New steering systems for tomorrow’s mobility

Bosch Mobility Solutions

Servolecetric® electric power steering systems for passenger cars

Automated driving

Fail-operational

Connected mobility
Automated mobility
Powertrain systems and electrified mobility

Bosch – Your partner for steering systems
Automotive competence from a single source

Bosch – Invented for life
Servolectric®
Connected driving with power steering

INTELLIGENT STEERING ASSISTANCE
The Servolectric® electromechanical power steering system controls and assists vehicle steering with the aid of an intelligent and controlled electric motor. Based on the steering signal from the torque sensor, the electronic control unit calculates the optimal steering assistance and sends this information to the electric motor, which then provides the force needed.

PASSENGER CARS AND LIGHT COMMERCIAL VEHICLES
The Servolectric® meets the requirements of all passenger car classes and even light commercial vehicles with only three variants. Depending on the variant, the motor torque is transferred in various ways. On the paraxial variant the torque is transmitted to the servo gear system (toothed-belt drive and recirculating ball gear) via a toothed disc located on the motor shaft. On the Servolectric® steering column variant and the dual-pinion variant, the torque is transmitted to the helical gear by means of a coupling.

NETWORKED SYSTEMS
With electromechanical steering, the servo assistance can not only be calculated on the basis of the steering torque applied to the steering wheel, but also take into account many additional vehicle parameters. To this end, Robert Bosch Automotive Steering has developed an intelligent steering concept that incorporates both the electronic control unit and innovative software that links other vehicle systems and components.

AUTOMATED FUNCTIONS
By integrating the electronic control unit into the vehicle electrical system, Servolectric® becomes the key technology for automated driving. The base model of electric power steering provides the foundation for driver assistance functions. The advanced fail-operational steering variant has a redundant system layout and in this way allows highly automated driving. The fail-operational steering system makes its contribution to highly automated driving via networking with the vehicle's assistance systems.

Standard values of steering rack force and mechanical performance for all vehicle classes

<table>
<thead>
<tr>
<th>Performance (W)</th>
<th>200</th>
<th>400</th>
<th>600</th>
<th>800</th>
<th>1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steering rack force (kN)</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
</tr>
</tbody>
</table>

EPSc servo unit on the steering column  EPSdp servo unit on the second pinion  EPSapa paraxial servo unit
**Servolectric® – the facts**

**Fail-operational**

With a redundant system architecture, the new generation of Servolectric® permits highly automated driving with maximum security.

**90%**

Up to 20%

**90% of all traffic accidents can be attributed to human error. Innovative steering systems from Bosch make highly automated driving possible and thus make an important contribution to accident prevention and optimal traffic management.**

**Over 70 million**

Passenger cars with Servolectric® electric power steering are already on the road worldwide.

**System benefits**

- Driver automated driving and, in the future, highly automated driving with fail-safe performance
- System architecture protected against unauthorized access from outside
- Speed-dependent steering precision
- High efficiency and low system friction
- Improved steering feel and steering performance
- Various drive modes can be implemented in a vehicle
- Optimal usage of installation space for maximum flexibility
- Performance-optimized configuration through use of scalable electric motor and control unit

**Connected mobility**

The Servolectric® is linked to the vehicle control unit and is an essential component. This linking provides improved safety, comfort, and convenience thanks to the ability to implement innovative driver assistance systems such as Evans Steering Support, Traffic Jam Assist, and Parking Maneuver Assist.

**Automated mobility**

Integration of the electronic control unit into the vehicle electrical system paves the way to automated driving functions. In this way, electromechanical power steering becomes the key technology for implementing automated driving.

**Powertrain systems and electrified mobility**

The Servolectric® electromechanical power steering system is one of the key technologies for powertrain electrification. With its power-on-demand principle, it achieves significant reductions in fuel consumption and CO₂ emissions.

**Servolectric® achieves weight savings compared to conventional power steering systems (in the compact class) by reducing the components required.**

**System components**

- Steering angle sensor
- Electronic control unit
- Electric motor of the EPSapa

**Additional components**

- Ultrasonic sensors
- Battery
- Stereo video camera
- Radar
- Engine control unit
Servolectric® electric power steering system

Fail-operational

PRODUCT BENEFITS

- The Fail-operational variant allows highly automated driving
- Maximum safety thanks to redundant system design
- Functions and characteristics of standard steering are retained in the non-automated mode
- Servo assistance assured even in the event of a fault through redundant electronics
- Same packaging as standard electromechanical steering system with flexibility for installation
- Robust EPSapa servo gear system assures assisting torque over the entire service life of the EPS

EPSapa servo gear system
Housing
Steering spindle connection
Sensor unit
Steering pinion
Tie rod
Bellows
Control unit
Electric motor
90% of all traffic accidents can be attributed to human error. Automated driving can lower the number of accidents.

**TASK**
The Servolectric® electric power steering system controls and assists the steering of vehicles by means of an electronically controlled electric motor. Through its electronic interface, the Fail-operational version of the Servolectric® functions as enabler for highly automated driving as defined by SAE level 4.

**FUNCTION**
The Fail-operational design of the Servolectric® system is based on paraxial electromechanical steering. This means that it has both its hardware and software functionalities. The Fail-operational steering system makes its contribution to highly automated driving via networking with the vehicle’s assistance systems. Thanks to its redundant system design, the EPS Fail-operational makes highly automated driving possible with maximum safety. In the unlikely event of a fault in the electronics, a second, completely independent electronic circuit continues to provide steering functionality. At least 50 percent of steering assistance is retained, guaranteeing safe stopping of the vehicle. This is true for both the manually controlled as well as automated driving modes.

The Servolectric® system is also ideal for SUVs and light commercial vehicles up to this steering rack force. Fuel savings on highways through synchronized traffic flow.

Structure of a Fail-operational steering system.
Servolectric® electric power steering system

Paraxial servo unit

**PRODUCT BENEFITS**
- Ideal electric power steering system for luxury-class vehicles, sports cars, and light commercial vehicles
- Excellent steering feel
- Interface for assistance functions to increase safety and comfort
- Allows semi-automated driving and, in the future, highly-automated driving with fail-safe performance
- Cyber security: system architecture protected against unauthorized access from outside
- Performance-optimized configuration through use of scalable electric motor and control unit
- Ideal packaging

![Diagram of Servolectric® electric power steering system with numbered parts](image)

1. EPSapa servo gear system
2. Housing
3. Steering spindle connection
4. Sensor unit
5. Steering pinion
6. Tie rod
7. Bellows
8. Control unit
9. Electric motor
Servolectric® electric power steering system
Paraxial servo unit

90%

of all traffic accidents can be attributed to human error. Automated driving can lower the number of accidents.

TASK
The Servolectric® electric power steering system controls and assists the vehicle steering with the aid of an electronically controlled electric motor. Servolectric® with the paraxial servo unit provides the ideal electric power steering solution for vehicles requiring very high steering effort – from the dynamic sports car, the upper mid-size and luxury class, to SUVs and light commercial vehicles. Thanks to the electronic interface, Servolectric® can be incorporated into the assistance functions of the vehicle. This already allows semi-automated driving today and even highly-automated driving in the future.

FUNCTION
To transform the rotational movement of the steering wheel into a linear movement of the steering rack, the Servolectric® variant with paraxial servo unit uses a drive concept consisting of toothed-belt drive and recirculating ball gear. Both drive stages are highly efficient. The recirculating ball gear is a system in which the ball chain is returned through a channel integrated in the ball recirculating nut. The recirculating ball gear generates minimal noise during operation. The slip-free toothed belt is also extremely quiet and able to transmit torque safely. Due to the combination of recirculating ball gear and toothed-belt drive, Servolectric® with paraxial drive is ideally suited for varying customer requirements. The flexible positioning options of the powerpack enable the best-possible use of the installation space available in the vehicle. The software developed by Bosch allows the electric power steering system to be programmed to the customer’s own requirements. In this way, a steering system with the same hardware components can be adapted individually to a given vehicle class.

VARIANTS
Servolectric® in the paraxial version is available in the variant Outbound, Inbound, and Inbound UP. The position of the powerpack is the distinguishing feature.

* compared with hydraulic steering, urban traffic only, passenger car with two-liter gasoline engine, average fuel consumption of 7.7 l/100 km

Fuel consumption and CO₂ emissions*

-10%

The Servolectric® system is also ideal for SUVs and light commercial vehicles up to this steering rack force.

18 kN

1
2
3
4
5
6
7

1. Steering rack
2. Ball return channel
3. Ball chain
4. Toothed disc
5. Ball recirculating nut
6. Toothed belt

*
Servolectric® electric power steering system

Servo unit on a second pinion

- Ideal steering solution for mid-size vehicles
- Interface for assistance functions to increase safety and comfort
- Permits semi-automated and, in the future, highly automated driving with full fail-safe performance
- Cyber security: System architecture protected against unauthorized access from outside
- Permits higher steering forces with optimized installation space
- Performance-optimized configuration through use of scalable components
- Guaranteed optimal steering feel

1. Drive pinion (second pinion)
2. Housing
3. Steering spindle connection
4. Torque sensor
5. Tie rod
6. Steering pinion
7. Thrust piece
8. Sensor cable
9. Electronic control unit
10. Electric motor
11. Helical gear
12. Bellows
90 %

of all traffic accident can be attributed to human error. Automated driving can lower the number of accidents.

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**TASK**

The Servolectric® electric power steering system controls and assists the vehicle steering with the aid of an electronically controlled electric motor. Servolectric® with the servo unit on a second pinion provides the optimal electric power steering system for mid-size vehicles. Thanks to the electronic interface, Servolectric® can be incorporated into the assistance functions of the vehicle. This already allows semi-automated driving today and even fully automated driving in the future.

**FUNCTION**

The servo unit is mounted on the second pinion, allowing physical separation of the sensor- and drive unit. The drive pinion ratio’s independence from the steering ratio paves the way for performance-optimized configuration. In this way, system performance is increased by 10 to 15 percent. Moreover, outstanding crash safety is guaranteed thanks to optimum use of the available installation space. By allowing the servo unit to rotate 360 degrees about the axes of the rack and the drive pinion through use of a suitably designed worm gear, the position of the servo unit can be defined to fit the particular application. The function of the sturdy worm gear is to convert the torque provided by the electric motor into assistance torque and to transmit that torque to the steering rack. At the same time, the performance and comfort requirements are exacting. To meet these requirements, the teeth of the worm and helical gear must remain in mesh without backlash throughout the steering gear’s entire service life. To this end, a specially developed spring damper element is used, providing optimum spring load on the worm in any driving situation. An innovative fixed bearing ensures that the worm can move as necessary. In unusual driving situations and in case of abuse, the helical gear is subjected to extreme loads. To prevent the gearing from being damaged in those rare cases, an overload safety device that limits the transmitted torque is provided between the helical gear and drive pinion. The software developed by Bosch allows the electric power steering system to be programmed to the customer’s own requirements. In this way, a steering system with the same hardware components can be adapted for different types of applications.

**VARIANTS**

Modular servo units for different power requirements are available for optimal adaptation of the electric power steering system to any given vehicle. The gear ratio of the rack and pinion steering can be either fixed or variable.
Servolectric® electric power steering system

Servo unit on the steering column

PRODUCT BENEFITS

- Ideal steering for vehicles up to the lower mid-size class
- Steering column and servo unit are immediately ready to install at vehicle production line
- Scalable to customer requirements
- Excellent driving feel
- New powerpack for maximum reliability
- Packaging: New generation with more compact powerpack, powerpack can rotate 360°
- MSG available with variable or fixed gear ratio

1. Interface steering wheel
2. Steering column with sensor unit
3. Adjusting lever
4. Servo gear
5. Power pack (ECU & motor)
6. Intermediate steering shaft
7. Steering spindle connection
8. Mechanical steering gear (MSG)
9. Interface wheel suspension
90% of all traffic accidents can be attributed to human error. Automated driving can lower the number of accidents.

**TASK**
The Servolectric® electric power steering system controls and assists the vehicle steering with the aid of an electronically controlled electric motor. The Servolectric® with servo unit on the steering column was developed by Bosch specifically for vehicles with low to moderate steering forces. As a result, it is particularly well-suited for use in compact and mid-size vehicles.

**FUNCTION**
The servo unit, together with its electronics, is integrated into the steering column. It connects to the mechanical steering gear via the intermediate steering shaft and his universal joints. Sensors and torsion bar are located next to the servo gear. The torque generated by the electric motor is converted into an assisting torque by the worm and worm wheel and transmitted to the steering shaft. The mechanical steering gear provides a ideal platform for this steering variant. High stiffness, good efficiency lightweight construction and low space requirement are the major benefits of this time-tested component, which has been built in the millions. The gear ratio of the Mechanical steering gear (MSG) can be fixed or variable. Software developed by Bosch makes it possible to program the electric steering to individual customer needs. In this way, a steering system with the same hardware components can be adapted for different applications and needs.

**VARIANTS**
Modular servo units for different torque requirements are available for optimal adaptation of the electric steering to any given vehicle. The gear ratio of the mechanical steering gear can be either fixed or variable.

**Fuel consumption and CO₂ emissions**

-10%

1000kg

**Servolectric® with the servo unit on the steering column is configured for up to this steering axle load, making it suitable for compact and mid-size vehicles.**
Servolectric® electric power steering system

Steering motors

PRODUCT BENEFITS
- Highly precise steering assistance
- Highly efficient electric motor thanks to state-of-the-art materials
- Extremely compact size
- Optimized noise level and torque ripple of the electric motor
- Optimal adaptation to customer requirements thanks to incremental output ratings and modular design of the powerpack
- Suitable for use at high speeds
- Extended temperature range

1. Control unit
2. Housing
3. Drive shaft
**2–8 Nm**

The available torque covers the requirements of all passenger cars and light commercial vehicles.

**400–800 W**

Power output available depending on the vehicle class for the individual variants of the steering motors.

**TASK**

Electronic control and steering assistance that uses Servolectric® only requires an easy-to-use medium: electric current. The electric motor provides the universally available, reliable, and economical energy supply. The newly developed generation of brushless electric motors provides the assistance calculated by the Servolectric® electronic control unit with high precision and in accordance with the particular driving conditions.

**FUNCTION**

Depending on the variant, the motor torque is transferred in various ways. On the paraxial variant the torque is transmitted to the servo gear system (toothed-belt drive and recirculating ball gear) via a toothed disc located on the motor shaft. On the Servolectric® steering column variant and the dual-pinion variant, the torque is transmitted to the helical gear by means of a coupling.

**VARIANTS**

The same motor and stator components are used for all Servolectric® steering variants. Various motor designs with ratings of 2 Nm to 8 Nm can be produced by modifying the interfaces and housings.

1. Drive shaft
2. Stator
3. Rotor
4. Integrated control unit
5. Signal input
Servolectric® electric power steering system

Electronic control unit

PRODUCT BENEFITS
- Intelligent and fast calculation of steering assistance and corrections within milliseconds
- For innovative assistance functions and automated driving
- Advanced driver assistance
- Incorporation into vehicle electrical system via CAN bus, CAN FD or FlexRay™
- Fully integrated and hermetically sealed unit

1. Plug-in contacts
2. Control electronics with heat sink
**32-bit**

Microprocessor flash memory

**TASK**
The electronic control unit (ECU) is the intelligent heart of the Servolectric® electric power steering system. Based on the steering signal from the torque sensor, the ECU calculates the optimal assistance and sends this information to the electric motor. In addition, the ECU processes various vehicle parameters and calculates the necessary steering corrections in milliseconds.

**FUNCTION**
The ECU links the electric steering to the electrical system of the vehicle and to other vehicle components. In this way, the electric power steering has access to parameters such as speed, steering angle, wheel revolutions and yaw rate. On the basis of these, the ECU can continuously calculate the longitudinal and lateral guidance of the vehicle as well as the optimal steering assistance, and intervene correctly with the aid of driver assistance systems in emergency situations. The vehicle manufacturer decides which driver assistance systems are used and in which way. For instance, it is possible to influence the lateral guidance of the vehicle in dangerous situations to prevent accidents or lessen the consequences. In future applications for highly automated driving, redundant electronics are provided in order to ensure control of the servo assist function in the event of a fault.

**TECHNICAL CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor</td>
<td>32-bit microprocessor</td>
</tr>
<tr>
<td>Memory technology</td>
<td>Flash</td>
</tr>
<tr>
<td>Networking options</td>
<td>CAN bus, CAN FD, FlexRay™</td>
</tr>
<tr>
<td>Current</td>
<td>60 to 110 A</td>
</tr>
</tbody>
</table>

**New functions**

through networking with the vehicle electrical system

**Function of the control unit:**

1. Acquisition of the steering signal by the torque sensor and sending to the control unit
2. Acquisition of the vehicle’s speed over the communication bus and sending to the ECU
3. Calculation of the optimal assistance and motor actuation
Servolectric® electric power steering system

Torque sensor

PRODUCT BENEFITS
- Highly precise measurement of the steering torque for exacting safety requirements placed on electric steering systems
- Extremely robust digital interface to the electric power steering system’s ECU

1. Sensor module
2. Sensor plug
3. Index magnet (optional)
4. Index sensor (optional)
5. Steering pinion
6. Pole wheel
7. Input shaft
**0,015 Nm**

Together with the torque sensor, the ECU can calculate the steering angle on the basis of sensor data with this precision.

**−40 °C to +125 °C**

The torque sensor in the electric power steering system works absolutely reliably over this temperature range.

---

**TASK**

The torque sensor in the Servolectric® electric power steering system measures the torque the driver applies to the steering wheel. Based on this data, the electronic control unit calculates the steering assistance which the electric motor needs to apply.

**FUNCTION**

The sensor sits on the steering pinion. A pole wheel is fitted on the input shaft, which is connected to the steering pinion by means of the torsion bar. When the driver applies torque to the steering wheel, the torsion bar is rotated and, in turn, the magnet relative to the sensor. The sensor consists of magnetoresistive elements whose resistance changes as the field direction changes. The sensor’s measuring range covers +/-10 Nm. A mechanical angle limiter prevents the torsion bar from being overloaded when higher steering torques are applied.

**VARIANTS**

Optionally, an index magnet and an index sensor can be incorporated into the torque sensor. The index sensor delivers a signal to the ECU for each full turn of the steering wheel.

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**TECHNICAL CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring principle</td>
<td>Magnetoresistive effect</td>
</tr>
<tr>
<td>Interface</td>
<td>PAS – robust digital two-wire current interface</td>
</tr>
<tr>
<td>Signal transmission</td>
<td>With clock spring</td>
</tr>
<tr>
<td>Measuring range</td>
<td>+/-10 Nm</td>
</tr>
<tr>
<td>Temperature range</td>
<td>−40 °C to +125 °C</td>
</tr>
<tr>
<td>Accuracy</td>
<td>0.015 Nm at 2 Nm/°</td>
</tr>
<tr>
<td>Torsion bar stiffness</td>
<td>2.0 to 2.5 Nm/° at 25 °C</td>
</tr>
<tr>
<td>Calibration function</td>
<td>Data is stored in the sensor</td>
</tr>
<tr>
<td>Steering angle</td>
<td>Can be displayed as an option with index extension</td>
</tr>
</tbody>
</table>

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**TASK**

The torque sensor in the Servolectric® electric power steering system measures the torque the driver applies to the steering wheel. Based on this data, the electronic control unit calculates the steering assistance which the electric motor needs to apply.

**FUNCTION**

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**VARIANTS**

Optionally, an index magnet and an index sensor can be incorporated into the torque sensor. The index sensor delivers a signal to the ECU for each full turn of the steering wheel.
The Servolectric® electromechanical power steering system

Servolectric® steering column variant and the dual-pinion to the servo gear system (toothed-belt drive and recirculating tric motor, which then provides the force needed. the torque sensor, the electronic control unit calculates the opti-
avants. Depending on the variant, the motor torque is transferred a coupling.

Performance for all vehicle classes

<table>
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<th>Performance (W)</th>
<th>Steering rack force (kN)</th>
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<tbody>
<tr>
<td>150</td>
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</tr>
<tr>
<td>300</td>
<td>700</td>
</tr>
<tr>
<td>450</td>
<td>1,000</td>
</tr>
</tbody>
</table>

AUTOMATED FUNCTIONS

With electromechanical steering, the servo assistance can not

Steering has developed an intelligent steering concept that

incorporates both the electronic control unit and innovative

software that links other vehicle systems and components.

fail-operational steering system makes its contribution to highly automated driving. The base model of electric power steering systems. Among these are 15,000 staff employed in the development and production of steering systems, among them 1,500 specialists engaged in creating the perfect steering feel.

Worldwide presence Robert Bosch Automotive Steering has a total of 25 locations in twelve countries. This means that we have a presence worldwide in all the core automobile markets – in Europe and Asia, as well as in North and South America. Worldwide there are 15,000 staff employed in the development and production of steering systems, among them 1,500 specialists engaged in creating the perfect steering feel.

INTELLIGENT STEERING ASSISTANCE

Steering rack force (kN)

performance for all vehicle classes

Standard values of steering rack force and mechanical

the proven quality of our steering systems, components and ser-

they have proven their quality and robustness millions of times
dering systems, power steering pumps and components for commer-

cial vehicles. Robert Bosch Automotive Steering is an experienced and capable partner to the automotive industry. Our customers appreciate us, because we are trustworthy, reliable and experts in our field, and because we can support them over the entire life cycle of the vehicle - from the joint development project to the worldwide supply of spare parts.

STAYING ON TRACK FOR THE LONG HAUL AND PULLING TOGETHER

Reliable partnership As the world’s leading manufacturer of steer-

ing systems, power steering pumps and components for commer-

cial vehicles, Robert Bosch Automotive Steering is an experienced and capable partner to the automotive industry. Our customers appreciate us, because we are trustworthy, reliable and experts in our field, and because we can support them over the entire life cycle of the vehicle - from the joint development project to the worldwide supply of spare parts.

 Hưng qua vày and pulling together

25 LOCATIONS ON FOUR CONTINENTS

Release on track for the long haul and pulling together

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