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Design and On-Orbit Performance of the Electrical Power System for the Quetzal-1 CubeSat

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Abstract

Quetzal-1, a 1U CubeSat developed by the Universidad del Valle de Guatemala (UVG), operated on orbit from April to November of 2020. It included an in-house developed Electrical Power System (EPS) that supplied power to the other systems of the satellite. The EPS incorporated six non-deployable solar panels coupled to three maximum-power point tracking chargers to generate power. A centralized EPS architecture was implemented with 3.3 V, 5 V, and 7.6 V rails used to power up the satellite's systems, all distributed from a central, unregulated power line connected to a rechargeable 4.2 V Li-ion battery. The system also incorporated protection circuitry against fault conditions, a battery heater, and deployment switches to activate the satellite after deployment from the International Space Station (ISS). This manuscript presents the design specifications of the EPS, as well as offering a detailed account of the system's operation on orbit. The EPS ensured a positive power budget throughout the satellite's mission, generating enough power to meet the satellite's demand and keeping the battery recharged regardless of the operating conditions. The system was able to remain power positive even at times when the solar panels' efficiency naturally decreased due to an increase in their superficial temperature during high beta angle seasons with no eclipse. Furthermore, the on-board heater prevented battery freezing even during maximum eclipse conditions. This paper also includes design recommendations, as well as open-source circuit schematics of the EPS that may be valuable to other teams working on future CubeSat missions.

1. Introduction

Quetzal-1 (ket-sahl-oo-noh) was a 1U CubeSat developed by Universidad del Valle de Guatemala (UVG) and supported, in terms of its launch to and deployment from the International Space Station (ISS), by the United Nations Office for Outer Space Affairs

(UNOOSA) and the Japan Aerospace Exploration Agency (JAXA) under their joint KiboCUBE Programme (Taniguchi et al., 2020). Quetzal-1's mission was selected via a methodology based on maximizing benefits while considering programmatic risk and technical feasibility (Zea et al., 2016). The satellite's

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