DALHOUSIE UNIVERSITY
FACULTY OF ENGINEERING

Electrical Power System of a Nanosatellite: Design & Analysis

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DALHOUSIE SPACE SYSTEMS LAB

Project Background

Dalhousie University was awarded $200,000 by the Canadian Space Agency (CSA) as a part of the Canadian CubeSat Project. Dalhousie proposed to build a 2U CubeSat, called LORIS, with the following objectives:

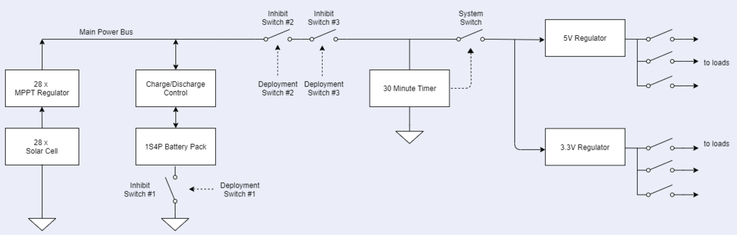
I. Learn and develop skills in the areas of satellite systems engineering
II. To organize long-distance radio contact events for amateur radio operators
III. To capture visible and near-infrared images of the Nova Scotian peninsula

System Requirements

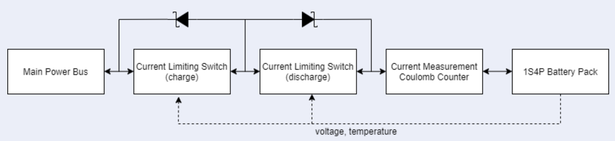
- Generate >4.20 Watts Orbit Average Power
- Store >20 Watt-hours of Energy for continued operation in eclipse
- Power distribution
  - 5V 1.5A bus line
  - 3.3V 1.5A bus line
  - Short-circuit protection
  - Load switching
- Collect and package telemetry
- Receive commands from Onboard Computer over UART
- Remain non-operational for 30 minutes post-deployment
- Interface with 3 deployment switches & 1 Remove-Before-Flight pin

System Design

Subsystem Block Diagram



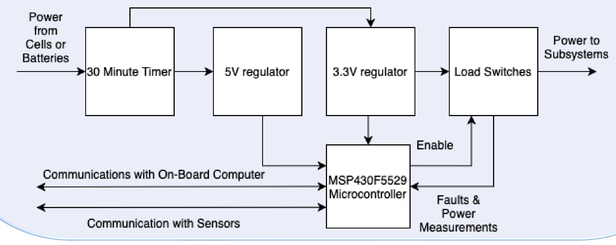
Battery Charger Architecture



Prototypes

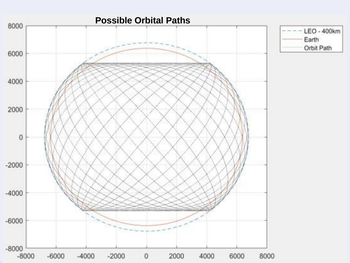
1. Power Distribution Unit Circuit #1
   - LTC6995 30-minute timer circuit
   - TPS2557 Current-limiting load switch
2. Power Distribution Unit Circuit #2
   - Charge Control circuitry
   - Current Tracking circuitry
3. Power Distribution Unit Circuit #3 (Design Phase)
   - MSP430F5529 microcontroller for control and telemetry
4. Solar Cell Voltage Regulator Circuit #1
   - SPV1040 solar battery charger (insufficient output voltage)
5. Solar Cell Voltage Regulator Circuit #2
   - Redesigned electrical connections to minimize losses

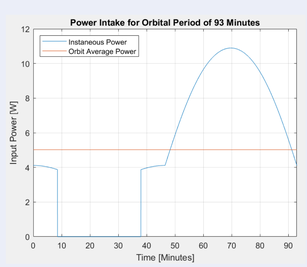
Power Distribution Unit Circuit #3 Layout



Power Generation

28 UTJ Solar Cells capture sunlight at 28% efficiency
Combination of deployable and body-mounted solar cells capture 5.02 Watts Orbit Average Power.

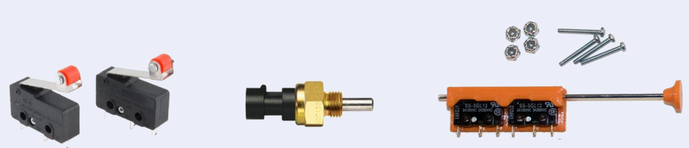




Energy Storage

4 Panasonic NCR18650b lithium-ion batteries provide ~50 Watt-hours of storage capacity.

Two Roller switches, a plunger switch, and Remove-Before-Flight pin prevent battery pack from powering load.



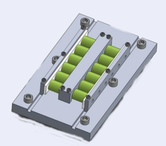
Test Results

Vibration Test Procedure

Shake cells along X, Y, & Z axis. Cells with >5% change in capacity or >0.1% change in voltage are rejected.

Vibration Test Results

Average capacity change: 2%
Average voltage change: 0.025%



14-day Open-Circuit Voltage Test

Discharge cells, then monitor voltage over 14 days. Cells with declining voltages >2mV are rejected.