Automatic Cat Litter Box

Electrical & Computer Engineering

ECE 445 Senior Design Laboratory

Team 12

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Project Objective

Problem:

Cat litter boxes in the current market lack the ability to give health insights derived from the cat's litter box behaviors. Behaviors such as prolonged visits or increased frequency of use may all be indications of potential health concerns.

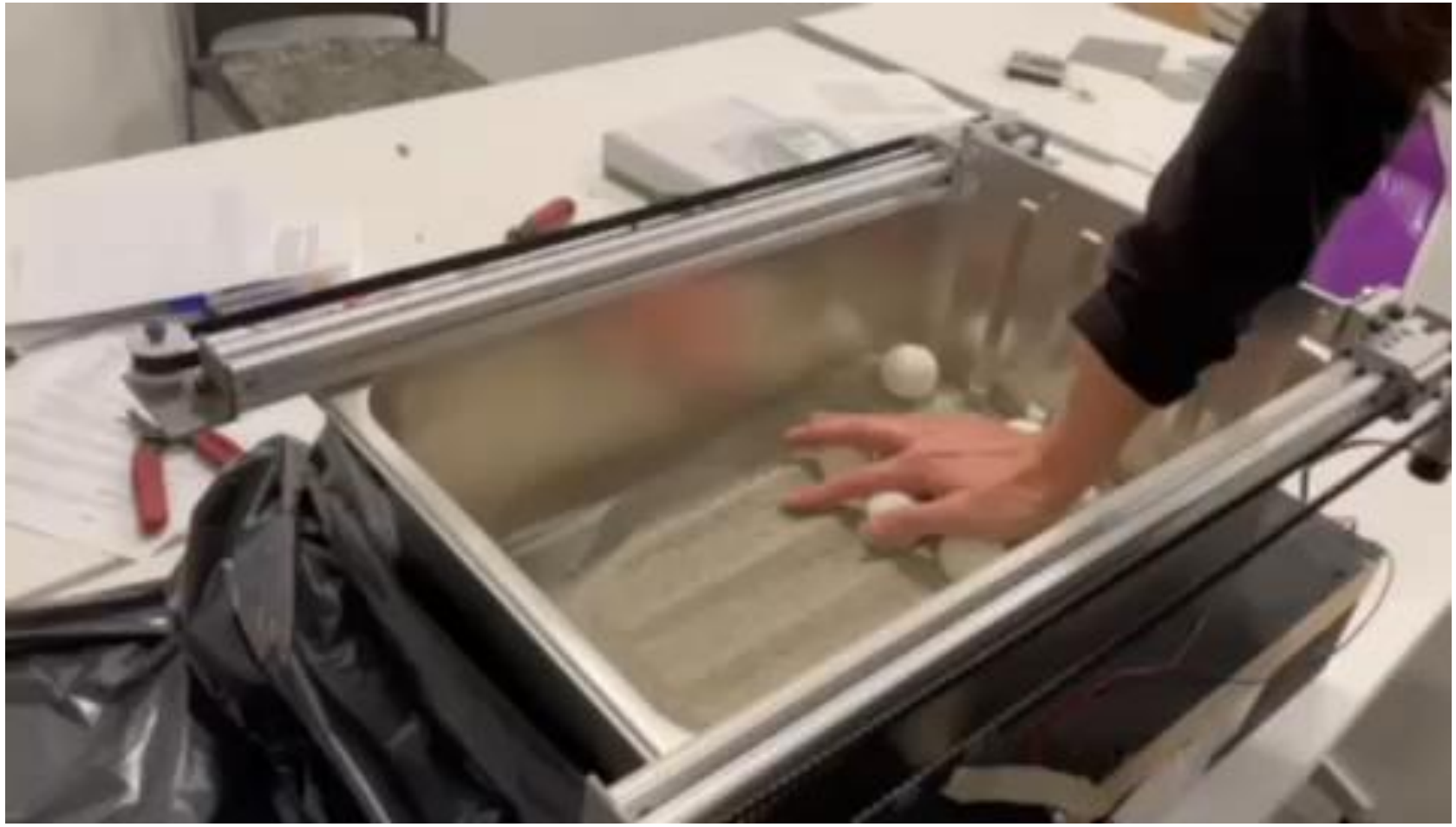
Solution:

- Track usage time each visit
- Frequency of visits
- Automatically rake waste
- Communicate with owner

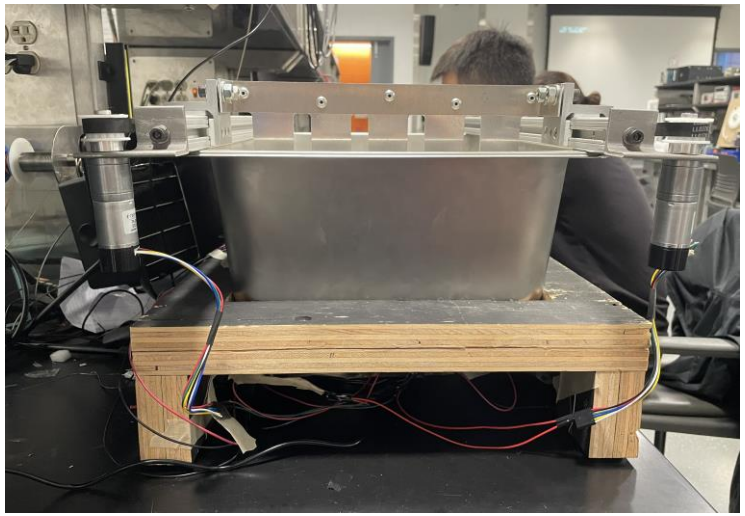
High-Level Requirements

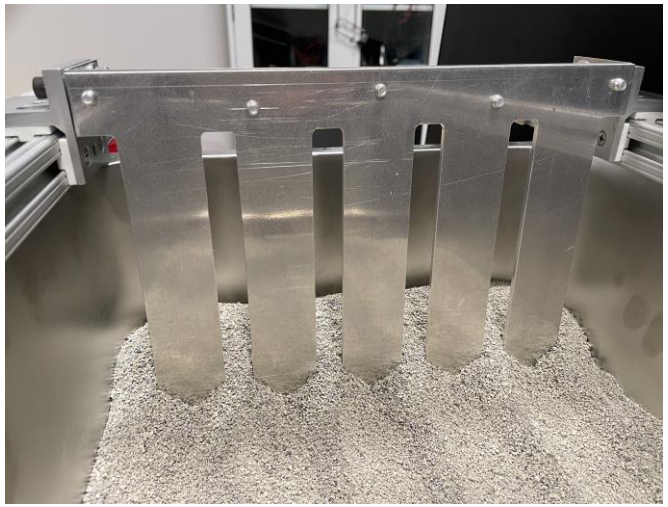
- The litter box should accurately detect the cat’s frequency of use, and the duration with an accuracy of 70% or higher.
- The rake should be able to rake most of the waste into the disposal area (>70%).
- The user should be notified in a timely manner, within 5 minutes from the detection of the sensors.

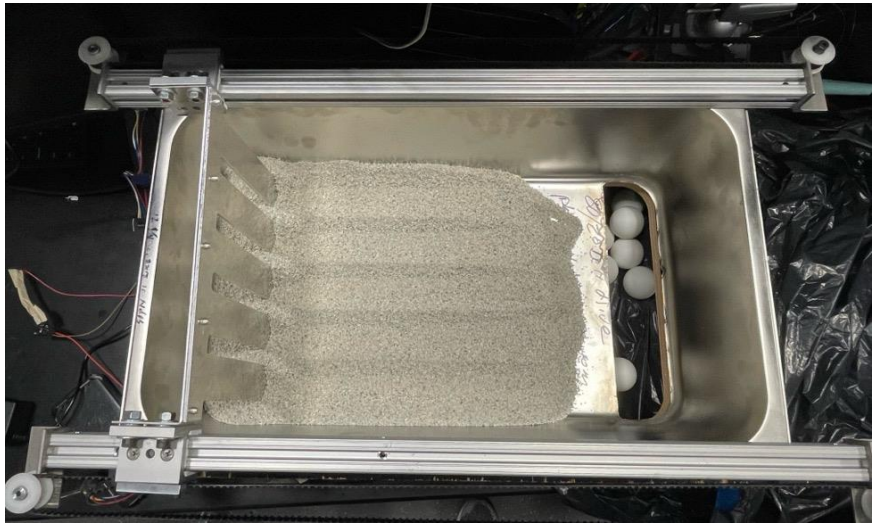
Video Demonstration

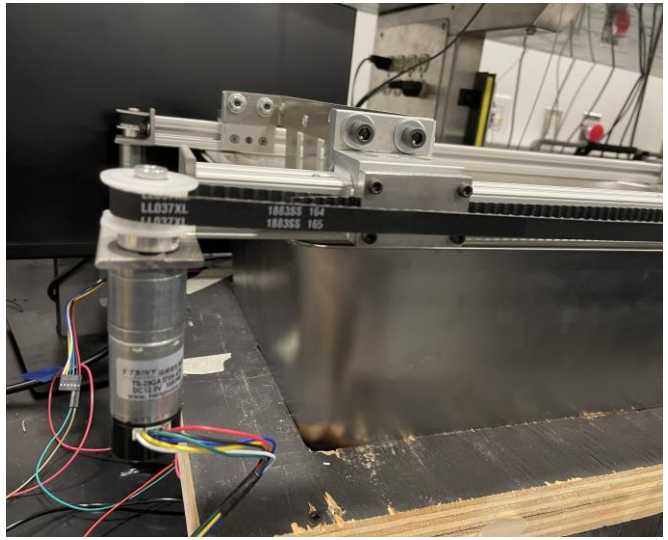


Mechanical Design

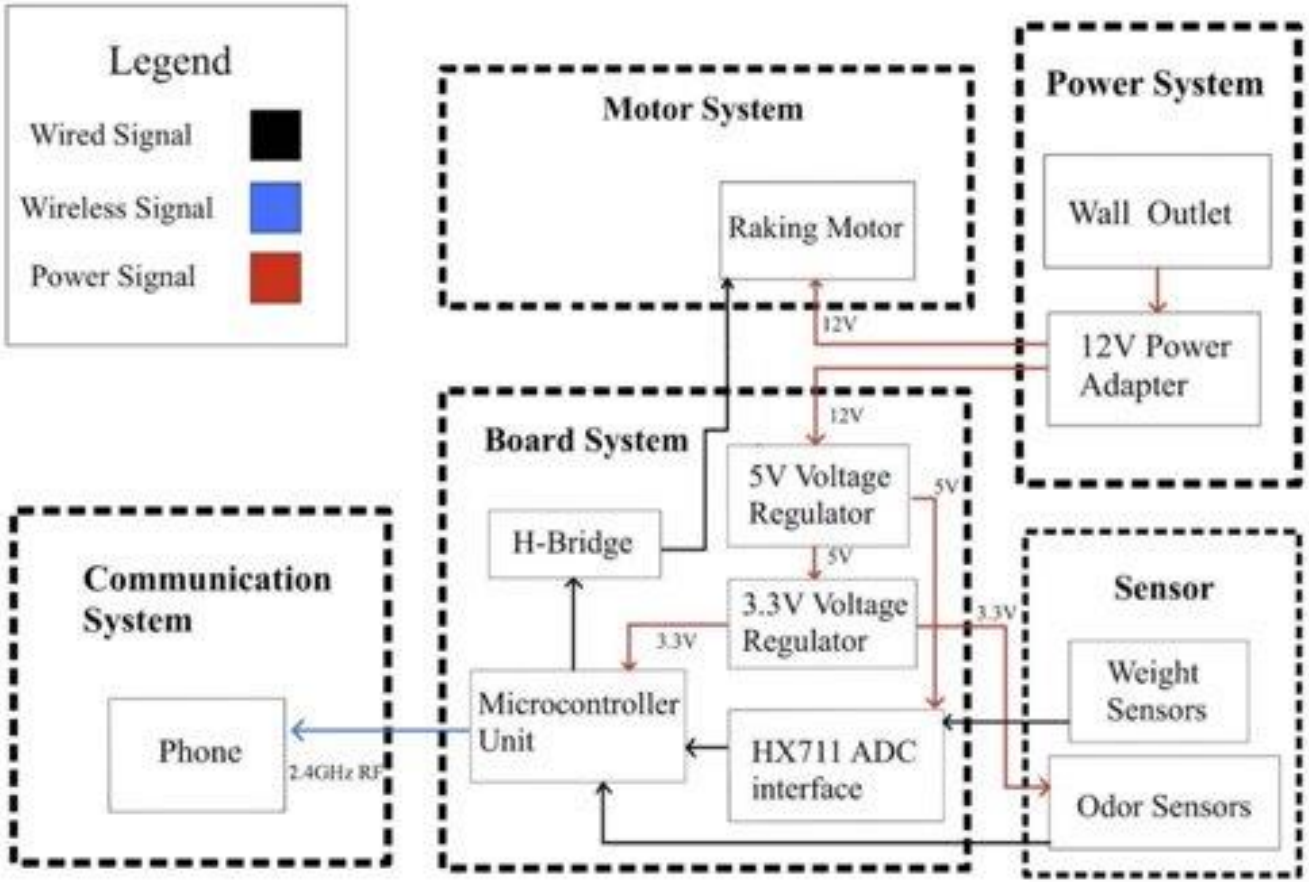




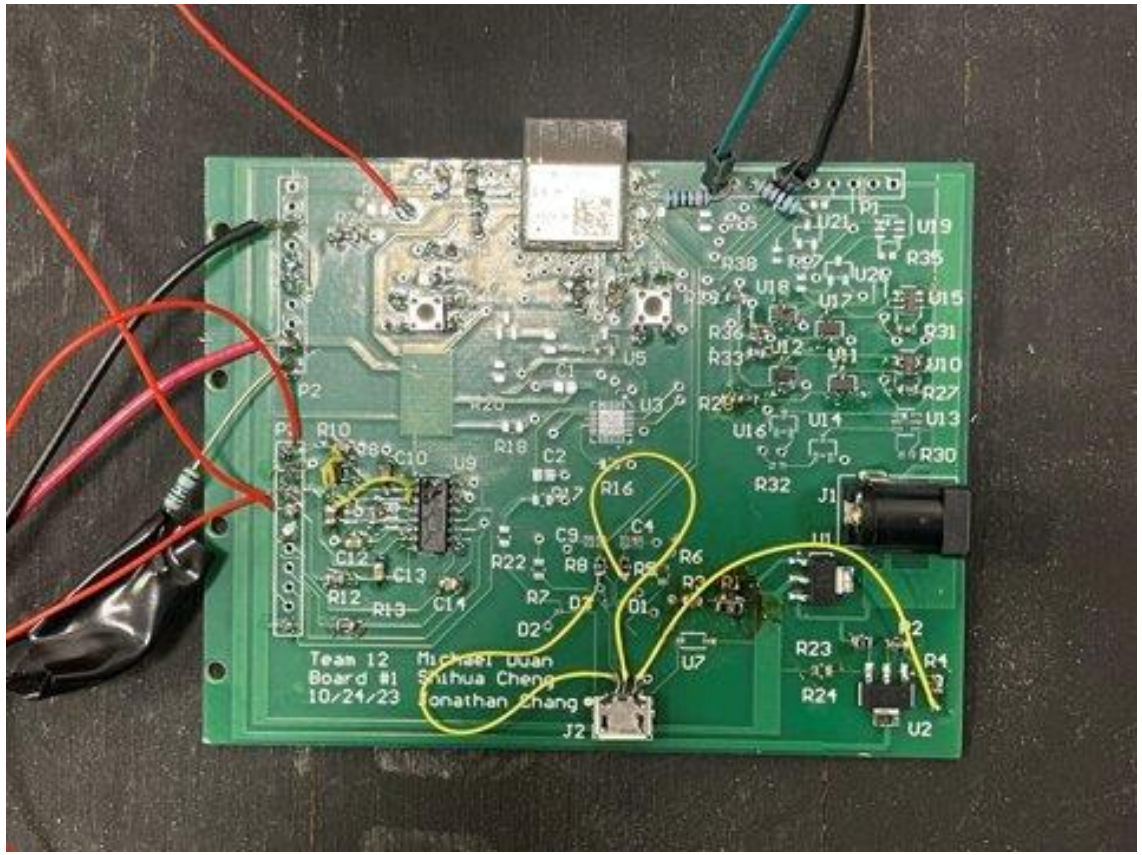


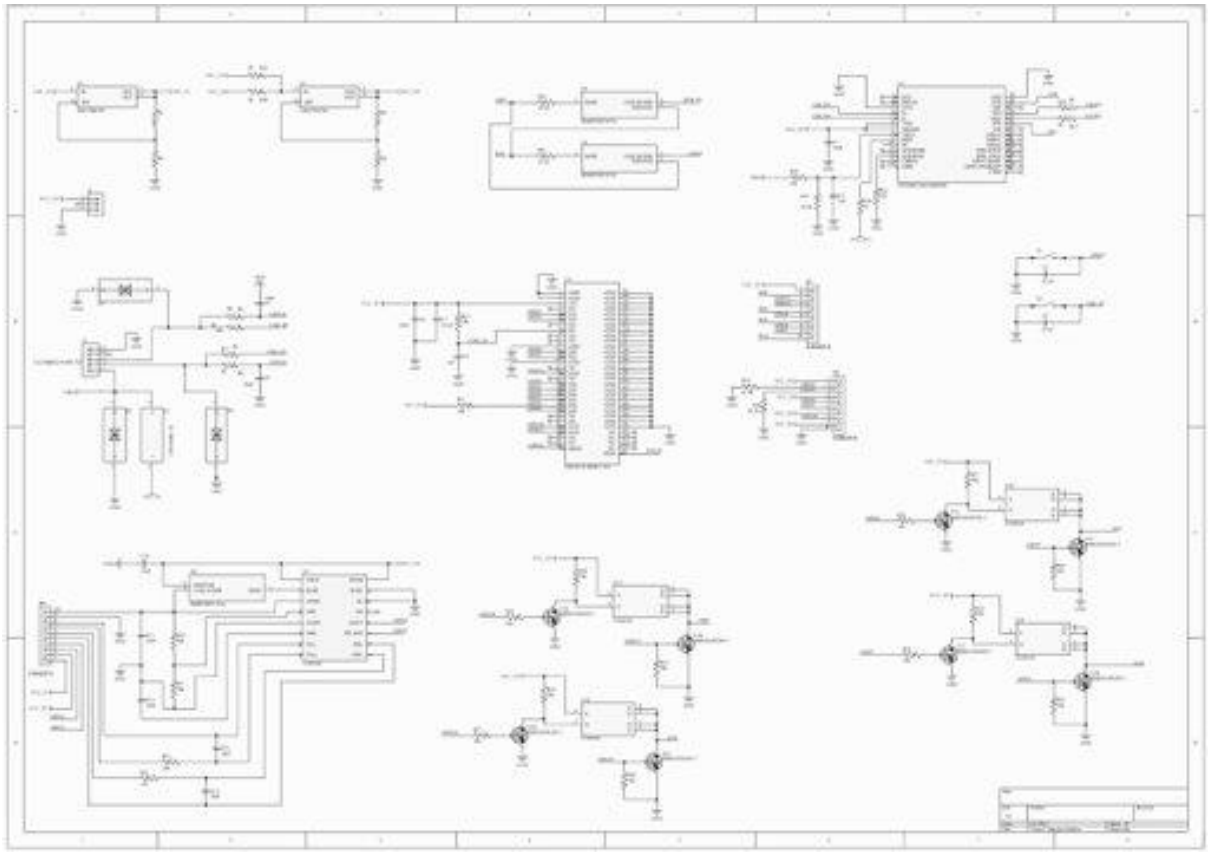


Block Diagram

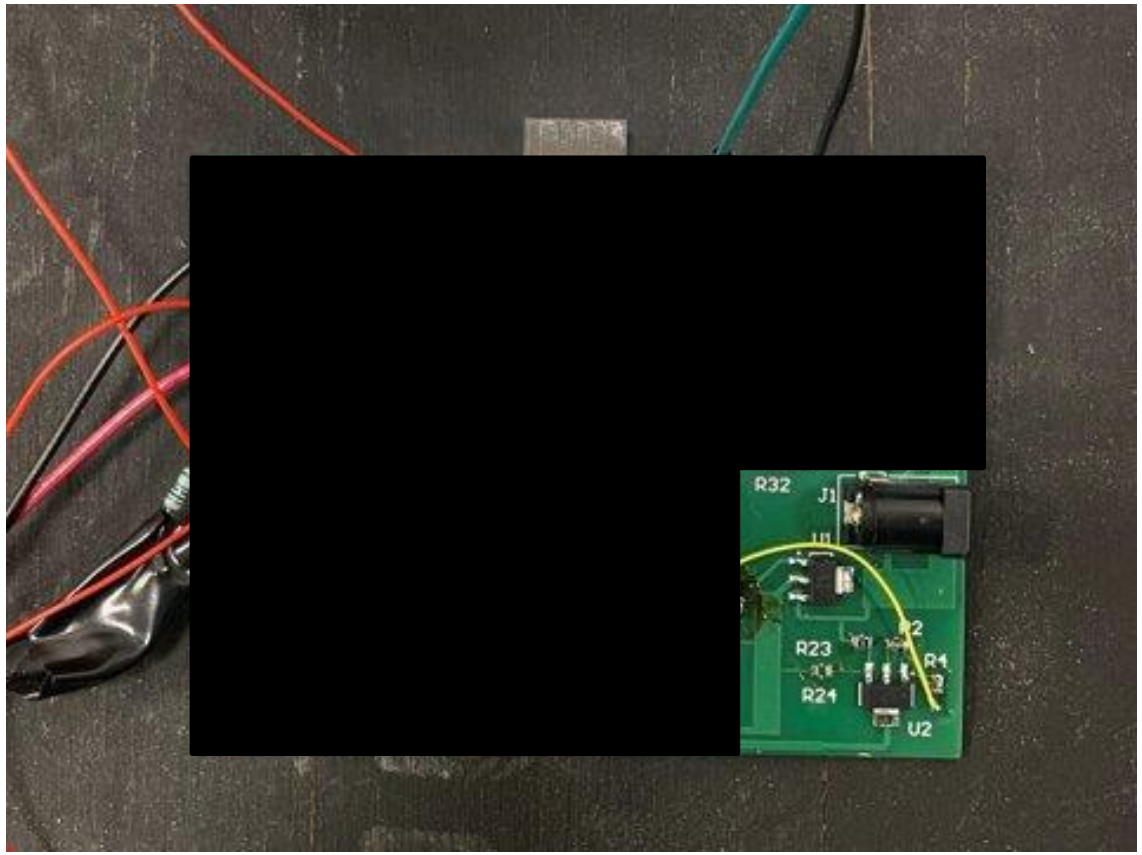


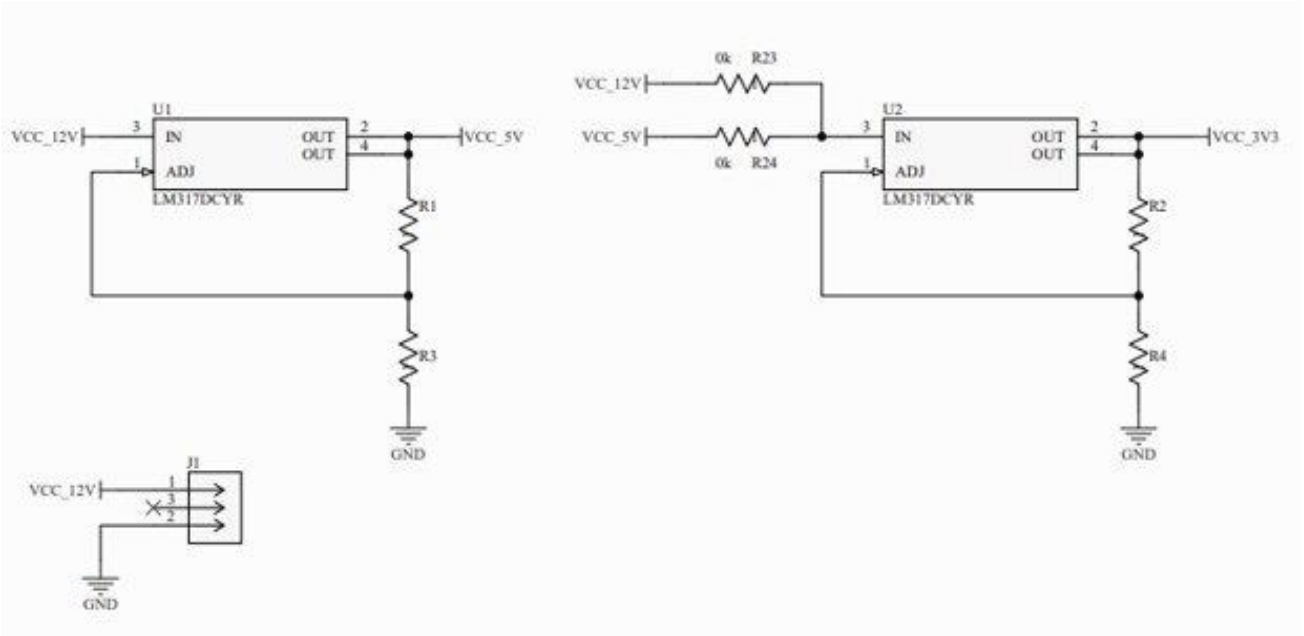
PCB and Schematics





Power Supply

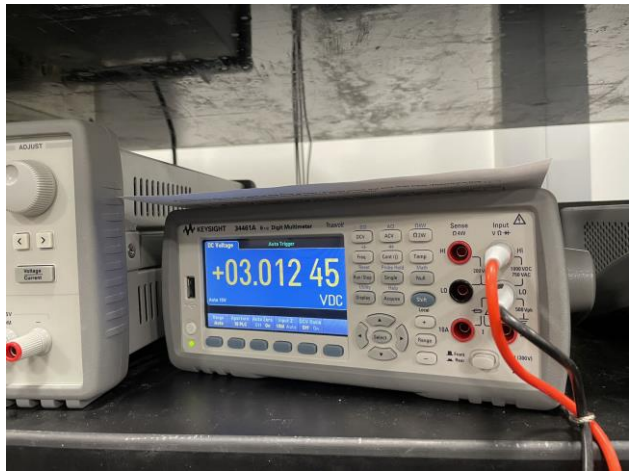




R-V Table

Voltage Regulator

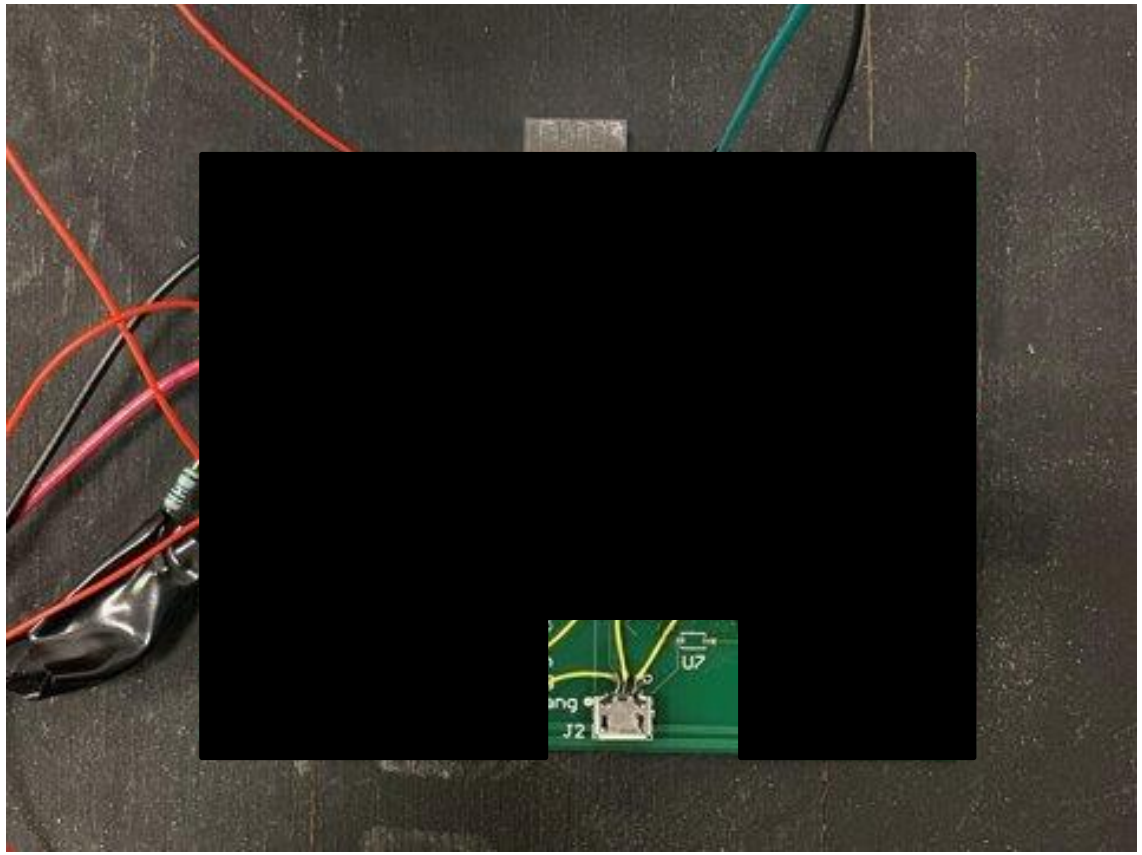
Requirement	Verification
R1. The voltage regulators must output a stable voltage within the operating voltage of the microcontroller, weight sensors, odor sensors (3.0-3.6V).	V1. Measure the output voltage of the regulator through a multimeter under load conditions and ensure it remains stable, within range.
R2. The voltage regulator must output a stable current that can supply all components of the PCB.	V2. Run the ESP32-C3 and weight sensor at the same time and measure the output current to make sure it is stable.

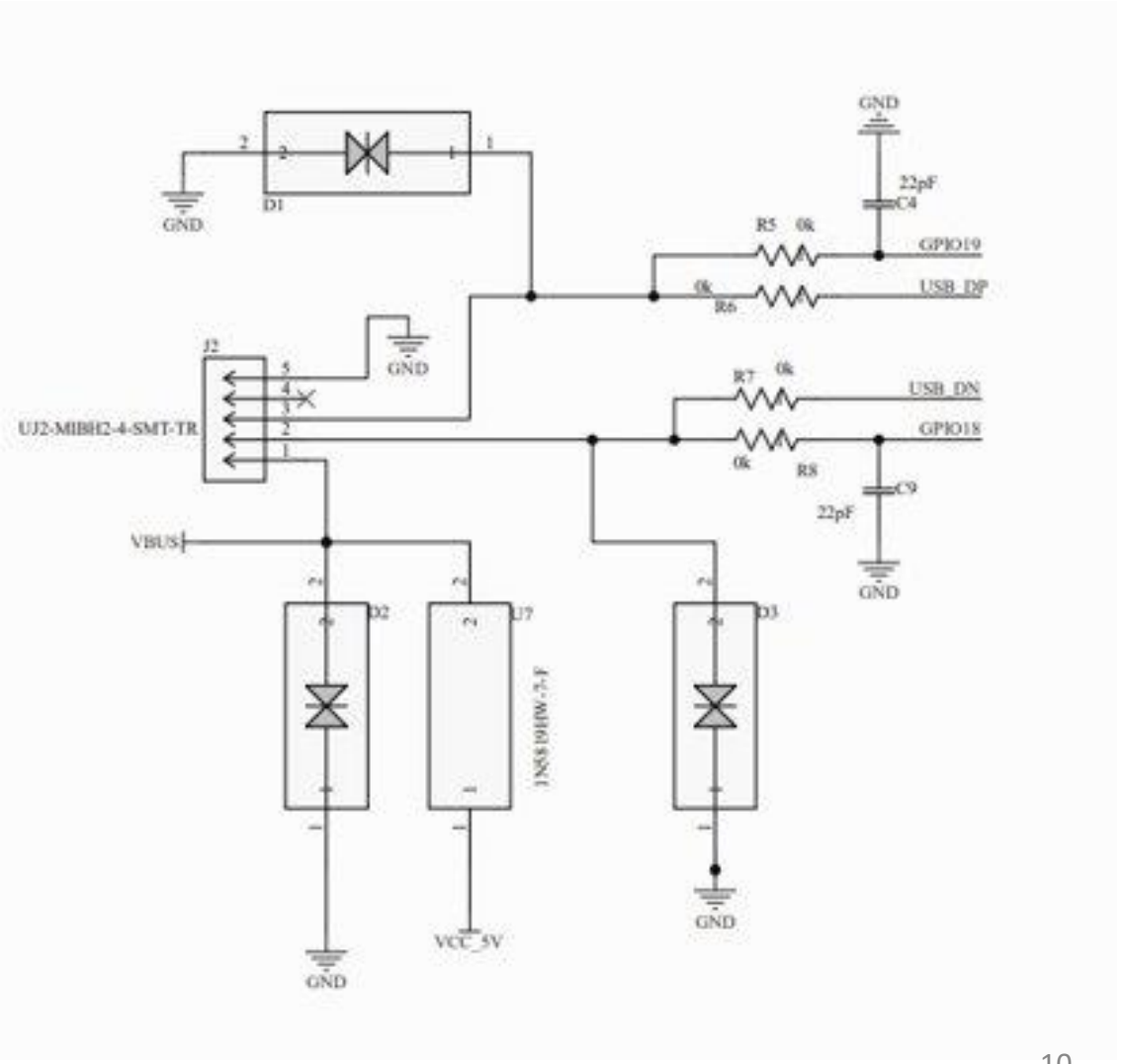


12V Power Adapter

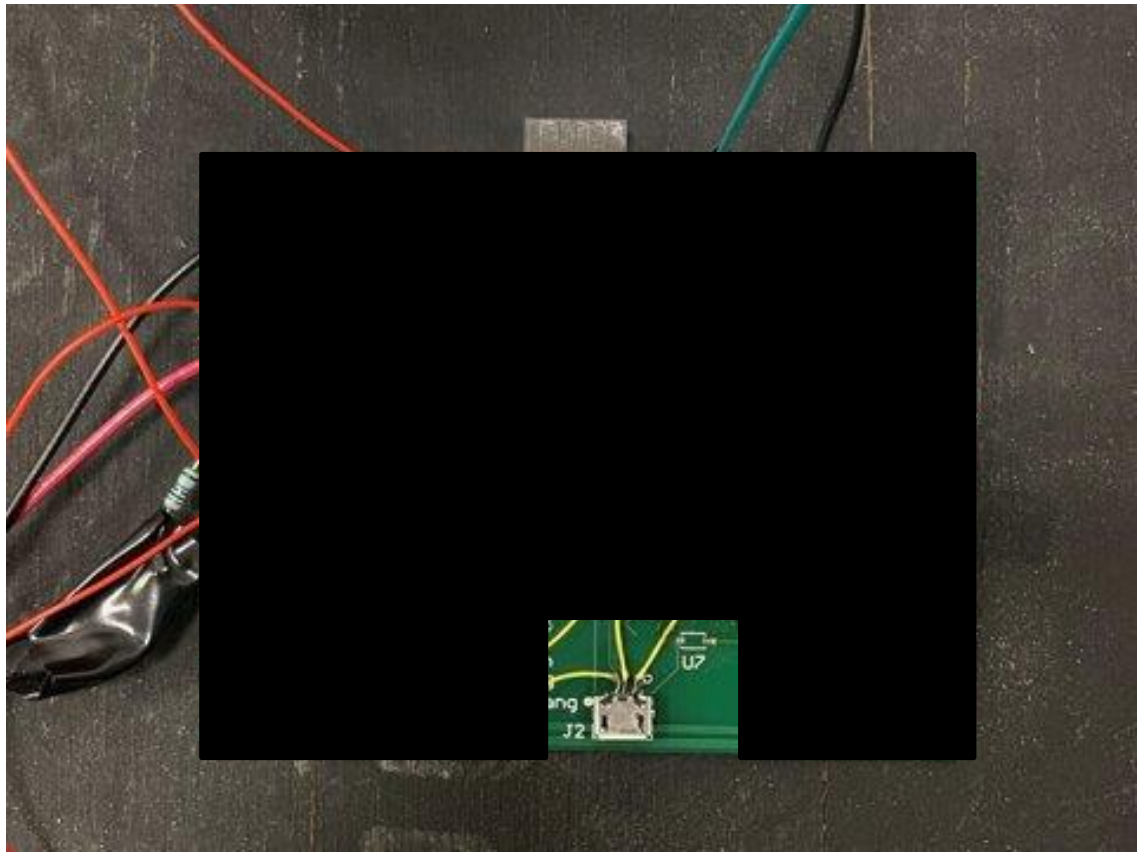
Requirement	Verification
R1. The voltage adapter must provide a stable 12V output with an error of less than 5%.	V1. Measure the output voltage of the adapter under load conditions and ensure it remains stable at 12V ±5%.
R2. The adapter must consistently provide a minimum current output enough to support the PCB and motors (≥2A)	V2. Plug the power adapter into the PCB and make sure the motor and sensors are working.

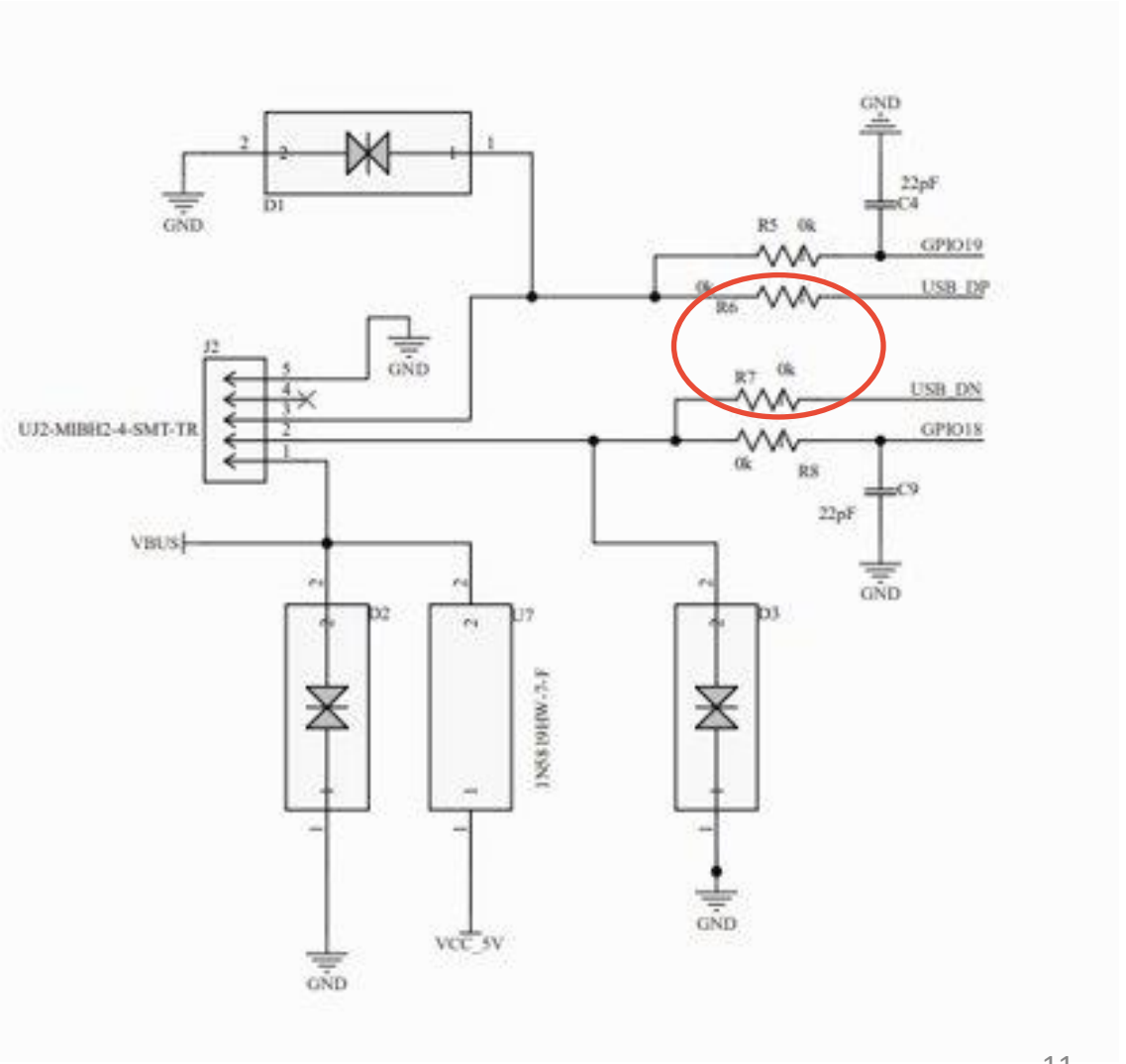
USB Receptacle



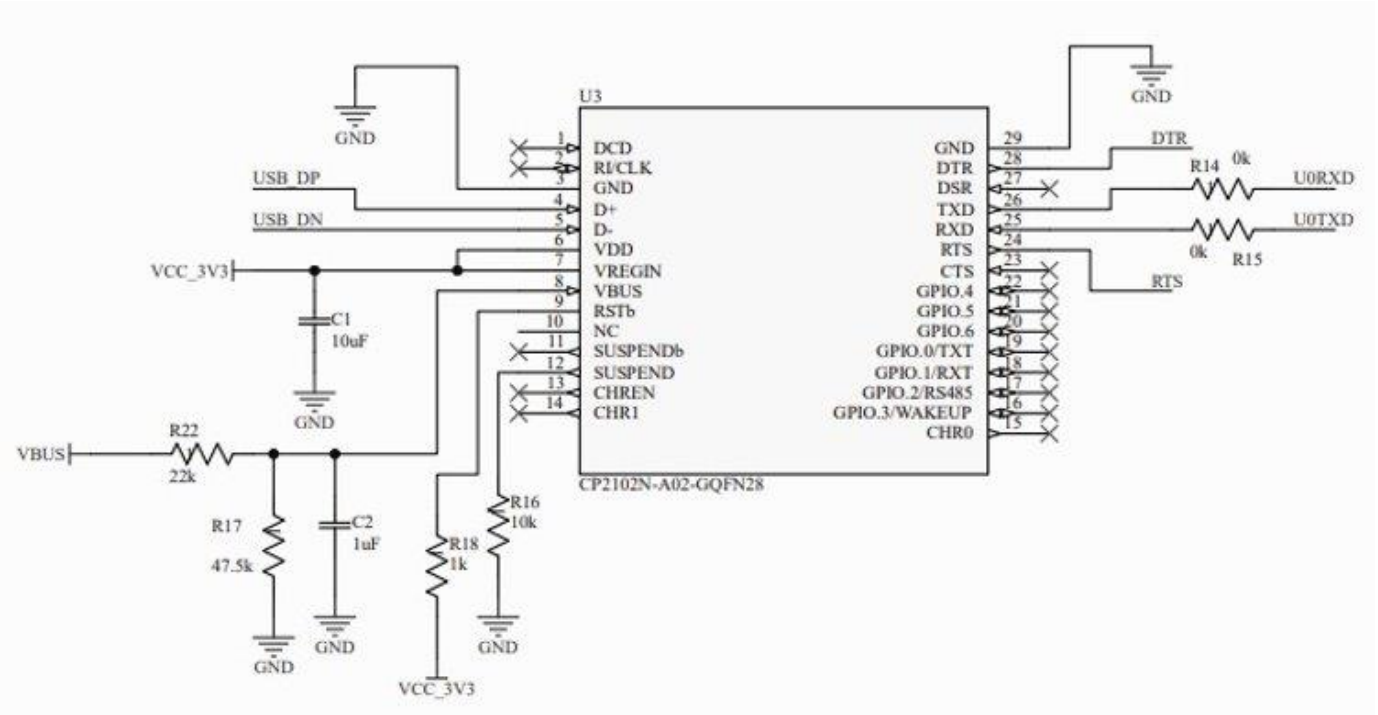


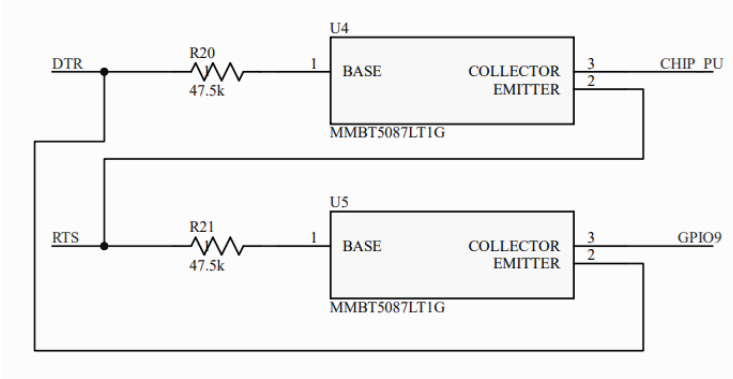
USB Receptacle w/ UART



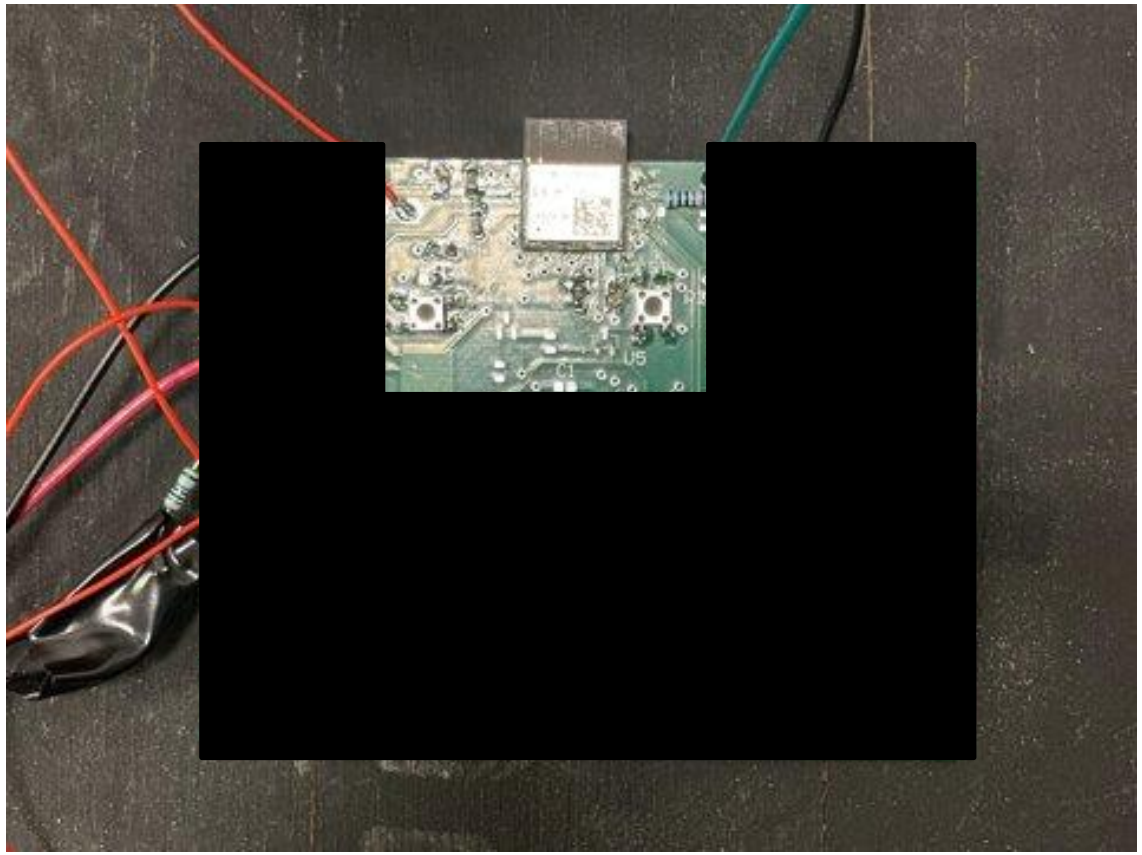


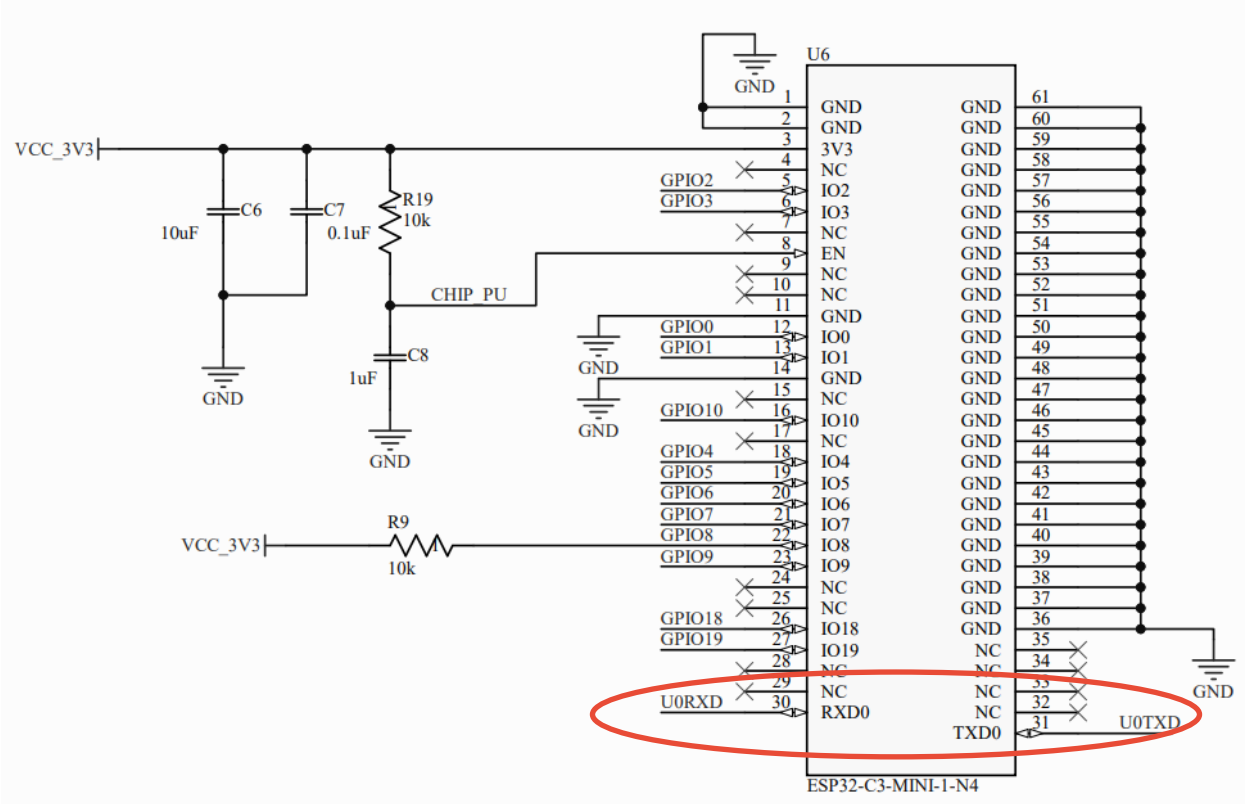
USB to UART Bridge



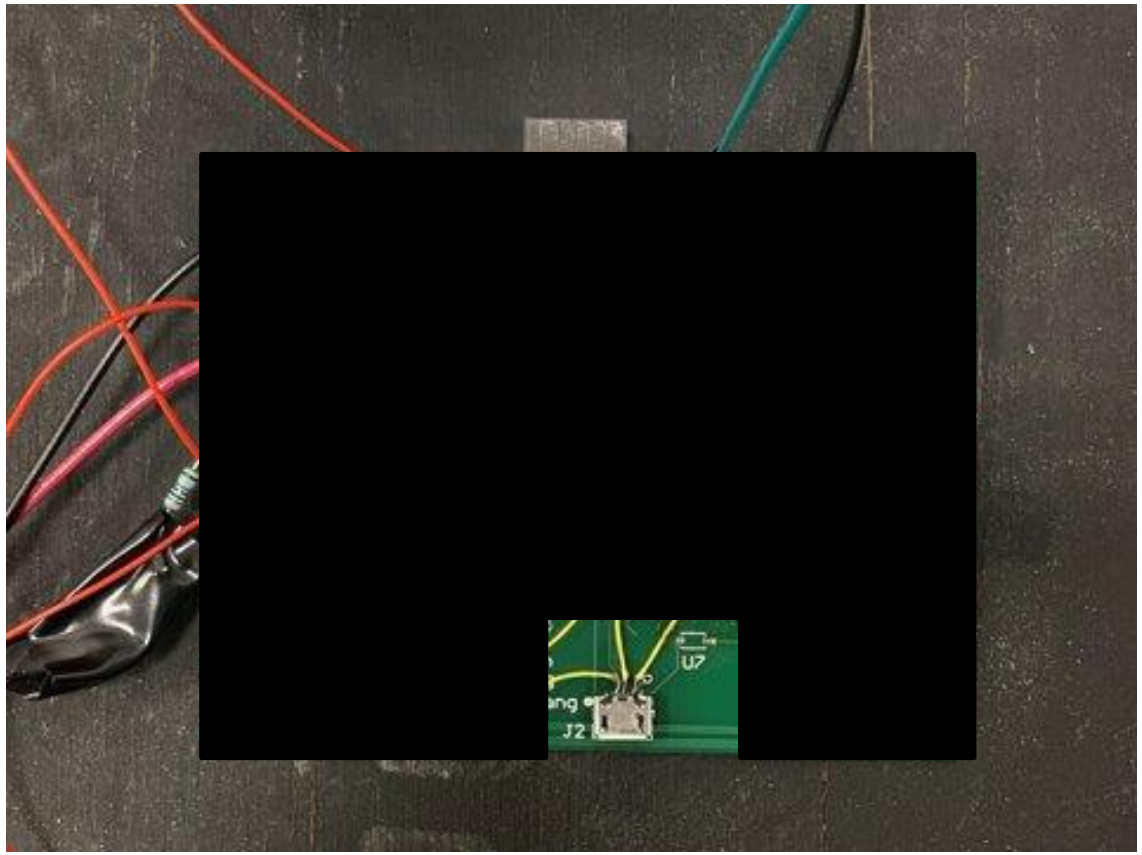


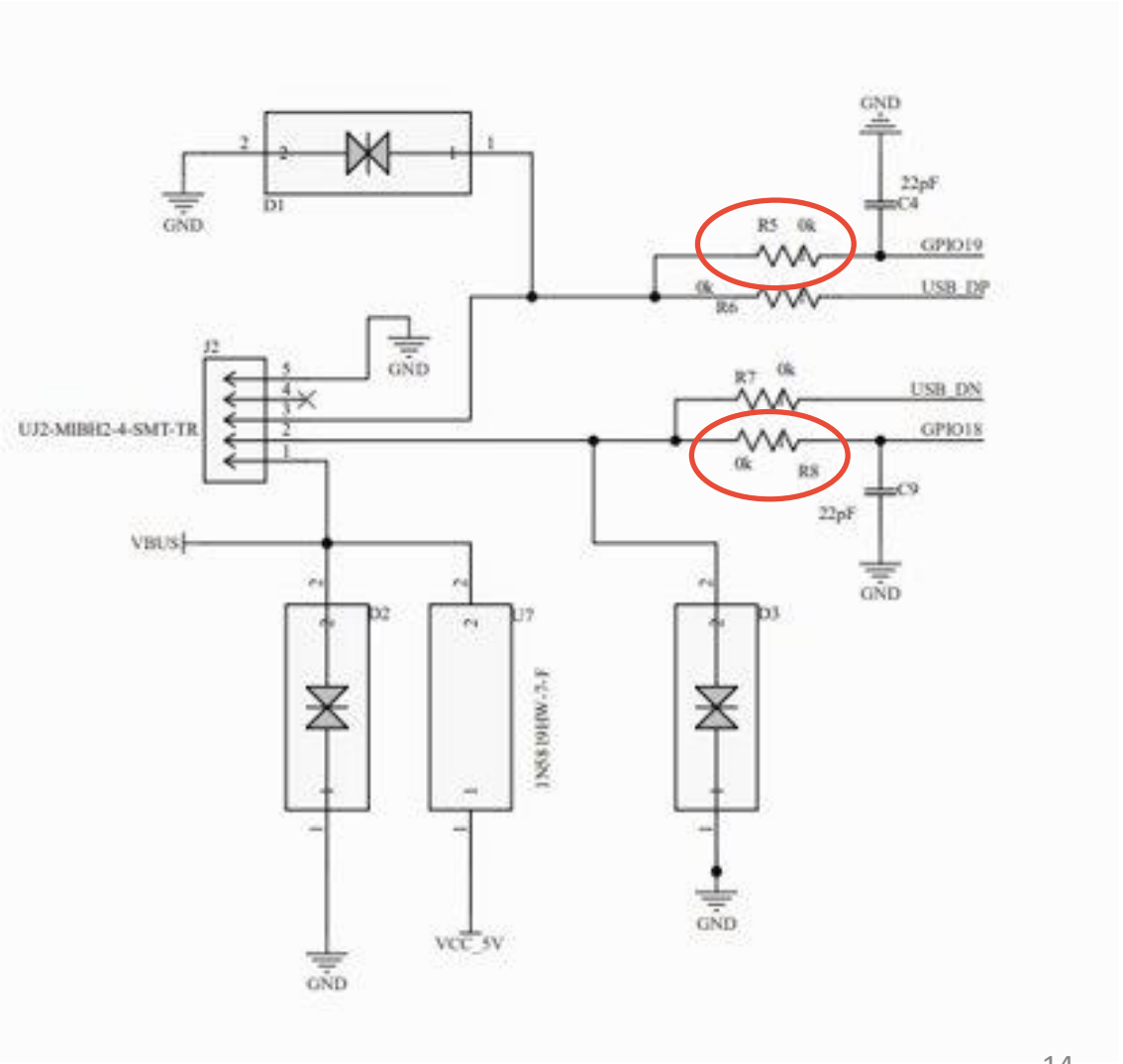
ESP32 Microcontroller w/ UART



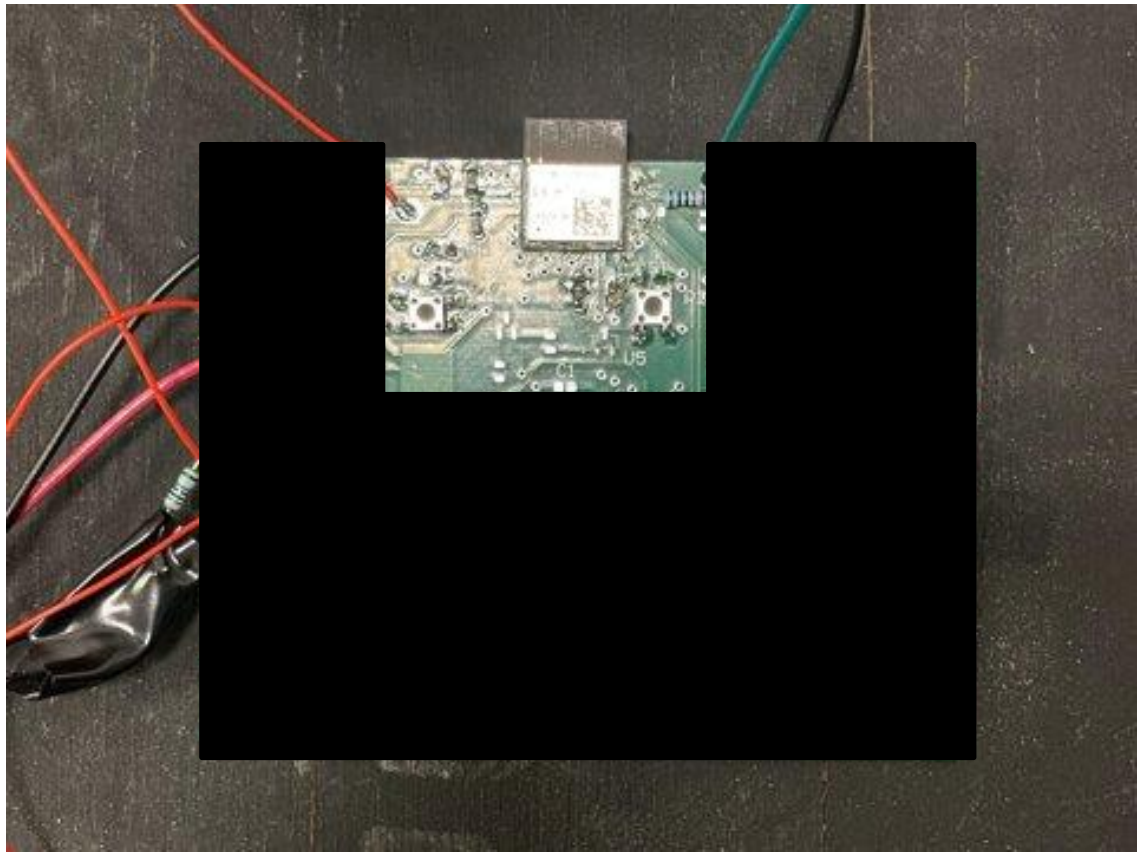


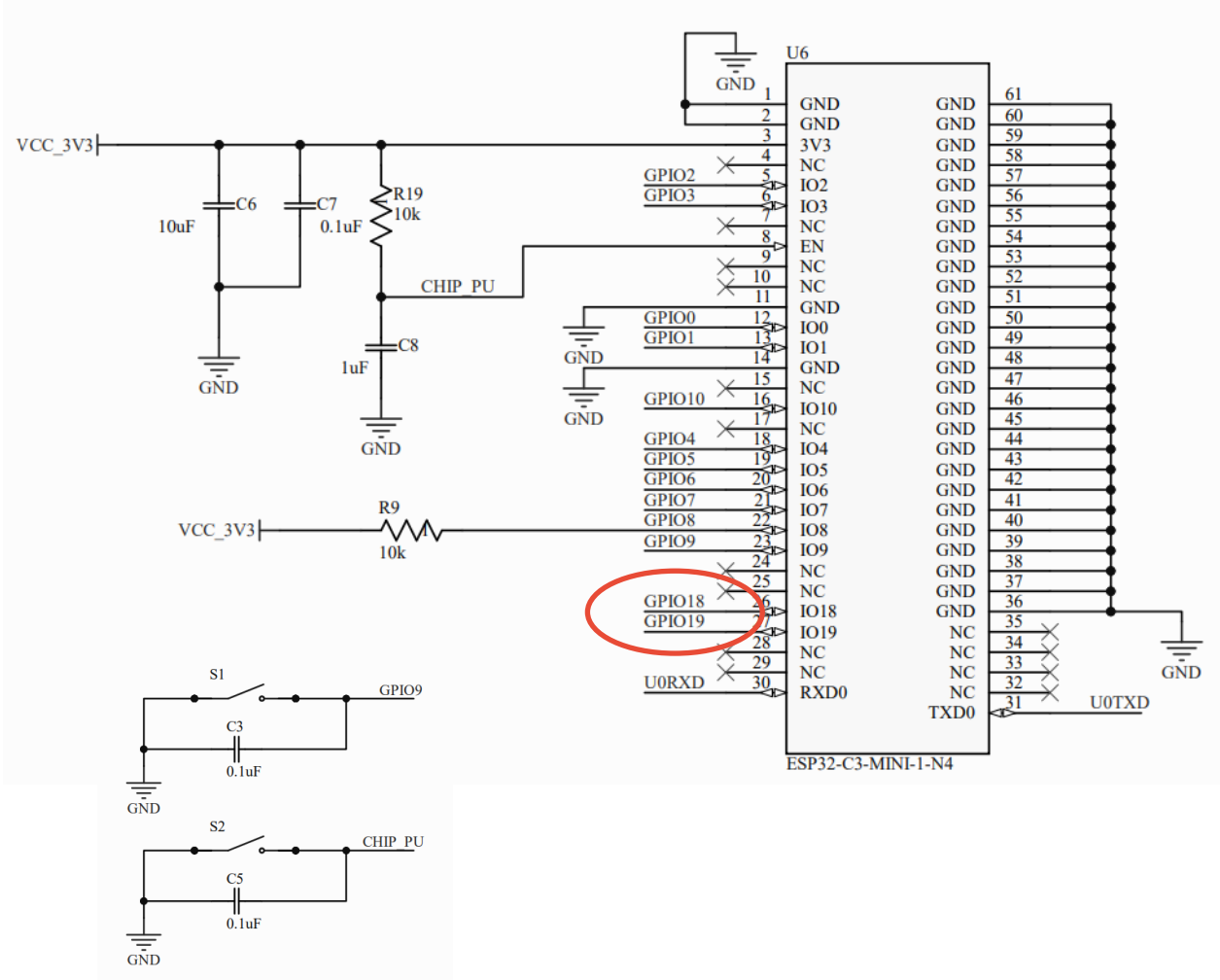
USB Receptacle w/ Direct Connection



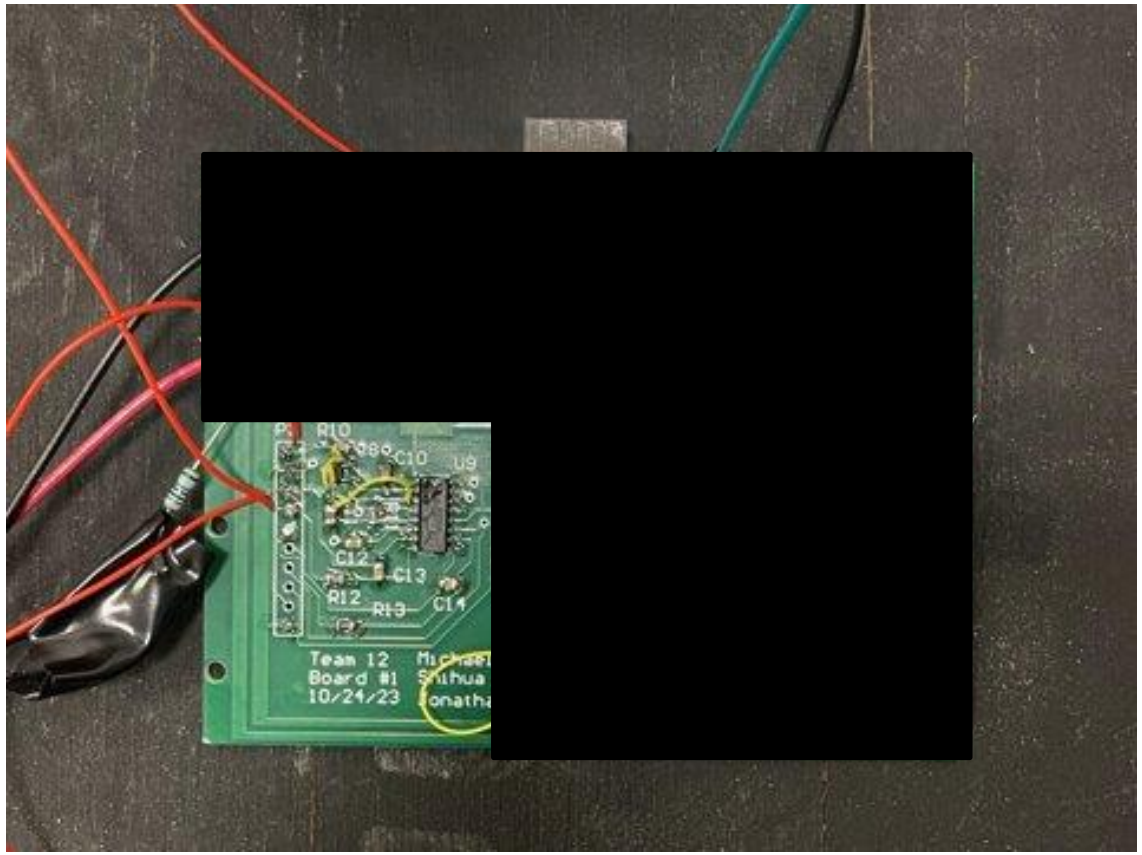


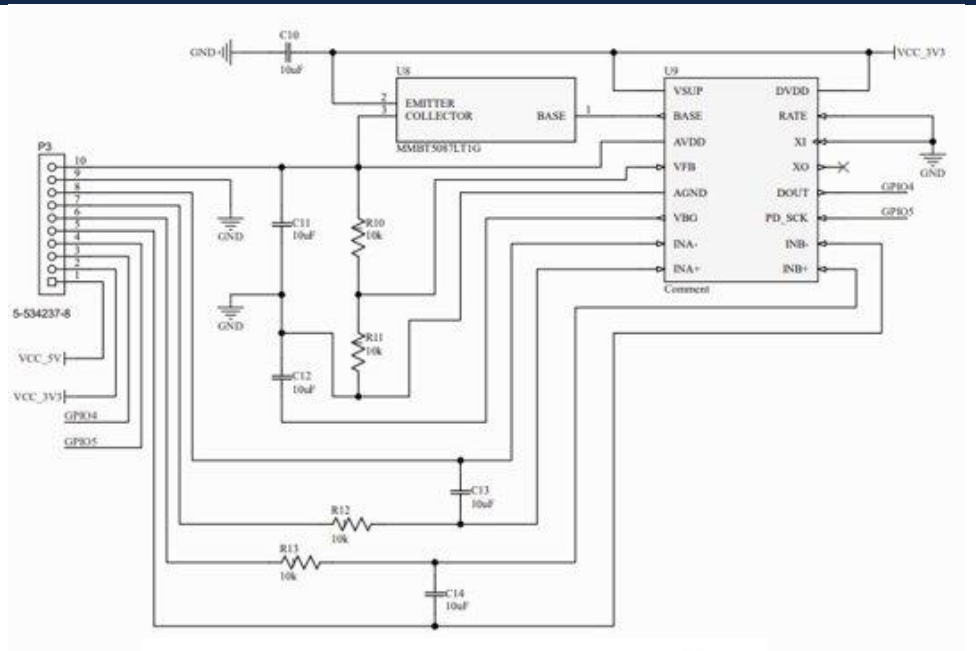
ESP32 Microcontroller w/ Direct Connection

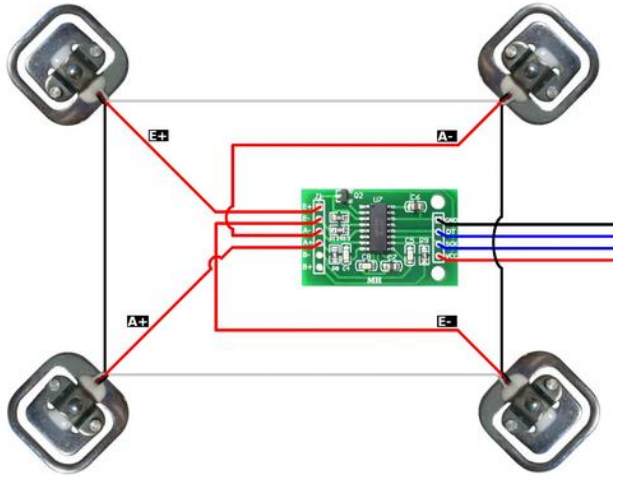




HX711 ADC





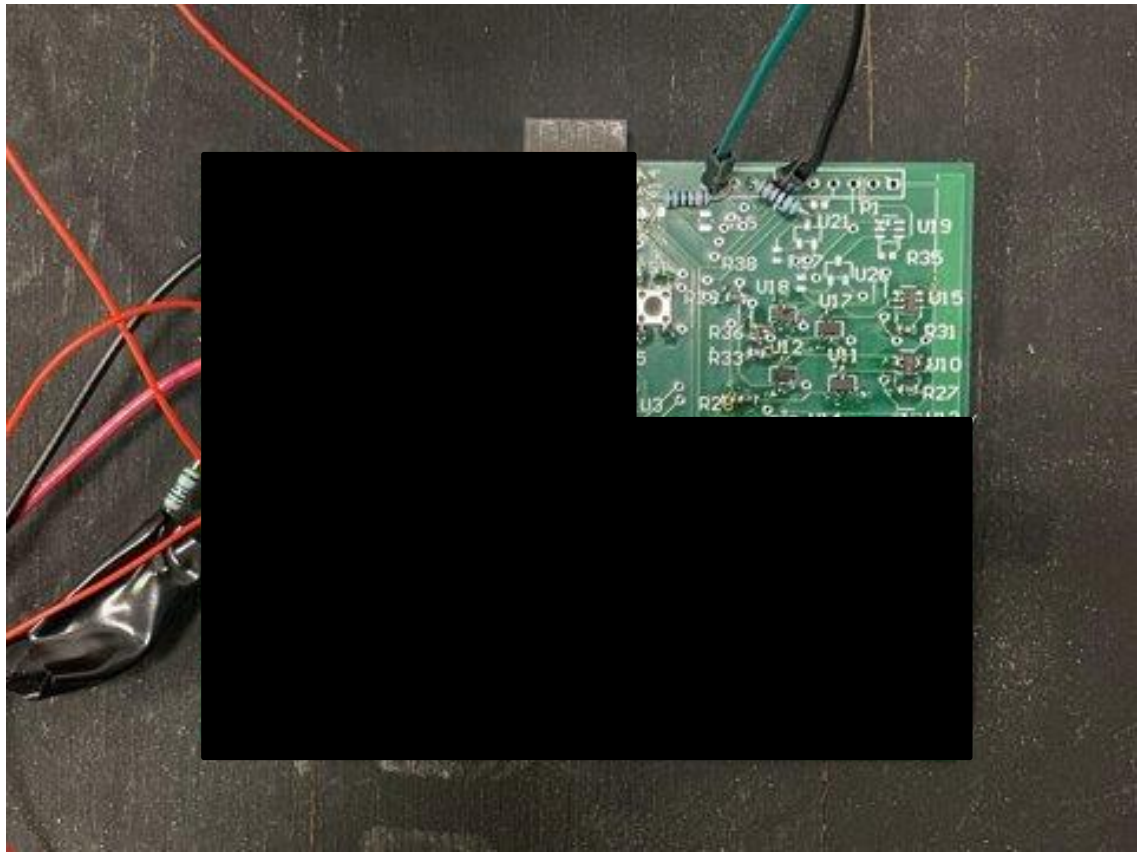


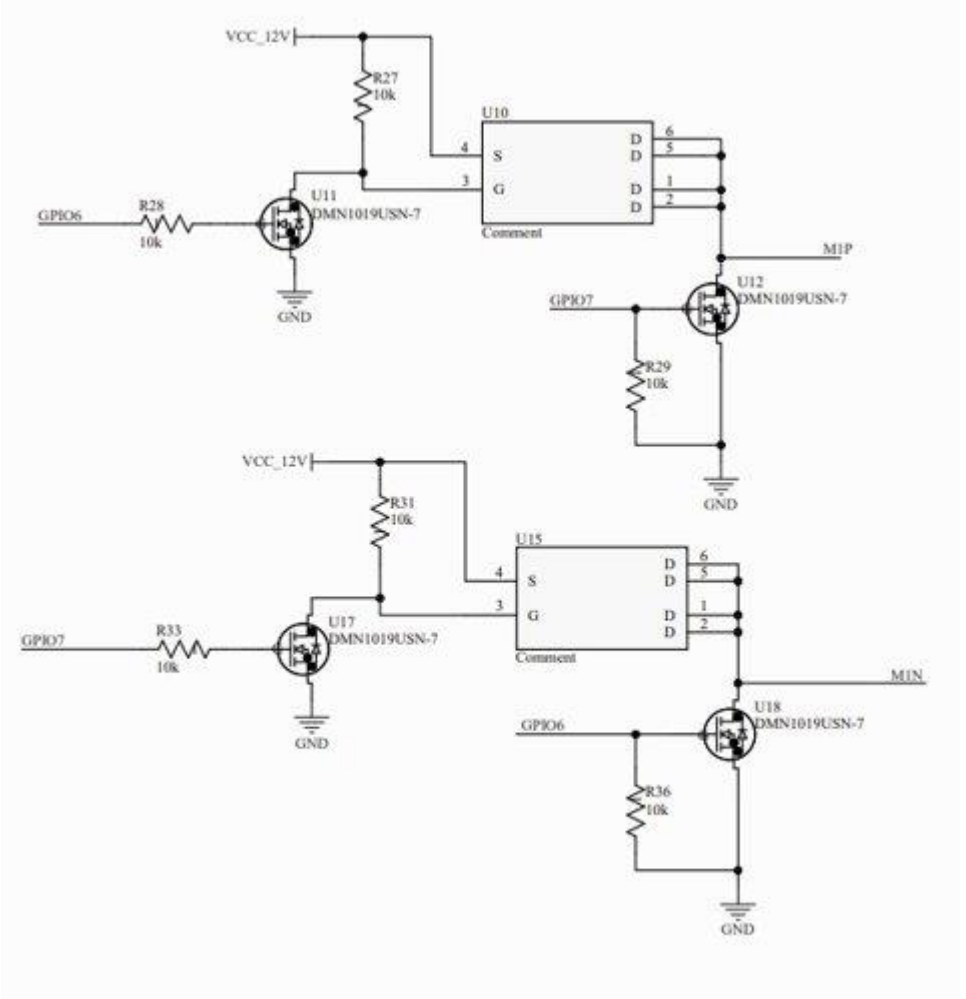
https://espeasy.readthedocs.io/en/latest/Plugin/P067.html

Weight Sensor

Requirement	Verification
R1. The weight sensor must support the maximum weight for its usage (Combined weight of litter box and cat).	V1. Apply known weights around 25kg on the sensor and confirm the system works.
R2. The weight sensor must have calibration functionality.	V2. Calibrate and test the sensor with known weights to ensure its readings are accurate. Choose several different weight points for testing to verify accuracy post-calibration, including the minimum and maximum values within the calibration range.

H-Bridge




VCC_12V
R27
10k
U10
S
G
D
D
D
D
Comment
GPIO6
R28
10k
U11
DMN1019USN-7
GND
M1P
GPIO7
U12
DMN1019USN-7
R29
10k
GND
VCC_12V
R31
10k
U15
S
G
D
D
D
D
Comment
GPIO7
R33
10k
U17
DMN1019USN-7
GND
M1N
GPIO6
U18
DMN1019USN-7
R36
10k
GND

R-V Table

H-bridge

Requirement	Verification
R1. The H-bridge must provide bidirectional control of the 12-V DC motor.	V1.Connect the H-bridge to the ESP32 and the 12-V DC motor. Use GPIO pins on the ESP32 to send control signals to the H-bridge, verifying both forward and reverse motor rotations.

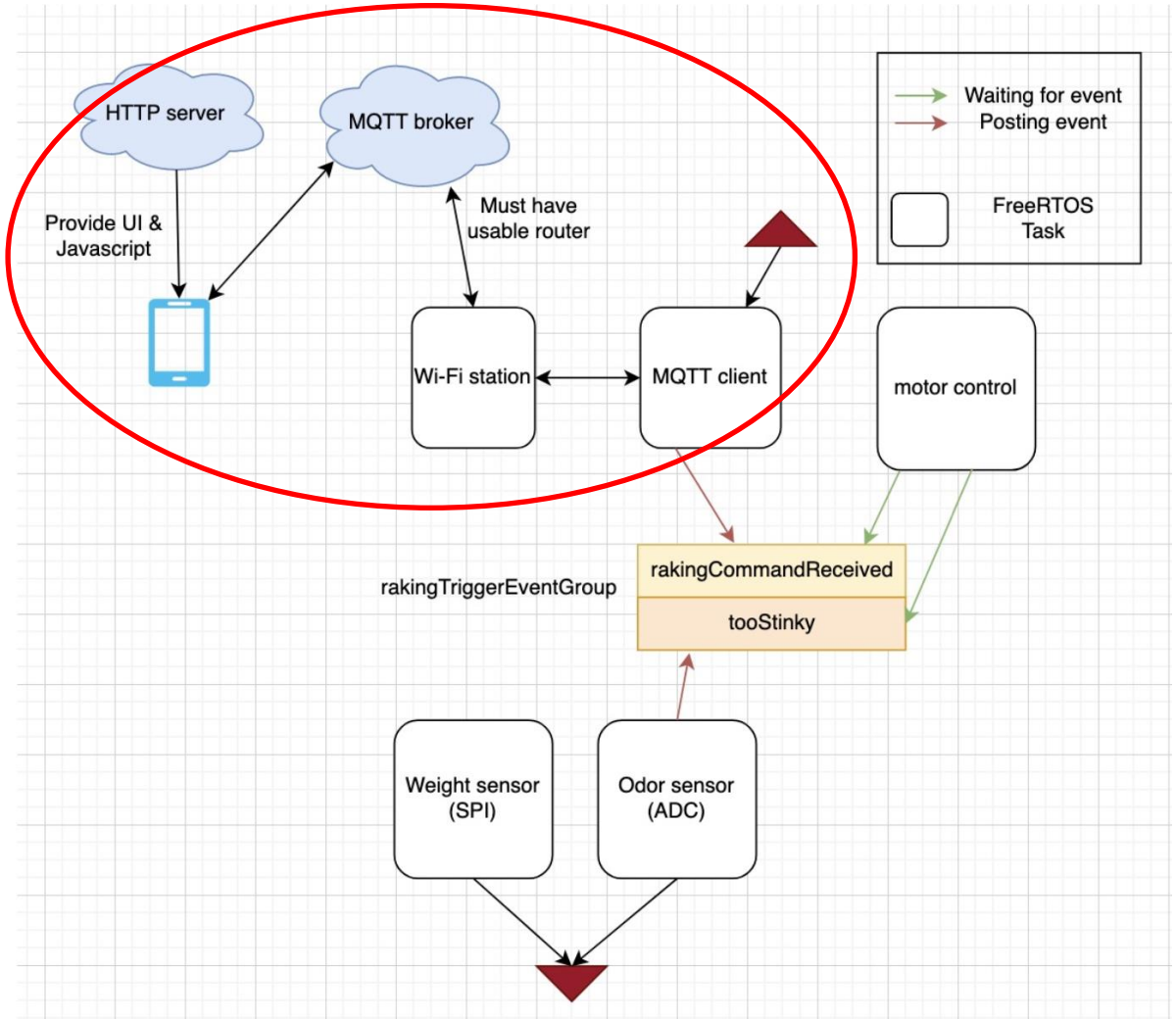
R-V Table

Raking Motor

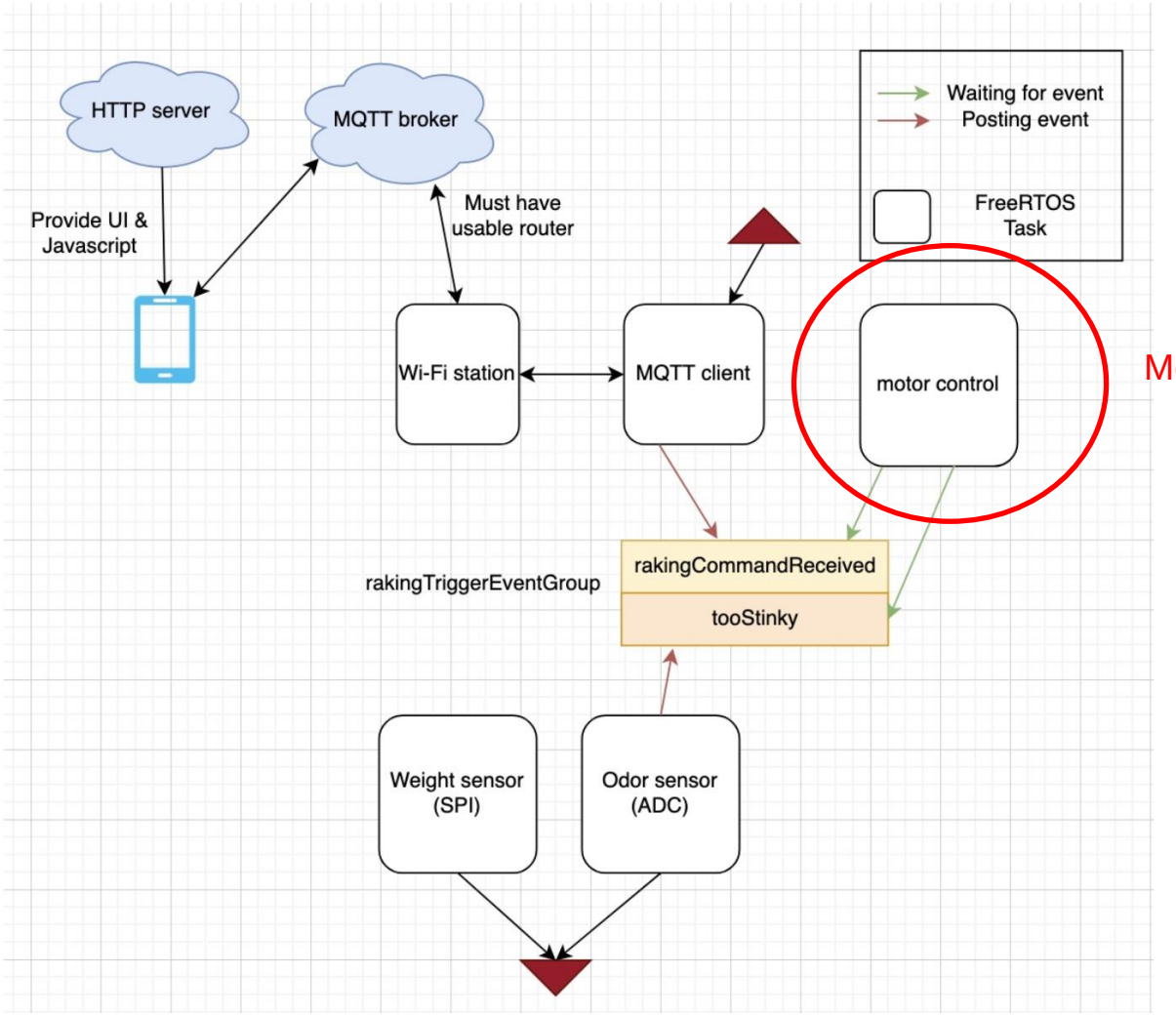
Requirement	Verification
R1. The motor will not produce positional deviation due to resistance.	V1. Place sand and balls to simulate cat feces in the litter box, start raking and ensure that the position does not change by more than 10%.
R2. The motor must provide sufficient torque to ensure the comb moves smoothly through sand, overcoming resistance without stalling.	V2. Place the comb in a tray of sand. Drive the comb through the sand using the motor and observe the movement of the comb, ensuring there are no instances of stalling or getting stuck. Measure the torque or current of the motor during this process, ensuring they are within normal ranges.

Software Block Diagram

Communication Subsystem

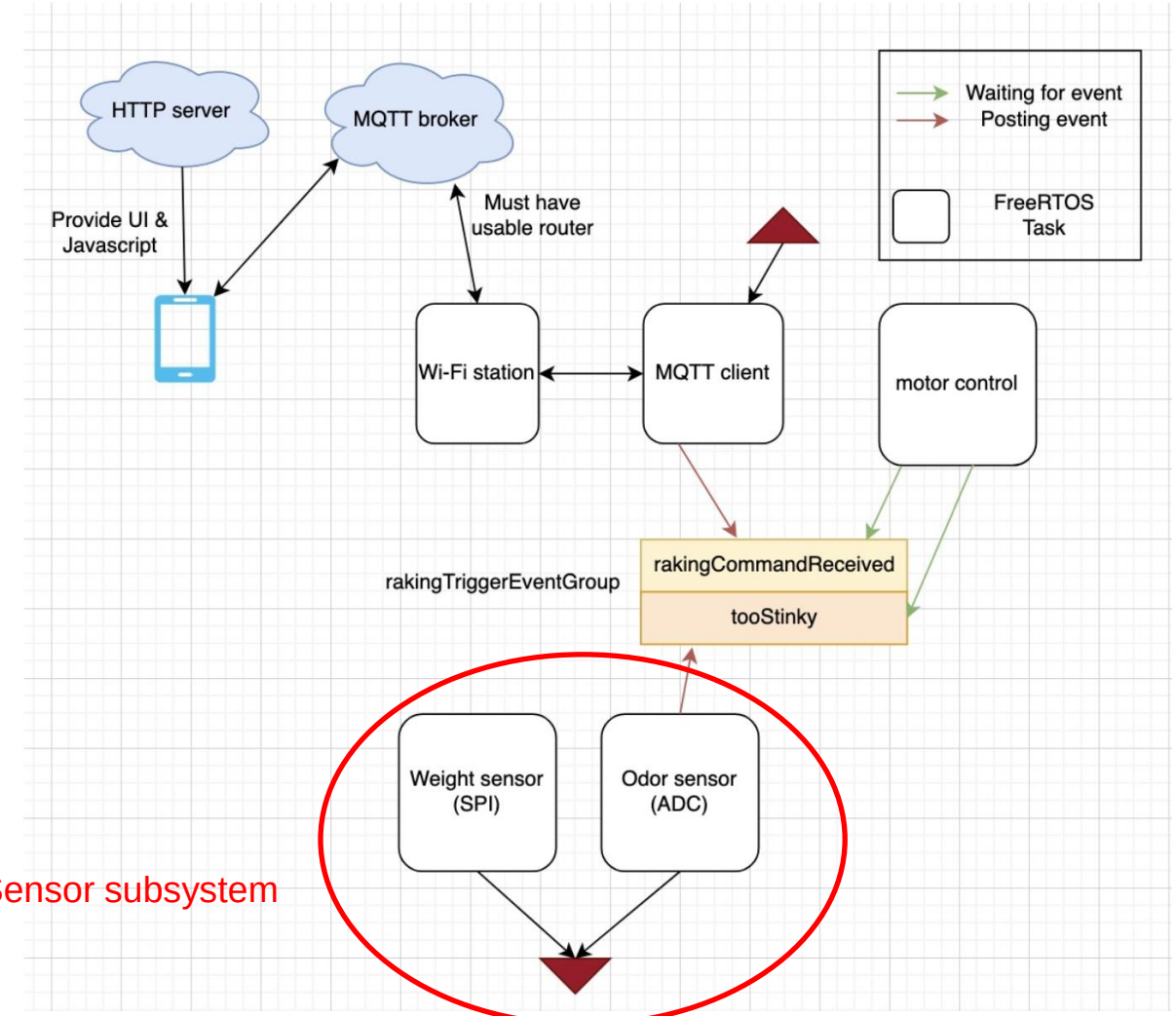


Software Block Diagram

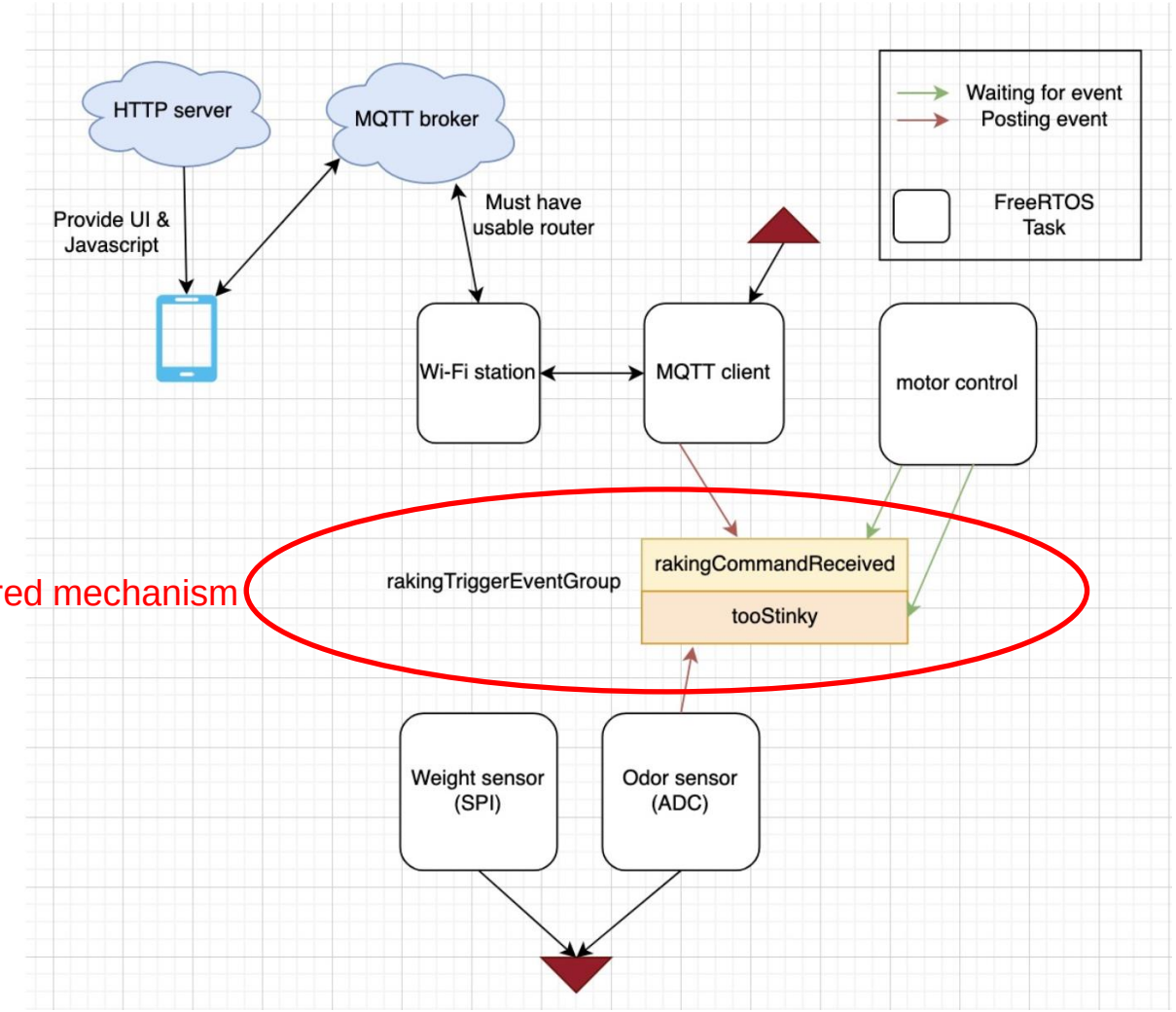


Motor Subsystem

Software Block Diagram



Software Block Diagram



Event-triggered mechanism

Video Demonstration

Web Application

Communication Subsystem

Requirement	Verification
R1. The communication system must reliably maintain a range of approximately 10 meters at 9dBm transmit power.	V1. Perform range tests by placing the ESP32-C3 with the communication system and a paired phone app at varying distances from 1 to 15 meters. Confirm stable communication at 10 meters.
R2. The system must provide timely notifications within 5 minutes to the web app upon detecting excessive odor or litter box use.	V2. Simulate odor or litter box use events using odor sources/weights, and verify that the system sends notifications to the app within 5 minutes.

Conclusion & Future Work

Failure:

Odor sensors broke during calibration of concentration threshold. Ammonia Solution touched the sensor, spiked in concentration level and stopped displaying a reading.

Future Work:

Calibrate Weight Sensors with a digital scale to be able to output the exact weight of the cat to display to users.

Store past usage data using a backend process and loads whenever the web application is accessed to avoid data loss.

Questions

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