ASTRODYNAMICS SYMPOSIUM (C1)
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FINITE-TIME CONTINUOUS SLIDING MODE MAGNETO COULOMBIC ATTITUDE CONTROL

Abstract

A magnetically actuated satellite cannot be magnetically shielded which causes malfunctioning of magnetic sensitive sensors and instruments onboard. The residual magnetic torque resulting from the currents in the circuitry also interferes with the magnetic control system. Further, the satellite surface charging, which may be on the order of 20 KV, due to its interaction with the charged particles and high energy photons further adds to the problem. This leads to problems related to the telemetry, spurious commands causing control malfunctioning, and damage to the satellite surface including failure of integrated circuits leading to a complete failure of the satellite. However, it is possible to overcome the aforementioned problems by channelizing the accumulated static charges, which can be used effectively for the active control of a satellite by placing Coulomb shells as proposed in this paper. This also allows magnetic shielding of the satellite as no longer current carrying coils are required inside the satellite body to produce torque. A magneto-Coulombic attitude actuation system is proposed and equations of motion are developed for the same in a circular orbit. Equations for the charges required on the Coulomb shells are derived, which are used to find the available torque for actuating the satellite. Global stability of the magneto Coulombic system is proved for a modified finite-time continuous sliding mode control input. Here, the controller is designed in terms of both the errors in quaternions and the relative angular velocity. The finite-time reachability to the neighborhood of the sliding surface followed by exponential convergence of the quaternion and angular velocity, with respect to the orbital frame, is shown using Lyapunov theorem. Simulations are carried out for various initial conditions of orientation and angular velocity to prove the efficacy of the magneto-Coulombic system for the global attitude and large angular velocity control. A comprehensive physical analysis of the system dynamics is presented, which sheds light on the working mechanism of the magneto-Coulombic system in producing the torque and controlling the angular motion and attitude.