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DEVELOPMENT OF A HIGH-PERFORMANCE LOW-COST PPU FOR AN ELECTROSPRAY COLLOID ELECTRIC PROPULSION SYSTEM FOR SMALL SATELLITE APPLICATIONS

Abstract

The current state-of-art electric propulsion (EP) systems are capable of providing impressive system performance but are associated with both significant volume requirements and high direct cost. These technologies have not been shown to be capable of being effectively scaled down in size, whilst retaining system performance. As a result, such technologies are not an established solution for nano and micro satellites, which represent a rapidly increasing share of the market due to the advent of large constellations.

Recognizing that the overall cost of an EP system is largely driven by the cost of the PPU (Power processing Unit), a tailored low power, low cost and high performance PPU is designed targeting the CubeSat Market. By studying the periphery and interfaces a straight-forward architecture was devised, containing 4 high voltage generators and 12 high voltage switches, all controlled by a microcontroller. The architecture is suited to drive two colloid thruster heads at opposite polarity, omitting the need of a neutralizer to keep the charge balance. The PPU is powered from a 5V and 12V power bus and communicates via I2C.

The PPU is designed using low cost COTS (Commercial Of The Shelf) components, which were selected for high efficiency and high accuracy. To achieve the high voltage accuracy 4 calibrated fine-tune regulation loops are implemented.

The high voltage switch needed in this architecture requires a breakdown voltage of > 6 kV and needs to carry 3mA of current. Transistors with breakdown voltages in the range of 6 kV are not available on the market. SystematIC is developing a high voltage stackable integrated circuit to provide a solution for the 6kV transistors and enable implementation of the PPU architecture.

During the bread board model testing we have verified that the maximum output power of a PPU with a volume of a quarter of a CubeSat cube is 20W. At full load the electrical efficiency of the overall PPU system is estimated to be about 80%. For an output power of 6W the overall efficiency drops to 66%. The high voltage fine-tune regulation is capable of setting the output voltage with an accuracy of 3 kV $\pm$ 5V. Measurement results for the voltage stackable integrated circuit will become available in May 2018.

Our thruster technology opens the door for small CubeSats to fly new and exciting missions.