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IMPLEMENTING LOW-COST ADCS FOR 1U CUBESAT: INSIGHTS FROM ALEASAT

Abstract

This paper presents the design and implementation of a low-cost Attitude Determination and Control System (ADCS) for ALEASAT, a 1U CubeSat developed jointly by UBC Orbit and SFU SAT student design teams. ALEASAT's mission objective is to enable radio amateurs to request and downlink imagery of specific Earth locations, with direct applications in disaster monitoring and relief activities.

The ADCS of ALEASAT relies on hybrid magnetorquer and reaction wheel actuation schemes to achieve precise pointing capabilities within the constraints of a 1U form factor. Commercial off-the-shelf (COTS) components, including sun sensors, magnetometers, and gyroscopes, facilitate accurate attitude determination for sun pointing and camera pointing modes.

The design process emphasizes practicality and affordability, with the development of ADCS test equipment in-house, including a Helmholtz cage and a 3 degree-of-freedom gimbal. This facilitates rigorous testing and validation of the ADCS algorithms under various conditions. High-fidelity simulations complement physical testing, ensuring the stability and performance of the ADCS under different scenarios. Specifically, stability analyses demonstrate the viability of the control system in hybrid scenarios where less than three reaction wheels are available, necessitating the optimization of torque distribution between these actuators. To address this, various control strategies will be tested to optimize the torque output of the reaction wheel while compensating for the remaining torque using the magnetorquers. This approach can also enhance the reliability and redundancy of the ADCS in the event of actuator failure. The iterative process of simulation and physical testing enables the refinement of control strategies to meet the precise pointing requirements of ALEASAT's imaging payload.

The successful implementation of the ADCS brings ALEASAT one step closer to fulfilling its mission objectives while inspiring future innovations in low-cost ADCS for CubeSats. This paper aims to provide valuable insights for students and researchers embarking on similar CubeSat projects, showcasing the feasibility of achieving precise attitude control within tight budget and size constraints. Additionally, it encourages collaboration among CubeSat groups to facilitate advancement in small satellite technology.