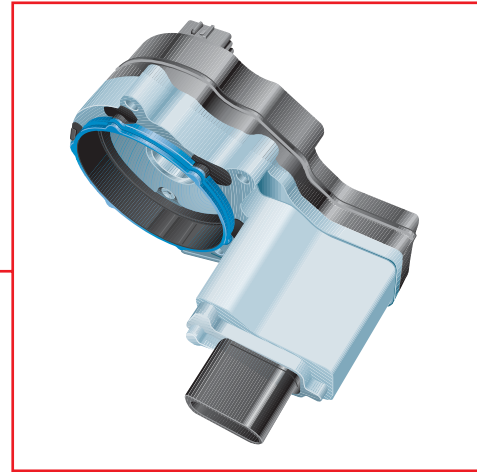
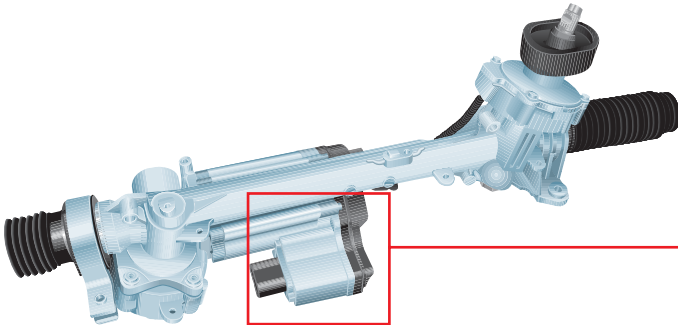
A magnet on the control end of the shaft is used by Power Steering Control Module J500 to detect the rotor speed. The signal is used to determine the steering speed.

Effects of Failure

An advantage of the asynchronous motor is that the motor can be moved by the steering gear even when no voltage is available.

This means that, in the event of failure of Electro-mechanical Power Steering Motor V187 and loss of power steering assistance, the steering can still be operated by applying a slightly greater amount of force. Even in the event of a short circuit, Electro-mechanical Power Steering Motor V187 will not freeze. Faults are indicated by Electro-mechanical Power Steering Indicator Lamp K161 lighting up red.

Power Steering Control Module J500



The Power Steering Control Module J500 is attached directly to Electro-mechanical Power Steering Motor V187, which means that there is no need for complex routing of wiring to the components of the power steering servo.

Based on the input signals, such as:

- the steering angle signal from Steering Angle Sensor G85
- the engine speed from Engine Speed (RPM) Sensor G28
- the steering force
- the rotor speed
- the road speed signal
- the signal that identifies the ignition key as being correct from Power Steering Control Module J500 with display in Instrument Cluster Control Module J285

Power Steering Control Module J500 calculates the correct level of force required to assist the steering. The strength of the excitor current is calculated and Electro-mechanical Power Steering Motor V187 is actuated.

Effects of Failure

A temperature sensor is integrated into Power Steering Control Module J500. This sensor is used to measure the temperature of the steering system. If the temperature rises above 212° F (100° C), power steering assistance is reduced gradually.

If the power steering capability is below 60%, the Electro-mechanical Power Steering Indicator Lamp K161 will light up yellow and an entry is made in the fault memory.



If the steering assembly needs to be replaced, use applicable repair information and the scan tool to restore the correct map for the vehicle.

Steering Electrics

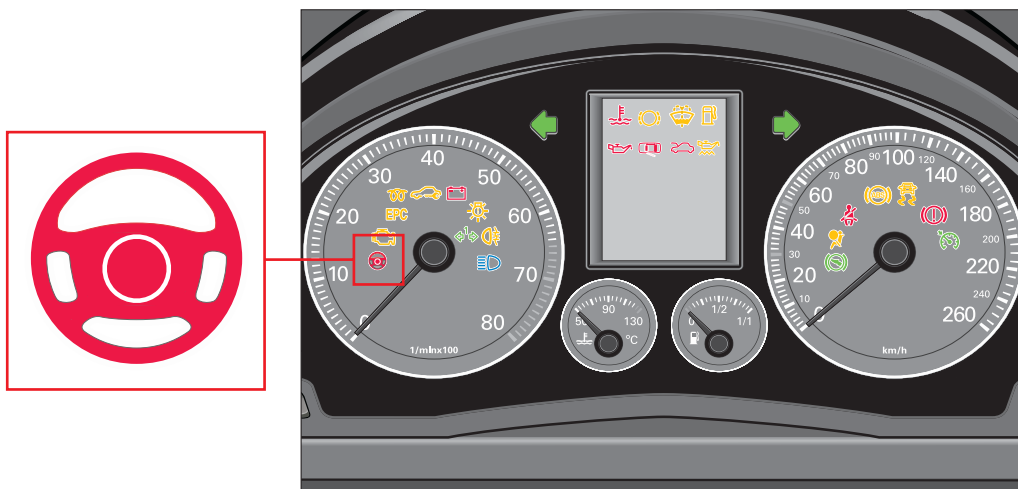
Electro-mechanical Power Steering Indicator Lamp K161

Electro-mechanical Power Steering Indicator Lamp K161 can be found in the display screen of the instrument cluster. It serves as a means of displaying malfunctions or disturbances in the electro-mechanical power steering system.

Electro-mechanical Power Steering Indicator Lamp K161 lights up in two colors if functional faults are detected. If it lights up yellow, the warning is of a lower priority. If it lights up red, the vehicle should be serviced immediately. If Electro-mechanical Power Steering Indicator Lamp K161 lights up red, it will be accompanied at the same time by an acoustic warning signal (three repetitions).

When the ignition is switched on, Electro-mechanical Power Steering Indicator Lamp K161 will light up red as part of the self-test procedure carried out by the electro-mechanical power steering system.

Once Power Steering Control Module J500 receives a signal, indicating that all systems are working correctly, Electro-mechanical Power Steering Indicator Lamp K161 will go out. This self-test lasts for approximately two seconds. When the engine is started, Electro-mechanical Power Steering Indicator Lamp K161 will go out immediately.



Special Features

Towing

Power steering assistance is available while the vehicle is being towed under the following conditions:

- speed greater than 5 mph (7 km/h) and
- ignition switch on

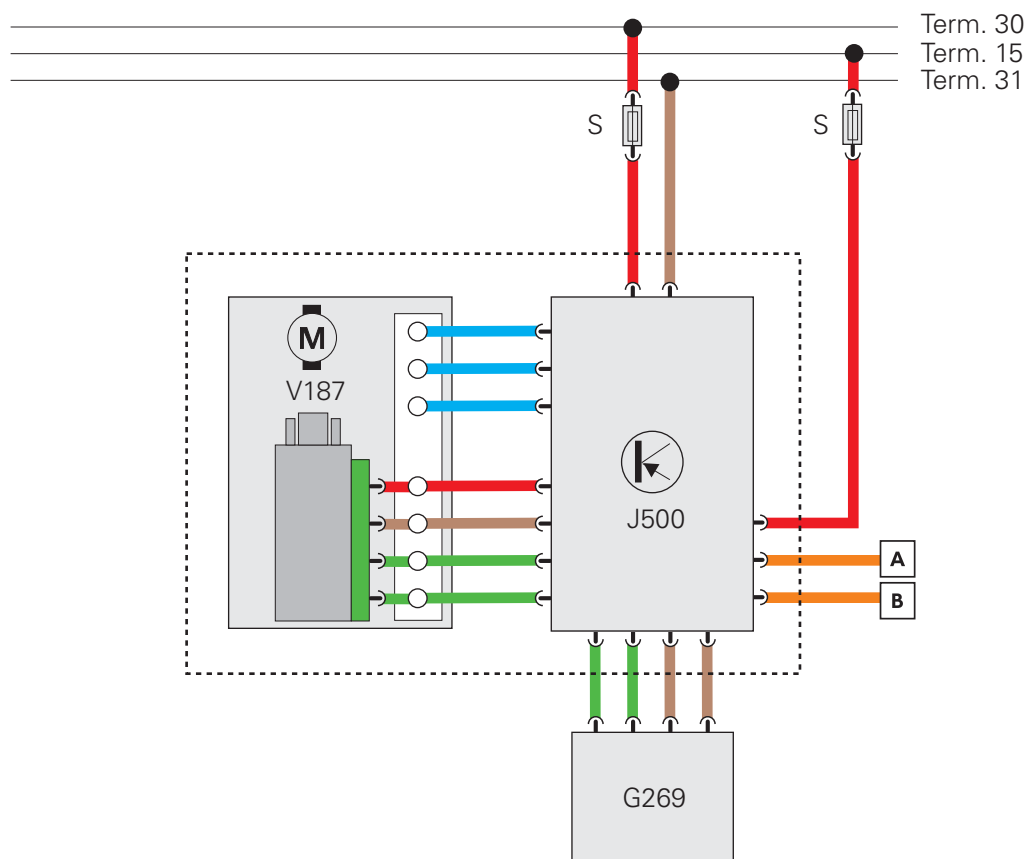
Discharged Batteries

The steering system can detect and react to low voltage situations. If battery voltage drops below 9 volts, power steering assistance will be reduced until it shuts down completely and Electro-mechanical Power Steering Indicator Lamp K161 will light up red.

In the case of brief voltage drops below 9 volts, Electro-mechanical Power Steering Indicator Lamp K161 will light up yellow.

Functional Diagram

Functional Diagram



A	CAN Low
B	CAN High
G269	Steering Torque Sensor
J500	Power Steering Control Module
S	Fuse
V187	Electro-mechanical Power Steering Motor

Color Codes/Key

Green	= Input Signal
Blue	= Output Signal
Red	= Positive
Brown	= Ground
Orange	= CAN Data Bus

Diagnosis

The system components of the electro-mechanical power steering system are capable of self-diagnosis.

Adaptation of Steering End Stops

To avoid the hard mechanical end stops of the steering, limitation of the steering angle is carried out by the software. The software-based end stop, i.e. the damping motion, is activated at approximately 5° steering angle before the mechanical end stop.

The assisting force is reduced depending on the steering angle and steering force. Using the scan tool, the steering end stops can be deleted using the "basic setting" function.

End stop adaptation is carried out without the scan tool, while driving the vehicle.

Notes

Knowledge Assessment

An on-line Knowledge Assessment (exam) is available for this Self-Study Program.

The Knowledge Assessment may or may not be required for Certification.

You can find this Knowledge Assessment at:

www.vwwebsource.com

From the vwwebsource.com Homepage, do the following:

- Click on the Certification tab
- Type the course number in the Search box
- Click "Go!" and wait until the screen refreshes
- Click "Start" to begin the Assessment

For assistance, please call:

Certification Program Headquarters

1 - 877 - CU4 - CERT

(1 - 877 - 284 - 2378)

(8:00 a.m. to 8:00 p.m. EST)

Or, E-mail:

Comments@VWCertification.com

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