Optiwave

OptiSystem
Optical Communication System and Amplifier Design Suite

Fiber Loop Mirror FBG Sensor

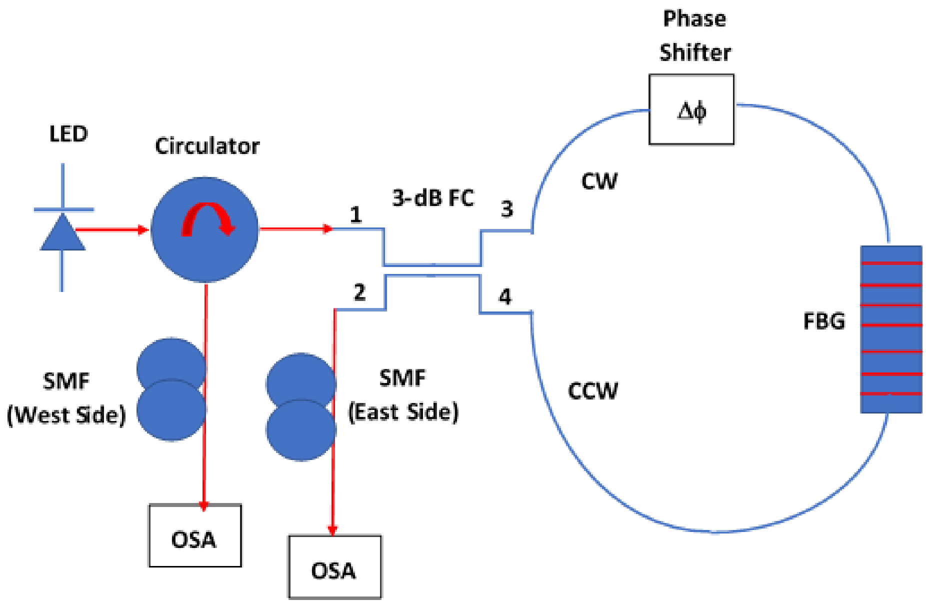
Applications

- Remote sensing
- FBG sensor synthesis
- Temperature, Stress and Strain sensing
- Civil projects like bridges, pipes, structures
- Multi-directional data sensing

Overview

Fiber loop mirror configurations have been used in several different applications. One important application is sensing. Inserting a Fiber Bragg Grating (FBG) in the fiber loop mirror allows exploiting the switching feature of the loop mirror to enable enhanced sensing and accessing capabilities. A wideband LED or white source can be launched into the FBG loop mirror to create a continuous wave (CW) optical signal at the FBG center wavelength, which can be accessed from both sides of the loop by controlling the setting of a phase shifter device within the loop. The CW light wavelength changes with environmental conditions of the FBG (which include temperature, stress and strain).

FBG Loop Mirror Sensor Layout



Benefits

- The FBG fiber loop mirror sensor can be used at any remote location to sense different parameters and carry the sensed data over single mode fiber.
- The sensed data can be accessed from both sides of the transmission system by controlling the phase of the phase shifter device.
- OptiSystem software allows users to investigate the effect of different parameters in the FBG fiber loop mirror sensor on overall performance.
- FBG parameters synthesis is possible using OptiSystem software.

OptiSystem Optical Communication System and Amplifier Design Suite
OptiSPICE Opto-Electronic Circuit Design Software
OptiBPM Waveguide Optics Design Software
OptiFDTD Finite-Difference Time-Domain Design Software
OptiFiber Optical Fiber Design Software
OptiGrating Integrated and Fiber Optical Gratings Design Software

Simulation Description

Figure 1. illustrates the layout used to conduct numerical simulations of the FBG fiber loop mirror sensor in OptiSystem. A low cost wideband LED can be used to probe the sensor. The LED light is launched into the loop in both directions through a circulator and a 3-dB fiber coupler. The FBG reflects the optical signal in each direction of the loop within its defined bandwidth and center frequency. The FBG also allows the optical signal outside its bandwidth to be transmitted and continue its direction of propagation. Once the reflected and transmitted fields return back to the output ports of the 3-dB fiber coupler, they interfere either constructively, destructively or partially depending on the phase difference between the two fields at each output port of the 3-dB fiber coupler. If the phase difference between the two fields is 0^o, the optical signal will be transmitted through the loop and appears at the other input port of the 3-dB fiber coupler (labeled 2). However, if the phase difference between the two fields is 180^o, then the optical signal is reflected back to the input port of the 3-dB fiber coupler (labeled 1). Any other phase difference would cause the optical signal to appear at both ports. The produced optical signal that is reflected or transmitted when the phase shift equals either 180^o or 0^o is a continuous wave (CW) centered at the FBG center frequency (1550nm) with 20dB linewidth of 90GHz (0.72nm) as shown in Figure 2.

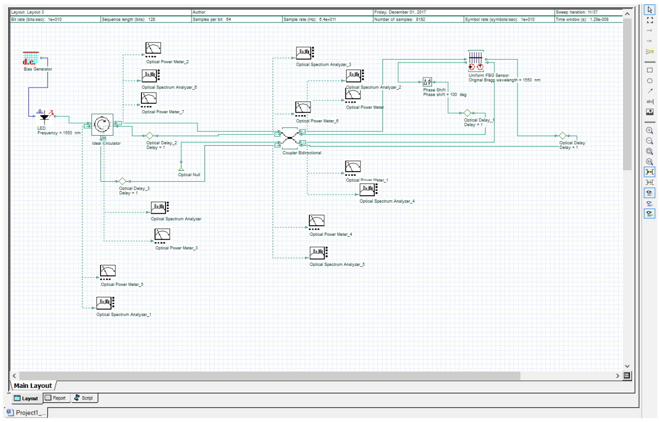


Figure 1: Simulated FBG Fiber Loop Mirror Layout.

When the environmental condition at the sensing location changes or stress and strain are applied to the fiber Bragg grating, the FBG physical condition changes affecting its center Bragg wavelength. As a result, the produced CW optical signal center wavelength varies. The drift in the center wavelength can be monitored remotely from the sensor location.

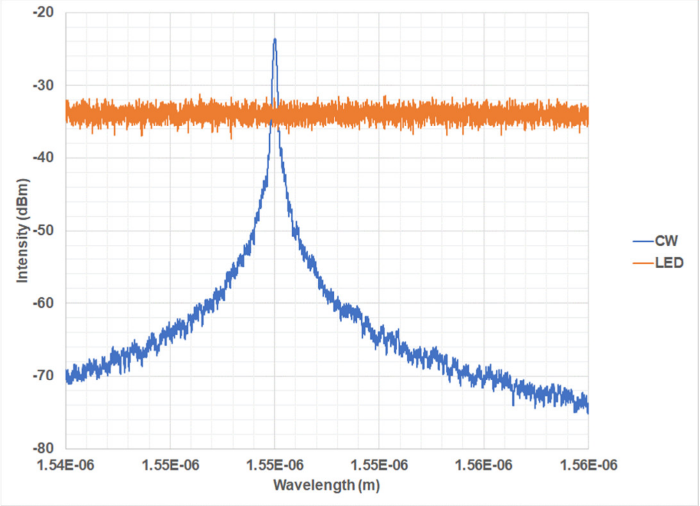


Figure 2: Transmitted CW signal when the phase shift device is set to 0^o.

Figure 3. shows the measured CW optical signal at the reflected port due to changes in the grating Bragg wavelength because of temperature variation at the sensing location when the phase shifter is set to 0^o. The temperature of the FBG is changed in the simulation from 0^oC to 100^oC.

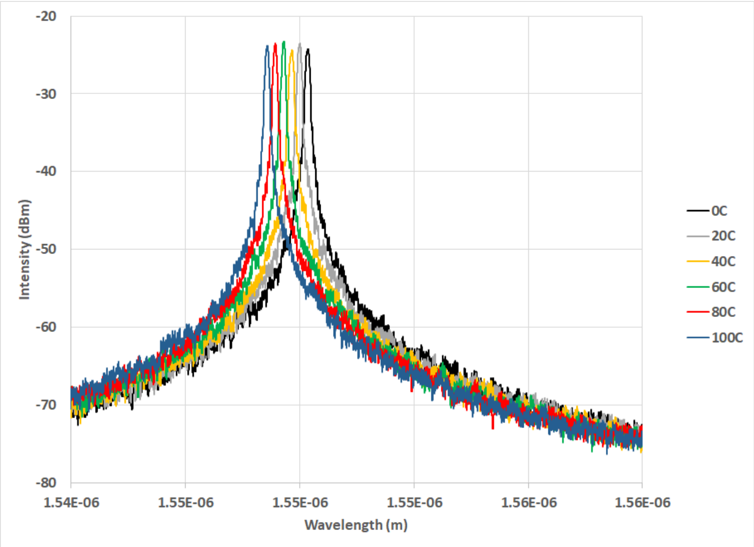


Figure 3: Response of thin rectangular cell to orientation angle.

The simulation tool can be used to synthesize the actual parameters of the FBG grating deployed in real life. This can be done during the installation and testing phase of the sensing system. Then the synthesized FBG can be used in the analysis phase of the actual sensing system by comparing the center wavelength of the measured CW optical signal and the simulated results of the synthesized FBG parameters.