Diseño e implementación de un giróscopo de fibra óptica

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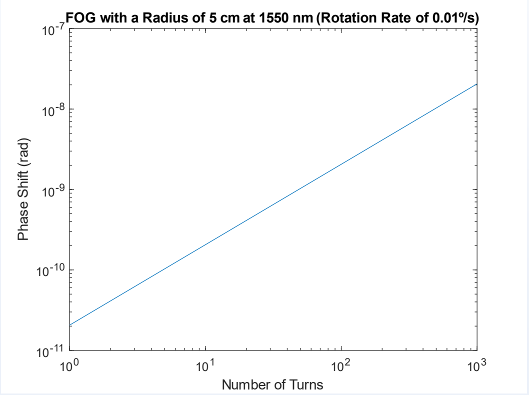
INTRODUCTION

Gyroscopes are widely used to measure orientation and angular velocity accurately. These can be of several types depending on the applied technology. Still, the most common ones are mechanical, those based on Micro-Electro-Mechanical Systems (MEMS), and those based on optical technologies like ring laser gyroscopes (RLG) and interferometric fiber optic gyroscopes (IFOGs). Gyroscopes, in general, play a key role in several applications in different fields, including consumption electronics, robotics, aerospace, submarine and military applications, among others. When most-demanding applications require high performance, long life and reliability, IFOGs are the most common solution in the current state-of-the-art [1].

OBJECTIVE

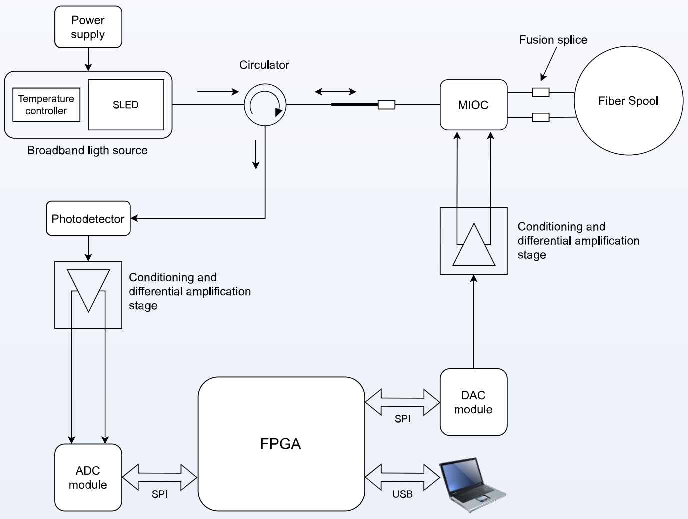
It is desirable for the project that the IFOG must be able to measure the earth rotation rate; therefore, this was established as the initial requirement for the IFOG sensitivity.



METHODOLOGY

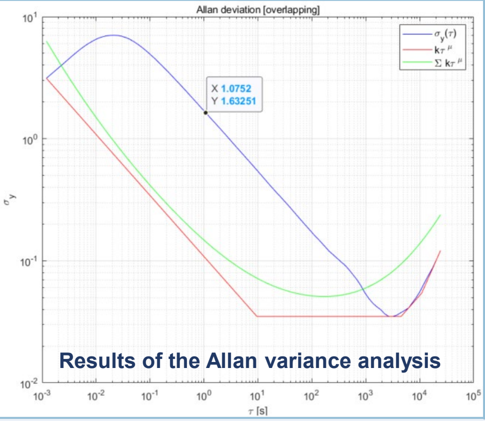
The block diagram of the instrument is shown in the figure. It includes a broadband light source, an optical fiber circulator, a multifunctional integrated optical chip (MIOC), a fiber spool, photodetection and conditioning electronics, and a closed loop [3] phase readout unit embedded in a FPGA.

Simulations were carried out in order to estimate the dimensions of the fiber spool (diameter, fiber length, etc.) and other fundamental parameters in order to obtain the target sensitivity and resolution. This simulation is focused on the fiber length (number of fiber turns) required in the design in order to obtain enough sensitivity to observe the earth rotation rate, which, according to World Geodetic System 1984 (WGS84), is Ωe= 72.92 µrad/s (4.17 ×10-3 °/s) or 15.04 °/h. For the simulation, it has been considered a fiber spool of 5 cm in diameter, and a light source with a wavelength of 1550 nm.

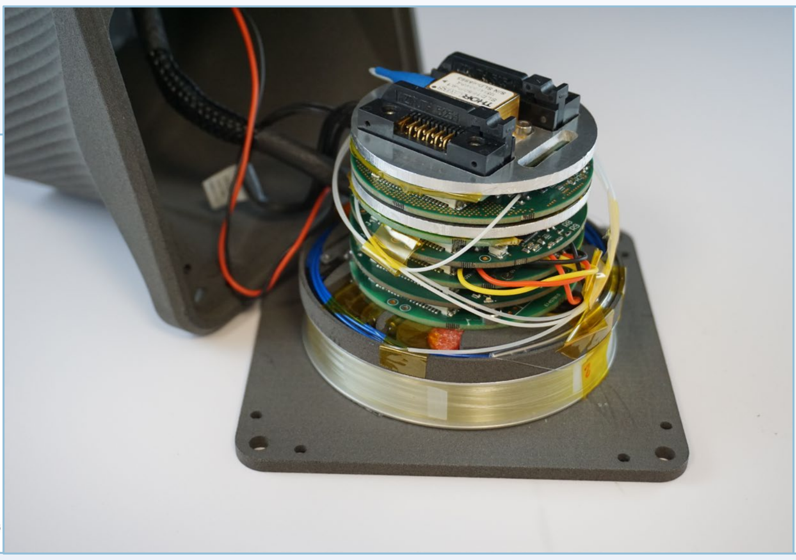


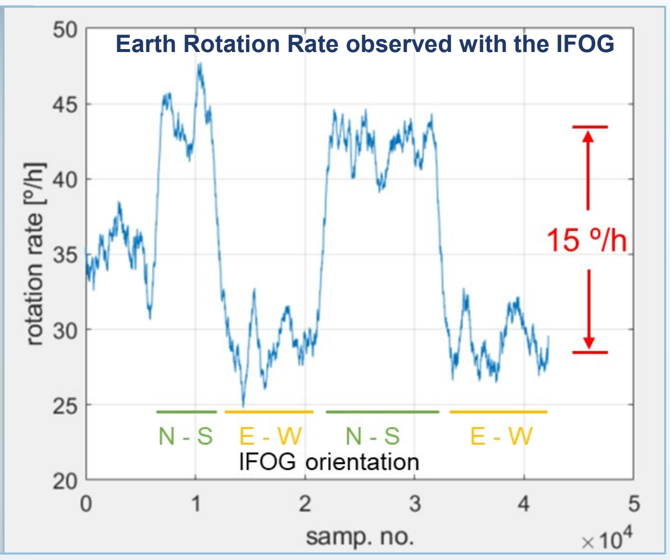
RESULTS

- System White Noise1.63°/√Hz
- Angle Random Walk 0.026°/√h
- Bias Stability 0.035°/h



Results of the Allan variance analysis





CONCLUSIONS

A high-performance IFOG has been designed and characterized [2]. The design is based on a sensing spool built with 1.2 km of optical fiber. The characterization results of the system mounted on an experimental platform show that the prototype IFOG has an ARW = 0.026 º/√h and a bias stability = 0.035 º/h. The achieved high performance allowed direct observation of the rotation rate of the earth during an additional test performed by orienting the IFOG to the directions north-south and east-west consecutively.

REFERENCES

[1] Passaro, V. M. N., Cuccovillo, A., Vaiani, L., de Carlo, M., & Campanella, C. E. (2017). Gyroscope technology and applications: A review in the industrial perspective. *Sensors (Switzerland)*,*17*(10).https://doi.org/10.3390/S17102284

[2] *952-2020 - IEEE Standard for Specifying and Testing Single-Axis Interferometric Fiber Optic Gyros*. (2021).

[3] E. Udd and M. J. F. Digonnet, 'Design and development of fiber optic gyroscopes'.