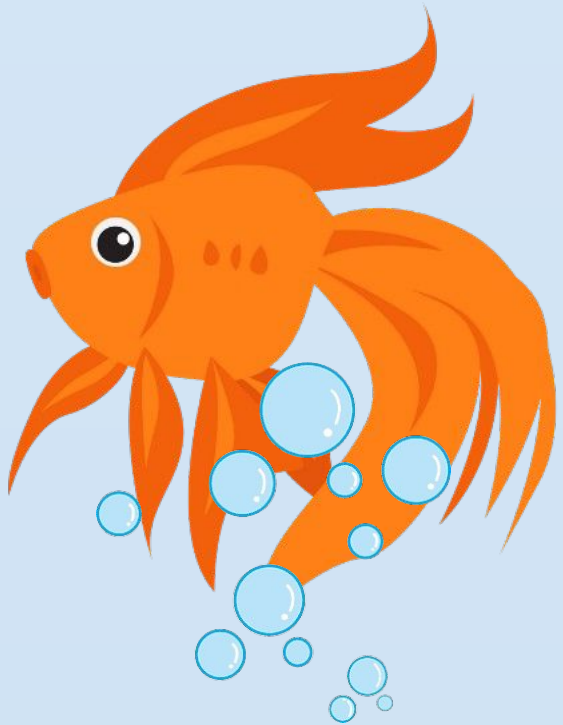
Azul Tank

A Fish Tank Helper



Final Presentation - Group 14

The Team

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Electrical Engineering

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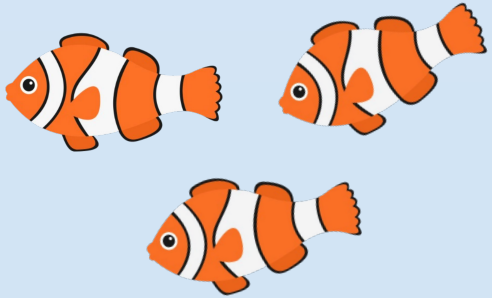
Problems and Motivation

- Problem
  - Inconsistent fish care
  - Challenges of taking care of aquatic pets during absence
  - Balancing fishkeeping with other responsibilities

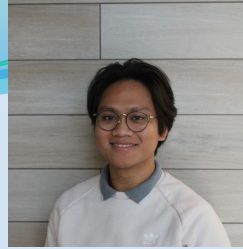
- Motivation
  - Improve the aquatic pet's well being.
  - Simplify and enhance fish ownership.
  - Personal convenience.
  - Support fish owners of all experience levels.

Goals and Objectives



- **Basic Goals**
  - Ensure optimal water conditions.
    - pH sensor
    - Temperature sensor
    - Turbidity sensor
  - Automated feeding
  - pH solution dispenser
  - Smart light systems
  - Mobile application for full remote monitoring and control
- **Stretch Goals**
  - Integrate live feed camera
  - Bubble System
  - Comprehensive Aquarium Monitoring and Analytics Dashboard

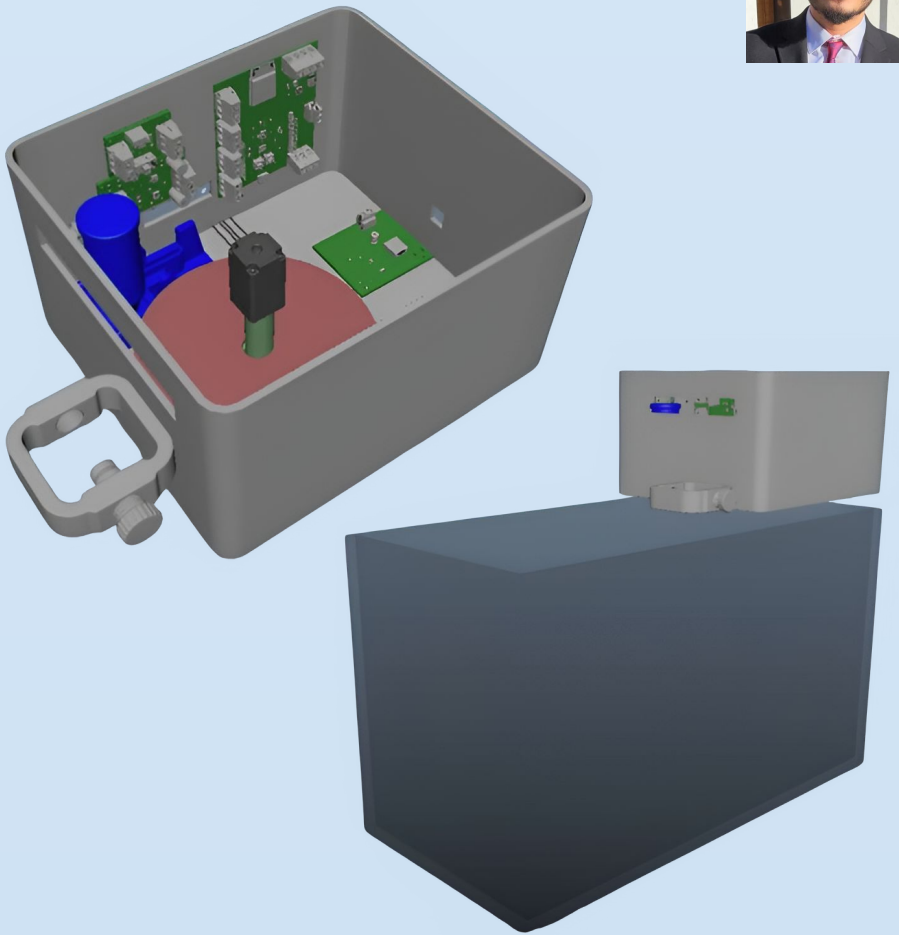
Engineering Requirements



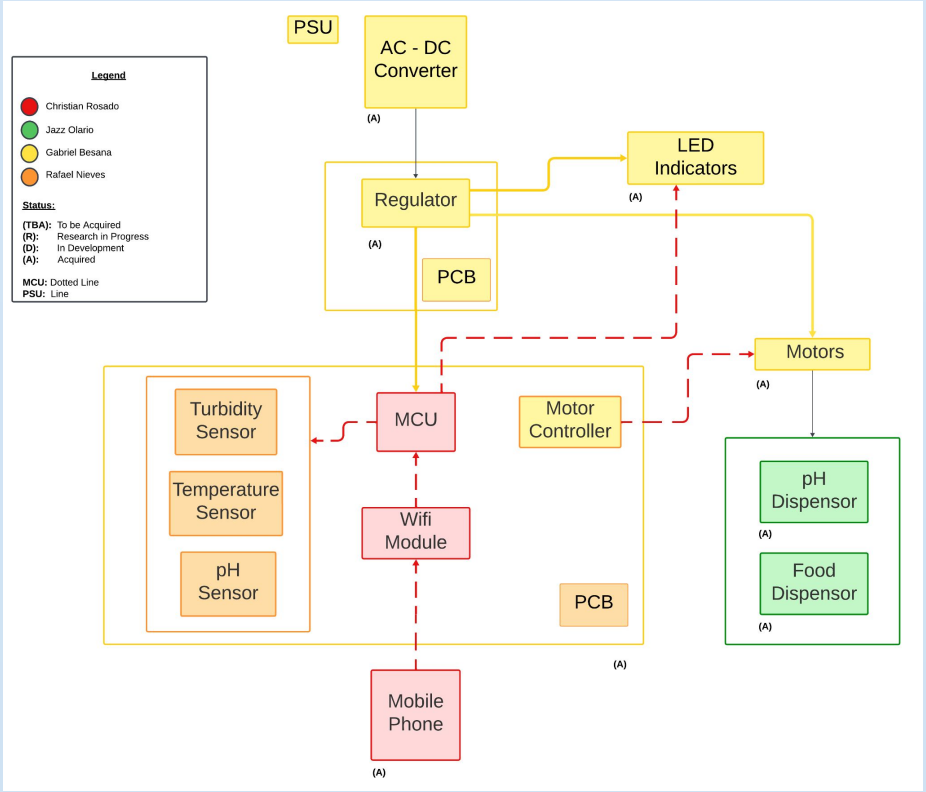
Specification	Criteria
Power Supply	Wall outlet power
Max Power Consumption	~24 Watts
pH Sensor Response time	≤ 2 min
Temperature Sensor Response Time	≤ 2 min
Temperature Sensor Accuracy	±0.9°F from 14°F to 185°F
pH Sensor Accuracy	4 and 10
Turbidity Sensor Accuracy	<5 NTU
Food Dispenser Accuracy	0.189 Oz Average per 26 sec
pH Dispenser Accuracy	1 tablet at a time
Dispensers Capacity	0.50 Oz
LED Response Time	2ms
Servo Motor Response Time	2ms
Stepper Motor Response Time	200ms
Cost	<$500

Design Concept

- This 3D-printed PLA container for the AzulTank showcases a robust design that houses all essential components.
- Most PCBs are securely attached to the walls.
- Two sturdy clamps securely attach the container to the edge of an aquarium.
- External access points for the probes make installation and servicing convenient.



Hardware Block Diagram



Temp. Sensor Selection

Manufacturer	Model	Price	Size	Key Features
DFRobot	DS18B20 Waterproof Probe	From $4.50	Cable length: 1m (Sensor: 6mm diameter)	• High accuracy (±0.5°C) • Operates on 3.3V or 5V • 1-Wire communication
TE Connectivity	TSYS01P Waterproof	From $12.00	Cable length: 1.5m (Sensor: 7mm diameter)	• High accuracy (±0.2°C) Operates on 5V • I2C interface
TE Connectivity	HTU21D Waterproof	From $15.00	Cable length: 1m (Sensor: 8mm diameter)	• High accuracy (±0.3°C) Operates on 5V • I2C interface

- The main comparison here is in the price range and interface.
- While offering similar accuracy, the other sensors come with complex interfaces and higher prices.

pH Probe Selection

Manufacturer	Model	Price	Size	Key Features
DFRobot	Gravity: Analog pH Sensor Pro	From $49.45	Probe length: 170.7mm, diameter: 20mm	• Good accuracy (±0.2 pH) • Response <2 min • Operates on 5V • Analog output
Milone Technologies	eTape Liquid Level Sensor (pH)	From $49.95	Probe length: 120mm, diameter: 8mm	• Great accuracy (±0.05 pH) • Response <2 min • Operates on 6V - 24V • Analog output
DFRobot	Gravity: Analog pH Sensor / Meter Pro Kit	From $56.90	Probe length: 90mm, diameter: 12mm	• Good accuracy (±0.1 pH) • Response <1 min • Operates on 5V • Analog output

- Analog output makes all sensors a viable option.
- Good for measuring solutions for an extended period of time.

Turb. Probe Selection

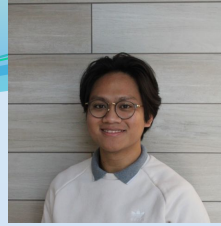
Manufacturer	Model	Price	Size	Key Features
Seeed Studio	Grove - Turbidity Sensor v1.2	From $33.90	Probe length: 45mm, diameter: 33mm	• Good accuracy • Analog output • Up to 100 NTU
DFRobot	Gravity: Analog Turbidity Sensor	From $9.90	Probe length: 42mm, diameter: 32mm	• Good accuracy • Analog output • Up to 100 NTU
Vernier	Turbidity Sensor	From $124.00	Probe length: 50mm, diameter: 30mm	• Very high accuracy • Analog output • Up to 200 NTU

- High ranges of NTU are not required for measuring water clarity in aquarium standards.

LED Selection

Manufacturer	Model	Price	Size	Key Features
Adafruit	NeoPixel Digital RGB LED Strip	$24.95	3.2 feet	• MCU compatible • Operates on 5V • Highly customizable • Flexible • Weatherproof options
HitLights	LED Strip Light	$29.99	16.4 feet	• Remote controlled • Operates on 5V • Dimmable • Flexible • Waterproof options
BTF	WS2812B RGB ECO LED Strip	$8.99-$15.99	3.2- 16.4 feet	• MCU compatible • Operates on 5V • Highly customizable • Flexible • Waterproof options

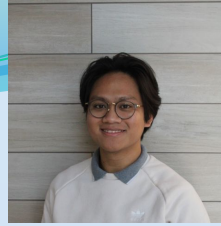
- Strips required to be cuttable to fit them in our design in case in case they were too long.



Motor Selection: Stepper

Manufacturer	Model	Price	VDC	Key Features
Adafruit Industries LLC	NEMA 17 Bipolar Hybrid Stepper Motor	$14.00	12V	• Step Angle 1.8° • Ease of use for general application • Moderate Torque with 1.2A per phase • Large Frame
MIKROE	ROHS 28BYJ-48	$5.00	5V	• Step angle: 5.625°/64. • Reduction ratio: 1:64. • Torque: Around 34.3 mN.m for in-traction. • Noise level: ≤40 dB.
STEPPERONLINE	NEMA8 Bipolar Microstep Stepper Motor	$25.08	6V	• Step Angle 1.8° • Precise Control • Low Torque, Efficient Power Consumption • Small frame

- Using the NEMA17 Bipolar model, it didn't give the necessary strength to turn our pH dispenser smoothly.
- The 28BYJ-48 Model worked as intended and allowed for a smooth spin of the dispenser with accurate 45° turns to dispense our pH tablets.



Motor Selection: Servo

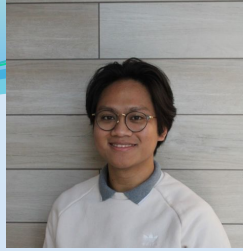
Manufacturer	Model	Price	VDC	Key Features
Parallax Inc.	900-00008	$15.00	6V	• Speed: 60 RPM at 6V • Torque: 38 oz-in (2.7 kg-cm) • Continuous rotation for wheeled robotics
TowerPro	SG90	$4.00	4.8-6V	• Torque: Up to 1.6 kg/cm at 6 V • Weight: Approximately 9 grams • Rotation: 180 degrees • Casing Material: Durable plastic
TowerPro	MG90S	$10.00	4.8-6V	• Torque: 2.2 kg-cm at 4.8V; 2.5 kg-cm at 6V • Speed: 0.1 sec/60° at 6V • High durability from metal gear construction

- We chose the SG90 due to the microcontroller applications and standard compatibility with PWM signals.
- Operational voltage is ideal for the 5V signal we send to it.
- Its rotational capabilities was more than sufficient for our food dispenser needs.

Microcontroller Selection

Criteria	TI-MSP430FR6989	Microchip Curiosity PIC32MX470	Expressif Systems ESP32 WROOM 32E - N16
Clock Speed	16Mhz	120Mhz	240Mhz
# of Cores	Single Core	Single Core	Dual Core
Storage	128KB	128KB	16MB
GPIO	83	43	38
ADC Resolution	12-bit	10-bit	12-bit
Wireless Connectivity	N/A	Via Add-ons	Wifi & Bluetooth
Programming	C/C++/Code Composer Studio	C/C++/MP Lab X IDE	C/C++/Arduino IDE
Cost	$20.00	$45.00	$5.00-$15.00

- Dual-core processor with a higher frequency
- Wi-Fi and Bluetooth support
- Higher RAM and flash storage

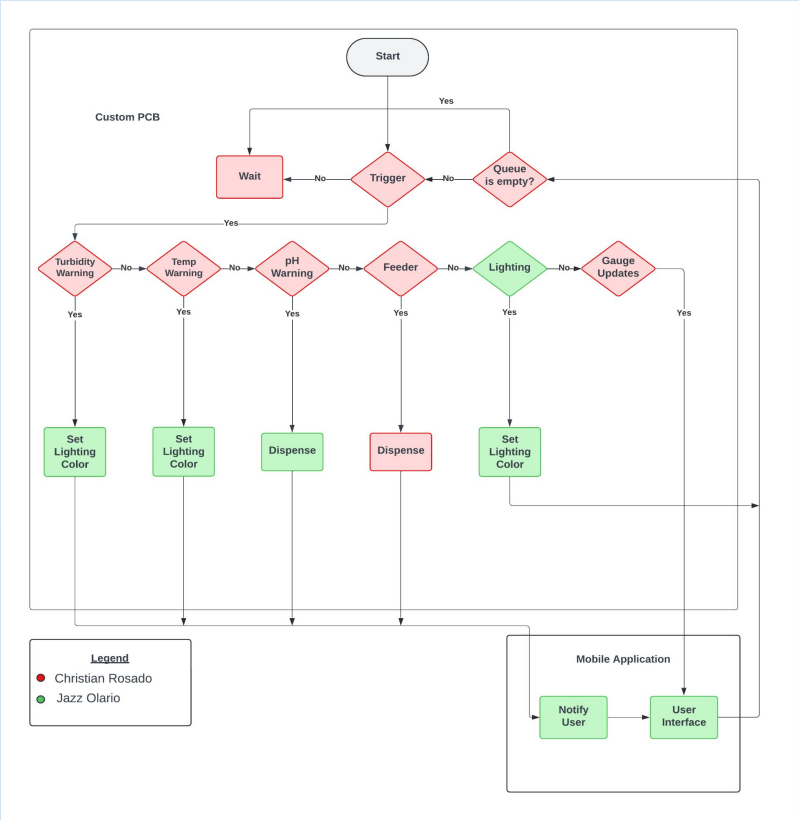


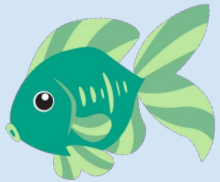
PSU Selection

Manufacturer	Model	Price	Watts	Key Features
Desvorry	B08QCBRYPT AC100-240V to DC12V	$10.99	60W	• Smooth, flicker-free output • Full protection of over voltages, over current, short circuits and over temperature
Alitove	ALT-1205 AC 100-240V input to 12V output	$11.99	60W	• Automatic overload cut-off, over Voltage cut-off, automatic thermal cut-off, short circuit protection. • Voltage consistency
LitStar	GMFINE	$11.99	24W	• Overload, overcharge, short circuit protection • Automatic current adjustment (50mA to 2A) • Large compatibilities with devices such as cameras, LED strips, routers, etc.

- Our system requires under 2A.
- Lighter loads than intended with our chosen components.
- Voltage regulator rated up to 5A in case of any spikes in voltage or current

Software Block Diagram



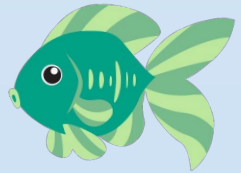


Sensors Communication Protocols:

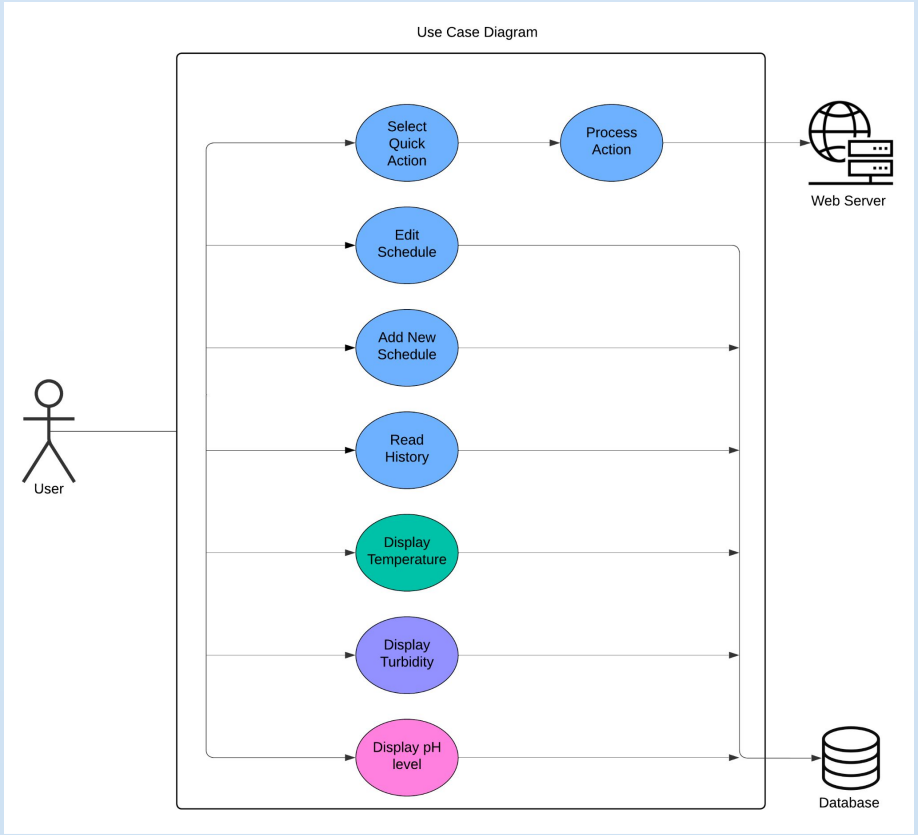
- Temperature Sensor: One-Wire protocol
- pH Sensor: Analogue Communication
- Turbidity Sensor: Analogue communication

Mobile Application:

- Utilizes Adafruit IO to communicate with the MCU.



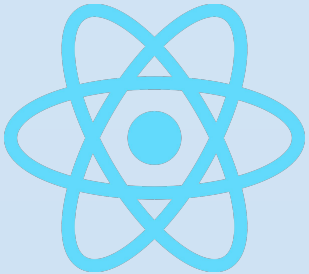
Use Case Diagram



Mobile Development

Criteria	Flutter	React Native
Learning Curve	Easier Difficulty	Higher Difficulty
Development Language	Dart	Javascript
Key Development Tools	Flutter Doctor	Expo Go
Automatic Component Updates	No	Yes
Performance	Faster	Limited by JavaScript bridge
Operating Systems	Windows & MacOS	Windows & MacOS
Cross Platform Development	Yes	Yes
Documentation	Easier to understand for newcomers.	More complex, but robust backed by a large community.

- Development Language: Javascript.
- Offers near native-looking user interfaces.
- Expo Go: Allows developers to see changes in real time.



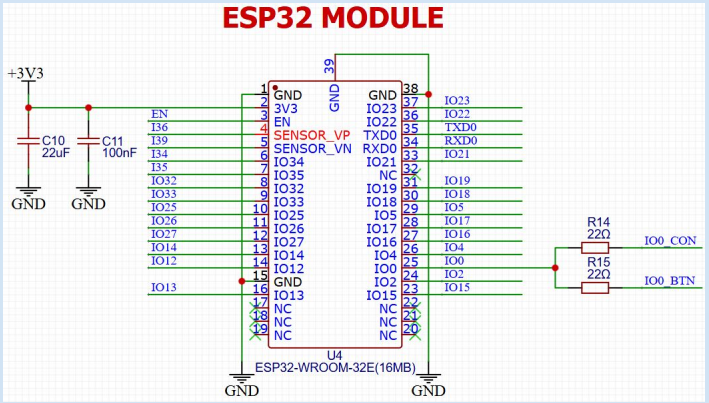
Database Selection

Criteria	SQL	NoSQL
Data Structure	Relational	Semi-structured
Query Language	Standardized query language	Varies by database type
Scalability	Vertically scalable	Horizontally scalable
Documentation	Highly consistent	Varies by database type

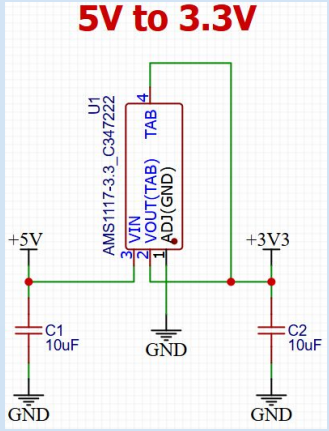
- Standardized query language.
- Schemas ensure consistent data.
- Consistent documentation.

MCU PCB Schematic

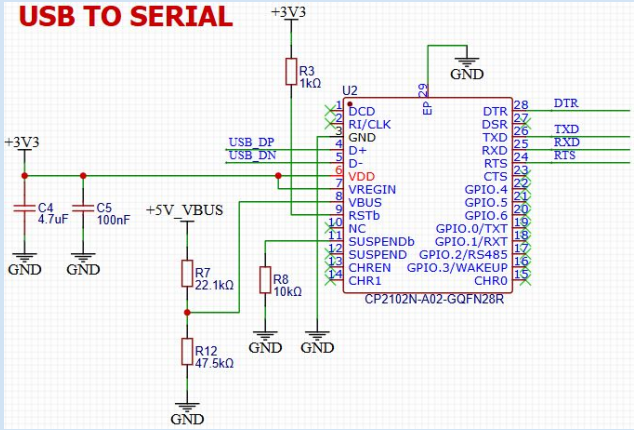
ESP32 MODULE



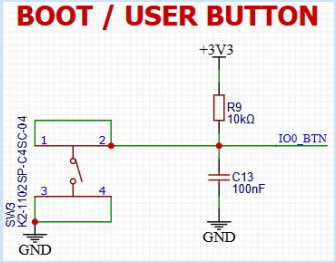
5V to 3.3V



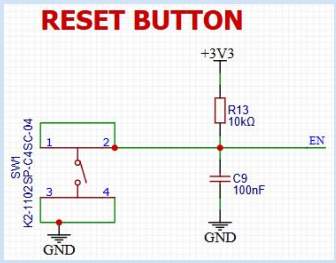
USB TO SERIAL



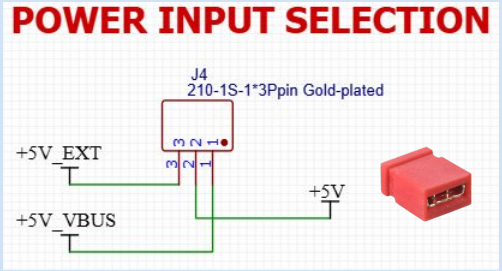
BOOT / USER BUTTON



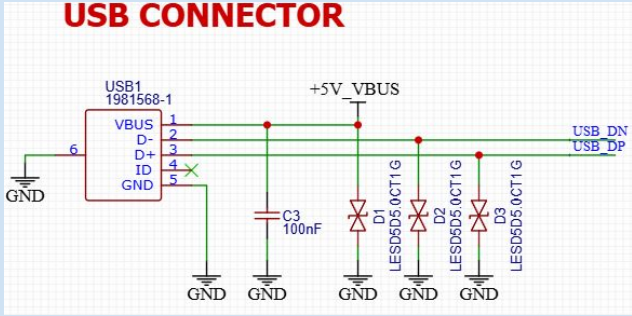
RESET BUTTON



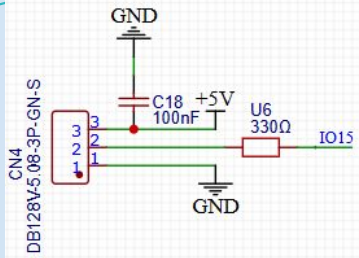
POWER INPUT SELECTION



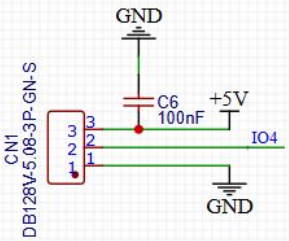
USB CONNECTOR



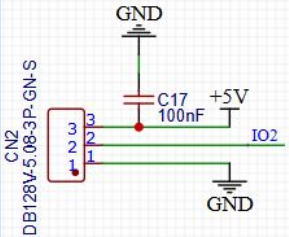
LED LIGHTS



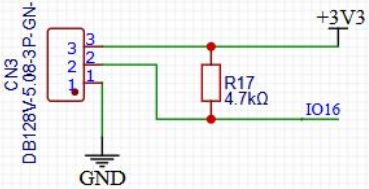
TURBIDITY SENSOR



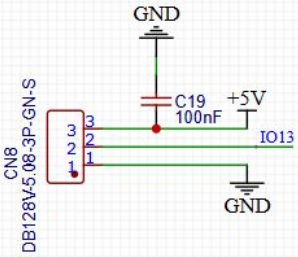
pH SENSOR



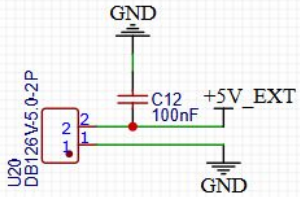
TEMPERATURE SENSOR



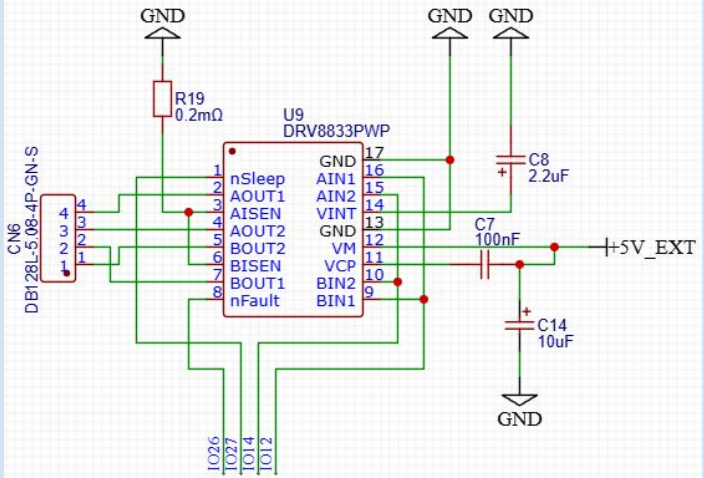
SERVO MOTOR



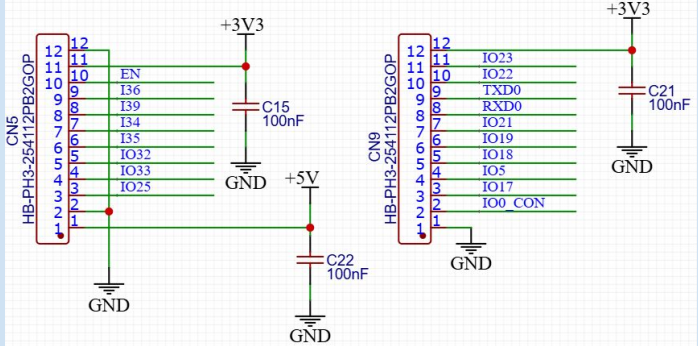
REGULATOR



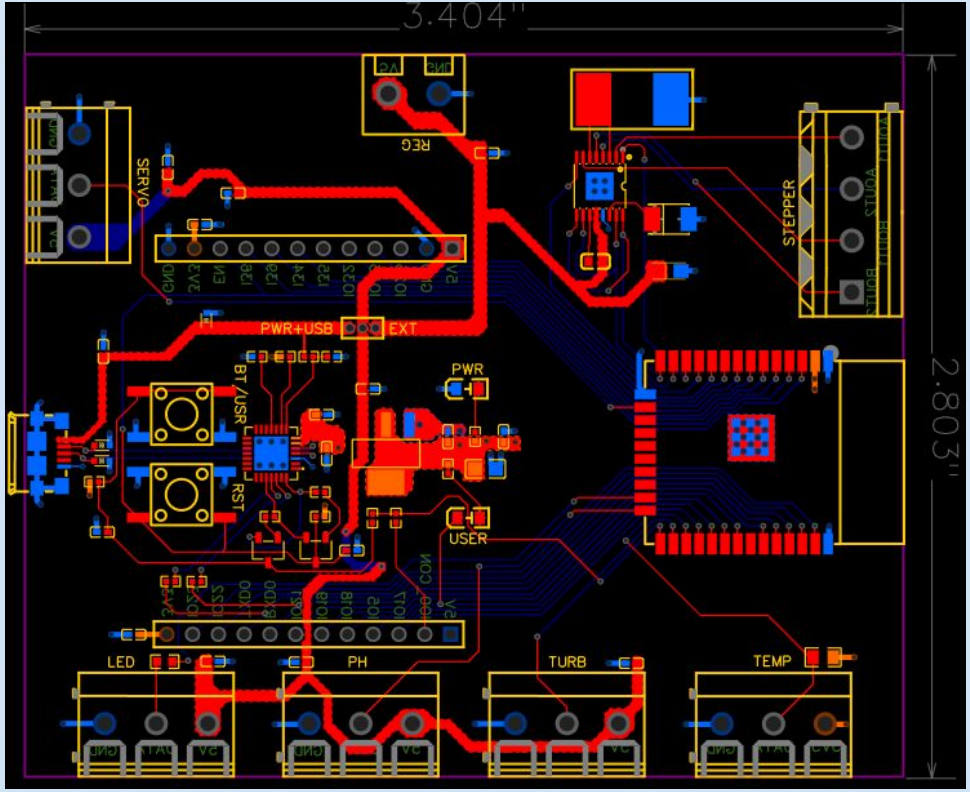
STEPPER CONTROLLER

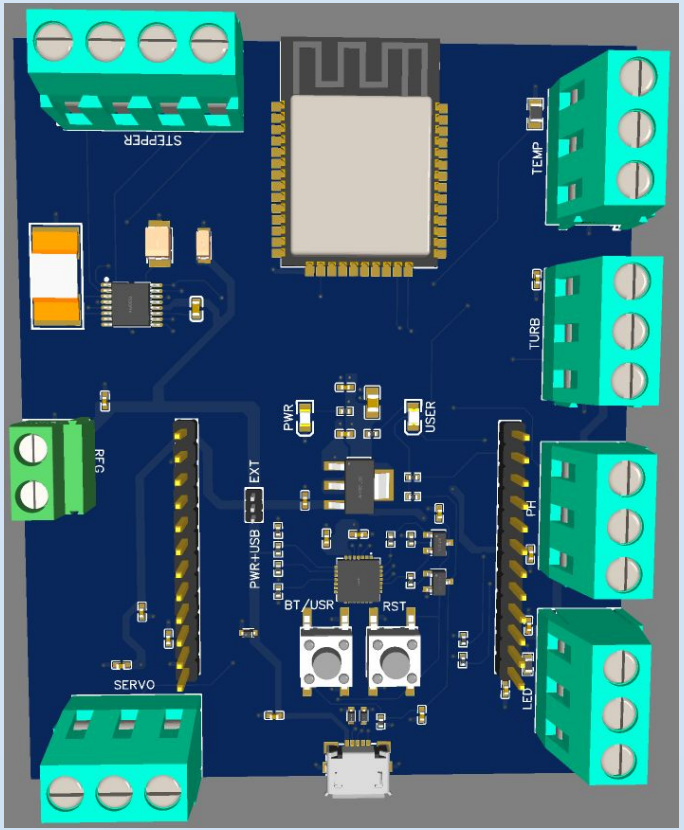


CONNECTORS

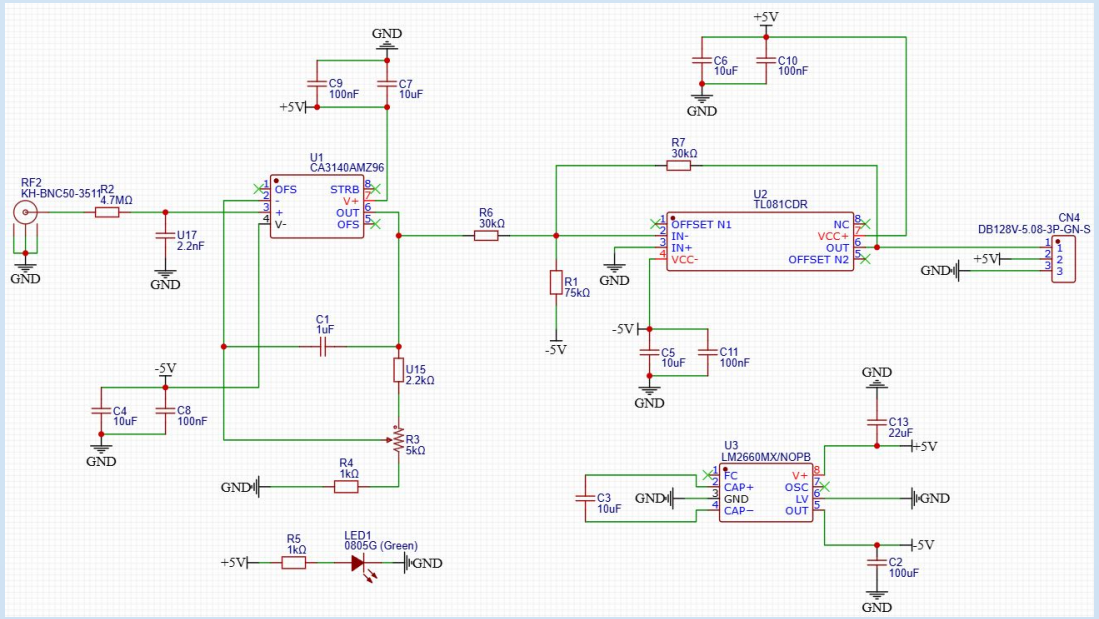


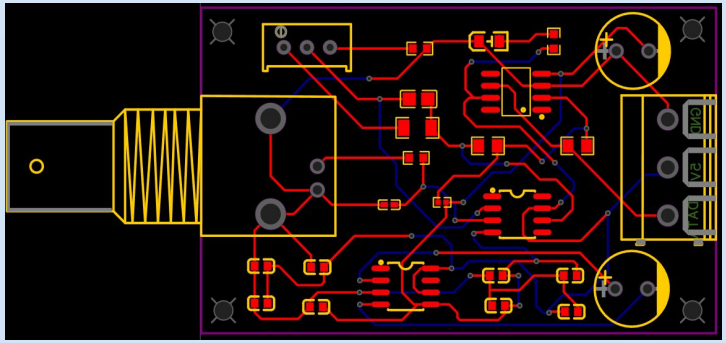
MCU PCB Design

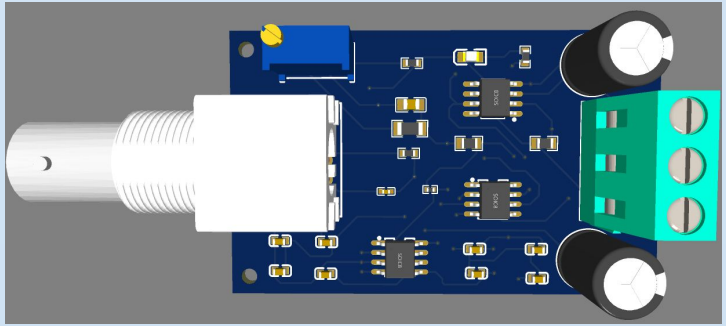




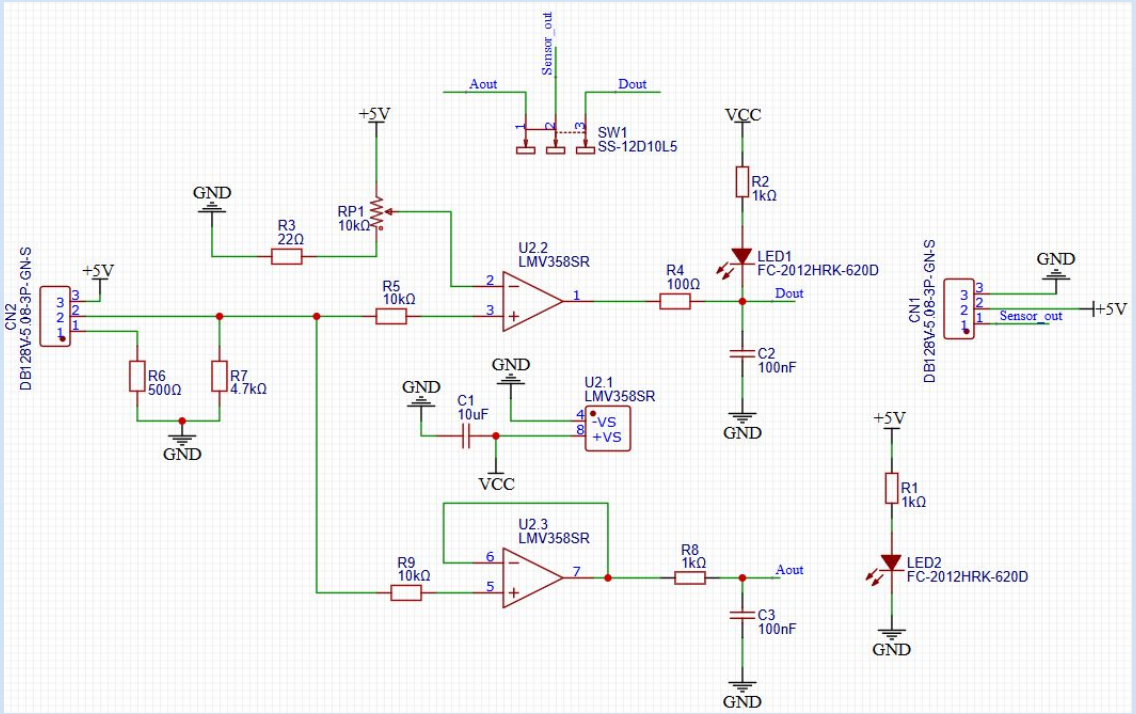
pH PCB Design

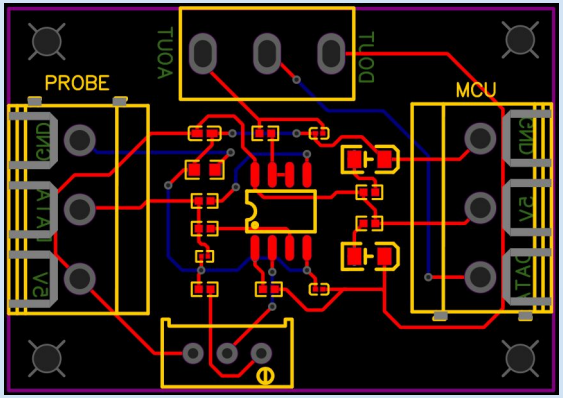


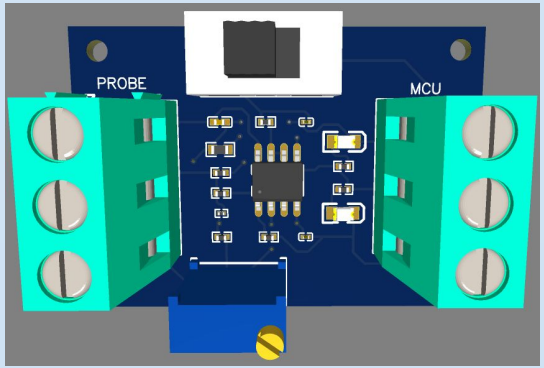




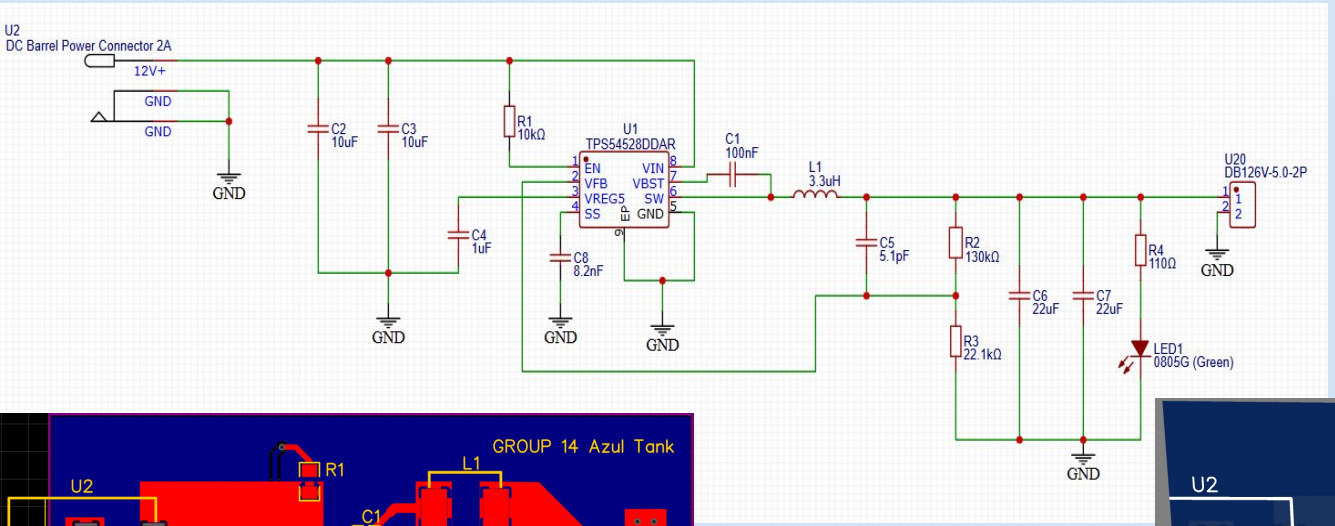
Turbidity PCB Design

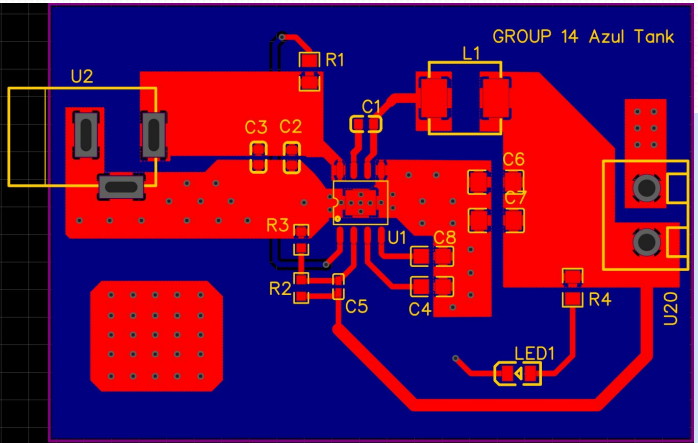


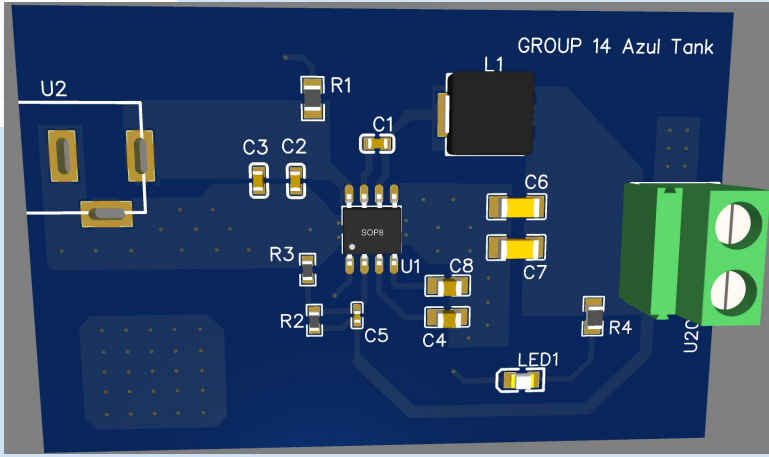




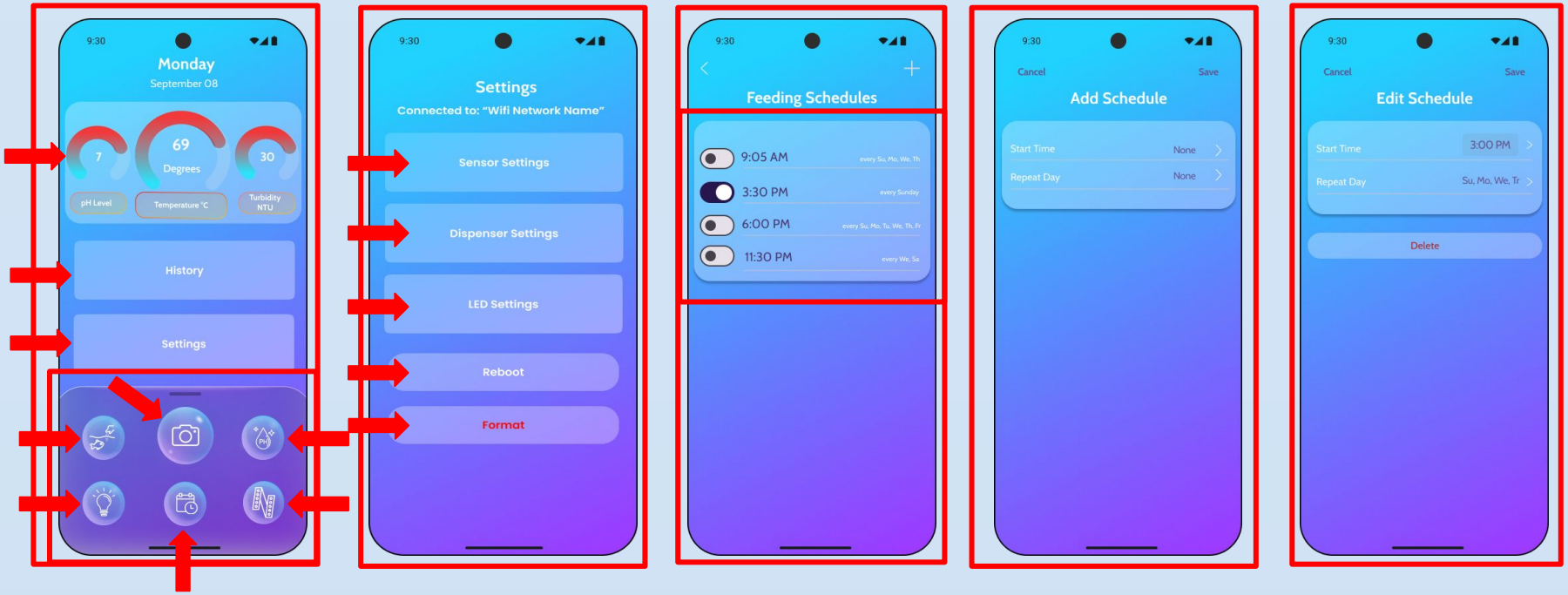
Voltage Regulator Board Design





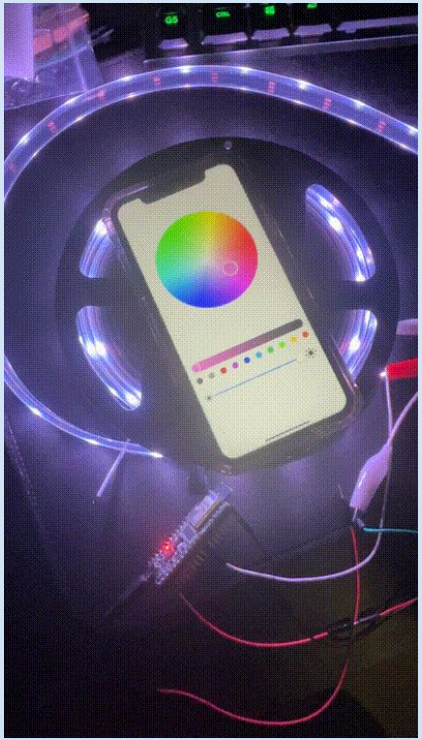


App User Interface



Prototype and Testing for LEDs

- **Setup**
  - The prototype features an ESP32 microcontroller directly connected to a WS2812B RGB LED strip.
  - Communication with the mobile app
- **ESP32 Microcontroller**
  - ESP32 serves as a web server
- **Communication**
  - The ESP32 connects to the local WiFi network
  - The app sends RGB colors and brightness levels to the ESP32



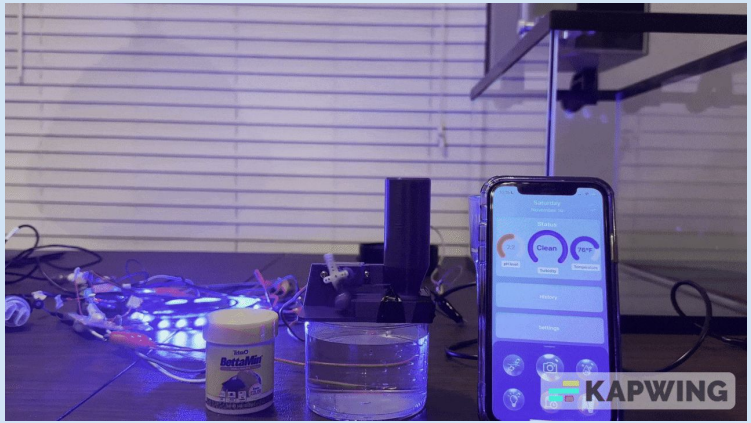
Prototype and Testing for Temp. Readings

- Setup
  - The prototype utilizes an ESP32 microcontroller connected to the DS18B20 temperature sensor via a terminal sensor adapter.
  - The sensor provides 9 to 12-bit temperature readings over a 1-Wire interface so that only one wire (and ground) needs to be connected.

- Communication
  - The mobile application can communicate either locally or remotely.
  - The MCU communicates with the mobile application via ADAfruit IO.

Prototype for Food Dispenser

- Setup
  - The prototype utilizes an ESP32 microcontroller connected directly to a sg90 servo motor.
  - The mobile application serves as the controller.
- Communication
  - The mobile application can communicate either locally or remotely.
  - The MCU communicates with the mobile application via ADAfruit IO.



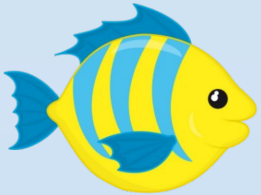
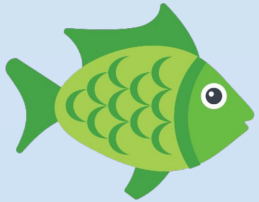
- The food dispenser releases 0.05 Oz of 2mm food pellets every 25 seconds

Bill of Materials

Budget and Financing	
Component	**Estimated Price**
pH Sensor	$50
Temperature Sensor	$10
Turbidity Sensor	$20
Dispenser(s)	$20
LED Lights	$16
Development boards	$18
Micro SD Card Module	$8
Servo Motor	$7
Stepper Motor	$24
PSU	$8
Custom PCB	~$79
Total	**$278**

Work Distribution

- **Christian Rosado**
  - Mobile Application UI
  - App Logic
  - Peripheral & MCU programming
  - Database
- **Jazz Olario**
  - Mobile Application UI
  - App Logic
  - Peripheral & MCU programming
  - Web Server
- **Rafael Nieves**
  - Sensor Schematics
  - Sensor PCB Design
  - MCU Schematic
  - MCU PCB Design
- **Gabriel Besana**
  - Motor Controller Schematic
  - Voltage Regulator Schematic
  - Voltage Regulator PCB Design

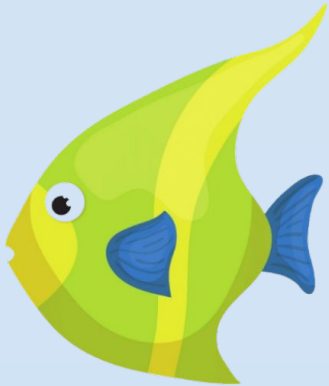
Software Challenges

Challenge:

- The MCU handling multiple sensor readings at a time.

Solution:

- Establish a queue system.



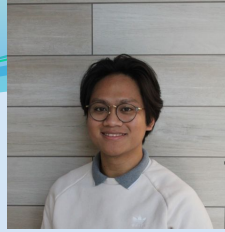
Challenge:

- Data synchronization problems between ESP32 and the mobile app.

Solution:

- Opting for long polling communication instead of websocket communication.

Hardware Challenges



Challenge:

- Communication issues with ESP32 board when connecting the sensors.

Solution:

- Troubleshoot the hardware and software side to find any discrepancies. Finding the compatibility issues, electrical noise, and or power supply issues

Challenge:

- PCB troubleshooting. Incorrect components, layout issues, grounding issues.

Solution:

- New board layouts and iterations or resoldering of new components to fix any issues on our boards.

Challenge:

- Improper data voltage signals from the sensors to the MCU.

Solution:

- Creation of a voltage divider board in between our mcu and sensors to step down the 5V signal to 3.3V signal that our MCU can read.

Thanks for watching!