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IAF SPACE SYSTEMS SYMPOSIUM (D1)
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A REVIEW ON PHOTONIC SENSING SYSTEMS FOR SPACECRAFT APPLICATIONS

Abstract

Spacecraft systems monitoring is crucial for early fault detection and troubleshooting of various subsystems and components. To counter unexpected performance degradation or anomalies during the mission lifetime, multiple spacecraft subsystems require in-situ real-time monitoring and delicate acquisition of the operations' data. Subsystems on a satellite or a probe that would require such monitoring include structures and mechanisms such as the spacecraft bus and the deployable antennas, the power generation and storage subsystem represented in the solar-panels and the batteries, as well as the propulsion system and its propellant storage, fluid management system, and thrusters. As high-performance systems are intrinsically sought, the spacecraft design complexity increases and onboard allowable volume decreases. Fiber-optic sensing figures prominently in such scenarios due to its significantly reduced size, mass, and power consumption coupled with its higher performance and reliability when compared to conventional electronic sensors. The article aims at surveying the current trends in optical fiber sensors and their interrogation systems and critically reviewing the state-of-the-art. The fundamentals and working principles are discussed for point sensors, quasi-distributed, and distributed sensors based on Fabry-Perot Cavity, Fiber Bragg Grating, Raman and Rayleigh scattering, and Brillouin dispersion, among others. As the opportunities and advantages of the photonic sensing systems based on optical fibers are highlighted, a major focus is put on studying the current technical challenges facing the utilization of this technology in space applications. A case study of the PROBA-2 mission's Fiber-optic Sensor Demonstrator (FSD), majorly relying on FBG/MEMS sensors, is presented to draw the future opportunities in innovative space systems enabling technologies such as the fiber-optic sensor networks utilizing the modern radiation-hard photonic integrated circuits (PICs) miniaturized interrogation units.