



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

Boston Instruments
 1971 Western Avenue#108
 Albany, New York 12003, USA
 Tel: +1 (518) 288-6880
 Email: sales@bostoninstruments.com

Temperature-compensated Pressure Sensor

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

$$P(t) = \kappa(p) \cdot [\Delta\lambda(1) - \Delta\lambda(2)]$$

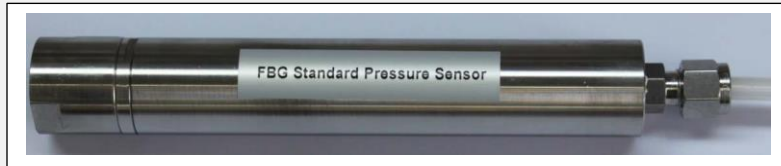
where $\kappa(p)$ is pressure sensitivity psi/pm, which varies with maximum pressure range.

Static and Dynamic Pressure Sensors

Depending upon different applications the pressure sensor may need to respond to external fast pressure change from a specific event. Current FBG pressure sensor design has considered such potential bandwidth requirement for either static or dynamic pressure response measurement. For static pressure sensor it has high-pressure measurement range, but it is more suitable for slow signal variation measurement. On the contrary, the dynamic pressure sensor may have low-pressure measurement range but it could respond to transient signal variation. If such a dynamic pressure variation is due to structural vibration, the power spectra of the dynamic signal could give vibration frequency signature. In certain case, these temperature compensated pressure sensors can measure static and dynamic temperature, static

and dynamic pressure, and structural vibration frequency at the same time. Furthermore, the dynamic pressure sensor can be cascaded as a distributed acoustic sensing cable for industrial process monitoring and automation.

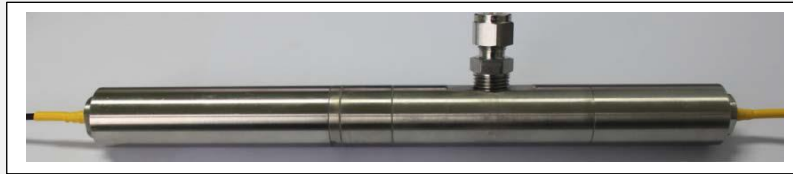
I. FBG Standard Pressure Sensors



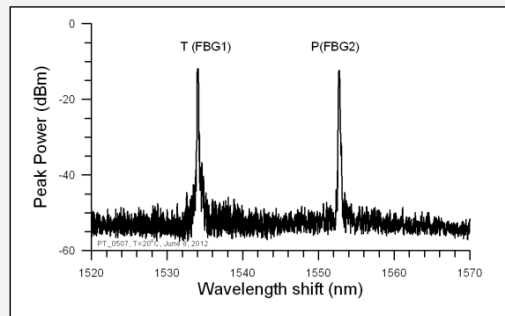
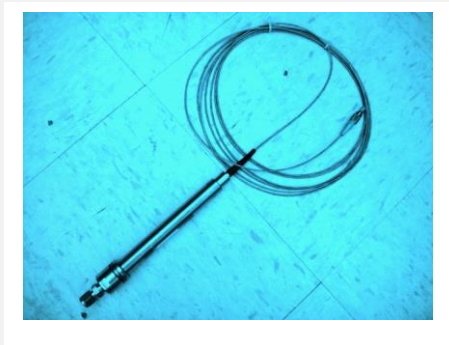
Standard Pressure Sensor



Mini-Size Pressure Sensor

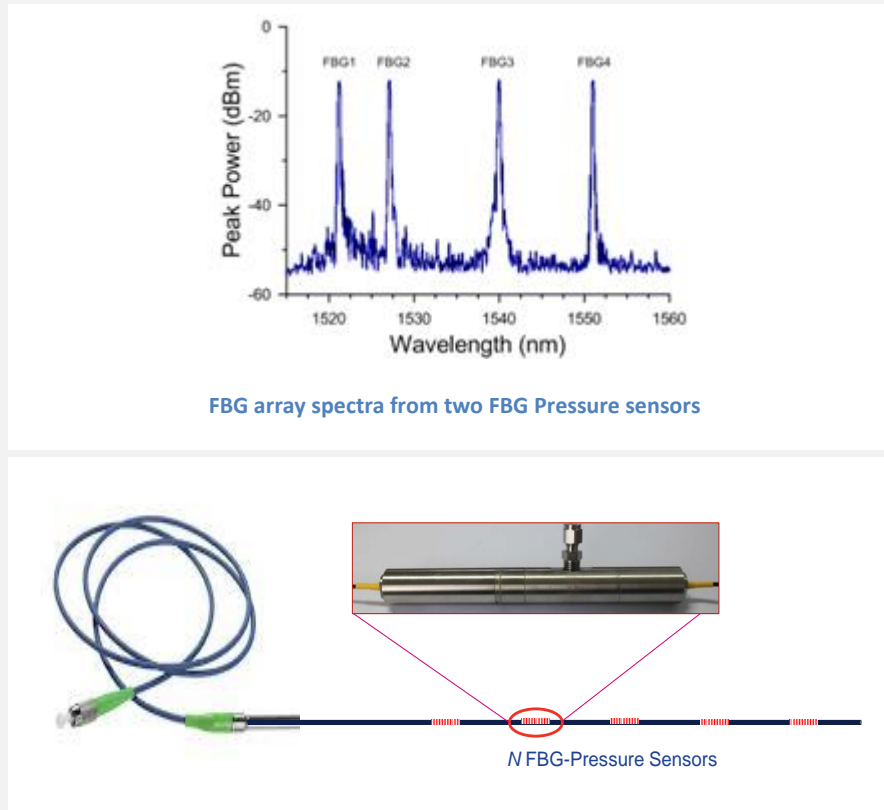


Cascaded Pressure Sensor



Arrayed FBG Pressure Sensing Cable

FBG Pressure 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 single-end and double-end FBG pressure sensing cables.



An engineered FBG pressure sensing cable could be made by splicing each individual pressure sensor in an Inconel or stainless steel small tube, where FBG pressure sensor array can be constructed with number of the pressure sensors, connected by armoured cable. According to customer's specific application, Boston Instruments will provide a proper package design for customer's review. These engineered FBG pressure sensing cable can be customized to fit to customer's installation and application requirements. To meet your needs, we provide following pressure sensor products for you to select:

Model: FBG-PS80-1000 (Standard, 80C/1000psi)

Model: FBG-TPS80-1000 (Temp compensated 80C/1000psi)

Model: FBG-TPS120-3000 (Temp compensated 120C/3000psi)

Model: FBG-TPS120-5000 (Temp compensated 120C/5000psi)

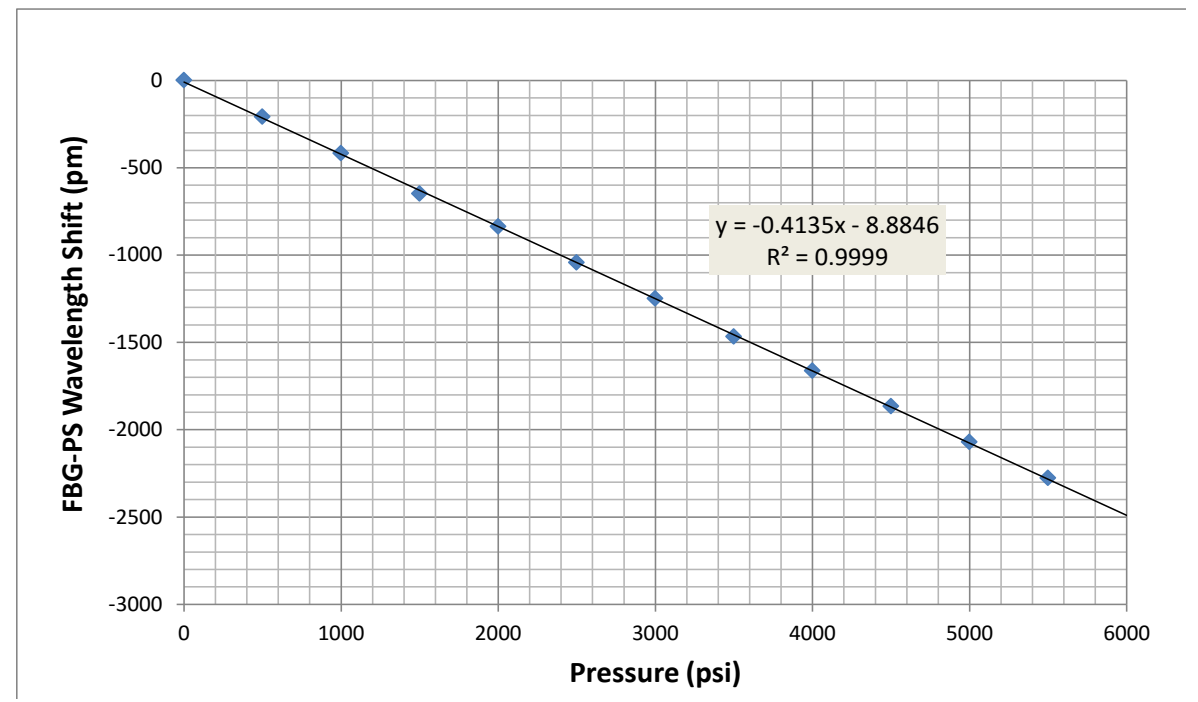
Model: FBG-TPS200-1000 (Temp compensated 200C/1000psi)

Model: FBG-TPS200-3000 (Temp compensated 200C/3000psi)

FBG Pressure Sensor calibration Processes

Each FBG pressure sensor(s) will pass a calibration process that consists of two steps. First step is to measure thermal response of FBG element(s) from a temperature range, specified by the customer. Second step is to measure pressure response under isothermal condition, normal at ambient. For a typical temperature compensated pressure sensor, such as FBG-TPS-120, one FBG will be used as temperature sensor (FBG_TS), the other FBG as pressure sensor (FBG_PS). The temperature calibration is under ambient pressure (1 atm.) but temperature is ramping from T_min=0 to T_max. For pressure calibration the FBG-TPS sensor will be tested under ambient temperature but varies pressure from P_min=0 to P_max=1000, 2000, 3000, 4000, 5000, psi etc.

Pressure (psi)	Pressure (bar)	Pressure (MPa)	FBG_PS(pm)	FBG_TS(pm)
0	0	0	0	0.00
500	34	3	-209	1.00
1000	69	7	-417	0.00
1500	103	10	-649	0.00
2000	138	14	-838	0.00
2500	172	17	-1043	0.00
3000	207	21	-1249	0.00
3500	241	24	-1468	0.00
4000	276	28	-1664	0.00
4500	310	31	-1866	0.00
5000	345	34	-2071	1.00
5500	379	38	-2278	1.00



Fiber Pressure Sensor Specifications

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)	~0.3
Pressure response (Hz)	1-1000
Operation Temperature(°C)	80-200
Thermal sensitivity (pm/°C)	~11
Pressure sensitivity (psi/pm)	0.5-10.0
Temperature accuracy (°C)	± 0.10
Pressure accuracy (psi)	1% Full range scale
Pressure range (psi)	500-1000-1500-3000-5000
Temperature range (°C)	80-200-300
Package material	Stainless Steel 316 or Inconel 625
Fiber connector	FC/APC or customer specified connector type
Jacket cable option	$\varnothing 3$ mm Kevlar cable/armored cable

To meet different demands from industrial and University R&DE, we can customize fiber sensors and packages. When you place your order, please specify your specific requirements to our sales department at: sales@bostoninstruments.com.