

CONNECTED MEASUREMENTS.

High-Voltage Measurement Technology and NVH in Mobile Testing

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.

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 partner of the PAK live ecosystem from Müller-BBM VibroAkustik Systeme (MBBM-VAS), the data acquisition side is extended by a specialist in mobile, robust, and compact measurement data acquisition in both low-voltage (LV) and high-voltage (HV) 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.

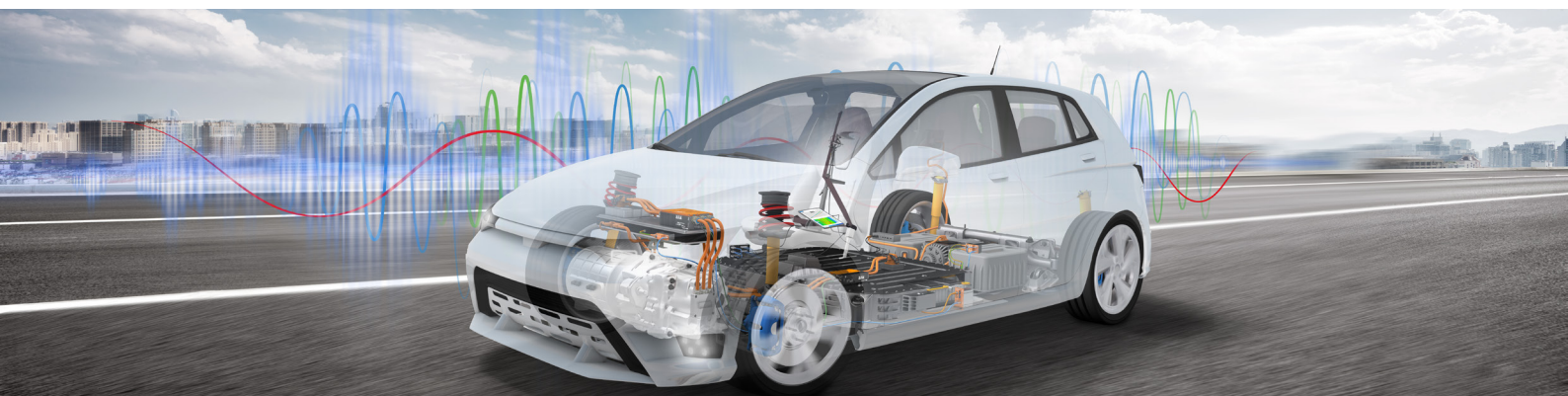
The sensors and microphones used for vibroacoustic analyses are connected directly to CSM's ECAT (EtherCAT®) MiniModules.

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 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 NVH measurement setup.

The measurement chain is integrated via an XCP-Gateway or

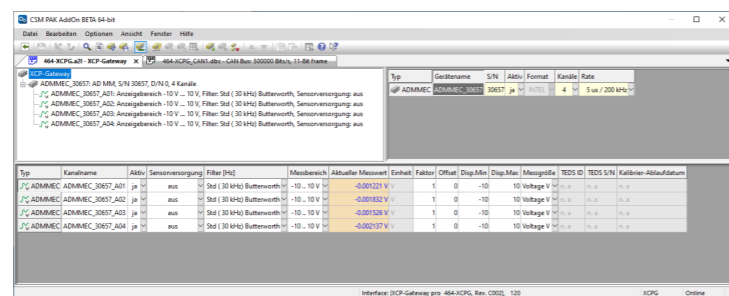


measurement modules with direct XCP-on-Ethernet output.

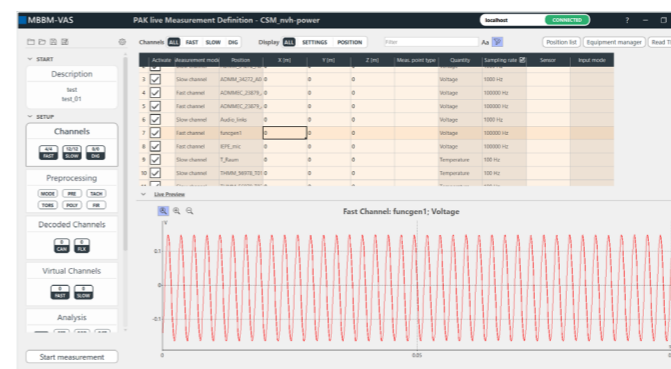
Via the CSM PAK AddOn Server, the measurement data is transmitted to the PAK live.hub of MBBM-VAS. All CSM modules continuously send the data stream to the PAK live.hub, which dynamically distributes the data stream as a data hub.

The PAK live.hub provides the PTP-synchronous data stream in real-time to the PAK NVH software suite.

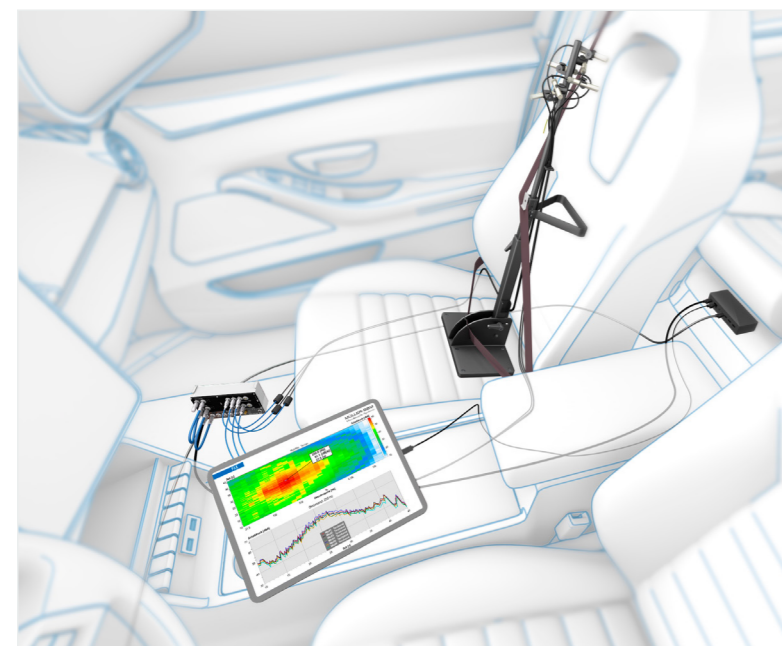
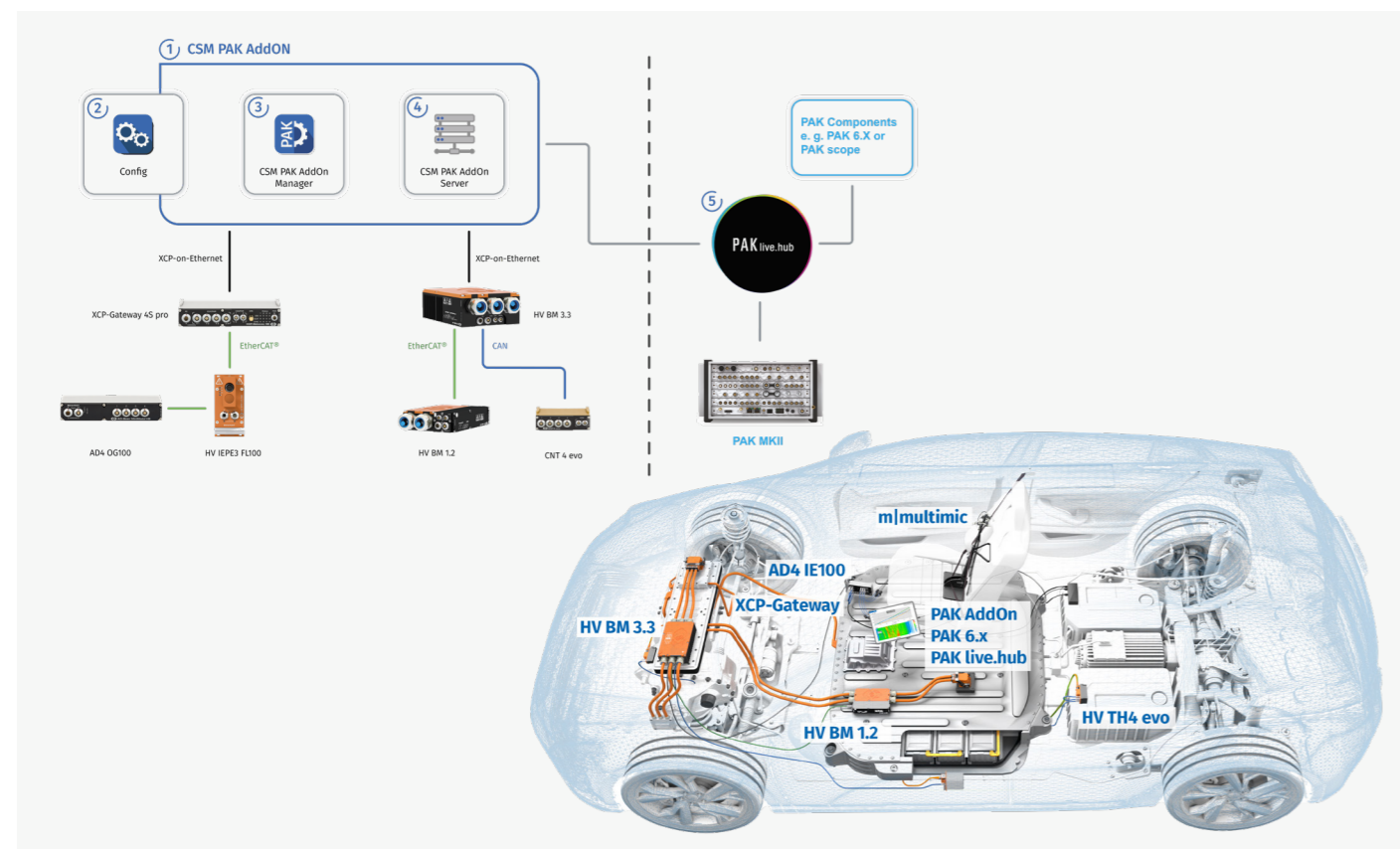
With PAK, the acquired data can be evaluated in real time – whether ECU, power or NVH data.



CSM PAK AddOn configuration



Measurement setup in PAK 6.x



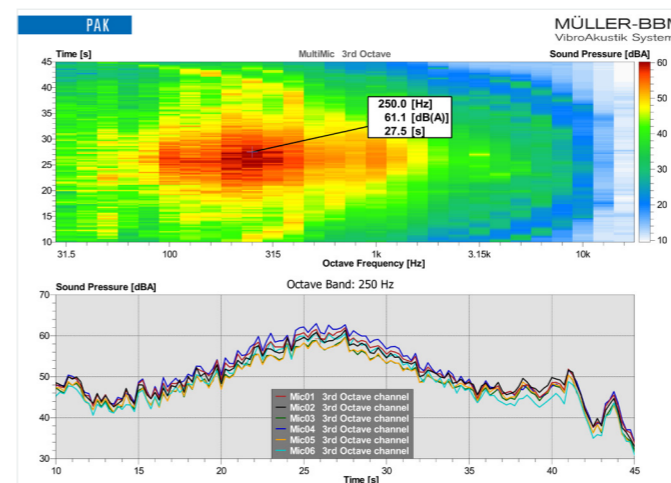
The microphones of the m|multimic® are connected directly to CSM ECAT-MiniModules.



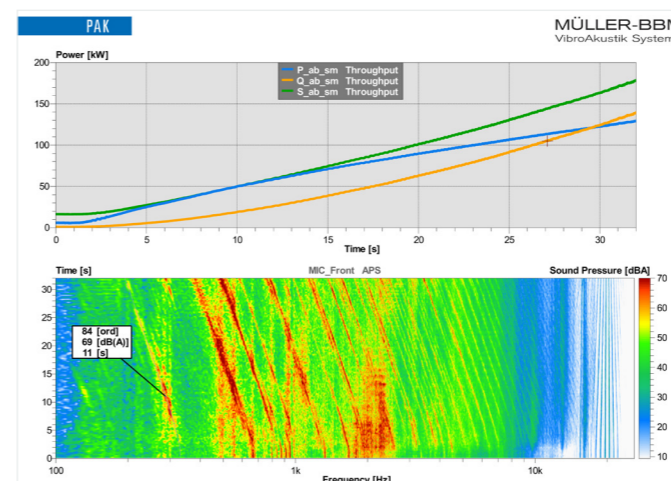
HV Breakout Module 1.2 for single-phase current and voltage measurement in the HV cables between HV battery and inverter.



The HV Breakout Module 3.3 measures currents and voltages directly in the HV power cables between inverter and e-motor.



Spatially averaged sound pressure level in the vehicle interior



Performance and NVH testing – Comfort level evaluation of powertrains

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

- d/q Transformation
- Modulation Analysis
- Torque Ripple
- Rotor positions from resolver / encoder data
- Frequency / Order analysis for PWM fans
- Sound Design and psychoacoustic parameters
- Electrical and mechanical performance
- Electrical cycle

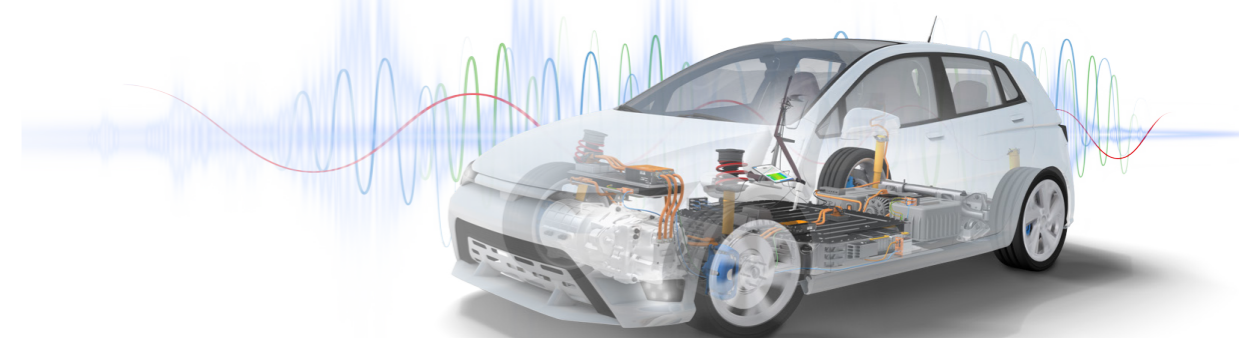
comprehensive analyses in the areas of structure, rotation, and sound quality can be performed with PAK.

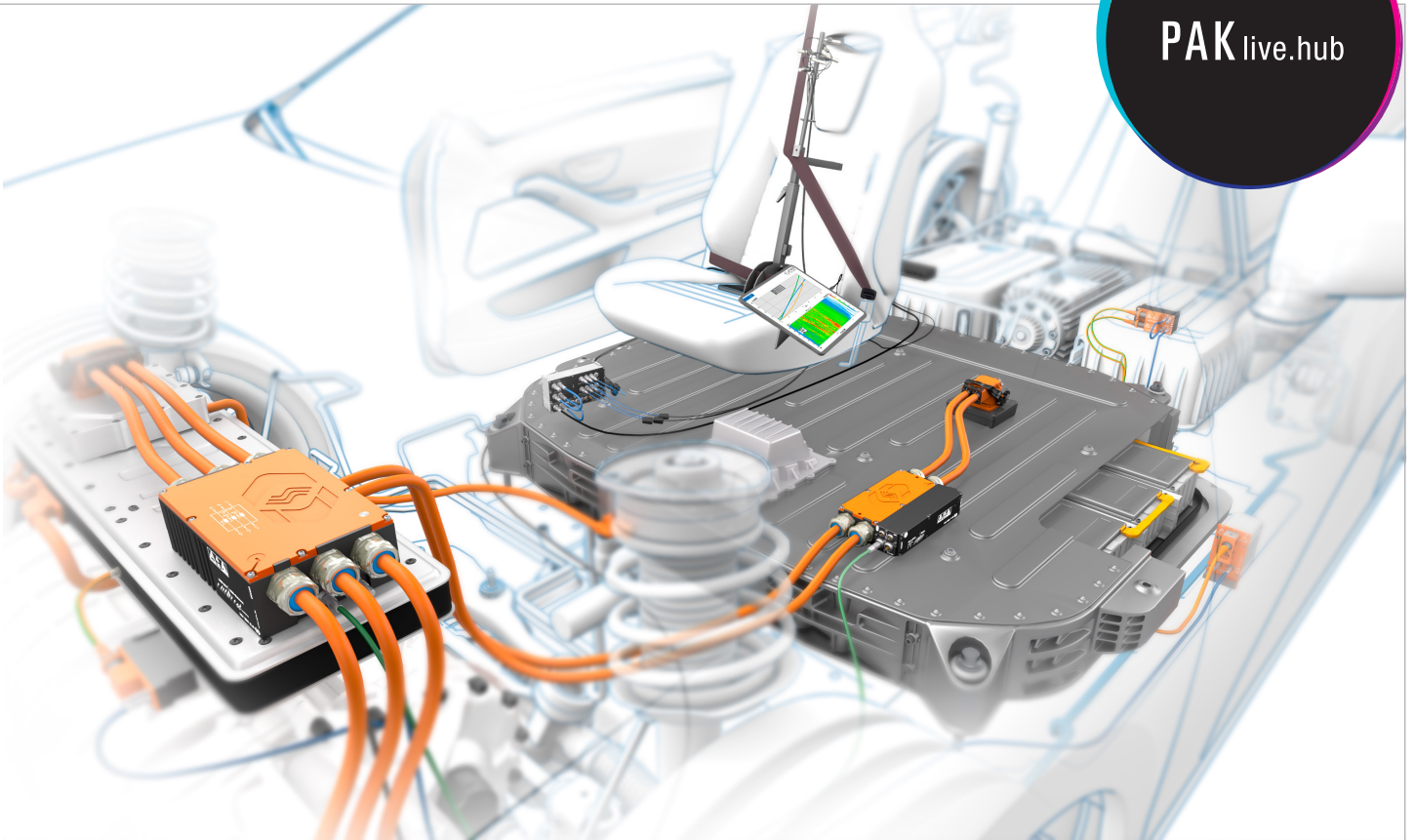
Intelligent networking of the data streams allows various tasks to be solved with just one measurement setup, thus accelerating testing processes in the long term. Interdisciplinary work and context-related statements on cause and effect are implicit.

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

Benefits

- Fast, mobile measurements 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 and 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





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

Featured MBBM-VAS' products

Measurement and Analysis Software

- **PAK live.hub** precisely connects data sources and applications and, as a data hub, dynamically controls the synchronous data flow of performance, ECU, test bench, bus, and NVH data
- **PAK 6.x** is the software for dynamic data acquisition and comprehensive analysis of measurement data, especially in the field of NVH and the correlation with performance variables

Data Management (optional)

- **PAK cloud** enables worldwide access to measurement data and seamless interaction with the measurement data

About us

Müller-BBM VibroAkustik Systeme is a global solution provider for the acquisition and analysis of physical data and the measurement data management. The PAK family software is used industry wide.

Our credo is openness, which we actively promote by continuously integrating standards, such as ASAM ODS, CAN, EtherCAT®, IENA, iDDS and openMDM®, and collaborating with innovative technology partners.

This openness is the foundation of our open platform architecture, which allows ecosystems to emerge around physical data – through the custom-fit integration of analog and digital data sources as well as smart applications.