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Attitude Testing Platform in a Vacuum Environment for a Lean Satellite with an Electric Thruster

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Abstract

Air-bearing tables are widely used for the verification of attitude control systems (ACS) based on reaction wheels (RW) and/or magnetic actuation. There is a demand for testing ACS based on electric propulsion systems (EPS) for lean (small) satellites. However, traditional air-bearing platforms cannot be used for such verification, since the test conditions require a vacuum environment. To address this problem, the current work presents the development of an attitude testing platform for lean satellites capable of working in a high vacuum environment, that can be used to verify ACS based on electric thrusters such as vacuum arc thrusters (VAT) and pulsed plasma thrusters (PPT). A testing platform with a spherical air bearing that allows a frictionless, rotational motion on three rotational degrees of freedom was placed inside a vacuum chamber equipped with a rotary pump and cryogenic pump. The vacuum achieved 2.4×10^{-2} Pa as pressure inside the chamber, while the platform was lifted by dry air with a 40-sccm flow rate. The instrumentation of the testing platform included an onboard control unit, a gyroscope sensor for the measurement of the platform angular rate, and an RW and a VAT as actuators that provide a controlled rotational motion. The response of the platform's angular rate under the controlled actuation of the RW and VAT was evaluated. Once the operation of the VAT inside the vacuum chamber was confirmed, the induced rotation speed by ignitions from the VAT was measured, to derive the VAT's impulse bit. This study confirmed the successful operation of the testing platform under vacuum conditions.

1. Introduction

Lean satellites are those that seek low-cost and fast mission realization by using non-traditional, risk-taking development and management approaches. As a result of the fast delivery and the low cost, these satellites are inherently small (Cho et al., 2017). Since lean satellites are rapidly being developed worldwide, along with the rise of mission opportunities and augmentation of capabilities to perform sophisticated tasks, the development process of their attitude control systems (ACS) must react to this trend.

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