

Electric Power Steering System

Jaguar XE and F-PACE adopt the latest ZF Electric Power Steering technology. Unlike a conventional hydraulic or electro-hydraulic steering system, power assistance is delivered by an electric motor and not by pressurized oil. A torque sensor built into the rack is used to measure the steering effort of the driver and calculate the assistance needed, allowing a variable assistance level under differing conditions.

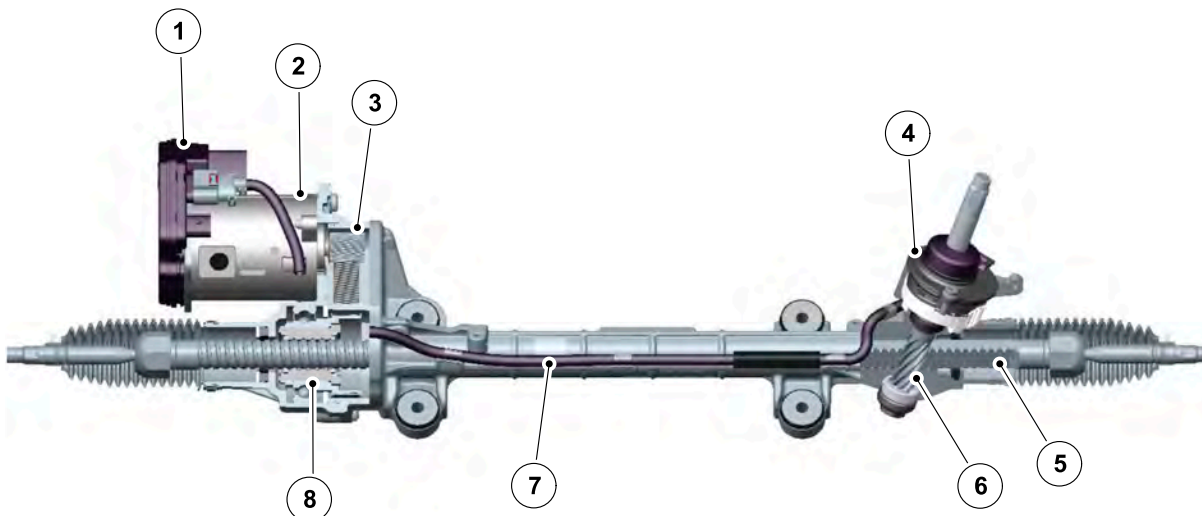
Advantages

Electric power steering provides assistance only when require, resulting in significantly reduced energy and fuel consumption for an overall 3% CO₂ emissions reduction on petrol engine vehicles.

The Power Steering Control Module (PSCM) enables the integration with functions such as Lane Departure Warning (LDW) and Park Assist. A pull/drift (camber) compensation feature helps avoid constant steering corrections, by reducing the effect of road camber variations. Soft lock stops provide a cushioned feeling to the driver, avoiding an abrupt feeling as the steering meets the lock stops. Active return improves the self-centering function of the steering. A parking torque control function provides consistently light and effortless steering when parking the vehicle.

The PSCM also adapts the steering feel according to the setting of Jaguar Drive Control (JDC). In Dynamic Mode, the steering map adjusts to give a sportier feel; in Winter Mode, on slippery surfaces, it will adapt to give more feel. The level of steering assist varies to provide more assistance when maneuvering at low speed, and more steering feel at high speed

Electric Power Steering System Components



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Item	Description	Item	Description
1	Power Steering Control Module (PSCM)	5	Rack
2	Electric Motor	6	Pinion
3	Belt Drive	7	Rack Housing
4	Torque Sensor	8	Recirculating Ball Nut/Screw

The steering gear is installed on the front subframe. The electric motor is attached to the steering gear and the Power Steering Control Module (PSCM) is located on the end of the electric motor.

A universal joint connects the steering column to the input shaft of the steering rack, directly turning the pinion shaft. A rubber seal is installed on the input shaft where it passes through the bulkhead and into the vehicles cabin.

Ball jointed tie-rods connect the steering rack to the front suspension steering knuckles. The steering rack is protected from water and dirt ingress by rubber boots at the ends of the rack, secured by band clamps. Heat protection comes in the form of heat shields attached directly to the steering rack housing.

A torque sensor connects the pinion shaft to the input shaft of the steering column. Mounted on the end of the steering rack is a reduction gear housing that contains a recirculating ball nut installed on a threaded section of the steering rack. A toothed belt transmits drive from the motor to the recirculating nut to provide the power assistance.

Electric Motor

The essential function of the electric motor is to generate the required torque calculated by the PSCM. The electric motor used is a brushless Direct Current (DC) motor. Although it is powered by direct current, the method of operation is based on that of an Alternating Current (AC) synchronous motor. The power electronics in the PSCM convert the power supply voltage (DC voltage) into phase voltages so as to produce a rotating field at the phase windings.



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This type of motor provides the following characteristics required for use in the power steering system:

- High efficiency
- High torque availability over a wide range of speeds
- Small external dimensions
- Low wear
- Long service life

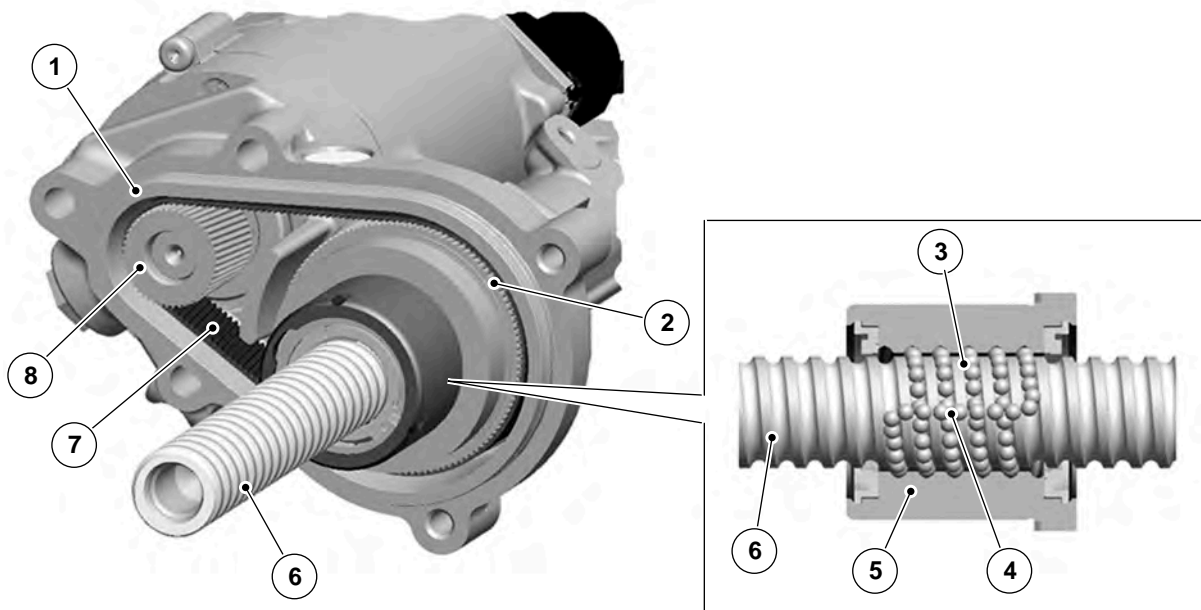
NOTE: Because the electric motor is integrated in to the PSCM, it cannot be tested or replaced separately.

The motor position sensor is integral to the PSCM and positioned adjacent to the electric motor shaft. Due to its location, the motor position sensor can directly signal the electric motor's rotor position to the PSCM. As the electric motor is directly connected to the steering rack by means of the reduction gearing assembly, the control module can determine the position of the road wheels and the steering angle from the rotor position. After first calibrating the straight-ahead position with the aid of the signal from the steering angle sensor, the motor position sensor signal is subsequently used for electric power steering functions.

Reduction Gear

The recirculating ball nut in the reduction gear housing is held in a bearing race, allowing the nut to rotate but preventing it from moving axially. As the electric motor rotates, the drive belt transfers drive to the ball nut drive gear, rotating the nut and driving the balls along the channels in the rack. This produces an axial force, moving the rack left or right dependent on motor direction.

A channel in the nut and mechanisms at either end of the bearing race allow for the balls to be recirculated from one side of the nut to the other.



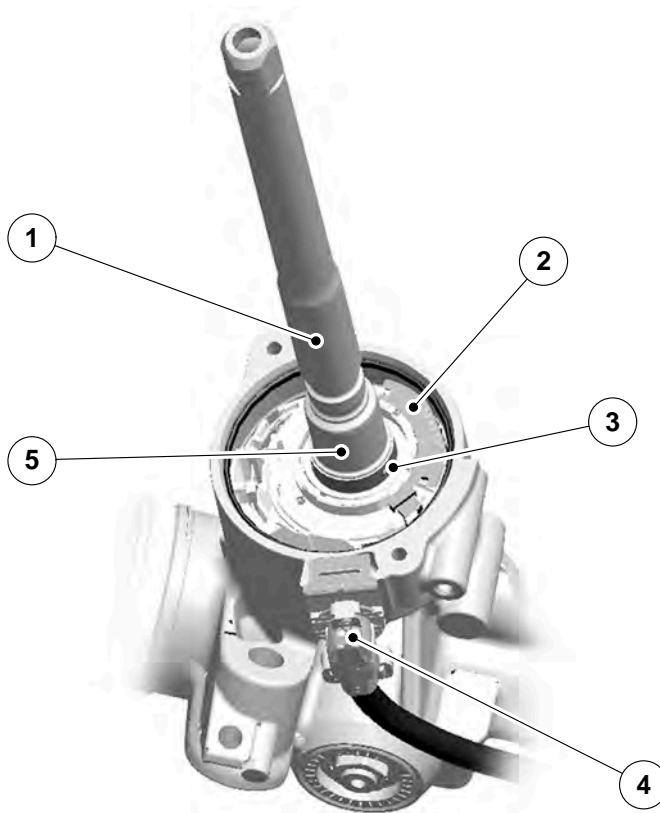
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Item	Description	Item	Description
1	Reduction Gear Housing	5	Ball nut
2	Ball nut drive gear	6	Steering rack ball channel
3	Ball train	7	Drive belt
4	Ball return channel	8	Motor drive gear

NOTE: Because the reduction gear is integrated in to the steering gear housing, it cannot be replaced separately.

Torque Sensor

The torque sensor is located between the input shaft from the steering column, and the pinion shaft inside the steering gear housing. Its purpose is to provide the PSCM with steering torque input from the driver to calculate the correct level of required power assistance.



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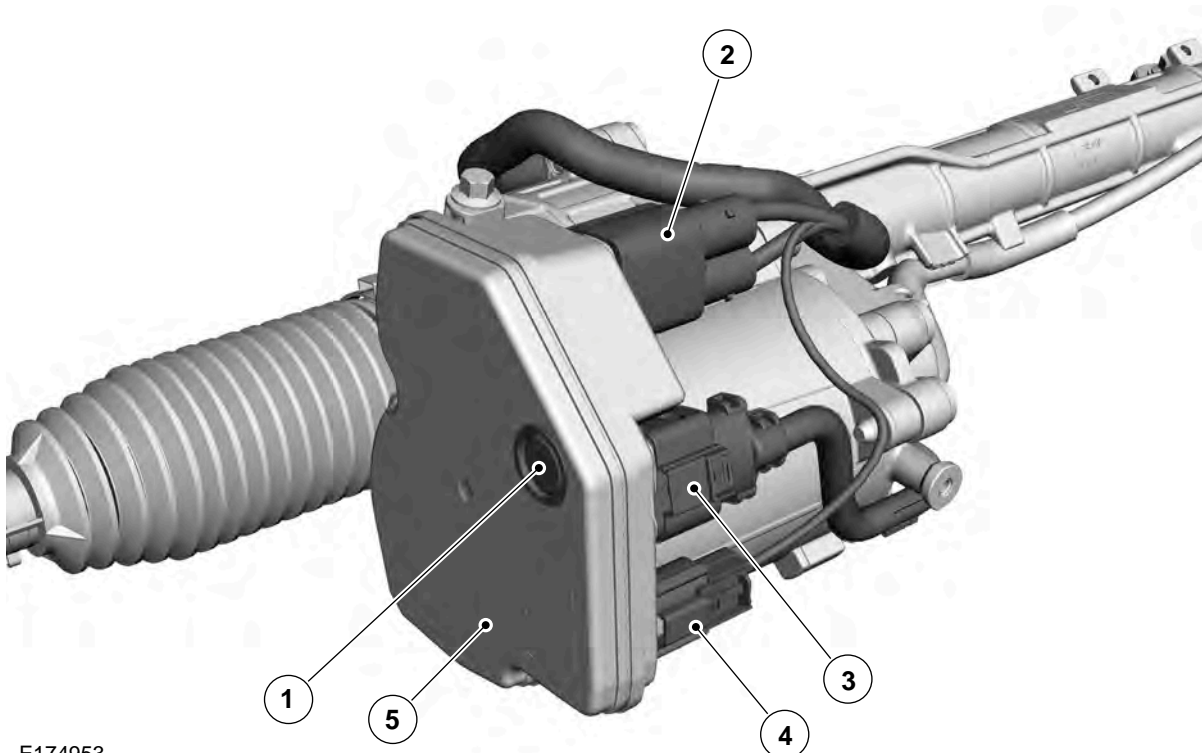
Item	Description	Item	Description
1	Torsion bar (not visible)	4	Sensor Connector
2	Sensor electronics	5	Input shaft
3	Magnet		

Torque is applied by the input shaft and transferred to the pinion shaft via a torsion bar, which twists when under load. A hall sensor calculates the level of deflection in the torsion bar by monitoring the angular position of the input shaft compared to the pinion shaft. This information is transmitted to the PSCM by way of a digital signal.

NOTE: Because the torque sensor is integrated into the steering gear, it cannot be tested or replaced separately.

Power Steering Control Module (PSCM)

The Power Steering Control Module (PSCM) is located on the end of the electric motor, under a sealed cover. A diaphragm in the cover, made from a waterproof breathable fabric, maintains the interior of the cover at ambient pressure, avoiding the need for an open vent. The PSCM contains the circuitry for electric power steering control and the power electronics for the electric motor.



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Item	Description	Item	Description
1	Diaphragm	4	Torque Sensor Connector
2	PSCM System Connector CAN/Ign/Live	5	PSCM Cover
3	Power supply Connector (+/-)		

Power assistance is only provided when the following conditions are met:

- A permanent live is present
- An ignition live is present from the BCM/GWM
- An 'Engine Running' message is present on the CAN bus

Supply voltage to the PSCM must be between 10.5V – 18V for 100% nominal power. Voltages outside these parameters may result in reduced or discontinued power assistance.

Power Steering System Functions

Active Damping

Due to the low ratio of the reduction gear by which the electric motor is connected to the steering rack, the inertia of the motor is geared up or amplified. This has a damping effect on the forces and movements transmitted from the road wheels to the steering wheel. The mechanical damping effects are supplemented by an electronic damping function of the power steering system. The system analyses the movements of the steering rack, using the signals from the electric motor position sensor, and operates the electric motor accordingly in response.

End Stop Function

The end stop function reduces the level of power assistance (to the point of producing a counter torque) shortly before the mechanical end stops are reached. Although the driver will perceive this as increased steering resistance, it makes turning the wheels to full lock much smoother overall. In addition, this function reduces the stresses on mechanical and electrical components of the steering system.

Temperature Limitations

If the power steering electric motor temperature reaches over 230°F C (110°), assistance will be reduced. Once the temperature reaches 257°F (125°C), assistance is cancelled. When the temperature has reduced, normal function is resumed. Temperatures higher than 230°F (110°C) will generate a DTC and warning messages in the Instrument Cluster.

Overload Protection

Additionally, the electric power steering system has an overload protection function which reduces assistance should an attempt to turn the wheels be made with the front wheels against a solid object, such as a parking curb. This is to mechanically protect the steering gear components against excessive mechanical stresses.

Warnings

If there is a significant reduction in power assistance, the amber general warning indicator will illuminate, and a warning message will be displayed in the Instrument Cluster.

If there is a total loss of power assistance, the Power Steering warning lamp will illuminate and a message will be displayed in the IC. The driver no longer benefits from power assisted steering, but the vehicle remains fully steerable, with greater physical effort required.

Water Detection

If the PSCM detects that water has penetrated the power steering gear and is beginning to freeze, an electric motor vibration is initiated. While the vibration is active, a general amber warning lamp is displayed in the IC, along with the message 'Steering vibration activated - Drive with care'.

System Control

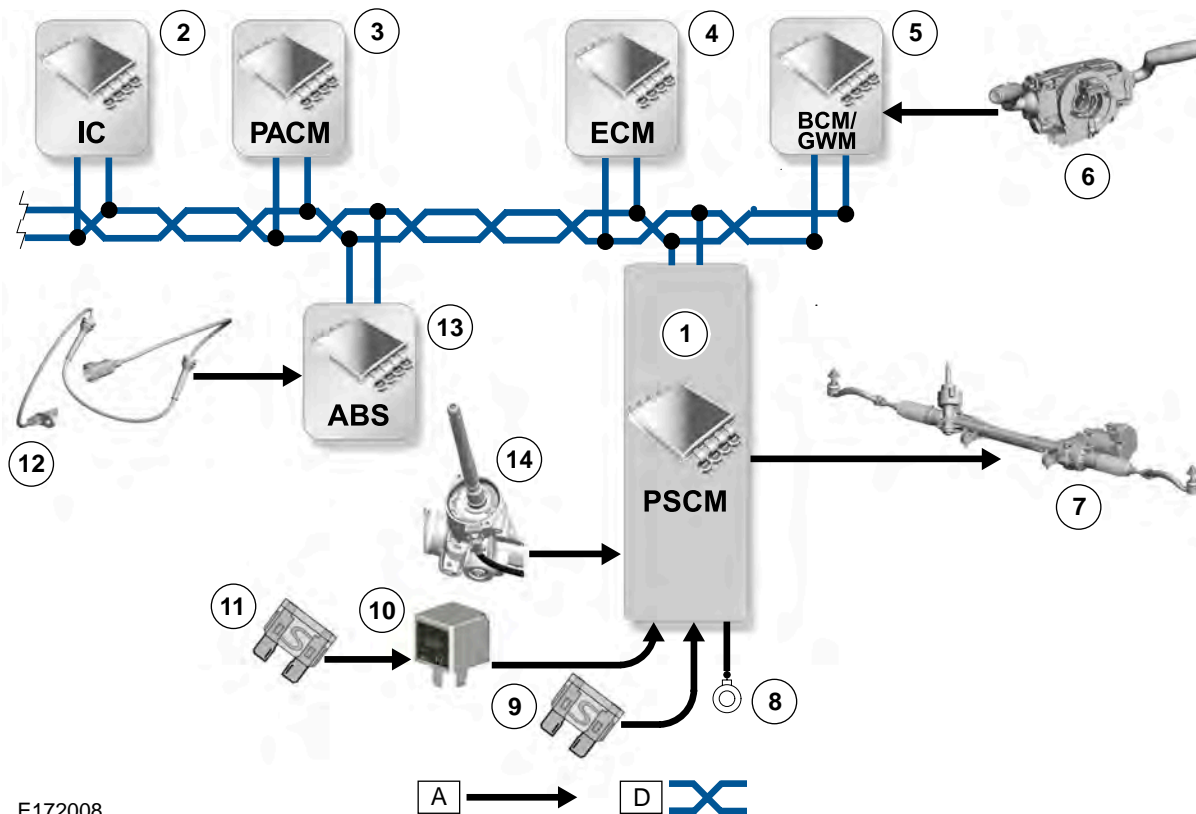
The PSCM receives hardwired digital inputs from the Torque Sensor, and HS CAN bus inputs for:

- Steering Angle (SWM)
- Engine Speed (ECM)
- Vehicle Speed (ABS)
- Yaw Rate (ABS)
- Vehicle Speed (TCM)
- Power Mode (BCM/GWM)
- Automatic steering requests from the Park Assist system
- Auto Stop/Start requests (ECM via BCM/GWM) (If fitted)
- Haptic steering wheel vibration requests from the Lane Departure Warning System (IPCM)
- The PSCM uses this input data along with software algorithms to control electric motor operation

If required, the PSCM can also transmit outputs on the Chassis HS CAN Bus, such as:

- Warning Status to the Instrument Cluster (IC) via the BCM/GWM
- Steering status to the Park Assist system (If equipped)
- Auto Stop/Start engine start or stop inhibit requests to the ECM via the BCM/GWM

Electric Power Steering System Control Diagram



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Item	Description	Item	Description
A	Hardwire	7	Steering Rack
D	HS Chassis CAN	8	Ground
1	Power Steering Control Module (PSCM)	9	Permanent Power Supply
2	Instrument Cluster	10	Relay controlled Ignition Power
3	Parking Aid Control Module (PACM)	11	Ignition feed power supply
4	Engine Control Module (ECM)	12	Wheel Speed Sensor
5	Body Control Module / Gateway Module (BCM/GWM)	13	ABS Control Module (ABS)
6	Steering Wheel Module (SWM)	14	Torque Sensor

Service

The Steering Gear and all its components (PSCM, Electric Motor, Torque Sensor, Rack and housing) form a pre-assembled unit that can only be replaced as a complete unit.

After a new steering rack has been fitted, the front wheel steering geometry alignment must be checked and adjusted if necessary. The PSCM must also be programmed to the vehicle using the Jaguar approved diagnostic equipment.