TECH NOTE :: Temperature compensation of FBG based sensors in catman

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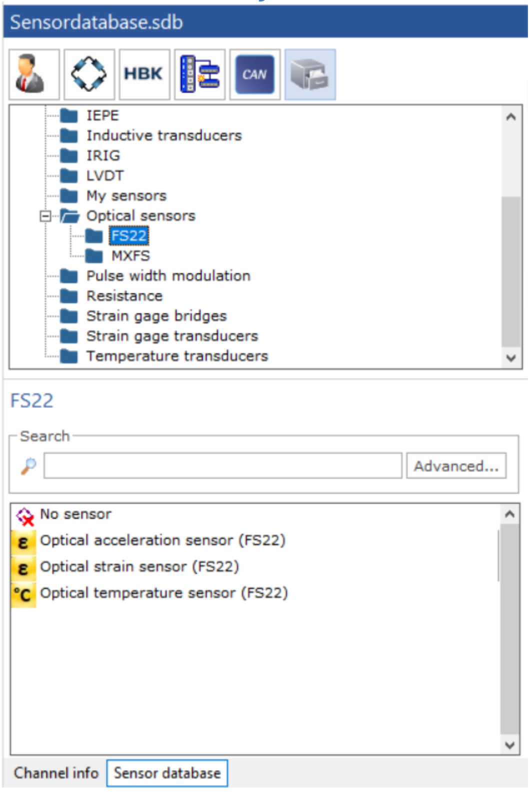
Introduction

The following document describes the implementation of temperature compensation of strain measurements based on Fiber Bragg Grating (FBG) technology using catman v5.5.

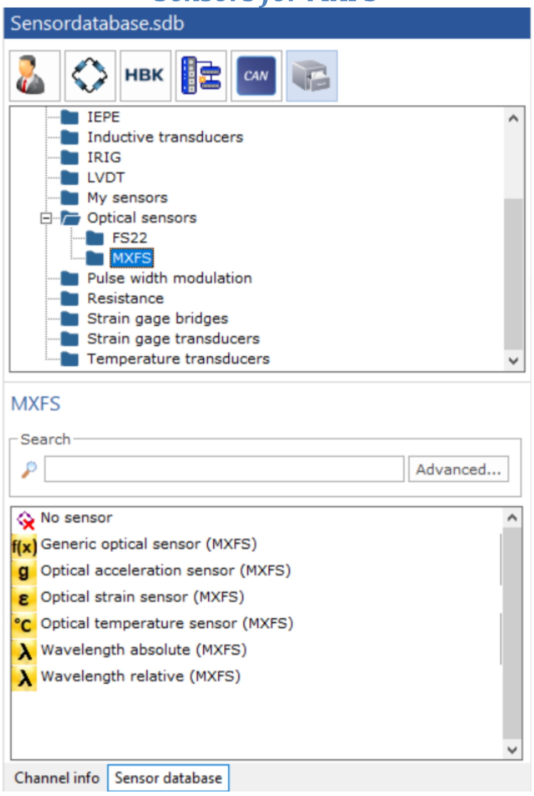
Note:
Fundamentals on temperature compensation are described on the «HBK FS_TECH NOTE_temperature compensation_v2».

For assigning optical sensors from the database on a catman project, care must be taken on the correct selection of the sensor as they are dependent on the used interrogator.

Sensors for FS22



Sensors for MXFS



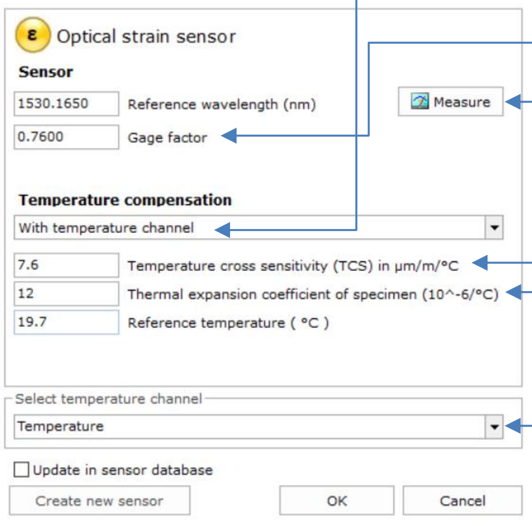
Temperature compensation within strain sensors adaptation

Temperature compensation of strain sensors using temperature measurements

Example description:
One FS62WSS Weldable Strain Sensor and one FS63WTS Weldable Temperature Sensor, both with armored cable, installed side by side. CTE of the specimen is 12 (µm/m)/ºC.

Prerequisites:
At least one sensor is defined as a temperature sensor (electrical or optical) and delivering temperatures in ºC.

Sensor adaptation:
For adapting a strain sensor:



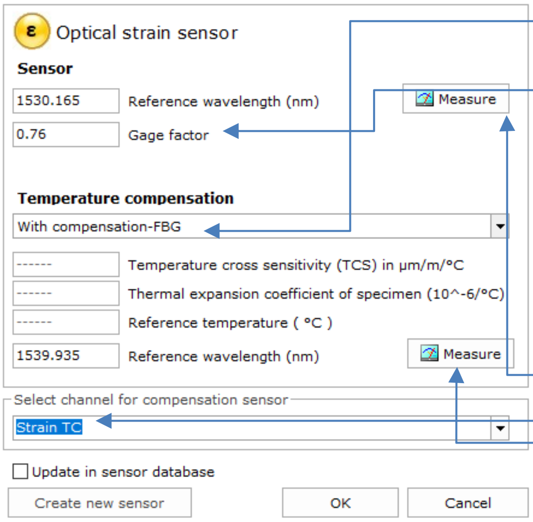
- use the “with temperature channel” option for temperature compensation;
- Fill in the gauge factor (k) of the strain sensor as given on the sensor characteristic sheet. The gauge factor corresponds to the sensitivity of the strain sensor: $\varepsilon = \frac{1}{k}.\frac{\Delta\lambda}{\lambda}.10^6$;
- Fill in the temperature cross sensitivity (TCS) of the strain sensor as given on the characteristic sheet. It corresponds to the thermally induced strain measurement on the sensor in (µm/m)/ºC;
- Fill in the specimen’s thermal expansion coefficient (CTE), in (µm/m)/ºC;
- Select the temperature channel from your project that corresponds to the temperature the strain sensor is at;
- Measure the reference wavelength of the strain sensor and the reference temperature of the temperature channel.

Temperature compensation of strain sensors using an optical FBG dummy strain sensor

Example description:
Two FS62WSS Weldable Strain Sensor with armored cable. One installed on the measurement point and the other one, next to the first one, installed on the same material free from strain.

Prerequisites:
The sensor to be used for temperature compensation is a dummy strain sensor, ie, it is a strain sensor of the same type, configured as wavelength, installed on the same material of the specimen under test and free from mechanical strain.

Sensor adaptation:
For adapting a strain sensor:



- use the “with compensation FBG” option for temperature compensation;
- Fill in the gauge factor (k) of the strain sensor as given on the sensor characteristic sheet. The gauge factor corresponds to the sensitivity of the strain sensor: $\varepsilon = \frac{1}{k} . \frac{\Delta\lambda}{\lambda} . 10^6$;
- Select the wavelength channel from your project that corresponds to the dummy strain sensor that is at the same temperature as the strain sensor to compensate;
- Measure the reference wavelength of the strain sensor;
- Measure the reference compensation channel.

Note:
For catman projects using FS22 interrogators, strain sensors show, at the moment, two additional temperature compensation options that are no longer being used as they are fitting to old sensors from the discontinued OP Line.

Temperature compensation not covered within sensors adaptation

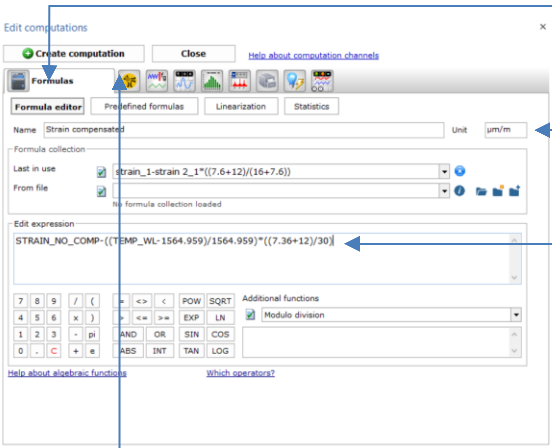
Temperature compensation of strain sensors using a non-calibrated HBK FiberSensing temperature sensor

Example description:
One FS62WSS Weldable Strain Sensor and one FS63WTS Weldable Temperature Sensor that does not have a calibration certificate, both with armored cable, installed side by side. CTE of the specimen is 12 (µm/m)/ºC.

Prerequisites:
The strain sensor is configured as strain sensor without temperature compensation ($\varepsilon = \frac{\Delta\lambda}{\lambda_0} . \frac{1}{k} . 10^6$); below named as «STRAIN_NO_COMP».

The temperature sensor is configured as wavelength (λ_{TC}); below named as «TEMP_WL»; reference wavelength should be the sensors' wavelength at the instant of zero strain (${\lambda_0}_{TC}$).

Computational channel:



Select the formula option;
Define an appropriate naming and unit;
Type the corresponding algebraic formula:

$$\varepsilon = \frac{\Delta\lambda}{\lambda_0}.\frac{1}{k}.10^6 - \frac{\Delta\lambda_{TC}}{\lambda_{0TC}}.\frac{TCS + CTE}{TCF_{TC}} <=>$$

$$\varepsilon_{compensated} = \varepsilon_{strain\ no\ comp} - \frac{\lambda_{TC} - \lambda_{0TC}}{\lambda_{0TC}}.\frac{TCS + CTE}{TCF_{TC}}$$

- Reference wavelength of the temperature sensor (λ_{0TC});
- TCS of the strain sensor as present on the characteristic sheet, in (µm/m)/ºC;
- CTE of the specimen under test material, in (µm/m)/ºC;
- TCF of the Temperature sensor as present on the characteristic sheet, in (µm/m)/ºC;

Create computation.

Temperature compensation of strain sensors using a strain sensor applied to a different material

Example description:

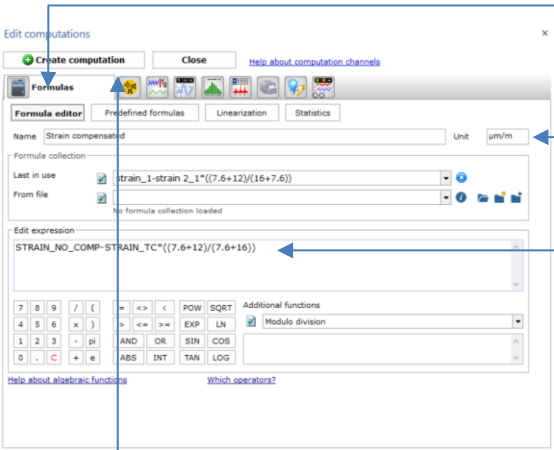
Two FS62WSS Weldable Strain Sensor with armored cable. One installed on the measurement point and the other one, next to the first one, installed on a material free from strain. CTE of the specimen is 12 (µm/m)/ºC and CTE of the compensation plate is 16 (µm/m)/ºC.

Prerequisites:

The strain sensor is configured as strain sensor without temperature compensation ($\varepsilon = \frac{\Delta\lambda}{\lambda_0}.\frac{1}{k}.10^6$); below named as «STRAIN_NO_COMP».

The compensation strain sensor is configured as strain without temperature compensation ($\varepsilon_{TC} = \frac{\Delta\lambda_{TC}}{\lambda_{0TC}}.\frac{1}{k_{TC}}.10^6$); below named as «STRAIN_TC».

Computational channel:



Select the formula option;
Define an appropriate naming and unit;
Type the corresponding algebraic formula

$$\varepsilon = \frac{\Delta\lambda}{\lambda_0}.\frac{1}{k}.10^6 - \frac{\Delta\lambda_{TC}}{\lambda_{0TC}}.\frac{1}{k_{TC}}.10^6.\left(\frac{TCS + CTE}{TCS_{TC} + CTE_{TC}}\right) <=>$$

$$\varepsilon_{compensated} = \varepsilon_{strain\ no\ comp} - \varepsilon_{TC}.\frac{TCS + CTE}{TCS_{TC} + CTE_{TC}}$$

- Reference wavelength of the temperature sensor (λ_{0TC});
- TCS of the strain sensor and of the strain sensor to be used for compensation as present on the characteristic sheet, in (µm/m)/ºC;
- CTE of the specimen under test and of the compensation materials, in (µm/m)/ºC;

Create computation.