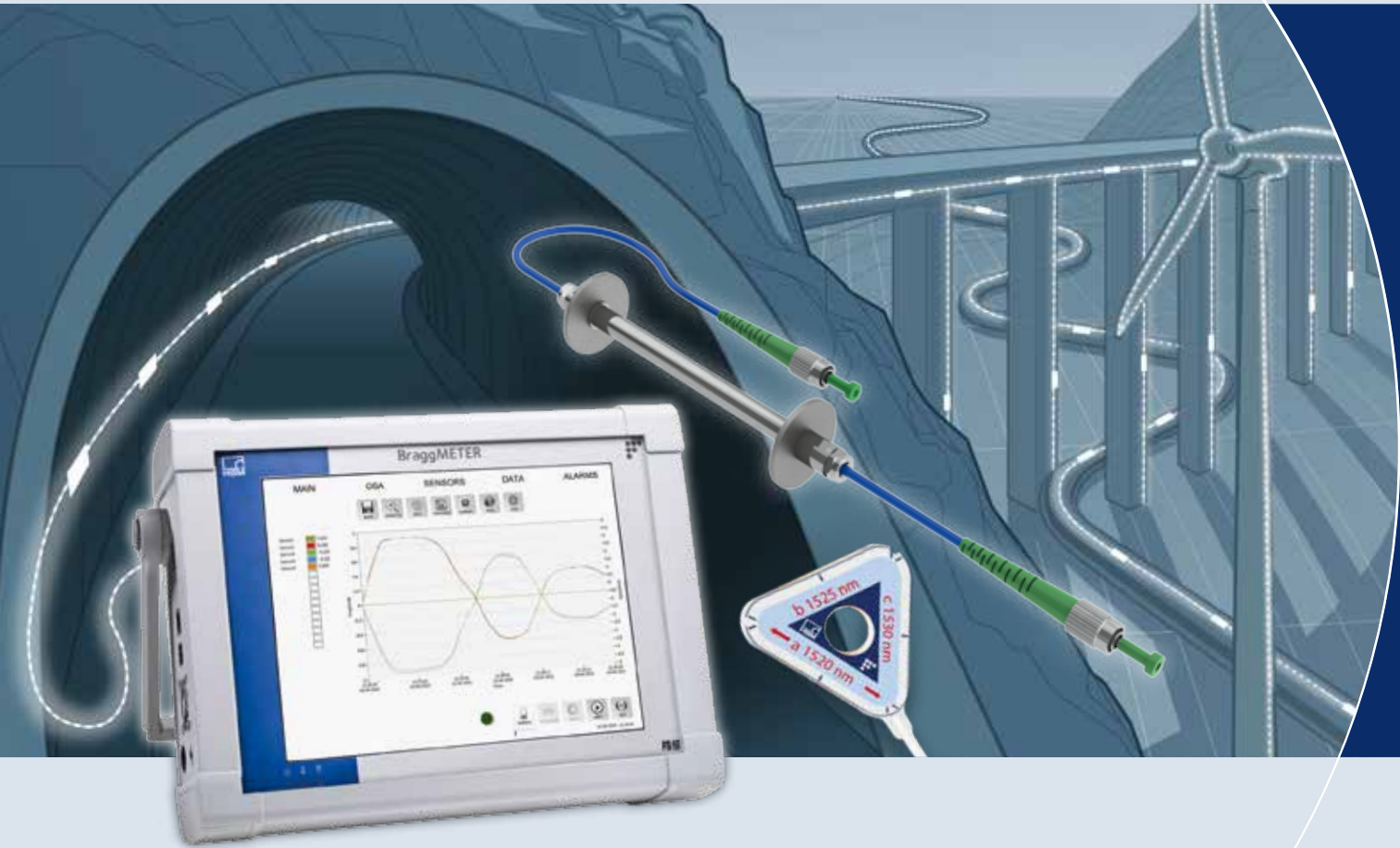




Optical Measurement Solutions



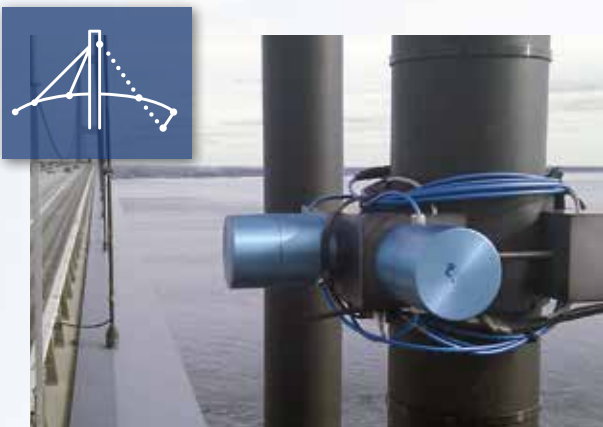
Bringing Light to Measurement



Take advantage of the many new possibilities offered by optical sensors based on Fiber Bragg Grating (FBG) technology:

- Determine strain, temperature, acceleration, displacement and tilt in components, structures and in environments where conventional technologies have reached their limits.
- 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.
- 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.

Applications and Markets:

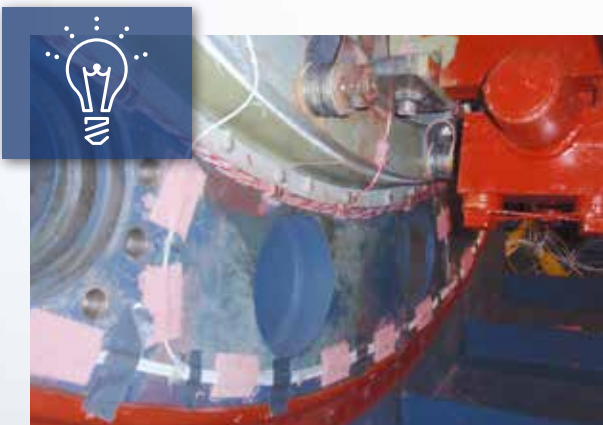


Vibration monitoring with optical sensors on the Great Belt Bridge, Denmark

Civil Engineering – Structural Health Monitoring of Civil Structures

Cost-effective when applied to large-scale structures (bridges, tunnels, dams and other civil structures) for:

- Strain assessment
- Deflections and displacement measurements
- Identification of vibration modes
- Thermal mapping



Optical temperature sensors installed on a power generator

Energy – Integrity Assessment in Real-Time

Extremely safe to use in all types of high-voltage and hazardous environments (such as in high power generators, high voltage transformers and large electric machines) for monitoring:

- Vibration
- Temperature
- Load
- Multipoint temperature

Wind Energy – Empowering Wind Turbine Monitoring

Powerful and cost-effective tool for multi-megawatt wind generators, leveraging solutions such as:

- Pitch control
- Condition monitoring
- Blade design validation
- Ice detection

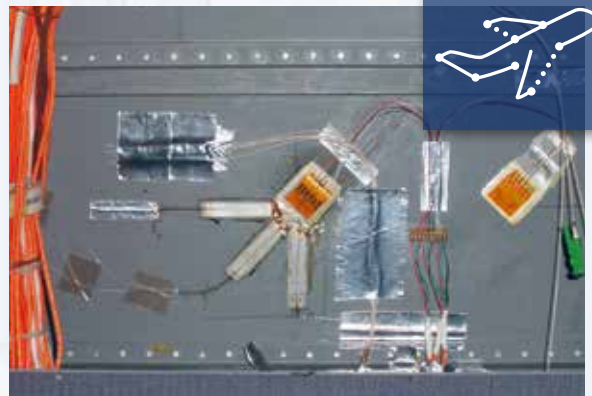


Optical strain sensors installed along a wind blade to test its behavior

Aerospace – Monitoring Aircrafts Structural Integrity and Building Solutions for Space

Ideal for space restricted locations and embedding applications, such as in composite structures. Often used in the aerospace industry for:

- Stress monitoring
- In-flight strain measurements
- Spacecraft health monitoring
- Thermal mapping



Integration of FBG systems for in-flight applications in a C-27J military aircraft

Other Applications – Optimizing Performance in Any Structure

Huge application potential in many different sectors, such as in industrial related processes, oil & gas, and R&D. Some examples are:

- Assessment of container load distribution
- Temperature profile measurements in chemical reactors
- Monitoring in cryogenic environments
- Pipeline monitoring



Installation of optical sensors for monitoring stress in a hydraulic pipeline

One Technology – Endless Possibilities

Discover some typical application examples of FBG systems in action:



Instrumented cross-sections along the tunnel

SysTunnel – Tunnels Structural Monitoring

Continuous structural health assessment of centenary Rossio railway tunnel (Lisbon, Portugal) after major rehabilitation process using a SysTunnel system:

- Measurement of deformation, convergence and temperature
- More than 100 monitored sections
- 872 sensors
- 1 single interrogator



WindMETER interrogator under operation in wind turbine

WindMETER – Wind Blade Load Monitoring

Installation of a WindMETER system for supporting the development of a Condition Monitoring System (CMS) at ECN – Energy Center of The Netherlands:

- Real-time measurement of strain in the blades
- Installation of strain and temperature optical sensors
- Interrogator installed in the hub
- Validation of new sensors



Strain measurements under cryogenic temperatures

Optical Sensors for ITER (International Thermonuclear Experimental Reactor) Monitoring in Cryogenic Environments

Qualification and supply of optical sensing systems for the superconducting magnets on the nuclear fusion reactor:

- Monitoring of strain, displacement and temperature
- High radiation, high vacuum and cryogenic environments
- Delivery of more than 600 sensors, related data acquisition systems and accessories



Customized Solution for Energy – Temperature and Vibration Monitoring in High Power Generators

Complete system developed and produced by
HBM FiberSensing for Siemens Energy:

- FOVM - Fiber Optic Vibration Monitoring system
- FOTM - Fiber Optic Temperature Monitoring system
- Real-time measurement of vibration, temperature and strain used for condition-based maintenance of Siemens power generators

Installation of a Large Fiber Optic System – High Pressure Water Pipe Monitoring

Strain monitoring of a steel water pipe in the Kاونertal Dam,
Austria, during several load and unloading cycles:

- 203 strain sensors installed on the inner surface of the pipe
- 3 interrogators
- Pressure close to 100 bar in some sections

Railway Instrumentation – Characterization of Railway Traffic and its Effect on Structures

Strain dynamic load test at a short span railway bridge in
Canelas, Portugal:

- Measurement of weight and brake force
- Determination of the weight per axle of a train passing over a bridge
- Simultaneous acquisition of fiber optic and electrical sensors



Installation of optical vibration sensors on a power generator



Installation of optical strain sensors on the water pipe



Installation of optical strain sensors in the rails

Fiber Bragg Grating Technology: Measurement using Light

HBM FiberSensing's 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.

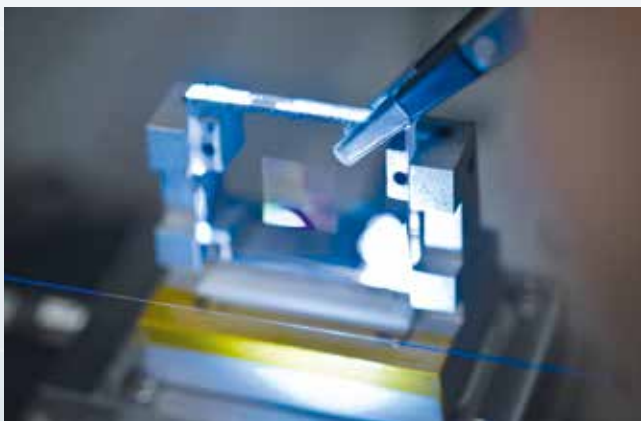
Due to their size and intrinsic features, FBG sensors are simple to work with turning measurements with optical fiber as easy as with traditional methods.

In fact, FBGs are inscribed on glass fiber with a very small core of no more than 9 micrometers and a cladding with a diameter of 125 micrometers, resembling that of a human hair strand.

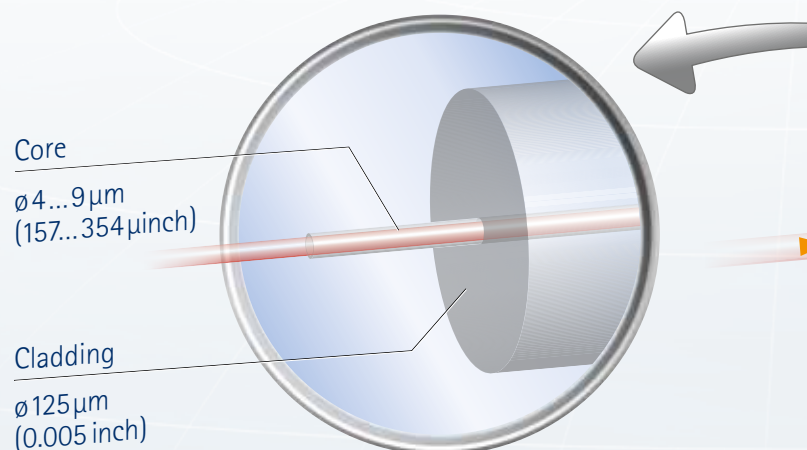
The Fiber Bragg Grating

A fiber Bragg grating is a microstructure that is typically a few millimeters in length and is written using a UV laser in the core of a standard single-mode telecom fiber.

When broadband light is inserted into the fiber, the inscribed Bragg gratings act as mirrors that reflect particular wavelengths of light. These reflected wavelengths can be valuable tools to measure several parameters such as strain, temperature, tilt, acceleration, and others.



FBGs workstation at HBM FiberSensing facilities



Measurement with FBG Sensor Technology

When the structure where the sensors are installed suffers the influence of external parameters such as strain and temperature, their effect is transmitted to the optical sensor. This will produce a wavelength shift that is proportional to the measurand of interest and is detected by the interrogator (data acquisition system).

Reduce your installation costs

With HBM FiberSensing optical sensors, you benefit from reduced wiring requirements since a single fiber can accommodate several FBG sensors. The optical measurement chain is individually adapted to suit your needs.

Get high-precision test results

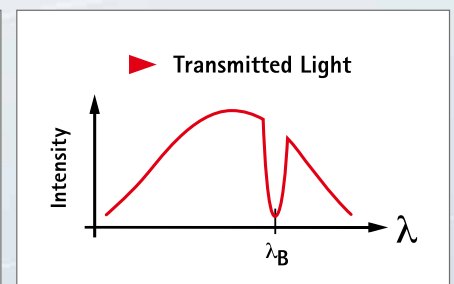
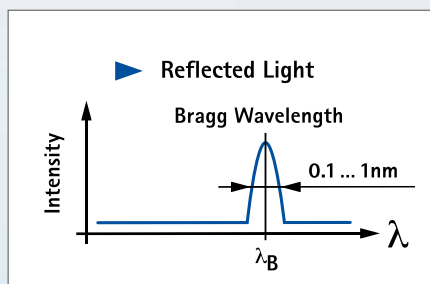
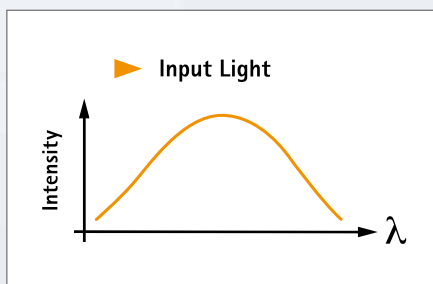
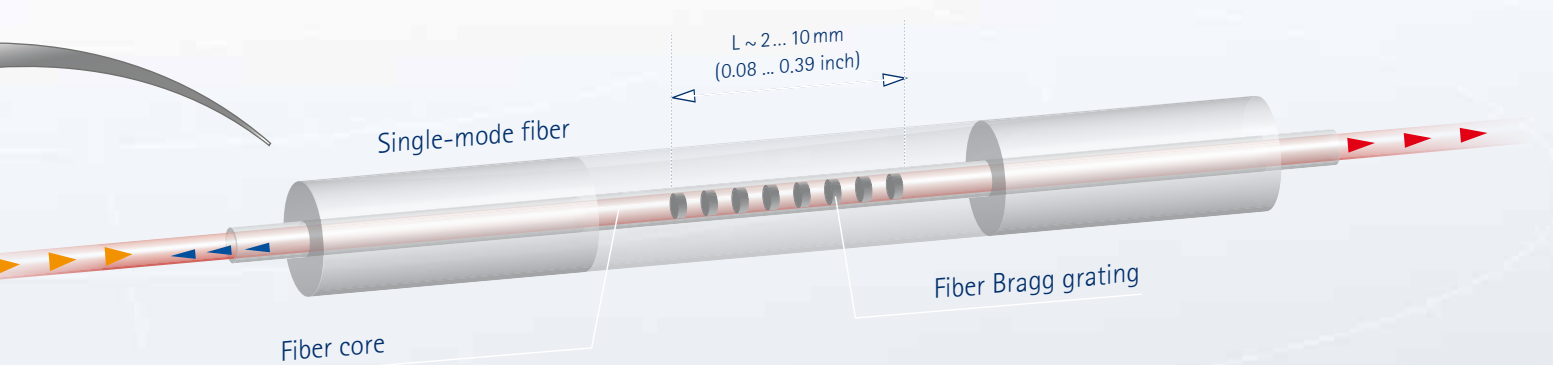
Even in harsh environments and under difficult measurement conditions, FBG sensors enable you to test the fatigue strength of your components and structures. Stress testing, for example, can be conducted even in materials with high levels of strain, and with high numbers of load cycles. You get consistent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

Long-distance transmission

The effects of distance and cable length on the test result can be neglected with optical sensor technology. Even if your data acquisition system is located many kilometers away from the measuring points, you can still rely on high-quality measurement results.

Benefit from the small size and weight of FBG sensors

Suitable for hard-to-reach locations and measurement points, these sensors are the ideal choice to maximize installation flexibility in remote sites and spots that are difficult to access. HBM FiberSensing delivers optical sensors with different types of packaging to address a wide range of applications, such as in laboratory, outdoor and concrete.



FBG Sensors & Strain Gauges





FS line: FBG sensors for large sensing networks

Robust optical sensors for measuring strain, temperature, tilt, acceleration and displacement in a wide range of applications.

 <p>FS62</p>	 <p>FS63</p>	 <p>FS64</p>	 <p>FS65</p>
Optical Strain Sensors	Optical Temperature Sensors	Optical Tilt Sensor	Optical Accelerometer
<p>Strain sensors designed to be glued to surfaces and materials, spot welded to structures and components, attached or directly cast into concrete wet mix.</p> <p><i>Available in Miniature Polyimide, Composite, Weldable, Surface, Embedded and Athermal configurations.</i></p>	<p>Temperature sensors designed to be bonded to surfaces and materials, spot welded to structures and components, attached or directly cast into concrete wet mix and applied in high temperature and EMF environments.</p> <p><i>Available in Composite, Weldable, Embedded configurations and as High Dielectric Probe.</i></p>	<p>Tilt sensor designed to measure small angle variations towards the vertical.</p> <p>Uses two FBGs in an innovative push-pull configuration for effective temperature compensation.</p> <p><i>Accessory for biaxial mounting available.</i></p>	<p>Acceleration sensor suitable for a large range of applications where low frequency and small amplitude vibrations are present.</p> <p><i>Simultaneous measurement of vibration along multiple axes also possible.</i></p>
<p>Main Specifications</p> <ul style="list-style-type: none"> Measurement range: Up to $\pm 5000 \mu\text{m/m}$ Operation temperature: -20 to $80 \text{ }^\circ\text{C}$ Protection Class: Surface and Embedded: IP68 	<p>Main Specifications</p> <ul style="list-style-type: none"> Measurement range: -20 to $80 \text{ }^\circ\text{C}$ Operation temperature: -20 to $80 \text{ }^\circ\text{C}$ Protection Class: Embedded: IP68 	<p>Main Specifications</p> <ul style="list-style-type: none"> Measurement range: $\pm 5 \text{ deg}$ Operation temperature: -20 to $80 \text{ }^\circ\text{C}$ Self-compensation of thermal effects 	<p>Main Specifications</p> <ul style="list-style-type: none"> Measurement range: $\pm 10 \text{ g}$ 0 to 50 Hz Operation temperature: -20 to $80 \text{ }^\circ\text{C}$ Protection Class: IP68
<p>Completely passive Inherent immunity to all electromagnetic effects (EMI, RFI, sparks, etc.) and safe operation in hazardous environments, such as potentially explosive atmospheres, high voltage areas and intense electromagnetic fields.</p> <p>High multiplexing capability Connection of a large number of sensors to a single optical fiber, reducing network and installation complexity.</p> <p>Remote sensing Large distance between sensors and interrogator (several kilometers).</p> <p>No mechanical failure High resistance to fatigue.</p> <p>Self-referenced Based on the measurement of an absolute parameter - the Bragg wavelength - independent of power fluctuations.</p>			

OP line: FBG strain gauges for high strain applications

Optical strain gauges with outstanding bending capability (6 micron core fiber) and high performance coatings.

			
OL/OL-W	OL-LT	OR/OR-W	OptiMet by HBM™
Optical Strain Gauge	Optical Strain Gauge with Extended Temperature Range	Optical Strain Gauge Rosette	Optical Fiber with Strain Gauges Chain
<p>Strain gauges designed to be glued (OL) or spot welded (OL-W) to structures and materials.</p> <p><i>Available in Plastic Modified Acrylic Resin and Weldable configurations.</i></p>	<p>Strain gauge designed to be glued to structures and materials.</p> <p>Features a wide temperature measurement operating range, being suitable for extreme climate conditions.</p> <p><i>Available in Plastic Modified Acrylic Resin</i></p>	<p>Small size strain gauge rosettes designed to be glued (OR) or spot welded (OR-W) to structures and materials, measuring strain in three directions.</p> <p>An optical temperature sensor (OTC) is available for compensation of thermal effects.</p> <p><i>Available in Plastic Modified Acrylic Resin and Weldable configurations.</i></p>	<p>Optical fiber with multiple FBGs that allows multipoint measurement of strain.</p> <p>OptiMet-OMF Suited for use in laboratory applications</p> <p>OptiMet-PKF Ruggedized with additional coating it is ideally suited for outdoor use</p> <p>Integrated temperature sensors available for compensation of thermal effects (OTC and PKF-OTC).</p>
<p>Main Specifications</p> <ul style="list-style-type: none"> ▪ Measurement range: $\pm 10000 \mu\text{m}/\text{m}$ ▪ Bending radius: OL: >2.5cm OL-W: >30cm ▪ Operation temperature: OL: -10 to 80 °C OL-W: -40 to 100 °C 	<p>Main Specifications</p> <ul style="list-style-type: none"> ▪ Measurement range: $\pm 20000 \mu\text{m}/\text{m}$ ▪ Bending radius: >2.5cm ▪ Operation temperature: -40°C to +80°C 	<p>Main Specifications</p> <ul style="list-style-type: none"> ▪ Measurement range: $\pm 5000 \mu\text{m}/\text{m}$ ▪ Bending radius: OR: >3cm OR-W: >30cm ▪ Operation temperature: OR: -10 to 80 °C OR-W: -40 to 100 °C 	<p>Main Specifications</p> <ul style="list-style-type: none"> ▪ Measurement range: Above $\pm 5000 \mu\text{m}/\text{m}$ (>10⁷ cycles) ▪ Bending radius (between FBGs): OptiMet-OMF: >10mm OptiMet-PKF: >70mm ▪ Operation temperature: OptiMet-OMF: -269 to 200 °C OptiMet-PKF: -40 to +140 °C

Completely passive

Inherent immunity to all electromagnetic effects (EMI, RFI, sparks, etc.) and safe operation in hazardous environments, such as potentially explosive atmospheres, high voltage areas and intense electromagnetic fields.

High multiplexing capability

Connection of a large number of sensors to a single optical fiber, reducing network and installation complexity.

Remote sensing

Large distance between sensors and interrogator (several kilometers).

No mechanical failure

High resistance to fatigue.

Self-referenced

Based on the measurement of an absolute parameter - the Bragg wavelength - independent of power fluctuations.

Note: Sensors from the two groups cannot be joined on the same optical channel due to technical differences.

FBG Interrogators: Measurement Data You Can Trust

HBM FiberSensing interrogators are available in standard, rack-mountable and portable models. Suitable for large scale sensing networks, HBM FiberSensing interrogators provide precise and high resolution static and dynamic measurements 24/7 through reliable software interfaces. Compatibility with catman® software enables hybrid optical/electrical sensing to be easily managed.



FS22



FS42

Industrial BraggMETER SI/DI

Static (1 S/s) and Dynamic (50, 100 and 500 S/s*) optical interrogators specifically designed to interrogate FBG based sensors in industrial environments.

High interrogation capacity

Broadband tuning range and 1, 4 or 8 parallel optical channels allowing the simultaneous measurement of a large number of sensors.

Real-time operating system

Consistent and deterministic operating system, prepared for stand-alone operation.

Smart Peak Detection (SPD)

Embedded in the static interrogators, this feature allows accurate and stable detection of all FBG peaks in large/ complex sensing structures.

Easy control

The interrogator has Ethernet Interface for connection to an external PC. It can be fully controlled using ASCII strings or by using BraggMONITOR or catman software.

*user-selectable

Main Specifications

- Measurement range:
100 nm (1500 to 1600 nm)
- Resolution
1 μm (SI)
5 μm (DI)
- Operation Temperature
10 to 40 °C
- Models
Standard and 19" racks

Portable BraggMETER

Optical interrogator with embedded software specifically designed to interrogate FBG sensors in the field.

High interrogation capacity

Broadband tuning range and 4 parallel optical channels allowing the simultaneous measurement of a large number of sensors.

iLog software

Full data logging capacity with an intuitive graphical user interface for data saving, managing and exporting optical spectrum analysis and sensor configuration.

Portability

True portability thanks to battery operation and rugged carrying case optimized for field operation.

Autonomous operation

Built-in batteries and optimized design for long term operation (spare batteries also available).

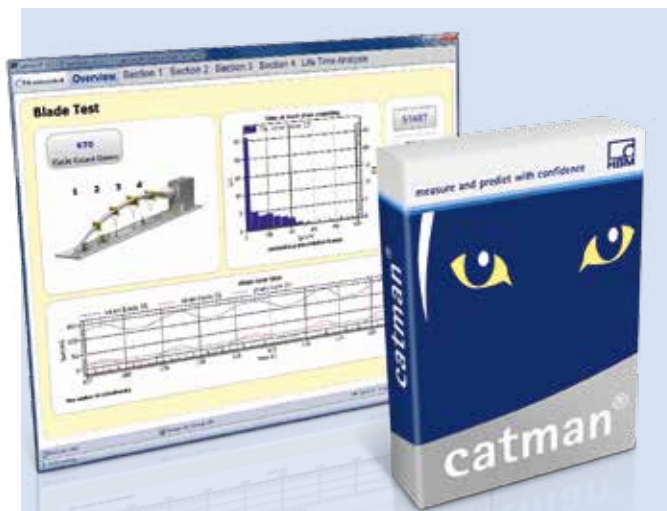
Main Specifications

- Measurement range:
100 nm (1500 to 1600 nm)
- Resolution
1 μm
- Operation Temperature
10 to 40 °C
- Interface
12" touch screen

Professional Software: Simplifying Measurements

The HBM FiberSensing software simplifies the acquisition, visualization and analysis of measurement data from optical FBG sensors and interrogators.

With its intuitive interface and adaptability, our software will help you streamline your measurement projects, and it's an ideal complement to the optical interrogators from HBM FiberSensing.



Take your measurements to another level with catman®:

Professional software for data acquisition, measurement automation and data analysis

- Data acquisition with up to 12 MS/s or 100 MB/s
- Easy adding of computed channels using formula editor
- Individual visualization and control on multiple pages
- Powerful data analysis and reporting
- Smart triggers based on signal analysis
- Event monitoring and alarming
- Automation of sequences using predefined functions, VBA script or AutoSequence
- Combination of optical measurements with other sources

BraggMONITOR DI, BraggMONITOR SI:

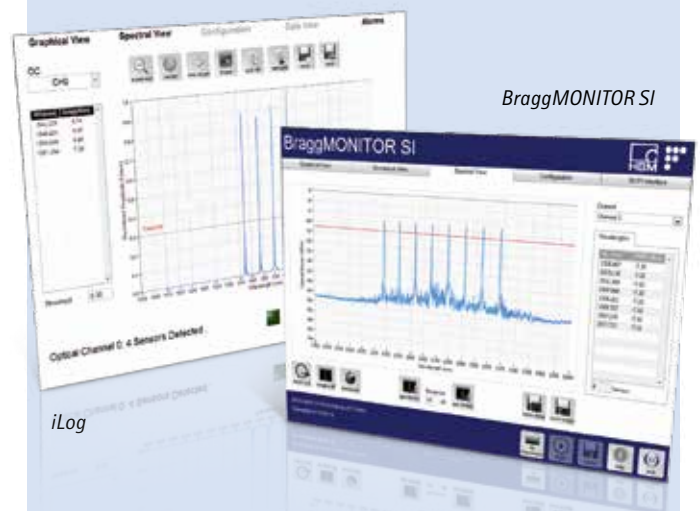
Specific software for FS22 interrogators

- Data acquisition and archiving
- Optical network spectrum visualization
- Easy and intuitive sensor configuration
- Full remote control of interrogator

iLog:

Embedded software for FS42 interrogators

- Data saving, managing and exporting
- Optical spectrum analysis
- Intuitive sensor configuration with history record and easy swapping
- Alarm/event logging





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measure and predict with confidence

