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COST-EFFECTIVE ATTITUDE CONTROL VALIDATION TEST METHODS FOR CUBESATS APPLIED TO POLARCUBE

Abstract

This work presents a proposed methodology for validation of CubeSat attitude control performance before launch that is demonstrated on the Colorado Space Grant Consortium's PolarCube 3U CubeSat. To date, published tests measuring performance of a CubeSat ADCS performing attitude control in a physical simulation of microgravity have been limited in their precision due to uncertainty in external torques and have mostly been conducted on commercially available attitude control system modules.

A string suspension testbed was chosen to provide a simulation of microgravity that allows the system to rotate free of friction. The work builds on the practices for string suspension testing developed for the MicroMAS CubeSat mission in which a "fit-predict-fit" method of producing metrics of attitude control system performance was first implemented for CubeSats. "Fit-predict-fit" methods rely on measuring uncontrolled attitude control responses to determine external torques produced by the testbed. The project set out to identify and solve points of failure that were limiting measurement performance of the tests conducted on the MicroMAS system and ultimately produce more accurate measurements and predictions of testbed and attitude control system dynamic response.

An engineering model of the satellite bus was designed and built to provide independent power, wireless communication and data handling to the attitude determination and control subsystem. Attitude determination was developed using MEMS magnetometers, accelerometers and rate gyroscopes to operate within a laboratory environment. A model of the dynamics of the enguneering model's behavior in the testbed was created to act as a platform to compare measured and expected test results, and verify the attitude determination method.

Attitude determination performance was determined through a combination of direct testing and dynamics modeling in software. The methods found a maximum (worst case scenario) heading determination error of 4.6°. Oscillation tests were used to determine the external torque properties of the string suspension testbed to within two significant figures, a drastic improvement in performance compared to the MicroMAS test results. Less than $300 were spent on hardware dedicated to testing.

The results will render attitude control validation testing and consequently the use of active attitude control more accessible to future CubeSat missions. Improvements in performance when compared to the MicroMAS test results were identified as the result of more robust and flexible software modelling of string suspension testbed dynamics, improved methods of characterizing testbed external torque properties as well as improved attitude determination performance