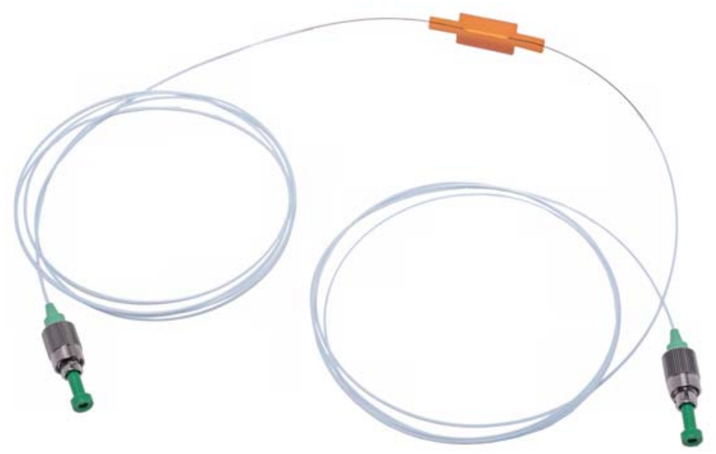
Installation Guide

English



FS62

Miniature Polyimide Strain Sensor

Hottinger Baldwin Messtechnik GmbH
Im Tiefen See 45
D-64239 Darmstadt
Tel. +49 6151 803-0
Fax +49 6151 803-9100
info@hbm.com
www.hbm.com

HBM FiberSensing, S.A.
Optical Business
Rua Vasconcelos Costa, 277
4470-640 Maia
Portugal
Tel. +351 229 613 010
Fax +351 229 613 020
fibersensing@hbm.com
www.hbm.com/fs

Mat.: 7-2002.4255
DVS: A4255-3.3 HBM: public
05.2015

Sensor Design Version: v1.0

1 Technical Details

1.1 General Information

This installation guide applies to the following products:

Part Number	Description
K-FS62-16-11-102	FS62 – Miniature Polyimide Strain Sensor • Laboratory • FC/APC
K-FS62-16-13-102	FS62 – Miniature Polyimide Strain Sensor • Laboratory • SC/APC
K-FS62-16-10-102	FS62 – Miniature Polyimide Strain Sensor • Laboratory • NC

1.1.1 Overview

The FS62 - Miniature Polyimide Strain Sensors are Fiber Bragg Grating (FBG) based sensors, designed to be bonded to surfaces and materials.

1.1.2 Characteristics

: Robustness

Long-term reliability ensured by innovative sensor design and careful selection of materials.

: Completely passive

Inherent immunity to all electromagnetic effects (EMI, RFI, sparks, etc.) and safe operation in hazardous environments.

: 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).

: Compatible with most interrogators

Provided with calibration sheet, allowing easy and accurate configuration.

: Self-referenced

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

1.1.3 Applications

HBM FiberSensing strain sensors can be used in several strain measuring applications. They are particularly suited for structural health monitoring in large structures (SHM).

: Civil Engineering
: Transportation
: Energy
: Aeronautics
: R&D

1.1.4 Quality

All HBM FiberSensing's processes are strictly controlled from development to production. Each product is subjected to high standard performance and endurance tests, individually calibrated and checked before shipping.

HBM FiberSensing, S.A. concentrates all optical sensing activity of HBM and is an ISO 9001:2008 certified company.

1.1.5 Accessories

The implementation of complex sensing networks in large structures is made simpler with HBM FiberSensing accessories. These include cables especially designed to resist harsh environments as in civil engineering, not only during construction, but also during the lifetime of the structure (humidity, corrosion, etc.).

For the installation of HBM FiberSensing FS62 - Strain Sensors in severe environments, an optional metallic protection cover is available.

1.2 General Specifications

Sensor	
Sensitivity[1)]	1.2 pm/µε
Measurement range	±2500 µε
Gauge length	<10 mm
Resolution[2)]	1 µε
Optical	
Central wavelength	1500 to 1600 nm
Spectral width (FWHM)	< 0.2 nm
Reflectivity	> 65%
Side lobe suppression	> 10 dB
Inputs / Outputs	
Cable type	Ø 0.9 mm laboratory (hytrel)
Cable length	2 m each side (±5 cm)
Connectors	FC/APC SC/APC NC (No Connectors)
Environmental	
Operation temperature	-20 to 80 ºC
Mechanical	
Materials	Polyimide film
Dimensions	40 x 12 x 0.2 mm
Weight	1 g

1) Typical values
2) For 1 pm resolution in wavelength measurement

2 Sensor Installation

2.1 List of Materials

Included Material

Miniature Polyimide Strain Sensor

List of Needed Equipment

Deburring Machine (optional)

List of Needed Material

Glue	Cyanoacrylate or epoxy
Paper	Sand Paper (optional)
Cleaning	Alcohol and tissues

2.2 Preparing the Surface

If there are protection layers applied on the material, such as paint or rust, deburr (*Fig. 2.1*) or sand (*Fig. 2.2*) the surface to remove them ensuring that the surface does not become irregular.

Fig. 2.1

Fig. 2.2

Clean the surface with a tissue and alcohol, always wiping in the same direction until the tissue comes out clean (*Fig. 2.3*).

Fig. 2.3

2.3 Placing the Sensor

Carefully take the sensor out of the box and align it in the desired position (*Fig. 2.4*).

Fig. 2.4

Fix the sensor using drafting tape (*Fig. 2.5*).

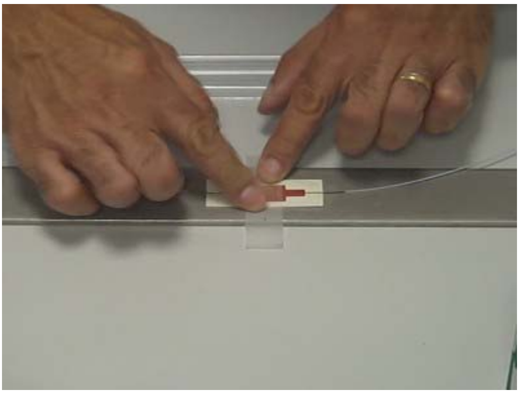


Fig. 2.5

Slowly fold and remove the paper protection (*Fig. 2.6*).

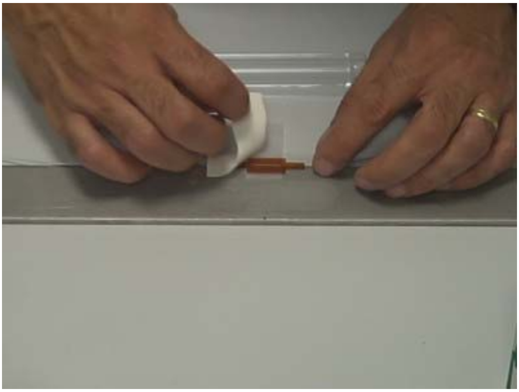


Fig. 2.6

Apply a uniform thin layer of glue on the entire surface of the sensor (*Fig. 2.7*). HBM FiberSensing suggests the use of cyanoacrylate with a PTFE (e.g. Teflon®) brush tool for short term measurements and small installation periods (for it cures faster), or Epoxy for long term applications despite requiring longer curing time.

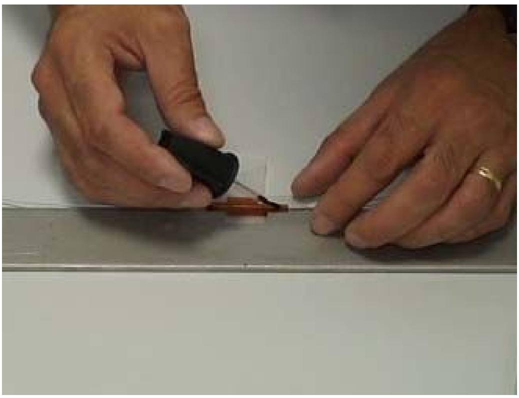


Fig. 2.7

Fix the sensor onto the surface. Press the sensor from the centre to the periphery ensuring that there are no air bubbles between the surface and the polyimide film (*Fig. 2.8*). Keep doing this movement until the glue is cured. For the suggested cyanoacrylate curing takes approx. 5 minutes.

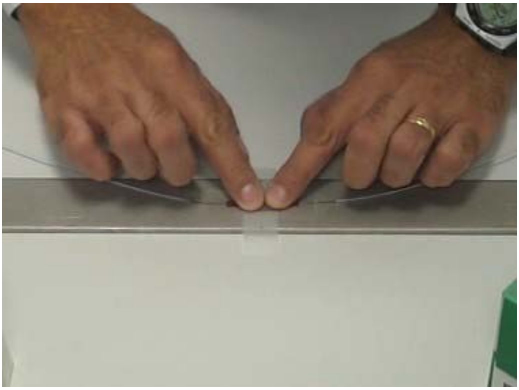


Fig. 2.8

2.4 Protecting the Sensor

The miniature polyimide strain sensor is a low cost fiber Bragg grating strain sensor designed with the minimal protection for handling.

Depending on the application there may be the need to further protect the sensor. The following instructions are only suggestions of procedure.

2.4.1 Cables Protection

The miniature polyimide strain sensor cables are protected with only 900μm buffer. For harsh environments there is the need to use ducts for fiber protection.

Small diameter tubes are advisable (3~5 mm).

Information

HBM FiberSensing sensor protection covers are designed for 3 mm protection buffer.

Carefully insert the fiber on the protection tube and then fix it next to the sensor. Ensure at least a 10 mm spacing between the end of the sensor and the beginning of the tube.

2.4.2 Moisture Protection

To protect the sensor from direct moisture contact HBM FiberSensing uses a synthetic air tight rubber (Polyisobutylene rubber).

Cut a piece of rubber tape with approximately 70x20 mm.

Fig. 2.9

Remove the protection sheet from the tape and carefully place it over the sensor, covering the sensor and the end of both 3 mm buffer. Press the tape towards the sensor and the surface.

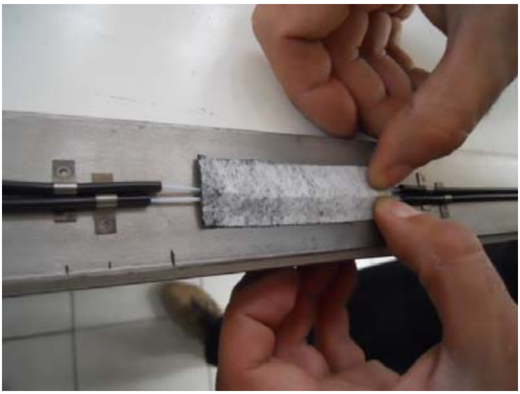


Fig. 2.10

2.4.3 Mechanical Protection

Sensors installed on Plane Surfaces

HBM FiberSensing has a sensor cover that can be used with the miniature polyimide strain sensor when a 3 mm tube or buffer is used for cables protection.

Glue the cover to the surface using an epoxy glue or sealant.

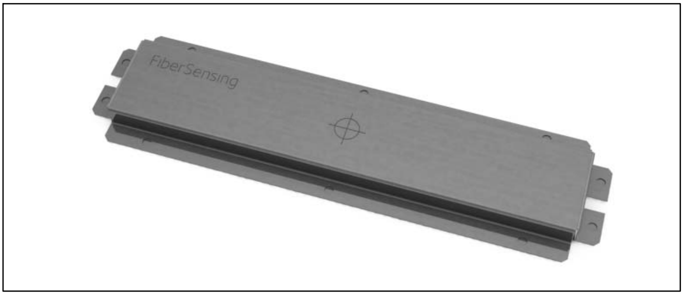


Fig. 2.11

Sensors installed on Rods

If a sensor is installed on a round surface with a small diameter, it is usual to use neoprene and self amalgamating tape for mechanical protection of the sensor.

Place a rectangular piece of approximately 20x50 mm (*Fig. 2.12*) over the sensor (after the butyl tape) and roll the self amalgamating tape covering the sensor and the cables protections (*Fig. 2.13*).

Fig. 2.12

Fig. 2.13

3 Sensor Configuration

3.1 Sensor Calibration Sheet

Every HBM FiberSensing sensor is provided with a calibration sheet. The layout of this document is the same for all strain sensors.

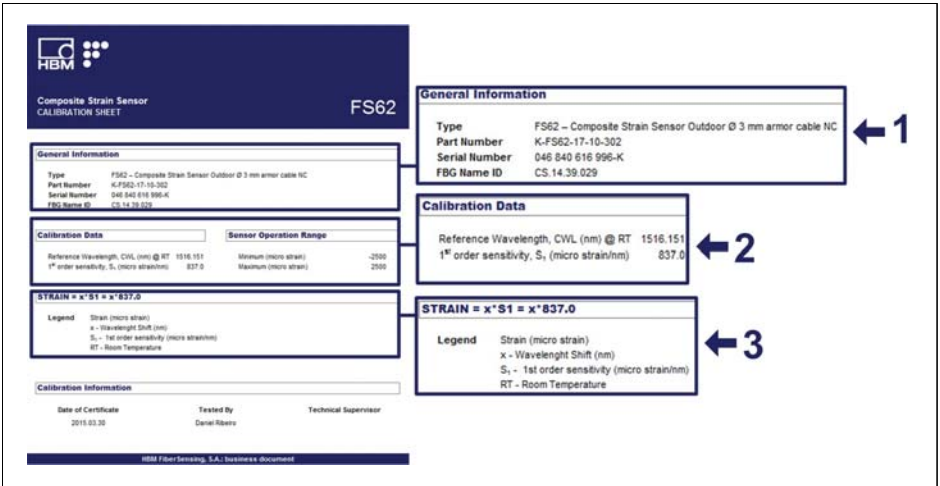


Fig. 3.1

3.1.1 General Information

Number **1** in *Fig. 3.1* shows the general information on the particular sensor, such as its type, the sensor part number, its serial number and the production tracking number, the FBG ID.

3.1.2 Calibration Data

Under the calibration data table (number **2** in *Fig. 3.1*), there is the most important information on the strain sensor: its central wavelength at room temperature and its sensitivity – values that should be used for strain computation.

3.1.3 Strain Computation

Number **3** in *Fig. 3.1* exemplifies the calculations that should be performed for wavelength measurement to strain conversion. The strain variation, under constant temperature, of a miniature polyimide strain sensor is given by the product of wavelength shift from the zero moment by the sensor's sensitivity.

$$strain = x * S \leftrightarrow strain = (WL - CWL) * S$$

Fig. 3.2

Where

- x is the wavelength shift in nm
- S is the given sensitivity in $\mu\varepsilon$/nm
- CWL is the central wavelength of the sensor at the zero moment in nm
- WL is the measured wavelength in nm.

3.2 Temperature Effect on the Sensor

The miniature polyimide strain sensor, as most sensors, is sensitive to temperature changes. The temperature induced wavelength shift can be confused as strain. For its correction, a representative temperature sensor should be used.

3.2.1 Effect of the Temperature on the Sensor

The temperature dependence of the miniature polyimide strain sensor is:

$$7{,}32 \times \Delta T$$

Fig. 3.3

Where:

- ΔT is the temperature shift from the zero moment, in ºC, measured with a representative temperature sensor.

This means that to compensate for the effect of temperature on the sensor measurement the computation should be:

$$strain = x * S - 7.32 \times \Delta T \leftrightarrow$$
$$strain = (WL - CWL) * S - 7.32 \times \Delta T$$

Fig. 3.4

Information

Note: this computation only corrects the effect of temperature on FBG and does not take into account the thermal expansion of the base material where the sensor is attached to.

3.2.2 Effect of the Temperature on the Sensor and on the Base Material

To compensate also for the deformation of the structure due to temperature effects, the computation should be done considering the coefficient of thermal expansion (CTE) of the structure.

The total strain variation of a structure is:

$$strain = strain_{Load} + strain_{Temp\ on\ FBG} + strain_{Temp\ on\ Structure} \leftrightarrow$$
$$strain = strain_{Load} + strain_{Temp\ on\ FBG} + CTE_{Structure}\Delta T \leftrightarrow$$

Fig. 3.5

Where

- Strain is total strain in $\mu\varepsilon$
- $Strain_{Load}$ is the strain due to loading that we want to measure in $\mu\varepsilon$
- $Strain_{Temp\ on\ FBG}$ is the temperature induced strain measurement, as explained above, in $\mu\varepsilon$
- $Strain_{Temp\ on\ Structure}$ is the temperature induced strain on the structure, in $\mu\varepsilon$
- $CTE_{Structure}$ is the thermal expansion coefficient of the structure material in $°C^{-1}$

Meaning that to compensate the deformation of the structure due to temperature effect, it is necessary to know the CTE value of the material of the structure where the sensor is fixed on.

The strain caused by loading can then be computed as:

$$strain_{Load} = strain - strain_{Temp\ on\ FBG} - CTG_{Structure}\ \Delta T \leftrightarrow$$
$$strain_{Load} = x * S - 7.32 \times \Delta T - CTE_{Structure} \times \Delta T$$

Fig. 3.6

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HBM Test and Measurement
Tel. +49 6151 803-0
Fax +49 6151 803-9100
info@hbm.com

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