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Design and Testing of a Low-Cost, Open Source, 3-D Printed Air-Bearing-Based Attitude Simulator for CubeSat Satellites

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Abstract

With the surge of interest in nano-satellites, there is a concomitant need for high quality, yet affordable simulation and testing environments. It is particularly challenging to experimentally evaluate nano-satellite attitude control systems in a test environment. This article investigates the technical feasibility of fabricating a low-cost air-bearing platform with three degrees of freedom of angular motion using desktop 3-D printing technology with limited printing resolution. An open source air-bearing attitude simulator for complete 1U CubeSat is proposed, manufactured, and characterized. The platform is equipped with directional air nozzles that enable external torque generation in order to cancel out i) parasitic moments of inertia from the satellite's enclosure and ii) error torque produced by imperfections. It is also capable of simulating disturbances in a space environment. The results show that the torques produced by the nozzles can reach beyond 0.001 Nm and are sufficient to remove error torques and provide torque compensation of the orders of 0.0004 Nm. Removing the effects of gravity torque with the nozzles proved to be unachievable with the current design, requiring precise positioning of the CubeSat within the enclosure. Future work has been identified for a number of improvements to the design and details for the further development of the platform.

1. Introduction

Satellites are generally out of reach of any unforeseen maintenance procedure after deployment in orbit. Thus, to ensure the success of a mission, engineers invest significant effort in satellite testing to ensure mission reliability. Tests like thermal-vacuum cycling (Parker, 1984) and mechanical quasi-static loads (ECSS-E-HB-32-26A, 2013) aid in simulating circumstances that a satellite can encounter. Replicating the space environment in a laboratory is

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