MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Environmental Effects and Spacecraft Protection (6)

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LOW COST THERMAL-VACUUM SYSTEM FOR THE DEVELOPMENT OF VERY SMALL SPACECRAFT

Abstract

Commercial-off-the-shelf components have often been employed in very small satellites (i.e. mass of <50kg), and such approach has attracted newcomers (e.g. universities and non-space-related companies) to a satellite development. However, at the moment, their success rates of in-orbit operation are too low, and in particular infant mortalities are dominant. It is important to ensure the maturation of each spacecraft, and therefore simulated space environments are necessary for validating the functionality of spacecraft and/or payloads during their development phase to identity any issue. However, such testing facility is not so easily accessible, and need a proper balance among reliability, deliver-time and cost. To tackle this, we have worked on a development of new testing standard (i.e. Nano-satellite Environment Test Standardisation -NETS) to simplify the environmental tests while keeping high reliability and low cost for the very small satellites.

A thermal-vacuum chamber is a key space environment simulator, and conventional facilities simulate a vacuum environment (e.g. <10-3 Pa) as well as thermal environments (as large as -196 to +200degC) that provide conditions similar to those encountered in space. However, even small such chambers are expensive (>100,000USD), and are often beyond the budget of a university-based space project. In addition, the need to use liquid nitrogen coolant adds an additional high running cost (i.e. >400USD per day or >25USD per cycle) and requires handling skills.

For this reason, we developed a thermal-plate (heating/cooling unit) consists of solid-state Peltier modules. This system can test target components in existing conventional vacuum facility, and provides a temperature range of -30 to +80degC with the total maximum heat-exchange capability of 1.2kW. This is adequate to test most electronics for operation inside a space vehicle, and indeed has already been used for testing electronic circuits for several space flight missions. Here, the required test range in the NETS standard is -15 to +50degC. The size of the thermal-plate is 305x150mm, which is also sufficient for accommodating 3U cube-satellite (without any deployment). In addition, a LabView based temperature

control program has been developed for automated thermal-cycle tests. The structure of this thermal-plate is simple, and component parts are available from online distributers. This means that this system can be replicated in any place, and in fact can perform thermal-cycle tests based on the NETS standard.

This paper will present the design of this thermal-vacuum chamber for scalable replication and will discuss how its performance meets the NETS standard.