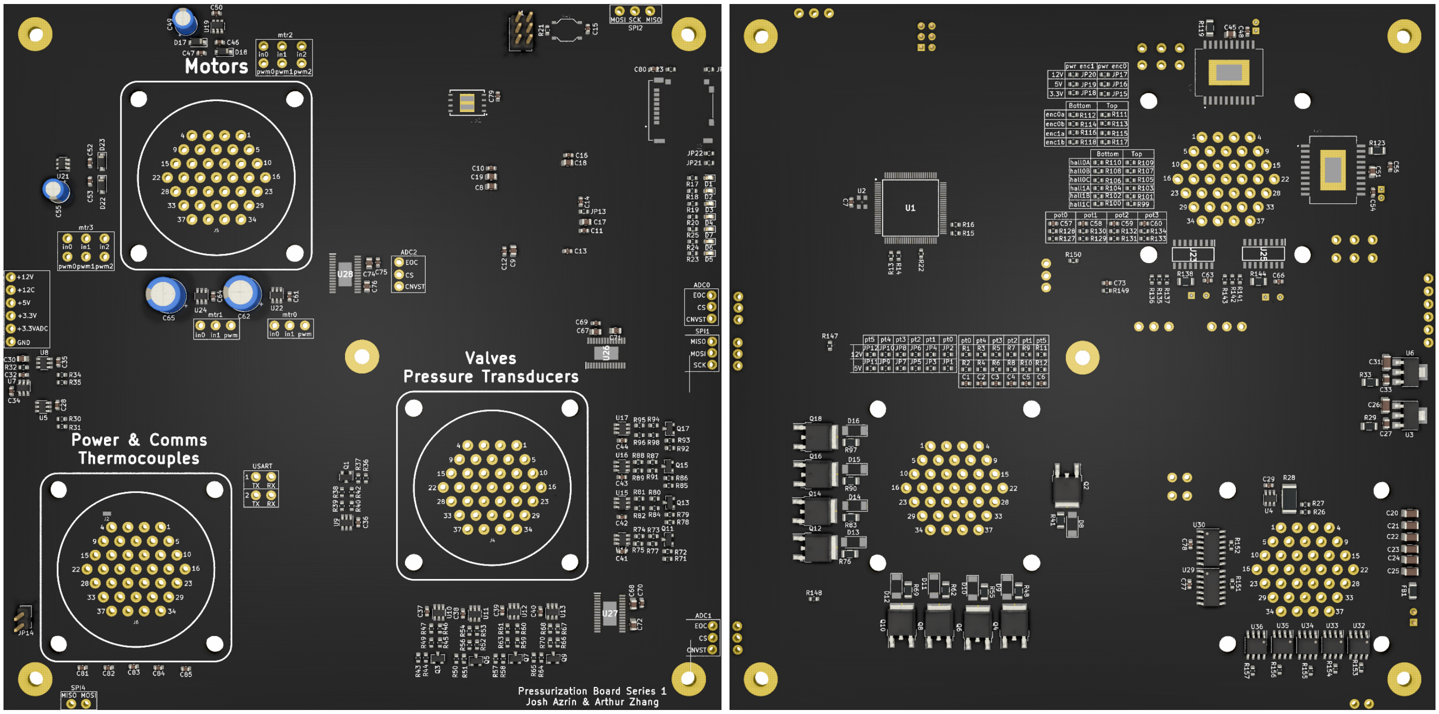
Pressurization Board



3D CAD Render of the Pressurization Board

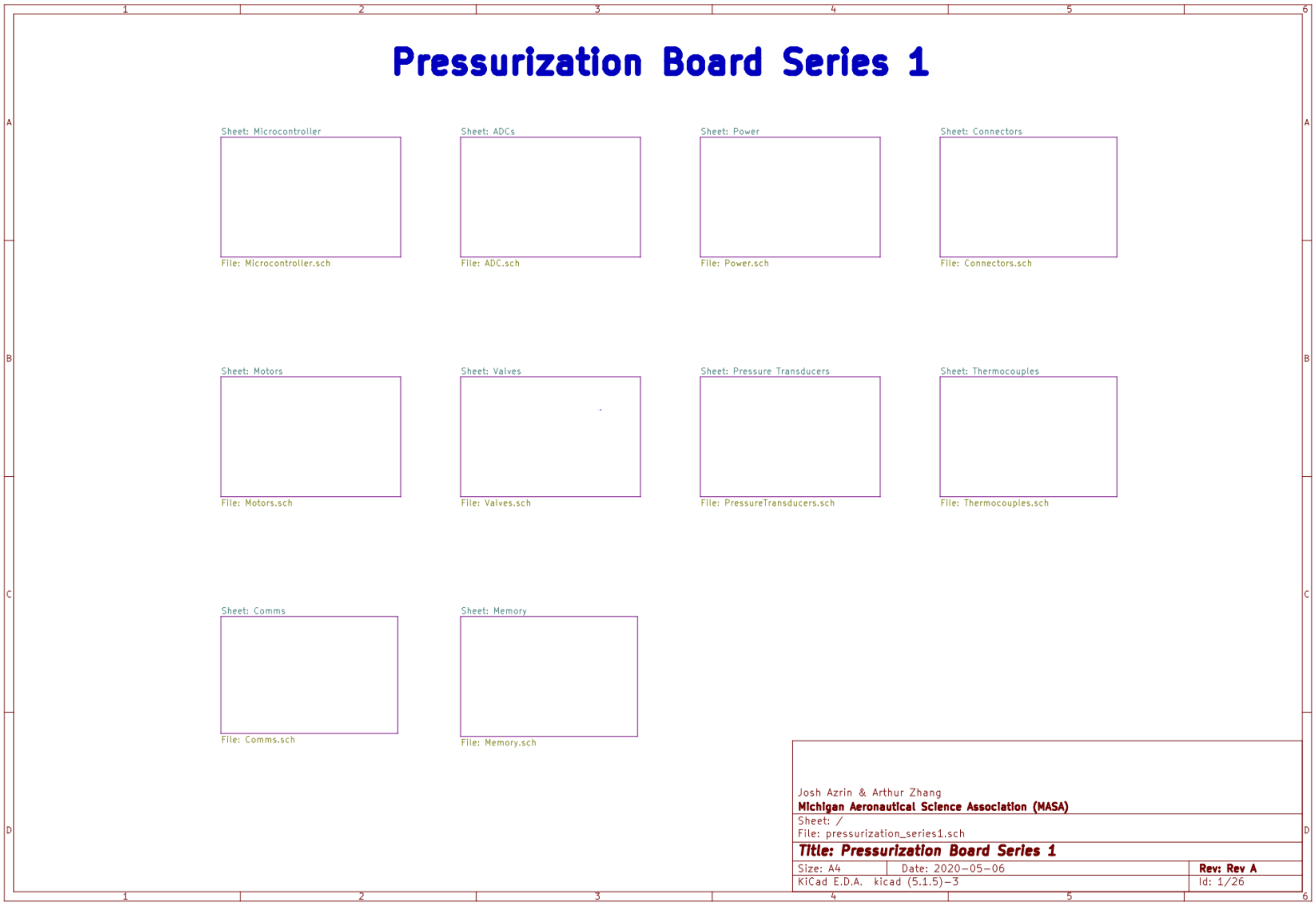
Over the course of second semester sophomore year, I researched and designed a pressurization board for the Michigan Aeronautics and Science Association (MASA), a collegiate project design team. Our team's primary objective is to design a liquid fueled rocket to participate in the Base11 Space Challenge, where we will compete with other colleges to see who can reach 100km, just pass the Karman line in the edge of space. Given that we are designing a completely liquid fueled rocket, we must develop sophisticated electronics capable of regulating our fuel tank pressures during liftoff. To accomplish this, I collaborated with members on the Propulsion, Atlo, Avionics subteams to design a PCB capable of monitoring and actively balancing our tank pressures for liquid oxygen and liquid nitrogen over the course of our rocket's flight.

The completed board shown above, is a four layer PCB with a dedicated 3v3, ground, digital signal, and analog signal plane. In addition, there are several copper pours dedicated to 12v, 5v, and ground power for various high current and voltage components that we need to control. Full hardware support details can be found in the board specs below:

Board Specs

- Full control of 9 dual state valves
- 6 Pressure transducers
- 2 BLDC motors (4A max)
- 2 Brushless DC motors (15A max)
- 6 Hall effect sensors
- 4 Potentiometers
- 2 Encoders
- 2 Full Duplex RS-422 Communication Channels
- 5 Thermocouples

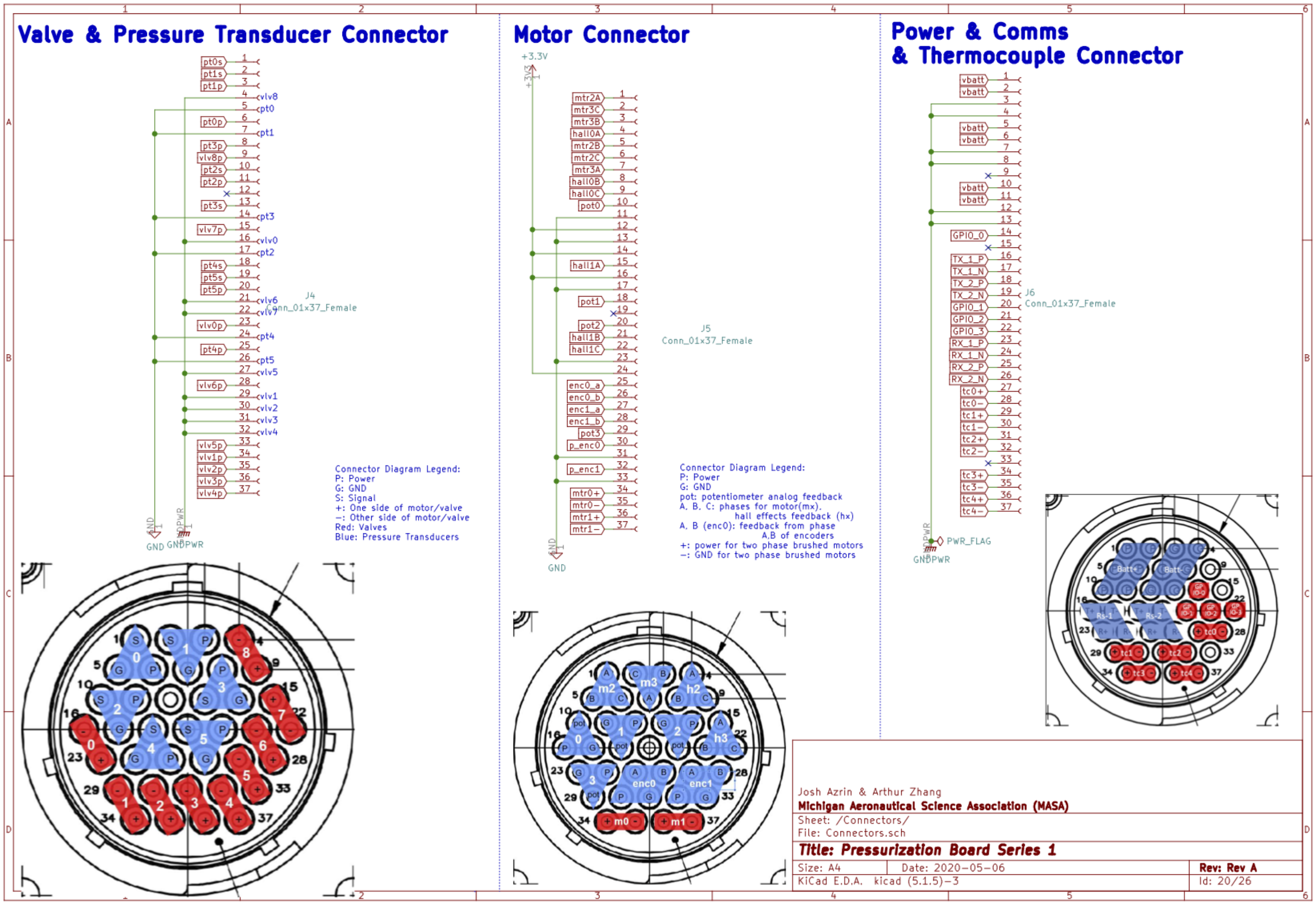
- 4 Miscellaneous GPIO connections as needed
- 1 Micro SD Card Reader
- 1 Non-volatile Flash Memory IC



High Level View of Schematic Organization Hierarchy

The board also supports advanced functionality for components like the ADC converters. I designed the ADC interfacing circuitry to easily allow for repeated sampling for any number of channels with each SPI read request. Any component that generates analog feedback is immediately passed through a low pass filter to minimize noise before it is sent to the ADC to be converted. In addition, I configured the ADCs to average samples from each channel in order to further reduce noise. This is essential for minimizing the risk of creating false positive scenarios for our in-flight autonomous abort sequences.

In addition, there is an abundance of motor position sensing hardware to enable simultaneous use of 4 motors in total at once. I designed with flexibility in mind because our team plans to experiment with the optimal way of controlling motor position. We plan on maintaining equivalent pressures in our liquid oxygen and nitrogen tanks by monitoring the current pressure in each of the tanks using the pressure transducers, and then controlling a variable orifice valve and shut off valve between the two tanks. The variable orifice size allows us to gradually increase or decrease the rate at which the tank pressures will be balanced. The size of this orifice will be actively controlled by two motors. On these motors, both the motor position and valve position will be monitored using position sensing hardware, like hall effect sensors and potentiometers. In addition, the shut off valve is a safe state for preflight tank pressurization. In combination with a PID control loop, which we are currently developing, we hope to actively monitor and balance the tank pressures exclusively using this technique.



Color Coded Schematic Diagrams for 37 Pin Circular Connector Interfaces

There are also two RS-422 communication chips, one to be used for communication directly with the flight computer, and one to be used for communications with other boards on the rocket. This becomes extremely important during hot fires because it allows us to monitor the rocket state for anomalies and abort the launch if necessary. Another security feature is the ability to write telemetry directly to non-volatile flash memory and a micro-sd card. This creates a small level of data redundancy on the board in case components malfunction during testing. Finally, the last notable feature of the schematic is the pinout organization diagraming I created for the 37 pin connectors we used. The connectors pinouts feature legends explaining pin functionality, color codings for various peripherals, and are organized in a method that reduces PCB trace crossover. Various pinout diagrams can be seen above.