Project Portfolio | Nathaniel Kalantar

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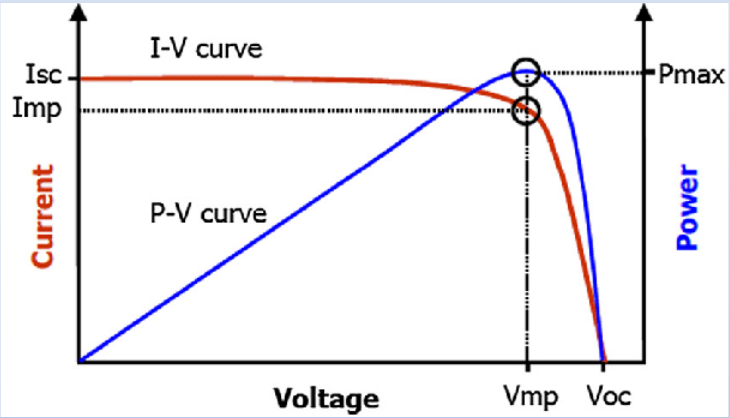
Vast – Avionics Power Systems

I worked on the power team at Vast in Summer 2024. I programmed and tested the solar maximum power point tracker (MPPT) for the company's first Haven-Demo mission, a 1.2 kW DC-DC converter that controls the solar panel operating point, spacecraft bus voltage, and battery charge current. The purpose of this testing was to validate the MPPT's control algorithm and develop a test procedure that could be used to measure energy margin over an orbit.

I developed a software model to predict the MPPT's operating point given the solar panel profile, spacecraft load profile, and controller outputs. This model predicted edge cases and unstable operating points for the MPPT control algorithm being considered, and matched the MPPT's actual waveforms in testing.

Above: A render of Vast's Haven-1 space station docking with a Crew Dragon vehicle in orbit



Left: Solar panel I-V and P-V curve (source: researchgate)

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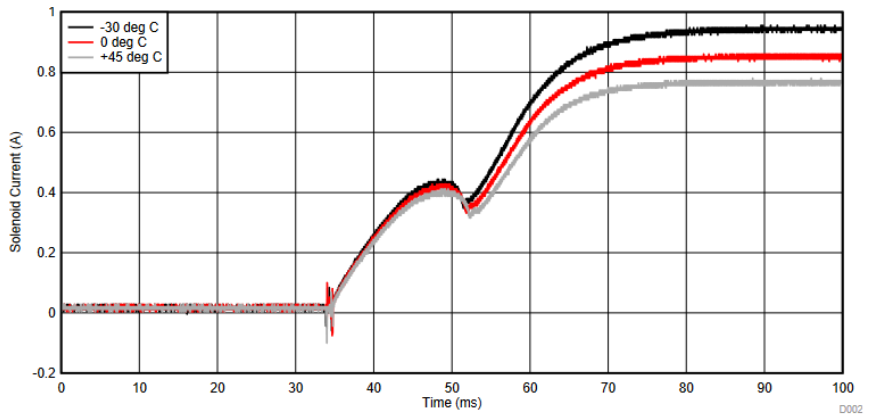
Impulse Space – Embedded Software

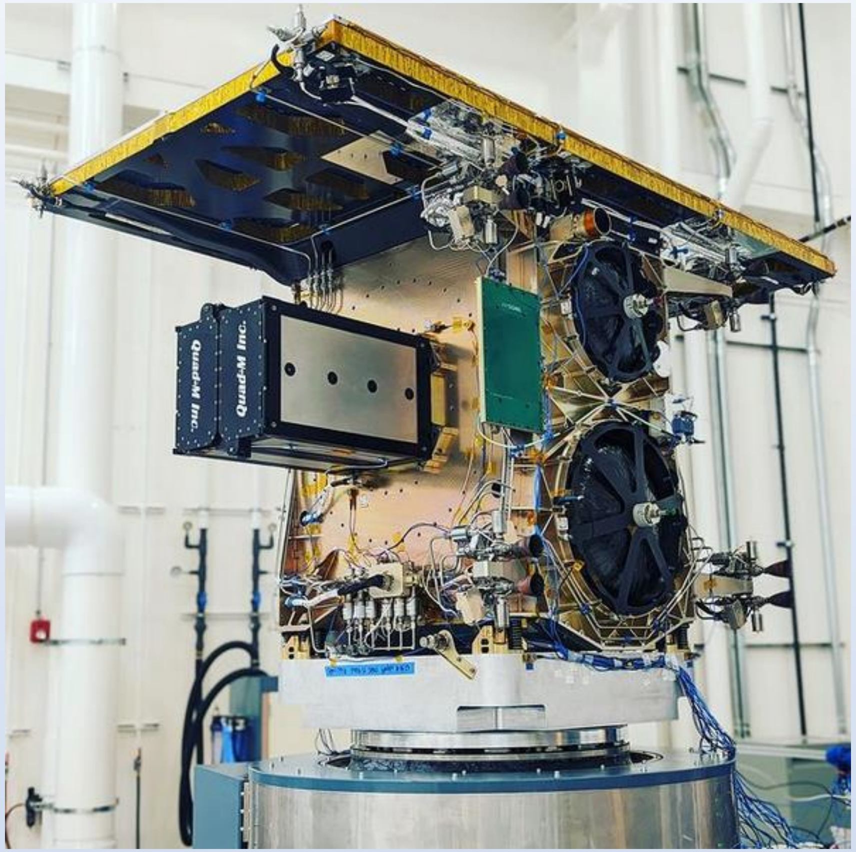
I was an embedded software intern at Impulse Space in Summer 2023, developing flight software for the company's first mission, Mira-1. Impulse Space develops orbital transfer vehicles (OTVs) and space propulsion systems.

I wrote the serial communications interface for the flight computer that receives serial data packets from the engine controller at 200 Hz. The flight computer code was written in C++ for embedded Linux.

In order to improve the vehicle's fault detection, I implemented real-time detection of short-circuit trip, open circuit, and poppet pullin in the valve control code. I also implemented the vehicle's RTD and TC calibrations, with a Python script that generated lookup tables in C++ using the NIST and ITS-90 standard calibration equations combined with the vehicle's onboard amplifier circuits. The engine controller code was written in C++ for an ARM based microcontroller.



Left: Example of solenoid valve current turn-on profile. Poppet pullin is detected by the drop in current caused by the solenoid core's motion (source: TI)



Above: Impulse's Mira vehicle, on the vibe table ahead of the company's first demonstration mission to LEO

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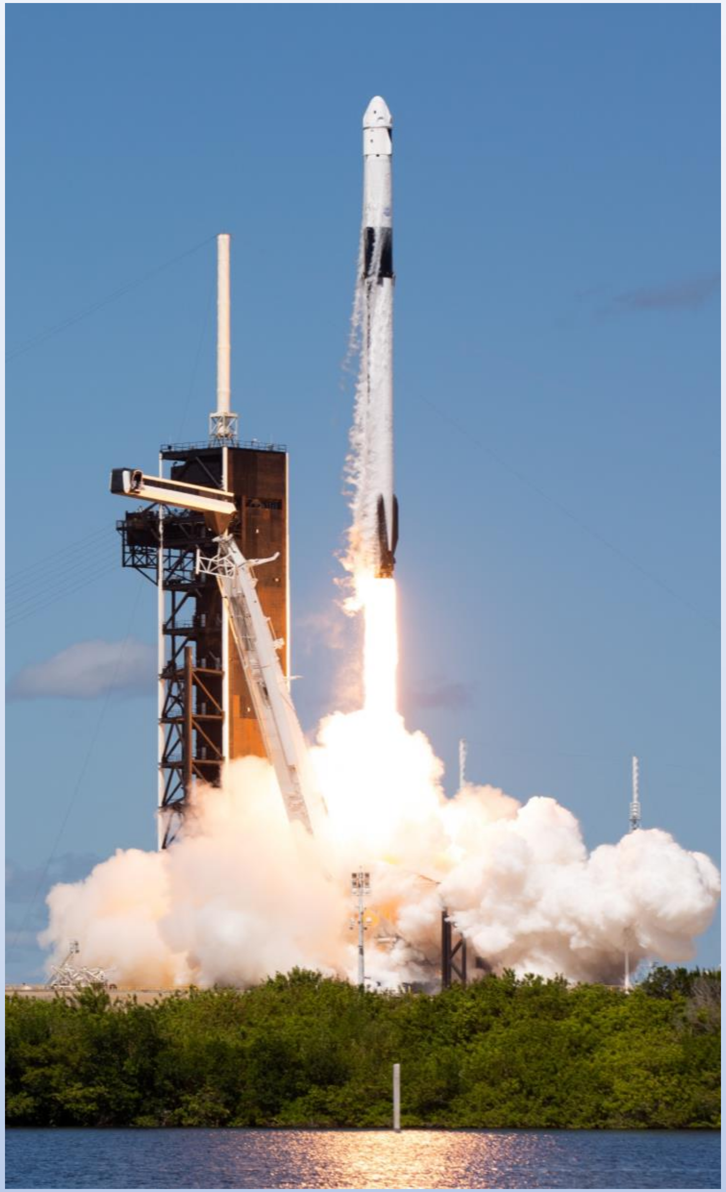
SpaceX – Cape Canaveral Launch Pad Engineering

During Fall 2022, I was an intern on the SpaceX Launch Pad Engineering team at Cape Canaveral. This team owns the launch pad hardware on LC-39A and SLC-40, and works closely with launch operations to refurbish and reset the pad between launches.

I reworked the Falcon 9 umbilical cable routing inside the launch mount, and split the cable run into two sections to reduce the number of technician hours required to replace burned cable sections. This included writing build instructions, refurbishment instructions, and wiring documentation for the new cables, as well as finding a mounting solution for the new cable interface.

Additionally, the pad technicians used a “checkout box” to verify pad functionality which contained an NI DAQ and a LabVIEW build that simulated the Falcon umbilical interface. There were previously 2 separate versions of the code to handle Falcon 9 and Falcon Heavy interfaces, and I updated the code and the box interface to allow technicians to run it in F9 Stage 1, F9 Stage 2, and both FH booster modes on a single firmware build.

I also debugged faulty launch pad hardware and data acquisition system anomalies to support refurbishment between launches, including blown PTC fuses, faulty load cell test devices, load pins inspections, and solenoid valve inspections.



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Ursa Major – Avionics Hardware

I was an avionics intern at Ursa Major in Summer 2022, where I developed a printed circuit board for a hardware in the loop test system. This PCB simulated open and short circuit faults in motor harnessing, and allowed for the automation of engine controller acceptance testing.

The PCB was 10 layers and included support for 4 BLDC motors, 8 limit switches, 12 Hall effect sensors, and 4 resolvers. Each channel contained relays to introduce open and short circuits, and an interface to panel-mounted LEDs to indicate which device was being tested at any given time.

The BLDC channels had to support 15A of continuous current, which was achieved with high-power relays and appropriately sized polygon widths.

Above: Ursa Major's Hadley engine, a 5000 lbf LOx/RP-1 liquid rocket engine

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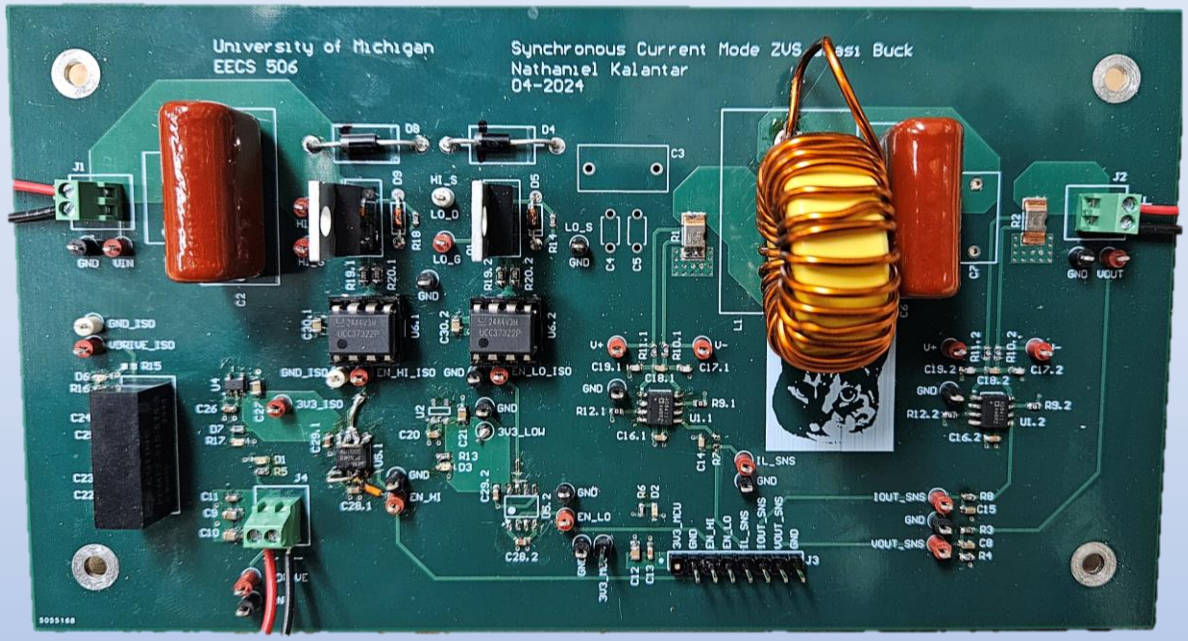
Power Electronics Course Project – Buck Converter Solar Panel Emulator

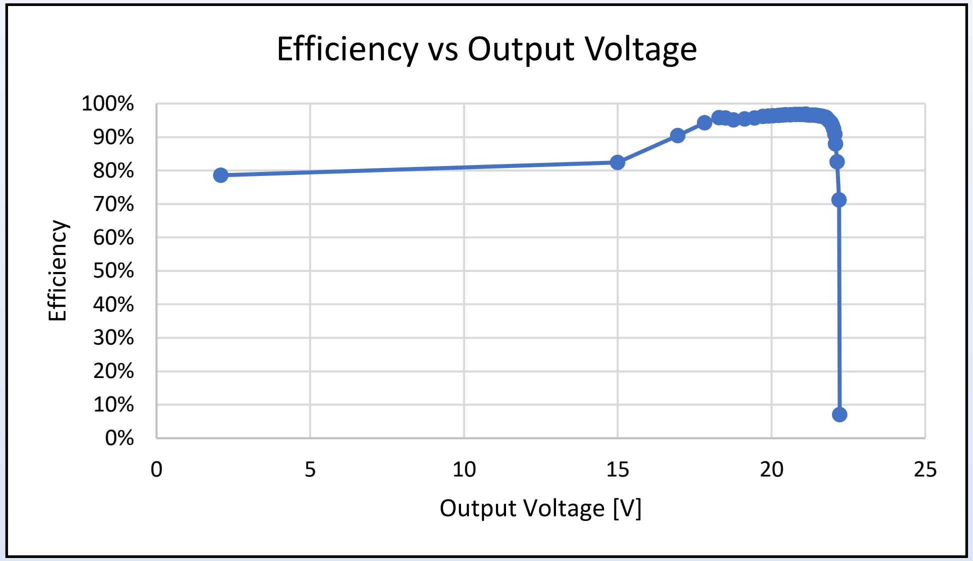
For my power electronics course in Winter 2024, I designed, built, and tested a solar panel emulator with a synchronous buck converter. The solar emulation and closed loop control was implemented digitally on a TI C2000 microcontroller, and peak efficiency was measured at 96.8%.

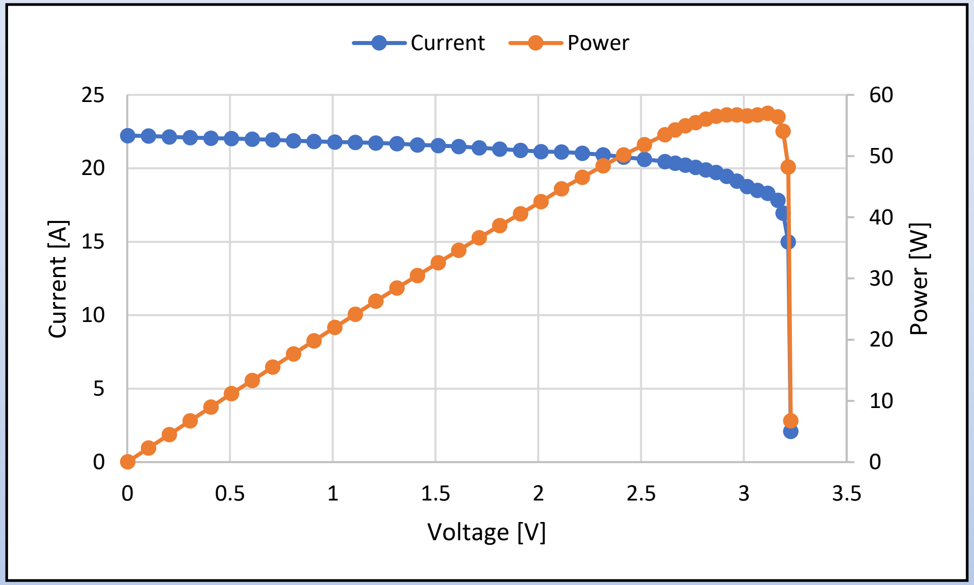
Top right: Efficiency plot

Bottom right: Output current and power plots

Below: Converter PCB







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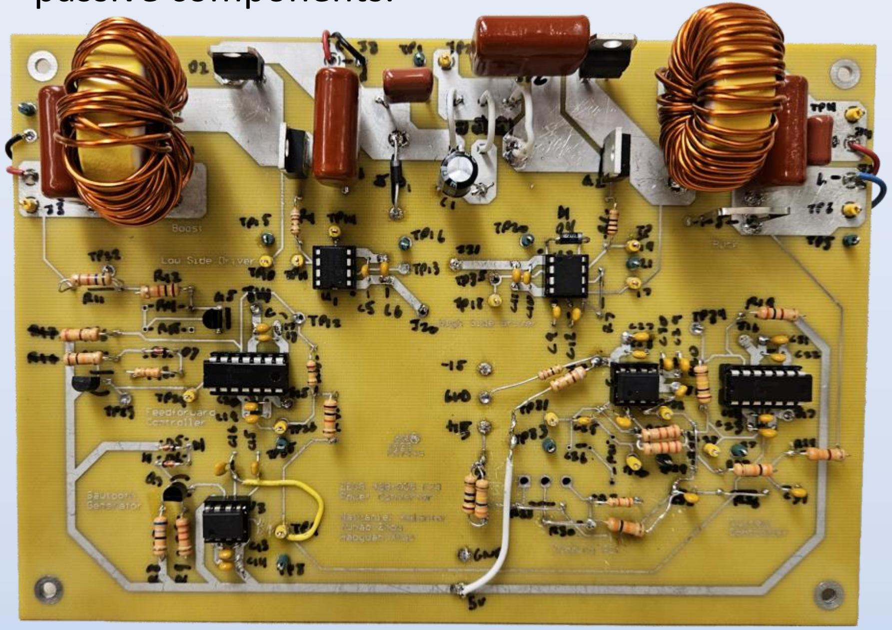
Power Electronics Course Project – Two-Stage Switching Converter for Constant Current LED Drive

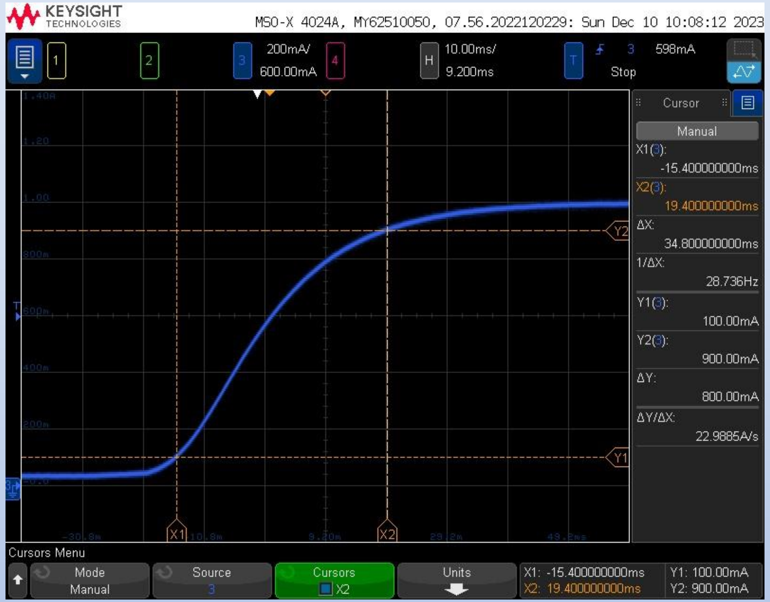
The final project for my power electronics course in Fall 2023 was to build a two-stage switching converter PCB. The first stage is a boost converter with an open loop feedforward controller, and the second stage is a closed loop current controlled buck converter. The converter was built with entirely with 555 timers, gate drivers, op-amps, transistors, and passive components.

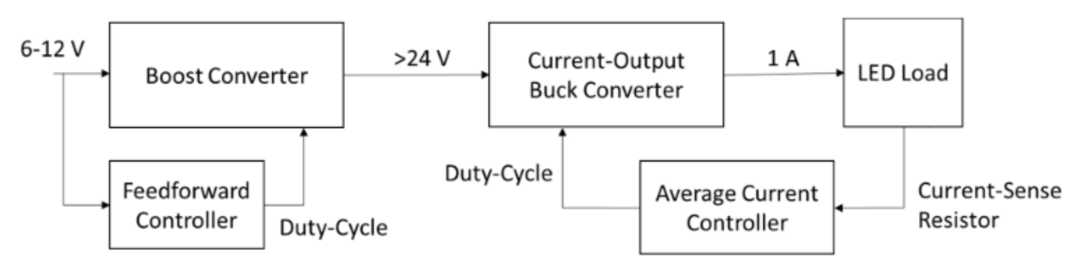


Left: Switching converter PCB

Right: Steady-state and step response waveforms

Below: Converter block diagram





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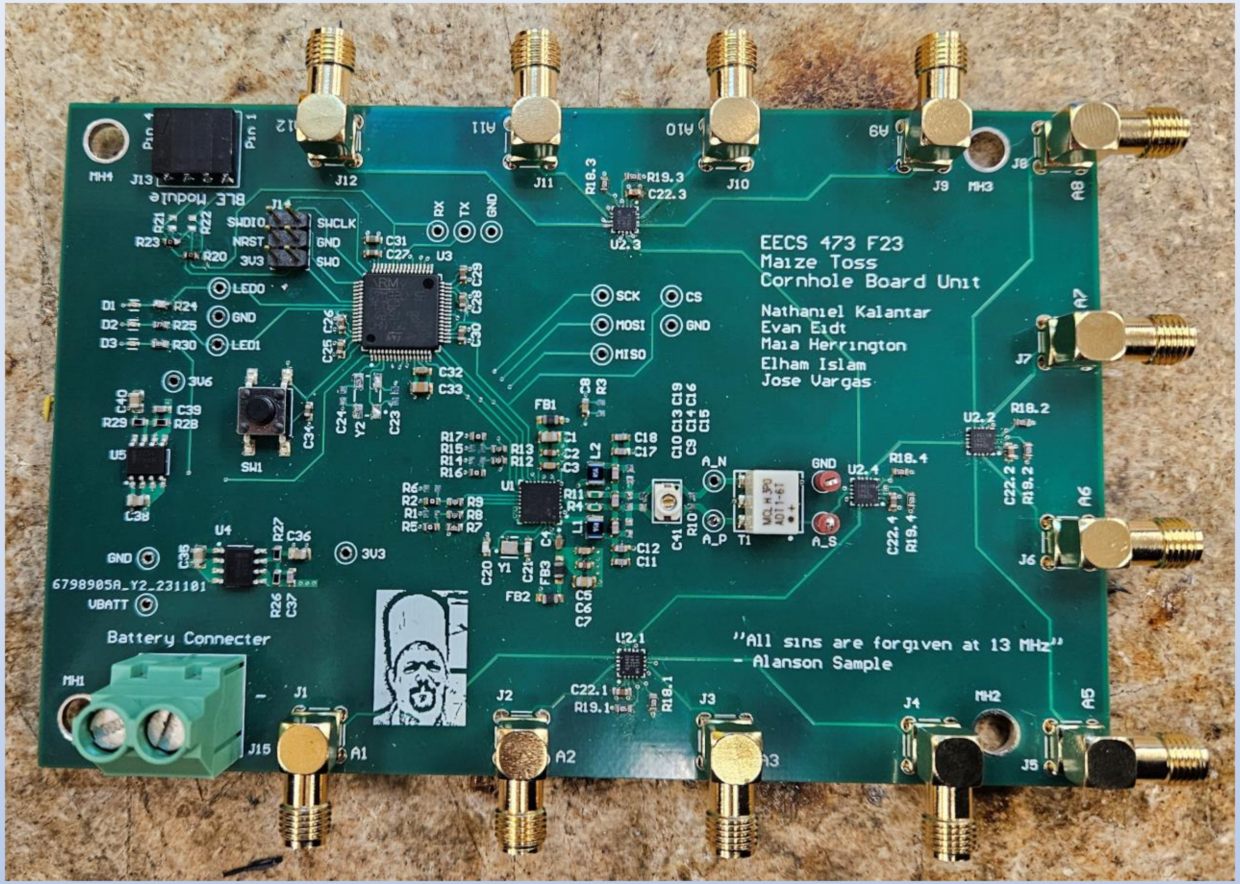
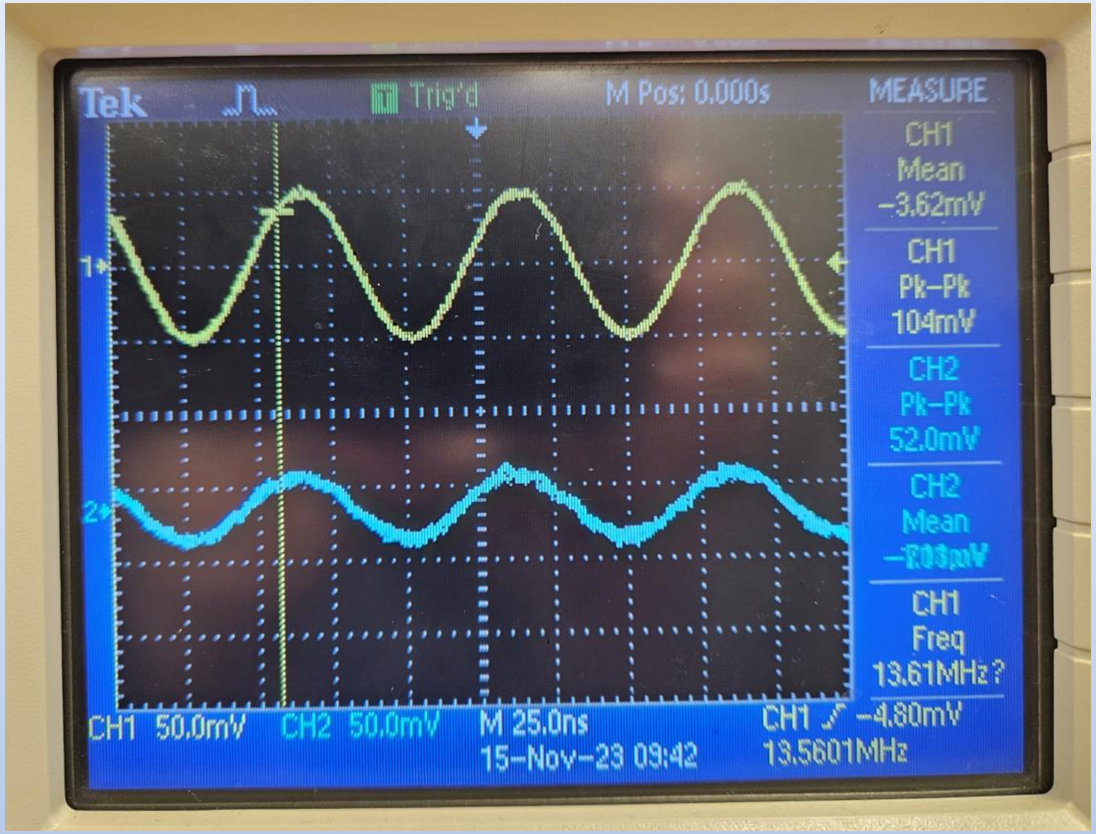
Embedded Systems Course Project – RFID Cornhole Scoring Automation

My senior design project in Fall 2023 was an automated cornhole scoring system utilizing RFID. I designed, assembled, and tested a mixed-signal PCB for interfacing a microcontroller to a set of 12 multiplexed antennas. An RFID reader IC was connected to a network of RF switches, and controlled by the microcontroller to select an antenna for transmitting and receiving.

Below: RFID reader PCB



Below: Scope waveform before and after passing through mux and matching circuit



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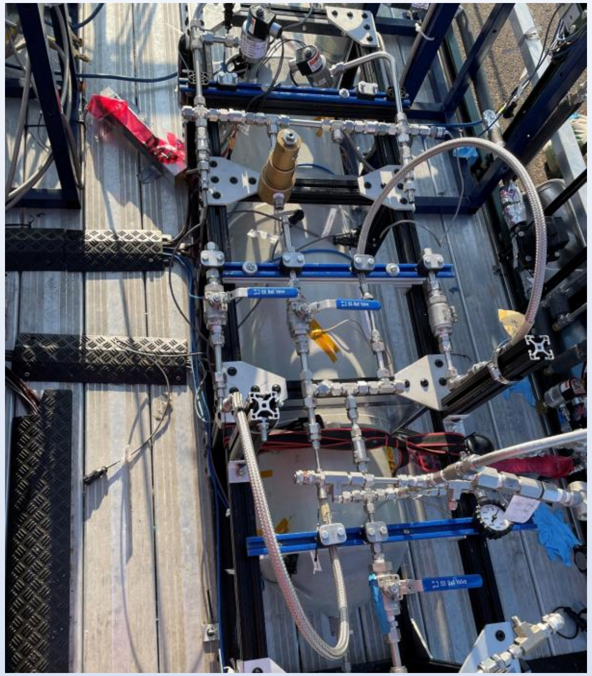
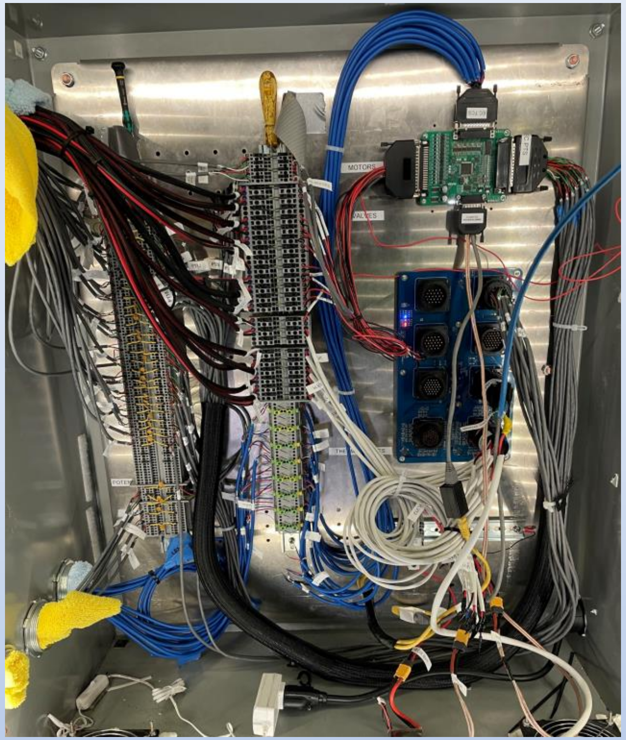
Michigan Aeronautical Science Association (MASA) – Instrumentation and Test Operations

In Spring 2022, I was Avionics Lead and Avionics Test Operator for MASA's coldflow campaign. I led the development of the instrumentation and controls systems used on our engine test stand, and operated the mission control console during tests. Our test stand included 17 solenoid valves, 23 pressure transducers, 9 thermocouples, 2 stepper motors, 2 potentiometers, and 3 load cells. The mission control GUI mimicked the physical system's layout, and commands and telemetry were processed in a Python backend.



Above: Nitrogen gas section of the engine test stand

Right: Initial revision of DAQ box layout



Left: Mission control operator interface

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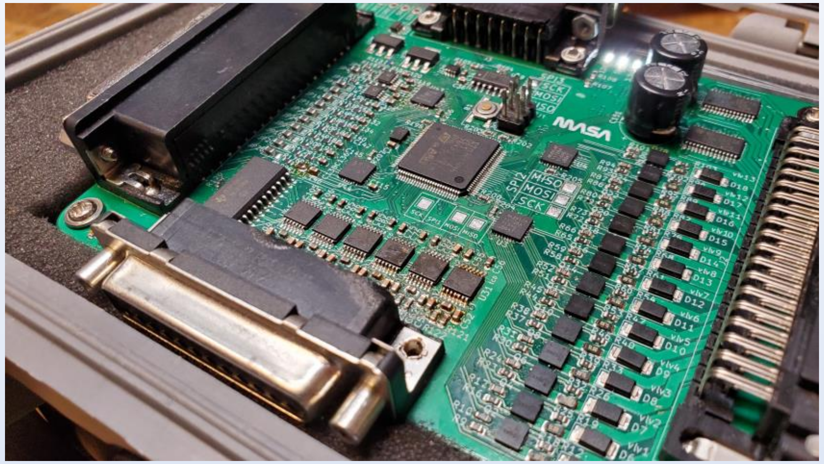
Michigan Aeronautical Science Association (MASA) – Avionics Hardware

During my time on MASA Avionics, I worked on a variety of hardware projects.

Right: Engine controller PCB. I assisted in its assembly, verification, and integration



Below/Right: System block diagram for a custom DAQ

Below: ESD protection circuit for an analog input card. The filter and input protection circuits were designed to allow no more than 100nA of leakage current, and protect against overvoltage events.