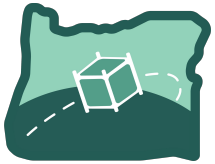

OreSat Electrical Power System

Overview of an inexpensive, modular, and open source 1U - 3U CubeSat power system

Open Source CubeSat Workshop 2021

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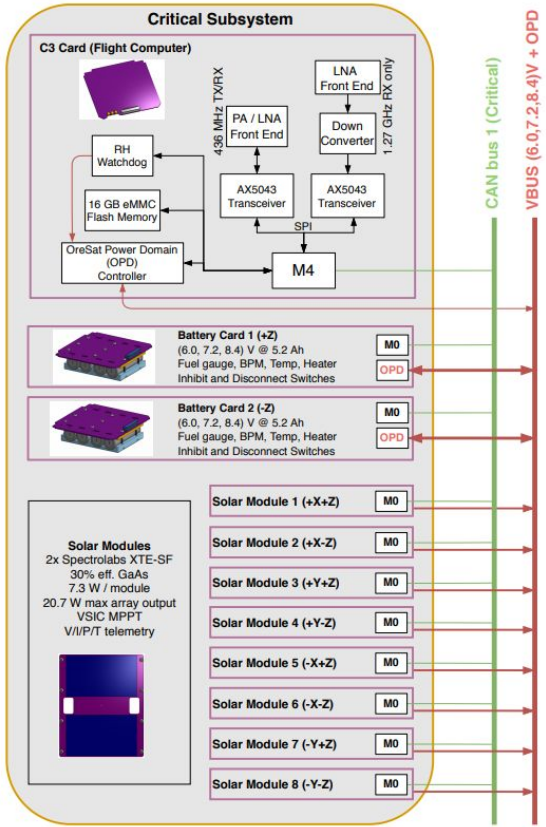
What we really really want (Requirements)

- 1 - 3U scalable design
- “Cheap” subsystems
  - Solar, battery, OBC, deployables, ADCS
  - Capable subsystems, not just educational toys
- Open source to understand how these things work
- Student team friendly
  - APIs everywhere - common interfaces for software, electrical and mechanical systems
  - Boards and systems are easily swappable
  - Uses common and obtainable development tools, with existing onboarding media
  - Documentation with explanation of *why* things are this way

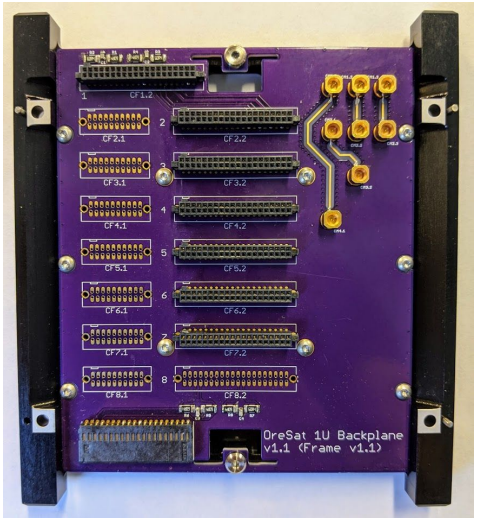
Electrical Power System Design Philosophy

- Series of proven design modules for reliability
  - Battery card
  - Solar module
  - “OreSat Power Domain” (OPD)
- “Distributed” EPS
  - Pros: Allows for modularity and flexibility
  - Cons: Leads to a more complex system architecture



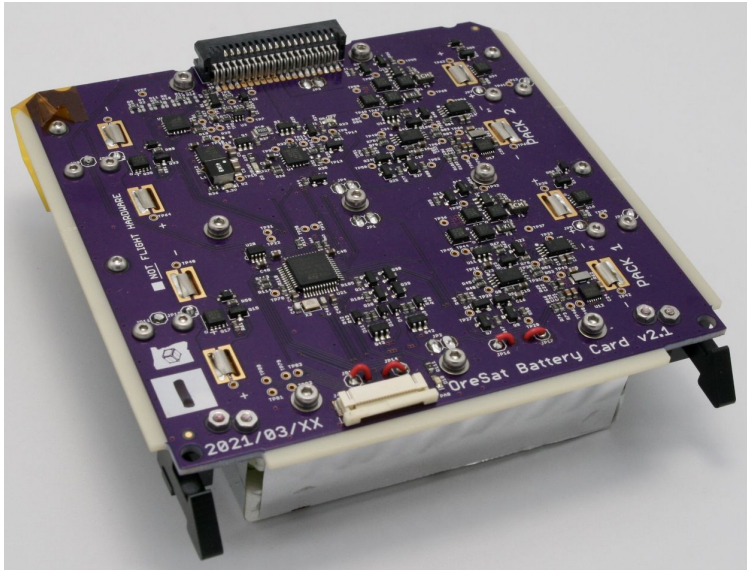
Backplane

- Main Connector
  - Power: Vbus = $7.2V_{NOM}$ (direct battery connection)
  - OreSat Power Domain
    - Fault tolerant I2C
    - Low power 3.3V rail
  - Satellite shutdown (inhibit switches and RBF)



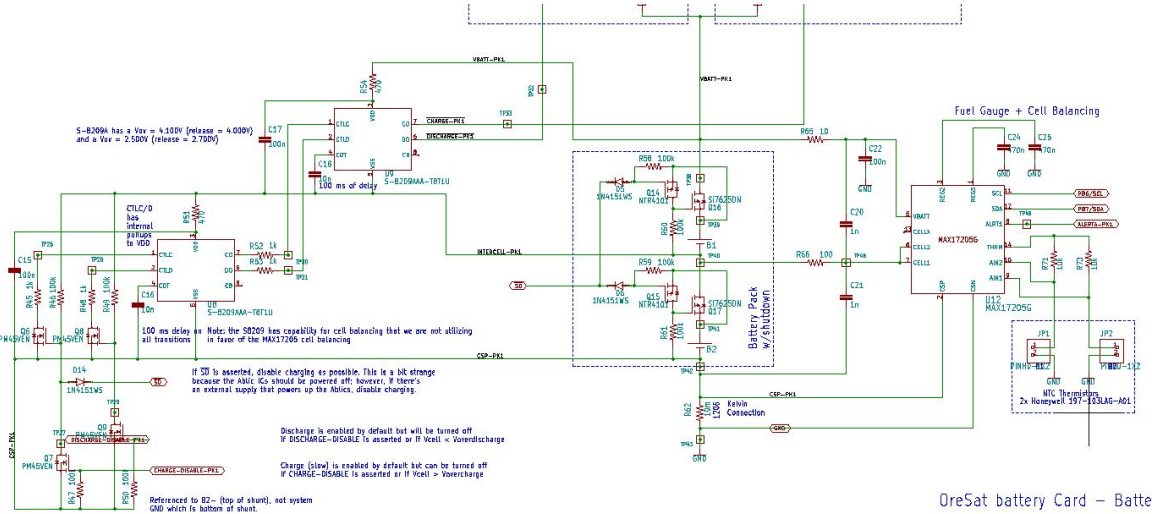
Battery Card

- Two independent 2S Li-ion packs on one card
  - Each pack operates independently of the other
  - 37.5 Wh per battery card
  - Boring ol' 18650s
- Embedded BMS circuitry
- Inhibit switches (in ±X axis rail face)
  - ISS compliant
- Integrated thermal insulation and heaters



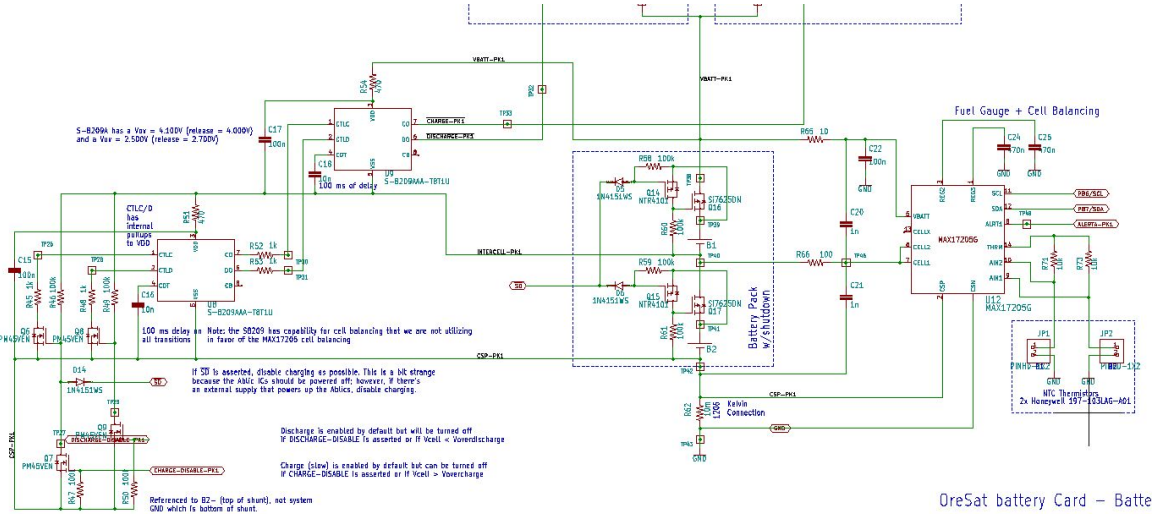
Battery Management System

- Overcharge/discharge protection: ABLIC S-8209
  - Hardware defined charge and discharge cutoffs
  - Software defined cutoff controlled via onboard STM32f09

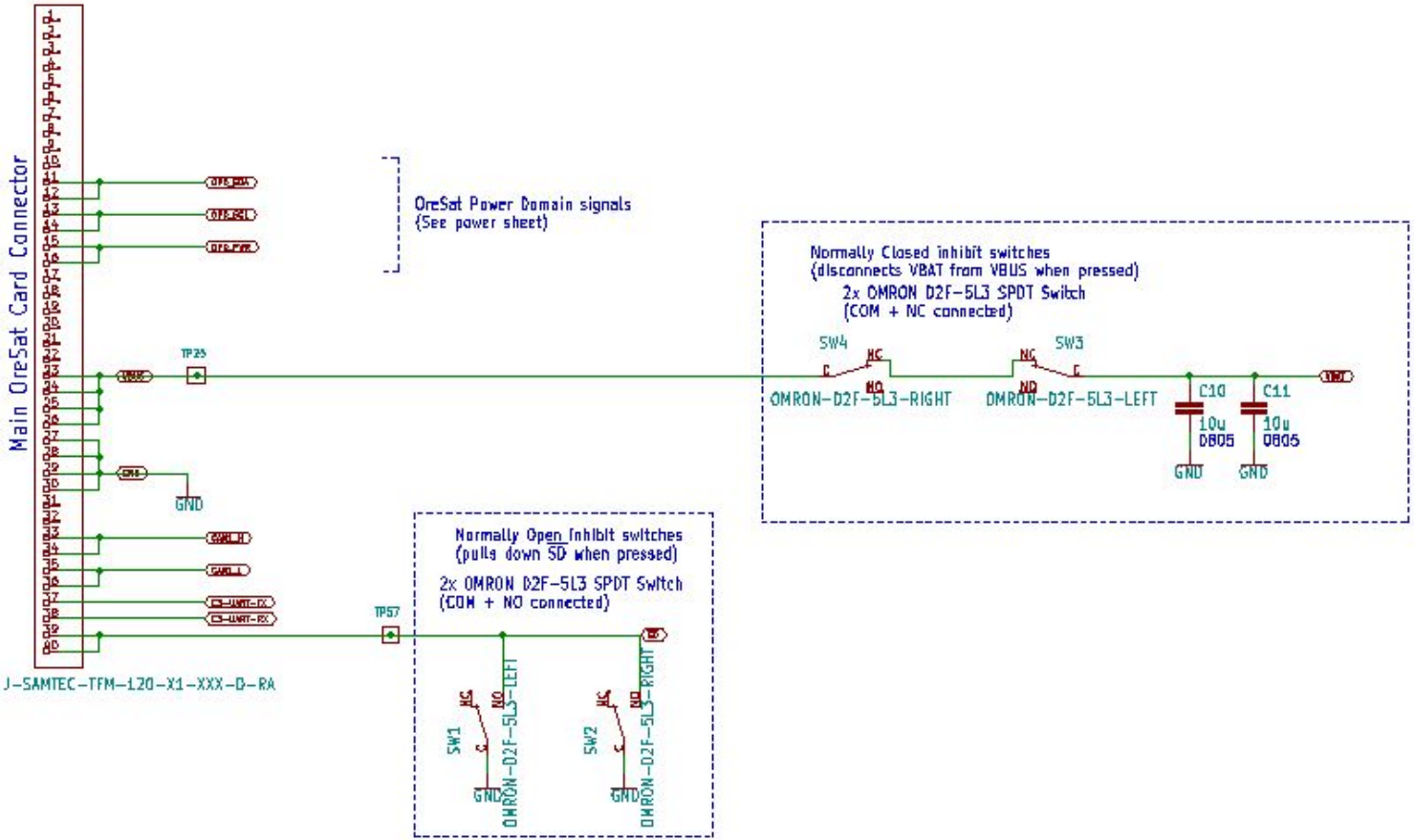


Battery Management System (con)

- Fuel gauge and cell balancing: MAX17205
  - Incredibly precise fuel gauge measurements
  - Temperature and current sense measurements
  - Includes dedicated alert pin for uC interrupts

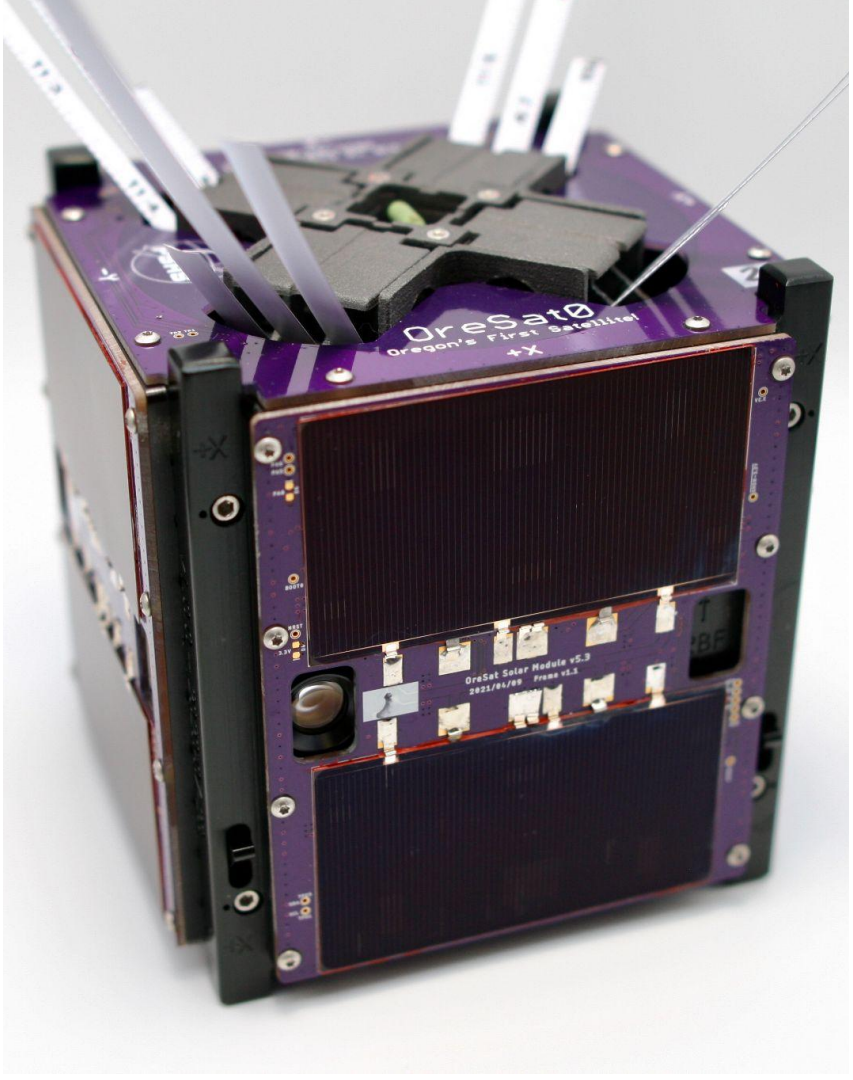


You want how many inhibits?

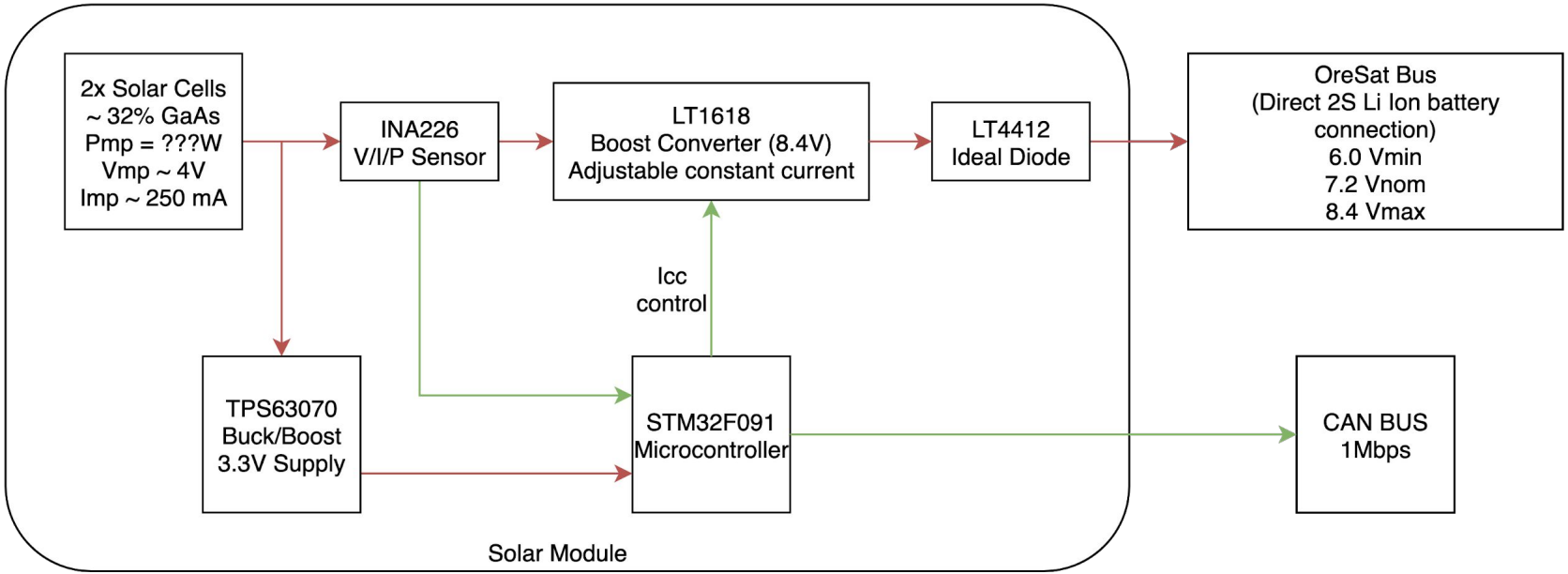

Main OreSat Card Connector
J-SAMTEC-TFM-120-X1-XXX-D-RA
OreSat Power Domain signals
(See power sheet)
TP25
GND
TP57
Normally Closed inhibit switches
(disconnects VBAT from VBUS when pressed)
2x OMRON D2F-5L3 SPDT Switch
(COM + NC connected)
SW4
SW3
NC
C
NO
OMRON-D2F-5L3-RIGHT
OMRON-D2F-5L3-LEFT
C10
C11
10u
0805
GND
Normally Open inhibit switches
(pulls down SD when pressed)
2x OMRON D2F-5L3 SPDT Switch
(COM + NO connected)
SW1
SW2
OMRON-D2F-5L3-LEFT
OMRON-D2F-5L3-RIGHT

Solar modules

- 1 per X,Y side (4 per U)
- 2 Spectrolab XTE-SF cells
  - 2.34 W_{pk} / module
- Active MPPT on each module
- Directly thermally connected to the frame
- RBF port!

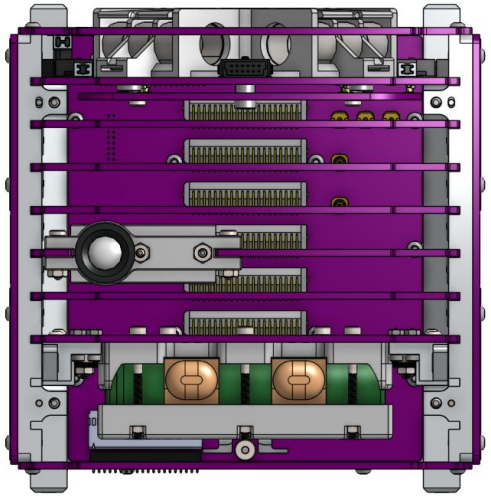


Solar Module Simplified Block Diagram



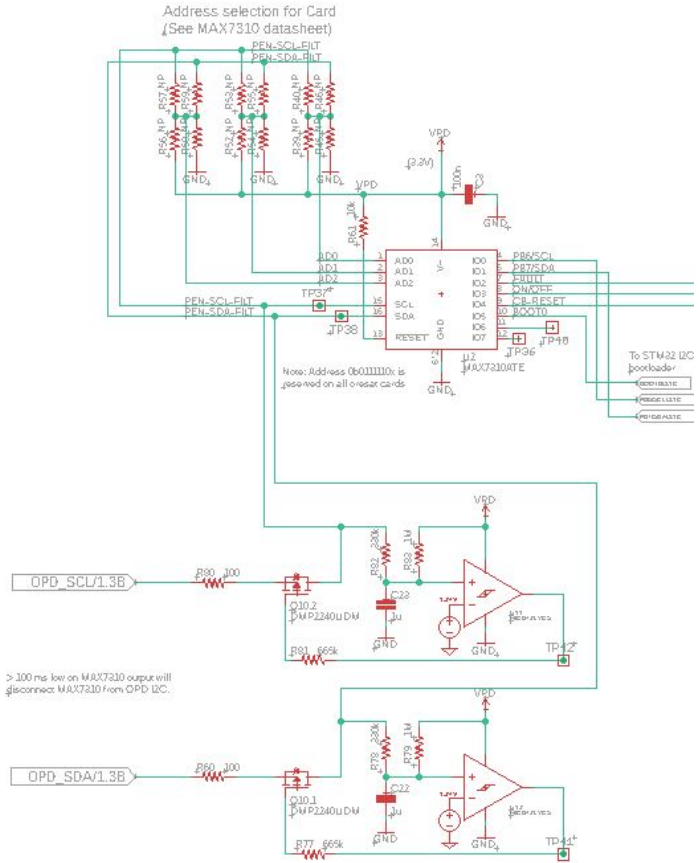
The OreSat Power Domain

- The Goal:
  - Provide a standard design for systems to interface with OreSat power systems
  - Isolate systems so a single card can not brick the satellite



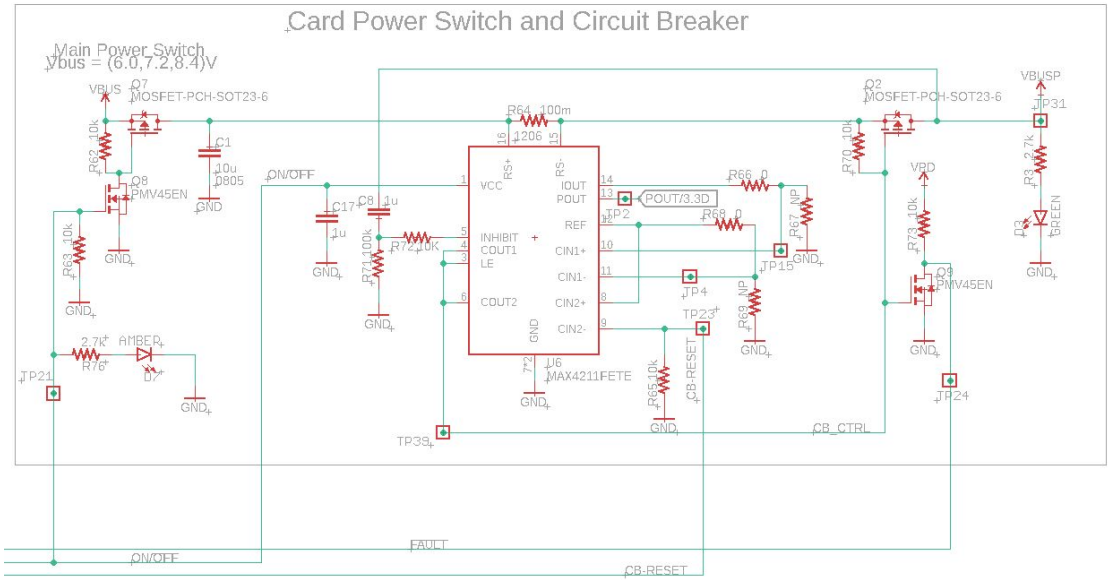
I2C Interface

- MAX7310 GPIO expander
  - C3 monitoring and control of each cards power system
  - Emergency I2C bootloader
- Fault tolerant isolation
  - I2C is vulnerable to SEU
  - In the event of an SEU, comparator circuit isolates card
  - Not perfect but better than nothing



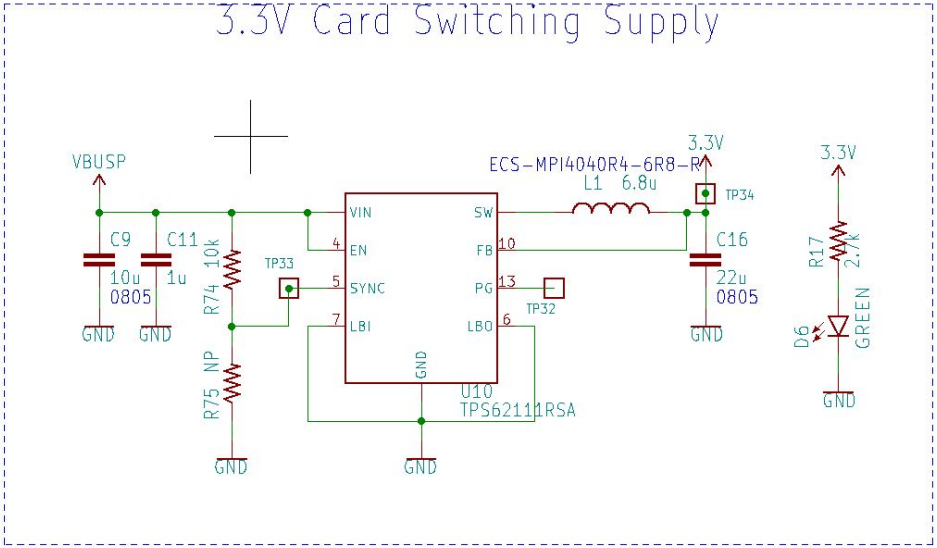
Power Switch and Circuit Breaker

- MAX4211 Current Monitor
  - Removes card from bus if OC is detected
  - Removes card from bus if signaled by C3
  - Reports power draw to local uC



Power Supplies

- Each card handles its own voltage regulation
  - Allows OPD to scale to missions with varying requirements
- Reference designs use AEC rated switching power supplies from TI
  - Cheap
  - High frequency
  - Efficient



More Information/Contact

More Information

- A good place to start: https://www.oresat.org/
- Full source:
  - Solar module: https://github.com/oresat/oresat-solar
  - Battery card: https://github.com/oresat/oresat-batteries
  - Backplane: https://github.com/oresat/oresat-backplane
  - OPD reference card: https://github.com/oresat/oresat-proto-card
- More open source aerospace: https://www.pdxaerospace.org/
- Contact me at dalay@pdx.edu or https://www.linkedin.com/in/davidalay/
- Contact us at aerospace@pdx.edu

Thank you!