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DESIGN DRIVERS OF AN ATTITUDE CONTROL SYSTEM FOR SMALL CUBESATS USING MAGNETORQUERS

Abstract

Attitude control in the case of 1U CubeSats is a crucial design choice in any mission of such scale. This leads to extensive studies being conducted before deciding on the architecture of this subsystem. In the case of Luleå University Technology's first student-led CubeSat project, Atmospheric Polar Transmission Alignment Satellite (APTAS), the driving design choices of the Attitude Determination and Control System (ADCS) were predominately impacted by its onboard payload requirements.

For successful operations of the camera, the ADCS must ensure a stability of less than 0.58 deg/s, while the pointing accuracy for both camera and EISCAT antenna system shall be less than 10 deg. In this regard, following a study of suitable hardware designs that would fulfill those requirements, the satellite shall be equipped with magnetometers, coarse sun sensors (CSS) and a gyroscope.

It is widely-known that ADCS-related tasks are notoriously computationally heavy. This presents another limitation of 1U satellites: available computational load. Preliminary studies and simulation have shown that an usual algorithm in the form of a Kalman Filter (or similar applications) would interfere with payload operations due to subsequent sensor-fusion iterations and the heavy computational load resulting from it. For this reason, the TRIAD attitude determination method was deemed a fitting alternative, due to its computational efficiency and lower number of operations. All data-processing tasks must also be conducted through the one on-board computer, due to the volume constraints of 1U.

In terms of control, the conducted simulations show that the B-dot algorithm for detumbling motion and the quaternion feedback control for nadir pointing are capable of meeting the requirements of the mission. For optimal payload operations, four operation modes have been defined, each to be functional at different stages of the satellite's mission. Each mode utilizes a distinct arrangement of ADCS components when needed.

Because of the prevalence of 1U CubeSats within the nanosat community, it is necessary to have an efficient ADCS system in order to meet the mission objectives. This paper describes in detail the developed and innovative solution for attitude dynamics of a small CubeSat.