MÜLLER-BBM

Condition analysis · Noise analysis · Design validation · Structural optimization

Multi-Channel Measurement Technology

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Multi-channel measurements by Müller-BBM – the key to increased quality, performance, and safety

In order to achieve a successful product development and optimization process as well as evaluating and monitoring machines, vehicles, and their components with confidence, the precise knowledge of these systems' dynamic behavior is crucial. This means that the system's response to excitations from regular operation or from defined signals (e.g. impulse hammer or shakers) needs to be observed simultaneously at multiple positions considering relevant physical quantities.

Measurements during operation

Multi-channel measurements performed on machines or vehicles during normal operation generate the data required for design validation and possible improvements.

To specifically correlate a certain system behavior to an operating condition, additional operational parameters are recorded along with the relevant airborne und structure-borne sound signals. All measurement data can also be transmitted via telemetry, e.g. when analyzing rotating components.

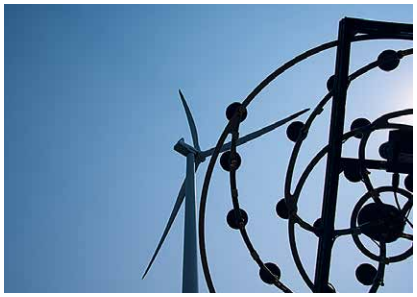
For analyses focusing on structural durability of single components, specific load spectra may be derived from strain measurements. The results can, for example, be used for an estimate of the individual component's life-time.

Measurement technology

Multi-channel measurement systems for vibrational investigations and acoustic analyses acquire highly accurate dynamic data and analyze them in real-time.

The PAK system developed by our affiliated company Müller-BBM VibroAkustik Systeme is a compact, modular measuring and analyzing system appropriate not only for highly standardized tasks, but also for flexible use in development or troubleshooting.

Intelligent controllers, integrated signal conditioning, as well as inputs for voltage and digital audio signals allow for dynamic measurements with an almost unlimited number of channels. Sampling rates up to 204 kHz with 24 bit quantization per channel can be achieved. In addition to a large number of analog measurement quantities, digital signals such as CAN, FlexRay™ and EtherCAT® can also be time-synchronously recorded and analyzed. Optionally, data can be stored directly on the PAK MKII measurement frontend.



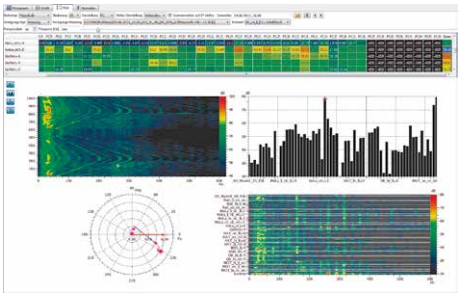
Array measurement technology

Array technology allows an efficient localization and evaluation of sound sources. It can be used in vehicle and engine test benches, but also for pass-by measurements or when analyzing large (industrial) facilities as well as other machines or their components.

From the signals of a spatially flat microphone arrangement, the distribution of source strength in a level parallel to the microphone level can be calculated directly. In doing so, the numerically realized beamforming replaces the time-consuming mechanical rotation of the focal point at the scan with a directional microphone.

Position and strength of single sound sources can be visualized in real-time by using color-coded contour graphs and therefore can be objectively evaluated even when varying in time or space.

An increased amount of measurement data does not always yield more information. The key to success is a clear understanding of the investigated system and an optimal measurement preparation – especially considering types, number, and position of sensors. Problem-specific analyses as well as the interpretation and summarization of measurement data are the next steps.



Transfer Path Analysis and Synthesis

By means of the Transfer Path Analysis (TPA) the transfer characteristics from source to receiver of airborne and structure-borne sound are determined in order to identify and effectively optimize the relevant transfer paths.

By linking source measurements to transfer functions in the Transfer Path Synthesis (TPS), the path contributions to the response signal can be calculated and ranked. To evaluate the influence of a path modification to the response signal, the path sensitivity is additionally determined with the Response Modification Analysis (RMA). The contribution of single emitting surfaces to the overall sound at the response position can be obtained by a Panel Contribution Analysis.

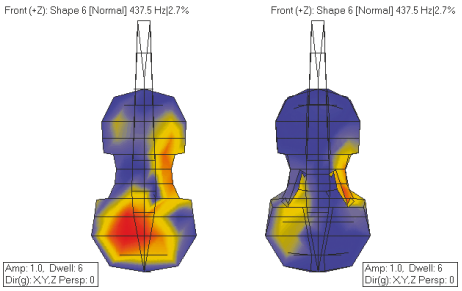
Users benefit from an efficient structural optimization process with regard to the acoustic and vibrational design. Time-consuming and cost-intensive modifications of the test object can be reduced to a minimum.

Operational Deflection Shape Analysis

While a well-defined external excitation is used in modal analysis to determine a structure's vibrational characteristic, Operational Deflection Shape (ODS) analysis determines a test object's vibration behavior under operating conditions.

Although it usually is not possible to clearly separate the system's structural properties from the properties of a specific excitation, ODS analysis often provides the required information for an effective problem identification and system optimization.

Additionally, deviations of mass distribution or pre-loads may cause changes in the structure's dynamic behavior during operation. In these cases the real system behavior can be described effectively by using vibrational analysis. The evaluation can be supported by the visualization of the structure's dynamic behavior.



Experimental modal analysis

When exciting components or structures with their natural frequencies, the occuring resonances may cause strong vibrations, increased sound emissions and in some cases even might affect the structure's stability.

Modal analysis can be used to specifically determine a structure's natural frequencies, vibration mode shapes and damping properties and therefore to identify the sources of undesirable vibrations.

The visualization of natural mode shapes supports the intuitive development of effective optimization measures, such as stiffening, additional masses or modification of damping characteristics. Dynamic structural modification allows for model-based evaluation of each modification's effect. Therefore, if experimental modal analysis is used side by side with numeric calculations early in the product development, it can pinpoint and prevent potential weaknesses in a structure's design.

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Müller-BBM has got many years of experience in the field of multi-channel measurement technology. The practical examples outlined below give a selection of possible applications. We would be glad to provide you with a customized solution to address your individual challenges best possible.

Monitoring systems

Multi-channel measurement technology is used in the continuous monitoring of machines and processes.

In the simplest case, measurement quantities such as airborne or structure-borne sound levels are used to display and document situations when limits are exceeded. Multi-channel measurement technology is also used in the continuous monitoring of the acoustic characteristics of road surfaces.

In order to fully evaluate a process or condition we use application-specific signal analysis. For example, a machinery monitoring system for maritime vessels developed by Müller-BBM continuously informs the operator about the structure-borne sound condition using red/green indicators in a ship scheme. In addition, the waterborne sound radiated by the ship can be predicted on the basis of the structure-borne sound condition.

Determination of acoustic material parameters in the test bench

Acoustical and vibrational material analysis is an effective tool for product development and product simulation.

In case the input parameters for these simulation models cannot be derived from geometric or elementary material parameters, they have to be determined using multi-channel measurement technology. Parameters such as the damping loss factor, absorption coefficient and flow resistance, as well as impedance or admittance, radiation coefficient, transmission loss, dynamic transfer stiffness and coupling loss factor can be determined.

Müller-BBM's measurement setups are always customized to the respective product. The input parameters for calculation models are evaluated on the basis of standardized procedures. This enables product developers to design, calibrate and validate realistic simulation models. The experts at Müller-BBM give comprehensive advice regarding the selection of appropriate measurement parameters.

Sound power measurements

Usually, the sound power level is used as a product-specific parameter to objectively evaluate a machine's or component's sound emission – independently from the acoustic properties of the location.

Müller-BBM performs measurements of the sound power level in accordance with international standards. For this purpose, special semi-anechoic test chambers with an especially low background noise level are available. In case of strongly inhomogeneous emission characteristics of the test object, the sound power level is calculated from multiple sound pressure levels measured on a given enveloping surface.

Multi-channel measurements help to significantly reduce the experimental effort, as all relevant points can be investigated simultaneously. Sound power measurements as well may be used as a tool for a continued acoustical monitoring during product optimization.

Examples of applications from project work

Railway vehicles

- Analysis of the vibrational behavior of the drive motor's rotors, of the interaction between motor, electric motor control and power train, data acquisition from rotating accelerometers, visualization of torsional vibrations
- Noise emission management for railway vehicles (e.g. contributions of stationary components, analysis of partial sound sources, assessment of measures, determination of the dynamic stiffness of coupling elements)
- Acceptance tests for interior and exterior noise emission
- Structural analysis of coaches and bogies

Automotive

- Transfer paths of the acoustically relevant partial sound sources
- Assessment of acoustic measures
- Locating of noise-dominating components at pass-by measurements
- Detailed analyses, e.g. of tyre/road surface interactions

Ships

- Checks of various, selected measurement points to determine the overall conditions
- Visualization and analysis of damaging vibrations in the resonance frequency of structures, e.g. of propellers

Household appliances and tools

- Assessment of the entire sound and vibration behavior e.g. of washing machines, vacuum cleaners, handheld equipment or other appliances

Industrial plants

- Petrochemical and other process plants, pipe vibrations
- Industrial large-scale machines, condition analyses, foundation vibrations

Buildings and transport

- Measurements of vibrations in buildings
- Automatic vibration monitoring of construction works
- Measurement of vibrational emissions of underground or surface railway systems, road traffic, industrial plants and blasting
- Measuring and monitoring of the acoustic properties of road surfaces

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Buildings

Building acoustics
Room acoustics
Media and communications technology
Thermal building physics
Building climatology
Sustainability
Fire protection
Structural dynamics
Building pollutants

Environment

Noise control
Air pollution control
Vibration control
Light and electromagnetic fields
Environmental compatibility
Plant safety
Legally compliant business organization
Risk assessment
Chemical analysis

Technology

Automotive acoustics
Ship acoustics
Rail technology
Industry plant acoustics
Machine acoustics and machine dynamics
Psychoacoustics
Mobile communication
Product testing

Comprehensive solutions from a single source

Consulting · Planning · Measuring Expert Opinion · Research

Müller-BBM GmbH is a subsidiary of Müller-BBM Holding AG, with headquarters in Planegg near Munich. Since 1962 Müller-BBM has been advising clients nationally and internationally and is now one of the world's leading engineering firms. More than 400 highly qualified employees form an interdisciplinary team of architects, scientists and engineers in the most diverse specialist fields. The company currently has twelve offices in Germany as well as branch offices in Austria and Switzerland.

Notifications

Müller-BBM is notified as an expert authority in accordance with § 29 b of the German Federal Pollution Control Act (BImSchG). The notification comprises

- determining emissions and immissions of air pollutants, noise and vibration,
- verifying the correct installation and function in addition to the calibration of continuous emission measurement systems (CEMS),
- checking combustion conditions.

As a test laboratory, Müller-BBM is authorized to render the services of an independent third-party provider for assessing and examining performance reliability in accordance with EU regulation no. 305/2011 (Construction Products Regulation).

Accreditations

Our testing and calibration laboratories are accredited according to ISO/IEC 17025:

- Test laboratory for sound and vibration, electromagnetic fields and light
- Test laboratory for immission protection, measurements of hazardous substances and chemical analysis
- Acoustic test laboratory for materials, components and equipment
- Calibration laboratory for acceleration and acoustical parameters.

Müller-BBM has a significant number of employees with competency certificates that were awarded to them on an individual basis. They include publicly appointed and sworn experts, state-recognised experts and otherwise appointed and notified experts. The competency certificates are closely associated with the specific areas of expertise, therefore, their details can be found on the web pages of the specific areas of expertise.

Notes on the scope of accreditation, the international validity and certificates can be found on our website at http://www.muellerbbm.com/quality/.

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