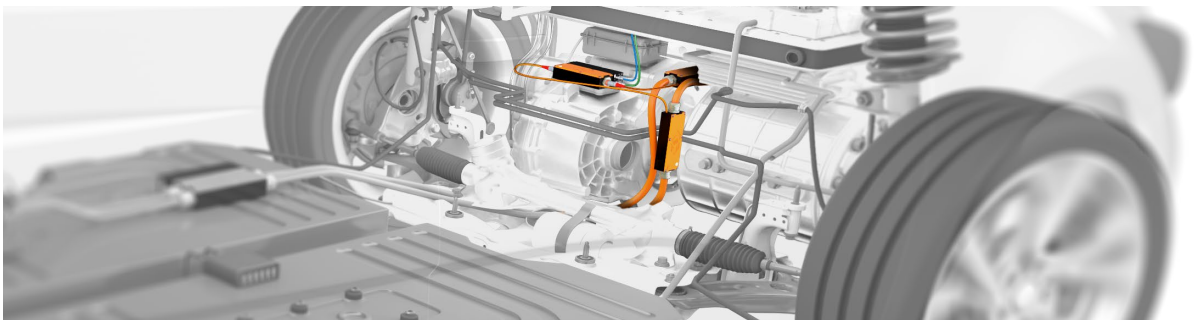


High-Voltage Current and Voltage Measurement in Confined Spaces



HV Current and Voltage Measurement

For tests drives of electric vehicles, high-frequency currents and voltages must be measured in the high-voltage vehicle electrical system. The installation options for the necessary measurement equipment can be very limited due to confined installation spaces. This application example shows how currents and voltages can nevertheless be measured with high sampling rates, HV-safe and protected from environmental influences.



Background

Components in the electric powertrain as well as the complete HV electrical system of electric and hybrid vehicles are extensively tested in simulations and on test benches. Nevertheless, current,

voltage and power must also be measured in road tests to validate the development results under real conditions. This is the only way to obtain accurate results for the many necessary optimization steps.

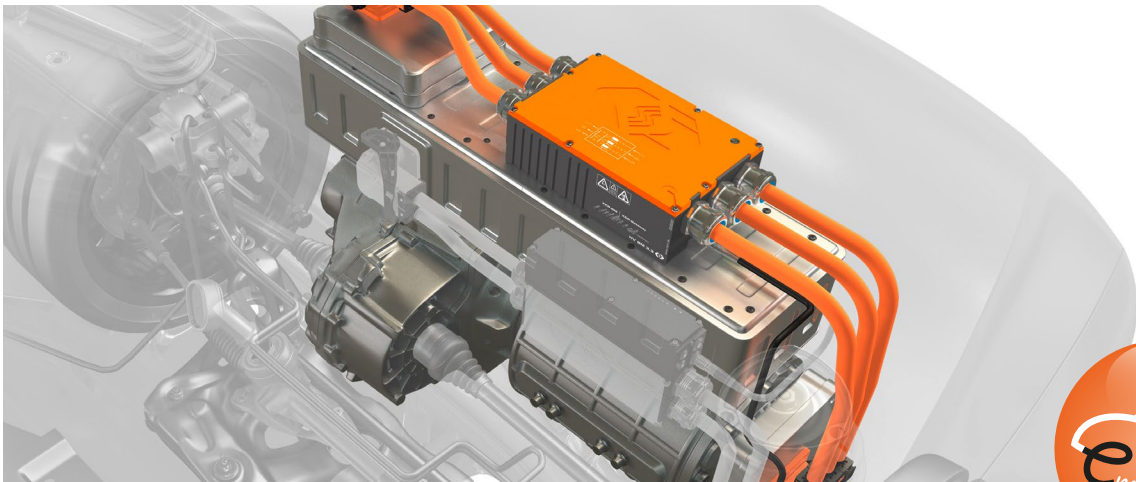


Fig. 1: HV Breakout Modules can be used to measure currents, voltages and power very precisely and reliably in the vehicle electrical system. Provided that sufficient installation space is available.

For the measurement of current, voltage and power in the HV electrical system on test benches and in the vehicle, CSM's HV Breakout Modules are a proven solution: They represent the most compact and least interference-sensitive measurement technology solution for such measurement tasks. The HV Breakout Modules have a robust housing for mobile use in vehicles and measure interference-sensitive up to 2,000 A and 2,000 V with a high sampling rate of up to 2 MS/s. The HV power cables are connected directly in the HV-safe housing

and cable is connected or passed through on the module housing.

Due to the direct measurement in the inner conductors (or also braided shields), extremely precise measurement results are achieved. However, the available installation space in the vehicle may be too small due to tightly installed components and narrow cable ducts for installation. In such cases, another solution must be found for measuring current, voltage and power in road testing.



Challenge

First and foremost, the measurement technology used must be able to be installed at the desired measurement points. Sometimes narrow cable ducts or surrounding components limit the available

installation space. For this reason, the measurement technology used must then be designed even more compactly and be able to be used decentrally.

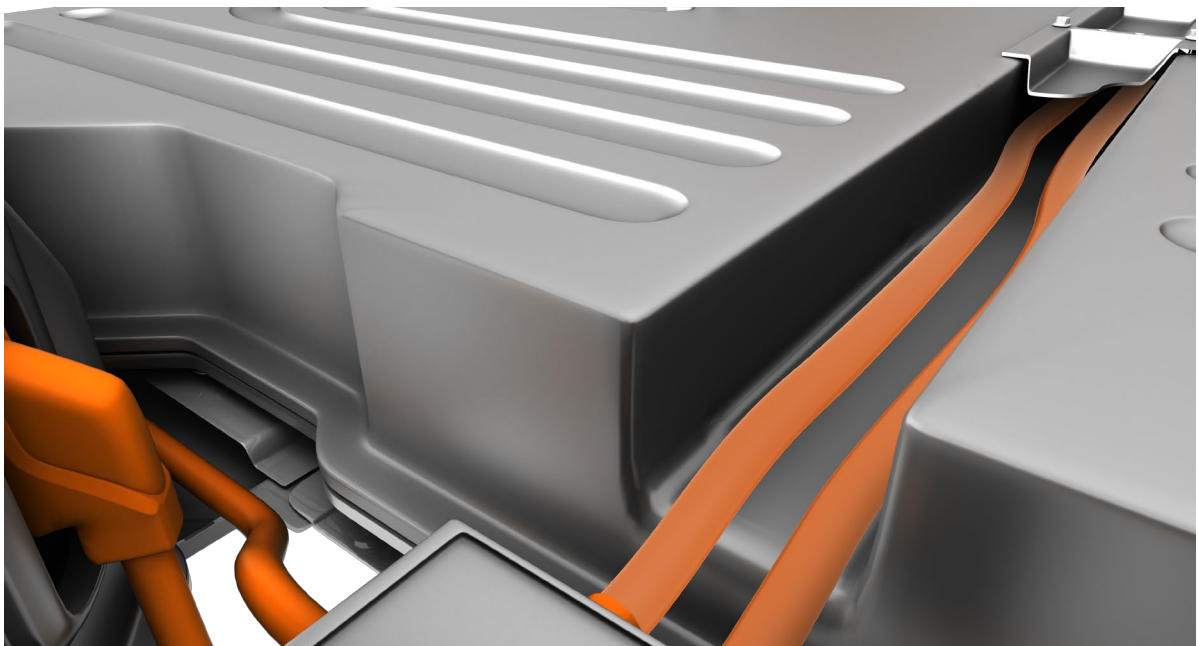


Fig. 2: Narrow cable ducts offer only limited installation space for the measurement technology to measure current and voltage in the HV power cables.

Nevertheless, very precise measurement results must be achieved, which is why further measurements directly in the inner conductor are necessary, since otherwise the results will be falsified by additionally measured shield currents and interference. In order to allow further analyses, measurements are to be made at a data rate of up to 1 MHz (or even more).

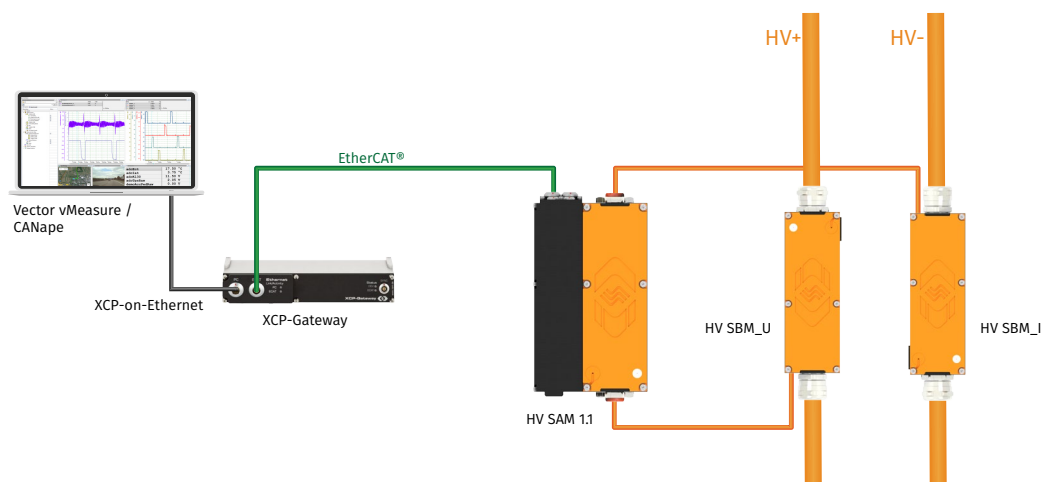
The measurement technology must be installed in robust housings in order to ensure high-voltage safety for users and systems on the one hand and to protect the measurement technology from environmental influences on the other.

The CSM Measurement Solution

HV BM Split Modules are used for measuring current, voltage and power in very confined installation spaces. High-voltage Breakout Modules of the Split family (HV BM Split Modules) use the same measuring principle as the well-known CSM HV Breakout Modules for measurements in the vehicle electrical system. However, the three main components are housed in their own small HV-safe enclosures:

By separating the three main HV BM components, the space required for installation in HV power cables or in busbars is minimized. The **HV SBMs** are inserted directly into the HV cables via cable glands and ring terminals. The cable shield is routed separately, as with the HV Breakout Modules.

HV SBM_I Split Breakout Module	Current measurement with temperature compensated shunt module
HV SBM_U Split Breakout Module	Voltage tap
HV SAM Split Acquisition Module	Measurement module



The current and voltage Split Breakout Modules are connected to the Split Acquisition Module (**HV SAM**) via shielded high-voltage sensor cables

using HV-safe plug connectors. This allows the slim HV SBMs to be used individually in confined spaces and installed where space is available.



Fig. 3: Group view of the HV BM Split Modules: HV SBM and HV SAM (from left to right).

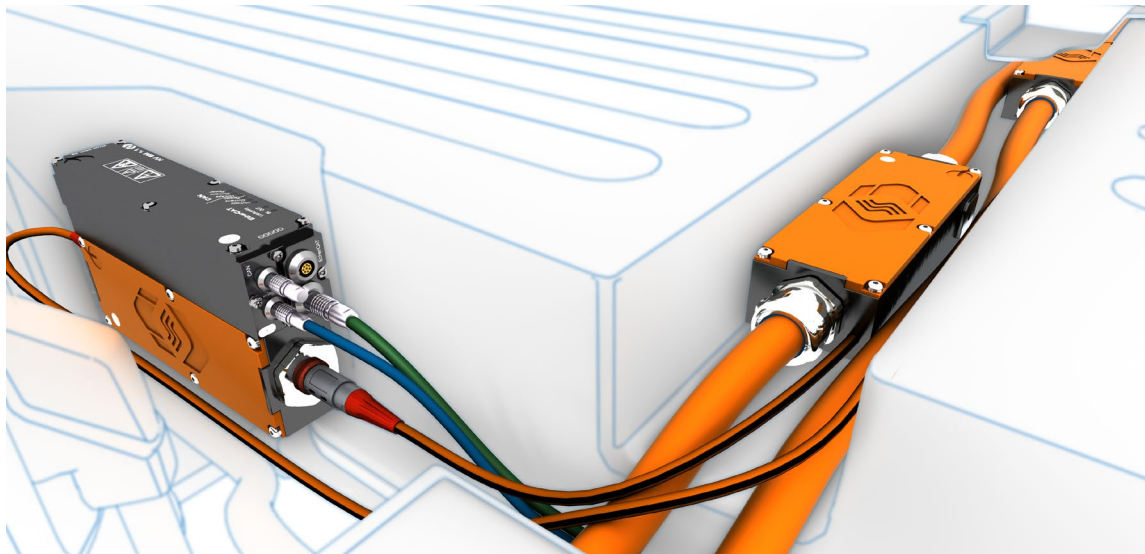


Fig. 4: High-voltage current and voltage measurement in a narrow cable duct. The Split Breakout Modules (HV SBM_I, HV SBM_U) for current and voltage are connected with high voltage safe sensor cables to the Split Acquisition Module (SAM). This is connected to the measuring computer via CAN or EtherCAT®.

The HV SAM performs sampling, AD conversion, filtering, online calculation, data acquisition, protocol conversion, and galvanic isolation. The HV-safe sensor cable to the HV SBM is 2 m long as standard.

As with the standard HV Breakout Modules, data output is via EtherCAT® or CAN with up to 1 MHz data rate.

The measurement data output via EtherCAT® is converted to XCP-on-Ethernet via an **XCP-Gateway** and forwarded to the measuring computer. Further measurement modules for the acquisition of additional measured variables can be easily integrated via the XCP-Gateway.

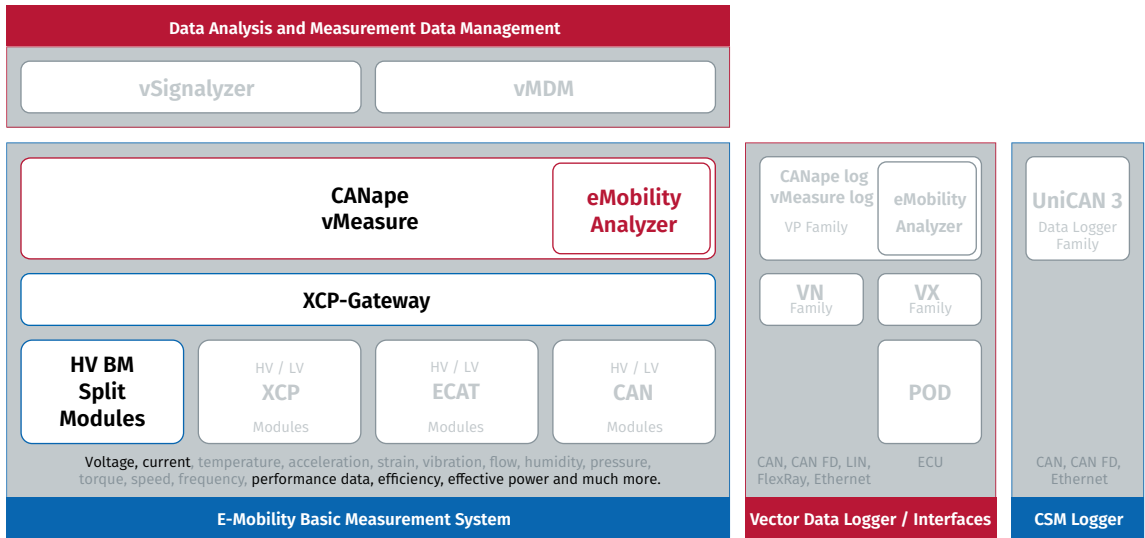


Fig. 5: The HV current and voltage measurement in confined spaces in the systematics of the Vector CSM E-Mobility Measurement System.



Benefits

The HV BM Split Modules enable precise current, voltage, and power measurements in very confined spaces. They use the proven technology of the HV Breakout Modules for accurate measurement results.

The sensor modules of the HV BM Split Modules are hardly larger than the HV lines themselves and can be installed in suitable locations. Measurements on closely installed high-voltage auxiliary consumers such as compressors, pumps, converters or braking resistors are thus made possible.

The HV BM Split Modules are part of the Vector CSM E-Mobility Measurement System. They expand the decentralized, scalable measurement system for high-voltage current and voltage measurement in confined vehicle installation spaces for E-Mobility online analysis with CANape and vMeasure.



Featured Products

HV BM Split Modules

The HV BM Split Modules use the proven technology of the HV Breakout Modules and allow the measurement of current, voltage and power in very confined installation spaces. The components of the HV Breakout Modules have been "split" into individual sensor and measurement modules, which are connected via shielded, HV-safe sensor cables. This allows currents up to $\pm 2,000$ A (peak) and voltages up to $\pm 2,000$ V to be measured safely and precisely directly in the HV power cables and busbars.



XCP-Gateway Series

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 measurement modules, sensors, connecting cables and software - customized to your individual needs.

Further information on our products are available on our website at www.csm.de or via e-mail sales@csm.de.



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