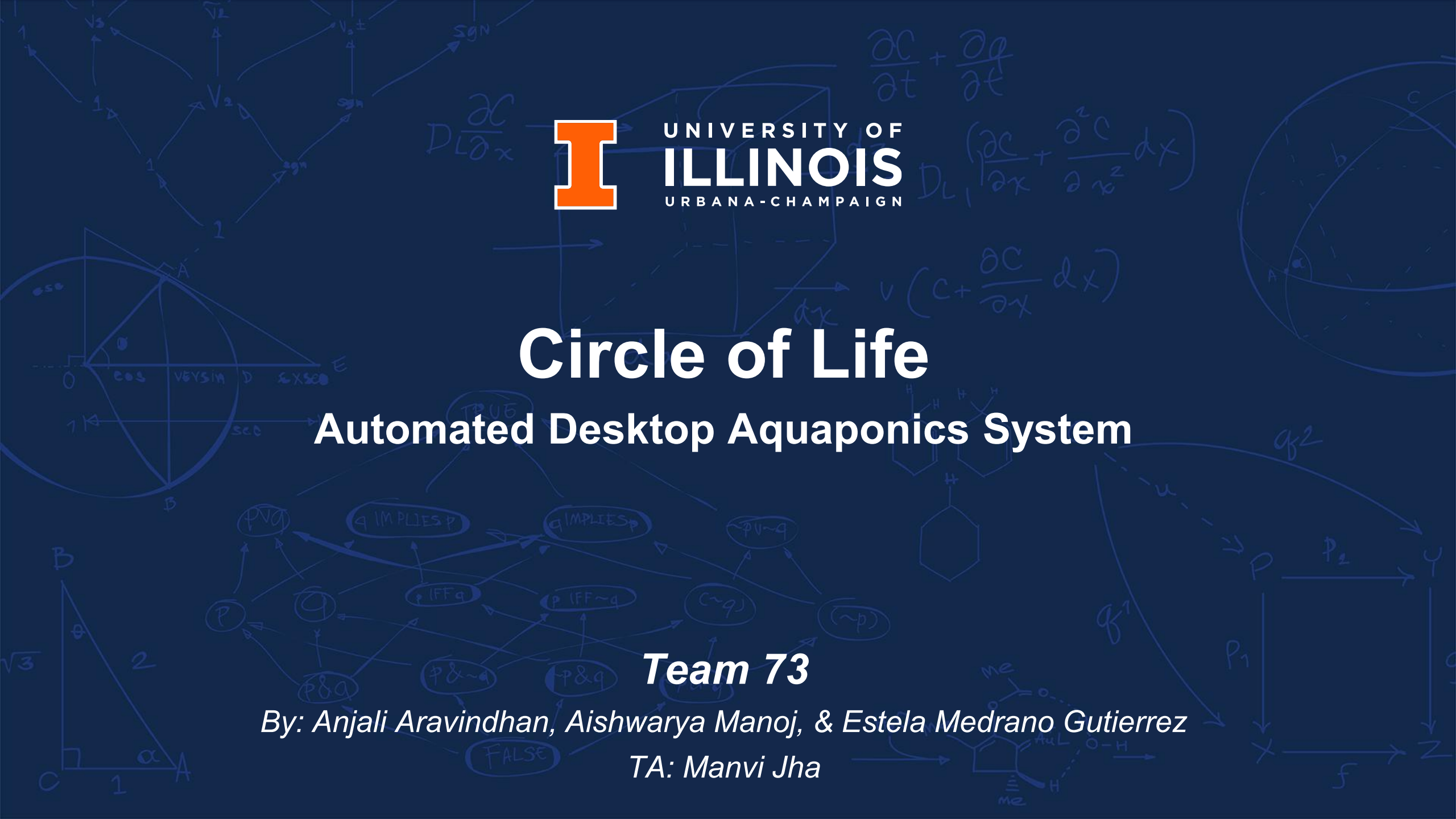


UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Circle of Life

Automated Desktop Aquaponics System

Team 73

By: Anjali Aravindhan, Aishwarya Manoj, & Estela Medrano Gutierrez

TA: Manvi Jha

Introduction & Objective

Objective

28% of the global population is in moderate or severe food insecurity.

Aquaponics, specifically desktop/small-sized aquaponics is the answer.

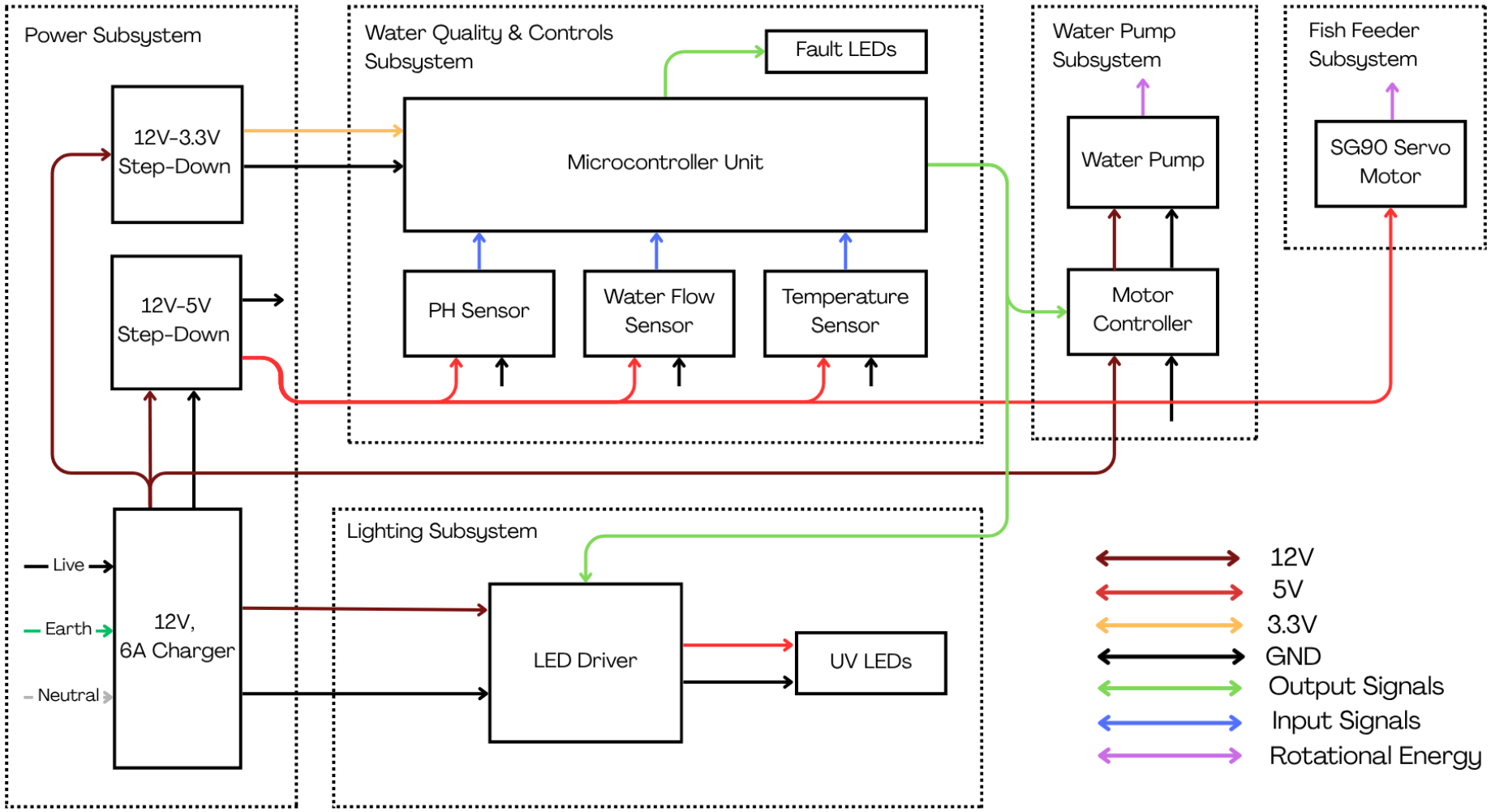
Traditional Aquaponics

Desktop Aquaponics

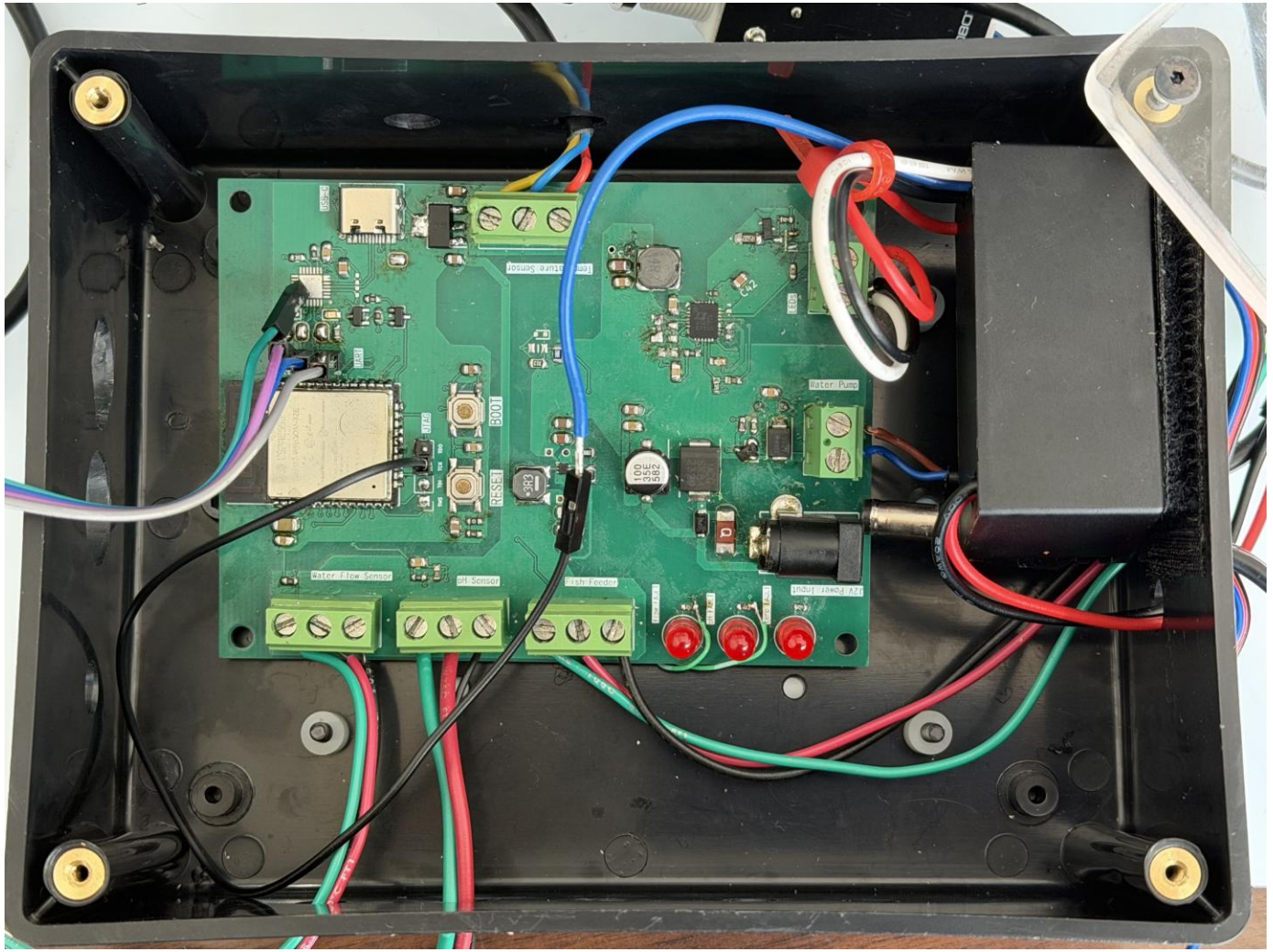
Our Project

Design

Block Diagram



PCB



High Level Requirements

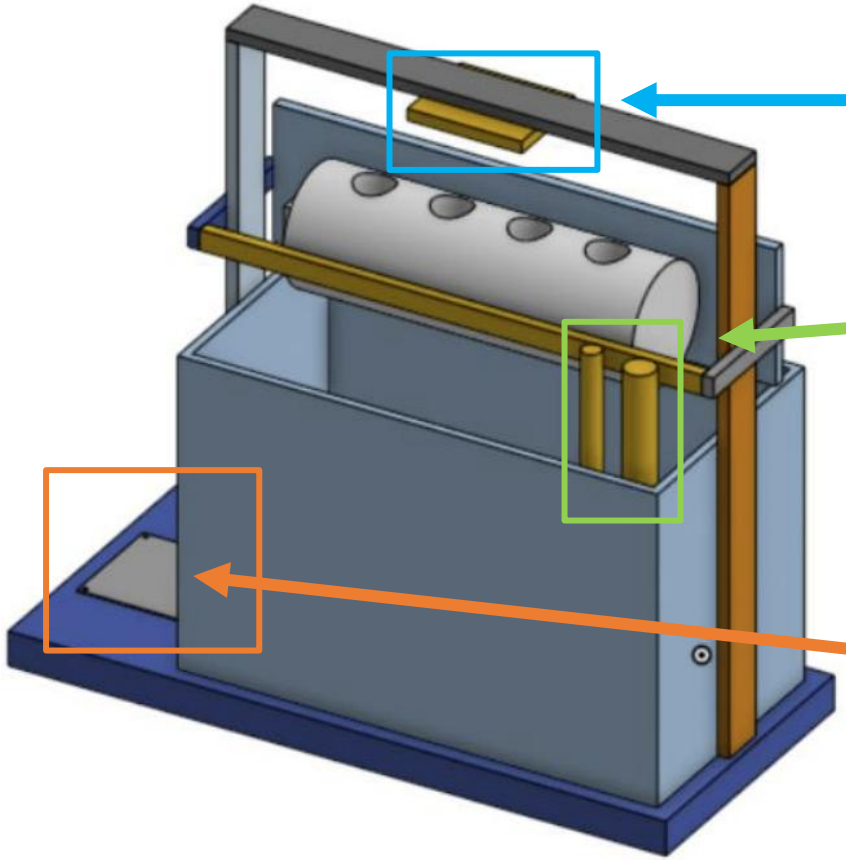
- **Sensor readings should be measured once an hour** for the water flow sensor and at least once every 10 seconds for the pH and temperature sensors, where **abnormal readings will be displayed via LEDs** (Outside of 6-8 pH, 78-80 degrees Fahrenheit, and rate of 3–5x the total tank volume per hour)

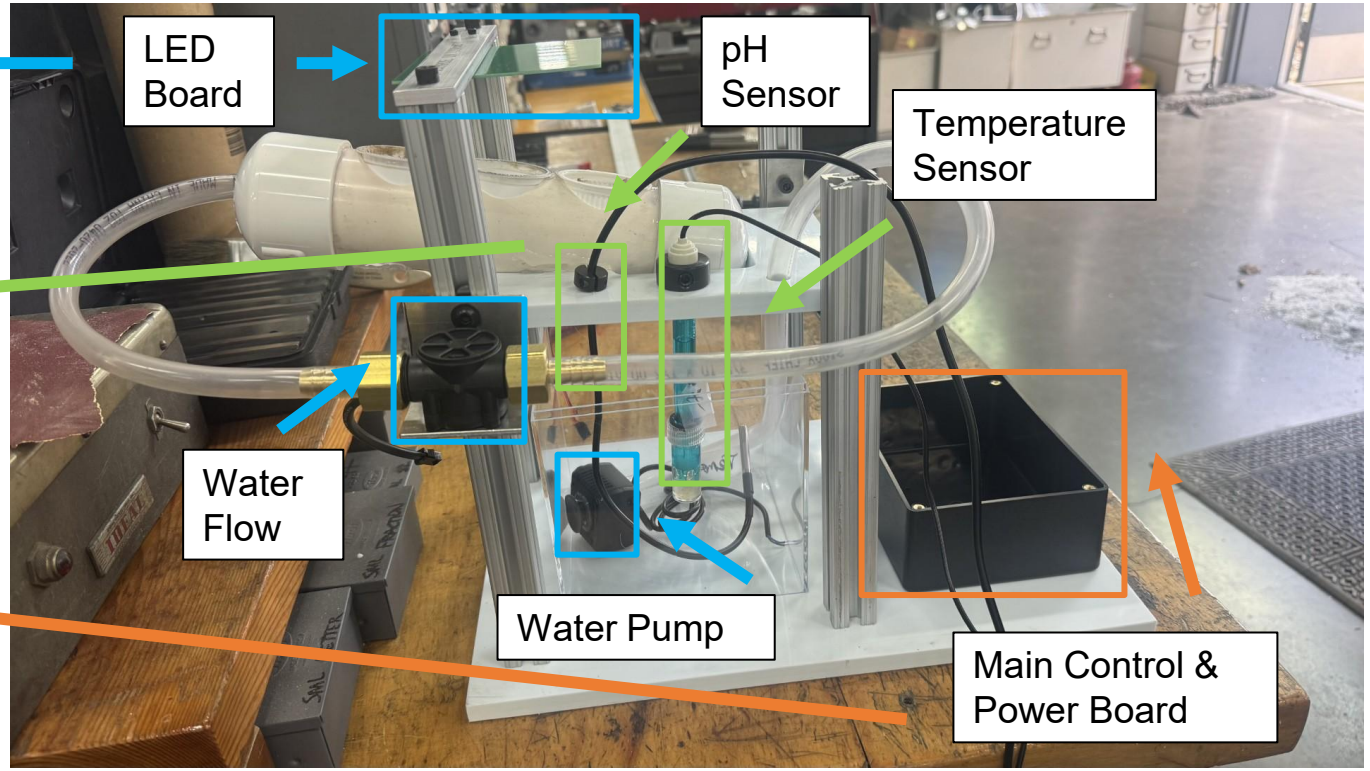
- All motorized subsystems such as the fish feeder and water pump will **operate for at least 24 hours** without issue, in which time the fish feeder should dispense food once and water pump will turn over the volume of the tank at least three times per hour.

- All visual indicators (LEDs) both used in the lighting schedule & displaying sensor abnormalities will be **updated/checked at least every 10 seconds**

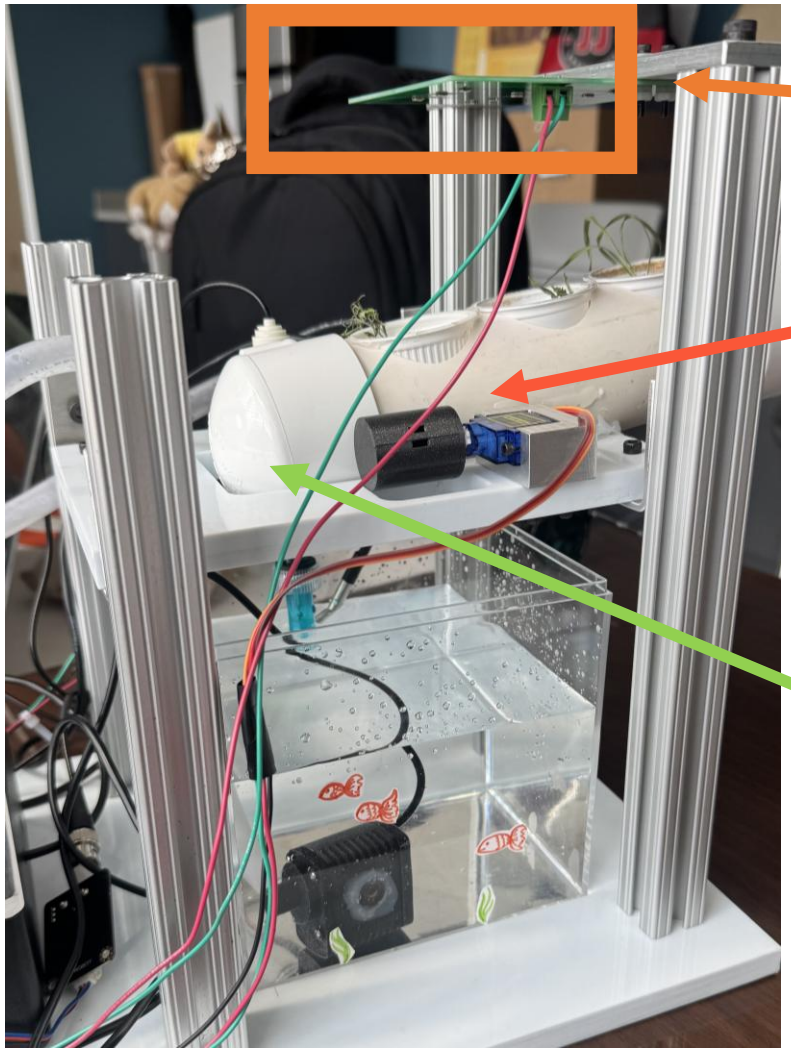
Physical Design

After talking to the machine shop, we decided to change our original water tank from **5 gallons to 0.8 gallons** for simplicity.





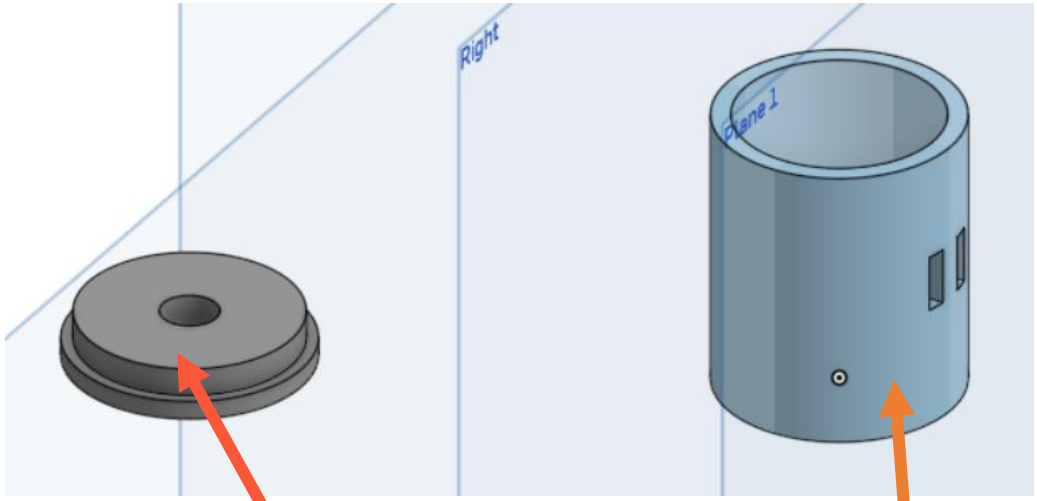
More Physical Design Details



LED Board with Grow Lights

Fish Feeder

Plant Grow Bed/Incubator



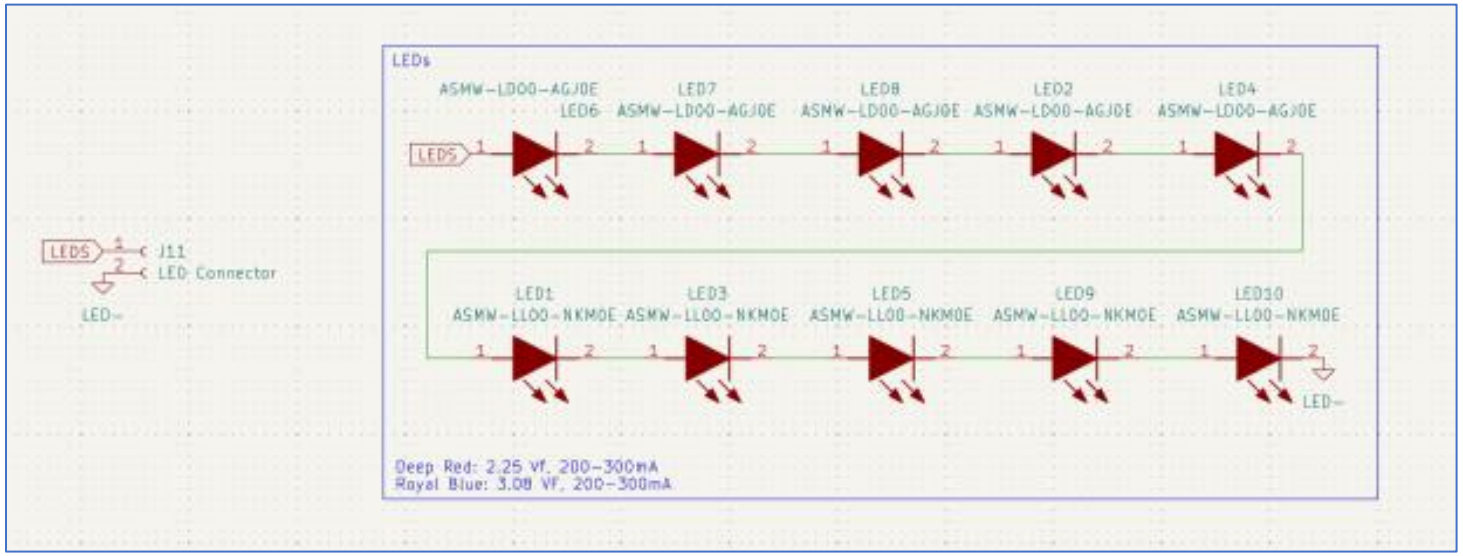
Fish Feeder Lid

Fish Feeder Cannister

Demo Video

Our lights:

- We are using horticulture power LEDs to supply the amount of light needed for our plants, with a combination of red and blue frequencies.



LEDs Requirements:

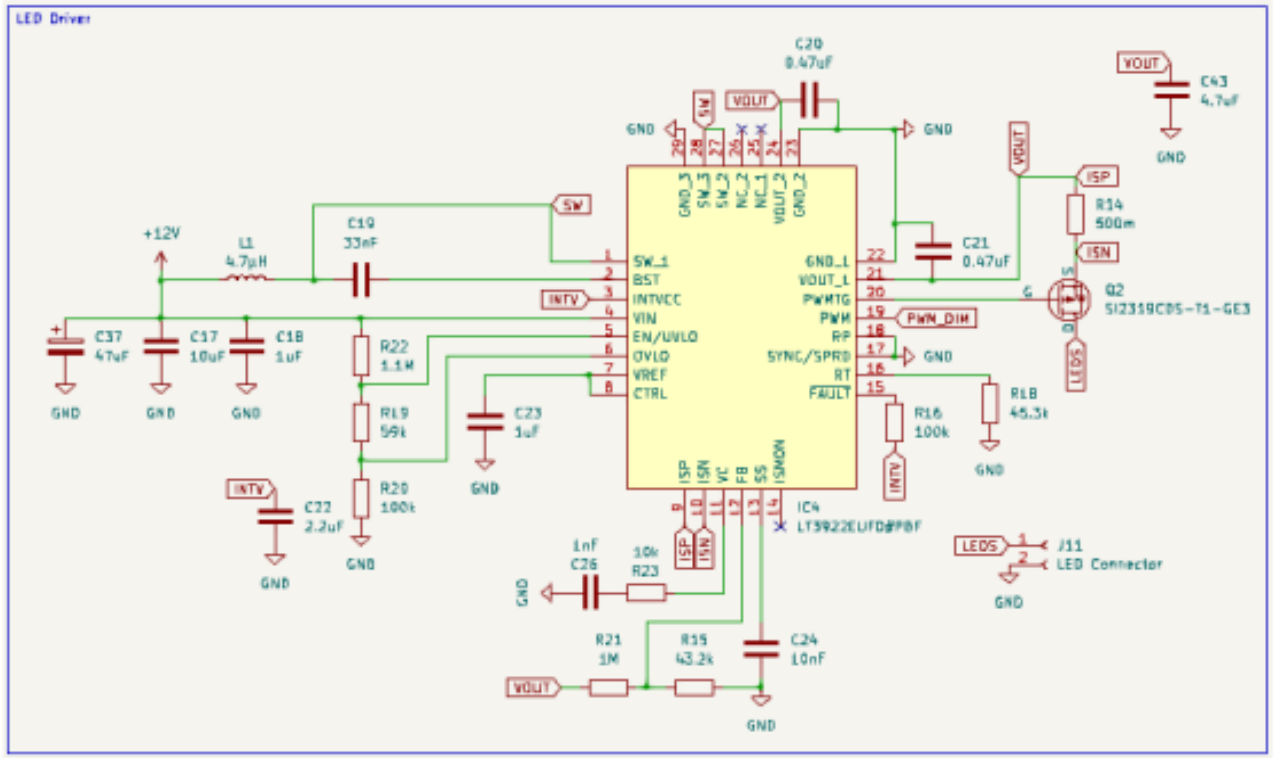
- **Deep Red:** 2.25 VF, 200-300mA
- **Royal Blue**: 3.08 VF, 200-300mA

- For the blue LEDs, 2 x 3.08 = 6.16V.
- For the red LEDS, 5 x 2.25 = 11.25V.
- In total, 6.16V + 11.25V = 17.41V.

- With PWM dimming, the average voltage seen through the multimeter is lower than the one theoretically calculated.

How we control the lights:

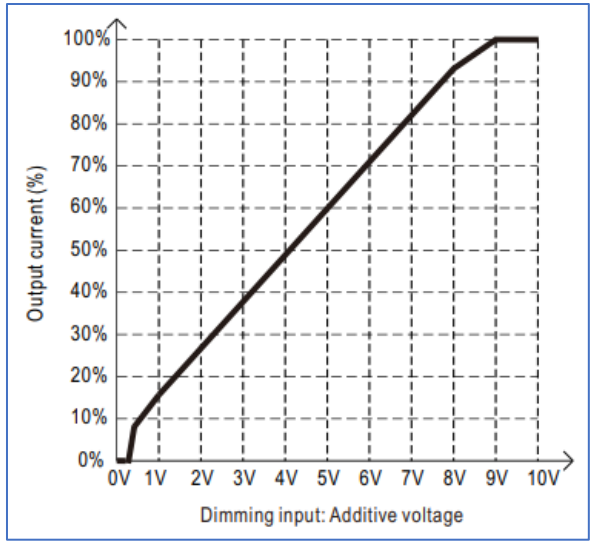
- We use a **constant current boost-converter led driver** that works by stepping up the voltage to the necessary level to keep the current stable at 200mA.
- It also includes a dimming function using a **PWM** signal from our microcontroller, which controls the amount of current going through the string of LEDs.



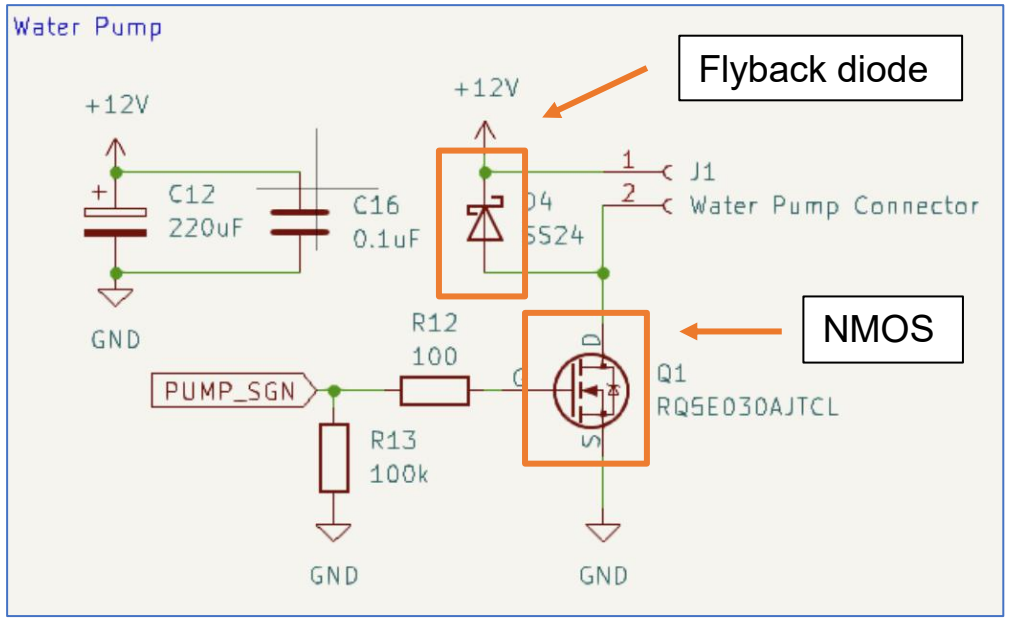
Lighting Subsystem

Changes to our project:

- Our LED driver did not work initially, so we bought a backup just in case.
- After debugging, we found the issue to be that the symbol did not match the footprint. However, in the process we broke both **LT3922** ICs we had, and we had to use our backup instead.
- Our new LED driver has a maximum total current output of **250mA**.
- Using a **3.3V PWM signal**, we limit the current to around 40% of the total output current.



Water Pump Subsystem



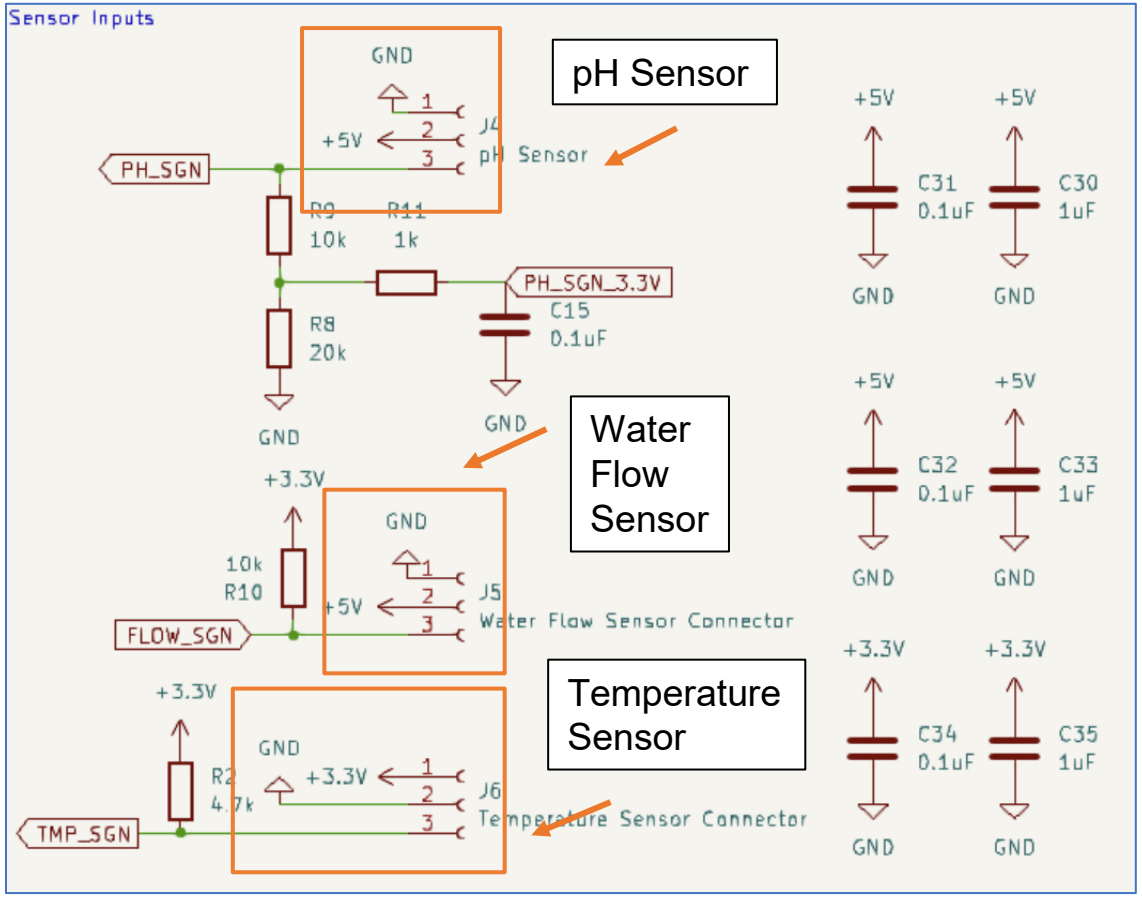
Water Pump Requirements:

- Change speed based on the PWM signal from the MOSFET
- Work over long periods of time (at least 24 hours)
- Circulate water at least for 3-5x the volume of the tank per hour

How It Was Accomplished:

- Powered by the 12V input from the power supply
- Used a MOSFET to control the flow rate through setting a duty cycle from the microcontroller (V = duty cycle * 12V)
- Used a flyback diode to prevent voltage from rising due to high current

Water Quality Subsystem



Water Flow Sensor

- Powered by the 12-5V Buck Convertor
- Water flow needs to be at least 3-5x of the tank volume
- Fault LED lights up when flow is lower

pH Sensor

- Powered by the 12-5V Buck Convertor
- Water pH needs to stay between 6-8
- Fault LED lights up when outside range

Temperature Sensor

- Powered by the 3.3V from the LDO
- Water temperature needs to stay between 75-85 degrees
- Fault LED lights up when outside range

Water Quality Subsystem

Temperature Sensor Output

```
09:15:41.082 -> ----------------------------------------
09:15:41.323 -> ----------------------------------------
09:15:41.355 -> Temperature: 74.19°F
09:15:41.387 -> Voltage:1.94 pH value: 7.44
09:15:46.069 -> Flow rate: 120.00 L/hr
09:15:46.210 -> ----------------------------------------
09:15:46.334 -> ----------------------------------------
```

pH Sensor Output

Flow Meter Output

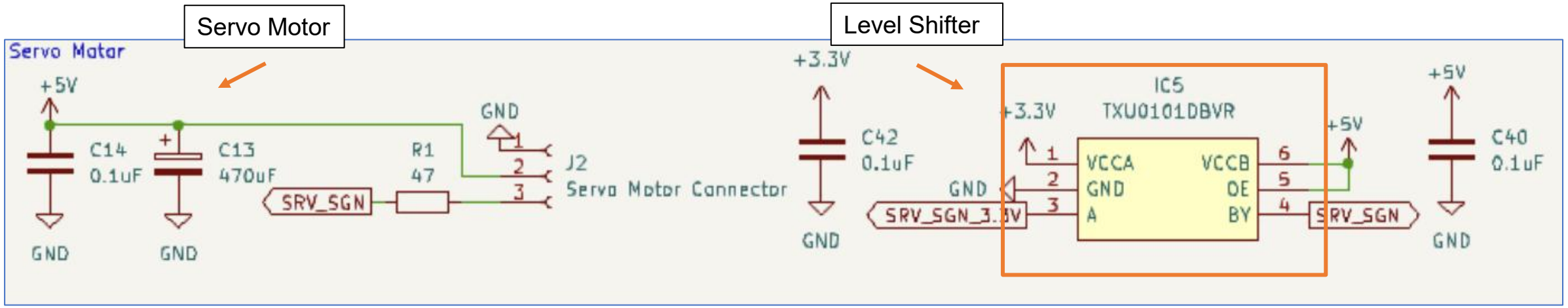
Flow Fault LED

Temp Fault LED

pH Fault LED

Serial Monitor Output

Fish Feeder Subsystem



Fish Feeder Requirements:

- Receive a PWM signal from the microcontroller
- Rotate approximately 180 degrees to dispense
- Operate once per day

How It Was Accomplished:

- 5V is from the 12-5V Buck Convertor
- Original design had a level shifter to get from 3.3V microcontroller PWM to 5V for the servo, but after testing realized it wasn't needed

Fish Feeder Subsystem

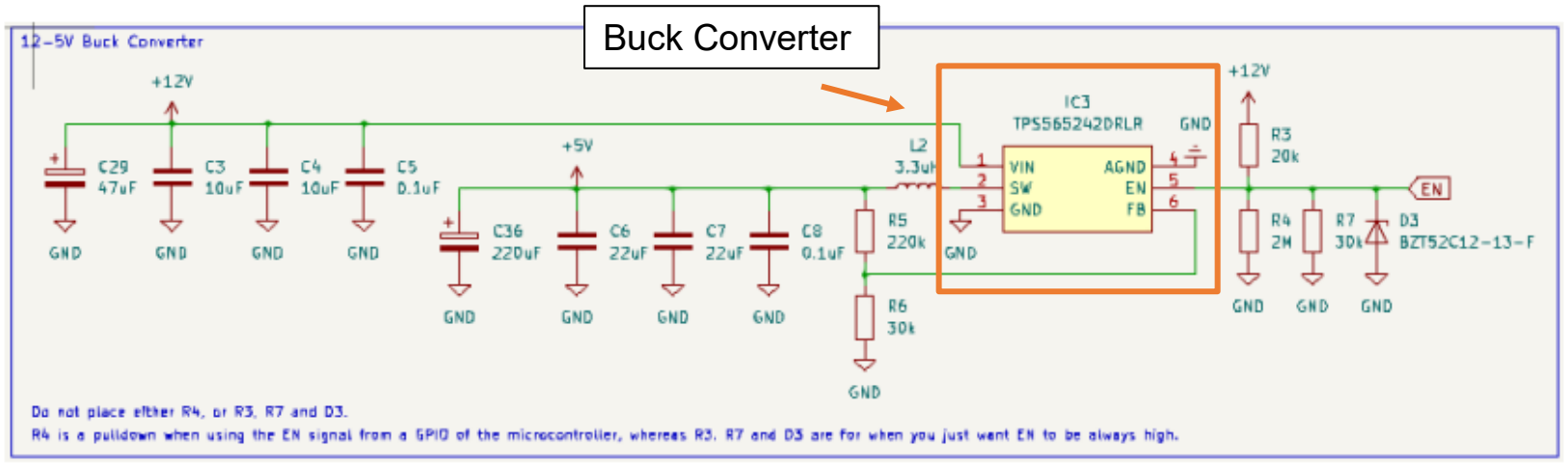
```
09:15:27.122 -> Flow rate: 0.00 L/hr
09:15:27.122 -> ----------------------------------------
09:15:27.260 -> ----------------------------------------
09:15:27.325 -> Temperature: 74.30°F
09:15:27.358 -> Voltage:1.93 pH value: 7.39
09:15:32.121 -> Flow rate: 104.00 L/hr
09:15:32.121 -> ----------------------------------------
09:15:32.303 -> ----------------------------------------
09:15:32.335 -> Temperature: 74.30°F
09:15:32.368 -> Voltage:1.94 pH value: 7.43
09:15:36.065 -> Flow rate: 120.00 L/hr
09:15:36.097 -> ----------------------------------------
09:15:36.297 -> ----------------------------------------
09:15:36.332 -> Temperature: 74.19°F
09:15:36.361 -> Voltage:1.94 pH value: 7.44
09:15:41.050 -> Flow rate: 120.00 L/hr
09:15:41.082 -> ----------------------------------------
09:15:41.323 -> ----------------------------------------
09:15:41.355 -> Temperature: 74.19°F
09:15:41.387 -> Voltage:1.94 pH value: 7.44
09:15:46.069 -> Flow rate: 120.00 L/hr
09:15:46.210 -> ----------------------------------------
09:15:46.334 -> ----------------------------------------
09:15:46.399 -> Temperature: 74.19°F
09:15:46.399 -> Voltage:1.94 pH value: 7.44
09:15:51.072 -> Flow rate: 120.00 L/hr
09:15:51.203 -> ----------------------------
09:15:51.354 -> ----------------------------
09:15:51.418 -> Temperature: 74.19°F
09:15:51.449 -> Voltage:1.94 pH value: 7.44
09:15:56.068 -> Fish feeder rotation started.
```

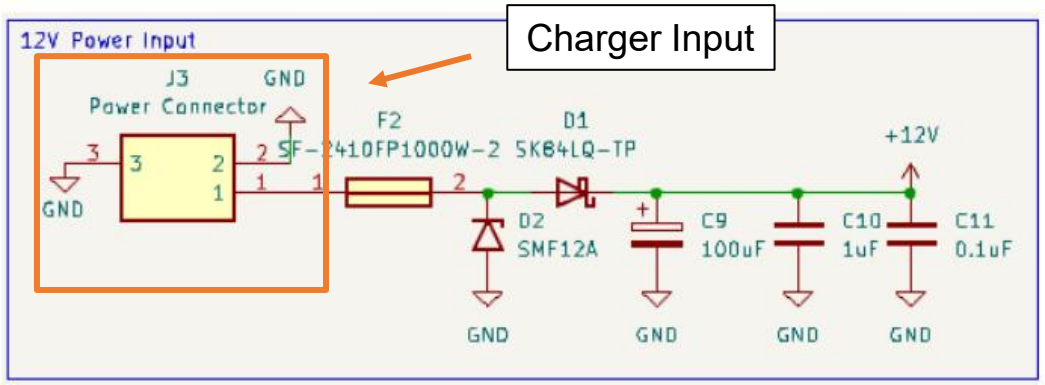
First Rotation

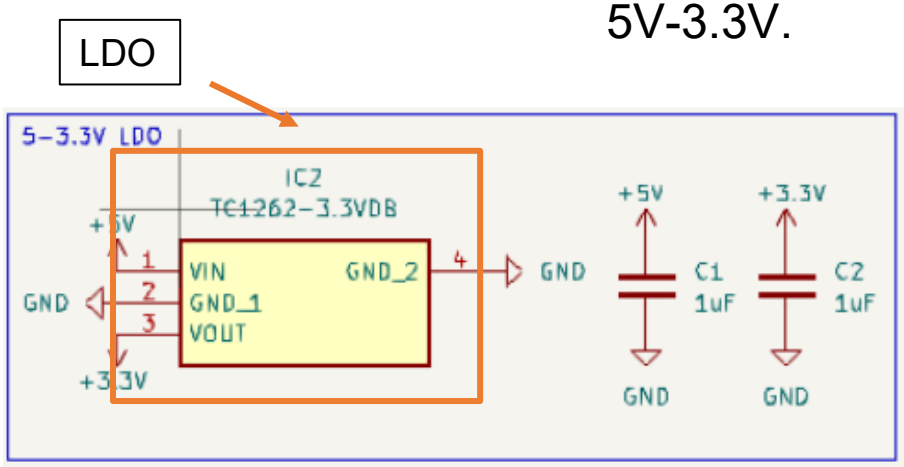
```
09:16:40.513 -> Flow rate: 120.00 L/hr
09:16:40.544 -> ----------------------------------------
09:16:40.687 -> ----------------------------------------
09:16:40.751 -> Temperature: 74.07°F
09:16:40.783 -> Voltage:1.94 pH value: 7.45
09:16:45.505 -> Flow rate: 120.00 L/hr
09:16:45.537 -> ----------------------------------------
09:16:45.741 -> ----------------------------------------
09:16:45.773 -> Temperature: 74.07°F
09:16:45.806 -> Voltage:1.94 pH value: 7.46
09:16:50.493 -> Flow rate: 120.00 L/hr
09:16:50.524 -> ----------------------------------------
09:16:50.745 -> ----------------------------------------
09:16:50.809 -> Temperature: 74.19°F
09:16:50.842 -> Voltage:1.94 pH value: 7.45
09:16:55.509 -> Flow rate: 120.00 L/hr
09:16:55.542 -> ----------------------------------------
09:16:55.792 -> ----------------------------------------
09:16:55.825 -> Temperature: 74.07°F
09:16:55.858 -> Voltage:1.93 pH value: 7.34
09:17:00.511 -> Flow rate: 120.00 L/hr
09:17:00.543 -> ----------------------------------------
09:17:00.825 -> ----------------------------------------
09:17:00.857 -> Temperature: 74.07°F
09:17:00.889 -> Voltage:1.94 pH value: 7.45
09:17:05.494 -> Flow rate: 120.00 L/hr
09:17:05.526 -> ----------------------------
09:17:05.859 -> ----------------------------------------
09:17:05.890 -> Temperature: 74.07°F
09:17:05.923 -> Voltage:1.94 pH value: 7.45
09:17:10.488 -> Fish feeder rotation started.
```

Second Rotation

Power Subsystem







How we accomplished it:

- We used a 12V-6A AC-DC charger to provide power to our system.
- From there, we used a buck converter to step-down 12V to 5V.
- Lastly, we utilized a LDO to step-down the voltage from 5V-3.3V.

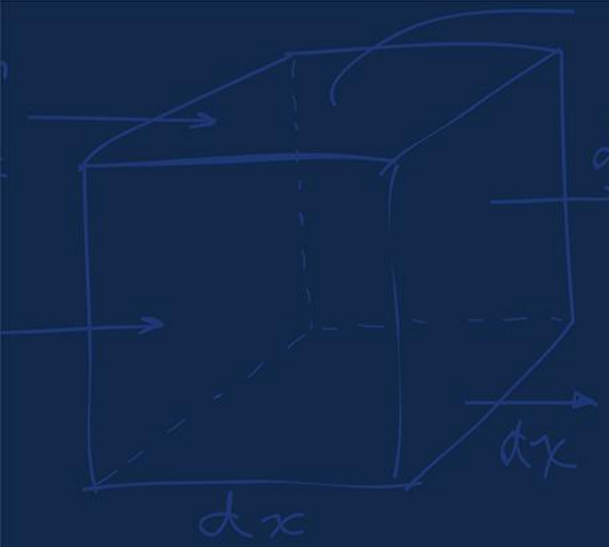
Power Subsystem

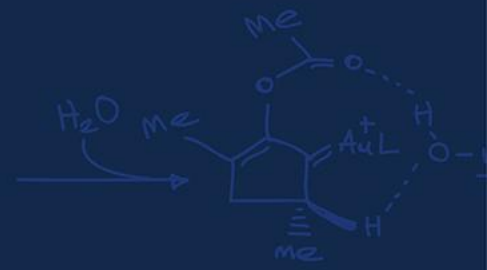
Power Supply To:	From:	Minimum:	Maximum:	Actual:	Units:
Servo Motor for Fish Feeder	12-5V Buck Converter	4.8	6	5.1	V
Water Pump	12V Power Input	6	18	12.41	V
LED Driver	12V Power Input	2.8V	26V	12.41	V
LED String	LED Driver Output	26.65V	N/A	14.51	V
Fault LEDs	MCU	1.8	3.6	3.34	V
Water Flow Sensor	12-5V Buck Converter	5	24	5.1	V
Water pH Sensor	12-5V Buck Converter	5	5	5.1	V
Temperature Sensor	12-5V Buck Converter	3	5.5	3.34	V
MCU	5-3.3V LDO	3.0	3.6	3.34	V

Power requirements and verification based on each subsystems:

- We used a multimeter to measure all the actual values.
- There is a small offset from the theoretical value compared to the actual value, but everything matches enough for correct functionality.

Conclusion





Challenges & Conclusion

Challenges and Conclusions

- Trouble with the **LT3922 LED Driver**, we ended up replacing it with the **LDH-25-W**
- Some early PCB errors like footprints being reversed or errors in wiring fault LEDs to input only pins on the MCU
- Calibrating the pH sensor and dealing with broken temperature sensor
- Only one PCB in the end, 4 rounds designed
- Lots of debugging and code integration especially for PWM signals
- Able to meet all requirements

Future Work

- Have a different LED Driver integrated into PCB
- Incorporate a full cycle with Fish to see nutrients cycle
- Test out one lifecycle of plants
- Add a mobile app component
- Make the physical design more aesthetic

Thank you for listening!
Any questions?

Contact Information:
Anjali Aravindhan (anjalia2@illinois.edu)
Aishwarya Manoj (am133@illinois.edu)
Estela Medrano Gutierrez (estelam2@illinois.edu)