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SATELLITE ATTITUDE CONTROL USING LORENTZ FORCE GENERATED BY CHARGE AT LOW VOLTAGE

Abstract

Satellite attitude control using Lorentz force was investigated in the past. This has got potential for implementation around planets having magnetic field. However, charge generation due to the presence of space plasma surrounding the satellite has proved to be major bottleneck in its implementation in the Earth's orbit. To overcome this problem, a new concept of charge generation at small voltage in the range 50-100 V, using nano conducting particles, is proposed and discussed in detail. To implement the system onboard the satellite, it is assumed that a pair of spherical shells are placed along each of the three body axes. A comprehensive new mathematical formulation is carried out to formulate the resultant Lorentz force acting on the satellite, generated as a byproduct of Lorentz force torquing, and its possible elimination. It is assumed that the charges are distributed over the surface of the shells. In general, the problem of Lorentz force actuated satellite is indeterminate due to the rank deficient matrices which arise naturally in the equation of force and torque. To make the matrices involved better conditioned two constraints are proposed and applied to the force and torque equations. It is shown that a complete elimination of the resultant Lorentz force is not possible while torquing but can be minimized under certain conditions. Moreover, it has been shown that the Lorentz force can be produced instantaneously at most along two orthogonal axes while the satellite is spinning at a very high angular velocity, otherwise only one axis Lorentz force generation is possible. In addition, a comprehensive new derivation of torque acting on the satellite, due to the presence of uniformly distributed differential magnitude charges on the opposite shells pairs along with constraints, is presented. This is followed by controllability and stability analysis of the proposed satellite system under different charge and angular velocity conditions. The proposed constraints make the control matrix better conditioned as compared to that without constraints resulting in faster convergence of attitude to the desired value. A PD controller is used for the attitude control of a Earth-pointing satellite in a circular low Earth orbit in the presence of destabilizing gravity gradient and external disturbances. The proposed system is locally exponentially stable and globally stable using the PD control. Simulation results are presented for angular velocity ranging from 0.1 to 10000 (hypothetical case) rad/s to substantiate the claim made.