Press News

A world first takes up position

Active driving pleasure assisted by the newly developed steering aid motor

Steering optimised for high speed stability is at odds with that demanded by winding roads, tight corners and parking. At motorway speeds steering adjustments passed to the wheels must be kept to a minimum, the steering effort required at low speeds is correspondingly high i. e. safety over action and effort. Were it not for the lack of feedback, the interaction between the road and driver, full electronic control (steer-by-wire) as found in aircraft could represent a solution for safe but agile
driving. But unlike aircraft, cars travel on the most varied of road surfaces in changing weather conditions where individual feel and sensory 'touch' are irreplaceable.

BMW introduces a world first in steering technology with their latest 5-series. Thanks to its unique 'active steering', this is the first time one can enjoy the advantages of electronic steering control without compromising that authentic driving feel. Intelligent, speed-sensitive active steering enables steering actions in every driving situation to be optimised. With stability on fast straight and agility on winding country roads, greater driving pleasure is assured for the whole journey.

Pure driving experience – BMW's new active steering

At the heart of BMW's world first is an innovative steering aid that integrates a planetary gearbox and an electronically commutated ebm-papst motor. This design enhances conventional powerassisted steering by adding a differential gearbox with two inputs. One for manual inputs from the steering wheel and a second for the electric motor. These two independent inputs are then converted into a single output speed (Fig. 1a, b).
The principle behind this solution is as follows: The mechanical connection between the wheels and steering wheel is retained through the gearbox and provides full road contact for authentic steering feedback. Depending on the driver's manual input and vehicle situation, a sophisticated electronic control system defines a particular speed and direction for the gearbox via the electric motor.

At low speeds the motor is controlled in a way that adds rotation in the direction of the steering wheel. For speeds up to 120 km/h the effort and action necessary for maximum steering lock is considerably reduced. At higher speeds the electric motor acts against the driver's turning direction (Fig. 2). The gearbox speed is lower, resulting in a smaller steering angle so that driving in a straight line becomes safer. In certain situations the electronic control system can also apply opposite lock. Sensors measure the car's telemetry and derive stabilising steering actions from them. This results in improved damping and reduces the load on the DSC (Dynamic Stability Control) system that is operated via the brakes. If, in an extreme case, the active steering were to fail the steering would continue to operate safely. The system simply locks and continues to work as a typical mechanical steering system.

Comfort requirements of a class leader

Vehicle-specific 'customer qualities' are required from all components of the steering aid motor. Reliable performance levels for all forms of driving is essential and this in an environment that places heavy loads on all components. Installation in the lower area of the vehicle is particularly well known for high stresses. For ebm-papst St. Georgen this meant developing a high-perfor-mance electric motor (Fig. 3) that operates reliably with minimum torque ripple and low noise. Resistance to extreme temperature fluctuations as well as motor oil and other substances meant it was also necessary to develop solutions that were not only of impressive quality but commercially viable as well.

A powerful drive in every situation

Over its entire lifetime the motor must be able to withstand speeds from 0 and 6,000 r.p.m., a stepping motor type operation for discrete and sensitive assistance and rapid acceleration during parking or manoeuvres where agility is required. Despite the forces this continuous 4-quadrant
operation places on the motor, reliability whenever the engine is switched on must be maintained throughout the life of the vehicle. The ebm-papst solution is based on the principle of a synchronous, three-phase, permanent magnet motor with internal rotor and sinusoidal commutation. The motor comprises a six-slot stator and four pole rotor. Its concentrated stator winding benefits from low copper losses and a robust construction by avoiding the cross over of windings. Technically, deliberate increases of the air gap (Fig. 4) between stator and rotor surface enabled modulation of the supply voltage's sin wave. Avoiding the use of skewed stator and rotor parts was also of particular benefit. Although this rotor configuration is well established within the industry, this is the first time it has been considered for assisting steering applications. Embedding the rare-earth permanent magnets

(neodymium-iron-boron) rotor pack also aids this particularly robust construction. The rotor and stator packs are punched from cold rolled steel with low eddy-current loss characteristics.

A particular challenge for the motor designers was ensuring that torque ripple, whether under power or not, along with running noise was kept to a minimum. Using a combination of analytical and numerical software and the appropriate algorithms, torque ripple could be optimised and reduced to a minimum using the finite element method. The best possible torque characteristics were achieved using the original rotor topology. This motor solution from ebm-papst St. Georgen can be described as a synthesis of electromechanical and thermal design.

Immune to temperature fluctuations

Components beneath the car's bonnet must function reliably even when exposed to high temperature fluctuations. In this case the performance specifications specify a range of -40 °C to +125 °C. A gearbox in the steering area must operate without any play despite temperature related expansion of materials. A conventional solution using expansion joints is not sufficient so, the ebm-papst motor has a spring-loaded rotor shaft that can deflect by a few degrees. This enables the motor's worm shaft (Fig. 5) to be in permanent contact with the differential's gear wheels. A complex design, given that the motor's electrical characteristics needed to be maintained at all deflection angles. An integrated shaft encoder (Fig.6), with a rotation angle accuracy of 1%, ensures that the external controller receives the data necessary for motor commutation and monitoring of the steering. Sealing the rotors permanent magnets and a special gasket ensure that a minimum operating life of 15,000 hours is achieved.

Extreme tests prove reliability

Demanding test conditions proved a compelling case for selecting the EC motor from ebm-papst. Obviously the motor is resistant to pressure washers and of course, thermal shock (motor cooled from 120 °C with a water jet at 4 °C in 3 seconds at 4 lt/sec), salt spray, immersion, hot water jet (at
80 °C and 100 bar), and vibration tests were also carried out. There were also tests for resistance to a complete range of liquids. Not just oil, petrol, diesel, and bio-diesel (RME), but even coolants, battery acids and screen wash. The ebm-papst motor was also commended for its electromagnetic compatibility (during EMC tests) – a factor that is particularly important in complex automotive systems.

Electronic assistance systems not only provide greater safety, but also unimagined driving pleasure. BMW has proved this with its innovative active steering which, with DSC and Servotronic, is by far the best assistance

system available. This worldwide unprecedented technological innovation was made possible by designing the unique customized steering aid motor meeting the requirements of the automobile industry.

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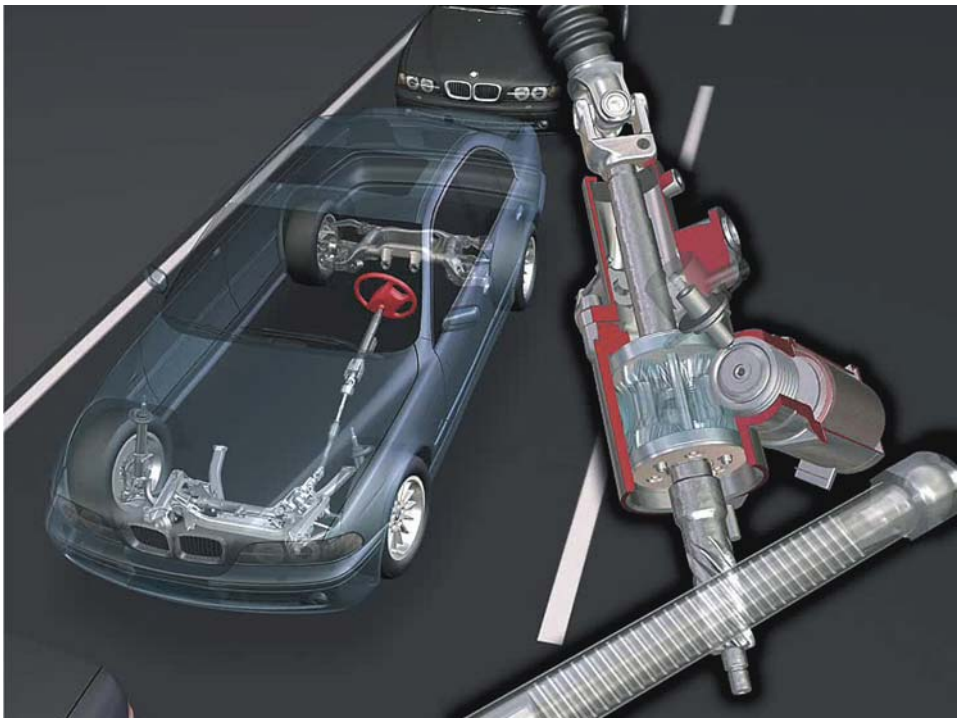

Intro: BMW vehicle incl. steering motor

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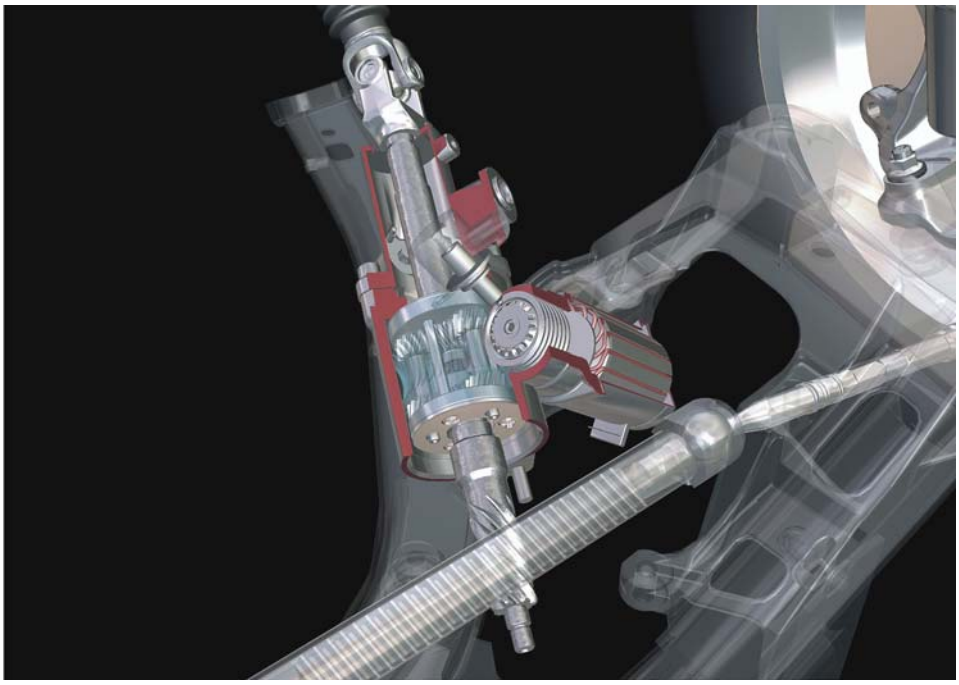

Fig. 1: Servo-assisted steering incl. servo motor and interactive gearbox in sectional view

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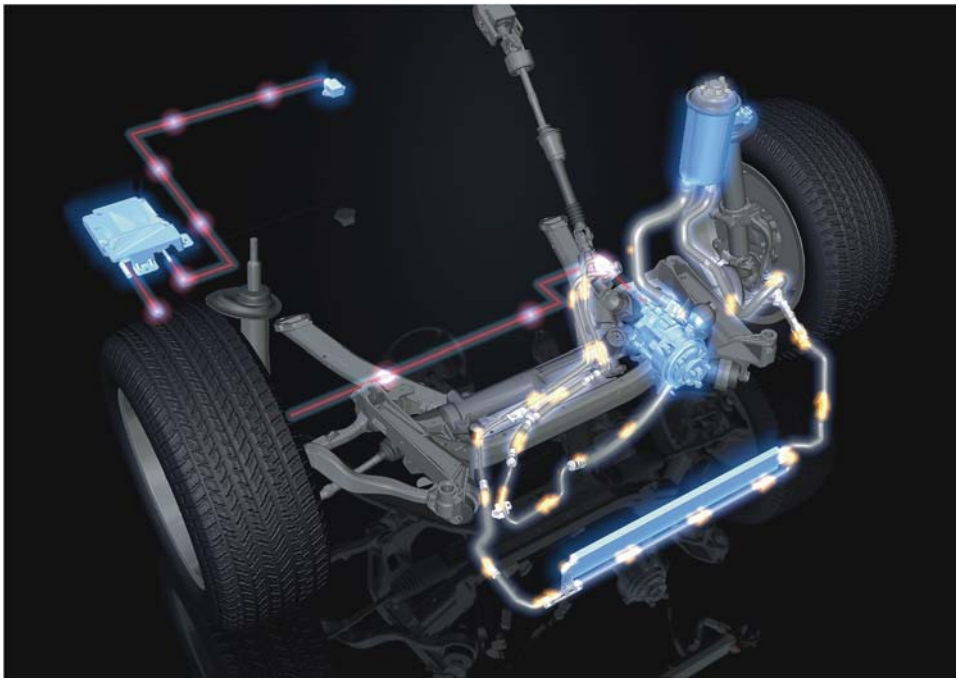

Fig. 2: Safe steering by means of an electronically assisted steering aid

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Fig. 3: Newly developed robust ECI steering aid motor

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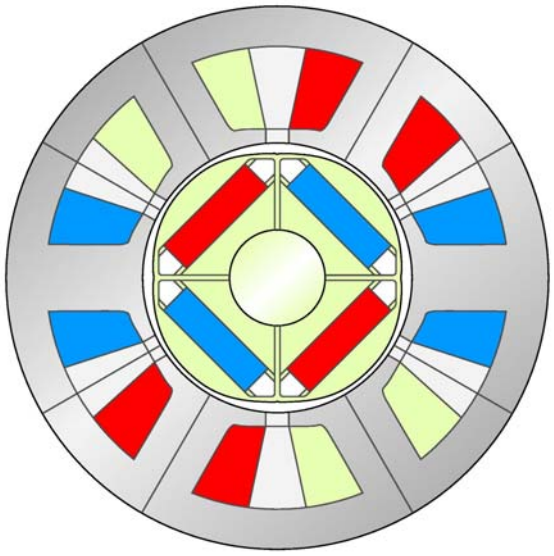

Fig. 4: Simple but effective construction; the head gap modulates the sinus shape of the voltage

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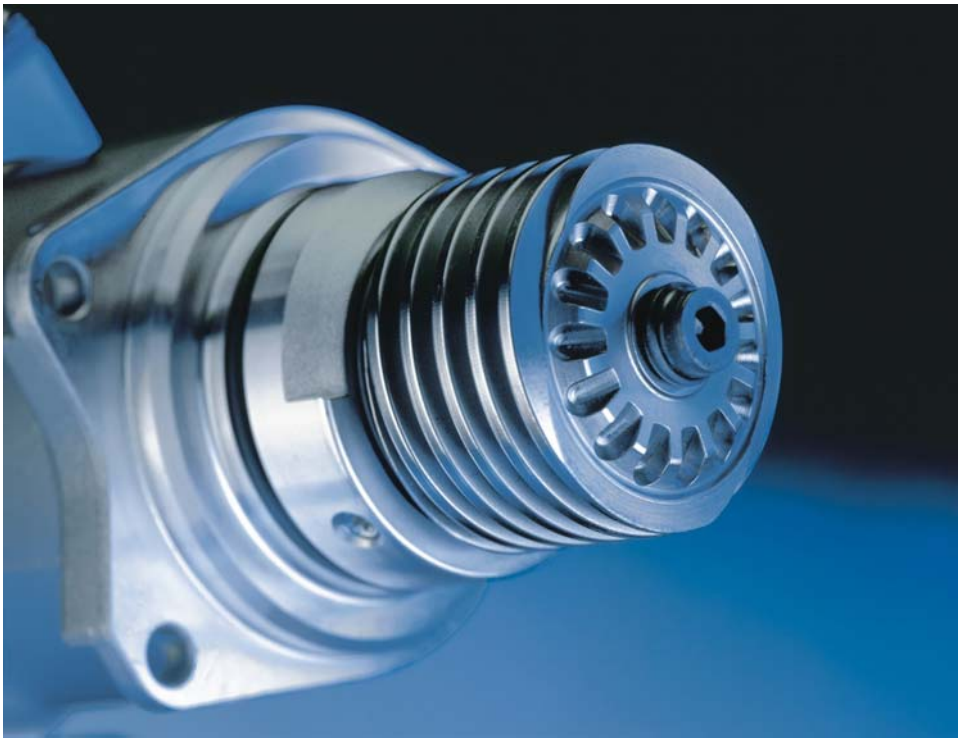

Fig. 5: A spring-supported prestressing of the worm shaft enables a steering aid free from play

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Fig. 6: The integrated speed sensor supplies the necessary data to both the motor and electronics