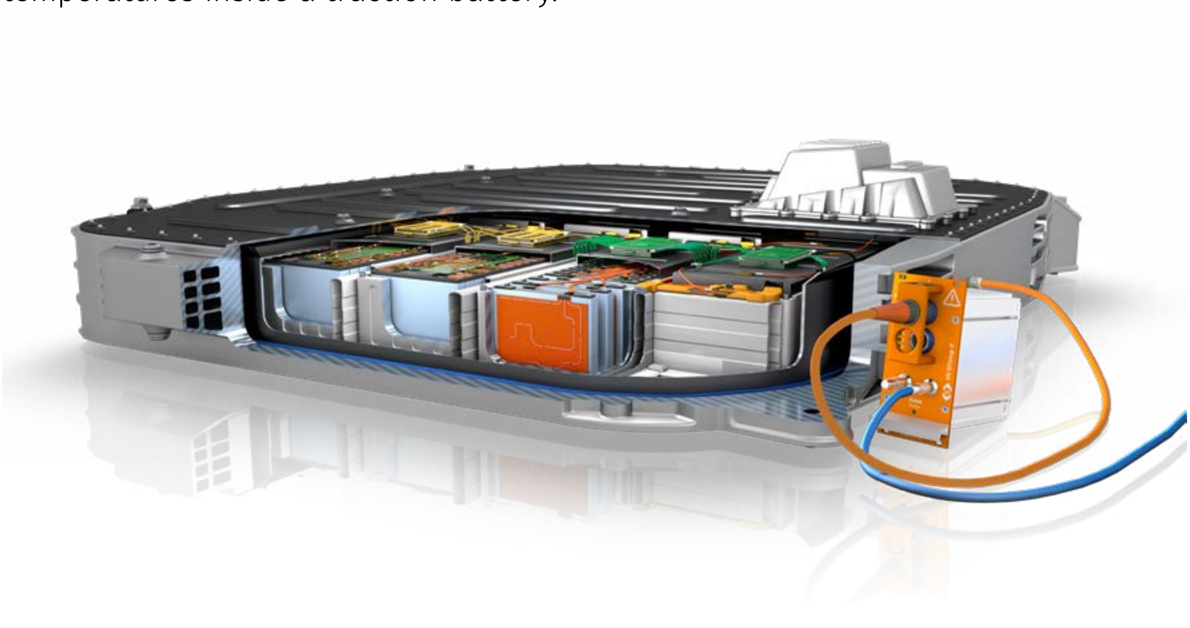
CSM

Understanding and Early Prevention of Thermal Runaway

HV Temperature Measurement

The mobility transition is essentially determined by the battery-powered, electric drivetrain – the optimization of the HV battery is therefore an important adjusting screw. One parameter is the focus of testing: temperature. It is relevant for the flawless and efficient operation of the vehicle. Valuable findings for the safety and correct design of the system can be derived from observing the thermal behavior. This is a good reason to perform detailed and close-meshed measurements of the temperatures inside a traction battery.



Why measure temperatures?

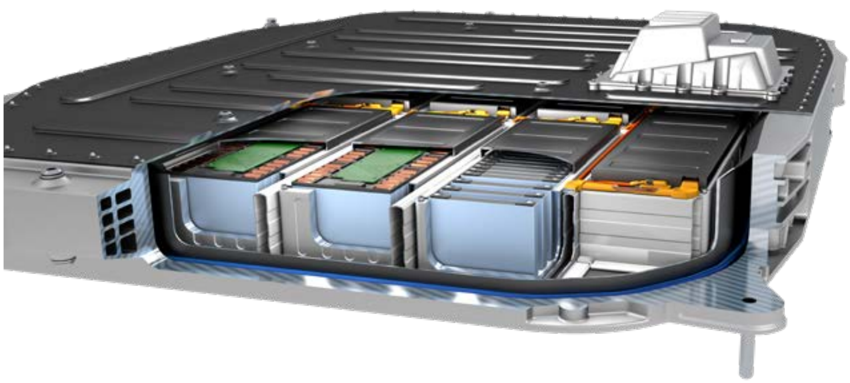
The use of an HV battery in a vehicle requires consideration of many aspects, including whether safe operation is possible in every conceivable scenario. One emergency that should be avoided at all costs is a “thermal runaway”. In this case, a malfunction of the battery cells leads to a chemical chain reaction and an uncontrolled and unstoppable fire in the battery. Failure to prevent or predict this in time can lead to considerable damage to property and personal injury. For this reason, the individual situations that can lead to a thermal runaway are examined in detail. These include, in particular, the temperature effect on the neighboring cells and modules as well as the heat transfer and accumulation within the battery.

Important influencing factor

The performance of high-voltage lithium-ion batteries is significantly influenced by temperatures due to their chemical properties - the optimum range is from 15 °C to 35 °C. At lower temperatures, the chemical processes in the battery are significantly slowed, which reduces the energy and power capacity - high temperatures also have a negative effect, as they can destroy the battery in extreme cases. One source of high temperatures is self-heating, which is caused by entropy changes and ohmic losses when charging and discharging the battery. As a result, over time different temperatures occur during different load conditions. The spatial distribution of temperatures is also by no means uniform: even within a single cell, they differ significantly in different areas. Dangers can arise from locally limited areas, so-called “hot spots”, with very high temperatures. These increase the risk of internal short circuits and affect all typical cell designs - cylindrical cells, prismatic cells and pouch cells - equally.

Monitor temperature management

To keep the ideal temperature constant, a powerful cooling and heating system must be installed in the battery housing to ensure that the battery neither overheats nor cools down too much. Temperatures must also be monitored here: Is the temperature management system successful and does it cool or heat the battery (evenly) to the desired temperature? The thermal behavior of all subsystems within the battery housing must be known. Simulations are often used in the development phase, but these cannot describe the complex chemical processes and their effects within the battery accurately enough for all situations, so extensive measurements are necessary. Precise measurements at cell, module and battery levels are necessary to verify operational safety and the effectiveness of the constructive properties.

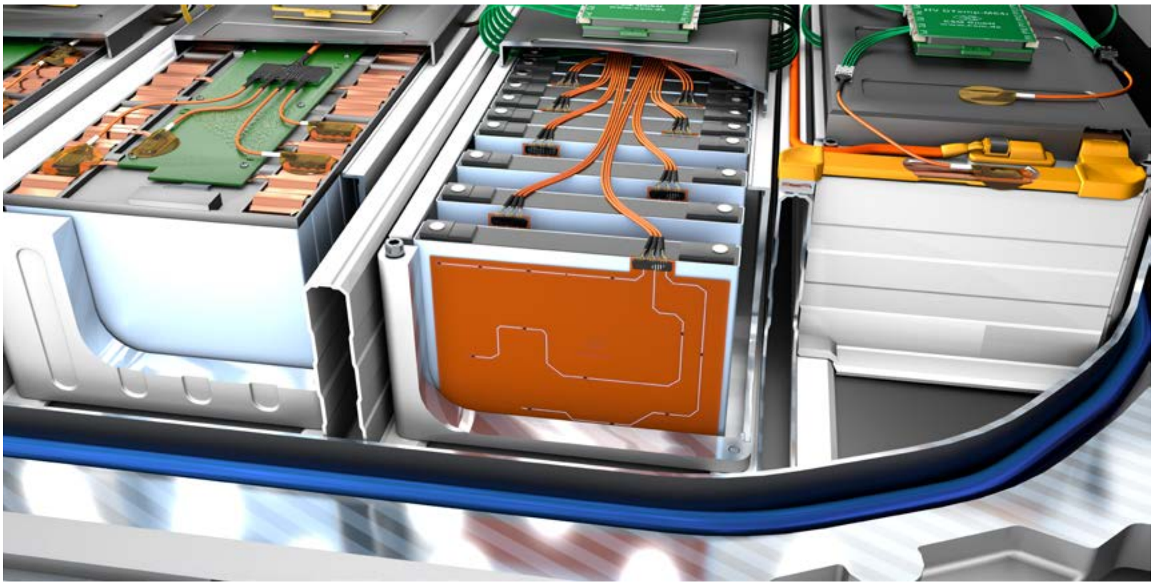


Many measurement points with the fewest interventions possible

Various types of batteries, including cylindrical, pouch or prismatic cells, are currently found in the traction batteries of electric vehicles. These in turn form battery modules, which are arranged in groups and connected by busbars and complemented by the cooling system to form the overall battery. Scalable measurement technology that offers suitable sensors for all these concepts is desirable for the necessary measurements during the various development phases. In addition to the measurement points on the battery cells, sensors must also be installed on the charging electronics, the busbars and in the coolant. Although this close-meshed monitoring of many temperatures on all components of the HV battery provides a very precise picture of the thermal processes, it also means that many measurement points have to be installed in a very confined space. At the same time, the sensors and their sensor cables must be small enough to be positioned between the cells. This poses new challenges for the testing engineers - how can these requirements be implemented without interfering too much with the battery and the housing? After all, the more intact the test specimen - in the case of the HV battery, the housing - is, the more realistic results can be expected from the measurements, as the sealing of the battery housing is an important factor for safe operation. There is also another safety aspect to consider: The entire measurement setup must be safe for use in the high-voltage (HV) environment so that personal protection when working on the HV battery meets the necessary safety standards.

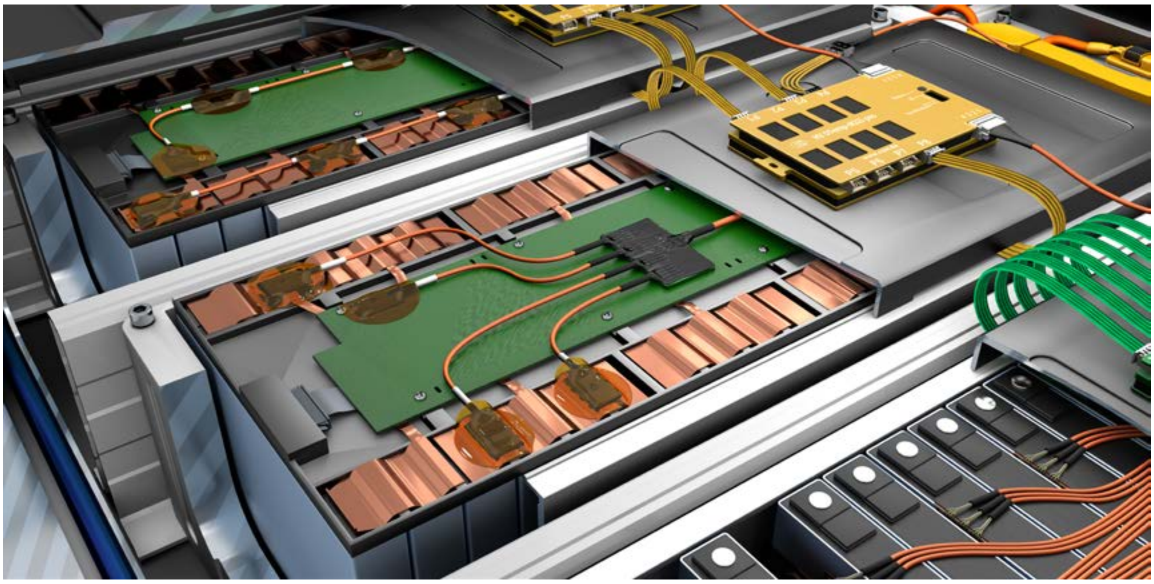
Measure at up to 512 points - with just one sensor cable

With the **HV DTemp measurement system** from CSM, comprehensive and precise temperature measurement in HV batteries can be performed safely. It enables the precise, digital, and interference-free acquisition of up to 512 temperature measurement points with a single sensor cable to the **HV DTemp-P central unit**. With miniaturized and interference-free **IC temperature sensors**, the overall system not only offers a measurement accuracy of ±0.1 °C to ±0.25 °C, they can also be applied particularly flexibly. Depending on the application, there are individual options for how the sensors can be installed, for example as encapsulated **individual sensors** or mounted on an **ultra-thin flexible circuit** – ideal for measurements between different cell types. For measurements on busbars, the sensors are used as individual sensors with a connecting cable for direct attachment to an **HV DTemp controller**.



An easily scalable system

Up to four IC temperature sensors can be connected as a sensor assembly to detect temperatures on the battery housings. These are either installed in series or connected via a small distribution board. The HV DTemp IC sensors are connected via HV DTemp controllers. Up to 16 sensor assemblies (corresponding to 64 temperature sensors) can be connected to one controller and up to eight controllers can be cascaded: They therefore provide connections for up to 512 temperature sensors. The controllers address the sensors, supply them with voltage and forward the temperature values to the central unit. All HV DTemp controllers are connected to the central unit via a high-voltage-safe sensor cable. All that needs to be done is to drill one hole with a cable gland in the battery housing. The HV DTemp-P Central Unit records the data from the HV DTemp controllers and ensures high-voltage safety through galvanically isolated inputs. In addition, the central unit assigns an individual CAN ID to each measurement point, enabling simple identification. All signals are transmitted in digital form, which minimizes susceptibility to interference. The measurement data is transferred to the measurement computer via CAN.



Analyze HV batteries precisely and comprehensively

With the growing importance of electromobility, it is becoming increasingly important for HV-safe measurements of temperatures at many points in and around the battery. One of the difficulties here is to intervene as little as possible in the battery. For this reason, all components of the HV DTemp system have a compact and robust design, so that the HV DTemp-M controllers can be easily installed in the battery housing, for example. As only one measurement module is required outside the battery, the system has a space-saving design with minimal impact on the measurement object. The sensors can be positioned between the cells, allowing the precise acquisition of temperature curves. The arrangement of the sensors on an ultra-thin flexible circuit can be repeated exactly from cell to cell. As each measurement point is clearly identifiable, measurement scheme planning is simplified and cabling errors are eliminated. The scalable system also offers further areas of application in the HV environment - for example, temperature measurements on other components of the electric powertrain, such as the inverter.

Featured Products

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 IC sensors, temperature profiles 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 or via e-mail sales@csm.de.

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