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DEVELOPMENT OF POWER PROCESSING UNIT FOR ELECTRICALLY PROPELLED SATELLITES

Abstract

A first-generation Power Processing Unit (PPU MK1) was developed by the Liquid propulsion system centre (LPSC) which operated an 18mN stationary plasma thruster (SPT) successfully in a GEO mission onboard the GSAT-9 satellite. LPSC is now developing a second-generation (PPU MK2) aimed at serving indigenous 300mN stationary plasma thrusters in spacecraft for Geosynchronous Equatorial Orbits. A thrust level of 300 mN and a specific impulse of around 2000 sec with around 5kW electric power supply are the system requirement specifications. PPU consists of four major sub-units; Power Supply Modules, Control Unit, the Thruster Selection Unit and the Filters. The Power Supply Modules control the power flow from the onboard source to the anode, cathodes, magnet, and ignitor, generating and conditioning the required voltages and currents towards powering the thruster. The Control Unit controls the entire Electric Propulsion System (EPS) while communicating with the onboard computer via MIL-STD 1553 interface. The Thruster Selection Unit enables the selection of any Power Supply Module for any thruster. The input filter help in EMI protection and the output filter in mitigating the plasma noise of the thruster in the range of 5-25kHz. PPU operates from an input voltage of 65 to 72 VDC, with the flexibility of scaling to accommodate various discharge power requirements of thrusters through the parallel operation of discharge modules. Each discharge power module in this PPU design, an important subsystem of the PPU, is capable of processing up to 2500 W of power and outputting up to 350 15V VDC to accelerate the plasma that generates the thrust. This module is configured with ZVZCS topology and operates at a switching frequency of 50 kHz. The discharge circuitry ensures load sharing between parallel modules without any additional sensors. Magnet, Keeper, and Heater PSMs are settable constant current sources. This is a cold redundant PPU built to support a spacecraft having three electric thrusters performing orbit-raising and station-keeping operations. The PPU MK2 demonstrated an efficiency of over 86.5 % with PSMs and filters at output power between 2kW to 4.8kW. It was demonstrated repeatably that the PPU can quickly and smoothly start up the stationary plasma thruster and allows for both hard and soft thruster start-up modes. This paper reports the design and configuration details of the PPU, technical issues faced during the development phase along with implemented solutions, modelling and simulation analysis and the test performance results of the PPU MK2.