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IMPLEMENTATION AND OPTIMIZATION OF ATTITUDE CONTROLLER FOR DE-ORBITING EXPERIMENT WITH ELECTROSTATIC PLASMA BRAKE

Abstract

An Attitude Determination and Control System (ADCS) required for de-orbiting a small satellite using Electrostatic Plasma Brake (EPB) is presented in this paper. The system will be flown onboard the Aalto-1 satellite. Aalto-1 is a 3U CubeSat mission being developed by a consortium of Finnish universities and R&D institutions lead by Aalto University. The satellite is designed to carry a de-orbiting device experiment conducted with EPB instrument. The de-orbiting concept of EPB is based on the principle of electrostatic interaction of a charged tether with moving plasma. EPB uses a charged tether that will be reeled out of one end of spinning satellite, using only centrifugal force, to a maximum length of 100m. It will then be charged negatively and will experience a drag due to the Coulomb force, whenever there is a relative motion between plasma and the charged tether. A small mass, attached to the tip of the tether, provides the centrifugal force to pull the tether out of the reel while the satellite is spinning. The EPB experiment phase begins with spinning up of satellite, using magnetorquers, to an angular velocity of 200 $^{\circ}/s$ while maintaining the satellite's rotation axis parallel to inertial Z-axis. During the deployment phase, the inertia tensor continuously changes with the changing tether length. The satellite thus starts to experience nutation as well as precession motion. Therefore, a spin controller is essential for safe de-reeling of tether. The controller has been implemented, analyzed and optimized to be able to control the spin motion at high angular velocities. The ADCS sensor suit is based on gyros, magnetometer, gps input and sun-sensors. A Kalman filter has been implemented for determining the attitude during the whole experiment, using the sensor inputs. Magnetorquers and the reaction wheels are the actuators for the ADCS. Previously, the magnetic actuation and control has been implemented and used for satellite missions where the required angular velocity was much smaller. Whereas, the work, presented here, focuses on spin control with high angular velocity. The control system has been optimized to avoid abrupt variations in the angular velocity during the tether deployment phase. The angular velocity directly controls the tension in the tether. Thus, a reliable and robust control system is essential for providing gradual reeling out of tether and also avoiding oscillatory motion beyond the safe limits.