

# Safe Temperature Measurement in High-Voltage Batteries

## HV Temperature Measurement

In electric vehicles, the battery is of central importance and is subjected to thorough testing in development and pre-production. Temperature measurement plays a particularly important role in this process.

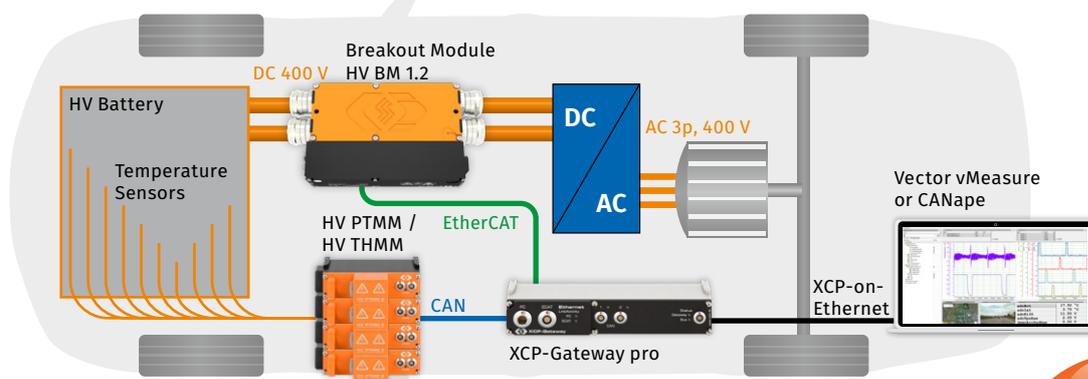


Fig. 1: Measurement setup for mobile temperature measurements in a test vehicle



## Background

The battery system, consisting of modules with their cells, varies between different vehicle types, and the design of the overall system must be verified. The temperature is measured under different operating conditions. Testing and verification take place both on the test bench and afterwards in the vehicle under real conditions. The same high-voltage measurement technology is used in both types of test, ensuring comparable measurement results.

The overall battery system also includes the cooling and heating system, as well as the battery management system (BMS) with fault management. The task of the BMS is to operate the battery system in the optimum temperature range, and should also

ensure a constant temperature inside the battery under load conditions. At lower temperatures, the cells have a higher internal resistance due to changes in the electrolytes, and the power consumption decreases. Higher temperatures also cause problem chains: electrolyte decomposition – heat generation – reduction in the number of cycles – faster aging.

Ideal operating range for battery cells		
-20°C	18°C	60°C
Lower point	Ideal range	Upper point

The various issues involved in verification are, for example:

- ▶ Are the expected battery conditions met in various standard situations: fast charging, acceleration, high current operation?
- ▶ How do the individual cells behave under extreme load and during recuperation?
- ▶ Do the cells behave as planned in the non-optimal temperature range?
- ▶ Is the balance between the cells correctly regulated?
- ▶ What is the temperature distribution in the battery under real driving conditions?
- ▶ Run error cases correctly, e.g. when the circuit-breakers open?



## Challenge

For temperature measurement in the battery under test, the placement of the sensors must be planned precisely. Batteries in electric vehicles may be so large that they often occupy the entire vehicle floor.

It is not uncommon to include 80 to 300 measuring points in a typical battery test setup.



## The CSM Measurement Solution

For measurement, HV-safe thermocouple cables are fed into the battery via sealed cable glands. The multiple thermocouple cables provide a reliable connection to CSM temperature measurement modules via their fully

Temperature measurements are typically performed with type K thermocouples. The HV-safe multiple cables are available with particularly small sensor ends of 1 mm to be able to measure also at narrow places.

If a higher accuracy than  $\pm 1^\circ\text{C}$  is required, resistance temperature sensors PT100 or PT1000 are used. The high-precision HV PT100/PT1000 sensor cables used are very thinly welded into a foil strip at their tip. This foil strip is attached in the battery at the critical points between the cells or modules.

The sketch (page 1) shows a mobile arrangement in the vehicle, which also measures battery current and output power via an HV Breakout Module. The picture on the right shows the temperature measurement in a test bench setup.

With the special CSM **HV PT** or **HV TH measurement modules**, conventional temperature sensors from low-voltage applications can also be used safely in the HV environment thanks to HV-safe cables.

The modules are available as space-saving mini-modules for mobile use or as 19-inch modules for easy installation in test benches.

PT100/PT1000 sensors and thermocouples are suitable for temperature measurement with a manageable number of measurement points. For demanding measurements with several hundred temperature sensors, which are to be installed in an exact and reproducible arrangement, the IC sensors on ultra-thin flexible circuits of the **HV DTemp measurement system** is suitable.

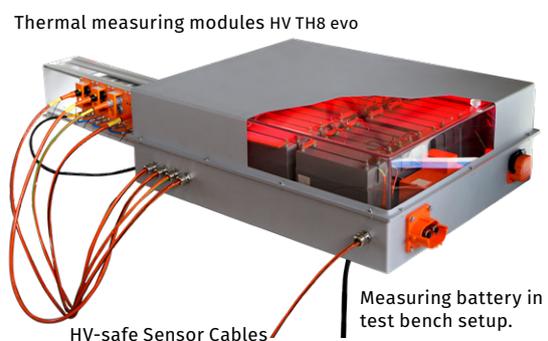


Fig. 2: Temperature measurement in a HV battery on the test bench.

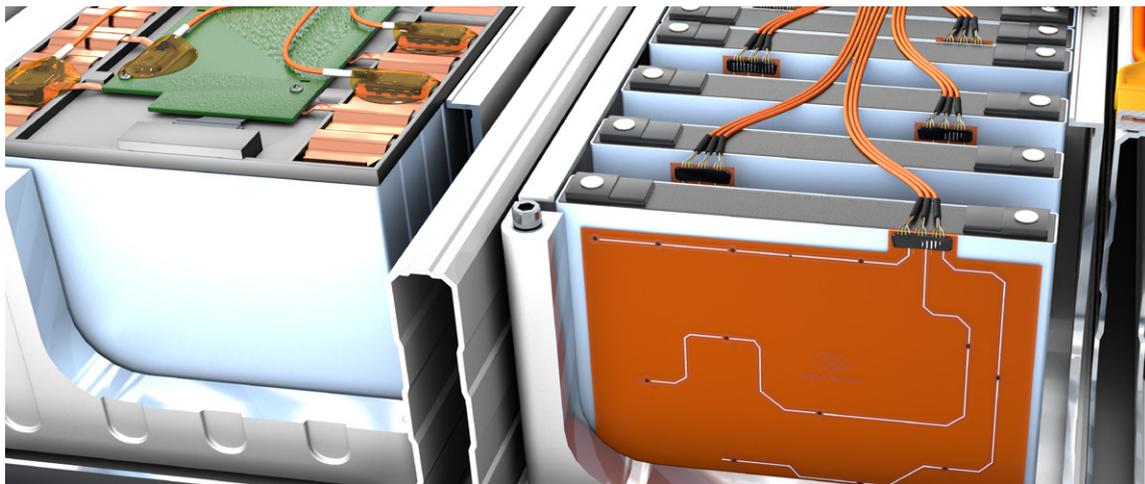


Fig. 3: HV DTemp Measurement System installed in a HV battery with prismatic cells. The IC sensors on larger ultra-thin flexible circuits allows positionally accurate and reproducible measurements directly between battery cells.

- ▶ The CSM HV measurement system guarantees a tested safety concept for measuring in live components from measurement module to plug and measurement cable up to the sensor tip.
- ▶ HV batteries can be equipped in advance with temperature sensors at the desired measuring points during assembly.
- ▶ Additional measurements with acceleration, humidity, pressure sensors and strain gauges are easily possible with the CSM HV measurement system.
- ▶ The same measurement technology can be used on the test bench, in the climate chamber and in test vehicles with the CSM measurement system.

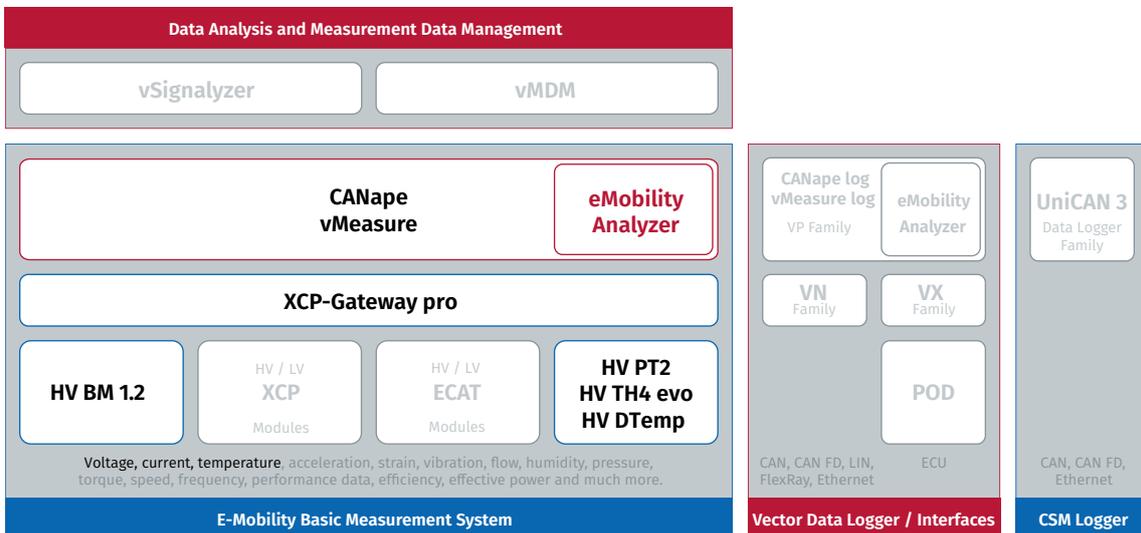


Fig. 4: The safe temperature measurement in high-voltage batteries in the systematics of the Vector CSM E-Mobility Measurement System



## Benefits

Often additional parameters must be determined. Acceleration sensors in the battery are used to track vibrations acting on the battery. Strain gauges are used to observe the twisting of the battery in the underbody. Humidity and pressure sensors help to

check the current operating status of the battery for tests. Such additional measurements can be performed with additional CSM HV measurement modules.



## Featured Products

### HV Breakout Module - Type 1.2

CSM's HV Breakout Module (BM) Type 1.2 was designed for single-phase measurements of current, voltage and power. It is ideal for measurement on large consumers such as electric motors equipped with separate HV+ and HV- cables.

The HV Breakout Module 1.2 is available in two versions for connection via cable glands or PL500 plug-in system (HV BM 1.2C).



### HV PT2

CSM's HV PT2 measurement module with 2 measurement inputs in 4-wire technology for PT100 or PT1000 sensors was specially designed for precise temperature measurements in a high-voltage environment.



### HV TH4 evo

CSM's HV TH4 evo measurement module allows safe temperature measurements with thermocouples on high-voltage components. Thanks to its compact design and reinforced insulation up to 1,000 V RMS, it is particularly suitable for decentralised use in road tests.



### HV TH8 evo

The HV TH8 evo thermal measurement module allows high-voltage safe temperature measurements with thermocouples on high-voltage components. With its 19-inch slide-in housing and reinforced insulation up to 1,000 V RMS, it is particularly suitable for use in test benches.



### HV DTemp

The CSM HV DTemp measurement system is designed for the digital and precise measurement of up to 512 temperature measurement points via a single cable connection to the HV DTemp Central Unit. With the flexible and reproducible arrangement of the HV DTemp 4 Sensor Modules, temperature curves can be recorded precisely between the battery cells.



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](http://www.csm.de) or via e-mail [sales@csm.de](mailto:sales@csm.de).



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