AMPTS FTA Avionics Design

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College of Engineering

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College of Engineering

Requirements I

Based on revision (E) of the flight test requirements document.

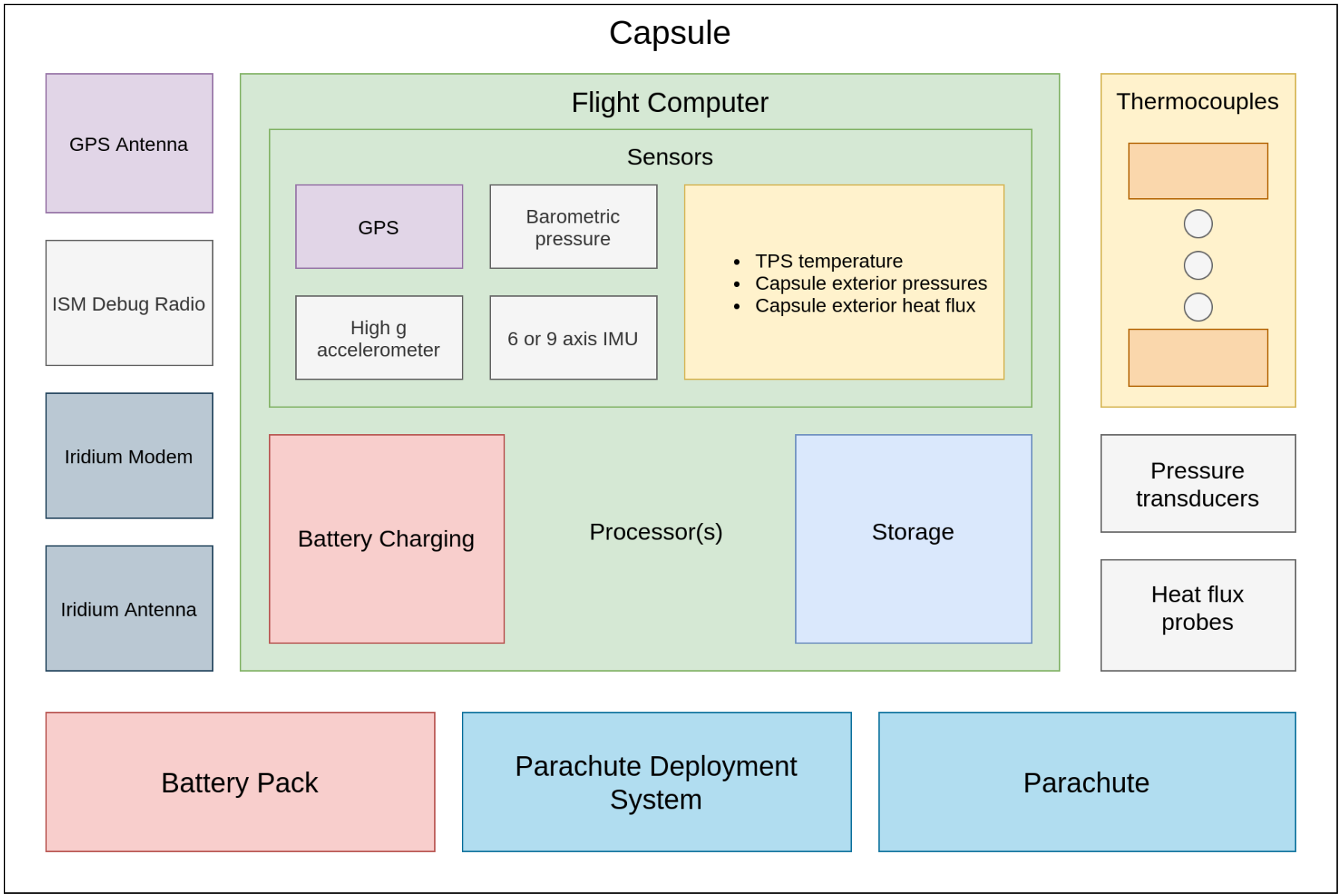
1. Instrumentation and telemetry
    1. Shall support betwen 8 and 20 thermocouples of varying type
    2. Shall support up to 6 absolute pressure sensors
    3. Shall support at least 1 intertial measurement unit (IMU)
    4. Should support 1 heat flux sensor
    5. Shall contain a GPS for recovery operations, accurate to with 100m
    6. Capsule shall contain an internal barometric pressure sensor
    7. Telemetry data shall be collected at a minumum of 10Hz
    8. Telemetry data shall be stored to onboard nonvolatile memory that will survive landing
    9. Location telemetry shall be transmitted through a vehicle-to-ground system (e.g. Iridium satellite, Xbee)
    10. Recovery location should be broadcasted at least once every 5 minutes post-flight
2. Activation and flight sequencing
    1. Shall be powered through the duration of the flight

Requirements II

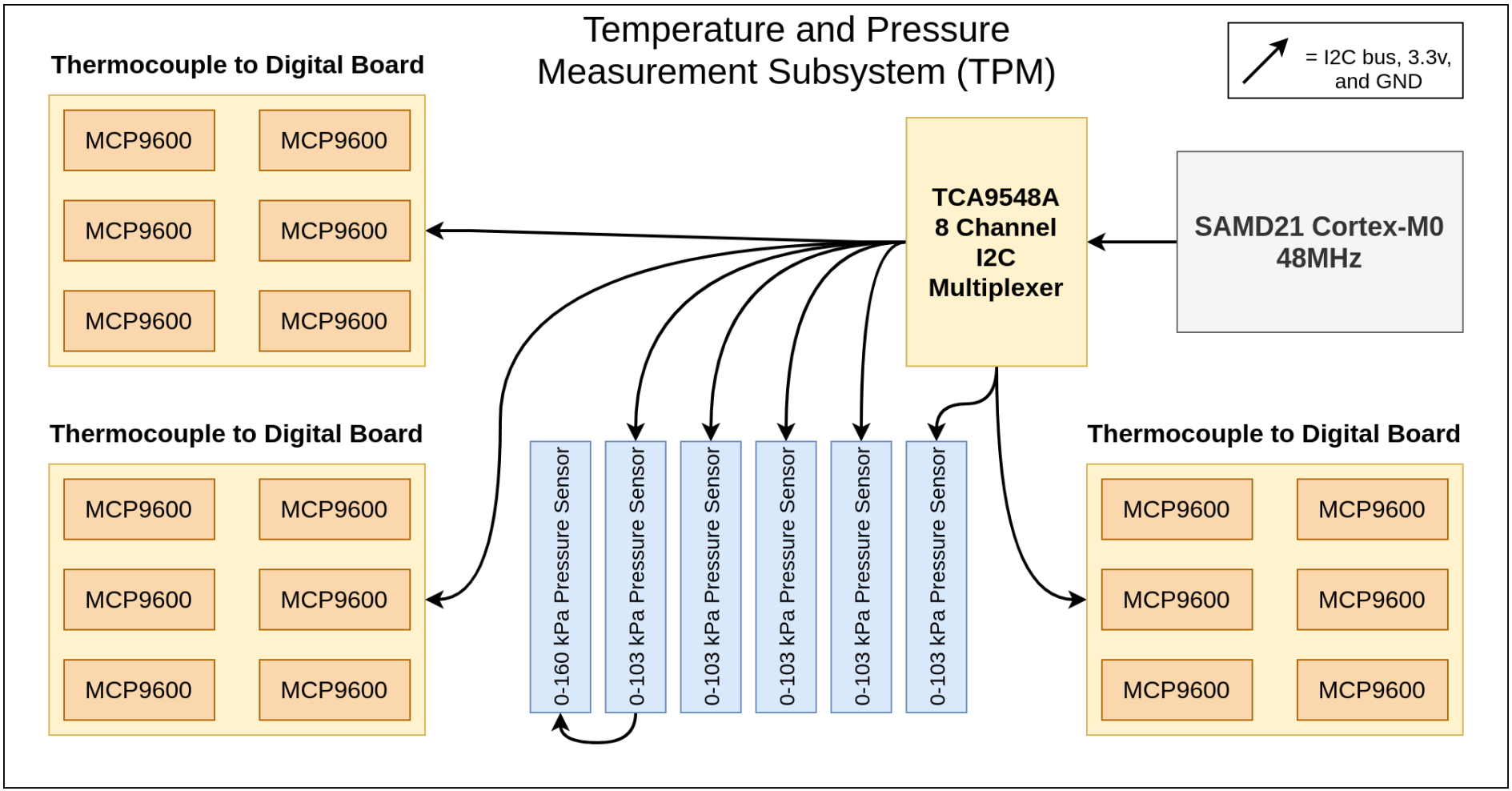
2. Shall support continuous operation between -20 deg C and 80 deg C
3. Shall support pre-launch activation on the ground; should support low power mode prior to deployment
4. Shall detect and/or sense when deployment has occurred via interfacing with the launch vehicle
5. Shall transmit in-flight telemetry with position information
6. In-flight telemetry should contain capsule velocity
7. Shall trigger parachute deployment at a specified time

3. Physical properties
4. Avionics hardware shall weigh under or around 0.5kg
5. Shall cost under $3,000

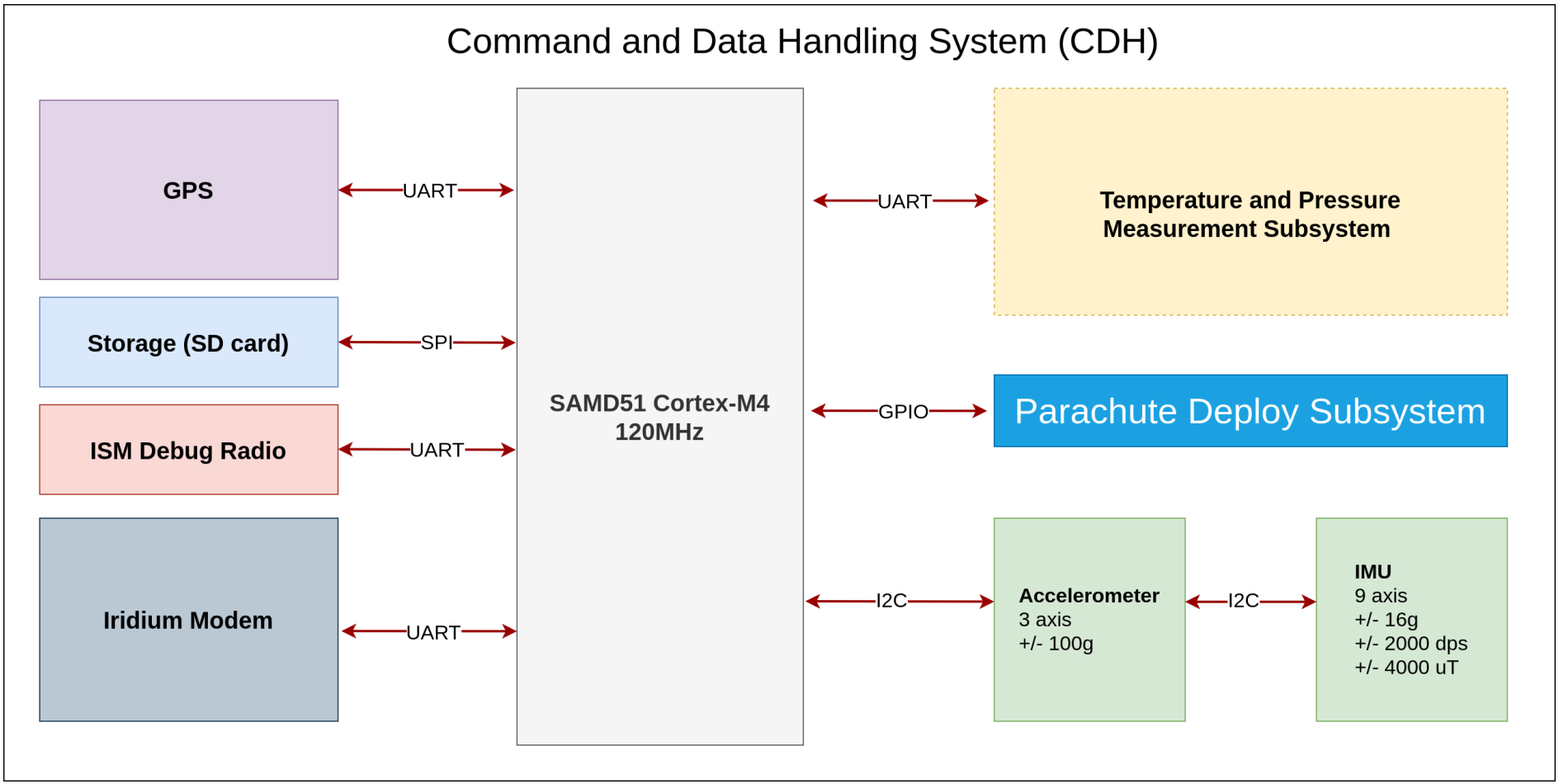
Overview


Capsule
GPS Antenna
ISM Debug Radio
Iridium Modem
Iridium Antenna
Flight Computer
Sensors
GPS
Barometric pressure
High g accelerometer
6 or 9 axis IMU
TPS temperature
Capsule exterior pressures
Capsule exterior heat flux
Battery Charging
Processor(s)
Storage
Thermocouples
Pressure transducers
Heat flux probes
Battery Pack
Parachute Deployment System
Parachute

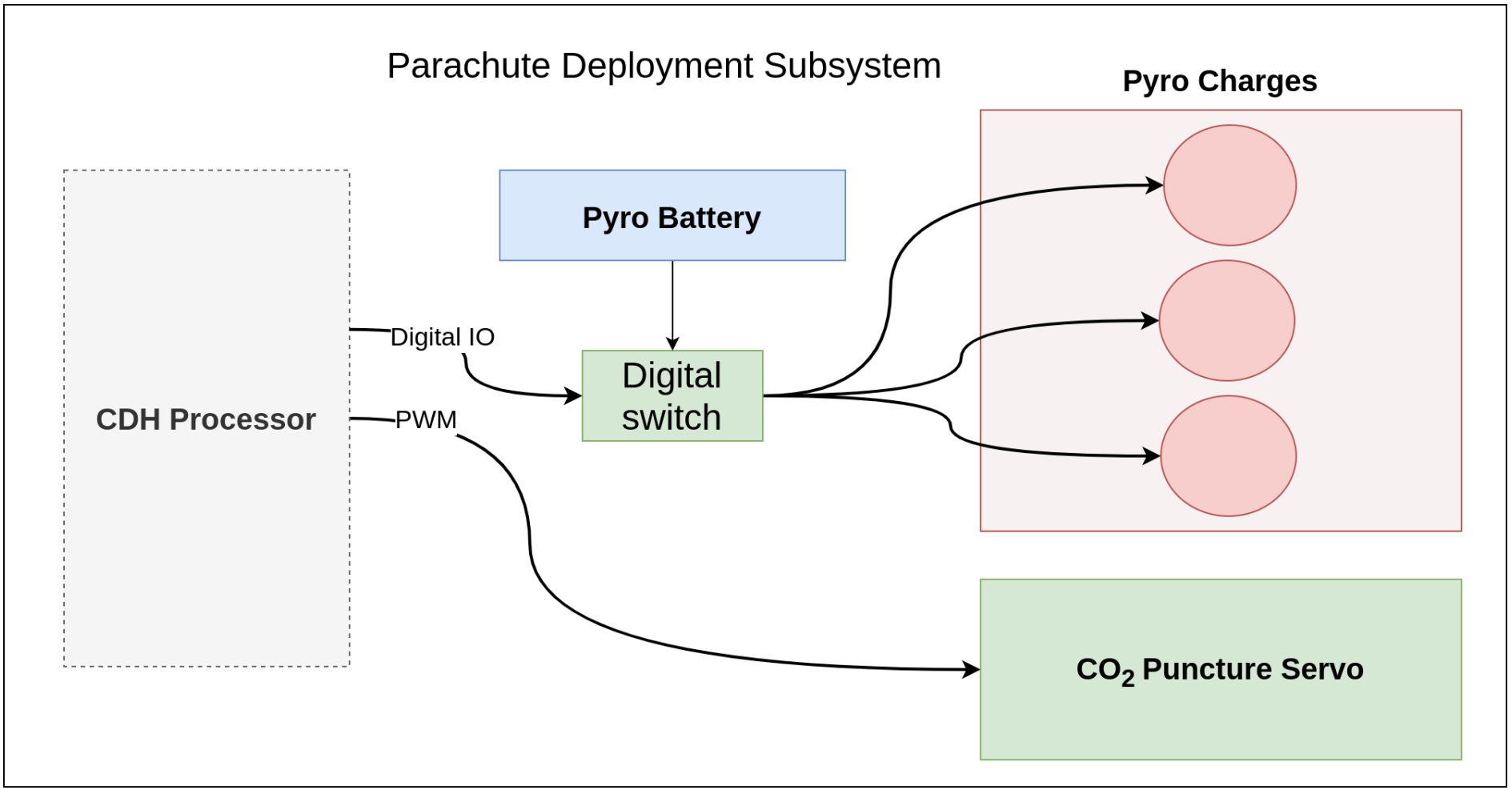
Temperature and Pressure Measurement)



Command and Data Handling

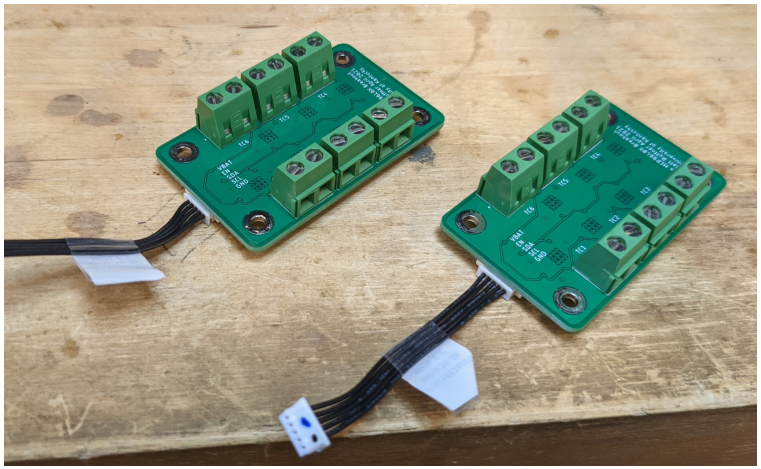


Parachute Control

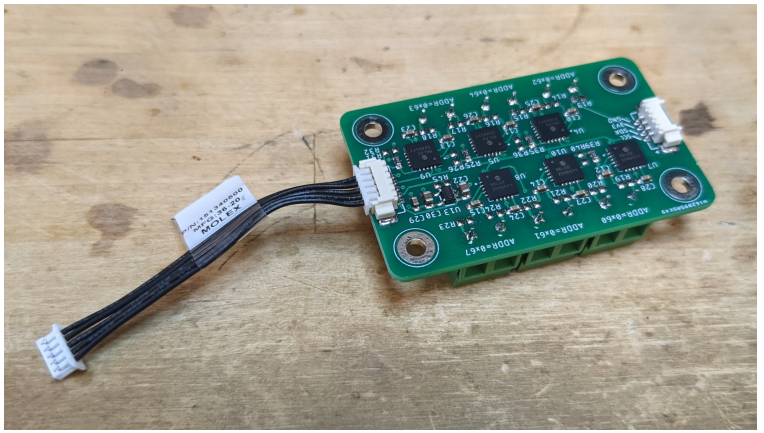


Prototype Hardware I

- TC to digital expansion



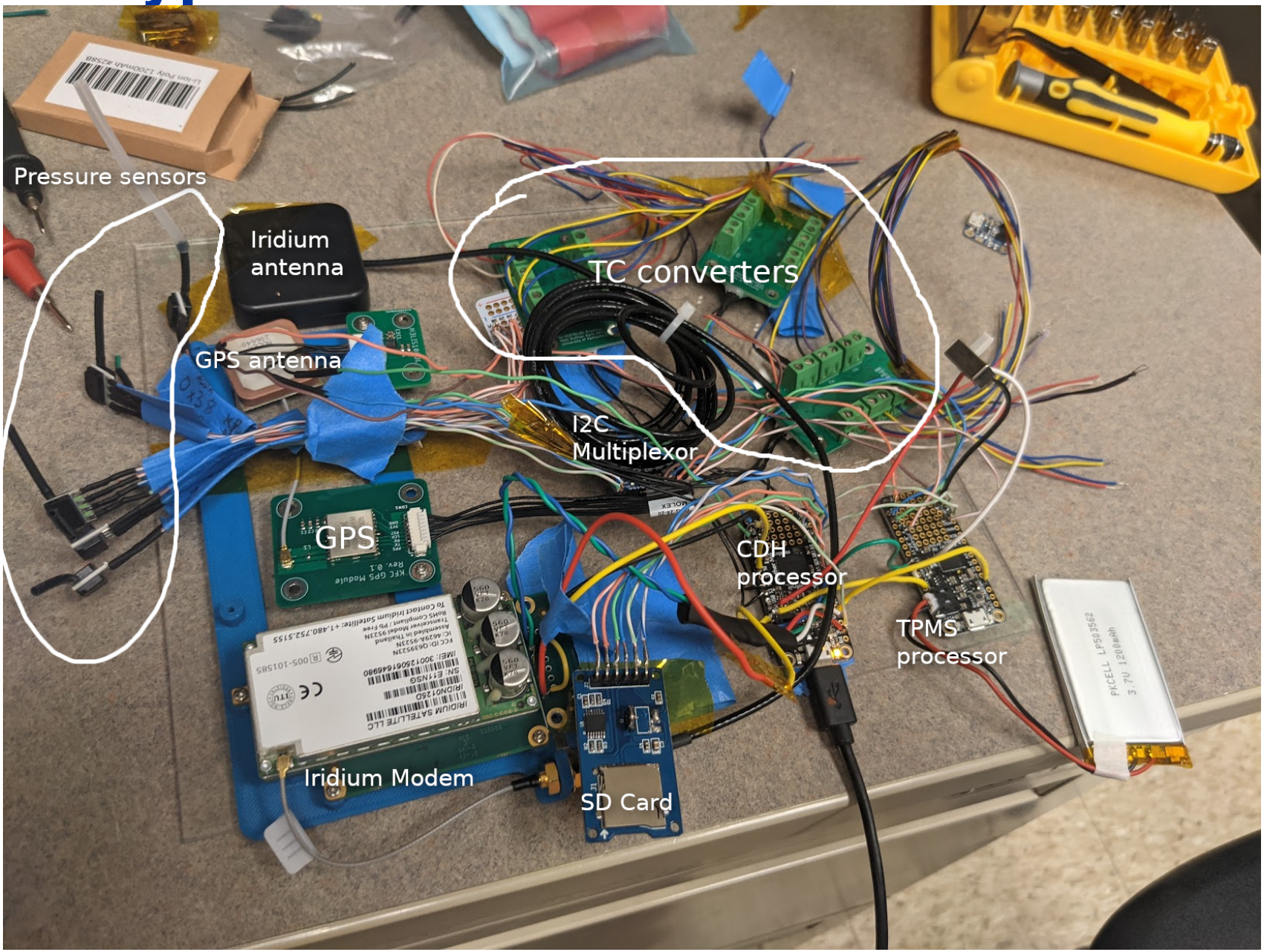
(a) Six channel MCP9600 breakout (top).



(b) Six channel MCP9600 breakout (bottom).

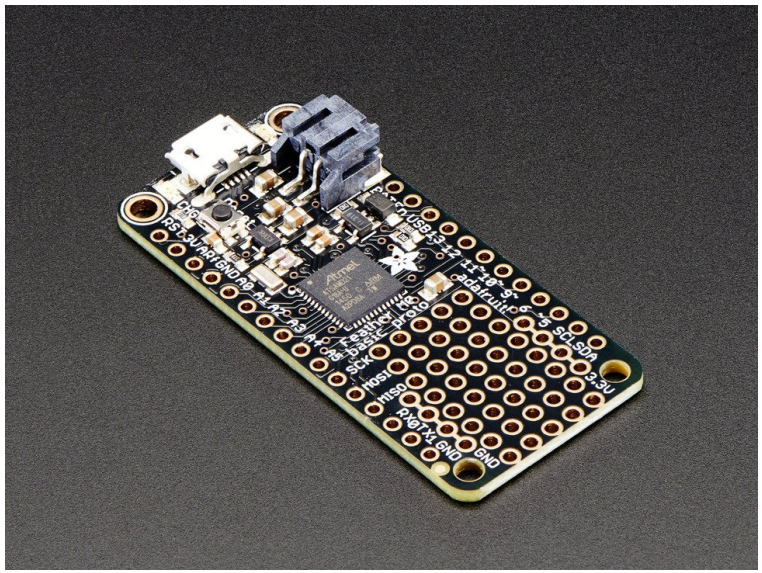
- Semtech SX1276-based 915 MHz ISM band LoRa modem for capsule-to-ground telemetry
- 1S2P LiPo for power
- Physical switch at capsule/vehicle interface for activation.

Prototype Hardware II

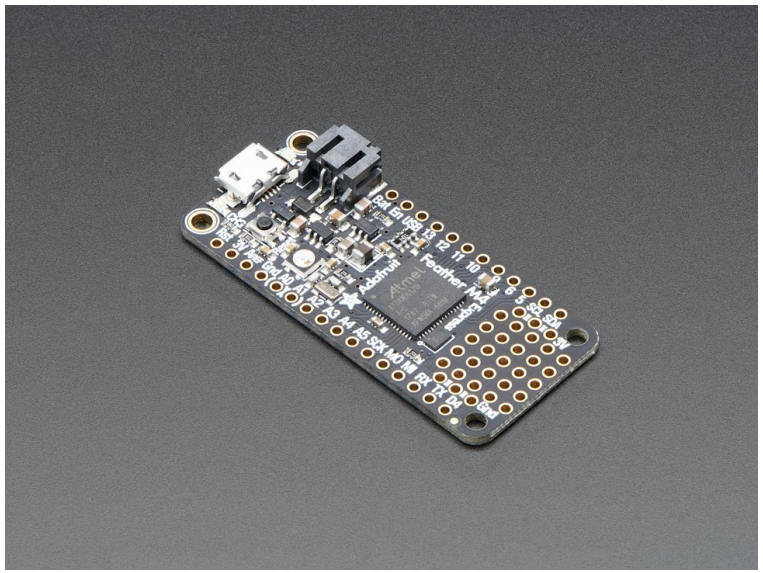


Final Design Considerations I

- **Supply chain constraints** - bare SAMD21/51 processors are hard to find on Digikey/Mouser etc. but pre-made development boards from Adafruit are still available.



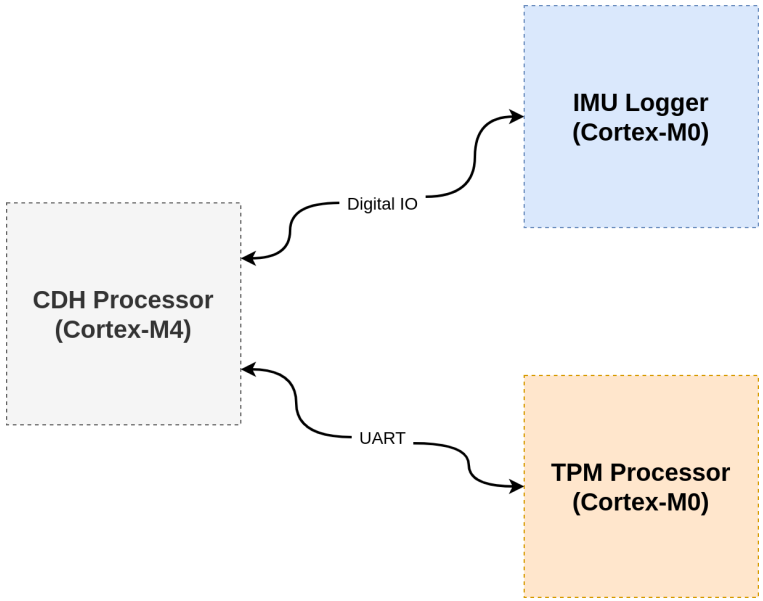
(a) Adafruit SAMD21 48MHz Cortex-M0 carrier
https://www.adafruit.com/product/2772



(b) Adafruit SAMD51 120MHz Cortex-M4 carrier
https://www.adafruit.com/product/3857

Final Design Considerations II

- **Plenty of processor overhead** - recording 12 channels of IMU and accelerometer data to an SD card at 100Hz requires strict timing and interrupt handling
- Current planned revision is to separate IMU and high-g accelerometer interfacing to its own Cortex-M0 processor.

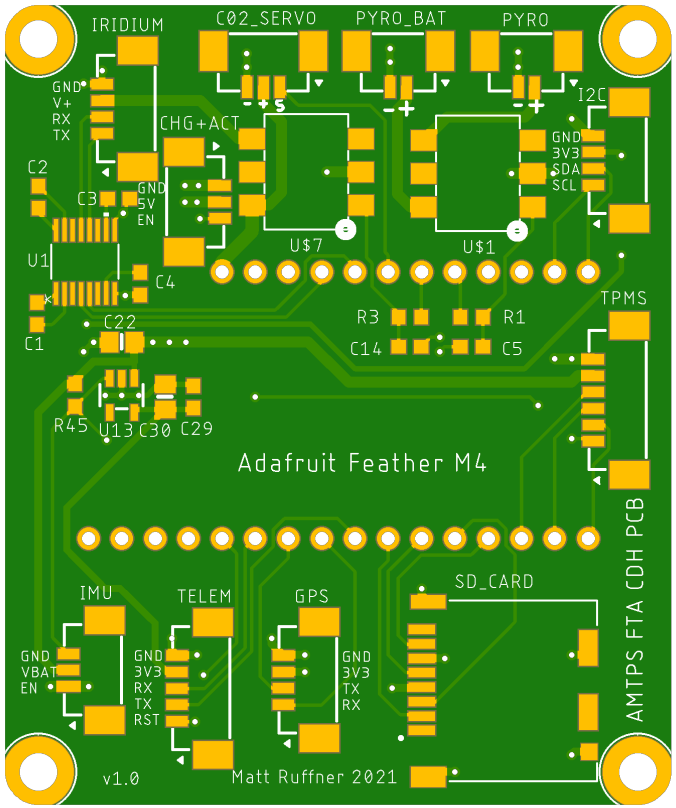


Processor separation of responsibilities.

Software Overview

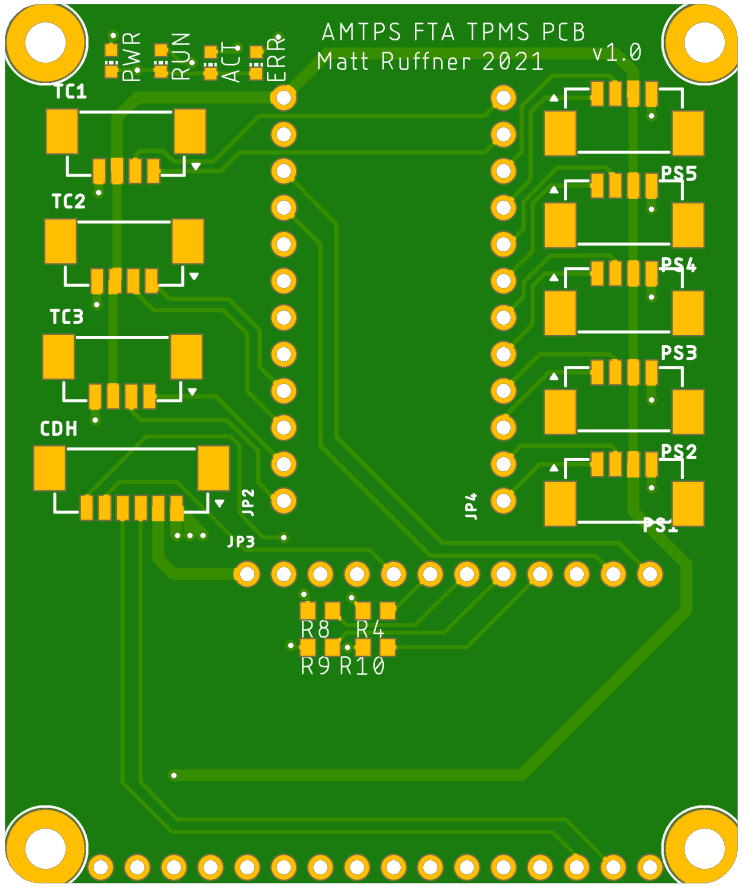
- Adafruit Feather line of boards is Arduino compatible
- SAMD21/51 series of processors has easily reconfigurable SERCOMs to support multiple hardware serial ports
- FreeRTOS tasks, queues, and semaphores allow for simple and reliable transfer of data and atomic hardware access
- Open source libraries available for all sensors
- All hardware design files and firmware, as well as ground assist tools for plotting recorded data are version controlled on private Github repositories:
  - https://github.com/krups/amtps-fta-hardware
  - https://github.com/krups/amtps-fta-software

Rev 2 board designs I



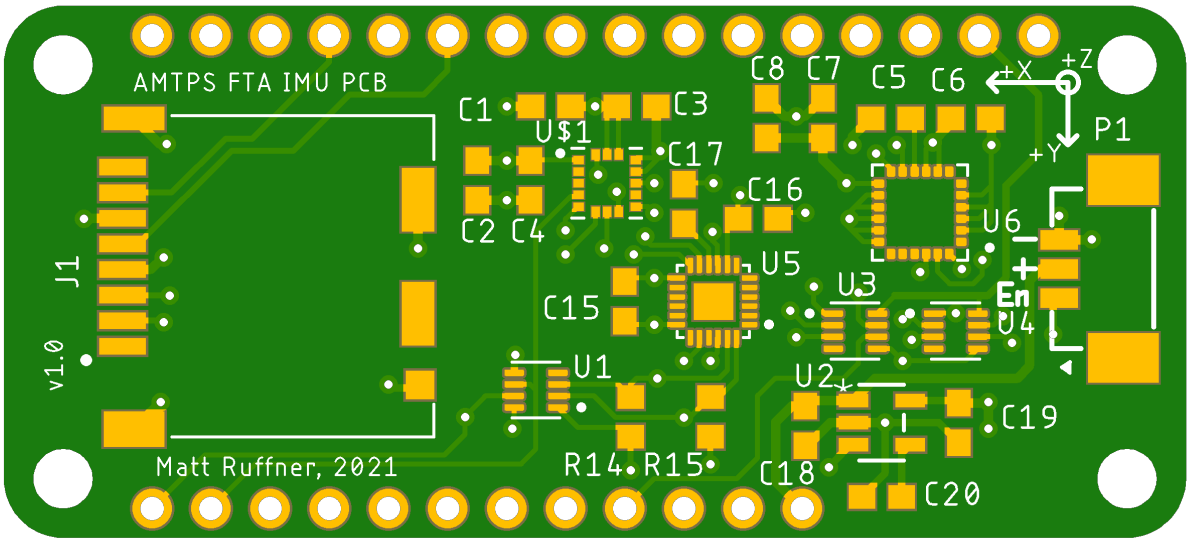
CDH processor carrier PCB.

Rev 2 board designs II



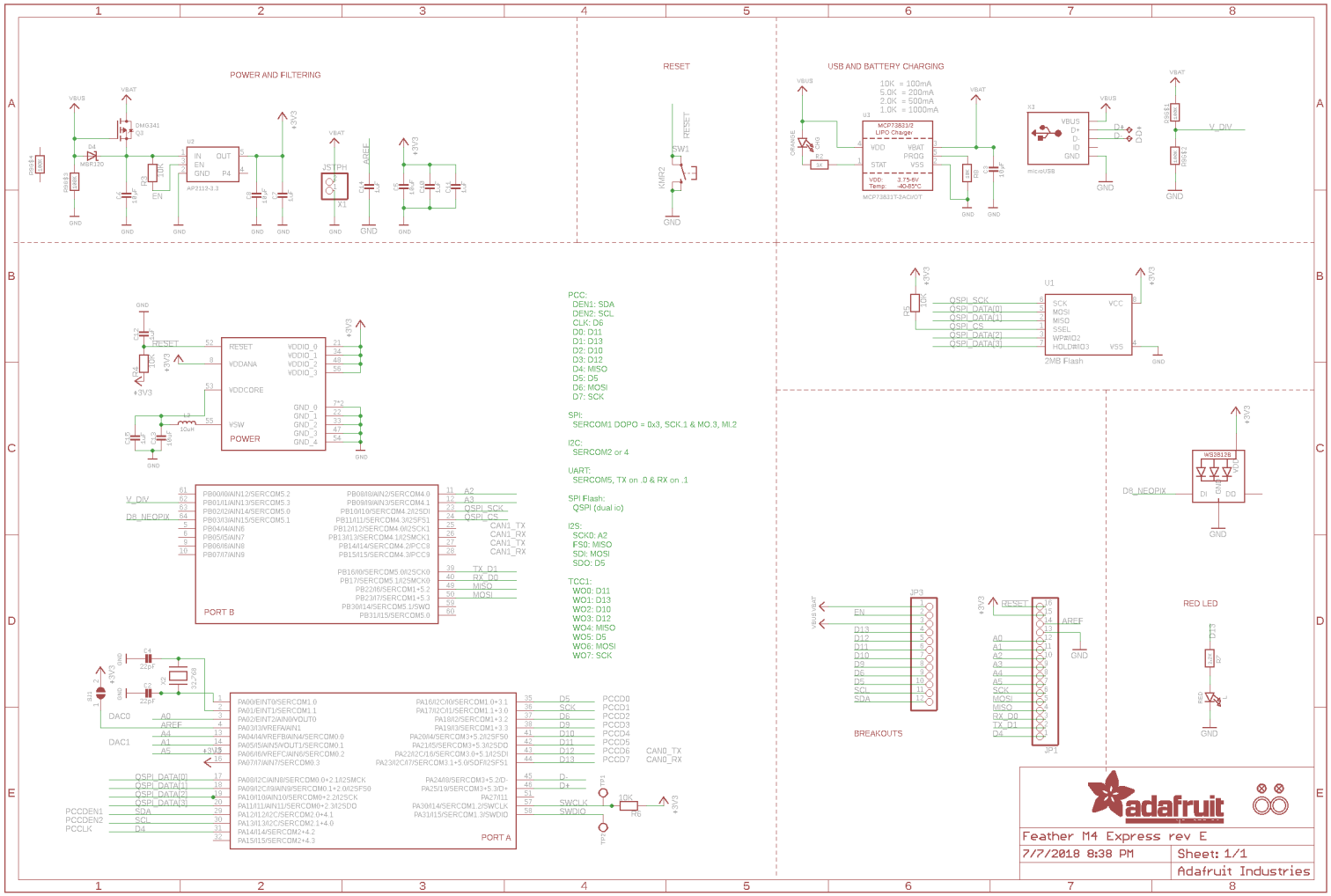
TMP processor carrier PCB.

Rev 2 board designs III

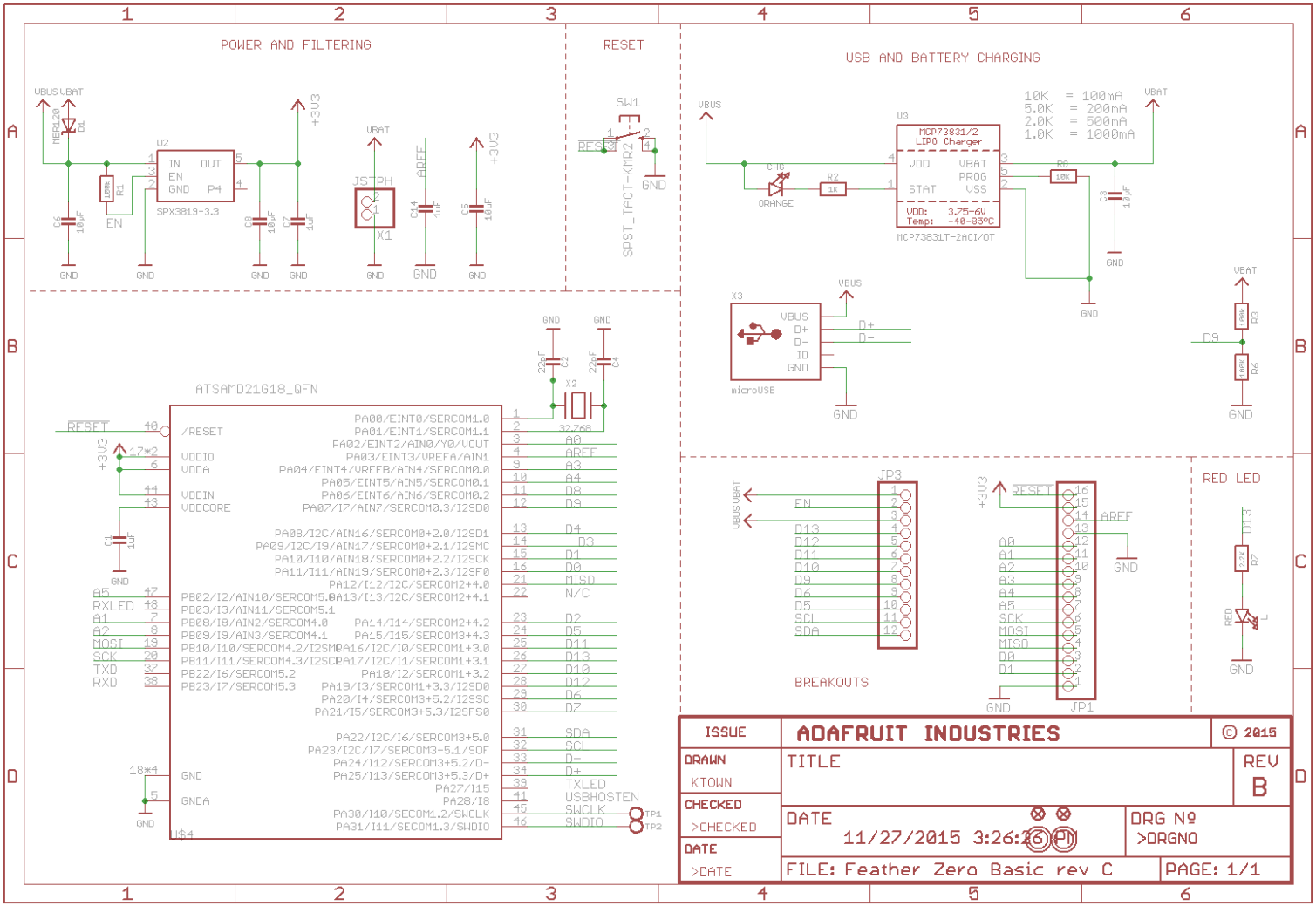


IMU logger processor carrier PCB.

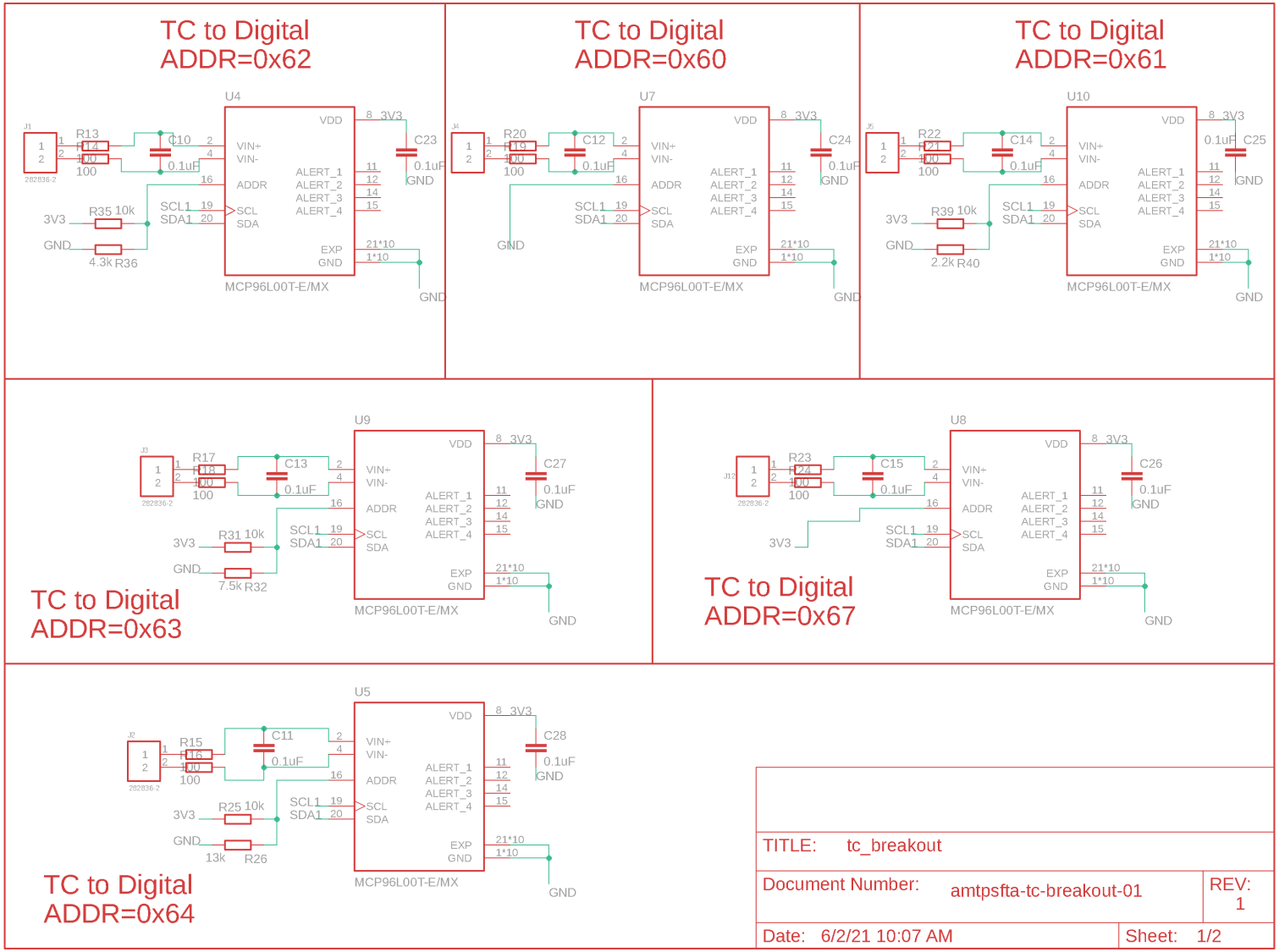
Feather M0/M4 Schematics I



Feather M0/M4 Schematics II

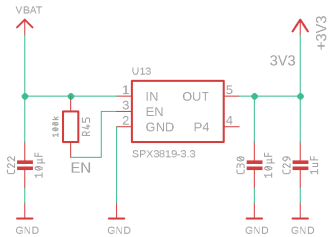


TC to Digital Schematics I

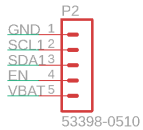


TC to Digital Schematics II

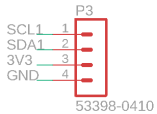
Voltage regulation and filtering



Voltage in and enable



Downstream I2C connections



Mounting Holes

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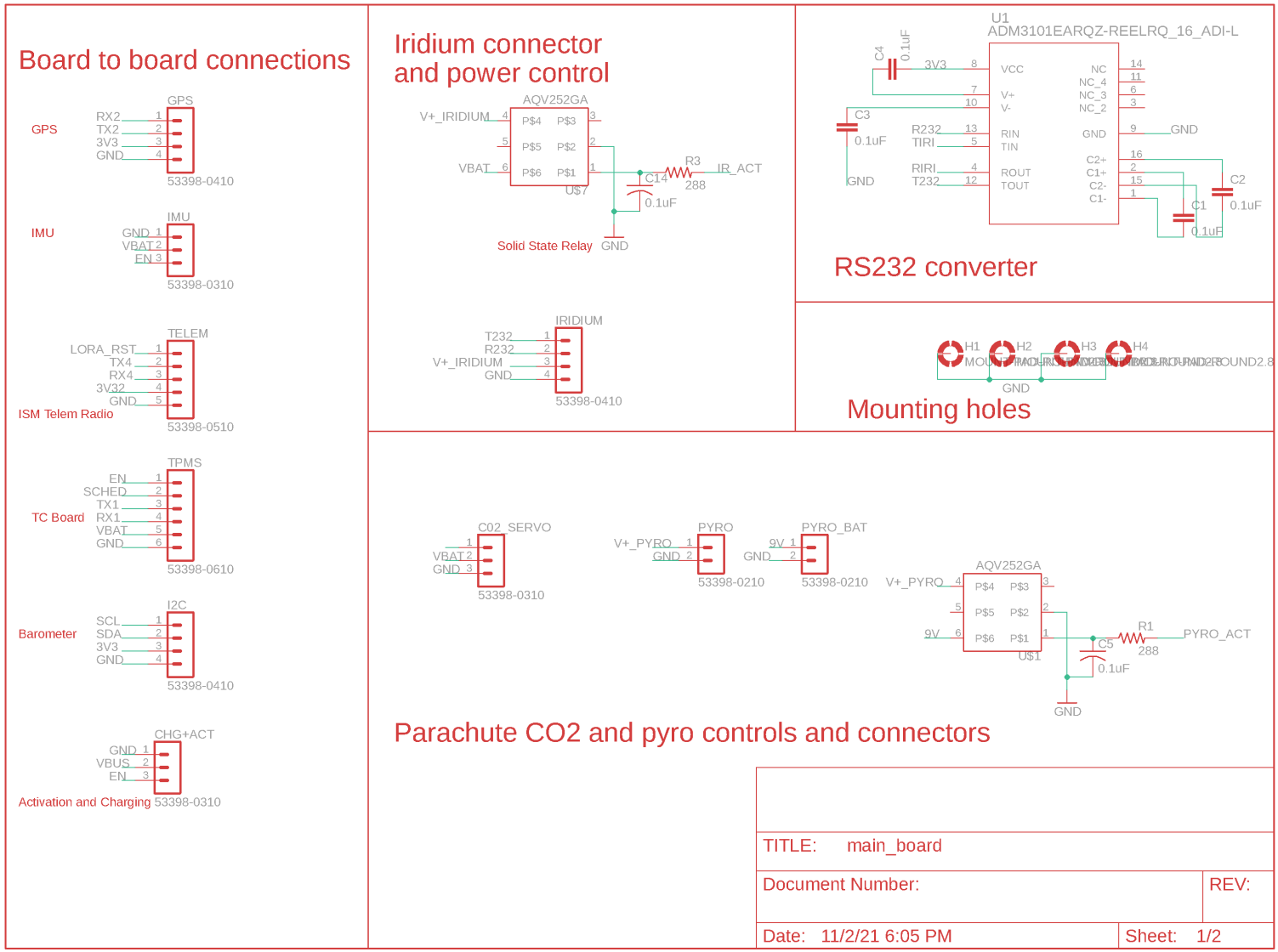
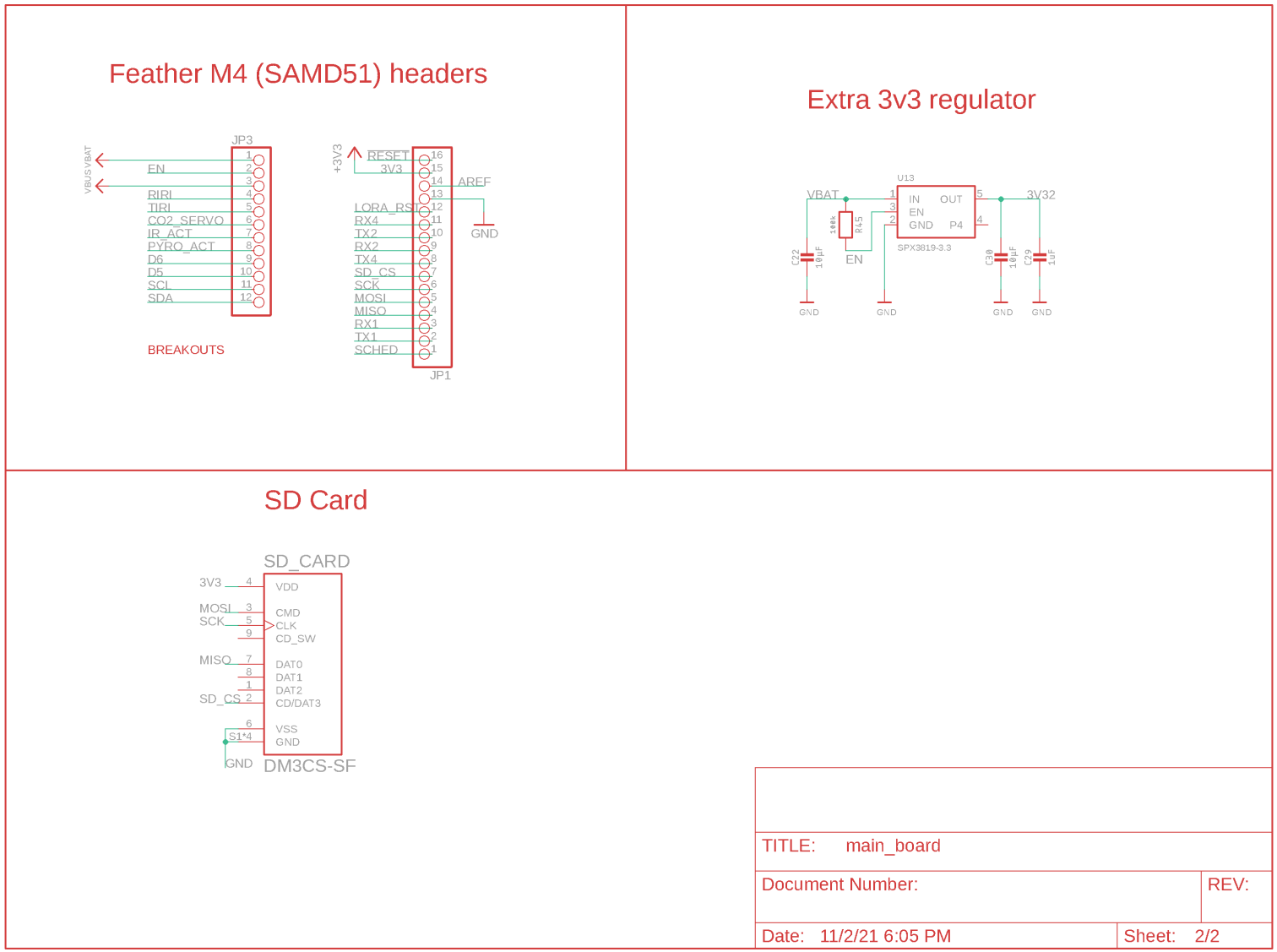
Date: 6/2/21 10:07 AM	Sheet: 2/2	

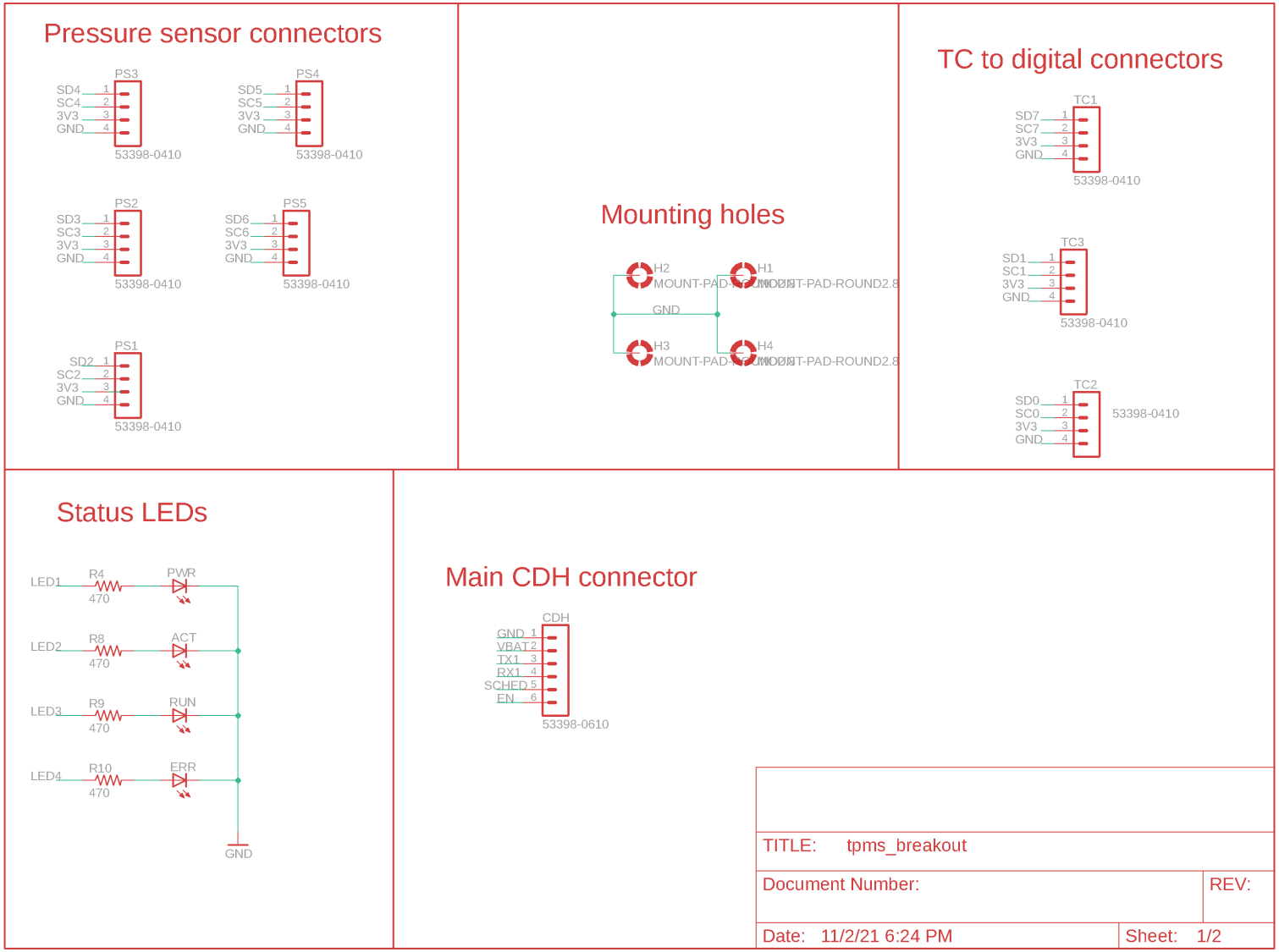
Main CDH Schematics I



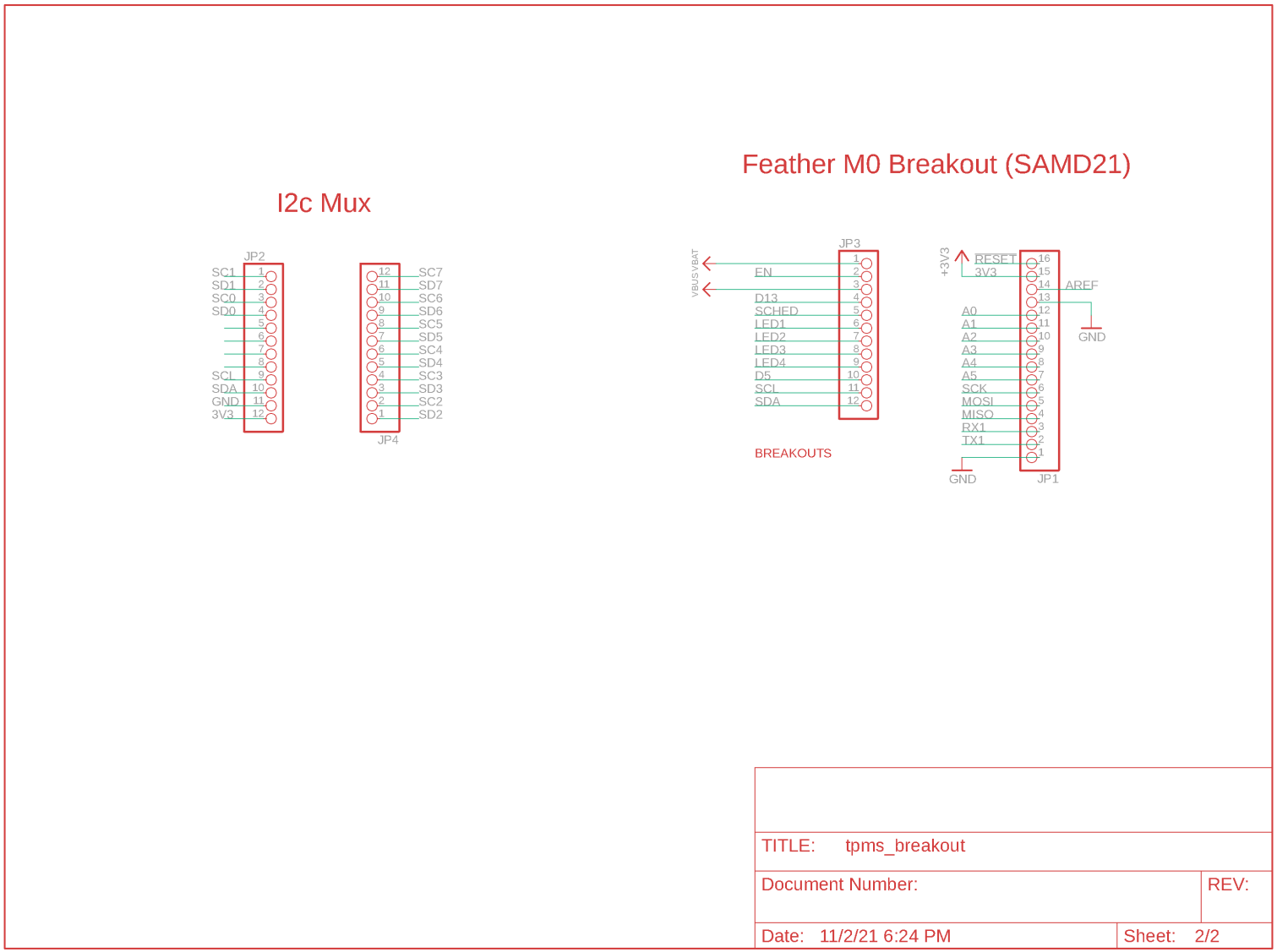
Main CDH Schematics II



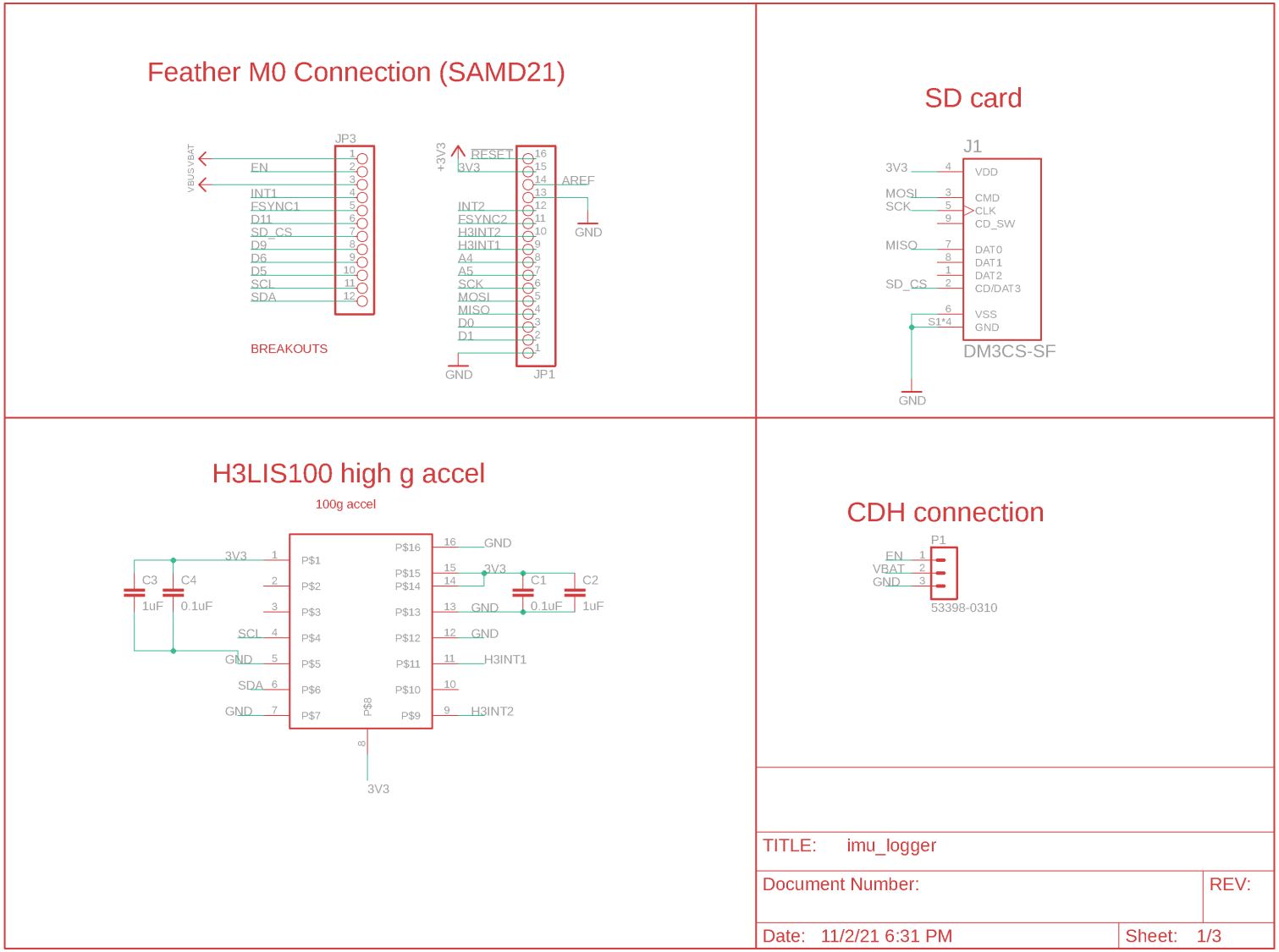
TPM Schematics I



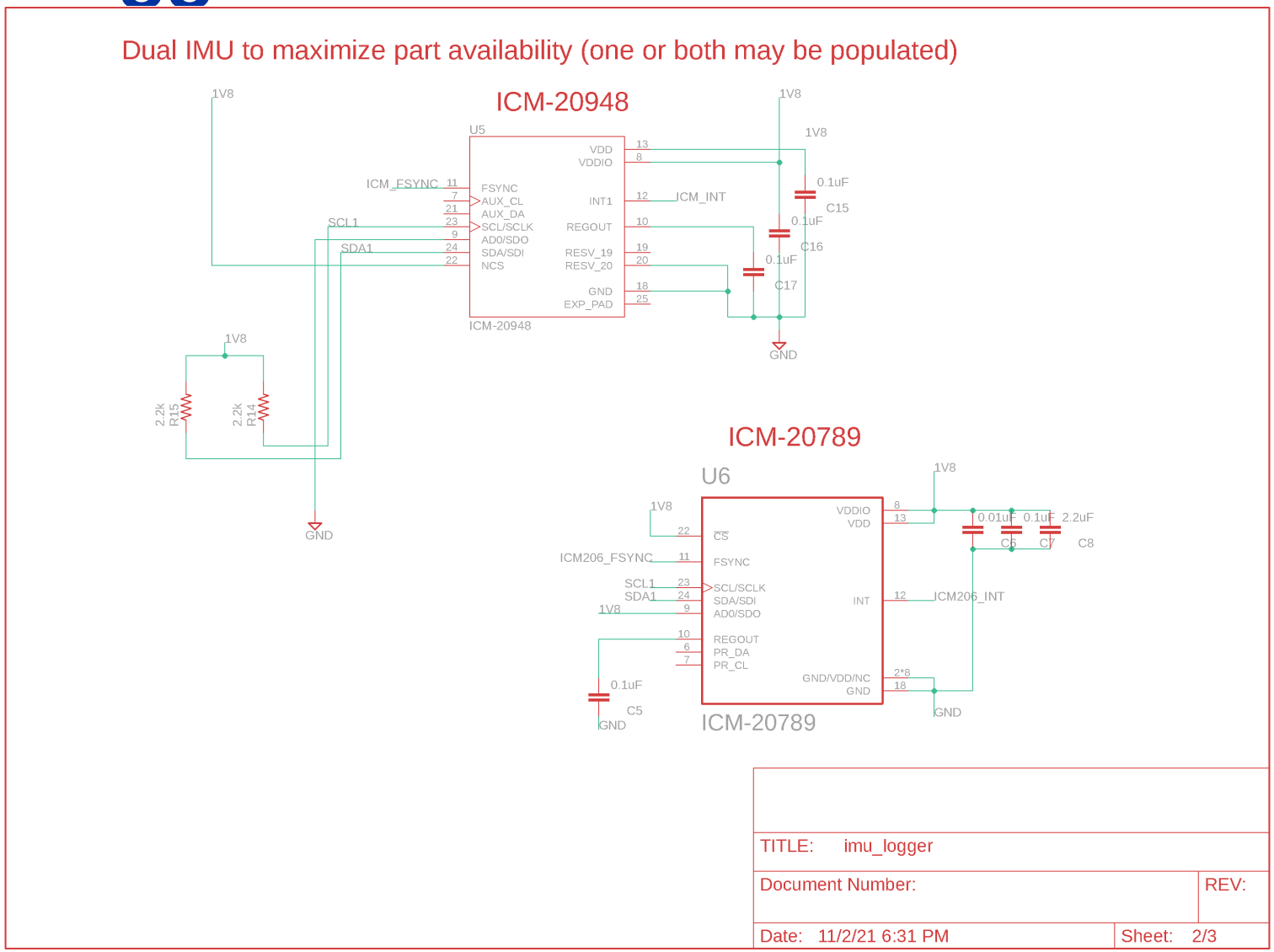
TPM Schematics II



IMU Logger Schematics I



IMU Logger Schematics II



IMU Logger Schematics III