Product Design Specifications

OreSat Command, Control, and Communications Card

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Version 1.0

10/23/2019

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Executive Summary / Concept of Operations

OreSat is an open-source cubesat project that is currently developing Oregon's first satellite to be launched into space. Our product is the command, control and communications (C3) module for OreSat's cubesat. It integrates several different sensors and actuators involved in the top level control of the OreSat project. As such, it has the responsibility of controlling the power and data flow to and from various subsystems in the satellite. For the practicum, we are developing a simplified C3 system that integrates the following: a basic radio interface for communicating with the CubeSat, a microcontroller with storage that manages the satellite, several sensors that collect system health data from the rest of the satellite via a CAN bus interface, and a power domain for monitoring and individually power-cycling each connected subsystem.

This practicum project will be used by the OreSat project to demonstrate the control of the rest of the satellite subsystems by the C3 module and will be an open-source project under the MIT Open Source Initiative License. This device will be used during a balloon flight where it will communicate with a ground station. This project will be used as a basis for the C3 flight module to be used on the launched CubeSat. In the future this will be useful to other groups using the OreSat CubeSat specifications on their own projects.

Marketing Analysis

Since the final deliverable product is a C3 module that will be used during a balloon flight test conducted by OreSat, we regard OreSat as our primary customer. Further down the line, when fully developed into the "space-ready" version that will be used in the actual OreSat CubeSat, this product may serve as a platform for future science missions and the growing CubeSat market. This will extend our potential customer base to include all scientists, engineers, and space hobbyists who would seek to take advantage of the many opportunities for research that have been made available with the advent of CubeSats.

Our product will provide a set of unique advantages over other CubeSats: it will be well-documented with respect to other open source CubeSat projects, it will be radiation-tolerant with minimal use of radiation-hardened components, and have a modular design allowing for variation in the system into which the design is integrated (with some small adjustments). Our product is not to be assessed in terms of selling price, as it is an open-source project developed with the betterment of humanity in mind, but its monetary benefit could instead be quantified in terms of the savings that its users may accrue. Our preliminary estimate of cost based on our Bill of Materials places our total expense at around $300, while similar COTS products are available online for $4,000-$10,000. Surely, our product will be highly coveted in the cubesat market when it is complete.

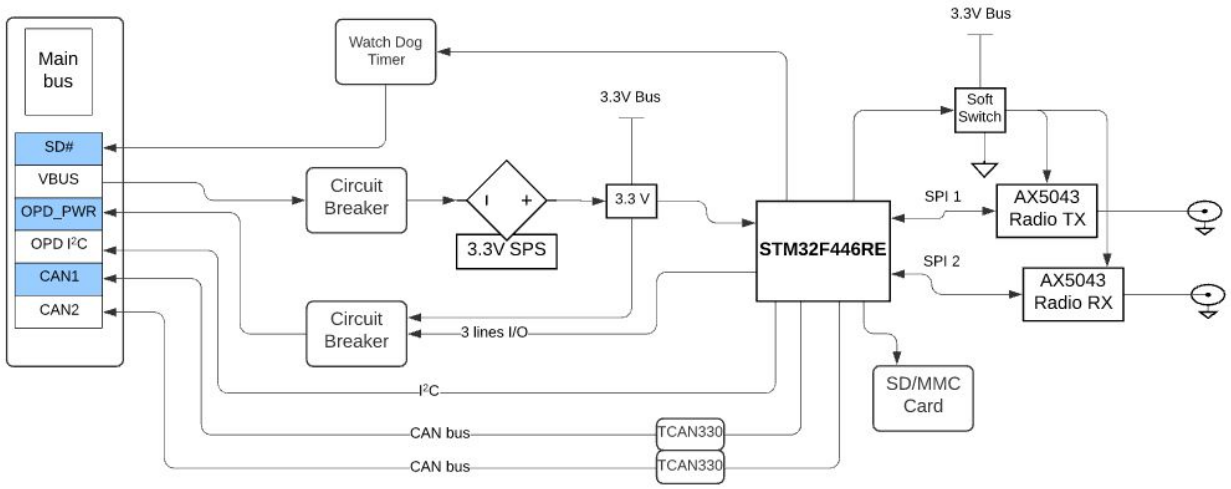
Requirements

- Must conform to OreSat card cage specifications
- Must be able to be powered from OreSat power bus
    - Must be self-isolating in case of overcurrent condition
- Must be able to provide power to OreSat Power Domain
    - Must be fault tolerant of OreSat Power Domain overcurrent conditions
- Must be capable of interfacing with OreSat Power Domain
- Must be capable of interfacing with OreSat critical subsystems
- Should be capable of interfacing with OreSat mission subsystems separate from critical subsystems
- Must provide communications interface with ground stations
    - Must provide system health status to ground stations
    - Must receive commands from ground stations
- Must provide non-volatile data storage
- Must be able to reset in case of radiation induced single event latch-up of the C3 card

System Architecture

The mechanical design of this project conforms to the OreSat card cage specifications with regards to dimensions and connectors. This project will have at its core a 32 bit ARM MCU capable of interfacing with all subsystems local to the card as well as all subsystems connected through the OreSat Backplane. VBUS power (6-8.4V) is provided via the backplane, which must pass through a self resetting circuit breaker before being regulated via an SPS to provide 3.3V for use on the card. This card must also provide, through a controllable circuit breaker, power to the OreSat Power Domain (OPD) subsystem via the OPD_PWR connection. It must also be capable of interfacing with this subsystem via I2C using the OPD_SDA and OPD_SCL connections in order to control power to all other subsystems connected to the backplane. Communications with OreSat subsystems are facilitated by two CAN buses provided via the backplane. One CAN bus (CAN1) is used for critical subsystems and must be fully functional, while another (CAN2) is used for mission subsystems and should be able to be used independently of CAN1. In order to communicate with ground stations, the card must provide two radios connected via SPI to the MCU. One radio will be used to broadcast the system health status, while another will receive commands. Non-volatile storage will be provided via a removable SD/MMC card. Finally, the card will incorporate a watchdog that, in case of the MCU hanging, will assert an active low SHUTDOWN signal on the backplane that kills VBUS power to the entire satellite. This is how the satellite is reset in case of an MCU single event latch-up.

Block Diagram



Design Specifications

Design specifications were developed after careful consideration of time, budget, current skillset of team, and extant constraints imposed by our predecessors and colleagues on the OreSat team. Those specifications are as follows:

- OreSat protocard mechanical design
- 1x STM32F446RE MCU (**processor**)
    - 2x CAN
    - 1x I2C
    - 3x SPI (2x if using SDIO)
    - 1x SDIO (if not using SPI)
    - 3x GPIO for OPD_PWR Circuit Breaker
    - Watchdog interface (protocol TBD)
- 2x TCAN330 (**sensor/actuator**)
- 2x AX5043 Radios (**sensor/actuator**)
- Power supply circuit breaker
- 1x Switching Power Supply for 3.3V
- OPD power supply circuit breaker (**actuator**)
- 1x Watchdog (**sensor/actuator**)
- Firmware based on ChibiOS RTOS
- Implements ECSS CANbus Extension Protocol for CAN interface to sensors (**sensors**)
- Implements CCSDS recommended standards for radio interface