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Author: Mr. Jens Schmidt
DLR (German Aerospace Center), Germany

Dr. Martin Grabe
DLR (German Aerospace Center), Germany
Mr. Yung-An Chan
DLR (German Aerospace Center), Germany
Ms. Clara Schäfer
DLR (German Aerospace Center), Germany
Mr. Felix Plettenberg
DLR (German Aerospace Center), Germany

INTERMITTENT ELECTRIC PROPULSION USING A MICROWAVE PLASMA THRUSTER

Abstract

On small satellites and CubeSats, there is often not enough power available to support high power electric propulsion. Therefore, thrusters need to be scaled down or are not even feasible. This can be compensated by intermittent (pulsed) operation of an electric thruster of a higher power than that commonly supported by the satellite power system. Since mass can be moved from the power subsystem, the overall satellite mass can be reduced. As a part of the described project, the electric propulsion subsystem is developed and shall be described. The propulsion subsystem consists of the power control and distribution unit (PCDU), the fluid management system (FMS), the microwave generator (MWG) and finally the electric thruster. The plasma for the electric thruster is generated by microwaves using electron cyclotron resonance (ECR) and is then accelerated by a convergent-divergent magnetic field, also known as a magnetic nozzle (MN) using permanent magnets. This electrodeless discharge reduces sputtering and erosion of thruster components, as the plasma is separated from the microwave antenna by quartz-glass. The accelerated quasi-neutral plasma removes the necessity of a neutralizer, and therefore decreases system complexity and cost. The thruster is designed for a nominal microwave input power of $P = 100$ W and a thrust of $F = 1-2$ mN is expected using xenon as a propellant. Due to the electrodeless nature of the discharge, other propellants such as argon or air can be used, although the thruster efficiency might different for these. The design of the fluid management system is based on commercial-off-the-shelf (COTS) components used for valves, flow and pressure sensors and the pressurized tank. The MWG is also a COTS component. The PCDU does not only condition and distribute the power input but also control the microwave generator and fluid management system necessary to operate the thruster. All subcomponents will be integrated and tested together. The concept of intermittent operation will allow the operation of electric thrusters on smaller satellites which could usually not provide the necessary power. The additional station-keeping capabilities provided by an on-board electric thruster can therefore extend the mission lifetime of small satellites.