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CUBESAT SLIDING-MODE ATTITUDE CONTROL WITH REACTION WHEELS AND COMPENSATION FOR CORIOLIS MOMENTS AT RAPID SLEW RATES

Abstract

Within the CubeSat industry, the increase of advanced payloads requires rapid and precise attitude control systems. Conventional attitude control of CubeSats has been utilizing Magnetic torque actuators to perform attitude stabilization. With the movement towards attitude dependent payloads, a need for more aggressive actuators and control strategies will yield the possibility of utilising more than one payload in one pass and more accurate attitude control. Reaction wheels would introduce several rotating bodies within the spacecraft which at high slew rates between the use of different payloads results in increased Coriolis moment exerted by the individual reaction wheels onto the satellite body and result in a perturbed rotation.

In this case study, the CubeSat is equipped with four reaction wheels in a Tetrahedron configuration. In order to accommodate the nonlinearities such as Coriolis moments, a Sliding-mode control is designed. The designed control law counteracts the Coriolis moment contributed by each of the four reaction wheels at high slew rates.

Attitude control of nano and pico satellites, such as CubeSats are inherently difficult to test and verify at ground levels. An attitude control test stand is designed and built to test the capabilities of three-dimensional attitude control algorithms, for nano and pico satellites, using an air bearing for frictionless motion.

The results shown is a nonlinear attitude control system design, which compensates for the nonlinear Coriolis moments generated by the cross product between the angular velocity of the satellite and the reaction wheels. This control law is verified and tested through simulations and practical tests on the teststand. The teststand is embedded with a MATLAB/Simulink interface which makes it possible to verify the control law through HIL (Hardware In the Loop) simulation.

The Attitude control algorithm shows a higher accuracy during attitude maneuvres with a high slew rate. This results in an increased abillity to perform precise active pointing of nano and pico satellites, flying multiple payloads, with e.g. antennas on different sides of the spacecraft. Spacecrafts having multiple closely spaced pointing objectives, such as pointing at several ground stations within one orbit, would benefit from this decreased settling time.