IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (1) (8)

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DEVELOPMENT AND ANALYSIS OF A PITCH SUN TRACKING ATTITUDE MODE FOR THE 2U CUBESAT ORCASAT

Abstract

The Attitude Determination and Control Subsystem (ADCS) is a critical part of any satellite and requires particular attention in the design. In addressing this concern, the team of ORCASat, a 2U CubeSat, has found it to be more economical, faster and safer to acquire a Commercial Off-the-Shelf ADCS than to design and build one from scratch. The selected system was CubeADCS Y-Momentum (CubeSpace). It comprises ten Sun sensors, three MEMS gyros, a triaxial magnetometer and three magnetorquers aided by a pitch momentum wheel. This hardware allows the ADCS to achieve an attitude determination accuracy within the 2° requirement and a pointing accuracy below the 10° requirement in Nadir Pointing (NP) mode. A common problem to many CubeSats in ISS orbits, such as ORCASat, is the fluctuation of the power available to the solar panels during the mission lifetime: if the satellite is constantly operating in NP mode, the power availability presents some minima which depend on the position of the Sun w.r.t. the spacecraft and which appear as unavoidable design constraints. This results in a non-optimal use of the available power. In fact, if the minimum value of the available power is taken as a design driver for the energy subsystem, for most of the time the solar arrays will produce more energy than needed.

This study shows, via numerical simulations, that ORCASat can acquire and maintain with an acceptable accuracy a Pitch Sun Tracking (PST) attitude mode to be employed when the minimum points of power production are foreseen. The PST mode can maximize the power production by tracking the projection of the Sun vector on the orbital pitch plane. This allows to overcome the power budget problem without overdimensioning the energy subsystem or having to put the satellite in safe mode. It is proven through realistic simulations that the employed EKF estimator can respect the required determination accuracy and that the same LQR controller designed for the NP mode can easily be adapted for use in the PST mode. Moreover, it is shown that the transition time between the two modes consists of around five minutes. The use of the PST mode allows the power production to stabilize around the maximum value enabled by the NP mode during an orbit, thus typically increasing the average power availability over one day by more than 1 W and requiring an almost irrelevant increase in the power required by the actuators.