High-Voltage temperature measurement

Safe Temperature Measurement in High-Voltage Batteries

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.

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.

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?

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.

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 insulated HV plastic plug.
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 +/- 1 °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.

**Measurement of vibration, torsion, humidity and pressure**

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.

**Advantages of CSM HV measurement technology**

- 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.
**Featured Products**

**HV Breakout Module - Type 3.1**

CSM’s HV Breakout Module (BM) Type 3.1 was developed for the three-phase determination of current, voltage and power on high-voltage carrying cables with currents up to ±32 A. One module performs three-phase measurement, therefore offering enormous cost and space advantages.

**HV Breakout Module - Type 1.1 | 1.2**

CSM’s HV Breakout Modules (BM) Type 1.1 and 1.2 have been specifically designed for safe measurement applications on high-voltage cables. Current and voltage are measured and the instantaneous power is calculated online in the module.

**HV PTMM 2**

CSM’s HV PTMM 2 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 THMM 4**

CSM’s HV THMM 4 measurement module was specially designed for reliable temperature measurement on high-voltage components, and is therefore ideally suited to mobile and stationary use in the field of E-Mobility applications - electric and hybrid vehicles.

CSM provides you with comprehensive complete packages consisting of measuring 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.