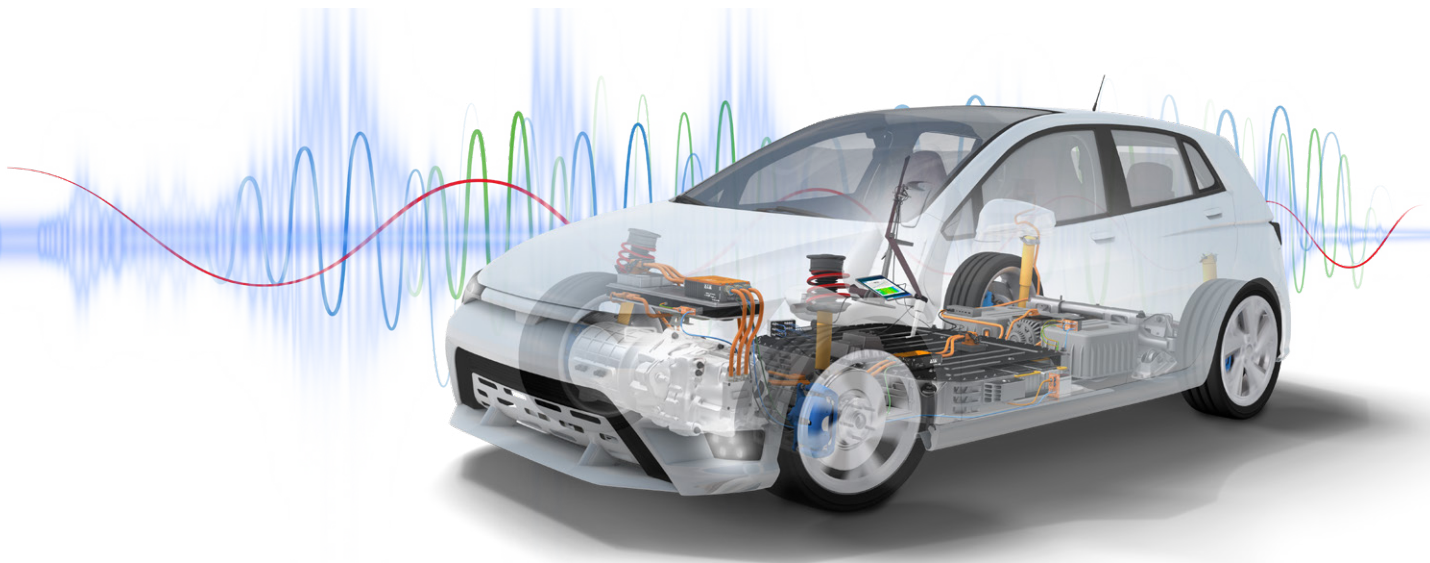


# High-voltage Measurement Technology and NVH in Mobile Testing



NVH Measurement

Electrification of the vehicle powertrain poses major challenges for the interaction of the individual components. Influencing factors include the high-voltage electrical system and its connected assemblies, new materials and the elimination of masking noise sources. With synchronous acquisition of NVH and powertrain performance data, it is possible to take a holistic view of development issues and efficiently address conflicting goals between acoustics and performance.



## Background

The move towards electromobility is changing the requirements for powertrain engineering and testing. New materials and technologies as well as a multitude of high-voltage components are leading to new acoustic and vibration-related challenges.

The development of new, high-performance electric vehicles requires innovative, holistic engineering and testing. For the development, a measurement system is required that combines both e-mobility power analyses and NVH analyses.

## Challenge

Testing and engineering tasks must be solved quickly and efficiently. For this purpose, highly specialized systems are available for a wide variety of tasks, whose data streams have not been recorded synchronously, until now, and thus require time-consuming, manual post-processing of the data.

Individual tasks are often processed one after the other. This blocks test bench capacities and human resources for longer.

Today's electric vehicles, their high-voltage electrical systems and their components are complex and compact. The measurement of currents and voltages must be HV-safe in shielded high-voltage power cables and confined installation spaces. At the same time, data from accelerometers, microphones and/or other sensors must also be acquired.

This means an increased number of measurement points and a significantly higher amount of raw data to be processed.

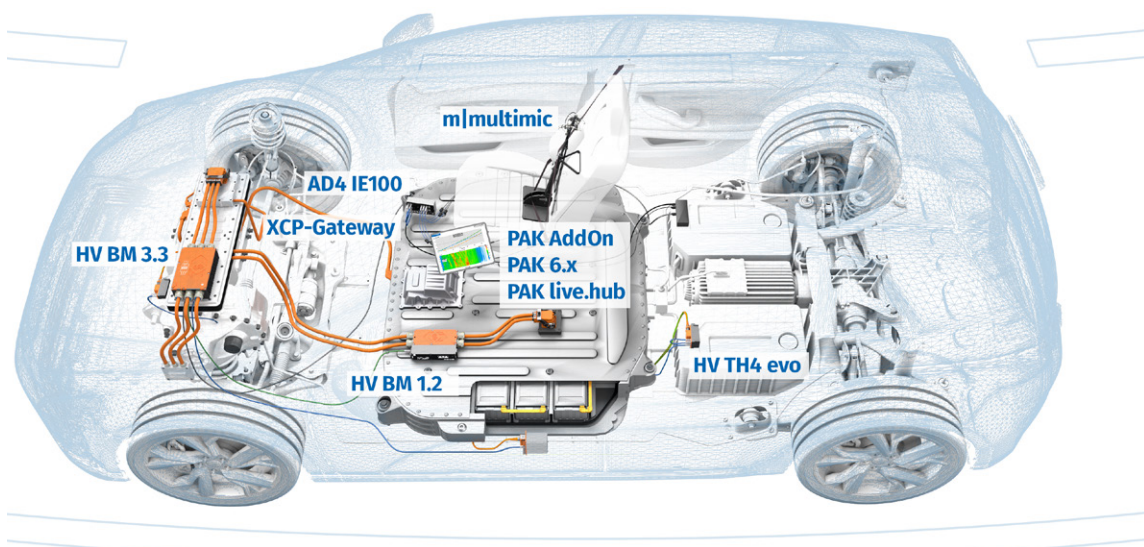
## The CSM Measurement Solution

To enable high-precision acquisition of dynamic data at high operating voltages and currents, a future-oriented system solution is required. With CSM as a new partner of the PAK live ecosystem from Müller-BBM VibroAkustik Systeme (MBBM-VAS), the data acquisition side is extended by CSM's specialty in mobile, robust, and compact measurement data acquisition in both low-voltage and high-voltage applications.

With this HV measurement technology for electric powertrains, real currents and voltages can be acquired and evaluated synchronously with other dynamic data in real time during operation.

For this purpose, the CSM measurement technology is placed directly in the high-voltage electrical system of electric and hybrid vehicles at the individual consumers that need to be evaluated. Each measurement module is compact, robust and interference-free for HV and LV environments.

The sensors and microphones used for vibroacoustic analyses are connected directly to CSM's **ECAT (EtherCAT®) MiniModules**.



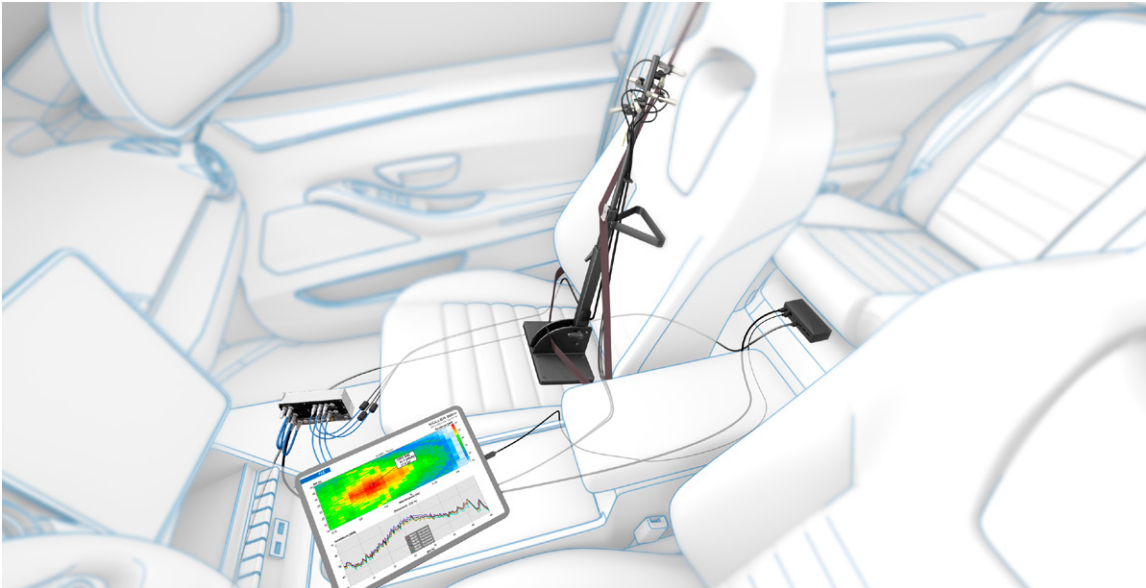


Fig. 1: The sensors and microphones of the multimic are connected directly to CSM ECAT MiniModules. This allows easy integration into the entire measurement chain.

The **HV Breakout Modules** used in the high-voltage electrical system simultaneously measure currents, voltages and power directly from the inner conductor of the HV power cables.

All modules used are networked via EtherCAT® and thus synchronized better than 1 μs. The CSM measurement modules are configured with CSM's own configuration software **CSMconfig**. This interacts with the **CSM PAK AddOn Manager**, which is included in the **CSM PAK AddOn**.

The CSM PAK AddOn allows easy integration of the CSM measurement modules into the MBBM-VAS measurement setup.

The **PAK AddOn Manager** is used for project management via a graphical user interface and for data preparation for a smooth integration into the PAK live ecosystem.

The measurement chain is integrated via an **XCP-Gateway** or **measurement modules** with direct XCP-on-Ethernet output. Via the **CSM PAK AddOn Server**, the measurement data is transmitted to the **PAK live.hub** of MBBM-VAS. All CSM modules continuously send the data stream to the PAK live.hub, which dynamically redistributes the data stream as a data hub.



Fig. 2: HV Breakout Module 1.2 for single-phase current and voltage measurement in the HV power cables between HV battery and inverter.

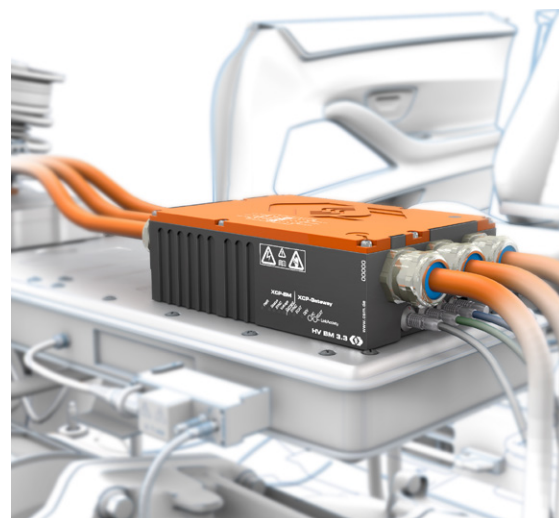


Fig. 3: The HV Breakout Module 3.3 measures the currents and voltages directly in the HV power cables between the inverter and the electric motor.



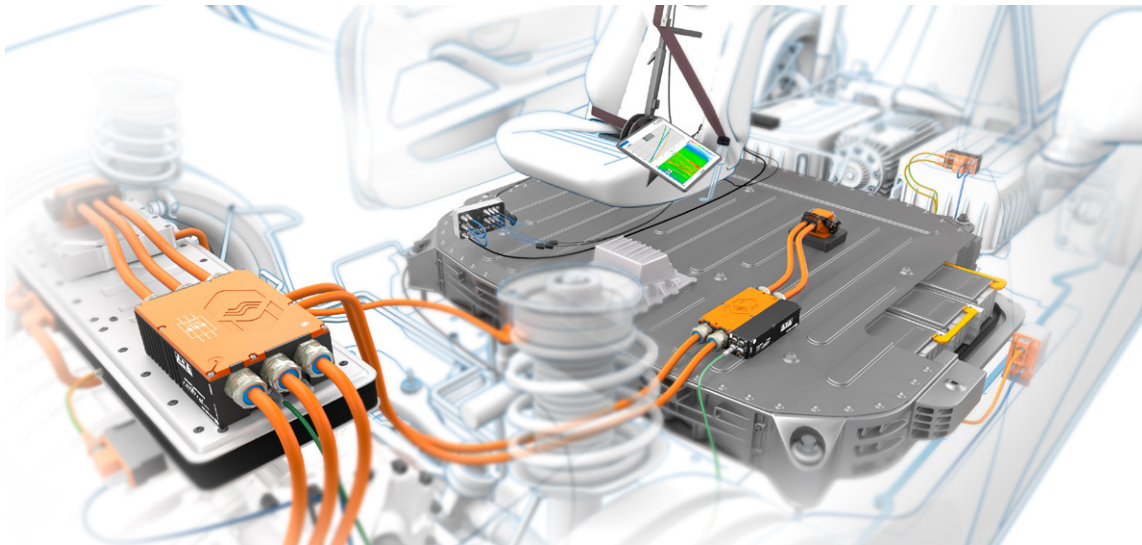


Fig. 4: With a lean measurement setup, the acoustic analyses can be easily correlated with performance values of the components in the electric powertrain.

The **PAK live.hub** provides the PTP-synchronous data stream in real-time to the PAK NVH software suite. With PAK, the acquired data can be evaluated in real time - whether ECU, power or NVH data.

- ▶ Rotor positions from resolver/encoder data
- ▶ Frequency/Order analysis for PWM fans
- ▶ Sound Design and psychoacoustic parameters
- ▶ Electrical and mechanical performance
- ▶ Electrical cycle

In addition to the E-NVH/E Power-analyses, such as

- ▶ d/q Transformation
- ▶ Modulation Analysis
- ▶ Torque Ripple

comprehensive analyses in the areas of structure, rotation and sound quality can be performed with PAK.

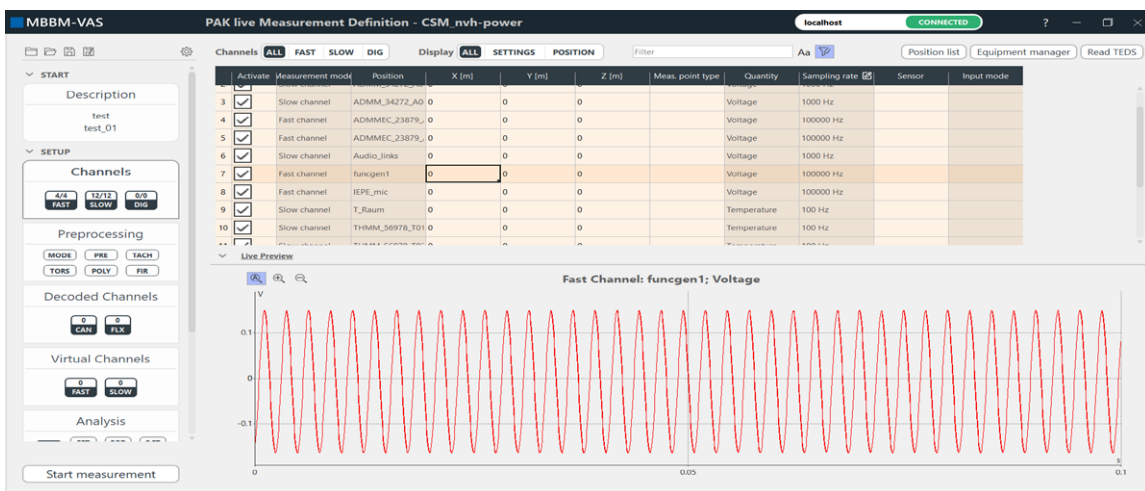


Fig. 5: Measurement setup in PAK 6.x (Müller-BBM VibroAkustik Systeme).

Intelligent networking of the data streams allows various tasks to be solved with just one measurement setup, thus accelerating testing processes in the long term. Interdisciplinary work and context-related statements on cause and effect are implicit.

The scalable system solution combines powerful measurement technology with precisely tailored applications in an open ecosystem.

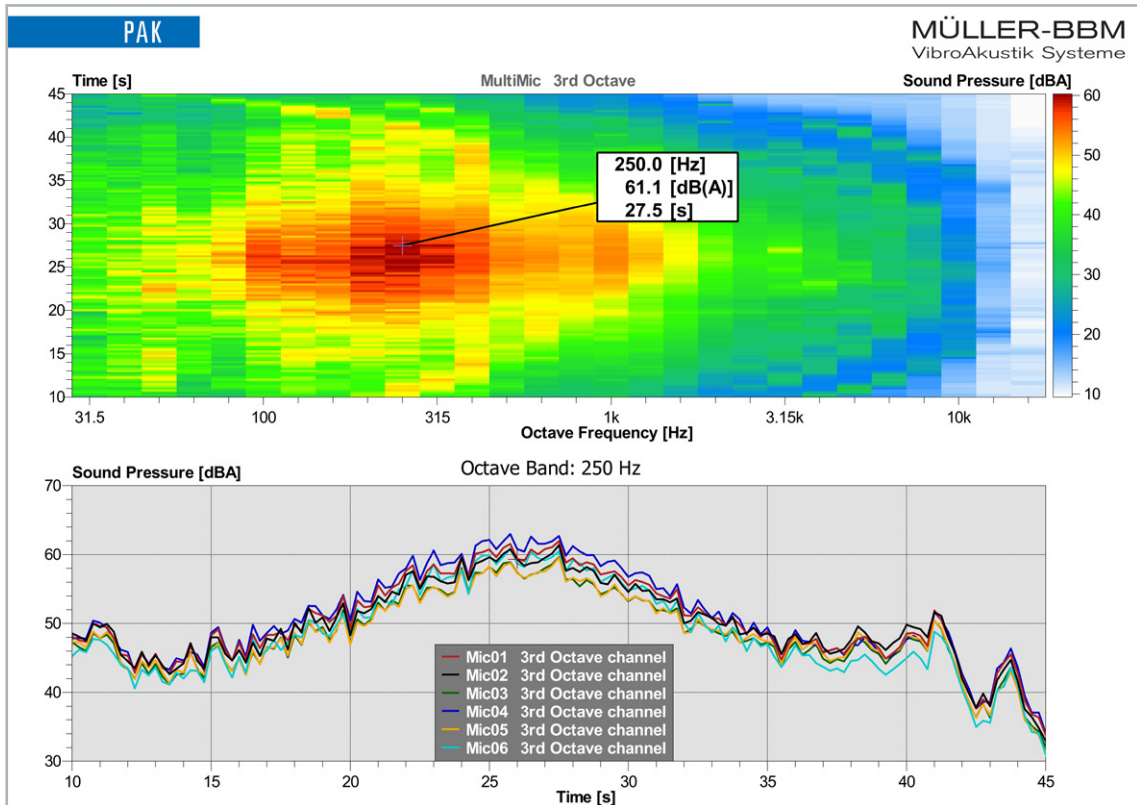


Fig. 6: Spatially averaged sound pressure level in the vehicle interior (Müller-BBM VibroAkustik Systeme).

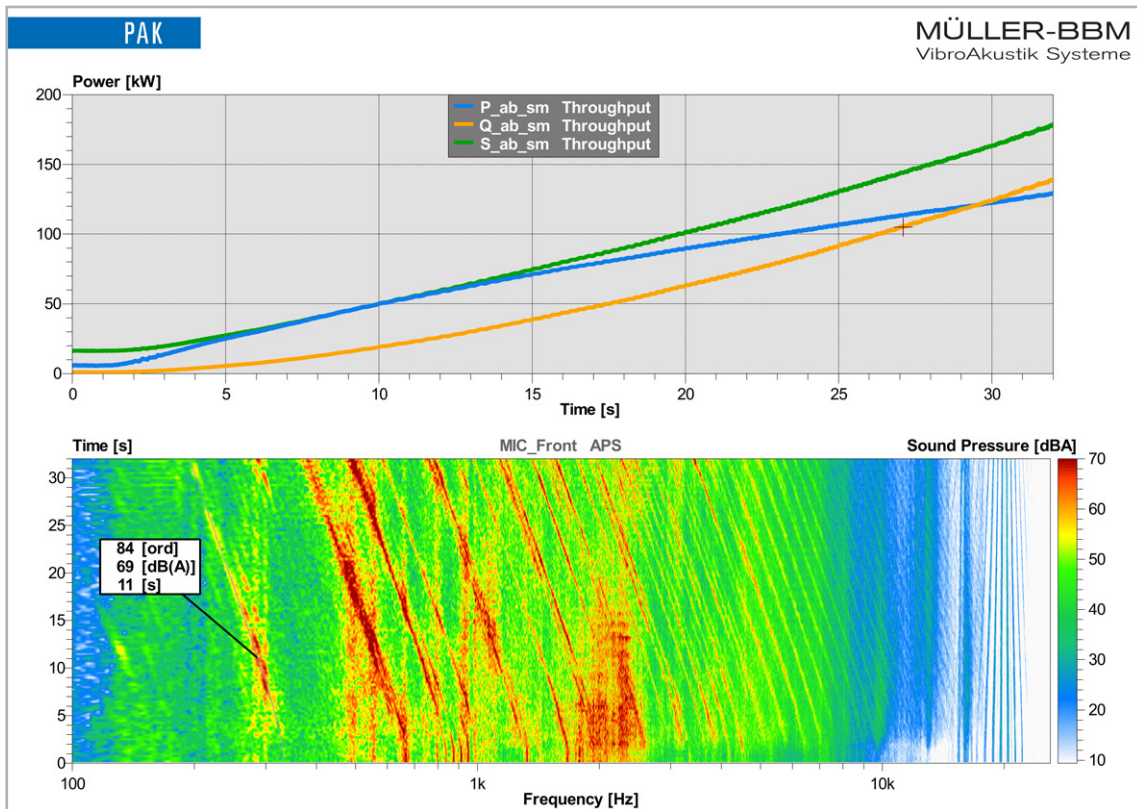


Fig. 7: Performance and NVH Testing – Comfort level evaluation of powertrains (Müller-BBM VibroAkustik Systeme).



## Benefits

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- ▶ Fast, mobile measurement with robust measurement technology for the validation of acoustic and power phenomena
- ▶ High-voltage-safe, PTP-synchronous data acquisition of analog and digital measurement variables with up to 1 MHz sampling directly at the relevant sources
- ▶ Distributed, compact measurement setup for reliable data acquisition especially in confined spaces in multiple locations around the vehicle, including harsh environments
- ▶ Direct measurement of current, shield current, voltage and power in high-voltage power cables
- ▶ Current, voltage and power measurement in electrical powertrains with synchronized NVH analysis for correlation of acoustic and electrical phenomena
- ▶ Real-time analysis of the measurement data stream
- ▶ Powerful graphical reporting online & offline
- ▶ Increased added value around measurement data through context-aware engineering
- ▶ Integrated measurement data management based on cloud technologies



## Featured Products

### HV Breakout-Module – Typ 3.3

The HV Breakout Module (BM) 3.3 has been specially designed for safe and precise three-phase measurement in HV cables. The inner conductor currents and outer conductor voltages are directly acquired and output 100 % synchronously and phase-accurately via XCP-on-Ethernet.

The connection is made either via cable glands through which the HV cables are led into the module (HV BM 3.3) or via a PL300 plug-in system (HV BM 3.3C).



### 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 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 1,000V RMS, it is particularly suitable for decentralised use in road tests.



### AD4 ECAT MM-Series – Typ IE 100

CSM's AD4 ECAT IE100 measurement module is ideally suited for the most accurate analysis of high-frequency signals with measurement data rates of up to 100 kHz per channel. It offers a high-precision and unipolar sensor excitation from 5 to 24 V DC for a variety of sensors.



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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