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Author: Mr. Kenton Greene
University of Iowa, United States, kenton-greene@uiowa.edu

TESSERACT: A NANOSATELLITE-SCALE, HIGH-STABILITY FLUXGATE MAGNETOMETER FOR CONSTELLATION CISSIONS

Abstract

Accurate high-precision magnetic field measurements are a significant challenge for many applications including nanosatellite constellation missions studying the magnetosphere. Instrument stability, orthogonality, and linearity are essential in a constellation setting to enable meaningful comparison between disparate satellites without extensive cross-calibration efforts. We describe the design and validation of Tesseract: a low noise, high stability fluxgate magnetometer for suitable for nanosatellite applications. Tesseract's design takes advantage of recent developments in the manufacturing of custom low noise fluxgate cores. Tesseract uses a novel configuration of six custom racetrack geometry cores mounted within a three-axis symmetric glass-filled polyether ether ketone (PEEK) base. Tesseract's feedback windings are configured as a four-square Merritt Coils to create a 'magnetic null' inside the sensor where the fluxgate cores are held in near-zero field. This ensures that the fluxgate cores always experience a near zero magnetic field, regardless of the ambient magnetic field which we hypothesize improves the linearity of the sensor response. Biot-Savart simulation was used to optimize the homogeneity of field generated by the feedback Merritt Coils and was verified experimentally to be homogeneous within one percent. Tesseract achieves a magnetic noise floor of 6-7 pT/Hz at one Hz. We expect that the three-axis symmetry of the sensor will improve its stability over a large range of temperatures such as might be experienced in planetary science missions. We are in the process of manufacturing a high-fidelity laboratory prototype of the Tesseract sensor and will conduct thermal vacuum and vibration qualification testing. Tesseract will be flight demonstrated on the ACES-II sounding rockets in December 2021.