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ATTITUDE DETERMINATION AND CONTROL SYSTEM TESTBED FOR HARDWARE AND SOFTWARE TESTING AND VALIDATION FOR HYPSO SMALL SATELLITES

Abstract

In recent years, there has been a significant increase in the number of small satellites that have been developed and launched into Low-Earth-Orbit (LEO), herein utilizing suited commercial-off-the-shelf components and further lowering the development and production costs. Attitude Determination and Control System (ADCS) is a critical ingredient to ensure survivability and successful operations of small-satellites and their payloads, communications, and other subsystems. This paper presents the design, development and construction of an ADCS testbed dedicated, but not limited to, for testing full-scale ADCS components for Cube-satellites built at the Norwegian University of Science and Technology (NTNU), such as HYPSO-1 (HYPer-spectral SmallSat for ocean Observation) and SelfieSat by Orbit NTNU. The ADCS testbed can also be used by other interested parties in academia and the aerospace industry, and the technical drawings and specifications will be available for all interested parties.

The ADCS testbed will be primarily used for a) characterization of small-satellite reaction wheels, magnetorquers and attitude sensors; b) calibration of small-satellite attitude sensors such as magnetometers, sun sensors, gyroscopes and accelerometers; c) development and performance testing of attitude control and estimation algorithms. The testbed enables a quasi-frictionless simulated environment with software-adjustable magnetic field model, sun emulation, and a spherical air-bearing. To generate a uniform and time-varying local magnetic field represented in-orbit, a $2 \times 2 \times 2$ m^3 Helmholtz cage has been constructed which can be controlled directly from an operator through a microcontroller. The magnetic field of the Helmholtz cage can be controlled in software based on adjustable orbital elements, an IGRF model and local calibration, or subtraction, with respect to the Earth's magnetic field. Furthermore, the spherical air bearing makes it possible to carry out actuation and/or sensor tests in quasi-frictionless rotational motion with 3 degrees of freedom, constrained only by ± 25 degrees in pitch and roll.

Theory, calculations, and simulations have been used throughout to verify construction, approaches, and results. The testbed has also been successfully demonstrated for performance characterization in detumble and sun sensor tests for a full 2U CubeSat. The testbed is planned to test parts for the upcoming HYPSO-2 and -3 satellites.