UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

# ECE 445 - Solar Car MPPT
# Team #25

Prepared by

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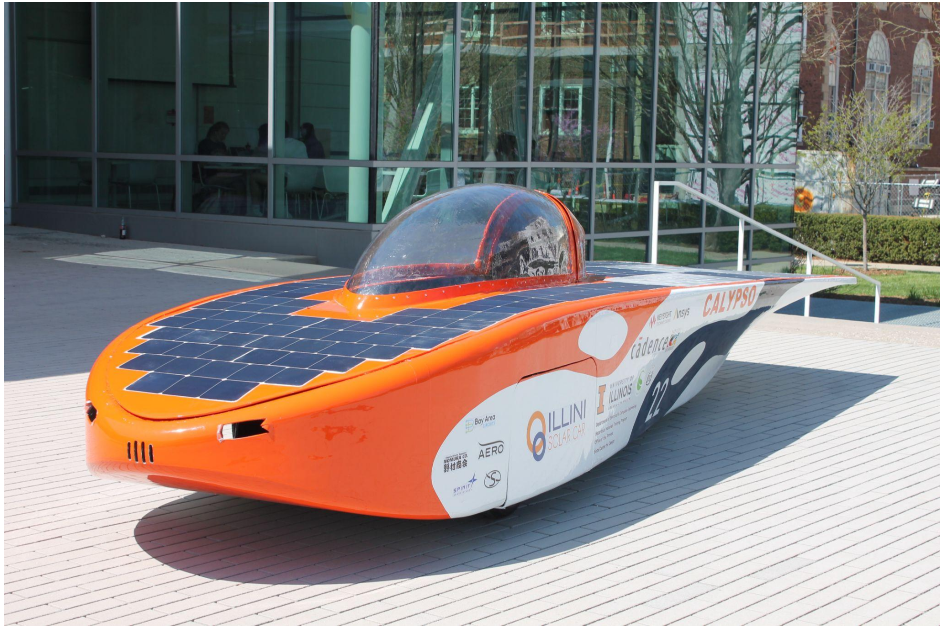
# Maximum Power Point Trackers (MPPT)

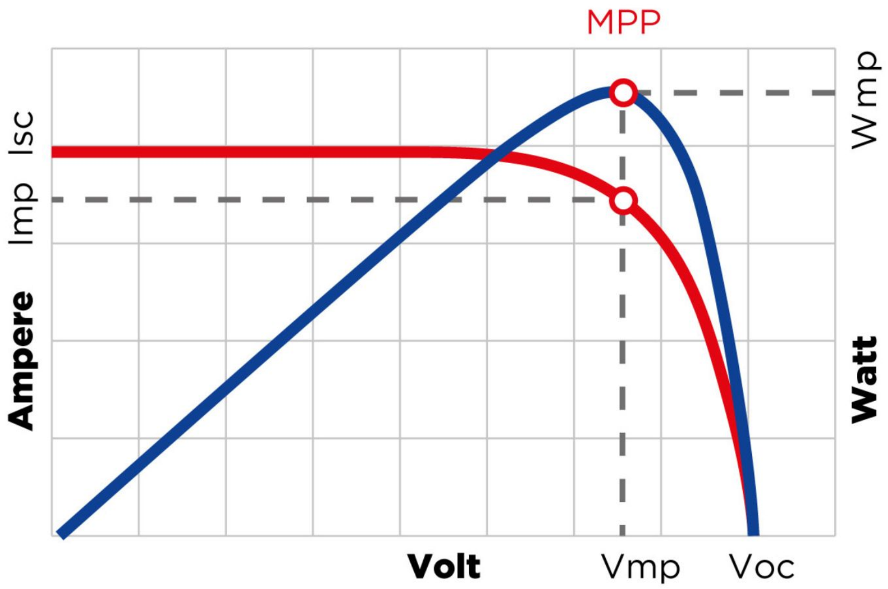
➢ **Objective:**
  ○ Create custom, simple, and low cost boost MPPTs

  ○ Designed for Illini Solar Car's 3rd generation vehicle



# What are MPPTs

- MPPT stands for Maximum Power Point Tracker
- Solar cells have a nonlinear IV curve, which has a point where the power output will be maximized.
  - The role of the MPPT is to ensure that the array will always be outputting at the MPP
- Our MPPTs also act as a boost converter to charge the battery



# Popular MPPTs

- **Objective:**
  - Off-the-shelf MPPTs are expensive and take time to integrate into the electrical system
  - If a part fails, we don't have access to the schematics to replace components

- **Best MPPTs on Market**
  - Cost ~$1500 for 1 module
    - (we have 3 subarrays)

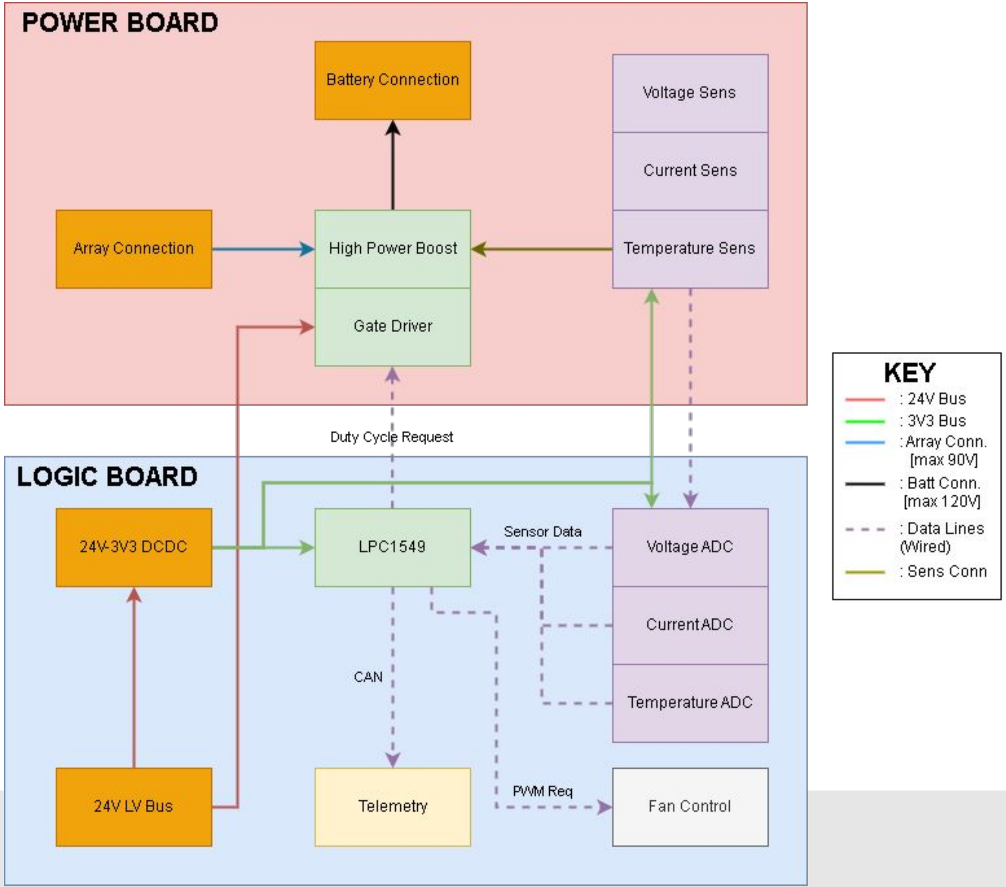
# High Level Requirements

High Voltage

Size

Telemetry

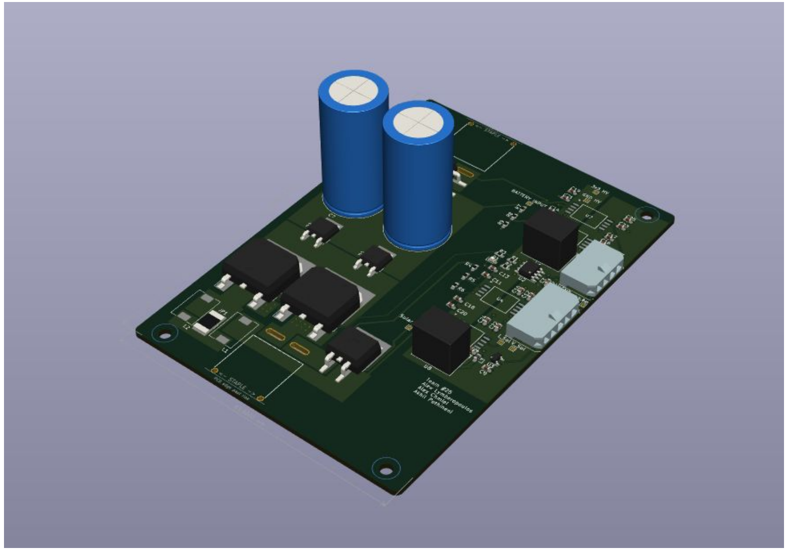
# High Level Overview



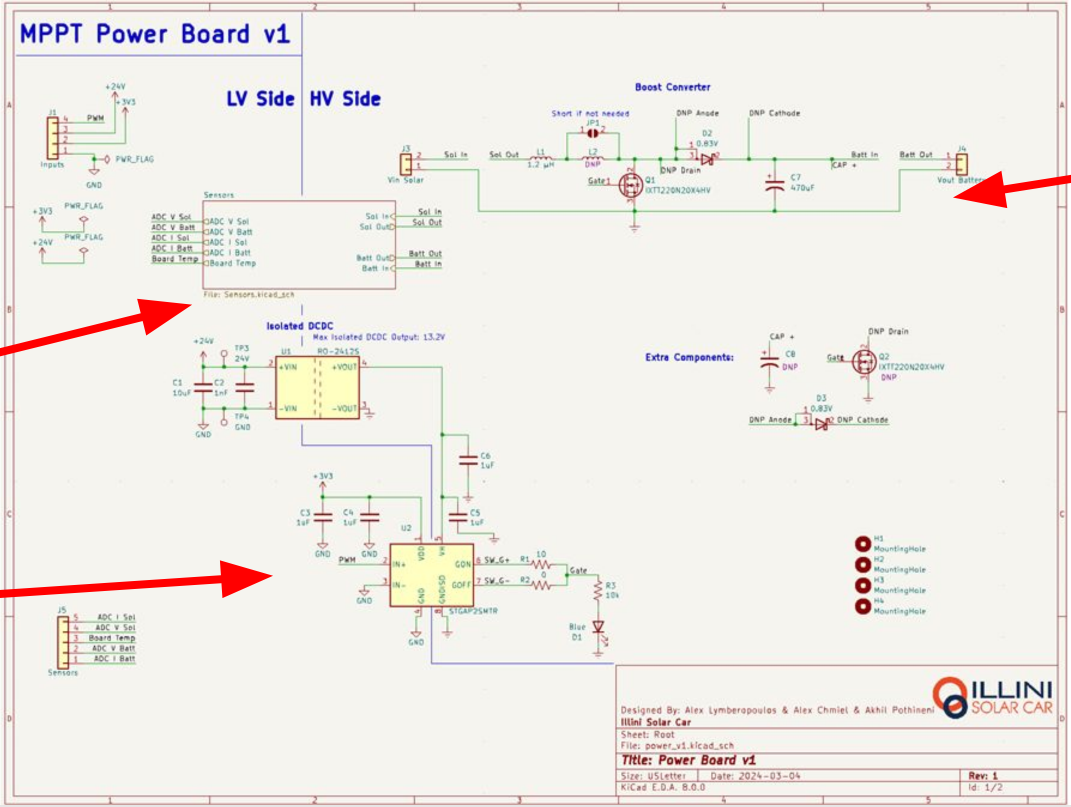
# Initial Design: Power Board

➢ **Main Function:**
  - Boost converter to control charging of battery module

➢ **Auxiliary Functions:**
  - Sense voltage, current, and temperature
  - Shut off overcurrent protection



# Initial Design: Power Board in Depth



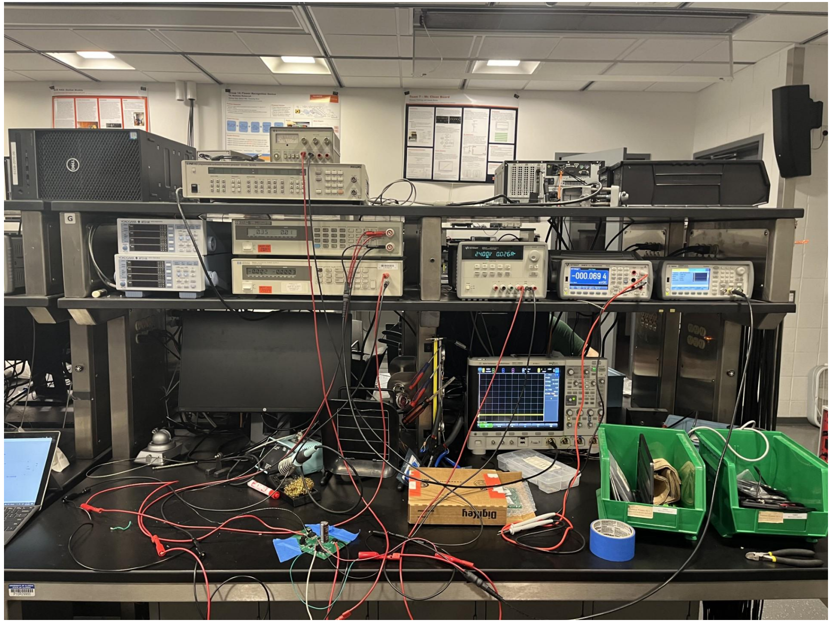

Boost Converter

Sensing

Gate Driver

# Power Board: R & V

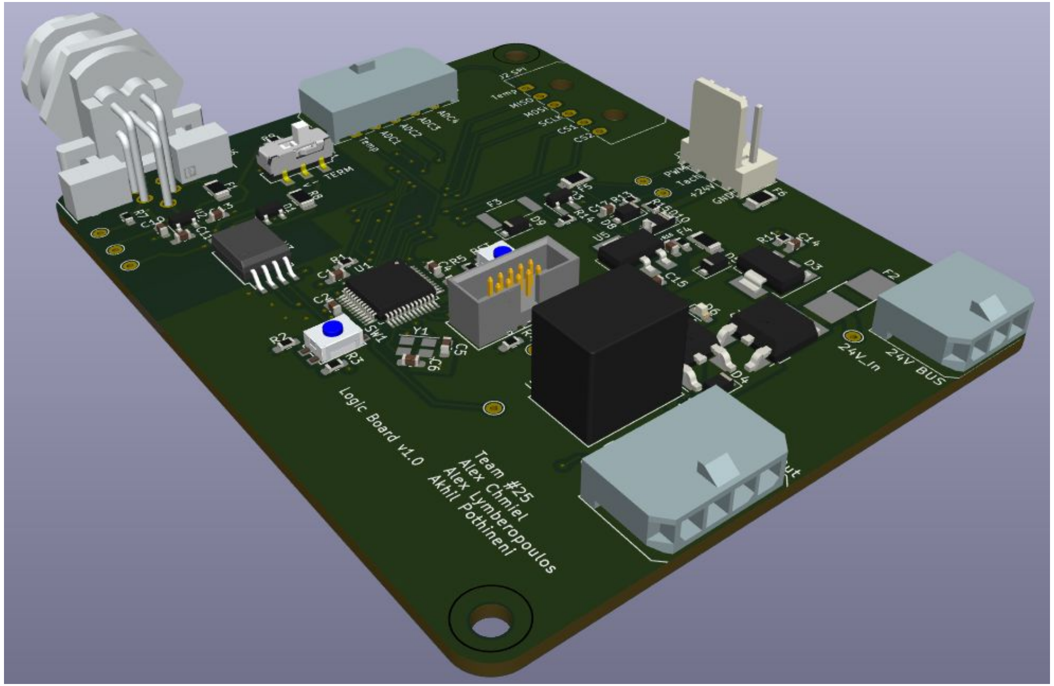
| Requirement | Verification |
| --- | --- |
| The boost converter handles inputs up to 90V at 400W, and is able to boost the voltage to an output range of 77-125V | We will make sure to test the converter at maximum and minimum inputs, and verify that the output is boosted correctly when tested with a load. |
| The duty cycle input adjusts output voltage of the boost converter. | We will test the MCU control loop with inputs from the sensors. We will test the PWM duty cycle output and make sure it is logical for the desired output |



# Initial Design: Logic Board

- **Main Function:**
  - Contains the MCU that performs all the measurement and tracking functions

- **Auxiliary Functions:**
  - Power and Control Fan
  - Provide protected low voltage power to power board
  - Communicate via CAN with the rest of the car

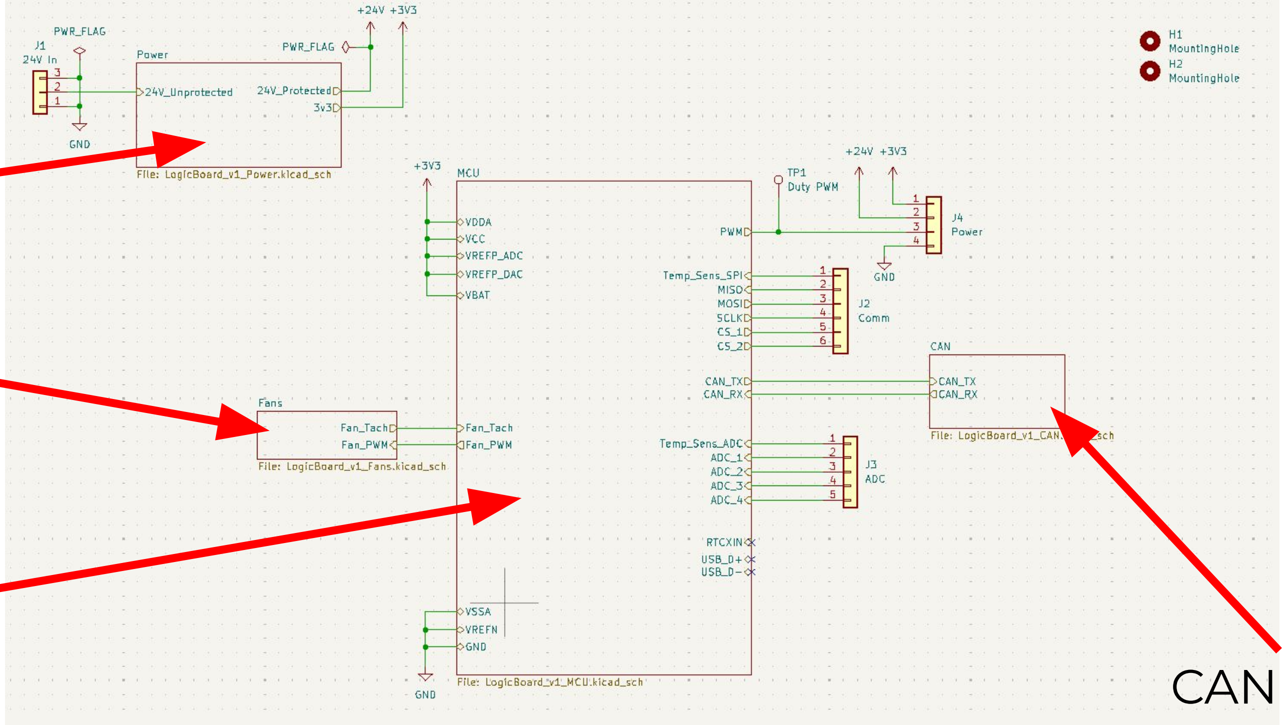


# Initial Design: Logic Board in Depth

Power Protection

Fan

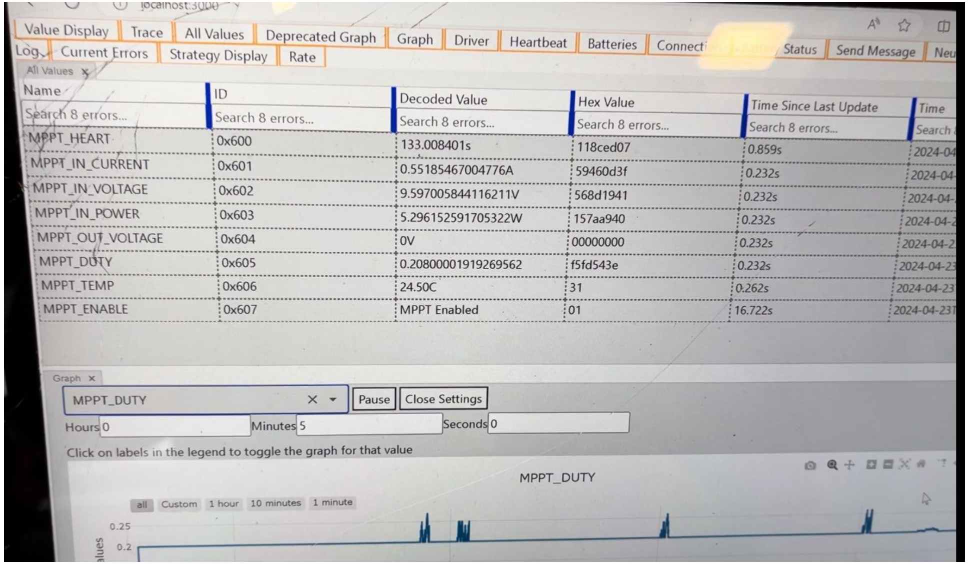
MCU Circuit




CAN Subcircuit

# Logic Board R & V

| Requirements | Verification |
|---|---|
| MCU receives temperature data and is within Actual Temperature ± 10°C. | We will use an infrared digital thermometer to verify the actual temperature and compare with our sensor readout using CAN telemetry application. |
| MCU receives voltage data from solar array and boost output. The reading is within Actual Voltage ± 10%. | We will use a multimeter to verify the actual voltage and compare with our sensor readout using CAN telemetry application. |
| MCU receives current data from solar array and boost output. The reading is within Actual Current ± 10%. | We will use a current sense probe to verify the actual current and compare with our sensor readout using CAN telemetry application. |



# Logic Board R & V Continued

| **Requirements** | Verification |
| --- | --- |
| MCU sends PWM gate signal requests to the power board. | Scope the PWM gate signal output to verify its voltage range(0V-3V3) and frequency(200kHz). |
| MCU sends a fan request rpm message and spins the fan. | The fan spins and a noticeable RPM change will be felt. Also scoping the PWM input to the fan can verify the speed request. |
| Can send and receive CAN data at 500kHz | Using the brain battery management system we are able to receive CAN information. By scoping the CANH and CANL signal, we view the frequency of data. Using the telemetry application made by Illini Solar Car we can verify the message integrity. |
| The bus voltage(24V) is stepped down to 3V3 ± 5% | We will use a multimeter to verify the actual voltage from a test point on the board and compare with 3V3 ± 5%. |

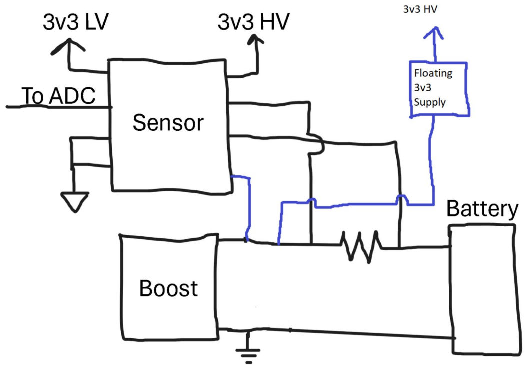
# Initial Design: Enclosure

- **Main Function:**
  - Secure, isolate and provide cooling for the boards
  - Separate enclosures for logic and power boards
  - Power board enclosure must have mounting for a fan

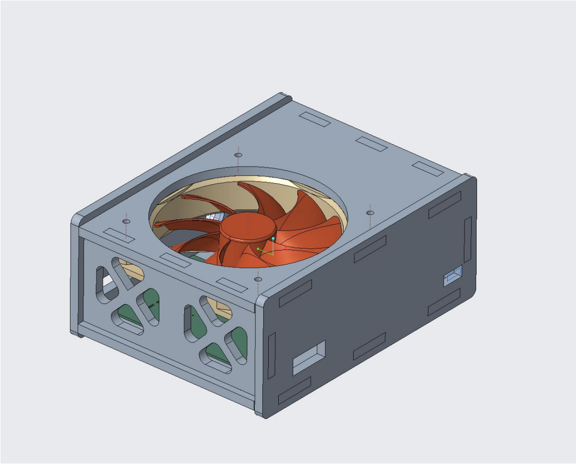
- **Designed for 3D-Printing**

# What Changed

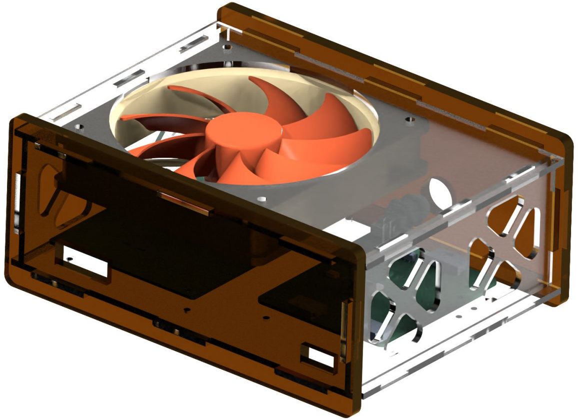
- **Power Board:**
  - Current Sense circuit
    - Added additional floating DCDC for amplifier power




- **Enclosure**
  - Didn't get access to 3D-Printers
  - Redesigned for laser cut

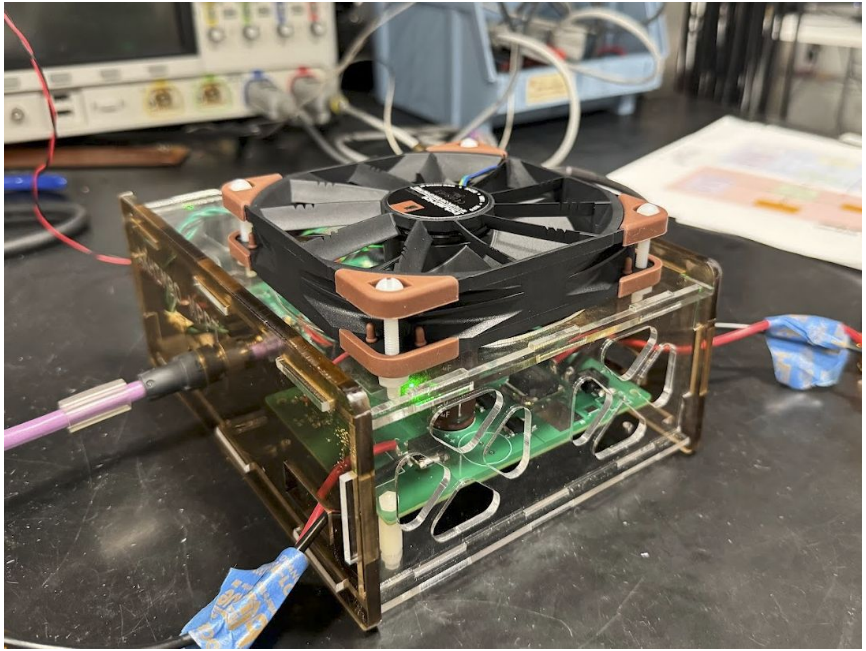


# Project Build and Functional Tests

# Successes and Challenges

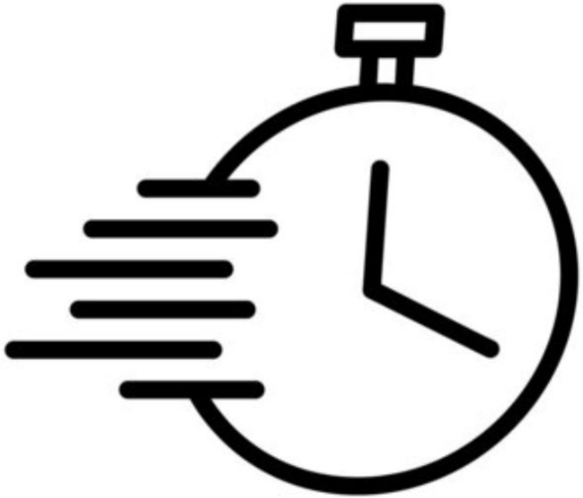
- ➢ **Boost converter itself worked first revision**
- ➢ **Every function of the logic board worked as intended**
- ➢ **Main issue faced was with sensing on power board**
  - Multiple isolated amplifiers were damaged
  - Current sense amplifier circuit needed redesigned
  - Gate driver was damaged once
- ➢ **CAN connection was intermittent during demonstration**



# Conclusion

- **What did we learn?**
  - How to design a boost converter from scratch
  - Details on how MPPTs work
  - Good Sensing Practices
  - The importance of shielding wires
  - How to deal with noisy data

- **If we had time…**
  - Redesign power board
  - Test with High Voltage
  - Test with actual solar array and battery



# Recommendations for Future Work

- ➢ **Test on high voltage**
  - ○ Use a real battery load
- ➢ **Better tracking algorithm**
  - ○ Improve sensing to get better data
  - ○ Use an actual PI controller
- ➢ **Implement all three power boards**

# Any Questions?