Overview of the OpenOrbiter Electrical System Design

Michael Wegerson
Jeremy Straub
Ronald Marsh

Available at: https://works.bepress.com/jeremy_straub/328/
Overview of the OpenOrbiter Electrical System Design

Michael Wegerson¹, Jeremy Straub², Ronald Marsh²
¹Department of Electrical Engineering, University of North Dakota
²Department of Computer Science, University of North Dakota

Introduction

The OpenOrbiter program at the University of North Dakota is developing a complete set of CubeSat hardware and software (see [1]) to facilitate the development of a 1-U CubeSat (10 cm x 10 cm x 10 cm, 1.33 kg spacecraft) with a parts cost of less than $5,000 [2]. The designs [3], documentation and computer code from this will be made publically available to enable the development of programs at other institutions.

In order to accomplish this effort, the Electrical Team is designed the major subsystems of the overall Electrical System and is in the process of fabricating and testing these subsystems (Figure 1). Using of System of Systems Engineering (SoSE) approach [4], the Team has been able to federate the satellite into 6 independent subsystems: On-board Flight Computer, Electrical Power System, Attitude Determination and Control, Radio Communications, Payload, and Interconnect Board. Each of these subsystems will be described below.

Work-to-date

Designs for the OBFC, EPS, Payload, and Radio Communications have been finalized, with several having gone through several testing revisions. Component selection has been finalized and prototyping module fabrication for testing is underway.

The ADCS and Interconnect Board circuit designs and component selection are still being finalized.

Future Work

Work will continue to focus on testing out each subsystem module prototypes. Specifically, the Electrical Power System is nearing all prototype fabrication completion and validation. The next step will be to connect the individual EPS modules together to run the first full power system test. Additionally, the photovoltaic panels have been fabricated and await testing. If EPS prototyping module testing is successful, full system integration will be the next step.

The On-board Flight Computer is currently being revised to incorporate the Raspberry Pi A+. With the removal of the previous Raspberry Pi version, a external Ethernet module will need to allow for intersystem Ethernet communication. Several designs are being considered for their efficacy. Additionally, the radio electronics will also be integrated into the OBFC printed circuit board to minimize the use of circuit board space.

Direction of work for the Attitude Determination and Control System is aiming towards a proof-of-concept model by the end of mid-May 2016. This will include sensing of the accelerator, gyroscopes, and magnetometers in real time and a prototyped reaction wheel system to control the rotation in one axis. The electro-magnet PCB will have to be fabricated, with the coils themselves to also be manufacture in-house. From there, full system prototyped integration and testing will be conducted. Long-term goal is to revise the ADCS software to allow for dynamic control over the spacecraft movement model.

Several adaptations of the payload module are under consideration. Previous work has partially developed a more powerful secondary payload computer based around a Gunstix microcomputer. Future work will be modifying the previous designs to update to the System of System Engineering design philosophy as well as prototyping, in-house fabrication, and testing.

Interconnect Board

Responsibilities:
- Allowing subsystem intercommunication
- Distributing power throughout satellite

Primary Components:
- 2 x 4 Ethernet Switch (Communication)
- ENC24J60 (Ethernet to microcontroller)

Attitude Determination and Control System

Responsibilities:
- Measures changes spacecraft orientation
- Controls spacecraft through active and passive methods
- Enables image stabilization through controlled movement

Primary Components:
- MCP73871 (Battery Charger)
- MAX669 (Output conditioning)
- SPV1040 (Solar conditioning)
- Arduino (EPS primary controller)
- ENC24J60 (Ethernet to microcontroller)

Electrical Power System

Responsibilities:
- Conditioning solar power input from photovoltaic cells
- Monitoring Battery's temperature and activate heater if needed.
- Collect Voltage/Current measurements from Inputs and Outputs
- Turning off other subsystems during critical mission periods

Primary Components:
- Arduino (EPS primary controller)
- SPV1040 (Solar Conditioning)
- MAX669 (Output Conditioning)
- MCP73871 (Battery Charger)

Radio Communication

Responsibilities:
- Provide full-duplex communications
- Communicate primarily on 434MHz band

Primary Components:
- SI4463 (Transceiver)
- RF6504 (1W Amplifier)

On-board Flight Computer

Responsibilities:
- Managing major decision during the mission
- Interpreting data queried from subsystems
- Overseeing function of Subsystems
- Interfacing with radio transceiver

Primary Components:
- Raspberry Pi A+

Payload

Responsibilities:
- Interchangeable for mission customizability

Primary Components:
- Raspberry Pi A+ (Earth Image-Sensing)

References