Business opportunities for Structural Health Monitoring based on Fiber Optic Sensing

NBG, September 2021
Your challenges:

- Status evaluation of bridges, tunnels, dams, retaining walls, etc.
- Time consuming and costly regular inspections
- 24/7 Monitoring of acute damages
- Predictive maintenance
- Preventive monitoring to ensure ideal service time.
Fiber optic sensing
our passion

Our solution
- We supply your fiber optic based monitoring system
- Complete solutions for application experts or system integrators
- Single projects or large scale implementations for smart cities
- Best in class equipment with optimal cost efficiency
- Extensive services simplify your project rollout
Advantages of working with us.

- Independent fiber optics expert and producer
- Own production facilities & selected external suppliers
- Strong partners and network available
- Exceptional customer service and fast communication
- 25 Years of experience in Fiber Optics
- In-house R&D and testing center
- ISO 9001 & 14001 Certified
**We provide customized fiberoptic solutions**

**Technologies:**
- **Point sensing** - Fiber Bragg Grating various parameter like strain, temperature, acceleration, load, tilt, etc.
- **Distributed sensing** of strain / temperature – Brillouin technology / Distributed Acoustic Sensing / Vibration sensing

**Products:**
- Tailor made cables and FIMT (Fiber in Metal Tubes)
- **Measuring devices** (Interrogation units, data server, Ready to use including USV, Rack, etc.)
- **Sensors** for point and distributed sensing
- **Fiber optic accessories**
- Complete system solutions
- Simple rental or buying options

**Services:**
- System design / setup
- Technical Support and Training
- Calibration of sensors
- Customized solution development
- Inhouse testing center
Why Fiber Optics in Structural Health Monitoring

- 24/7 operation independent of weather conditions (fog, rain etc.)
- Monitoring without interruption of object use (closed roads / bridges / tunnels)
- High sensitivity / accuracy
- Structural deterioration can be detected at an early stage
- No blind spots
Applications

Bridges

Tunnels

Buildings

Towers and pylons

Dams
NBG is based in Austria.
We export to more than thirty countries

https://youtu.be/euoNDiYaoVI
Fiber Optic Sensing

- Pressure
- Tension
- Strain
- Temperature
- Bending
Why Fiber Optics

Lifetime
Sensor / cable lifetime
>20 years

Passive sensor
No electrical power at the measurement point

Longe distance
Remote monitoring
(50 km and more)

High sensitivity and accuracy
with almost no ageing of fiberoptic sensors

Harsh and explosive environments
Resistant to corrosion, lightning

Immune to EMI
Electromagnetic interference
Technologies

Point Sensing
- Monitor well defined points
- Sensors for strain, temperature, tilt, acceleration, displacement, etc.
- Up to 40 multiplexed sensors per channel
- Fiber Bragg Grating Technology
- up to 16 channels on one interrogation unit

Distributed Sensing
- Monitor parameters on the complete length of the fiber
- Strain and / or temperature
- Up to 50km with one device
- Raman and Brillouin sensing technology
**Fiber Bragg Grating Sensor Technology - FBG**

- FBGs are microstructures which are directly integrated into the fiber
- Each FBG has its own unique wavelength
- Wavelength of the reflected signal will be analyzed
- Simple multiplexing of up to 40 different sensors at various locations of one fiber
- Distance between farthest sensor and interrogation unit could be >50km
- Signal changes the predefined wavelength of each sensor, therefore completely independent from fiber attenuation like OTDR based systems
FBG based fiber sensors can detect various physical parameters

- Temperature (air, surface)
- Strain on surface (glued, weldable)
- Strain embedded into concrete
- Elongation
- Pressure
- Acceleration
- Tilt
- Vibrations (Intrusion, damage)
- Displacement (Open / Close status)
- Waterlevel
- Windspeed
- Traffic sensors (speed, vehicle classification, number of axles, etc.)
- Sensor arrays

We'll supply the best fitting and most cost efficient sensors for your project requirements, no matter if from internal production or selected external partners around the globe.

Contact us for more information.
Interrogation units
for your specific needs

- Universal Fiber Bragg Grating Measurement device
- Multifunctional measurement platform including signal processing, data analysis, visualization, data export
- Fully autonomous system design
- Easy configuration and integration of several devices on one data processing / visualization server
- Individual data processing for each FBG

<table>
<thead>
<tr>
<th></th>
<th>19” rack version</th>
<th>Mini version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of channels</td>
<td>1, 2, 4, 8 or 16</td>
<td>1, 2, 4 or 8</td>
</tr>
<tr>
<td>Size</td>
<td>Rack compatible</td>
<td>Compact</td>
</tr>
<tr>
<td>PC inside</td>
<td>Powerful</td>
<td>Industrial</td>
</tr>
<tr>
<td>Customization</td>
<td>OTDR, WIM, TDM</td>
<td>×</td>
</tr>
<tr>
<td>Battery ready operation</td>
<td>×</td>
<td>✔</td>
</tr>
<tr>
<td>Electrical sensors handling</td>
<td>×</td>
<td>Optional</td>
</tr>
<tr>
<td>WiFi/LTE module</td>
<td>×</td>
<td>Optional</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Optical</th>
<th>19” rack version</th>
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</thead>
<tbody>
<tr>
<td>Number of measured FBG sensors</td>
<td>Up to 40 FBG sensors per channel</td>
</tr>
<tr>
<td>Number of channels</td>
<td>1, 2, 4, 8</td>
</tr>
<tr>
<td>Scan frequency</td>
<td>2000 samples/sec all channels: 1000 samples/sec/CH @2 CH 500 samples/sec/CH @4 CH 250 samples/sec/CH @8 CH</td>
</tr>
<tr>
<td>Dynamic range</td>
<td>30 dB</td>
</tr>
<tr>
<td>Optical connector</td>
<td>FC/APC or other on request</td>
</tr>
<tr>
<td>Durability of optical switch</td>
<td>&gt; 10^11 cycles</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Embedded PC/SSD Disk</td>
<td>Yes/Yes</td>
</tr>
<tr>
<td>Communication protocol</td>
<td>TCP/IP, RS-232, Modbus</td>
</tr>
<tr>
<td>Interface and Ports</td>
<td>12 VDC, IN/OUT, RS 232, HDMI, 2x USB 3.1, RS 485 IN/OUT (on request), Ethernet</td>
</tr>
<tr>
<td>Compatible sensor types</td>
<td>Strain, displacement, acceleration, vibration, inclination, load, application customized etc.</td>
</tr>
</tbody>
</table>
**Portable interrogation units**
for your specific needs

- Universal Fiber Bragg Grating Measurement device
- Cost effective 1, 4 or 8 channel mini-interrogator
- Optimized for direct use in the field onsite
- Up to 24kHz sampling rate for dynamic measurements
- Large temperature range without active cooling
- Simple quasi-static to fully dynamic measurements
- Remote device management
- Multi device integration into IoT software platform for large scale project with many different locations
Fiber optic monitoring projects
20 years of experience

FBG based sensing:
- Railway bridge, Austria
- Auxiliary bridges different sites in Austria
- Railway bridge Vienna, Austria
- Cannara bridge, Italy
- Railway Twin bridge, Netherlands
- Railway bridge, Hungary Budapest
- Different road bridges, Czech republic
- Different tunnels, Austria
- Nuclear power plant, Czech republic
- Historic church, Czech republic
- Roof monitoring, Germany
- Slope protection, Austria

Distributed sensing:
- Different railway tunnels, Austria
- Different highway tunnels, Austria
- Railway tracks, Austria
- Retaining walls, Austria, Turkey
- Piles, Austria, Switzerland, Germany
- Ship, Denmark
- Airport cost movement, France
- Subway Paris, France
- Land sliding, Austria
- Earth dam, Austria
**Road Bridge Italy**

Application example / Case study

**Background:**
- Deck arch road bridge with 2 lanes, in Italy, built in 1920
- Main traffic connection in Cannara
- Massive damages in concrete structure

**Challenge:**
- 24/7 long term monitoring of bridge required to immediately react in case of emergency
- Existing cracks need to be monitored
- “Health parameter” of bridge like own frequency, dynamic load testing etc. to be detected
Road Bridge Italy

Structural health monitoring based on fiber optic sensors only

- Based on Fiber Bragg Grating (FBG)
- 6 Accelerometers, 2 Tilt Meters, 4 Long-Gauge Sensors
- 4 Asphalt sensors for additional traffic monitoring
- FBGuard Interrogation unit onsite including integrated data analysis with remote 4G mobile connection
- Data interpretation and FEM model by local university
**Railway Tunnel Austria**

Application example / Case study

**Challenges**
- Monitoring of the tunnel lining
- Alarm in case of threshold is exceeded
- Limited access to the tunnel

**Solution**
- Development of special mechanic for FBG strain sensor
- 24/7 real-time measurement
Fundament of historic church in CZ
Application example / Case study

Fiber optic extensometer for measurement of ground stability
- Antic church, changes in ground water level => cracks in the masonry
- FBGs are fixed to traditional inclinometer tube
- On both sides of the church holes have been drilled (approx. 20 m depth)
Wall monitoring

Application examples / Case studies

Paris – Subway:
- Construction works directly next to existing subway tunnel
- Monitoring of strain 200m / 1km cable directly on affected wall

Paris – Tour Montparnasse:
- 210m / 59 floors
- Structural Health Monitoring
- Monitoring of strain directly attached to concrete wall
Background:

- Because of steep topography, the Nice airport was built along the coast, on artificial land in 1944.
- Reclaimed land is on top of the Var river delta experiencing subsidence and fresh water circulation.
- In 1979 the collapse of a seawall on the edge of the landing tracks triggered an underwater landslide / tsunami.
Fiber Optic Solution:
- Measurement of strain (Coast movement / subsidence), temperature and acoustics (freshwater)
- Cable buried in -20m seabed
- Trisens cable to measure strain and acoustics (tight buffered)
- Triple tube construction for additional temperature measurement (lose tube) and optimal fiber protection
Data visualization and processing

Directly on interrogation unit / server:
- Sigproc / Graflux Software
- Ideal for single projects / small scale implementation
- Supports all alarming options, data export, data processing

Project specific visualization:
- Customized web based applications dependent on requirements
- Using signal processing on device itself.

IoT platform on top:
- For large scale implementations / high number of sites and sensors
- Data preprocessing on devices
- Communication via standardized interfaces to IoT software platforms (MQTT)
- Alarming and visualization in IoT software
- Integration with other sensor technologies
Simple data management and visualization
using IoT Software platforms

4G gateway including Micro-PC / power management

Portable devices directly onsite

Fiber optic connection to operation center

Rack-mounted devices in operation center

Customer

Data Solutions

Cloud Services

IOT

SUPPORT

(authorized)
Sigproc / Processguard Software platform

- Universal data analyzing and processing
- Using artificial intelligence methods
- Direct integration on FBGuard or server
- Suitable for single or large scale projects
- Supports all alarming options
- 3rd party integration / data export external software platform
- Web-based user-interface
- 60 predefined modules for simple configuration
THANK YOU

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