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ATTITUDE DETERMINATION AND CONTROL SYSTEM OF THE STUDENT SMALL SATELLITE (SSS): AN INTERNATIONAL HANDS-ON SATELLITE PROJECT AMONG ASIA PACIFIC UNIVERSITIES

Abstract

Student Small Satellite (SSS) is the first hands-on satellite project of the Asia Pacific Space Cooperation Organization (APSCO), which was planned to put a constellation of three satellites into the Low Earth Orbit (LEO). The project was successfully launched into space in October 2021. SSS constitutes one Micro-satellite (SSS-1) and two CubeSats (SSS-2a, SSS-2b), aiming to train students from eight member-states and prepare them to take careers in the space industry. Space Research Laboratory (SRL) at K. N. Toosi University of Technology, in collaboration with Beihang University, has developed the Attitude Determination and Control Subsystem (ADCS) of the SSS-1. A team of graduate students and professors took part in the project to find gaps and solutions in different stages, from the design and simulation to implementation and integration tests. One of the most critical challenges was facing system requirements and constraints that limited the choice of subsystem design. SSS-1 is a microsatellite with a pointing accuracy of better than 1 degree, and it is essential to compromise between hardware selection and meeting the high accuracy and stability requirements. Thus, the SRL team did a comprehensive investigation over three years to develop algorithms according to these limitations and potential failures. In this paper, Model in the Loop (MIL) simulation results for two proposed SSS-1 ADCS configurations have been presented. The ADCS is simulated using two wheels on the Y-axis and Z-axis and is compared with the simulation using three wheels on three axes. Moreover, in both cases, three magnetorquers work to desaturate wheels. As a result, both methods show that the accuracy remains around 1 degree on three axes, but the first proposed configuration has lower power consumption and mass properties. Moreover, considering the high probability of wheels failure, developing reliable algorithms with two wheels is a promising solution. The main challenge when using magnetorquers and two reaction wheels is avoiding singular points in the control allocation, which are points along the orbit where it is physically impossible to realize the required control torque due to the physical limitations of magnetorquers. Here we show how to tackle these challenges to meet control requirements even by having two wheels in the loop. Singularity avoidance techniques reduce the risk of mission failure. This is particularly relevant to miniaturized satellite missions, where mass and volume are critical. The proposed solutions provide an alternative approach to dealing with reaction wheel failure without hardware redundancy.