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CONTROL DESIGN FOR AN ELECTRICAL PROPULSION SYSTEM IN A DRAG-FREE CUBESAT

Abstract

Drag-free satellites such as TRIAD I, Gravity Probe B, GOCE and LISA-Pathfinder have demonstrated the use of a free-floating test mass as a gravitational reference to the satellite's feedback control system. In drag-free motion, gravity is the only disturbing force and therefore the satellite is not affected by the non-conservative atmospheric drag which dissipates most of the orbital energy in satellites on a geodesic orbit. A drag-free 3U CubeSat equipped with Ionic-Electrospray Thrusters and an off-the-shelf Attitude Control and Determination System (ADCS) has been in development to make atmospheric measurements in a Low Earth Orbit. Ionic-Electrospray thrusters are emitter arrays featuring a highly dense concentration of porous glass emitter tips from which ions are expelled with an applied voltage between two electrodes, controlled with current or voltage. A propulsion and an attitude control are required for countering the drag force at a micro-Newton scale and other internal disturbances. In this work, we first achieve an optimal propulsion control using linear quadratic regulation and then analyse the non-linear dynamics of the controlled satellite, determined from the test mass' motion. Changes in air density, environmental noise from the gravity gradient and aerodynamic torques, noise from the thruster arrays (in the current, and alignment errors), and a pointing error from the ADCS are all considered in the design process. Finally, the propulsion control performance and power consumption have been traded off in radial-transverse coordinate system and Clohessy-Wiltshire-Hill formulation.