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Title

Flight results of the miniature 1J pulsed plasma thruster PETRUS

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Abstract

Using solid inert propellants in electric propulsion systems for CubeSats or other small, micro- or nano-satellites allows for robust, safe and simple systems that do not require the additional certification or testing required for liquid or gaseous propellant systems. Pulses plasma thrusters (PPT) can be operated with solid inert propellants such as PTFE. They operate by storing high voltage electric energy in a capacitor bank that is periodically discharged across a propellant surface in a discrete pulse. Each pulse ablates a surface layer of the propellant, ionizes it into plasma and then accelerates it through thermal and magneto-plasma-dynamic forces out of the thruster.
The Institute of Space Systems (IRS) is has developed the Pulsed Electric Thruster of the University Stuttgart (PETRUS), a family of scalable, solid propellant, coaxial PPTs. They can be scaled to different mission requirements and versions with discharge energies between 1 J and 68 J have been tested in our laboratory.
In July 2022 a module containing four 1 J PETRUS thrusters was launched to orbit aboard the 3U CubeSat GreenCube which is build and operated by the Sapienza University of Rome and was successfully operated in space. In this paper we will present flight results including in-orbit thrust measurements obtained by rotating the CubeSat, lifetime tests of the thruster and general functional results of the operation in comparison to ground based tests of the thruster module.
Built on know-how of this mission and in cooperation with the university of Würzburg we are now working on the development of a follow-up PPT-System on the 6U Cubesat SONATE-2 which is to launch in Q1 2024. On SONATE-2 a redundant pair of improved PETRUS 1J thrusters will be used to desaturate reaction wheels of one axis of the satellites attitude determination and control system (ADCS). Since the moment of inertia of these wheels is well known and their speed is precisely measured by the ADCS, this will allow for accurate thrust measurements of PETRUS in orbit. A preliminary description of the PETRUS mission on SONATE-2 will be provided accompanied by ground-based performance data of the improved PETRUS 1J thruster. The previous and planned missions are technology demonstrators without the required mass of propellant or a sufficient number and arrangement of thrusters to allow for serious manoeuvres. Following the first two in-orbit missions the following will have the goal of providing a CubeSat or other nano/micro-satellites with a usable PPT-based ADCS and potentially even propulsion system. This paper gives a short overview of the planned future propulsion module that will use the design of the thrusters and mounting developed for SONATE-2 but mount a larger number of thrusters with a discharge energy between 2-5 J around a shared capacitor bank. A specific arrangement will allow the ADCS of the satellite to be augmented by the thrusters. If possible, an additional number of thrusters will be mounted all facing in the main thrust direction to provide propulsion capabilities to the satellite.