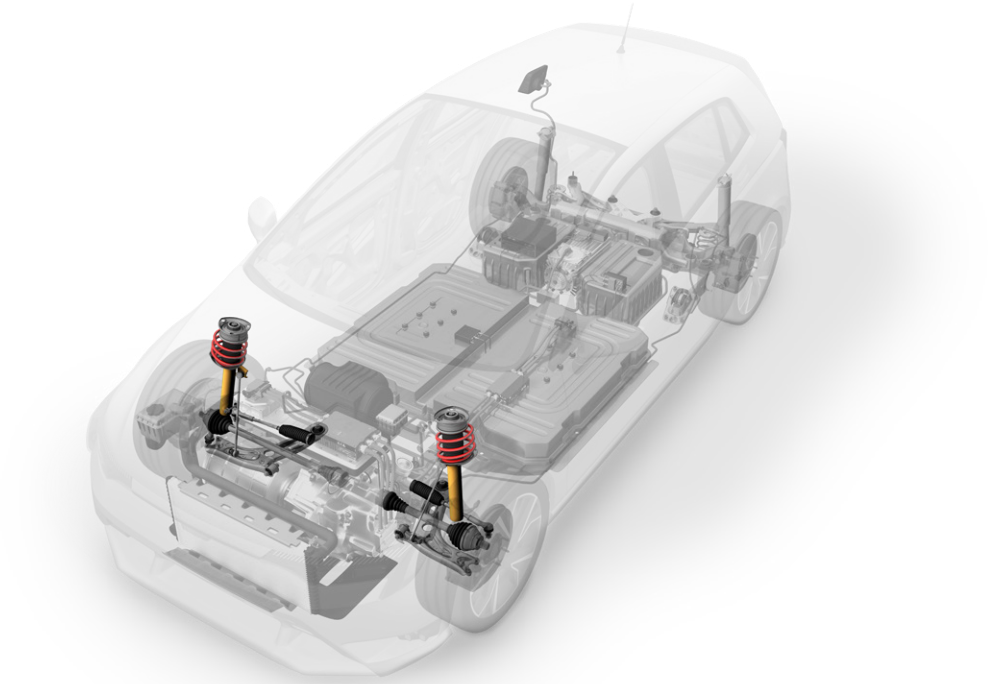
Harmonized system simplifies tests of mechanical loads

Measurement of mechanical stress

The optimization of hybrid and electric vehicles does not only extend to the electric drivetrain, but also includes all vehicle components. The aim is to save weight in order to achieve maximum performance and energy efficiency. At the same time, the vehicle must be permanently stable and safely designed for the planned service life. For this reason, chassis components are also tested and continuously improved with regard to mechanical stress. Measurement modules from CSM and telemetry measurement technology from AXON are used to measure the fatigue strength of parts of the wheel suspension.



Simulation and validation

The control arms and track rods are part of the unsprung masses and have a significant influence on driving dynamics and ride comfort. When designing the components, the aim is to achieve an optimum balance between strength and mass. The expected forces that occur during various driving situations are predicted in simulations during development and must then be validated in road tests and on the test bench. The data obtained is then fed back into simulation models and helps to improve future developments. To validate the simulations, the forces acting on the axle geometry are determined. Strain gauges are applied to the control arms and the two track rods and the data obtained is correlated with

other measured variables. These measurements can be used to trace the transmission paths of the forces to the body and, for example, to the steering. In addition, the torque and temperatures are to be measured on the drive shaft in order to record the loads in different driving situations.

What should be considered?

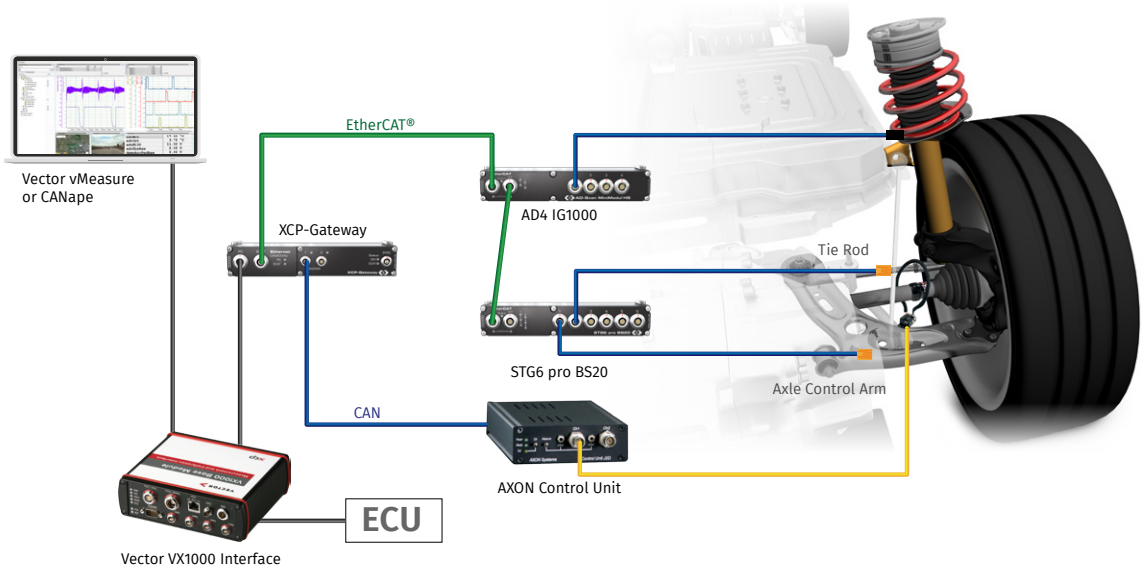
To measure the durability of the steering arm and tie rod, the acting forces as well as the suspension travel, steering angle and speed must be measured. For a simple application, all measured variables are recorded in parallel with one measurement system. Data is collected during different driving situations and on various ground surfaces (road and test track) as well as on the test bench. The measurement system used should be able to be used in all test scenarios in order to avoid long conversion times and to enable simple comparison of the data obtained due to identical sensor technology and measurement data acquisition.

Component-specific requirements

Tie rods and control arms are very stable components, which means that only low strain values are to be expected in normal driving situations. The measurement technology used must therefore be very high-resolution in order to record very small signal values. However, since very high values can occur during misuse tests, such as driving over a curb the measurement technology must offer sufficient dynamics: Measurements with a high data rate should make it possible to reliably record even faster processes. In addition, when measuring rotating parts, there are difficulties in transmitting the values as the sensors have to be attached to the shaft. This rotates with the component and the data must therefore be recorded wirelessly – a challenge for the measurement technology. The available installation space and movements of the drive shaft make installation even more difficult.

Combine all data in one measurement system

Components from the Vector CSM E-Mobility Measurement System are used for the measurements. This means that all required measurement values can be easily acquired with a perfectly coordinated measurement system and expanded with additional measurement technology. The tensile/compression load in the tie rods is measured using strain gauges, which are applied in pairs opposite each other as a full bridge, offset by 90° (so-called T-Rosette). Depending on the geometric design of the axle control arm, strain gages are used to measure individual strains, bending or tensile/compressive loads. This means that full, half or quarter bridges are used depending on the application. Furthermore, a combination of different bridge circuits is possible for each individual channel.



Automatically adjusted in the measurement module

All strain gages are connected to a STG6 pro BS20 strain gage measurement module. Quarter bridges are added directly in the sensor cable to form half bridges. The strain gauge is simply added to the full bridge in the measurement module, eliminating the need for further wiring and allowing a wide range of strain gauge resistance values to be supported. Thanks to the extremely low input voltage range of up to ±0.3 mV/V, very small measurement signals can be precisely recorded. Depending on the selected measurement range, the appropriate input voltage range is automatically assigned in the measurement module. The measurement data rate of up to 20 kHz per channel allows the detection of rapid load changes. To further improve the measurement accuracy even with the smallest signal amplitudes, the STG6 pro BS20 also measures its own bridge supply voltage separately for each measurement channel and offsets this against the signal voltage. This method is known as the ratiometric measurement principle and enables very accurate measurement results.

The spring travel is measured using suitable travel sensors and an AD4 IG1000 measurement module.

Fig. 1: Strain gauge measurement module STG6 pro BS20

Measurements on rotating parts

Telemetry systems for recording torques from AXON Systems GmbH, a long-standing partner of CSM, are used for the measurements on the drive shaft. With the solution from AXON, the data from a rotating strain gauge measurement point for torque measurement and a thermocouple for recording temperatures are transmitted without contact. For this purpose, the strain gauge measurement point is connected to a rotor electronics unit, which is installed on the drive shaft and provided with a multi-layer protective coating so that environmental influences such as contamination

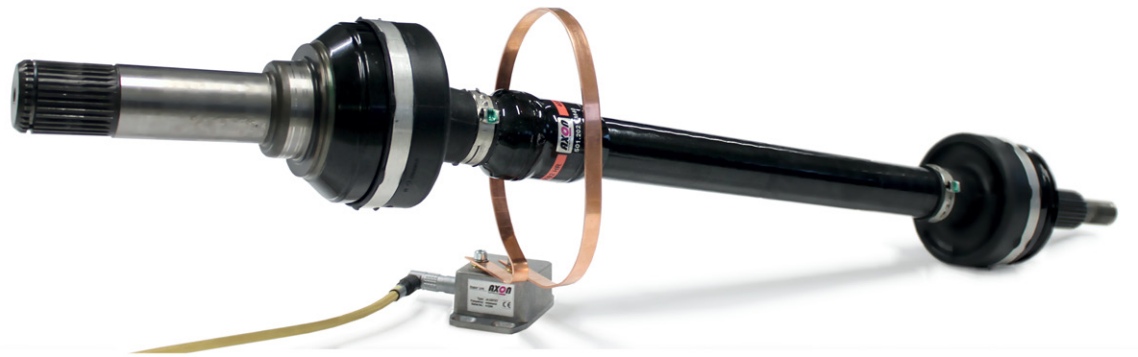


Fig. 2: AXON rotor electronics and antenna for non-contact transmission of the recorded data from the strain gauge and temperature sensor on the axle. (Photo: AXON Systems GmbH)

or moisture do not affect the measurement results. The data is transmitted wirelessly to a stator unit, the antenna of which is placed in a ring around the axle, allowing the axle to move during driving maneuvers. The antenna of the stator unit can be freely shaped and thus flexibly adapted to the conditions at the installation site with little installation space. The control unit generates the necessary supply voltage for the sensors on the rotor unit and forwards the recorded measurement data. A special feature of the system is that the energy for the rotor electronics is generated by the control unit and transmitted inductively via the stator unit, meaning that the rotor electronics do not require a battery and are therefore extremely low-maintenance. AXON's telemetry system is equipped with another feature for the highly EMC-loaded environment in an electric vehicle – digital noise canceling. For this, the electromagnetic background spectrum is recorded using a throw antenna and offset against the actual measurement signal as a counter-signal: The result is virtually interference-free measurement data.

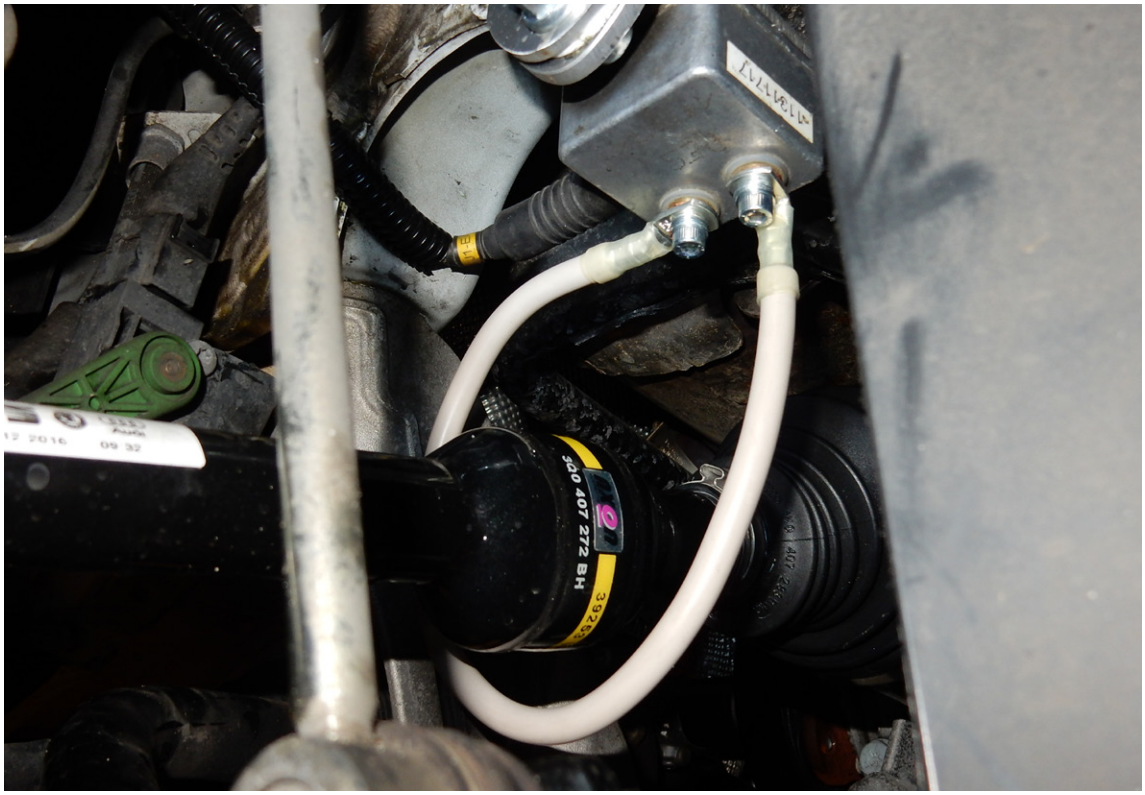


Fig. 3: The AXON telemetry system installed in the vehicle. Thanks to the flexible antenna, the axle has sufficient space for demanding test drives. (Photo: AXON Systems GmbH)

Fig. 4: In addition to sensors installed on the axle, AXON also offers torque measurement flanges for acquiring acting forces. The entire measurement technology is also suitable for harsh environmental conditions, such as off-road driving tests. (Photo: AXON Systems GmbH)

Simply merge signals for analysis

The CSM measurement modules are connected to an XCP-Gateway via EtherCAT®. Thanks to the high total sampling rate of up to over 4 Mbit/s, a large number of measurement channels can be integrated with EtherCAT®. The XCP-Gateway synchronizes the measurement modules via the Precision Time Protocol (PTP) better than 1 µs and converts all signals to XCP-on-Ethernet. The data from the AXON telemetry system is integrated into the measurement chain via CAN, bundled in the XCP-Gateway and also forwarded via XCP-on-Ethernet. A Vector Informatik Interface VX1000 is used to additionally acquire the steering angle and speed from the vehicle's control unit. The collected data can be recorded either with a data logger or a measurement computer. The subsequent data evaluation can be carried out with Vector CANape or vMeasure.

Suitable measurement technology for high requirements

With the components of the Vector CSM E-Mobility Measurement System and measurement technology from AXON, all required measurement variables can be recorded precisely with a standardized system. Thanks to the compact and robust design, the measurement modules and telemetry systems can be installed close to the measurement point and used both in road tests and on the test bench. As long conversion times are therefore not necessary, the measurement technology impresses with considerable cost and time savings.

Featured Products

STG6 pro BS20

The STG6 pro BS20 is suitable for measurements with strain gauges under demanding conditions. With the extended supply voltage range, sensors with up to 10 V supply can be used. Due to the automatic selection of the suitable input voltage range, as well as a better signal-to-noise ratio, extremely small measurement signals (e. g. strain) can be accurately acquired with the STG6 pro BS20.

AD4 ECAT MM-Serie – Typ IG1000

The AD4 IG1000 measurement module is optimally suited for the most accurate analyses of high-frequency signals with measurement data rates of up to 1 MHz per channel. It offers a highly accurate, bipolar and channel-wise adjustable sensor supply from 1 to 20 V DC for a wide range of sensors.

XCP-Gateway-Serie

CSM's XCP-Gateway Series protocol converters were specially developed for CSM EtherCAT® measurement modules and for measurement tasks with multiple measurement channels and high measurement data rates. The XCP-Gateway is available in "Basic" and "pro" versions. The "pro" version has two CAN interfaces via which CAN-based CSM measurement modules can be connected and integrated into the XCP-on-Ethernet measurement data protocol. In the "pro" version, temperature data from the HV Breakout Modules can also be transferred directly via EtherCAT®.

Complete solutions from a single source:

CSM provides you with comprehensive complete packages consisting of measuring modules, sensors, connecting cables and software - customized to your individual needs.

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