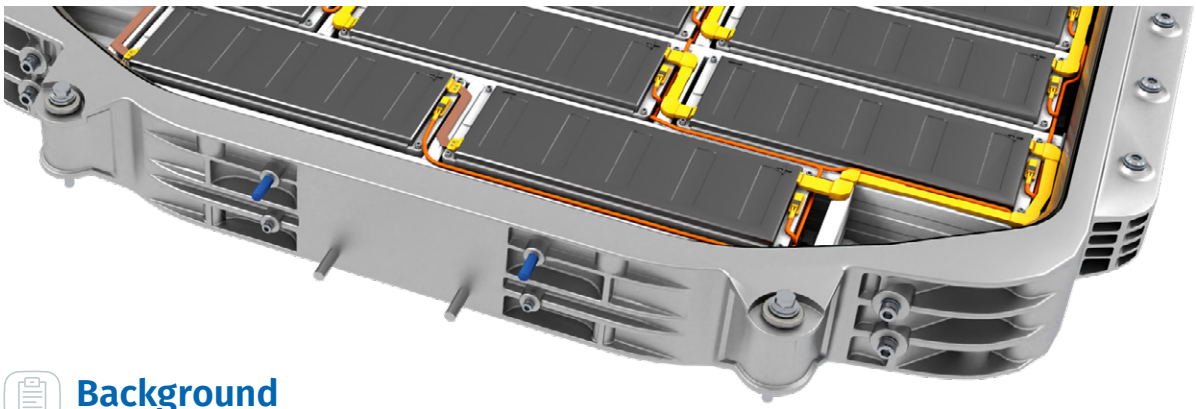
Current and Voltage Measurement in High-Voltage Busbars

HV Current and Voltage Measurement

Within the high-voltage components of electric vehicles, the currents and voltages must be measured at high frequency and with high accuracy for testing, validation and verification. However, the installation space for the necessary measurement technology directly into integrated e-axles, inverters or high-voltage batteries is extremely limited. The following application example shows how CSM's innovative measurement technology simplifies the instrumentation on busbars.



Background

In HV batteries, simulations of the current flows in the busbars connecting individual battery modules are used to design the battery and the Battery Management System (BMS). These simulations must of course be verified with data collected from real physical loads. Likewise, in integrated e-axes, the currents and voltages in the busbars between the inverter and the electric motor must be measured for the performance analysis.

Challenge

For the measurement and analysis of current flows in busbars, current sensors are required that can be used on both the DC and the AC sides of the inverter, cover a wide measuring range, are insensitive to interference and are as small as possible so that they can be installed without changing the production intent assembly. In general, various technologies and corresponding sensors are available for current measurement, with the more popular ones being fluxgate current transformers, Hall-effect current transformers, Rogowski coils and measurement shunts. The measurement technology solution deployed should be very insensitive to possible interference. In addition, the space required for the measurement technology is minimized by installing it directly in the busbar. For these reasons, measurement shunts are ideal for such applications.

The measurements should also be carried out at high sampling rates (up to 1 MHz) in order to measure even fast current peaks and enable precise analyses to be carried out subsequently.

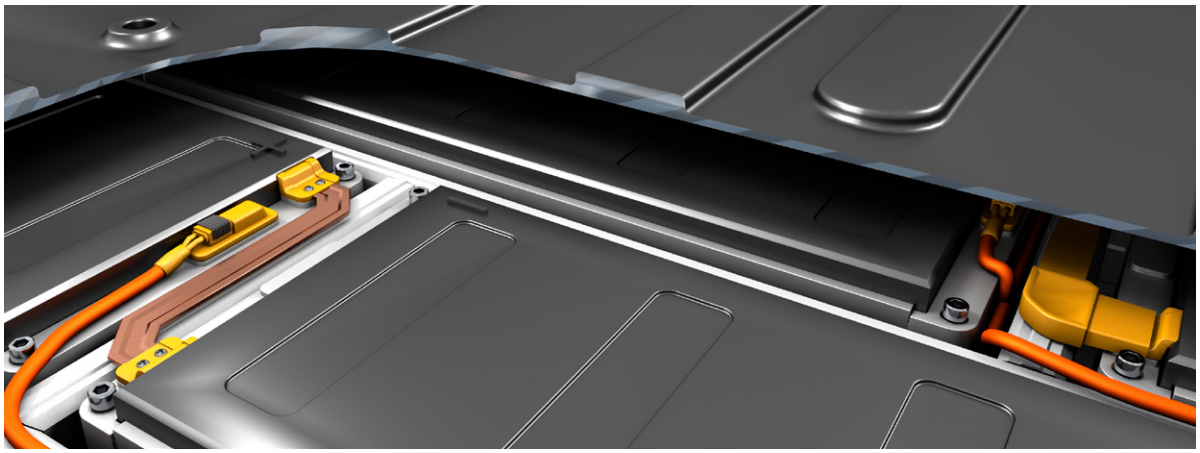
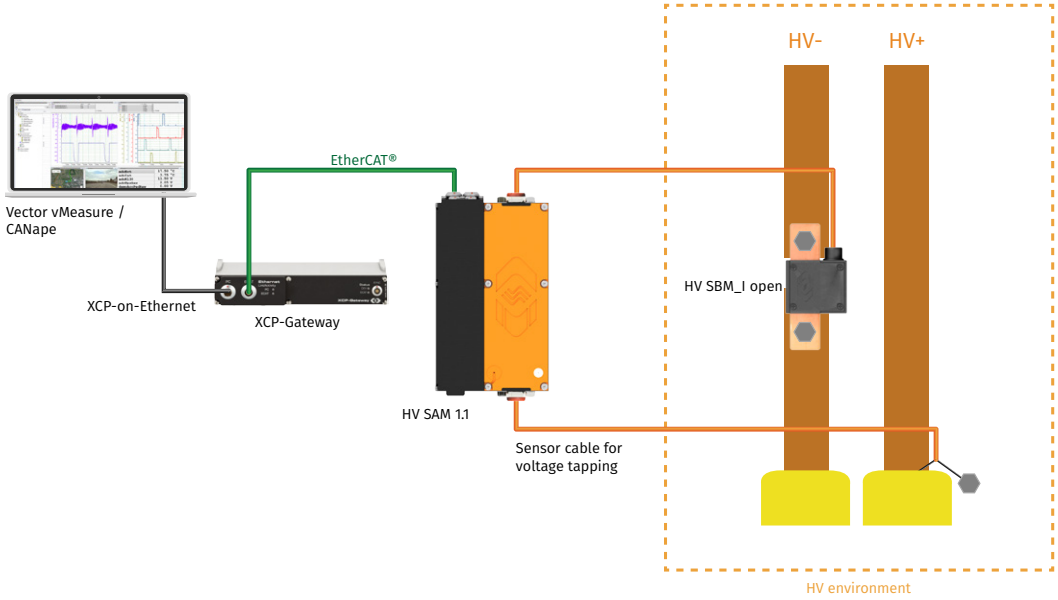


Fig. 1: For measurements of HV current and voltage in busbars, there is often very little space available for the installation of the measurement technology.

The CSM Measurement Solution

When measurement shunts are combined with sophisticated electronics to form shunt modules, this results in highly accurate and very small packaging of current sensors. These can measure currents of constant current intensity and also current peaks. Such shunt modules have been used very successfully for a long time in combination with HV voltage taps in the well-known CSM HV Breakout Modules. For use at measurement points where very little space is available for installation, the proven measurement technology of the HV Breakout Modules has been “split” to individually measure current and voltage and now are available in the form of the **HV BM Split Modules**.



The current is measured directly in the busbar with a single active shunt module called **HV SBM_I open** (SBM - Split Breakout Module). The measurement shunt, temperature sensor, sensor electronics and sensor cable are encapsulated in this module meeting EN61010-1 safety requirements.

The two copper connection lugs with holes can be attached to the busbar very easily.

With the HV SBM_I open, currents up to ±2,000 A can be measured. This makes them also suitable for the acquisition of very short current peaks.

The analog current measured values and the temperature of the shunt for online temperature compensation are transmitted via a HV-safe and shielded sensor cable. Furthermore, the supply of the sensor electronics and the provision of the HV voltage (HV-) is carried out via this sensor cable. The exact type of the shunt module and the calibration data can be read out at any time.

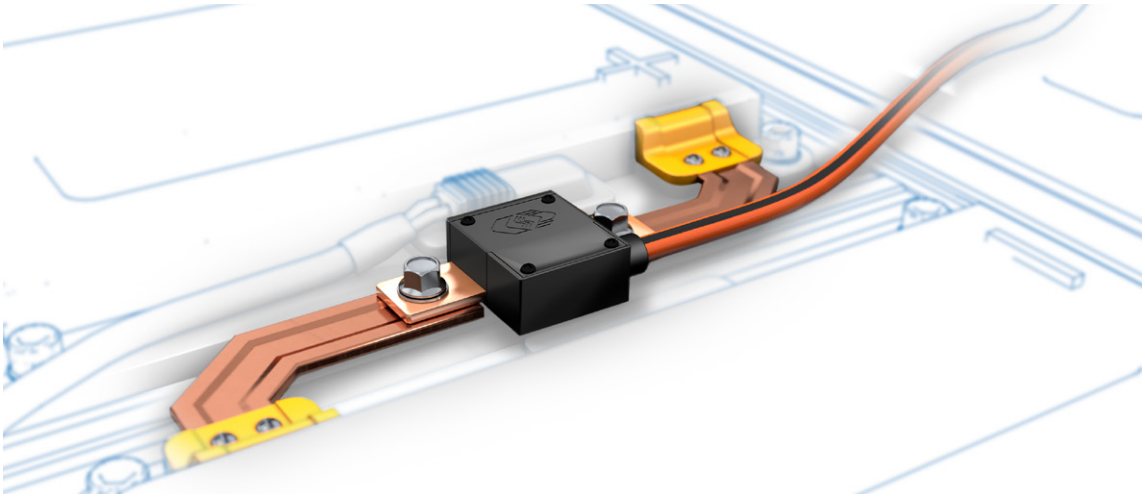


Fig. 2: CSM open shunt module HV SBM_I open mounted on a busbar between two battery modules of a high-voltage battery.

The sensor cable is connected to a measurement module **HV SAM** (SAM - Split Acquisition Module). The HV SAM can be installed at a suitable location outside the high-voltage measurement points where there is more packaging space available. This measurement module performs the galvanic isolation, filtering and AD conversion, online calculation and protocol conversion for all data to be communicated via CAN bus or EtherCAT® network.

The sensor cable for a voltage tap (HV+) can also be plugged into the HV SAM. The HV SAM measurement module outputs the measured values of current and voltage with up to 1 MHz transmission rate via EtherCAT®, for further processing with software from the Vector CSM E-Mobility Measurement System. At the same time, the current and voltage values can be transmitted very easily via CAN bus. In addition, the highly precise calculated RMS values of current and voltage as well as active power, apparent power, reactive power and power factor are available to the user via CAN bus.

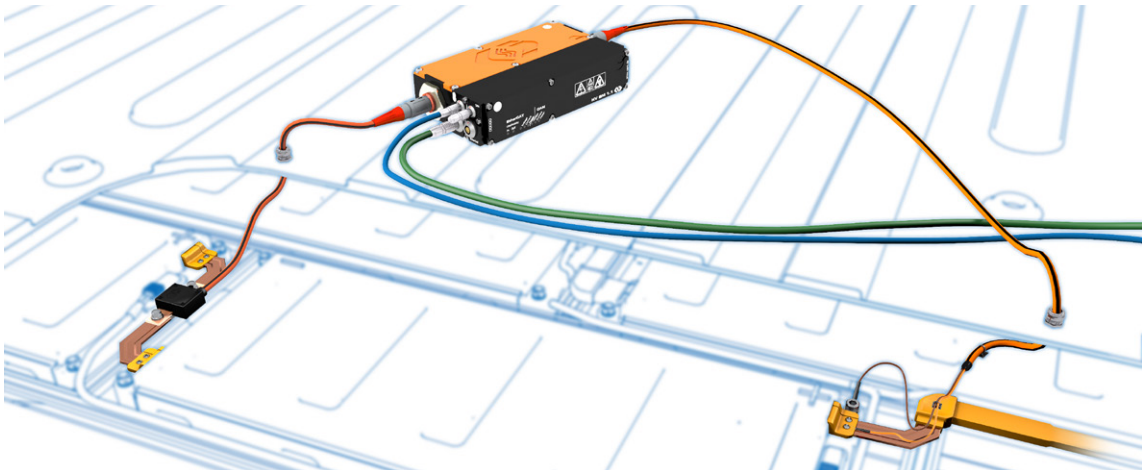


Fig. 3: The open shunt module mounted in the busbar is connected to the HV SAM measurement module outside the high-voltage battery via an HV-safe sensor cable.

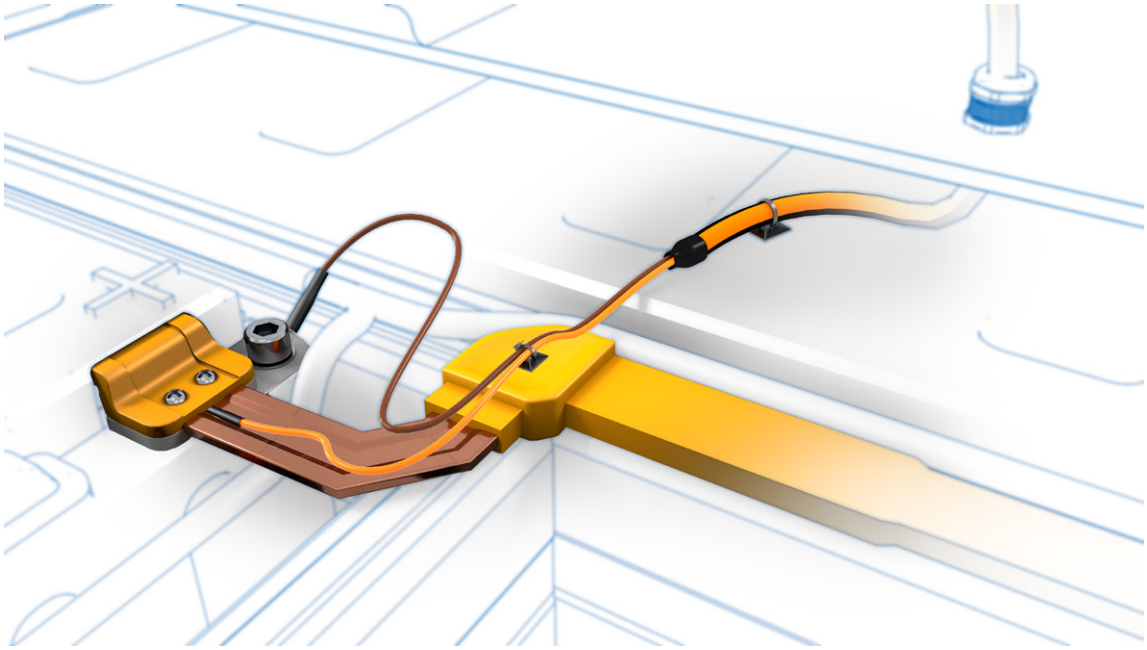


Fig. 4: Voltage tap (HV+) with suitable HV-safe sensor cable. The cable shield (brown) is connected separately.

An **XCP-Gateway** converts the EtherCAT® data to XCP-on-Ethernet and transmits it to the measuring computer. The XCP-Gateway can be used to easily integrate and synchronize other measurement modules for the acquisition of additional values, such as temperatures in the busbars or pressures and flows of coolant in the battery thermal management system.

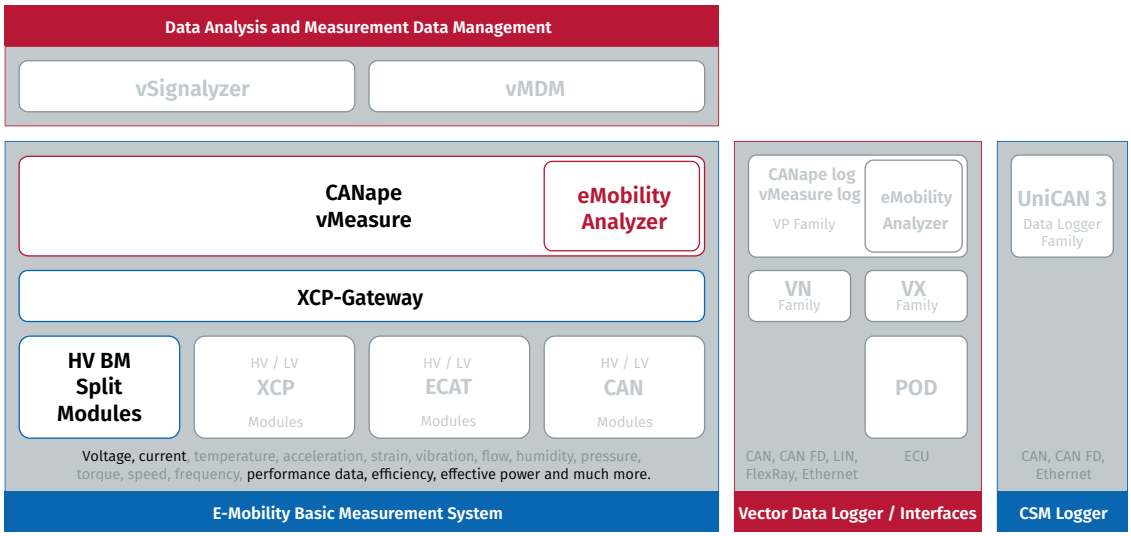


Fig. 5: The current and voltage measurement in HV busbars in the systematics of the Vector CSM E-Mobility Measurement System

Benefits

With the HV SBM_I open (HV Split Breakout Modules), currents in busbars, e.g. of HV batteries and E-axles, can be measured directly, quickly and highly accurately in combination with the HV SAM (Split Acquisition Module). In addition, the HV voltage can also be acquired.

The shunt-based measurement, in combination with the special shunt electronics, provides very precise measurement results for further analysis.

The HV BM Split Modules are part of the Vector CSM E-Mobility Measurement System. They expand this distributed and easily scalable measurement system to include HV current and voltage measurements in confined vehicle installation spaces for online analysis with CANape or vMeasure.

Depending on the application and the space available for installation, different designs of HV BM Split Modules are used and allow measurements on closely installed HV auxiliary consumers such as compressors, pumps, converters or braking resistors.

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 ±2,000 A (peak) and voltages up to ±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.

CSM GmbH Headquarters (Germany)

Raiffeisenstraße 36 • 70794 Filderstadt
+49 711-77 96 40 sales@csm.de

CSM Office Southern Europe (France, Italy)

Site d´Archamps
178, rue des Frères Lumière • Immeuble Alliance – Entrée A
74160 Archamps France
+33 450-95 86 44 info@csm-produits.fr

CSM Products, Inc. USA (USA, Canada, Mexico)

1920 Opdyke Court, Suite 200 • Auburn Hills, MI 48326
+1 248 836-4995 sales@csmproductsinc.com

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