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ATTITUDE CONTROL USING 3 AXIS MAGNETORQUERS AND PITCH AXIS REACTION WHEEL FOR SOLAR SAILING SATELLITE COEPSAT-2

Abstract

This paper presents the design and testing methodologies of the actuators proposed for the Solar Sailing NanoSat, COEPSAT-2 which is being developed by students of College Of Engineering Pune. The objective of maximising solar thrust requires a 90 degree pitch axis manoeuvre during the orbit. High inertia of the large sails challenges the ability of regular actuators to function as required thus making their design complex. Thus, the main focus is towards maximizing the torque generated by the actuators over the constraints of power and size. The 2-axis controllability of magnetorquers necessitates the presence of a pitch axis reaction wheel. The analysis and feasibility study of a reaction wheel has been proposed. The choice of the reaction wheel is based on a comprehensive study of inertia values of different designs while taking into account mass and dimensional constraints. The material is decided on the basis of density value comparisons and machining abilities. The testing of the reaction wheel requires frictionless or low friction environment. Thus, an air-bearing testbed has been selected to carry out testing as well as further implementation of reaction wheel control algorithms. Magnetorquers serve as the most optimum solution to the design requirement of low earth orbiting NanoSats. Comparative study between air core and ferromagnetic core reveals that, using an appropriate ferromagnetic material can suffice the higher torque requirements. The choice of the soft ferromagnetic material for the core arises by considering the properties of remanence, coercivity, and demagnetization. Power consumption, playing a key role in NanoSats, is studied for various sizes of core radii and wire diameter combinations. Based on the results, the optimal core and wire dimension has been selected. This paper presents the arguments for the choice of dimensions. For efficient and strain-free coiling of the magnetorquer, various coiling methods have been studied and tested. The test setup for the magnetorquer enables two axis rotations in order to measure the field generated. Magnetic moment is then evaluated by numerically integrating the field strength, which is measured by a magnetometer, over the complete volume. Thus, this paper includes the comparison of various technologies of actuators and the evaluation of their performance for a solar sailing mission.