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Development of a Dual-axis Pulsed Plasma Thruster for Nanosatellite Applications

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Abstract

This paper reports on the development and evaluation of a dual-axis pulsed plasma thruster (dPPT) for Aoba Velox-III 2U CubeSat at Nanyang Technological University. The mission requirements and thruster design, including electronics and mechanics, are described in detail. A test campaign was conducted to evaluate the dPPT performance in terms of impulse bit I_{bit} , specific impulse I_{sp} , mass bit m_{bit} , discharge voltage, and current of energy storage unit (ESU) response. Finally, experiments were carried out to verify the design consistency with mission requirements. Experiment results were collected to optimize the thruster in the future.

1. Introduction

Since the first nano-satellite (CubeSat) concept was proposed by teams from California Polytechnic State University and Stanford University, the CubeSat sector has grown rapidly as a low-cost solution for access into space for both the space industry and university-level academic research. The absence of a propulsion sub-system, however, limits the lifetime of a CubeSat, due to drag-induced de-orbiting at low earth orbit (LEO). The first ablated pulsed plasma thrusters (PPTs) were successfully employed in space on the Zond-2 and LES-6 CubeSats (Burton and Turchi, 1998). Since then, the PPTs have been used to perform a variety of propulsion tasks not only for drag compensation and formation flying (Ebert, Kowal, and Sloan, 1989; Janson, 1993), but also for station keeping needs (Guman and Nathanson,

1970; Vondra and Thomassen, 1974; Vondra, 1976; LaRocca, 1970), orbit transfer (Akimov et al., 1997), and attitude control (Meckel et al., 1997; Cassady, 1996). The delivered impulse bit of such PPTs ranges from 10 μ Ns to over 10 mNs, with a wide energy span of 1–700 J (Kamhawi, Arrington, and Pencil, 2005; Kumagai et al., 2003). Hence, the PPTs are a favorable propulsion system in CubeSat applications due to their low energy consumption, simple structure, high specific impulse, no propellant leakage and toxic propellant, low cost, and develop time (Ciaralli et al., 2013).

This article presents the development and test campaign of a dual-axis PPT (dPPT) for a 2U CubeSat named Aoba Velox-III, addressing the mission requirements first. The mechanics and electronics of the dPPT are designed to counteract atmospheric drag

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