Design of three axis attitude control system for a double CubeSat using only magnetic torquers

Gaute Bråthen, Roger Birkeland[†] and Jan Tommy Gravdahl
Department of Engineering Cybernetics,
Norwegian University of Science and Technology

Abstract

The NUTS (NTNU Test Satellite) is a satellite being build in a student CubeSat project at the Norwegian University of Science and Technology. The project was started in September 2010 as a part of the Norwegian student satellite program run by NAROM (Norwegian Centre for Space-related Education). The NUTS project goals are to design, manufacture and launch a double CubeSat by 2014. As payload an IR-camera observing waves in the air-glow layer is planned, as well as a short-range RF experiment. The satellite will fly two transceivers in the amateur radio bands. Final year master students from several departments are the main contributors in the project and most of the system components are designed and built by students.

As the main payload is an IR-camera and one of the main goals once in orbit is to take pictures of the atmosphere, a reliable attitude control system (ACS) is important. A pointing accuracy of less than 10 degrees in every axis is necessary. Even though the control actuators are magnetic torquers (magnetorquers) this is considered as a feasible requirement.

In this presentation, comparisons between a proportional derivative (PD) controller and a linear quadratic regulator (LQR), using respectively a nonlinear and linear satellite dynamics model are presented. Parameters used for comparison are pointing accuracy, angular velocity, settling time, effieciency, model accuracy and ease of implementation on a microcontroller. An important concern is that with worst case disturbance torques acting on the satellite, three axis stability is not achievable. It is, however, suggested that with measurements of the satellite's residual dipole moment incorporated in the attitude determination system, the torquers can cancel it out.

Further, the required dipole moments from the magnetic torquers are calculated and a prototype is tested. The magnetorquers, basically electric coils are integrated on three of the PCB's with solar panels. This yields limitations on the number of windings available, but simulations indicate that the number is sufficient in order to satisfy the pointing accuracy requirement.

[†]Department of Electronics and Telecommunications

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Author for correspondence: Gaute Bråthen
Department of Engineering Cybernetics
Norwegian University of Science and Technology (NTNU)
N-7491 Trondheim
Norway
Tel: +47 45210305
E-mail: gaute.braathen@gmail.com