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MAGNETO-COULOMBIC FAULT TOLERANT SLIDING MODE ATTITUDE CONTROL OF EARTH POINTING SATELLITES

Abstract

Satellite attitude control is one of the key technologies for space missions. Many passive and active attitude control schemes have been developed and implemented on various satellites. Nevertheless, new control technologies are emerging. However, the success of emerging technologies depends on their feasibility of practical implementation and economic viability, because they need to surpass the existing ones which are already in extensive use. Some of the emerging technologies may be even mission specific. One such emerging technology is magneto-Coulombic actuator which harnesses the magnetic field of the planetary body to generate the necessary torque using static charge onboard the satellite. Although, theoretically any initial angular velocity can be controlled, but the management of charge and other related issues put a hyphenation on the upper limit of charge that can be managed with the current technology. The present paper aims to get rid of such technological barrier for practical implementation of the magneto-Coulombic satellite. Indeed satellite missions closer to the Sun and planets with magnetic activity will get benefited from the technology proposed in this paper. Managing charge of the order of 0.1 C may be required for controlling the satellite with an initial angular velocity of around 6 deg/s along all the body axes as observed in the geomagnetic field for low and near polar circular Earth orbit. This requires potential of the order of a million volts considering spherical charge shell as an actuator, which seems to be on the higher side from the consideration of energy efficient attitude control. To combat this issue, in this paper, a sliding control strategy and various system configurations are proposed to bring down the potential requirement to the order of hundred volts making the onboard implementation possible. Extensive computations are carried out to show that the proposed control and configurations can indeed bring down the charge requirement thereby getting rid of the potential barrier. A fault tolerant sliding control is also proposed and implemented, and it is shown that the system performance does not deteriorate with one axis actuator failure. Global stability of the attitude control system is proved using the proposed sliding control for the intact and the failed systems in the presence of noise and gravity gradient. Simulation is carried out to verify the theoretical results for various initial conditions, noise, and destabilizing gravity gradient.