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Design, Fabrication, and Testing of an Electrical Double-Layer Capacitor-Based 1U CubeSat Electrical Power System

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Abstract

At the present time, rechargeable batteries such as Li-ion or Ni-CAD are widely used in CubeSat Electrical Power Subsystems (EPS) as a power source in the absence of sunlight because of their many advantages, including their compact size and the amount of energy they can store. However, robustness, simplicity, reliability, safety, and reduction of the overall failure rate of the EPS must also be considered as requirements for CubeSat EPS in harsh space environments. These requirements can be addressed, however, by eliminating the batteries and using an Electrical Double-Layer Capacitor (EDLC)-based 1U CubeSat EPS, as described in this paper. A new EDLC-based EPS board was developed and tested in this study for its electrical performance and robustness in space environments, including launch environments and thermal environments. The total EDLC capacitance was 1600 F, the EPS occupying a volume of 90 × 87.3 × 64.6 mm. The functionality of the board was tested, assuming realistic power, voltage, and current profiles based on actual orbital periods, and assuming release of the satellite from the International Space Station (ISS). The CubeSat power consumption profile was assumed to be from 920 mW to 2.67 W, and the photovoltaic power generation output to be 2.93 W, at its peak. The board was proven to withstand space environments, and to provide the power to operate a CubeSat in orbit, with a remaining energy level of 52% at the end of eclipse.

1. Introduction

CubeSats are built for simple, basic missions to support space research and experiments, space education, and data exchange; however, the commercial sector is also increasingly interested in their use. At this time, CubeSats are mainly developed at universities and institutes and by small companies, because of their low cost, short building time, small sizes, reliability, and mass, and they are most commonly put into orbit from the International Space Station (ISS), or launched on rockets as a secondary payload (Mehrparvar, 2014). However, as technology and reliability improve, and access to the space environment increases (presenting higher orbit possibilities), the useful life of CubeSats is also enhanced, foreseeably attracting more interest in their use from larger-scale commercial businesses and emerging companies.

Such developments are in progress. New launch capabilities can accommodate larger sized satellites, including up to 1 × 6U, 2 × 3U, or even 2 × 6U. In addition, double-wide deployers are now available, as are piggy- backed opportunities for both single-wide

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