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DESIGN OF A PLUG AND PLAY SOLAR SAIL MODULE AS THE PROPULSION SYSTEM FOR NANOSATELLITES

Abstract

The enormous potential shown by current nanosatellites is leading to an innovative approach for carrying out space missions with much reduced budgets. In the academic or scientific field, they are becoming the test-bench for new technologies that need to be checked in space environment. Nonetheless, due to its limited size, the propulsion system of these spacecraft is still a subject under development. Consequently, finding a cutting-edge propulsive system for nanosatellites would boost their capabilities and further their scope of operation, even allowing interplanetary missions.

This project presents the design of a solar sail as a feasible solution to thrust nanosatellites. A solar sail is a high-energy space propulsion system that uses solar radiation pressure to push large ultra-thin mirror to high speed, enabling the combination of low-cost operations with long operating lifetimes. In this project, the solar sail module (SSM) is designed to be packed into a Plug and Play (PnP) module of 2U size (20cmx10cmx10cm). The solar sail is aimed for cubesats performing missions orbiting the Moon. Basically, the sail is sized for a trajectory that departs from a GEO orbit, follows a spiral to escape from the Earth and finally drives the nanosatellite to the target lunar orbit.

The SSM detailed design has been done using Commercial Off-The-Shelf (COTS) components. The design focus remains on the sail configuration, deployment mechanism and pointing actuator. Furthermore, the structural and thermal analyses are performed with Abaqus®. With respect to the trajectory calculation, a 4 body problem is implemented through a self-developed Matlab® code with RKF7 integrator. As well, the control algorithm of the SSM pointing actuator is not included because it depends on each specific mission. Finally, a budget considering SSM manufacturing cost is also attached.

The main contribution of this work is to provide the nanosatellites community with a feasible PnP SSM design that can drive these kind of satellites from the Earth to the Moon. Furthermore, the Plug and Play manufacturing philosophy enables to build nanosatellites faster, increasing reliability and reducing costs.