## Installation Guide

English


# FS62

## Athermal Strain Sensor

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Sensor Design Version: V1.0

# 1 Technical Details

## 1.1 General Information

This installation guide applies to the following products:

| Part Number | Description |
|---|---|
| K-FS62-15-11-102 | FS62 - Athermal Strain Sensor • Standard • Laboratory • FC/APC |
| K-FS62-15-13-102 | FS62 - Athermal Strain Sensor • Standard • Laboratory • SC/APC |
| K-FS62-15-10-102 | FS62 - Athermal Strain Sensor • Standard • Laboratory • NC |

### 1.1.1 Overview

The FS62 - Athermal Strain Sensor is a Fiber Bragg Grating (FBG) based sensor with an innovative proprietary design that ensures athermal operation of the strain gauge by cancelling the intrinsic fiber optic thermal sensitivity (standard option).

The measurement of temperature for the compensation of cross-sensitivity is, therefore, not necessary. This benefits large scale system design and overall performance.

The FS62 - Athermal Strain Sensor can be designed to be bonded onto different structures or components made of several materials.

### 1.1.2 Characteristics

**: Intrinsic athermal design**

Possible adjustment to further compensate for the thermal expansion of a given structure, thereby enabling stress and load-induced strain-components to be measured.

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

: Aeronautics
: Civil Engineering
: Industry
: R&D

### 1.1.4 Quality

All HBM FiberSensings'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 - Athermal Strain Sensors in severe environments, an optional metallic protection cover is available. It must be used in combination with 3 mm armor protection cables.

## 1.2 General Specifications

| | |
|---|---|
| **Sensor** | |
| Sensitivity[1)] | 3.9 pm/µε |
| Measurement range | ±1500 µε |
| Gauge length | 23 mm |
| Resolution[2)] | 0.6 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<br>SC/APC<br>NC (No Connectors) |
| **Environmental** | |
| Operation temperature | -20 to 80 ºC |
| Cross sensitivity | < 2 µε/ºC |
| **Mechanical** | |
| Materials | Aluminum, polyimide, polycarbonate and vinyl |
| Dimensions | 32 x 10 x 0.8 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**

Athermal Strain Sensor (Standard)

**List of Needed Equipment**

Deburring Machine (optional)

**List of Needed Material**

| | |
|---|---|
| Glue | Cyanoacrylate |
| Paper | Sand Paper (optional) |
| Cleaning | Alcohol and tissues |
| Tape | Drafting tape |

## 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*

► Clean the surface with a tissue and alcohol, always wiping in the same direction until the tissue comes out clean (*Fig. 2.2*).

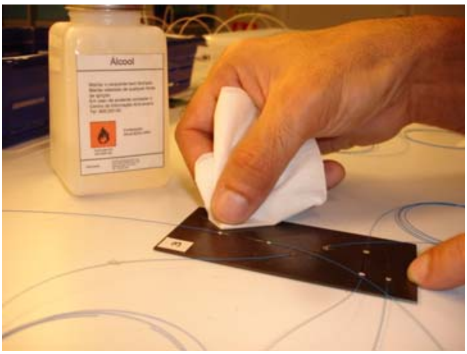


*Fig. 2.2*

## 2.3 Placing the Sensor

► Carefully take the sensor out of the box and align it in the desired position.

► Fix the sensor using drafting tape (*Fig. 2.3*).

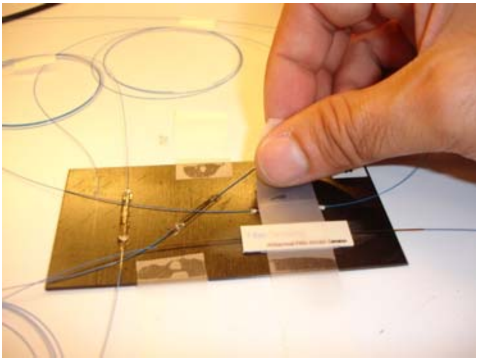

*Fig. 2.3*

► Keep one side of the tape fixed to the base material so that the sensor is kept on its position. Fold the tape so that the gluing surface of the sensor is facing up.

► Apply the glue on the fixing area, carefully filling the sensor holes. Apply a small amount line of glue along the sensor (*Fig. 2.4*).

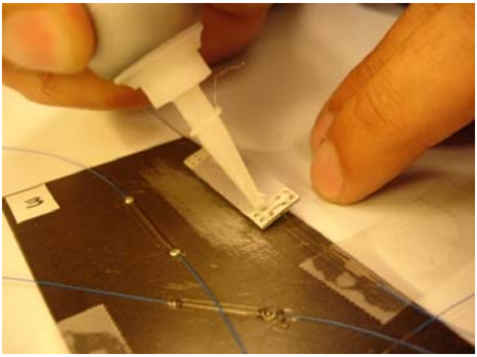

*Fig. 2.4*

► Turn the sensor back to its final position pressing only on its extermities (*Fig. 2.5*).

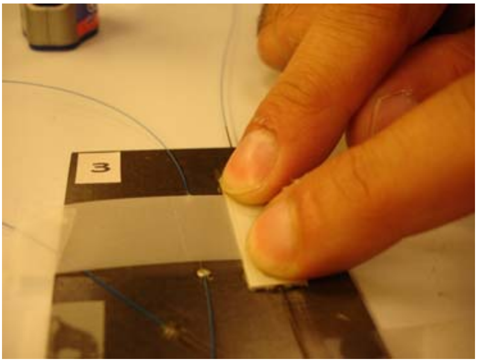

*Fig. 2.5*

## 2.4 Protecting the Sensor

Athermal strain sensor is a 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 athermal 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. 2.6*

► 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.

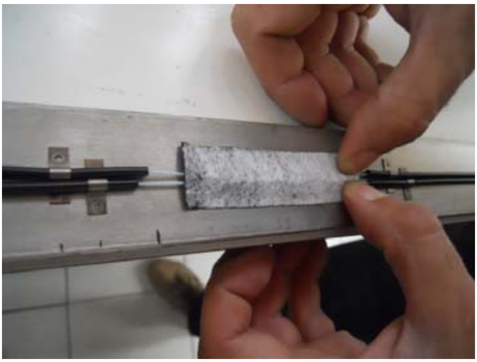

*Fig. 2.7*

### 2.4.3 Mechanical Protection

**Sensors installed on Plane Durfaces**

HBM FiberSensing has a sensor cover that can be used with athermal strain sensor when a 3 mm tube or buffer has been used for cables protection.

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

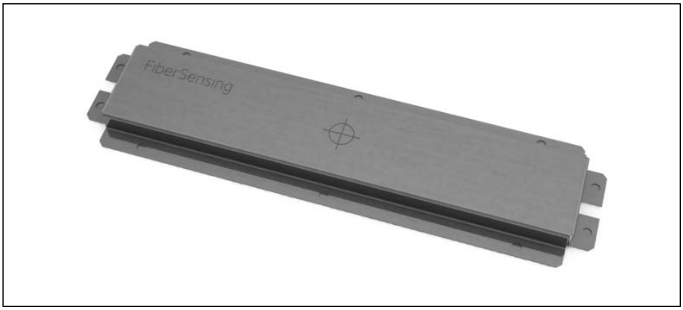


*Fig. 2.8*

# 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.

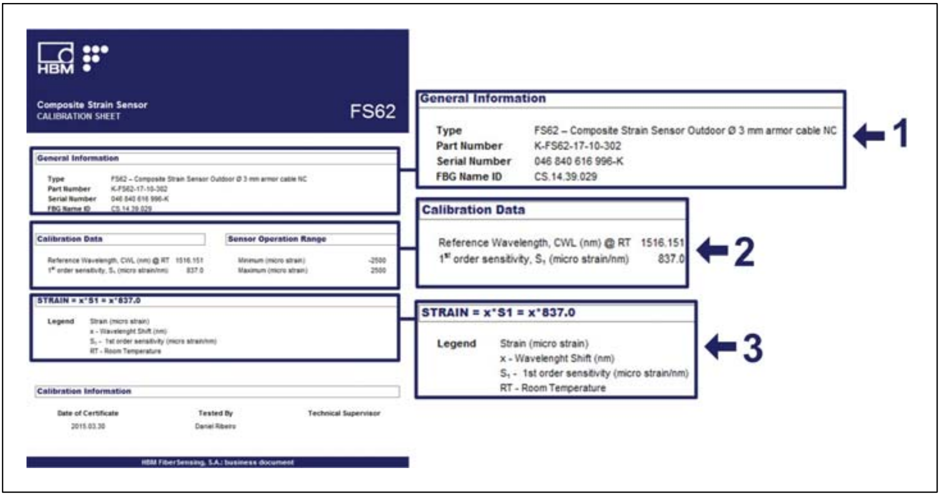


*Fig. 3.1*

### 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 athermal 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 με/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 athermal strain sensor is designed to intrinsically compensate the effect of temperature on the measurement.

### 3.2.1 Standard Athermal Strain Sensor

The standard athermal strain sensor compensates only the effect of temperature on the refraction index of the fiber, which means, it compensates only for the effect of temperature on the strain measurement, but not the effect of the temperature on the structure the sensor is applied to.

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:

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

*Fig. 3.3*

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 that is zero for this sensor

- $Strain_{Temp\ on\ Structure}$ 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:

$$strain_{Load} = strain - CTE_{Structure} \Delta T \leftrightarrow$$
$$strain_{Load} = x * S - CTE_{Structure} \times \Delta T$$

*Fig. 3.4*

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