Fiber Bragg Grating-based Temperature-compensated Strain Sensors and Sensing Cables

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Temperature-compensated Strain Sensor

The strain effect of a FBG can be functionalized for strain measurements. Depending upon the packaged FBG strain status, external strain could shift wavelength. Depending upon temperature range, the fiber package could use polymeric or metal materials for T<300^{o}C application. However, a FBG may respond to both thermal and strain variation in real environment. At constant temperature environment, a standard strain sensor may not need temperature compensation. If this is not the case, the measured strain response amplitude may also include temperature variation amount. To substrate temperature effect second FBG, acting as a temperature sensor, is also packaged inside the strain sensor to form an athermal strain sensor package. Since second FBG measured temperature can be used to deduct first FBG sensor thermal response amplitude, the real strain will be determined by

$$S(t) = \kappa(\varepsilon) \cdot [\Delta\lambda(1) - \Delta\lambda(2)]$$

where κ(ε) is strain sensitivity, which varies with maximum strain range.

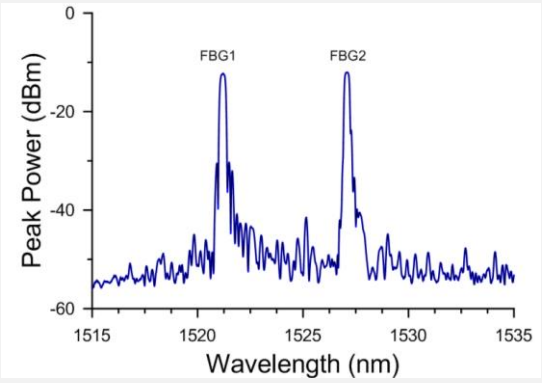


Figure 1 Two FBG sensor Peak power spectrum from a standard strain gage

Static and Dynamic Strain Sensors

Depending upon different applications the strain sensor may need to respond to fast strain change from a specific event. A strain sensor design has considered such potential bandwidth requirement that the existing strain sensors can be divided into static and dynamic sensors. For static strain sensor it has high-strain measurement range, but it is more suitable for slow strain variation measurement. On the contrary, the dynamic strain sensor may have low-strain measurement range but it could respond to transient strain variation. If such a dynamic strain variation is due to structural instability, the power spectra of the dynamic strain could give vibration frequency signature. When such a temperature compensated strain sensor can measure static and dynamic strain, then, a structure vibration frequency could be determined at the same time by Fast Fourier transform. Furthermore, the FBS strain sensors could be packaged for field installation as "Weldable", "Clampable" or "Embeddable" mechanical structures. For electric equipment environment, the strain sensor package has used Polymeric material to avoid electromagnetic interference, and electric short.

Mountable/Weldable Strain Sensors

The AMS-01 athermal strain sensor is a Fiber Bragg Grating based sensor with a special design. It decreases greatly the strain caused by the thermal expansion of stainless steel structures. It is welded on the surface of SS structures.

Mountable Strain Sensor MS-01

Embedded Strain Sensor ES-01

Mountable Strain Sensor MS-02

The strain sensors make use of the sensitivity of fiber grating to measure the strain. The FBG is fixed inside stainless steel housing between two anchoring points. The housing consists of a sliding mechanism that allows both ends to move freely relative to each other.

Arrayed FBG Strain Sensing Cable

FBG Strain Sensing cable is an array of fiber Bragg gratings, inscribed on a single optical fiber core, where the resonant wavelength of each FBG will be 1-2nm different in spectral band. Since the spacing between FBGs and number of the FBGs can be easily controlled and manufactured, this offers great flexibilities for making arrayed FBG strain sensing cables.

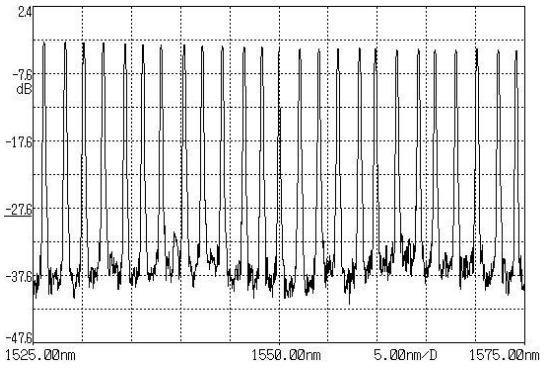
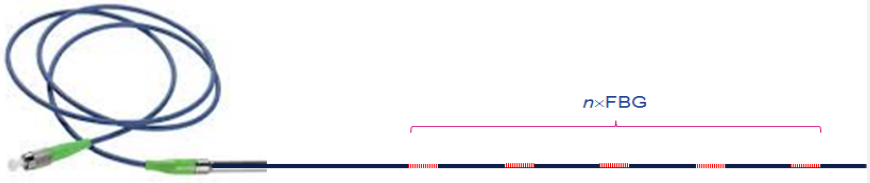


Figure 3 FBG array spectra from 25 FBGs



An engineered FBG strain sensing cable could be made by sealing fiber in a sheath or capillary, where FBG strain sensor array package material could provide both protection and also thermal conduction. For fast response or dynamic signal measurement, the diameter of the sheath should be as small as possible. On the other hand, when the fiber sensor array is used in oxidized or corrosive environment, Inconel based metal sheath should be a better option. According to customer's specific application, Boston Instruments will provide a proper package design for customer's review.

Boston Instruments provide following FBG strain sensors:

Model: ESS80-1500 (Standard, ±1500με, 80C)
Model: EST80-1500 (Temp compensated, ±1500με, 80C)
Model: EST80-1500PI (Temp compensated, ±1500με, 80C, PI house)
Model: EST200-1000 (Prototype, Temp compensated, ±1000με, 200C)
Model: EST200-1000PI (Prototype, Temp compensated, ±1000με, 200C, PI house)

Fiber Strain Sensor Specifications

Parameters	Values
Central Wavelength (nm)	1500-1600
Wavelength tolerance (nm)	±0.5
Gage length (inch/mm)	2"-4"/50-100
Reflectance	>90%
Peak Width at 3dB (nm)	~0.3
Response frequency (Hz)	1-1000
Operation Temperature(°C)	80-200
Thermal sensitivity (pm/°C)	~11-20
Strain sensitivity (pm/με)	1.2pm/με to 2.5pm/με
Temperature accuracy (°C)	±0.10
Strain accuracy (με)	1% Full range scale
Strain range (με)	500-1000-1500
Temperature range (°C)	80-200
Package material	Stainless Steel 316 or Inconel 625
Fiber connector	FC/APC or customer specified connector type
Jecket cable option	ø3mm kevlar cable/amoured cable

Please send your request directly to: sales@bostoninstruments.com