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MODES OF OPERATION FOR A 3U CUBESAT WITH HYPERSPECTRAL IMAGING PAYLOAD

Abstract

The paper discusses the design of modes of operation of a 3U CubeSat developed by a group of undergraduate students at Birla Institute of Technology and Science, Pilani. The nanosatellite features a hyperspectral camera as its primary payload and a field programmable gate array as its secondary payload. A hyperspectral camera poses a unique challenge for nanosatellites as it has high power requirements, stringent pointing requirements for imaging and generates a large amount of data. Nanosatellites are constrained by limited downlinking rates which restrict the amount of data that can be sent back to the Earth. This is tackled by employing a hyperspectral image compression algorithm (CCSDS-123.0-B-1) on the FPGA that is shown to achieve compression ratios of up to four. The satellite follows an amalgamation of centralized and distributed architecture with the On-Board Computer (OBC) controlling the sequence of operation and communicating the required set of parameters to Electrical Power System (EPS) microcontroller and to Communication System microcontroller. These microcontrollers are responsible for handling the required operations for a particular mode, thereby offloading work from OBC microcontroller which reduces the latency of the system in case of a system failure.

The proposed architecture can be divided into normal modes, emergency modes and contingency modes of operation. The switch between modes is determined by a binary array of flags that represents system state variables. These system state variables such as satellite location in the orbit, current power generation, state of charge of the battery and required power for the next mode determine whether the mode will be able to sustain for a period of time in which it is able to complete the required action. Since the power consumed by electronic components largely depends on temperature, the power consumption for the next mode is calculated using lookup tables and power estimation equations with temperature as an input.The contingency modes of operation are defined to achieve mission success in case of a component failure. The paper also presents the choice of components, sustainable modes of operation and redundancy added to the system to counteract the harsh space environment.