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DEVELOPMENT OF A HARDWARE-IN-THE-LOOP TEST FACILITY USED FOR CHARACTERIZING THE NEW PULSED PLASMA THRUSTER PETRUS

Abstract

Next to theoretical design of a Pulsed Plasma Thruster (PPT) experimentally characterization is a major process within the overall development. Due to this a new test facility, a so called Hardware-In-the-Loop (HIL) test facility, for PPTs at the Institute of Space Systems (IRS) at University of Stuttgart is developed. The test stand is based on existing measuring instruments as well as know-how gathered during the long-term development and investigation of PPTs at IRS, i.e. ADD SIMPLEX, PETRA and PET. The HIL facility is distinguished by being compact, modular and extensible for future experiments enabling a characterization of miniature PPTs and Pulsed Electrothermal Thrusters (PET) in the energy range of some Joules. Main basis for the test stand is an already existing and well proven micro newton thrust pendulum. In order to set up the HIL facility the pendulum is equipped with several measuring instruments to receive thruster specific performance data, i.e. thrust, capacitor's discharge current and voltage as well as magnetic field data of the plasma plume. Additionally, high speed imaging of the plasma plume will be performed. To investigate the thruster's behavior at different capacitances, capacitors can be disabled or engaged during test campaigns enabling, e.g. investigation of a complete or temporally failure of capacitors during a mission. The development of the HIL facility is in close connection to the new development thruster PETRUS (Pulsed Electric Thruster of the University of Stuttgart). PETRUS is a coaxial, PTFE based, low energy thruster designed and optimized for CubeSat applications like "CubeSat Atmospheric Probe for Education" (CAPE). As PPTs are characterized by a simple design and a high reliability, PETRUS shall be used as a primary propulsion system performing a controlled de-orbit maneuver. Furthermore, the modular design of PETRUS allows the investigation of thermal and magnetodynamic effects by using different attachments, e.g. nozzle or cylindrical acceleration path making it possible to: 1) verify or improve present simulation models and 2) investigate scaling laws of PPTs. This paper describes the development of a state-of–the-art HIL test facility characterizing low energy PPTs and PETs. Moreover, a new PPT based thruster (PETRUS) for CubeSat applications is introduced which is tested and characterized by using the HIL facility.