Installation Guide

English

FS62

Weldable Strain Sensor

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Sensor Design Version: v2.0

1 Technical Details

1.1 General Information

This installation guide applies to the following products:

Part Number	Description
K-FS62-20-11-202	FS62 – Weldable Strain Sensor • Indoor • FC/APC
K-FS62-20-13-202	FS62 – Weldable Strain Sensor • Indoor • SC/APC
K-FS62-20-10-202	FS62 – Weldable Strain Sensor • Indoor • NC
K-FS62-20-11-302	FS62 – Weldable Strain Sensor • Outdoor • FC/APC
K-FS62-20-13-302	FS62 – Weldable Strain Sensor • Outdoor • SC/APC
K-FS62-20-10-302	FS62 – Weldable Strain Sensor • Outdoor • NC

1.1.1 Overview

The FS62 - Weldable Strain Sensors are Fiber Bragg Grating (FBG) based sensors, designed to be spot welded to structures and components.

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

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 HBM covering elements are available.

1.2 General Specifications

Sensor	
Sensitivity[1)]	849 (μm/m)/nm
K factor	0.76
Measurement range	±2500 μm/m
Gauge length	40 mm
Resolution[2)]	<1 μm/m
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 3 mm indoor (kevlar) Ø 3 mm outdoor (armor)
Cable length	2 m each side (±5 cm)
Connectors	FC/APC SC/APC NC (No Connectors)
Environmental	
Operation temperature[3)]	-20 to 80 ºC
Temperature Cross Sensitivity (TCS)	7.6 μm/m/ºC
Mechanical	
Materials	Stainless steel
Dimensions[4)]	83 x 23 x 6 mm
Weight	3 g

1) Typical values
2) For 1 pm resolution in wavelength measurement
3) Valid for dynamic measurements (enhanced creep). For static measurements up to 60°C (creep observed <0.5%, zero point return <10μm/m after cycle in the full temperature and strain range), above 60ºC higher levels of creep may be observed.
(Technical Note is available for further details)
4) Welding plate thickness of 100 μm

2 Sensor Installation

2.1 List of Materials

Included Material

- Weldable Strain Sensor
- Cable fixation steel sheets

List of Needed Equipment

- Spot Welding Machine
- Deburring Machine (optional)

List of Needed Material

- Drafting tape
- Sand paper/ emery cloth
- Cleaning agent (1-RMS1 or 1-RMS1-SPRAY)
- Non woven pads (1-8402.0026)
- Covering agents (1-AK22 and 1-ABM75)

2.2 Spot Welding Machine

For the installation of the FS62 weldable strain sensor Spot welding devices similar to c30s from Walter Heller GmbH is recommended (http://www.heller-dieburg.de/standardmaschinen/impulsschweissgeraet-c30).

Ideal welding settings may vary (depending on material, thickness, electrode position...). Nevertheless it is recommended that electrode tip diameter is <1.5 mm and voltage set between 40 V and 60 V.

2.3 Preparing the Surface

Deburr the surface until reaching a weldable area while ensuring that there are no irregularities on the surface. Clean the surface with a tissue to remove any dust.

Fig. 2.1

Use the RMS1 Cleaner (order number 1-RMS1 or 1-RMS1-spray) and non-woven pads (order number 1-8402.0026) for better results. If larger impurities still remain, use an emery cloth by performing rotatory movements, cleaning the surface for grease and dust as mentioned above.

2.4 Welding the Sensor

Align the sensor on the surface and fix it with a small piece of drafting tape.

Fig. 2.2

Fig. 2.3

It is advisable to connect the sensor to the FBG Interrogator and observe its Spectrum and Central Wavelength while welding (*Fig. 2.3*).

2.4.1 Welding Procedure

The welding sequence should be performed from the middle to the outside of the sensors with points spaced at approximately 1 mm.

Information

Sensor's spectrum may change due to heating while welding.

Follow the path as presented in *Fig. 2.4*. When the full length of the sensor is welded on both sides, proceed with welding the strain relieve points.

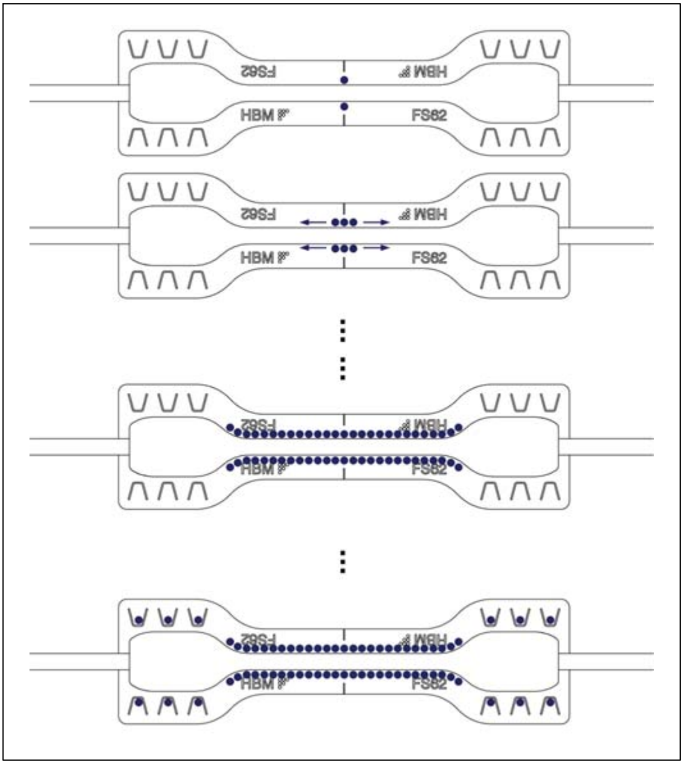

Fig. 2.4

Secure the fiber cables with the enclosed steel sheets (see *Fig. 2.5*).

Fig. 2.5

2.5 Protecting the Sensor

The sensor design and material selection make it robust and resistant. Nevertheless, degradation from the welding points may occur if no moisture protection is applied.

2.5.1 Moisture Protection

To protect the sensor from direct moisture contact HBM FiberSensing uses the AK22 and ABM75 covering agents (ordering numbers 1-AK22 and 1-ABM75).

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.

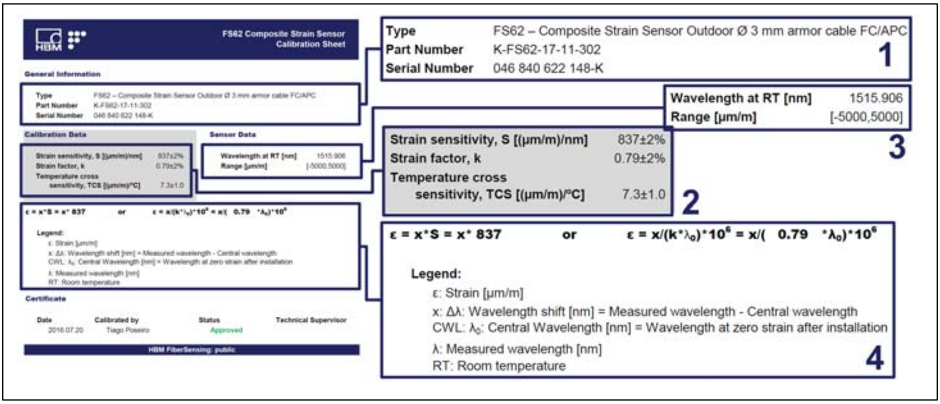

Fig. 3.1

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

The important information related to the strain sensor for configuration - sensitivity (or k factor) and thermal cross sensitivity - is shown in the highlighted calibration data table (number **2** in *Fig. 3.1*). These values should be used for strain computation.

Other relevant information on the sensor is shown under the sensor data area (number **3** in *Fig. 3.1*).

3.1.3 Strain Computation

Number **4** in *Fig. 3.1* exemplifies the calculations that should be performed for wavelength measurement to strain conversion. The strain variation (Δε), under constant temperature, of a weldable strain sensor is given by the product of wavelength variation from the zero moment (Δλ) by the sensor's sensitivity (S) or by the inverse of the product of the k factor and the Bragg wavelength of the sensor (λ_0).

$$\frac{\Delta\lambda}{\lambda_0} = k.\Delta\epsilon \leftrightarrow \Delta\epsilon = \frac{\Delta\lambda}{k.\lambda_0} \leftrightarrow \Delta\epsilon = S.\Delta\lambda$$

Fig. 3.2

Where

- Δλ is the wavelength shift in nm
- S is the given sensitivity in (µm/m)/nm and k is the k factor
- λ_0 is the central wavelength of the sensor at the zero moment in nm

3.2 Temperature Effect on the Sensor

The weldable 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 weldable strain sensor is:

$$\Delta\epsilon_{\text{Sensor}}^{\text{Temp}} = \text{TCS}.\ \Delta\text{T}$$

Fig. 3.3

Where:

- $\Delta\epsilon_{\text{Sensor}}^{\text{Temp}}$ is the temperature induced strain in μm/m
- ΔT is the temperature shift from the zero moment, in ºC, measured with a representative temperature sensor
- TCS is the temperature cross sensitivity in μm/m/ºC

This means that in order to compensate for the effect of temperature on the sensor measurement the following computation should made:

$$\Delta\epsilon = \Delta\epsilon_{Corr} + \Delta\epsilon_{Sensor}^{Temp} \leftrightarrow$$

$$\Delta\epsilon_{Corr} = \Delta\epsilon - \Delta\epsilon_{Sensor}^{Temp} \leftrightarrow$$

$$\Delta\epsilon_{Corr} = S.\Delta\lambda - TCS.\,\Delta T$$

Fig. 3.4

Where:

- $\Delta\epsilon_{Corr}$ is the measured strain without the effect of temperature on the sensor in µm/m.

Information

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 made considering also the coefficient of thermal expansion (CTE) of the structure.

The total strain variation of a structure is:

$$\Delta\epsilon = \Delta\epsilon_{\text{Load}} + \Delta\epsilon_{\text{Sensor}}^{\text{Temp}} + \Delta\epsilon_{\text{Structure}}^{\text{Temp}}$$

Fig. 3.5

Where

- $\Delta\epsilon_{\text{Load}}$ is the strain due to loading that we want to measure in µm/m
- $\Delta\epsilon_{\text{Structure}}^{\text{Temp}}$ is the temperature induced strain on the structure, in µm/m

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:

$$\Delta\epsilon_{\text{Load}} = \Delta\epsilon - \Delta\epsilon_{\text{Sensor}}^{\text{Temp}} - \Delta\epsilon_{\text{Structure}}^{\text{Temp}} \leftrightarrow$$

$$\Delta\epsilon_{\text{Load}} = \text{S}.\Delta\lambda - \text{TCS}.\Delta\text{T} - \text{CTE}_{\text{Structure}}.\Delta\text{T}$$

Fig. 3.6

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