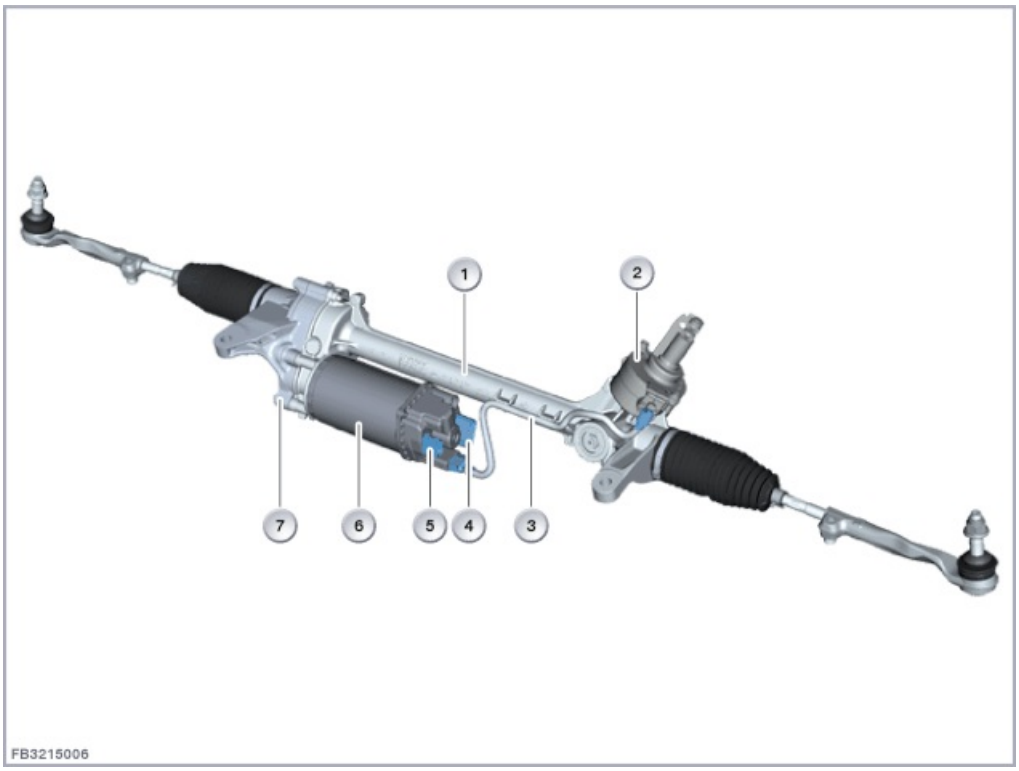
Electronic power steering (EPS) with Integral Active Steering (HSR)

The electromechanical power steering (EPS) differs from conventional hydraulic steering in that it has steering servo. The EPS supports the driver using an electrical servomotor instead of a hydraulic electric motor. The servomotor is only active when the vehicle is being steered. This means that the servomotor consumes no power during straight-ahead driving.
Electromechanical power steering offers the following advantages:

- lower steering forces on parking
- integrated, driving-speed-dependent steering servo (Servotronic)
- lower bumpiness when cornering as well as lower steering wheel vibrations
- active steering wheel return
- Fuel saving of up to 0.3 l/100 km and therefore lower CO_2 emissions
- no hydraulic fluid necessary

The electromechanical power steering is available in the following equipment specifications:

1. electromechanical power steering (EPS): Voltage supply with **12 volts**
2. **Depending on the series:** Electromechanical power steering (EPS) with Integral Active Steering (HSR) or a particular combination of engine and transmission (weight on the front axle): Voltage supply with **24 V** via auxiliary battery, cut-off relay and charging controller for auxiliary battery with DC/DC converter



Index	Explanation	Index	Explanation
1	Steering box	2	Steering-torque sensor
3	Electrical line between steering-torque sensor and EPS control unit (not replaceable)	4	2-pin plug connection

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5	6-pin plug connection	6	EPS unit
7	spindle drive		

Brief component description

The following components are described for the electromechanical power steering:

EPS unit

The EPS unit consists of the following components:

- EPS control unit
- Servomotor with integrated rotor position sensor

The EPS control unit is part of the electromechanical power steering. The EPS control unit is connected to the vehicle electrical system with 2 plug connections. The steering-torque sensor is connected via another plug connection to the EPS control unit.
A number of characteristic curves for power assistance, active steering wheel return as well as damping characteristics are stored in the EPS control unit. The values calculated from the input variables added to each characteristic curve result in the necessary steering servo.
Depending on equipment specification, the EPS unit may also be supplied via terminal 30. The front right power distribution box or the rear power distribution box supplies the EPS control unit with terminal 15 N.

Servomotor with rotor position sensor

The servomotor is a non-collector, synchronous direct current motor (permanent magnet). The servomotor drives the reduction gear. This transfers the power output of the servomotor to the rack.
There are 2 rotor position sensors (redundancy) on the printed circuit board of the control unit. Both sensors use the principle of the Hall effect (Hall sensor with magnet wheel). The magnet wheel is attached to the motor shaft. Rotor position sensor 1 determines the position of the servomotor. The sensor delivers a sine-wave signal and a cosine-wave signal. The signals are used to determine the rotor position of the servomotor. This position is then used to calculate the non-linearised value of the steering angle. Rotor position sensor 2 is used for monitoring (plausibility check). Both sensors are supplied with voltage by the EPS control unit.

Reduction gear set

The reduction gear transfers the power output of the servomotor to the rack. The rotational ratio between servomotor and steering wheel is approx. 18.37:1 (13.37 with Integral Active Steering).
The reduction gear consists of a belt drive and a ball screw. The ball screw has a pitch of 9 mm per revolution (10 mm with Integral Active Steering). The servomotor drives the toothed belt. The belt drive has a reduction ratio of 2.85:1 (2.49:1 with Integral Active Steering). The toothed belt drives the ball screw. The ball screw has an internal ball return (5 rotations). The ball screw is noise-optimised.

Steering-torque sensor

The steering torque sensor digitally senses the steering torque applied by the driver. The working area is approx. 3 steering wheel turns from limit position to limit position.
The steering torque causes the torsion bar to twist. The torsion bar then transfers the steering torque to the pinion. The function of the steering-torque sensor is based on the magneto-resistive principle. This utilises the effect that arises in response to changes in the magnetic field and changes in resistance. Different voltage signals are generated by these magneto-resistive elements and these are then forwarded to the EPS control unit. The EPS control unit uses this information to calculate the assistance torque required.

Functional networking, Integral Active Steering (EPS and HSR)

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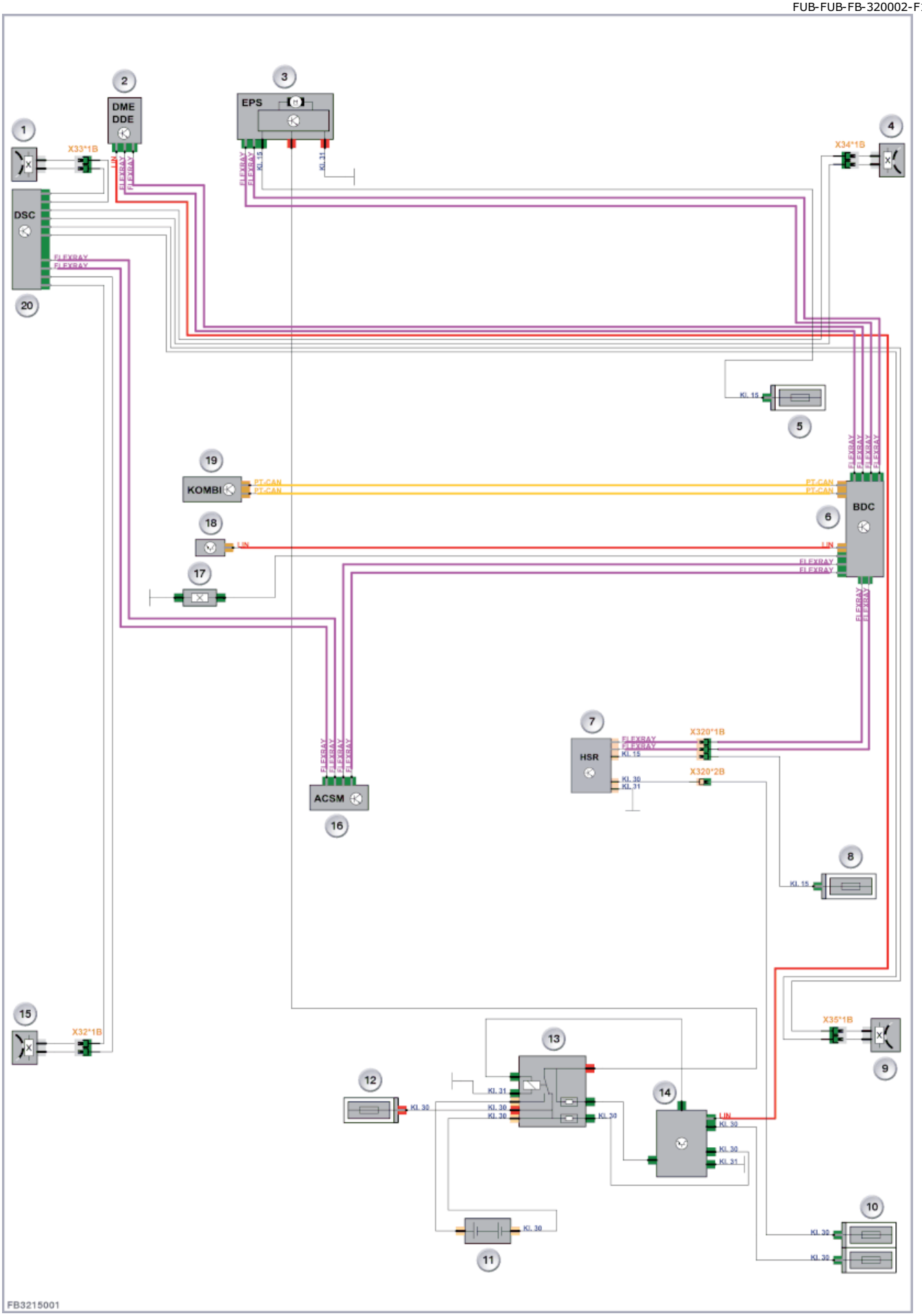

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Index	Explanation	Index	Explanation
1	Wheel speed sensor, front left	2	DME (Digital Engine Electronics) or DDE (Digital Diesel Electronics)
3	Electronic Power Steering (EPS)	4	Wheel speed sensor, front right
5	Front right power distribution box	6	Body Domain Controller (BDC)
7	Rear axle slip angle control (HSR)	8	Fuse box 3
9	Wheel speed sensor, rear right	10	Power distribution box, right rear
11	Auxiliary battery (battery 3)	12	Fuse box
13	Cut-off relay	14	Charger unit for auxiliary battery
15	Wheel speed sensor, rear left	16	Crash Safety Module (ACSM)
17	Brake light switch	18	Steering column switch cluster
19	Instrument cluster (KOMBI)	20	Dynamic stability control (DSC)

The following other control units communicate with the electromechanical power steering:

DSC: Dynamic Stability Control

The DSC control unit supplies the driving speed via the wheel speed sensors.

DME and DDE: Digital Motor Electronics or Digital Diesel Electronics

The engine control system delivers the signal "Engine running" on the FlexRay. For certain operating conditions (e.g. engine start), the engine speed is required as a signal.

KOMBI: Instrument cluster

In the event of failure of the electromechanical power steering (EPS), a yellow Check Control symbol appears in the LC display. Simultaneously, the fixed indicator light lights up in the instrument panel. The Check Control symbol has the following meaning: **Steering behaviour! Drive with care!**

Example figure

Index	Explanation	Index	Explanation
1	Instrument cluster	2	Indicator light and Check Control symbol

Possible causes for the Check Control message lighting up can be:

- Fault in the EPS control unit, in an integrated sensor or in the servomotor
- EPS overheat protection

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- Undervoltage or overvoltage
- Failure of external signals with influence on steering servo assistance
- Faulty or incomplete initialisation of the steering (e.g. learning end stops)

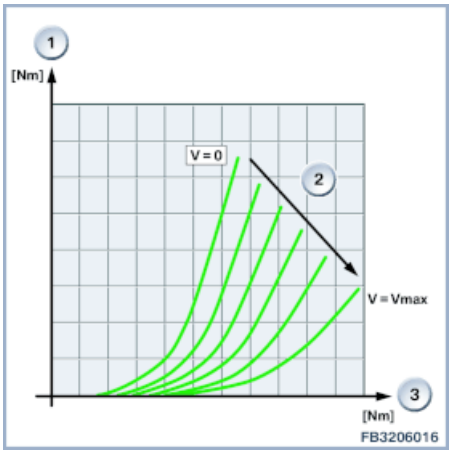
System functions

The following system functions are described for the electromechanical power steering (EPS):

- Steering assistance
- Active steering return
- Active road feedback
- Overvoltage detection and undervoltage detection
- Overheat protection
- Identification of overload current
- End stop as software function
- Park Assist

Steering assistance

Integrated in the system is the Servotronic, the electronic control of the speed-dependent steering servo assistance. The EPS control unit determines the required steering servo assistance from various input variables.



Index	Explanation
1	Steering servo torque
2	Driving speed
3	Steering torque applied by driver

Characteristic maps for the support and damping characteristics are stored in the control unit. The values calculated from the input parameters combine with the characteristic curve to produce the required level of steering servo assistance. The servomotor and reduction gear provide the steering servo assistance.
Important input variables for steering servo assistance are:

- Driving speed
- Steering torque on the driver side via steering torque sensor
- Current vehicle voltage
- Operating temperature

The EPS adapts the deviation of the signals from the rotor position sensor and steering angle sensor (e.g. curbed roadway with straight-ahead driving).

Active steering return

After cornering, the active steering return brings the steering back to the straight-ahead position as soon as the driver no longer applies steering torque. To achieve this, the EPS control unit requires the steering angle from the steering angle sensor. The active steering return ensures a harmonious return of the steering across the entire operating temperature. Active steering return from the end positions is particularly important at low temperatures. This increases operating convenience.
A gyrostabiliser is integrated in the active steering return.

Active road feedback

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Information on the road surface is e.g. changes in the friction coefficient or properties. The EPS provides this information by changing the steering torque.
The following variables are used to calculate the acceleration at the front axle:

- Driving speed
- Yaw rate
- Lateral acceleration

In turn, the EPS calculates a proportion of the steering torque for the active road feedback.

Overvoltage detection and undervoltage detection

EPS 12 V: In the case of overvoltage greater than 17 V, the steering servo assistance switches off.
EPS 24 V: In the case of overvoltage greater than 33 V, the steering servo assistance switches off.
The EPS control unit stores a fault. A Check Control symbol lights up in the instrument cluster. When the voltage returns to below 16 V (32 V), the steering servo assistance returns to the currently requested value. The Check Control symbol goes out when 100 % of the requested steering servo assistance is reached.
In the case of undervoltage less than 9.5 V, the motor output is reduced (linear) to 9 V. Below 9 Volts, steering servo assistance is no longer provided. The Check Control message is issued at 40 % of steering servo assistance (with fault entry). When the voltage returns to above 10 Volts, the steering servo assistance returns to the currently requested value. The Check Control symbol goes out when 100 % of the requested steering servo assistance is reached.
With the 12 V EPS with Integral Active Steering, engine performance is reduced 10% beforehand in a linear fashion.

Overheat protection

As overheat protection, the EPS reduces the nominal engine torque depending on the output stage temperature between 0 % and 100 %. Here, the EPS control unit carries out the reduction in the following steps:

- 100 % at 95 °C
- 60 % at 110 °C
- 0 % at 115 °C

Identification of overload current

The EPS detects overload current when the steering presses against the kerb. The following signals are included in the detection:

- Steering angle
- Steering angle speed
- Driving speed
- Steering torque applied by driver

End stop as software function

The EPS has an end stop on the left and right as a software function. This protects the mechanical end stops (buffers) against wear at an early stage. The software function uses the following signals to calculate the end stops:

- Steering angle
- Steering angle speed

Park Assist

The parking assist consists of the PMA control unit and 4 ultrasonic sensors which take charge of measuring out the parking space. The steering movements required for parking the car which are calculated by the control unit are then carried out by the electromechanical power steering system (EPS).

Notes for Service department

General notes

Caution! Learn end stops!!
After replacement of the steering, the limit positions of the steering box have to be relearned. Incorrectly learned end stops can lead to sudden elimination of the steering servo in the end stop.

The following preconditions must be met on learning the end stops:

1. Vehicle parked on a level surface.
2. Front wheels free for steering wheel movements.
3. Brake pedal not pressed and parking brake not engaged.
4. No fault code entry in the Dynamic Stability Control (DSC).
5. Indicator light and Check Control symbol light up in the instrument panel.

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6. Steering wheel in straight-ahead position.

On learning the end stops, the steering wheel must be fully turned slowly once to the left and once to the right. The steering speed must be below 1 steering wheel turn per second. In the end stops, slowly increase the steering force until the steering wheel no longer turns.
Then return steering wheel to its centre position and let go of the steering wheel.
After approx. 5 seconds, the indicator light and Check Control symbol in the instrument panel go out.

Diagnosis instructions

The following service function is available in the diagnosis system:

- EPS: Steering start-up

This service function is used to delete the values for the end stops (e.g. after incorrect learning). At the same time, the deviation to the steering angle is deleted.

Notes on encoding/programming

After replacement, the EPS control unit must be coded.

Switch-on and switch-off conditions

The steering servo assistance is activated under the following conditions:

- PWF status “Drive” (terminal 15N via FlexRay and voltage on the EPS control unit)
- Engine running or electrically operational (hybrid drive)

When the engine is at a standstill and the driving speed is 0, the steering servo assistance is disabled.

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