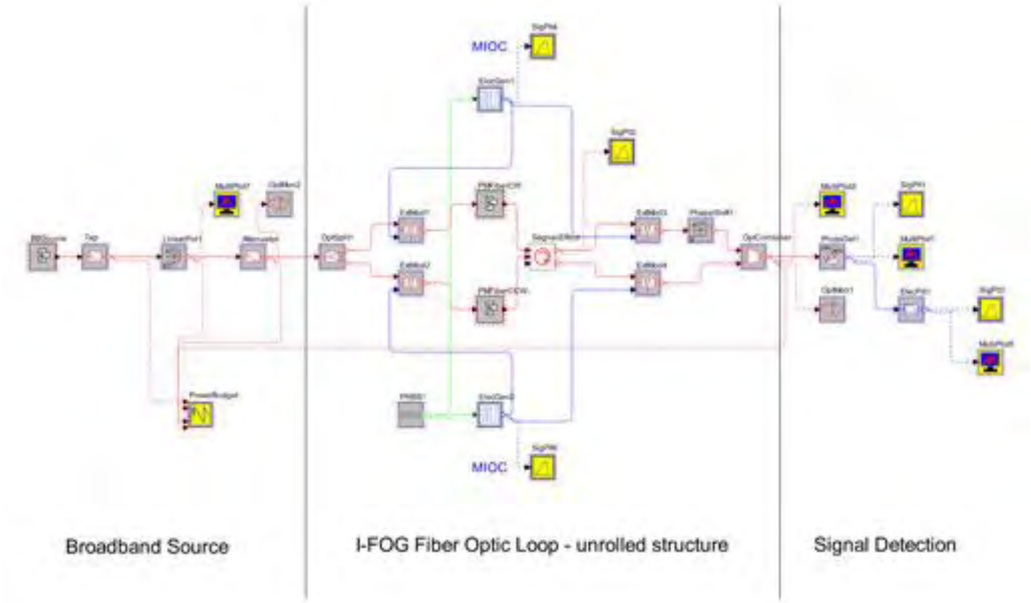
Interferometric Fiber-Optic Gyroscope (I-FOG)

Tool Used: OptSim

This example shows modeling of an Interferometric Fiber-Optic Gyroscope (I-FOG) in OptSim. The interferometric fiber-optic gyroscope (I-FOG) is today an important option for many civilian and military applications such as inertial navigation and guidance systems for automotive, aircraft, and space industries, satellite antennas pointing and tracking, mining and tunneling operations, and helicopter attitude control. It brings the advantages of solid-state technology (guided-wave optics and low-voltage low-power electronics) with a cost reduction that enlarges its domain of application.

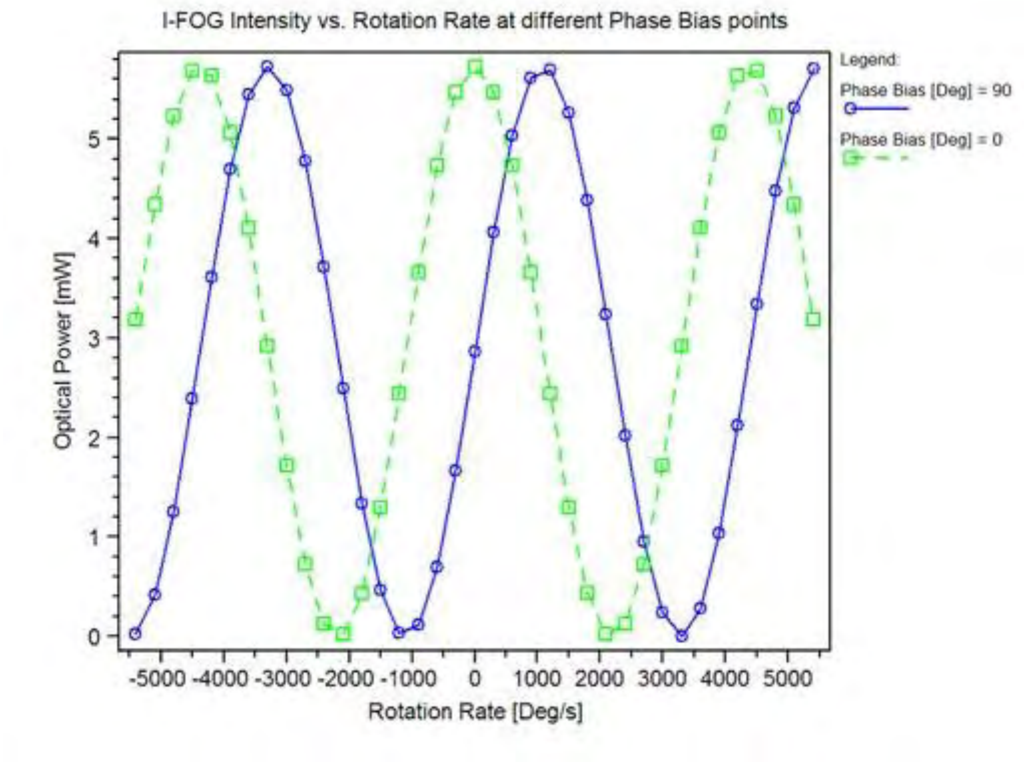
The I-FOG is based on the Sagnac effect, which produces in a ring interferometer a phase difference proportional to the dot product of the rotation rate vector by the area vector enclosed by the optical path, and takes advantage of single-mode optical fiber as the propagation medium. Several critical system components and design characteristics affect the FOG performance: the coil optical fiber; the active source; the passive and integrated-optics components; the optical circuit configuration for reciprocity; and the detection schemes.

The figure below shows OptSim layout for the I-FOG:



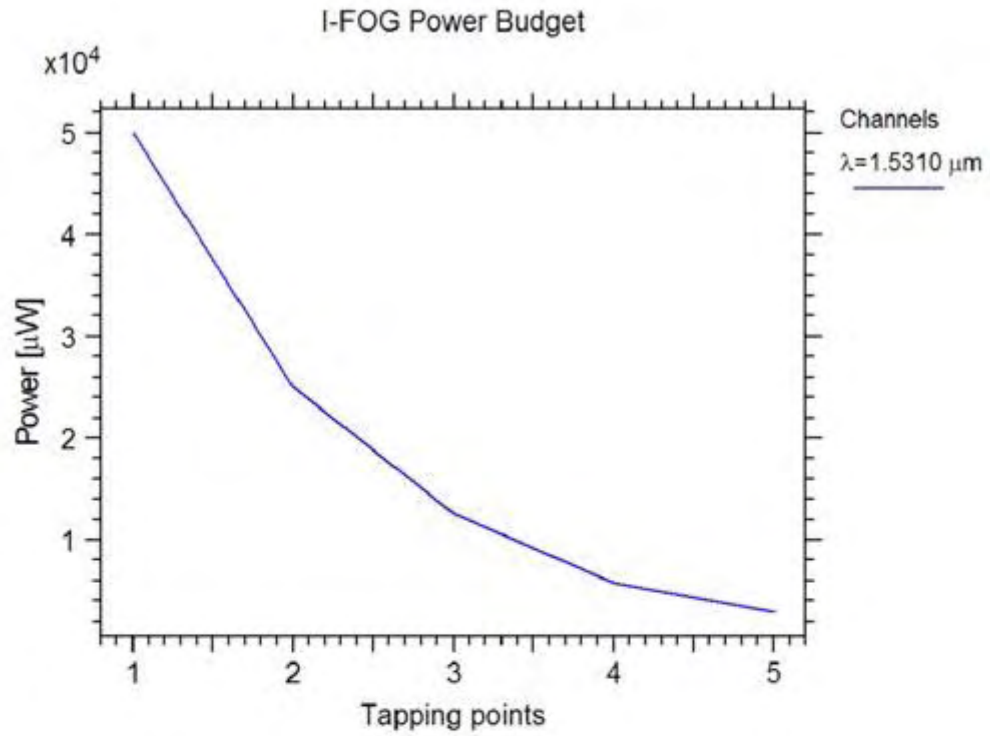
The optical source is represented by an SLD centered at 1531 nm. The multifunction integrated optical circuit (MIOC) includes two phase-modulators in a push-pull configuration, driven by a square wave with a period equal to the fiber coil transit.

The resulting 90-degrees phase shift biases the FOG around the point of maximum slope in the curve intensity versus rotation rate, maximizing its sensitivity as shown in the figure below:

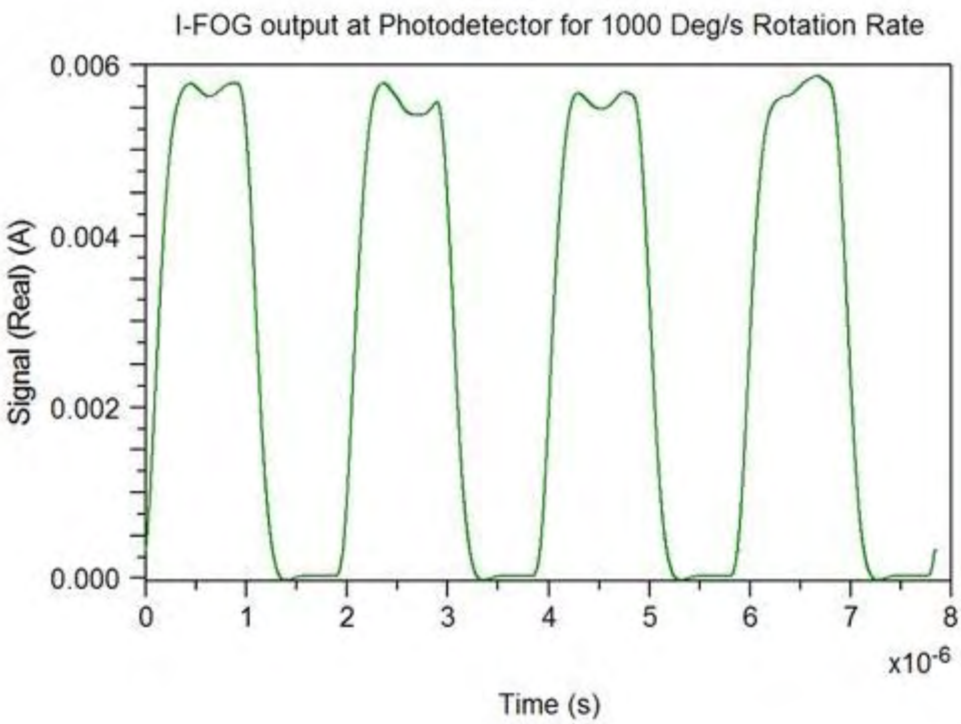


Polarization-maintaining fiber is used for the gyro coil and takes into account both polarization crosstalk and birefringence. The FOG scale factor, that is the proportionality coefficient between the Sagnac phase shift and the rotation rate, is automatically calculated from the fiber length and the gyro coil diameter. The Sagnac component models the Sagnac phase shift for both constant and time-varying rotation rates. The phase shift and polarization rotation models enable the user to simulate both phase and polarization nonreciprocity (PNR).

The figure below displays the power budget at five different tapping points as measured from the corresponding analysis component.:



The figure below shows the photodetector output signal over time for a 1000 Deg/s rotation rate. The same received signal can be used to feed the feedback section for both analog and digital signal processor (DSP) -based closed-loop detection schemes.



In conclusion, OptSim's advanced optical components and analysis tools enable the user to design and simulate next generation I-FOG. The various optical sources and rare-earth doped fiber components can model broadband and SLD sources. The comprehensive fiber model takes into account the signal propagation and polarization effects. The Monte Carlo analysis capabilities enable the user to study phase and polarization nonreciprocity effects.