IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IP)

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ATTITUDE DETERMINATION AND CONTROL SYSTEM DESIGN FOR A 3U CUBESAT TO MONITOR FORWARD LIGHT SCATTERING OVER EARTH HORIZON

Abstract

The design of the attitude determination and control system (ADCS) of nanosatellites plays a crucial role in the success of their missions. Due to budget constraints, and mass, size and volume limitations, the nanosatellite ADCS design is a challenging task with commercial-off-the-shelf, low-cost, and small-size equipment. In this paper, the proposed ADCS design of the LEOPARD satellite is presented. The LEOPARD is a 3U cubesat developed by the Kyushu Institute of Technology and its main missions are to perform technology demonstration for an on-orbit positioning system and observe the horizon for light-intensity experiment. The light-intensity experiment requires 8 degree attitude control accuracy to realize its mission. The ADCS of LEOPARD is equipped with a three-axis gyroscope, three-axis magnetometer, six coarse sun sensors, three-axis magnetorquer, and a reaction wheel. The attitude determination part consists of a coarse attitude determination algorithm that is to be used to initialize the attitude information and an extended Kalman filter as a main attitude estimation technique that makes use of all the sensors. As a backup solution, a gyroless extended Kalman filter is designed in case of gyro failure. An estimation algorithm is designed to determine the residual magnetic moment. The attitude control algorithms provide the satellite detumbling using the B-dot control algorithm and target-pointing PD-type control algorithms. The estimated residual magnetic moment is also compensated by the feedforward control approach. The simulations show that the attitude and angular velocity can be estimated in sunphase as well as in eclipse using gyroscope measurements in addition to the magnetometer and sun sensor. Nadir pointing and Sun pointing modes can be realized using solely magnetic actuation within the requirements for communication and Sun acquisition. Horizon detection algorithm with Sun

pointing is achieved for scientific missions in sunrise and sunset phases by using a reaction wheel in addition to magnetorquers. For the verification of the algorithms, software in the loop and hardware in the loop simulations are conducted.