Fiber Bragg Grating-based Temperature Sensors and Sensing Cables

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Fiber Bragg Grating and Temperature Sensor

Using FBG sensor for temperature measurement from various industrial applications requires the fiber sensors to be packaged for reliability. This is not only due to fiber itself fragility but also due to the detrimental long-term effect of corrosive gases, fluids, moisture, and chemicals potentially attacking the sensors. Since each industrial system application may vary in temperature, strain, flow-rate, vibration, and corrosion, for example, the sensor packages may differ from one industrial system to another industrial system. Depending upon temperature range, the fiber package could use polymeric materials for T<300^{o}C application. Otherwise, fiber sleeve, metal sheath, or ceramic small tubing will be required to ensure the reliability for sensor performance.

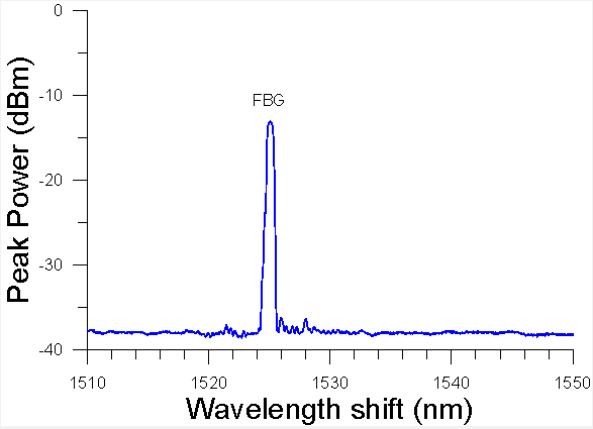


Figure 1 Peak power spectrum from a standard Bragg grating and peak shift as a function of temperature

Fiber Bragg Grating Engineered Temperature Sensor (FBG-ETS)

A FBG can be made onto different photosensitive fibers with jacket material, such as acrylate, polyimide, and metal. The periodic modulated refractive index can be uniform inscribed in the fiber core as regular FBG for temperature detection. The grating length has a typical length of 5-10mm. A typical FBG spectrum has a peak that can be up- or down-shifted by thermal effect. After a calibration process, a FBG can be used as a temperature sensor. Our FBG manufacturer has full License Agreement from CRC/UTC Fiber Bragg Grating Technologies Portfolio for FBG and sensor fabrications.

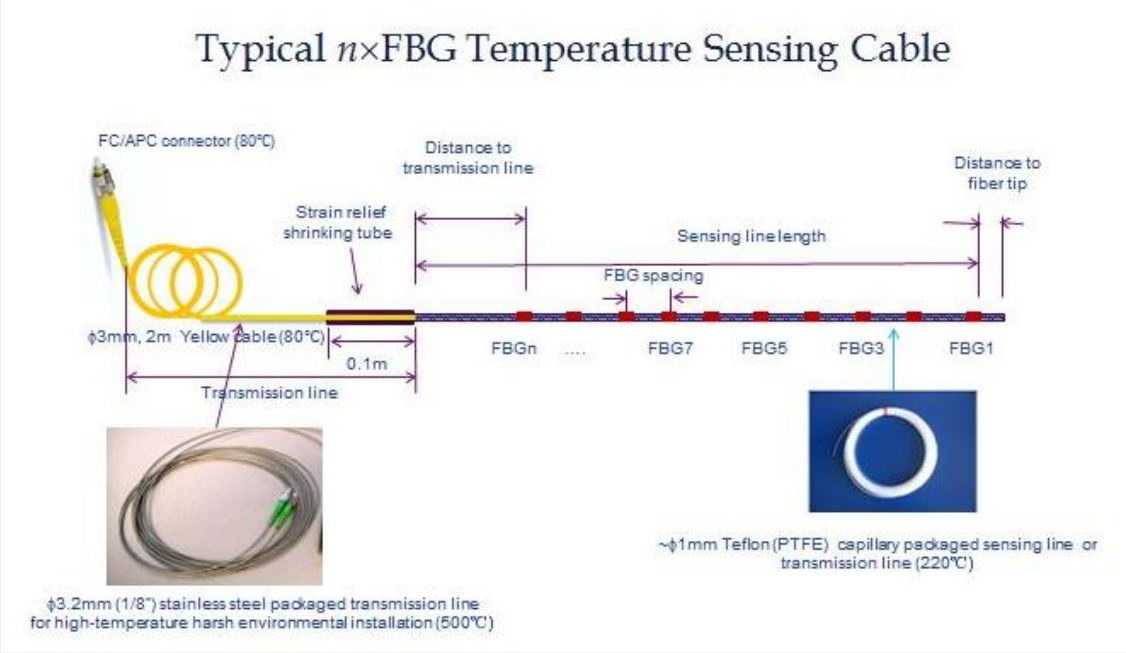
Boston Instruments FBG engineered temperature sensors are based on packaged FBG elements that are designed for high-magnetic, high-voltage, high-current, microwave, and radioactive environmental

applications. The packaged FBG-ETS sensors have a specific temperature sensitivity of ~10pm/℃. For different environmental application, the package material could be flexibly chosen to meet the maximum operation temperature requirement. These packaged FBG temperature sensors will be connected with a fiber cable either with fire-resistant Kevlar or fiber sleeve. In a specific harsh or corrosive fluid environment, a Inconel/Stainless steel based armored cable could be used for long-term operation. Here are seven types of FBG based temperature sensing cables:

Model: FBG ETS-180 (Standard bared fiber sensors, 180°F)
Model: FBG-ETS-4K (Fiber silica sleeve protected cryogenic temperature sensors, 4K-500K)
Model: FBG-ETS-370T (Teflon tubing protected fiber sensors, 370°F)
Model: FBG-ETS-570S (Fiber silica sleeve protected fiber sensors, 570°F)
Model: FBG-ETS-570P (Polyimide capillary sealed fiber sensing cable, 570°F)
Model: FBG-ETS-1000SS (Stainless steel capillary sealed fiber sensors, 1000°F)
Model: FBG-ETS-1500C (Ceramic capillary sealed fiber sensors, 1500°F)

FBG temperature sensing cable

A typical fiber temperature sensing array with *n* FBGs actually consists of three parts. First is FBG sensor spacing that can be from 0.5" to any length (1-12"). Second is up-limit temperature. Third is package material that provides fiber sensor protection against installation and operating environmental damage. The standard package material is based on flexible fiber silica sleeve (570°F) or Teflon tubing 370°F.



Third is called as "transmission line", which is transmitting signal between the interrogator and FBGs. Normally, a 3mm diameter (yellow) and 2m length cable with a FC/APC connector. However, this transmission line cable could have other package material such as fiber silica sleeve, Teflon capillary, Polyimide capillary, and stainless steel capillary for different harsh environments. BI will provide a best

package material recommendation to customer based on application conditions. For quote purpose, customer can specify exact lengths by referencing this typical fiber sensing cable diagram.

Parameters	Values			
Central Wavelength (nm)	1500-1600			
Wavelength tolerance (nm)	±0.5			
Grating length (inch/mm)	0.40"/10			
Reflectance	>90%			
Peak Width at 3dB (nm)	0.25~0.35			
Fiber coating layer	Acrylate	Polyimide	Metal	Ceramic
Operation Temperature(°C/°F)	80/180	300/580	650/1200*	850/1560*
Sensitivity (pm/°C)	~10	~12	~14	~15
Accuracy (°C)	±0.50		±1.0	
Fiber connector	FC/APC or customer specified connector type			
Fiber type	SMF28-compatible			
Pigtail length (m)	1 (standard)			
Grating Profile	Apodized			
Mechanical test (kpsi)	>100			
Grating recoating option	Acrylate/polyimide			
Jacket cable option	ø0.9mm tight buffered cable/ø3mm Kevlar cable/Armoured cable			

* Engineering prototype

BI's FBG temperature sensing cable can be designed for high-magnetic, high-voltage, high-current, microwave, and radioactive environmental applications. To assist customer application installation these wire like sensors could be mounted by adhesive bonding, welding, or clamping methods. Please specify following parameters:

- Up-limit and low-limit operating temperatures;
- FBG sensor number in each sensing cable? Ideally, each sensing cable may have a number of FBGs from 20-30.
- What is the FBG sensor spacing? Minimum spacing is 1".
- How many fiber sensing cables are needed and what are requirements from each cable?
- What are the sensing cable length and transmission line length?
- What is the temperature requirement on transmission cable?

To meet different demands from customers, we can customize fiber sensing cable by using specific package material and fabrication method. When you place your order, please specify your specific requirements to our sales department at: sales@bostoninstruments.com