IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IPB)

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ATTITUDE CONTROL OF AN EARTH-POINTING SATELLITE EMPLOYING NOVEL ACTUATOR CONFIGURATIONS FOR GLOBAL ASYMPTOTIC STABILITY

Abstract

The unprecedented boom in both the quantity and quality of space missions has directly led to a requirement for cost-effective measures. Control mechanisms that greatly reduce the overall cost of the missions from manufacturing to assembly, to deployment and maintenance is the need of the hour. To this front, this paper proposes a novel configuration of an attitude control system for an earth pointing satellite considering in both circular as well as elliptical orbits. The actuator system involves the use of both reaction wheels and magnetorquers in an optimal configuration. The proposed design involves the combination of two reaction wheels and three magnetorquers. The magnetorquers are placed along the principal body axes while the reaction wheels are oriented at angles to the axes. It is chosen to orient the two reaction wheels at angles in any two mutually perpendicular planes of the satellite body frame. Reaction wheels are responsible for generating required torques along two axes while the magnetorquers provide torque along the remaining axis. This configuration is capable of handling any under actuation arising due to the alignment of the Earth's magnetic field with any of the body axes of the satellite. In such a case, the speeds of reaction wheels are determined in order to provide torque along the axis to which the magnetic field is parallel, as well as any one of the two remaining axes. The magnetorquers are then used to generate torque along the remaining axis. The proposed hybrid actuator formulation can provide control torque along any required arbitrary direction. In addition, the magnetorquers are used for momentum dumping in order to desaturate the reaction wheels. To further reduce the cost of the mission, we also implement the bare minimum actuator configuration of one reaction wheel and three magnetorquers. A control law is then developed to estimate the torque requirements and to effectively allocate them between the various actuators. It is designed using Lyapunov stability analysis and proved to be globally asymptotically stable. Several numerical simulations for both circular and elliptical orbit conditions are carried out for varying initial conditions to demonstrate the capabilities of the hybrid actuator configuration. Studies are conducted to determine the optimal orientation of the reaction wheels on the basis of the power consumed by the reaction wheels.