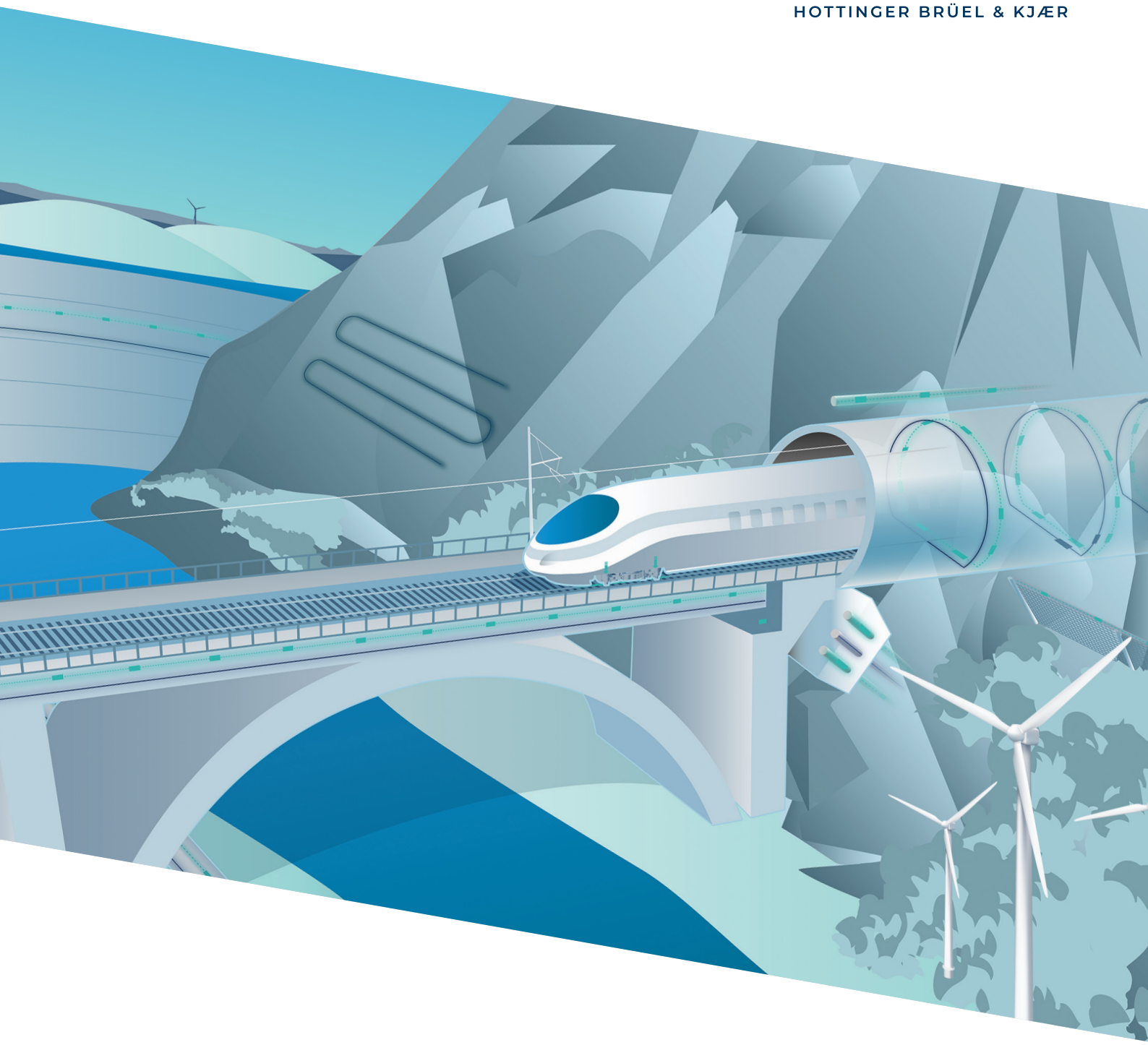
HBK
HOTTINGER BRÜEL & KJÆR



ENSURING STRUCTURAL INTEGRITY

Advanced monitoring solutions for bridges and tunnels

WHO IS HBK?

Hottinger Brüel & Kjær (HBK) provides integrated solutions and domain expertise across the test and measurement product life cycle, bridging the gap between the physical world of sensors, the portfolio of testing and measurement and the digital world of simulation, modelling software and analysis.
Our modular test and measurement equipment, combined with our highly skilled experts offer exceptional support and service for all aspects of your project. Whether you require guidance, troubleshooting or project management, we are here to help.

WHY DO WE MONITOR STRUCTURAL HEALTH?

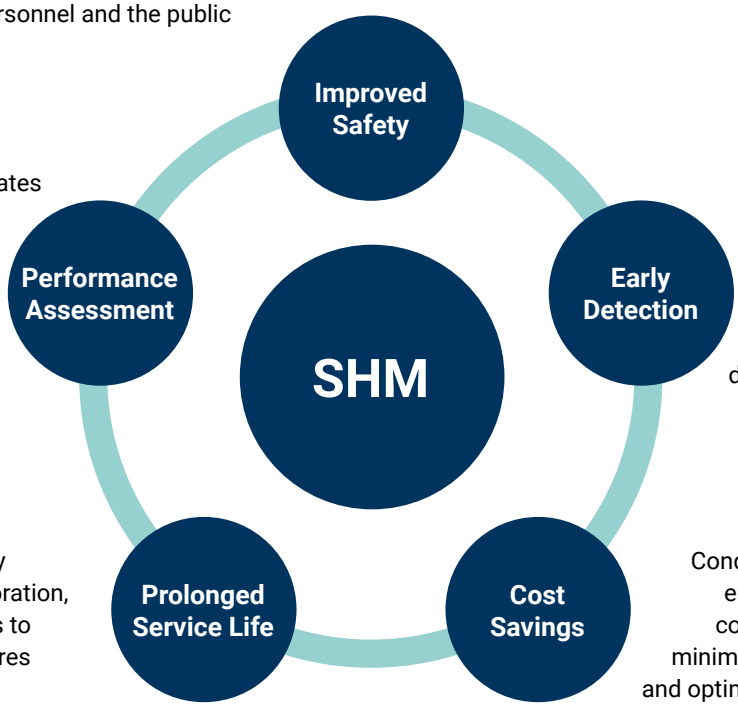
Structural Health Monitoring (SHM) is essential for a wide range of structures, including bridges, wind farms, pipelines, tunnels, oil rigs, ships, planes, and trains as well as other related infrastructures. These structures are constantly exposed to internal and external factors that can lead to wear, malfunction, or damage. Factors such as deterioration, construction errors, lack of quality control, accidents, or environmental loads can contribute to structural issues.

Implementing a robust monitoring system is crucial to observe material changes and detect anomalies in structural behaviour, ensuring the safety of users and of the infrastructure. By identifying issues in a timely manner, maintenance and repair actions can be implemented more efficiently, resulting in reduced operating costs.

THE PRIMARY OBJECTIVE OF INFRASTRUCTURE MONITORING

The primary objective of infrastructure monitoring is to shift from schedule-driven maintenance to condition-based maintenance for improved safety, early detection, cost savings, prolonged service life and performance assessment.

Monitoring structural behaviour helps identify potential safety risks, allowing for timely mitigation measures to ensure the safety of personnel and the public



Continuous monitoring generates valuable data on structural performance, enabling informed decision-making, optimisation of maintenance strategies, and future design improvements

Monitoring structural behaviour ensures timely detection of anomalies that allows for proactive maintenance and repair actions, reducing downtime and maximising structural performance

Effective SHM facilitates early detection of structural deterioration, enabling preventive measures to extend the lifespan of structures

Condition-based maintenance enables more targeted and cost-effective interventions, minimising unnecessary repairs and optimising resource allocation

WHY CHOOSE HBK FOR STRUCTURAL HEALTH MONITORING?

- **Modular SHM portfolio:** HBK offers a modular SHM portfolio, allowing you to tailor your solution according to your specific needs. Whether you require individual sensors, a complete measuring system, or a turnkey solution for your structure, HBK provides the flexibility to choose the components that suit your requirements

- **Expertise in multiple sensor technologies:** HBK excels in both strain gauge-based and optical sensors. Instead of promoting a specific technology, HBK focuses on understanding your needs and recommending the most suitable solution. If a combination of technologies offers an advantage, HBK seamlessly integrates them to achieve optimal results

- **Field proven technology and in-house R&D:** With field-proven technology and a robust research and development (R&D) division, HBK ensures that its SHM solutions are reliable, accurate, and meet the highest industry standards. This commitment to technological excellence is backed by HBK's own manufacturing facilities, ensuring quality control throughout the production process

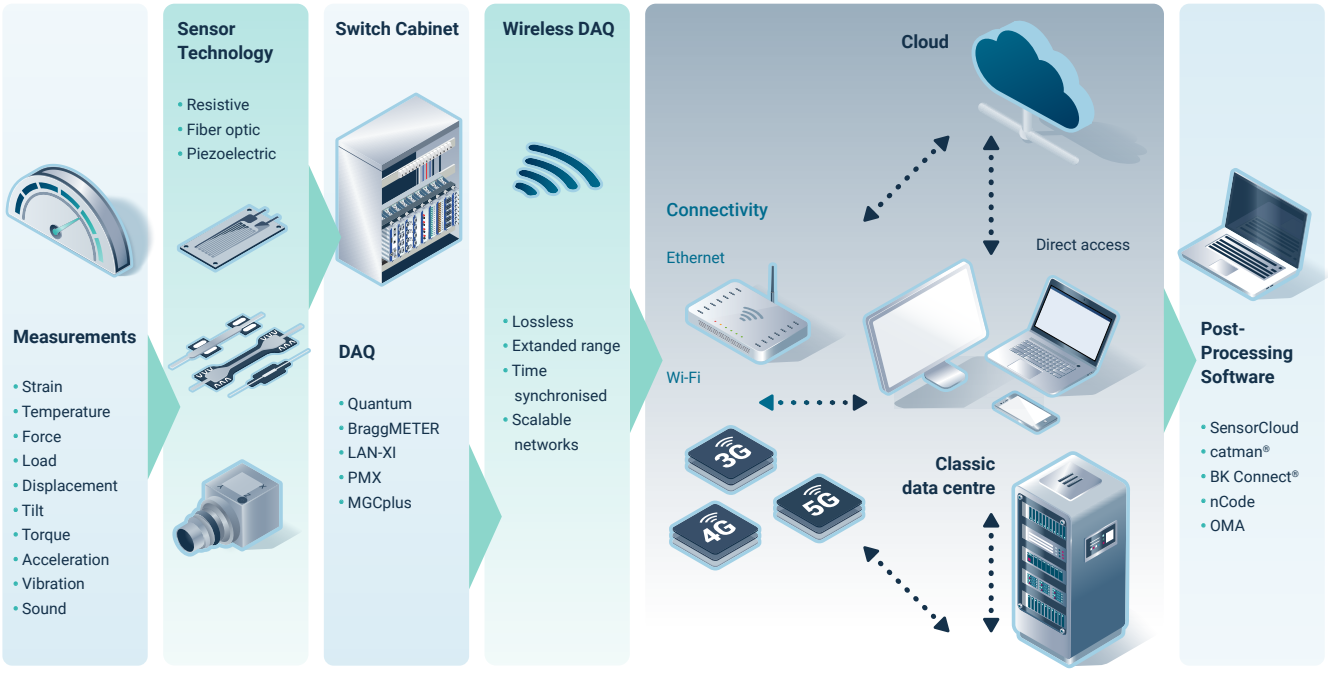
- **Experienced engineering services team:** HBK boasts a highly experienced engineering services team with extensive knowledge and expertise in SHM. Their proficiency enables them to provide comprehensive support and guidance throughout the implementation and operation of your SHM system

- **Strong references:** HBK's track record of successful SHM projects serves as a testament to our expertise and capability

- **Global presence:** Our global presence allows us to serve clients across different regions. This global reach ensures that our SHM solutions are accessible and available to customers worldwide

THE MODULAR HBK SOLUTION

HBK's modular and scalable monitoring solutions, complemented by our competent support and service, save time and money, provide valuable insights, and help to increase the structure's service life and safety.



STRAIN GAUGES FOR EXPERIMENTAL STRESS ANALYSIS OFFER BOTH HIGH PERFORMANCE AND COST-EFFECTIVENESS

From fatigue testing of an aircraft wing, strain analysis of a printed circuit board, to structural monitoring of a bridge or residual stress measurement, HBK strain gauges for experimental stress analysis are used to determine the level of stress on a material. Benefit from over 65 years of experience, a broad range of standard products that are available from stock, a committed customer service, and an excellent knowledge transfer. Alongside four standard series of high-quality strain gauges for stress analysis in different geometries, we offer a comprehensive range of special strain gauges for residual stress analysis, crack propagation and challenging installation requirements. Further useful accessories for simple and quick installation, documentation and parameterisation of your strain gauges are also available.

WHEN TO USE?

Use strain gauge technology if you are looking for an optimal combination of cost-effectiveness and high performance. If the device under test (DUT) offers a good infrastructure, so that electricity and communication interfaces are available at all measurement collection points, the electric strain gauge is often the better choice. In addition, they offer the following advantages:

- Half or full bridge configurations are possible if the loading direction is not multidimensional and known. This gives a very good compensation of temperature -induced errors already in the circuit
- Electrical strain gauges can be manufactured to be very small and are therefore preferable when installation space is severely limited

BENEFIT FROM...

A solution-oriented approach

- Broad range of standard designs with different material adaptations
- Special strain gauges precisely tailored to the respective application
- Custom strain gauges according to your needs

Standard or custom solution, we have the optimal product for you.

Reliability and flexibility

- Large selection of strain gauges available directly from stock
- Delivery promises you can rely on
- 24/7 safe and convenient shopping in the HBMshop

Carry out your measurement task with high quality in the given time.

Optimal support

- Extensive knowledge base and excellent training through the HBK Academy
- Worldwide sales network and strain gauge installation service
- Specialised strain gauge designers in Germany

Competent consultancy services for your application.

TYPICAL MEASUREMENT CHAIN SETUP

Strain gauges *DAQ amplifier QuantumX* *catman® DAQ software*

OPTICAL TECHNOLOGY: MEASUREMENT USING LIGHT

HBK optical sensors are based on Fiber Bragg Grating (FBG) technology, a suitable and reliable solution for long-term structural health monitoring in the most demanding applications. Large structures can be monitored with different types of sensors, connected in line to a single instrument. Strain, temperature, acceleration, displacement, tilt and other sensors can be connected in series reducing the network complexity and cabling.

Even in harsh environments and under difficult measurement conditions, FBG sensors enable you to test the fatigue strength of your components and structures. Stress testing, for example, can be conducted even in materials with high levels of strain, and with high numbers of load cycles. You get consistent and accurate test results even in adverse ambient conditions, for example, in high-voltage systems.

The effects of long distances and cable length on the test result can be negated with optical sensor technology. Even if your data acquisition system is located away from the measurement points, you can still rely on high-quality measurement results. Their small size and low weight make FBG sensors the ideal choice to maximise installation flexibility in remote sites and spots that are difficult to access. HBK delivers optical sensors with different types of packaging to address a wide range of applications, such as outdoor and concrete.

WHEN TO USE?

- To determine strain, temperature, acceleration, displacement and tilt in components, structures and in environments where conventional technologies have reached their limits.
- For test structures and materials with high levels of strain, high numbers of load cycles, high electromagnetic noise or in highly explosive environments in a safe and reliable way.
- To monitor the condition of large structures in harsh environments using different types of sensors, connected in line over long distances and interrogated by a single instrument.

BENEFIT FROM...

Easy handling

- Compatible with telecom fiber for long-distance measurements
- Simple installation resulting in reduced setup costs
- Robust designs

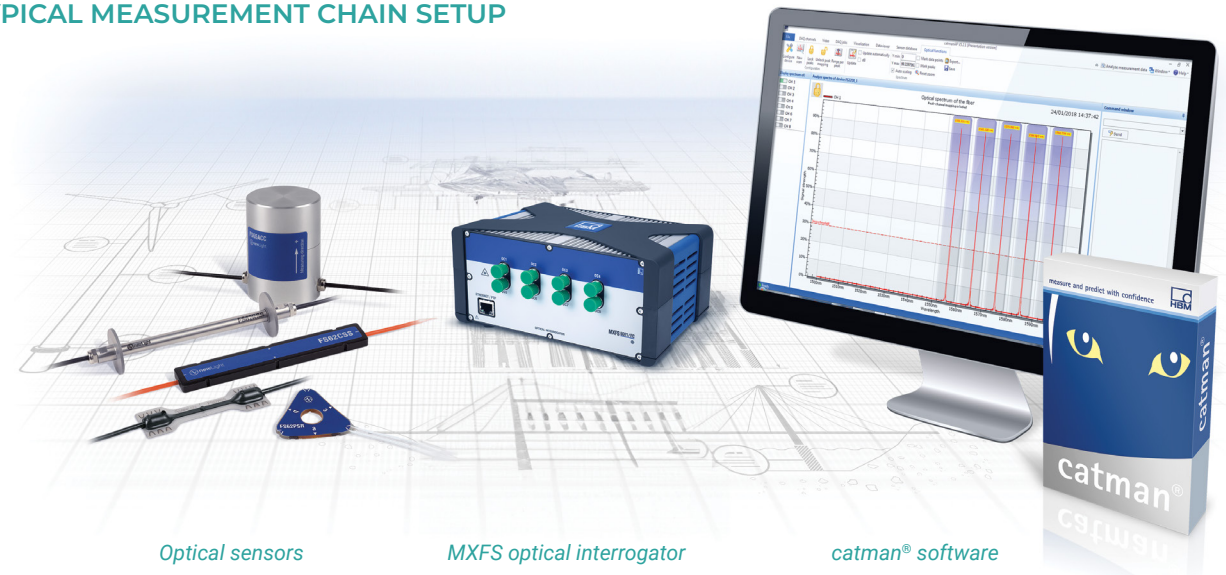
Configurability

- Selectable wavelengths, cable types, and connectors
- Multiple sensors assembled in arrays with spliced connectors for fast installation
- Bare fiber with mutiple FBG

Versatility

- Diverse sensor fomats
- High strain and high fatigue resistance
- From simple FBG to complex sensor
- Reinforced or dielectric for applications in different hazardous areas

TYPICAL MEASUREMENT CHAIN SETUP



Optical sensors *MXFS optical interrogator* *catman® software*

WHEN TO USE MICROSTRAIN WIRELESS SENSORS

MicroStrain wireless sensors are ideal for SHM in scenarios where traditional wired systems may be impossible, impractical, or cost-prohibitive:

- **On remote or hard-to-access structures**: Wireless sensors can eliminate the need for extensive cabling and the associated labour costs for the following: infrastructures like bridges where laying cable is difficult; infrastructure located in remote areas; infrastructure governed by strict regulations, which makes access difficult. Additionally, with our wireless solution, data collection as well as configuration changes can be performed remotely, not requiring site visits
- **Moving structures**: Any structure or part of a structure that rotates, travels, or flexes presents a great opportunity to go wireless
- **For rapid deployment/redeployment**: Some projects require or benefit from a quick setup time. Wireless is quick to install compared to cabled solutions. Additionally, wireless sensors can be quickly removed and re-deployed to another location
- **To reduce signal noise exposure**: Interferers such as power lines can cause excessive noise on long cable runs carrying analogue measurement signals. Wireless amplifiers sit close to the measurement point and help customers avoid electrical noise
- **To avoid costly damage to cables**: Maintenance of a structure, construction and even vandalism can damage or destroy exposed cables

BENEFIT FROM...

Reduced project cost and installation time

- **Reduced installation costs**: Wireless solutions require less installation time, thereby reducing labour costs. Avoid cost and complexity of using specialised equipment to run cable through structures
- **Reduced material costs**: Eliminating cable reduces the overall material cost of the project
- **Reduced operational costs**: Avoid costly and time-consuming site visits by starting and configuring networks remotely, from the comfort of an office. Send the data to the cloud

Hard-wired performance

- **Synchronised data collection**: Time-synchronised sampling ensures accurate correlation of data across all sensors in a network. Synchronisation is achieved to within ±50 microseconds
- **Lossless**: MicroStrain by HBK's proprietary lossless protocols, LXRS and LXRS+, ensure data throughput in tough and changing RF conditions
- **High sample rates**: Achieve up to 4000 Hz sampling
- **Diverse, high-fidelity measurements**: Sensors deliver precise data on parameters such as strain, temperature, and acceleration
- **Operate in tough conditions**: All of our hardware is designed to operate in temperatures ranging from –40°C to 85°C. IP-rated enclosures protect sensors deployed in tough environments

Comprehensive data management and accessibility

- **Cloud integration**: Seamless connectivity with platforms like SensorCloud™ enables real-time data access and analysis
- **Customisable alerts**: Users can set specific thresholds to receive immediate notifications of structural anomalies
- **Scalable networks**: Easily expand monitoring systems by adding sensors without extensive reconfiguration

Integrating MicroStrain wireless sensors into your SHM strategy enhances your ability to monitor structural health effectively, ensuring safety and extending the lifespan of critical infrastructures.

SensorCloud

DYTRAN AND B&K PIEZOELECTRIC ACCELEROMETERS FOR MODAL ANALYSIS OF LARGE STRUCTURES AND MONITORING OF SEISMIC ACTIVITIES

HBK offers high-quality uniaxial and triaxial accelerometers for monitoring small, medium or large structures. Large structures vibrate at lower frequencies and lower amplitudes, and they are harder to excite with sufficient energy to support good coherence between excitation and response sensors. Dytran and B&K high sensitivity, low-noise accelerometers assure high level, high quality response signals and integrity of data, even on the largest structures.

SENSORS FOR MODAL AND STRUCTURAL ANALYSIS

Analyse and define the dynamic properties of structures with Dytran by HBK modal analysis sensors.

Applications

- Small structures: Since smaller structures resonate at higher frequencies, it is important to use accelerometers with low mass to avoid mass loading the structure. We offer a variety of low-mass accelerometers that are ideal for modal and structural analysis of small structures
- Medium structures: These structures require accelerometers with a wide frequency response and high sensitivity. We offer a variety of uniaxial and triaxial accelerometers that are well-suited for modal and structural analysis of medium structures
- Large structures: Since larger structures resonate at lower frequencies and lower amplitudes, it is important to use accelerometers with high sensitivity and low noise. We offer a variety of high-sensitivity accelerometers that are ideal for modal and structural analysis of large structures
- Forcing function/Impulse hammers: Our dynamic force sensors and impedance heads are important tools for determining the input force parameters at the driving point when exciting a structure with a modal shaker. These rugged and reliable sensors are ideal for both lab and industrial environments. We also offer the industry's broadest range of impulse hammers to cover almost any size of test article, from small structures like turbine blades and castings to large structures like ships and bridges. The hammers are designed with interchangeable impact tips of various durometers, allowing structural engineers and dynamicists to determine the correct combination of pulse width and frequency content of the forcing function to efficiently excite all modes of a test article or structure

CAN-MD®

With applications including high-speed rail and transit systems, and civil engineering projects like buildings, bridges and towers, CAN-MD® offers digital data transformation using highly configurable CAN-bus based sensors with integral DSP microprocessors. Other benefits include:

- Digital bus-based, single-cable installation reduces complex centralised hardware
- Highly expandable system with the capability to add channels
- Turns complicated broadband vibration data into CIs that have actionable outcomes
- For more CAN-MD® info, see https://www.hbkworld.com/web/dytran/global/en/applications/can-md

HBK Engineering Services

INSTRUMENTATION REQUIRING CUSTOM MADE SENSORS DEVELOPED FOR A SPECIFIC REQUIREMENT

Sometimes a project requires the ability to design and produce special sensors specifically for that particular type of application. Custom sensors can normally perform functions that are not performed by standard sensors, such as: special sensitivities, particular shapes and fixings, conformation or whatever is of specific interest to the customer.

The components to be instrumented can therefore be part of a structure or elements made 'ad hoc'. The instrumentation then consists of the installation of one or more strain gauge bridges to measure the physical quantities (traction/compression force, bending, torsion) required.

The instrumentation will be preceded by a feasibility study to optimise the specifications required by the customer. A 'working standard' calibration certificate can be produced at the customer's request. The components to be instrumented can be supplied by the customer or manufactured by HBK. The work is carried out by certified HBK personnel, either at HBK or at the customer's facility.

INSTRUMENTATION OF COMPONENTS AND STRUCTURES

As part of the modular concept, HBK with its experienced engineering services department provides a range of services related to the instrumentation of components and structures. These include:

- Engineering analysis for the study of measurement feasibility
- Selection of the best fitting technology and products for the project and customer requirements
- Instrumentation of components and structures at its own laboratories and/or at the customer's premises with resistive or optical strain gauges
- Sensor installation such as accelerometers, displacement transducers, thermocouples, and others on request
- Supply of data acquisition systems
- Procurement, supply and installation of accessories for long-term connection and protection of complete sensing networks
- Set-up of instrumentation to optimise data acquisition according to customer requirements
- Monitoring the component/structure behaviour during working operation
- Test report
- Data processing support

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