SPACE PROPULSION SYMPOSIUM (C4)
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CONTROL OF MINIATURIZED ELECTROSPRAY ION THRUSTERS FOR CUBESAT DESIGNS

Abstract

Since the turn of the millennium, the definition of the CubeSat standard has boosted the popularity of nanosatellite designs among universities and the space industry. However, as the vast majority of these low-budget satellites are meant for Earth applications and LEO missions, they have involuntarily contributed to exacerbate the problem represented by space debris and pollution in low-Earth orbits. In 2010, the UN's Office for Outer Space Affairs suggested to cope with this problem by implementing post-mission disposal, via active or passive deorbiting systems. After years of experimentation with passive deorbiting systems, Polytechnique Montréal's student society PolyOrbite—in collaboration with the Canadian Space Agency—is designing a 3Unit CubeSat equipped with four electrospray ion thrusters to perform an active deorbiting maneuver at the end of its mission. To generate thrust, these propellers electrostatically extract ions from an ionic liquid and accelerate them through a strong electric field. We expect our design to produce a total thrust of approximately 600N and to achieve a delta V of 57.2 m/s with an electrical consumption of 0.25 W per thruster. In this paper, we discuss the challenges we encountered in designing the electrical system used to control the thrusters and the safety issues associated with it. We also describe how we managed to obtain variable thrust from a single motor by tuning the value of the electric field. A fundamental requirement of our system is the independent control of each motor. To do so, we parallelize the thrusters so that each line is controlled by an opto-isolator activated by the microcontroller. Voltage and amp sensors continuously measure data from each motor so that, in case of failure, thrusters can be dynamically turned on or off to compensate for the loss. High voltages are a notable risk factor for the success of the mission. To maximize the safety rating of our CubeSat, we use a highly-insulated microchip to step up the 5V provided by the power subsystem into the 1-to-1.5kV range needed to generate the electric field. We must alternate the electric field to accelerate both positive and negative ions and to prevent the spacecraft from being electrically charged after emitting the same polarity of charged particles. At an interval of approximately 20 seconds, we alternate the polarity at each thruster terminals to auto-neutralize the CubeSat. We explore the use of an IGBT H-bridge to comply with these requirements.