SPACE POWER SYMPOSIUM (C3)
Small and Very Small Advanced Space Power Systems (4)

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ELECTRICAL POWER SYSTEM FOR ESTCUBE-1: A FAULT-TOLERANT COTS SOLUTION

Abstract

As nanosatellite missions are becoming more complex, the requirements for their power systems also increase while the physical constrains remain the same. ESTCube-1 is a student-built CubeSat tasked with the first proof of concept mission of the electric solar wind sail: unreeling a thin conductive tether in-orbit, charging it electrostatically using electron guns and measuring the force resulting from its interaction with ionospheric plasma. This mission consists of several phases with radically different power needs requiring a very efficient, adaptable and dependable power system while using only Commercial-off-the-Shelf (COTS) components. In this work we will present the design and testing results for the Electrical Power System (EPS) of the satellite.

The requirements of the tether reeling motor and electron guns make the mission very energy-intensive for the spacecraft, including prolonged periods when the satellite's power production by solar panels is exceeded by demand, so the system had to be very efficient at harvesting solar energy, storing it, and transforming it into usable electrical power for the satellite. For the experiment the satellite also has to spin, which makes efficient energy harvesting more difficult due to the fast-changing maximum power-

point of the solar cells. In addition the satellite is to be deployed during a period of high solar activity, making reliability a major concern.

To solve these problems the EPS was designed simultaneously with a high order of hot redundancy and high efficiency while using only COTS components. The system is powered by 12 triple-junction solar cells, which are controlled by three completely independent and self-contained maximum power point tracking modules, achieving efficiencies of 80% and above. System uses 2 battery cells for 4.3 Ah of combined energy storage, both of which are coupled to the satellite's central power bus through independent control circuits. All of the converters powering other sub-systems are doubled and working in tandem, and two extra power buses are used to provide a fault-tolerant power supply for the EPS microcontroller and other critical systems. Better radiation tolerance of control systems is achieved by using Ferroelectric RAM technology to provide fault-resistant memory and state-saving functionality for hardware-integrated switches.

The work shows that it is possible to build an adaptable, fault-tolerant and efficient power system using only COTS components. This paves way for making complex nanosatellite missions a commonplace, reducing the cost in time and money for space science missions.