

### Team 13: Sun Tracking Umbrella

Electrical & Computer Engineering

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### Introduction

**ELECTRICAL & COMPUTER ENGINEERING** 

**GRAINGER ENGINEERING** 





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#### **Project Overview**



#### What is Our Project?

This umbrella autonomously adjusts such that the user is provided a maximum area of shade.

This is achieved by tracking the sun via photodiodes and adjusting the twist and yaw off of the z axis to account for varying intensities across the photodiode array.

#### What problem does it solve?

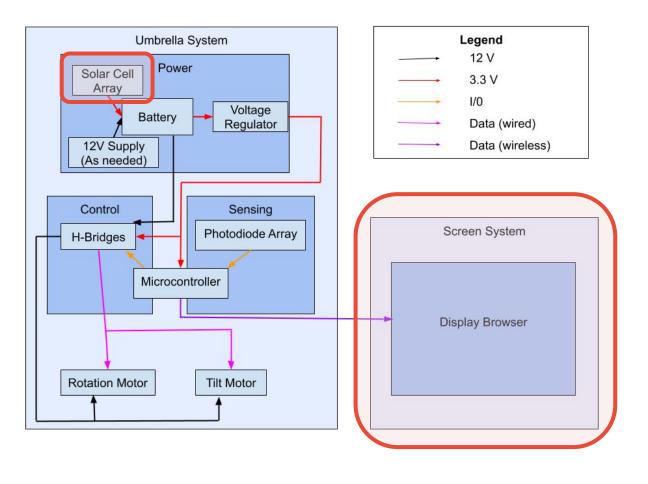
- Difficult to maneuver patio umbrellas
- The area of shade provided by an umbrella being offset



#### Original Design



#### **Block Diagram (Original)**



#### **Highlighted Changes**

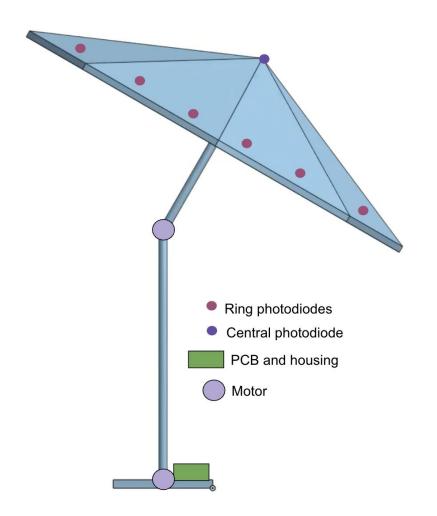
Rather than including the solar cell array, a 9V,
 0.25AH battery was utilized to power the system

 Allowing for the user to manually override the motor functionality shouldn't be required, should the photodiodes be able to accurately assess the position of the sun

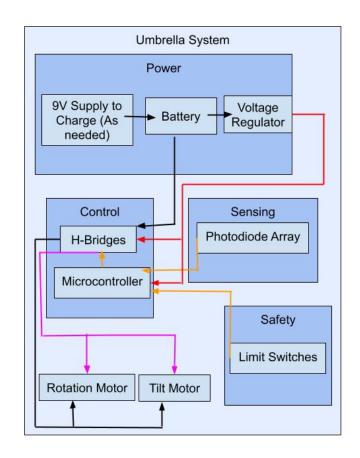
#### Final Design

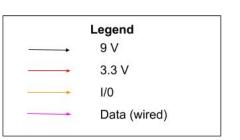


#### **Visual Aid**



#### **Block Diagram**







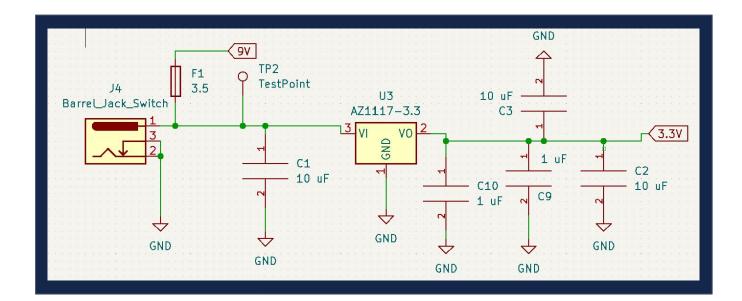
# Power Subsystem

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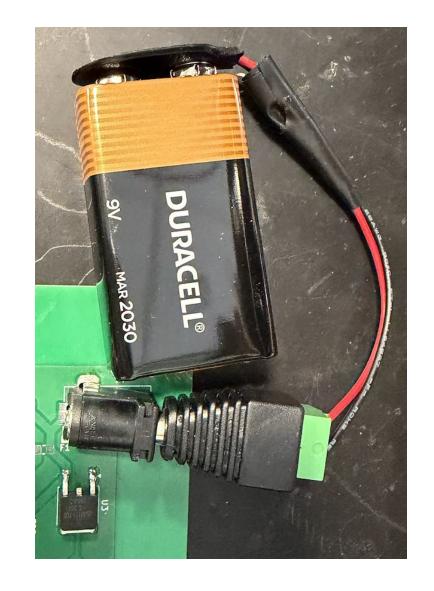
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#### Overview





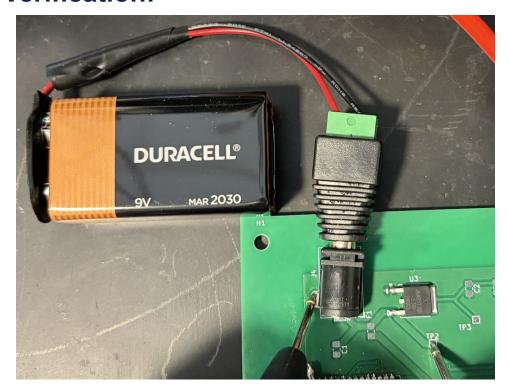
The power subsystem needs to deliver power to all other subsystems at the specified voltage levels. It is supplied by a 9V battery, and passes 3.3V to most subsystems through a voltage regulator.





**Requirement:** The battery must be able to provide 9V +/- 1V and 3A +/- 0.25A to the barrel jack of the printed circuit board.

#### **Verification:**

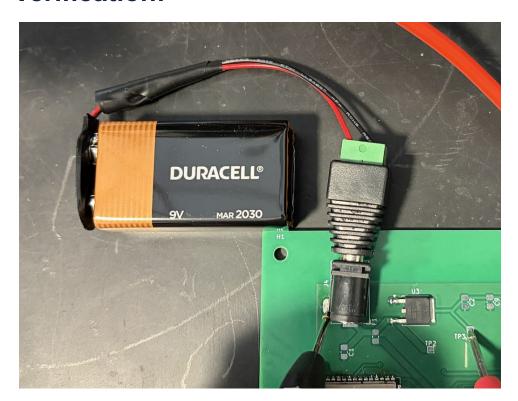






**Requirement:** The voltage regulator must provide 3.3V +/- 0.2V and at least 500mA of current.

#### **Verification:**

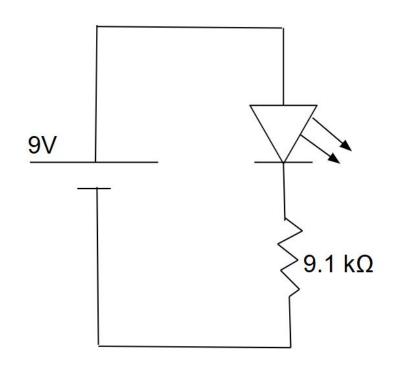






### **Requirement:** The battery must be able to provide an average of 9V +/- 1V for a minimum of 1 hour.

#### **Verification:**



Time Elapsed	Battery Voltage (Vb)	Diode Voltage (Vd)	Calculated Current
0 minutes	9.522 V	1.862 V	0.8418 mA
10 minutes	9.591 V	1.863 V	0.8492 mA
20 minutes	9.593 V	1.863 V	0.8496 mA
30 minutes	9.593 V	1.862 V	0.8496 mA
40 minutes	9.587 V	1.862 V	0.8489 mA
50 minutes	9.583 V	1.861 V	0.8782 mA
60 minutes	9.577 V	1.861 V	0.8479 mA

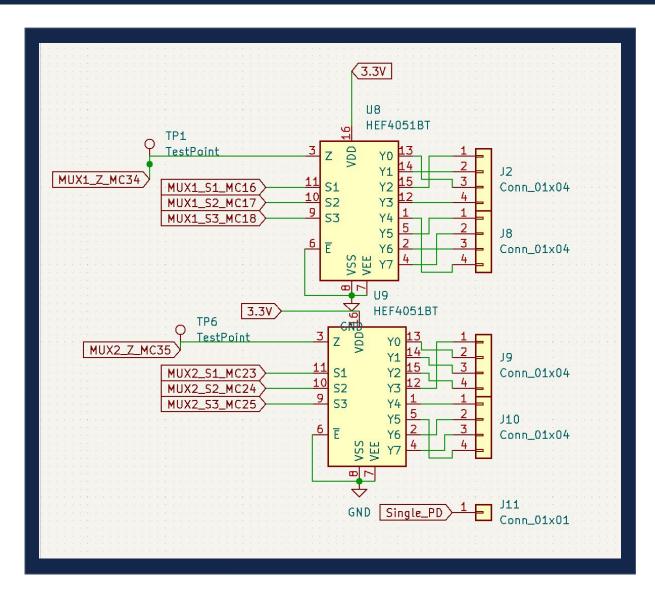


# Sensing Subsystem

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#### Overview





The sensing subsystem contains 8 photodiodes on the perimeter and a central photodiode. Sensitivity was the priority. Full set up pictured on the left and individual on the right.





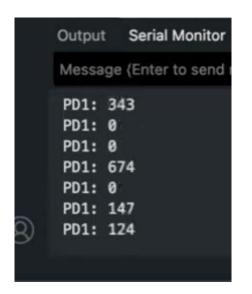


**Requirement:** PDs/system can determine whether "best case" scenario was reached.

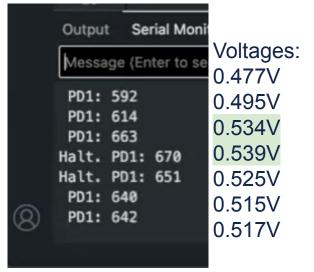
#### **Verification:**



Max Output: 674 ~ 0.54V



Polling center diode: when above threshold (+/- 0.01V of max) "Halt"



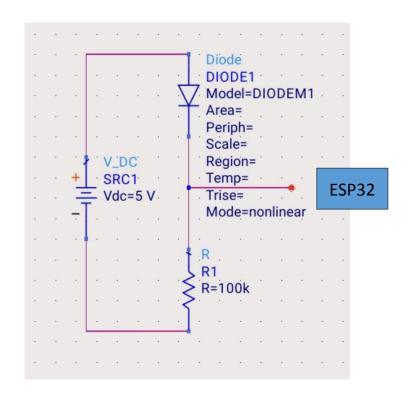


**Requirement:** PDs on opposite sides detect a difference of 0.2V with a difference in intensity of 30 lx.

#### **Verification:**

- Maximum current output from flashlight: 5µA
  - 0.1V difference when the photodiode outputs 1µA
- Could use the same 100kΩ resistor for all PDs
- Largest difference between two:

1 inch above		2 inches above		
PD1	PD2	PD1	PD2	
0.150V	0.144V	0.065V	0.066V	





Requirement: The system does not adjust more than three times in a row for the same photodiode pair.

#### **Verification:**

Comments on the video:

- 1. Zoomed in for clarity of movement
- 2. Increased to 2x speed
- 3. Needed to stabilize after tilt 3





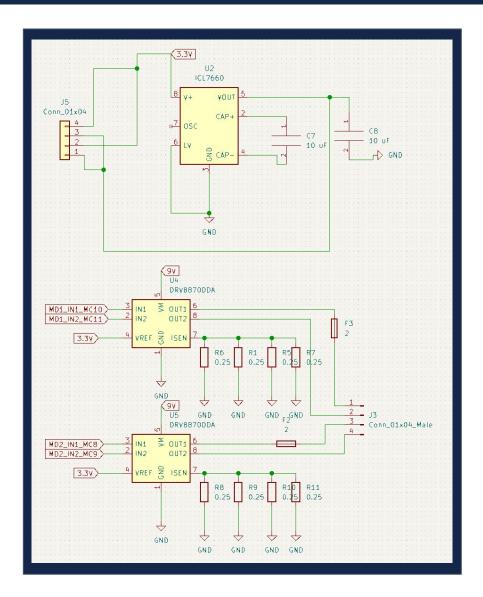
# Control Subsystem

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#### Overview





The control subsystem takes in data from the sensing and safety subsystems and uses this to control the motors as specified in the high level requirements.

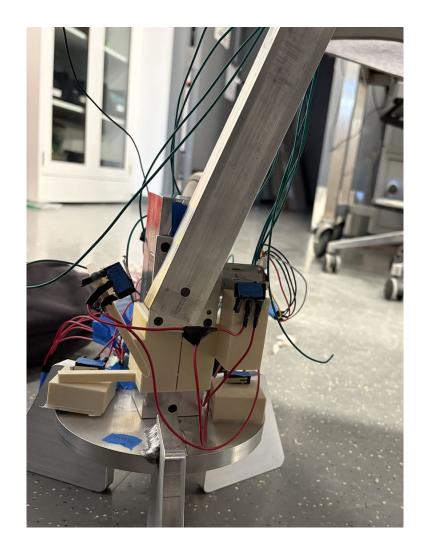


#### Overview





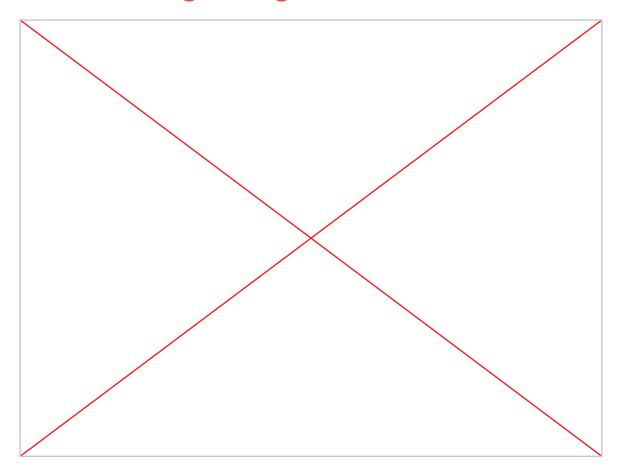






**Requirement:** H-Bridges are able to move motors in the forward and reverse directions based on signals given from the microcontroller.

**Verification:** 





#### Requirement: H-Bridges must be able to move motors in 10° increments.

#### **Verification:**

#### Maximum encoder position

```
Encoder position: -6553
```

```
\frac{6553 \mathrm{ticks}}{360 \mathrm{deg}} * 10 \mathrm{deg} = 182 \mathrm{ticks} \cong 200 \mathrm{ticks}
```

```
if(abs(delta_pos1) > 200){
    digitalWrite(Pin1, LOW);
    digitalWrite(Pin1_R, LOW);
    moving1 = false;
    delta_pos1 = 0;
    delay(50);
    return;
}
```



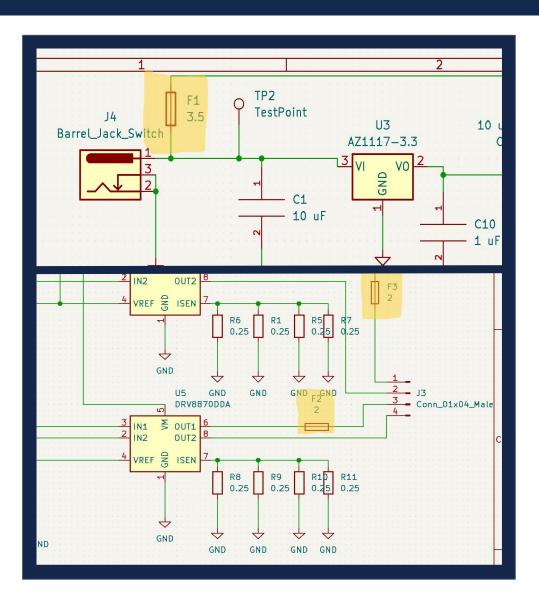
## Safety Subsystem

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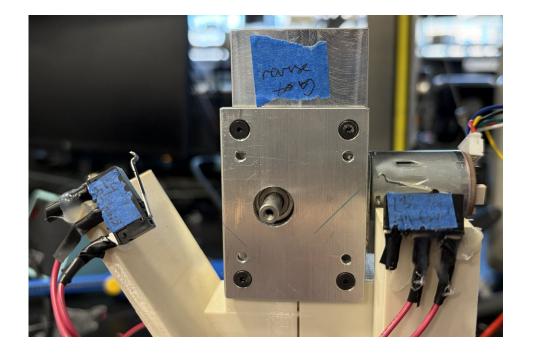
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#### Overview





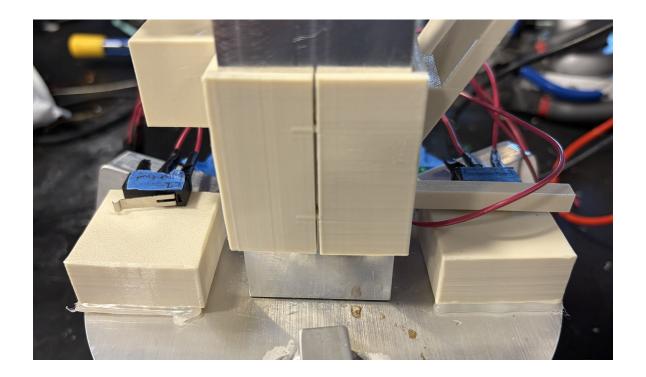
The safety subsystem includes fuses and limit switches. The limit switches will override any motor movement if pressed in order to ensure the motors do not move past the specified limits.





**Requirement:** Limit switches successfully halt all motor movement in the specified direction when the mechanism hits 180°/45° as described in the motor requirements.

#### **Verification:**

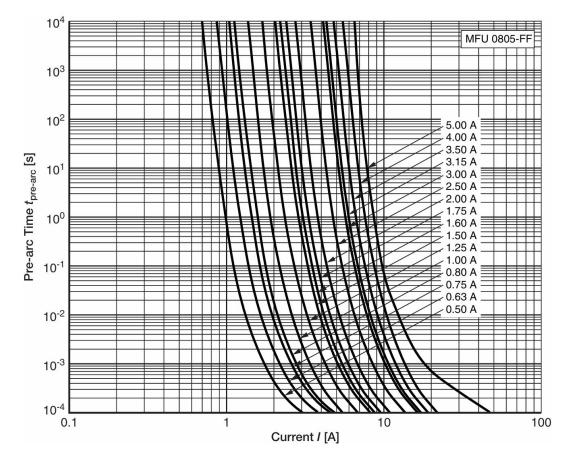




**Requirement:** Fuses successfully limit current going to motors at 1.5A as this is the maximum rating for the motors.

#### **Verification:**

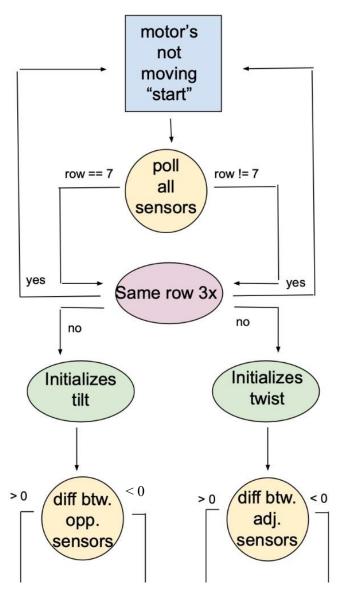
Fuses have not needed to be replaced thus we assume that the current has not exceeded 1.5A to each motor or 3A to the board.

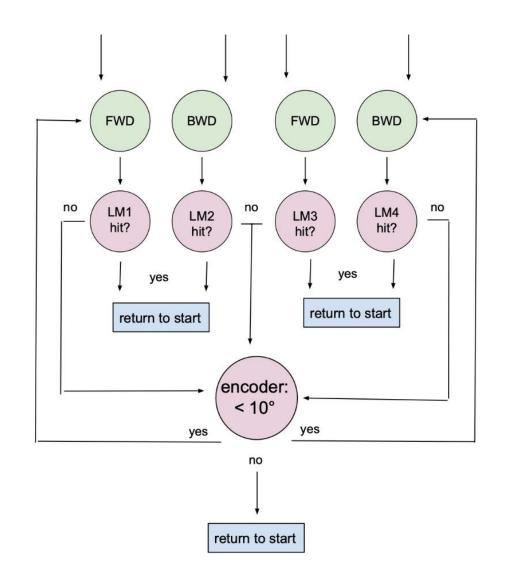




### Software









### Conclusion

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#### Results



#### Successes

- Power subsystem reliably outputs 9V where needed and 3.3V for the rest of the board
- Sensing subsystem able to take inputs from up to 17 photodiodes
- Motors start and stop when specified in the code with little to no delay
- Motors spin a set amount at any time
- When limit switches are hit, the corresponding motor will no longer attempt to spin in that direction

#### **Challenges**

#### PCB Design

- KiCad footprints
- Minor errors

#### Motor control

- Motors are jerky
- Motors are unable to lift umbrella once it tilts too far

#### Sensing

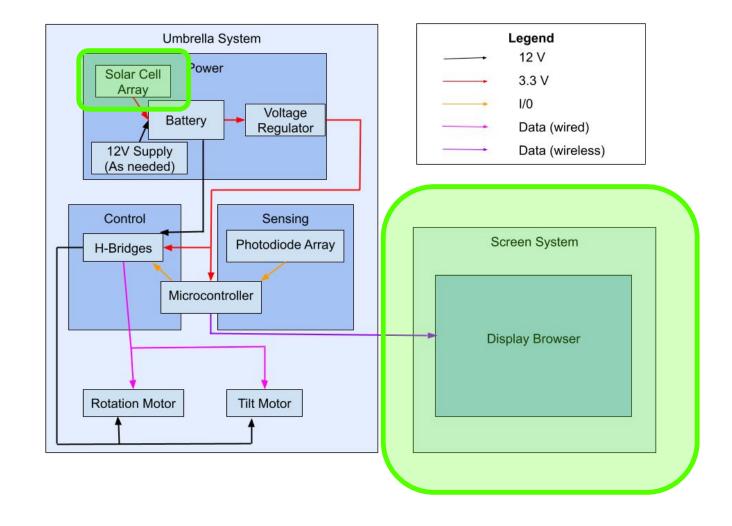
False positives cause motors to turn at the incorrect time

#### **Future Work**



 Integrating solar panels into the power subsystem to incorporate a self-powered design

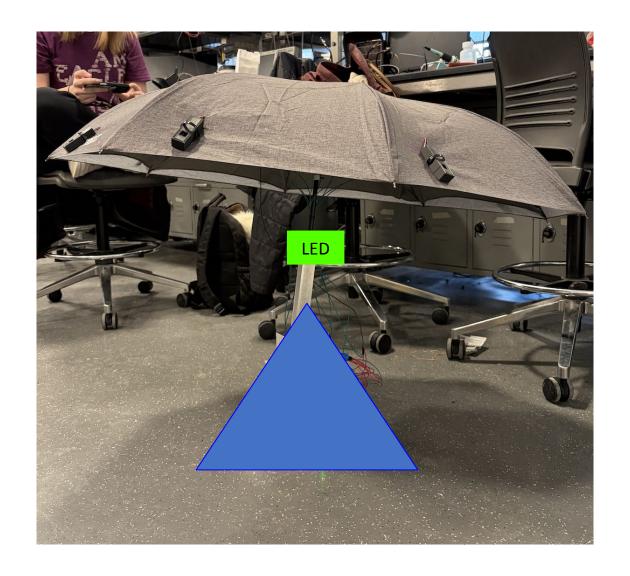
 The implementation of a screen system to display data to the user and allow for manual override



#### **Future Work**



- The addition of an LED that notifies the user when the umbrella will be moving
- Cleaner wiring and a housing to properly enclose all base electronics



### Thank You!



# The Grainger College of Engineering

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#### Citations



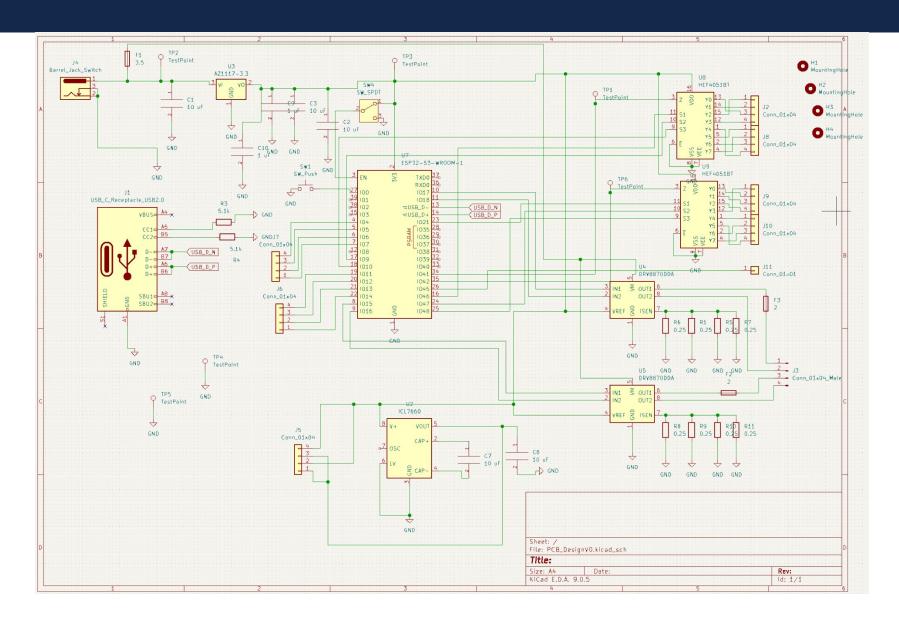
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# Appendix

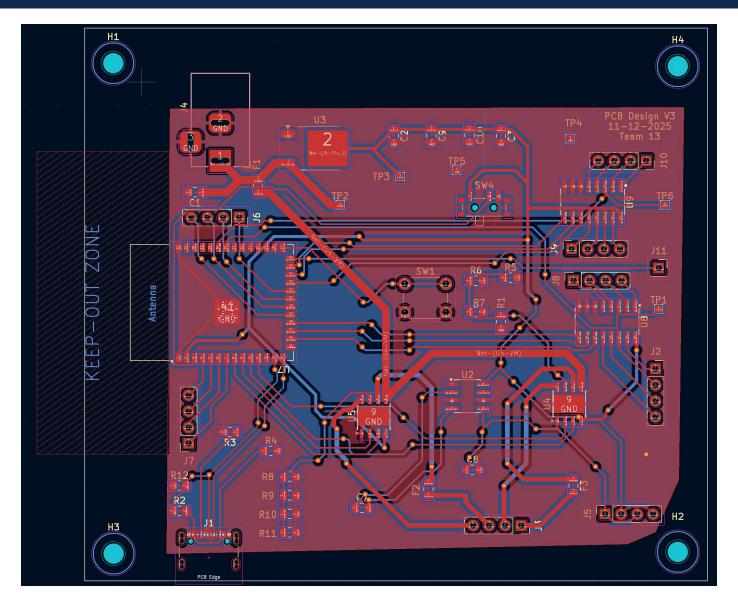
#### **PCB Schematic**





#### **PCB Layout**





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#### Sunlight Proof



Flashlight:	Beam Diameter	Half Angle	Solid Angle	Beam Intensity	Illuminance
2.5 cm away	0.08m	58°	2.95sr	45.7cd	7.312 per cm <sup>2</sup>
5 cm away	0.105m	46.5°	1.95sr	69.2cd	2.768 per cm <sup>2</sup>

Source	Illuminance
Flashlight: 2 inches away	27,680
Flashlight: 1 inch away	73,120
Bright Sunlight	> 110,000
Typical Overcast Day	1-2,000