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Optimized Design of a Thermal Vacuum Testbed for Nanosatellite Verification Tests

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Abstract

Before a satellite is launched into orbit, specific verification exercises should be conducted, including the thermal vacuum (TV) test, among the critical environmental tests. However, many low-budget nanosatellite projects, most of which are led by universities, opt to forego this high-cost testing. Others may perform the testing using superfluous infrastructure, with a process unsuitable for nanosatellites. This article provides guidelines for designing a designated TV chamber for nanosatellites, so that a low-cost test infrastructure can be constructed for the performance of qualification and acceptance tests of nanosatellites. It is further shown that the temperature regime of an orbiting nanosatellite is relatively small, and is easy to emulate in a test facility. For their small size and limited temperature range, nanosatellites can be tested at a system level in a conduction-based facility, reducing the required infrastructure cost significantly in comparison to a radiation-based facility. The results show that a TV chamber measuring 0.6m in diameter and 0.5m in length, based on a conduction cold plate, with a temperature range of −25°C to +55°C, is suited for the verification testing of a 1U-6U nanosatellite and/or one of its subsystems. Due to its restricted temperature range, several low-cost commercial coolants, such as propylene glycol water or ethylene glycol water, may be used in the TV chamber thermal control system.

1. Introduction

With their low-cost, short development timeframe, and ever-increasing capabilities, nanosatellites and CubeSats, which have already served as an important research tool at the university level, are becoming increasingly feasible ventures for industrial companies and space agencies all over the world.

However, before launching any satellite into orbit, it is necessary to validate its design and verify that it does not fail after the launch. This is achieved through a series of qualification and acceptance tests, which include environmental tests in which the satellite is exposed to simulated space environment conditions.

One environmental verification test is the thermal vacuum (TV) test. The TV test is a procedure in which

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