PUMPED

The Smart Portable System for Weighing, Labeling, and Tracking Breast Milk Bags.

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We Are Group 15 and this is our PUMPED Team!

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Project Motivation

- There is no consumer product on the market that does this.
  - Opportunity to serve important groups.
  - Opportunity to improve quality of life.
- Properly labeling breast milk is critical for mothers and prone to errors
  - Tired mothers labeling bags at odd hours may make mistakes.
  - Time of day affects milk composition so its important these are both properly recorded.
- Associated mobile app provides extra tracking and information for breast milk bags
  - Mobile app provides ability to check milk inventory remotely.
  - Fixes problem of limited label space.
  - Gives statistical view of milk production to review later.

Goals and Objectives

Basic

- The device accurately weighs the breastmilk bag placed on the scale portion of the device.
- Device prints a label for containing volume, date, name, and id details.
- An integrated app that displays current breastmilk stock for the user., and ability to look up specific bag with ease using a designated id.
- The device is portable and easily carried around.
- OLED screen displaying various bag information

Advanced

- The App notifies users that a breastmilk bag is approaching its expiration date.
- Users can add detailed allergen information to each bag inside the app.
- User is able to print in 3 stages: Offline, Online, and Offline(synced).
- Battery charge will be displayed on our screen in real time, and also show changes when charging.

Stretch

- The app shows detailed daily/weekly/monthly production stats.
- Individual users can schedule drop-off times with local hospital/milkbanks.
- Automatic shutdown of device depending on certain conditions

Engineering Specifications

Specification	Engineering Requirement
• Weight should be accurate	Accurate within +/- 3 grams
• Time to print after print button is pressed should be immediate	7 seconds or less
• Time for recorded breastmilk bag data to be sent to the mobile app should be short	5 seconds or less
• Time for breastmilk bag to be weighed after placed on scale almost immediate	3 seconds or less
• Device weight should permit it to be portable	8 pounds or less
• Battery Voltage	12V or less
• Battery Capacity	At least 10 hours
• Battery lifespan	At least 2 years

Microcontroller Comparison and Selection

When we were deciding between what MCU to choose from all the existing ones, we had a couple of key features that we needed to have that would allow us to successfully and easily implement all of our features. The key features that were a requirement for our MCU to have were that it needed to have Wifi and Bluetooth capabilities, good power efficiency, be cost effective, have good amounts of GPIO pins, and be able to run SPI, I2C, and UART communication interfaces. We needed all those communication interfaces to be able to connect multiple peripherals to the MCU.

MCU options that we had in mind:

- MSP430
  - Familiarity, low power, no wireless connection
- Raspberry Pi Zero 2 W
  - Wifi, bluetooth, costly, voltage concerns (4.75V - 5.25V)
- Arduino Uno R4 Wifi
  - Wifi, costly, voltage concerns (6V - 24V)
- Arduino MKR Wifi 1010
  - Wifi, bluetooth, costly, good voltage (3.3V)
- ESP32S

MCU of Choice:

- ESP32S-WROOM
  - Wifi
  - Bluetooth 4.2
  - 3.3V
  - Cheap
  - Powerful (up to 240 MHz)
  - 4 SPI, 2 I2C, 3 UART, CAN
  - Able to work with Arduino IDE
  - Excellent flexibility and scalability for interfacing with many different sensors and peripherals

MCU	Architecture	Clock Speed	Memory (Flash/SRAM)	GPIO Pins	Communication Interfaces
MSP430FR6989	16-bit	16 MHz	128 KB FRAM	16	4 SPI, 2 I2C, UART
Raspberry Pi Pico	ARM Cortex-M0+ (Dual-core)	Up to 133 MHz	2MB Flash / 264KB SRAM	26	UART, SPI, I2C
Raspberry Pi Zero 2 W	ARM11	1 GHz	512MB LPDDR2 RAM	40	USB, CSI, HDMI
Arduino Nano	ATmega328 (8-bit)	16 MHz	32 KB Flash / 2 KB SRAM	14 digital, 8 analog	UART, I2C, SPI
Arduino Uno R4 Wi-fi	ARM Cortex-M4 + ESP32	48 MHz (RA4M1) / 240 MHz (ESP32)	256 KB Flash / 32 KB SRAM	14 digital, 6 analog	UART, I2C, SPI, CAN
Arduino MKR Wi-Fi 1010	SAMD21 Cortex-M0+	48 MHz	256 KB Flash / 32 KB SRAM	8 digital, 7 analog	UART, I2C, SPI
ESP32 (30-pin)	Xtensa LX6 (Dual core)	Up to 240 MHz	4MB Flash / 529 KB SRAM	25	4 SPI, 2 I2C, 3 UART, CAN

MCU	Wireless Connectivity	Power Voltage	Size	Cost ($)	Notes
MSP430FR6989	No	1.8V - 3.6V	-	~ $10-$15	Low power, not ideal due to lack of Wi-Fi/Bluetooth
Raspberry Pi Pico	No (Pico W has Wi-Fi, no Bluetooth)	1.8V - 3.6V	51 mm x 21 mm	< $10	Low-cost, flexible, lacks built-in wireless
Raspberry Pi Zero 2 W	Wi-Fi (2.4GHz), Bluetooth 4.2	4.75V - 5.25V	65 mm x 30 mm	$ 10-$15	Small, good wireless support but voltage concerns
Arduino Nano	No	5V (Op. Voltage), 7-12V (Input)	45 mm x 18 mm	< $10	Small, widely supported, lacks wireless connectivity
Arduino Uno R4 Wi-fi	Wi-Fi, Bluetooth	6V - 24V	68.85 mm x 53.34 mm	~ $20	IoT capable, good wireless support
Arduino MKR Wi-Fi 1010	Wi-Fi, Bluetooth LE	5V (Power), 3.3V (Circuit)	61.5 mm x 25 mm	~ $38.60	Great for IoT, expensive
ESP32S(30-pin)	Wi-Fi, Bluetooth 4.2	3.3V	25.5mm x 18 mm	< $15	Powerful, cheap, great for IoT

TTL Thermal Printer Comparison and Selection

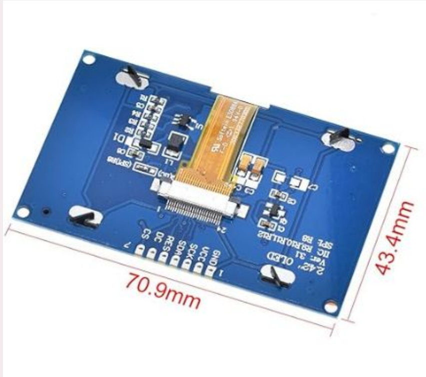
- Finding a printer that operated at a lower voltage range was important.
- Lower baud rate mitigates potential data integrity issues due to electrical noise
- Utilizes UART Serial
- Compact enough to fit within our 3D printed case.

Thermal Printer	Size	Operating Voltage	Operating Current	Baud Rate
GY-EP204x	77 mm x 53 mm x 42 mm	9 - 24 V	1.5 amps	115200
MC-EH300	75 mm x 49 mm x 49 mm	9 – 24 V	1.5 amps	9600
MC206H	81 mm x 45 mm x 56 mm	5 – 9 V	2 amps	9600

Display Comparison

- Finding The right display that will be capable of connecting with ESP32s via I2C or SPI.
- Voltage range should be between 3-5V.
- Adequate size for our portable device.

Display	Type	Size	Resolution (pixels)	Voltage	Communication
ILI9341	TFT LCD	2.8 Inches	320 x 240	3.3V (supports 5V with level shifting)	SPI
ST7789	TFT LCD	1.69 Inches	240 x 280	3.3V	SPI
HiLetgo SSD1306	OLED	1.3 Inches	128 x 64	3.3V	I2C
HiLetgo SSD1309	OLED	2.42 Inches	128 x 64	3V - 5V	I2C or SPI (Both Options)
Waveshare Ink Display	E-Paper	4.2 Inches	400 x 300	3.3V (also supports 5V)	SPI
Waveshare Ink Display	E-Paper	2.13 Inches	250 x 122	3.3V (onboard translator for 5V	SPI



Battery Technologies Comparison and Selection

During development, we looked at different ways to power our device. Our goal was to find an option that would be safe, easy to use, and able to power everything in the system. Including some of our peripherals that need a lot of energy, such as the thermal printer that draws a peak of 2 Amps. We also wanted something that would keep the device portable and convenient for everyday use. Below are the main options we considered:

Battery options that we had in mind:

- AA Rechargeable Batteries
  - Easy to find and reuse
  - Limited current output
  - Would require a BMS to charge.

- 18650 Lithium-Ion Cells
  - High energy density
  - High output current
  - Requires custom BMS and charging circuit

- USB Power Bank
  - Rechargeable and regulated
  - Built-in protection circuitry (BMS)
  - Bulky compared to internal battery packs

Battery Comparison Table					
Battery Type	**Nominal Voltage**	**Charge Voltage**	**Energy Density**	**Current Limit**	**Note**
Lithium-Ion (Li-Ion)	3.6-3.7V per cell	3.7-4.2V	150-250 Wh/kg	Depends on C-Rating of Battery	1
Lithium-Polymer (Li-Po)	3.6-3.7V per Cell	3.7-4.2V	100-200 Wh/Kg	Depends on C-Rating of Battery	1
Nickel-Metal Hydride (NiMh)	1.2V per Cell	1.4-1.5V	50-80 Wh/kg	Depends on C-Rating of Battery	2
Sealed Lead-Acid (SLA)	Typically sold in sealed 6V or 12V packs	2.3-2.4V	30-40 Wh/kg	Typically, High current limits	3
Portable Battery Bank	Typically found in 5V, 9V, or 12V	Typically charged via USB 5V	100-250 Wh/kg	Varies between Battery bank	4

Notes

[1] High risk of Fire/Explosions without proper Battery management system.

[2] Low Risk has safety valves for pressure relief of hydrogen gas buildup. Battery management system needed.

[3] Low risk of catastrophic failure, sealed containers have safety valves to vent built up pressure. Made of toxic materials like lead and sulfuric acid. Battery management system is needed.

[4] Low risk, equipped with its own battery management system. Power limits must not be exceeded.

Battery Bank Comparison and Selections

Battery of Choice:

- ROMOSS Sense 8+ (30,000mAh) (PHP30 Pro)
- High capacity – 111Wh
- Two USB-A outputs – 5V/2A and 5V/3A
- Built-in protection (overcurrent, overcharge, short-circuit)

Our system uses about 9–10 Watts during operation. To meet our 10-hour usage goal, we needed a battery with around 100Wh capacity. The ROMOSS Sense 8+ provides 111Wh (30,000mAh at 3.7V), giving us enough power to meet our runtime needs.

Battery Comparison Table

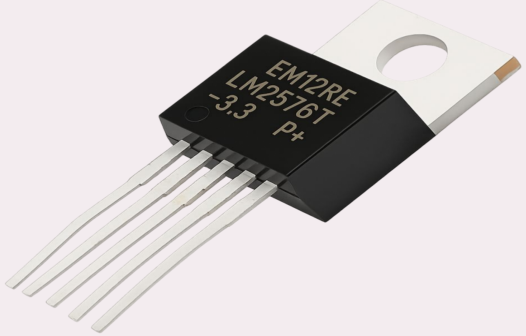
Battery Type	I/O Ports	Energy Capacity (Wh)	Size (Inches)	Weight (lbs.)	Cost
Talent Cell YB1208300-USB	•(Input/Output) DC5521:12V/6A •(Output) USBA: 5V/2A •(Output) DC5525: 9V/1A	9Ah @ 11.1V ≈ 99.9Wh	5.39"x 3.11"x 1.54"	1.57	$47.99
ROMOSS PHP30 Pro	•(Input)Micro-USB: 5V/2A, 9V/2A •(Input) Lightning: 5V/2.1A •(Input/Output) USB-Type-C/B: 5V/3A, 9V/2A, 12V/1.5A •(Output) USB-A#1: 5V/3A, 9V/2A, 12V/1.5A •(Output) USB-A#2: 5V/2.1A	30Ah @3.7V ≈ 111Wh	6.6"x 3.1"x 1.3"	1.48	$26.99
ROMOSS PEA40-282	•(Input)Micro-USB: 5V/2A, 9V/2A •(Input) Lightning: 5V/2A, 9V/2A •(Input/Output) USB-Type-C: 5V/3A, 9V/3A, 12V/3A, 15V/3A, 20V/3.25A •(2x Outputs) USBA: 4.5V/5A, 5V/4.5A, 9V/2A, 12V/1.5A	40Ah @3.7V ≈ 148Wh	6.67" x 3.21" x1.73"	2.1	$54.99

Voltage Regulation Comparison and Selection

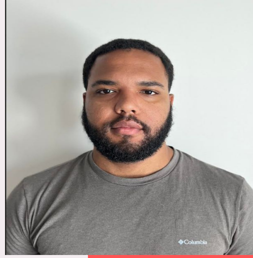
Comparison Table

Feature	AMS1117	TLV767	LM2576	AP62300T	LM2679	MP2338
Type	Linear (LDO)	Linear (LDO)	Switching (Buck)	Switching (Buck)	Switching (Buck)	Switching (Buck)
Input Voltage	4.75V-10V	2.5V-16V	7V-40V	4.2V-18V	8V-40V	4.5V-28V
Output Voltage	3.3V or 5.0V	0.8V-6.6V (fixed), 0.8V-14.6V (adjustable)	3.3V, 5V, 12V, 15V, Adjustable (1.23V-37V)	0.8V-7V	3.3V, 5V, 12V, Adjustable (1.2V-37V)	0.5V-16V
Max Output Current	1A	1A	3A	3A	5A	3A
Efficiency	Low	Moderate	High	High	High	High
Switching Frequency	N/A	N/A	52kHz	750kHz	260kHz	450kHz
Dropout voltage	1.2V	0.9V	N/A	N/A	N/A	N/A
Protection Features	Thermal Shutdown	Foldback Current Limit, Thermal Protection	Over-Temp, Over-Current, UVLO	Over-Current, UVLO, Thermal Shutdown	Over-Temp, Current Limit, Soft-Start	Over-Current, Thermal Shutdown, Soft-Start
Best Applications	Battery Powered Systems	Printers, Wi-Fi access points	Test and Measurement equipment	General purpose point of loads	Simple designs	Multi-functional Printers

All of the components within our design, except the thermal printer, will require the voltage produced by the power bank to be stepped down to 3.3 volts. To bring the voltage from the power bank down we will be using a LM2576T switching voltage regulator that will supply voltage to the peripherals at their respective operating ranges. We went with a switching regulator because of its high efficiency and ease of implementation into our design. Since we are using BLE communication in our device, to prevent noise interference, we placed the MCU's antenna and the regulator on opposite ends of the pcb.

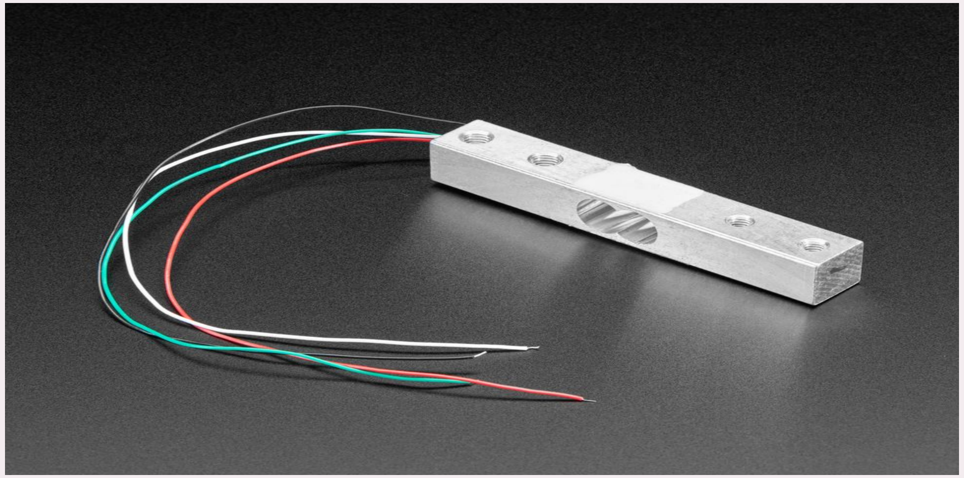


Weighing Technology Comparison and Selection

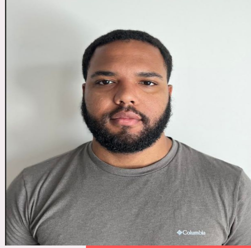


When selecting a scale to implement in our device we needed it to have a fast response time when calculating the weight while also providing sufficient accuracy so that the user can have confidence in knowing the exact amount of milk that is in their inventory.

Selection
10 Kg (22 lbs) Strain gauge load cell

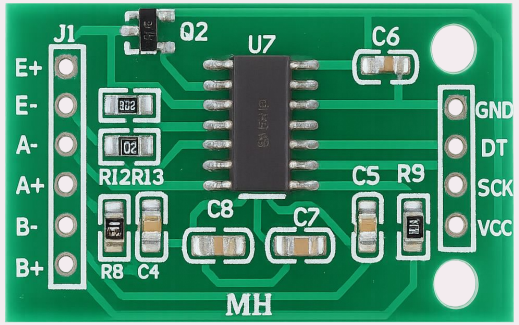


Features	Strain gauge Load Cell	Capacitor load cell	Piezoelectric sensor
Accuracy	Sufficient	Sufficient	Sufficient
Uses	Static weight measurement	Static weight measurement	Dynamic force measurement
Complexity	signal conditioning required	Signal processing required	charge leakage
Cost	~$8.00	~$100.00	~$100.00
Power Consumption	Negligible	Negligible	Negligible
Stability Over Time	Very stable	Moderately stable	Poor (due to voltage decay)
Temperature Sensitivity	Affected	Affected	Affected



ADC Comparison and Selection

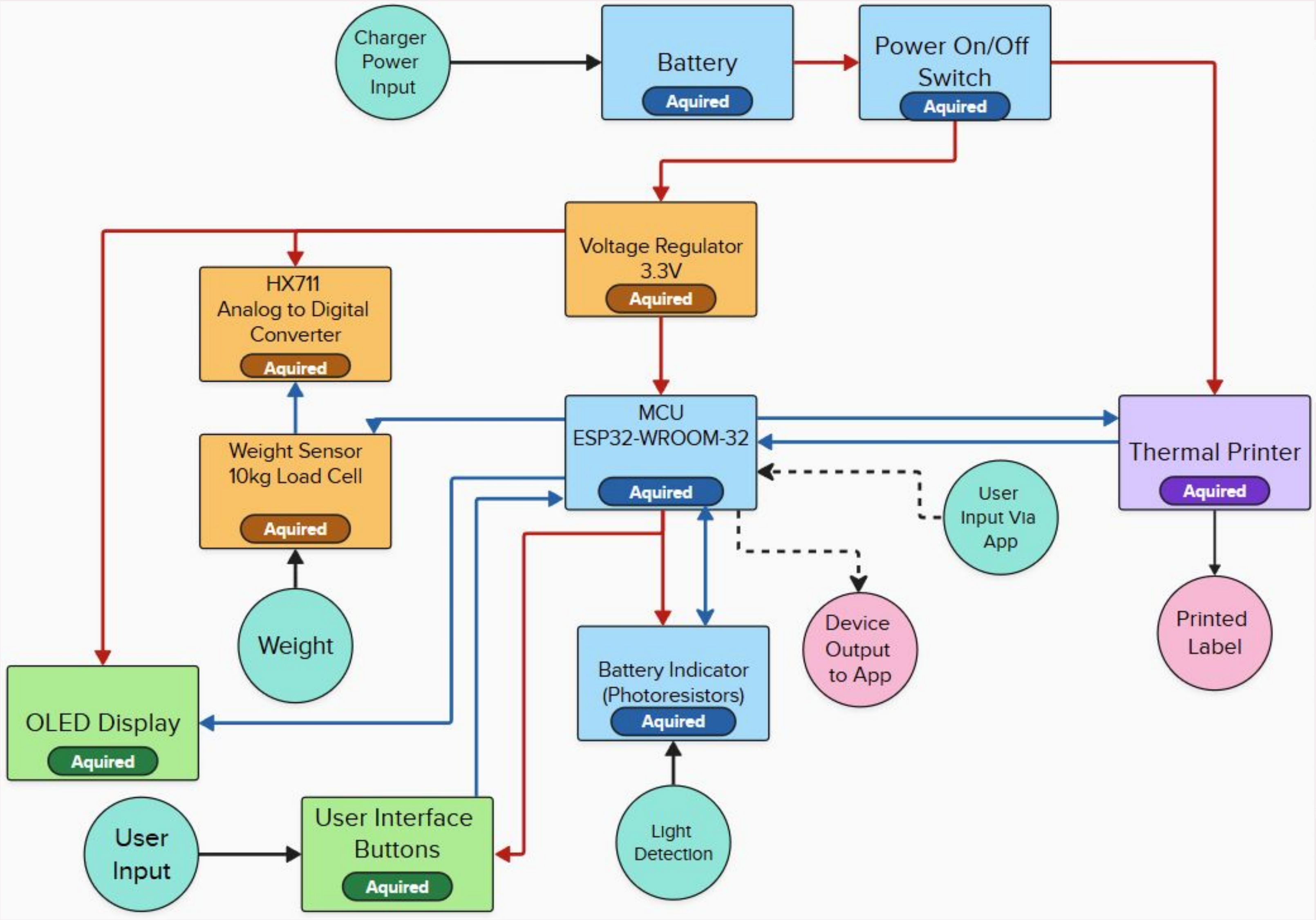
From the available ADC options we had for pairing with our load cell, the HX711 was the best choice because of its compatibility with the load cell we chose, making integration easy. The HX711 having a 24 bit resolution benefits measurement accuracy, making it a much better choice over the ESP32's built in 12 bit ADC .



Comparison Table

Features	ADS1256	HX711	ESP32 built in ADC
Resolution	24-bit	24-bit	12-bit
Ease of Use	Further programming required	Works with simple implementation	Further programing required
Best Used For	High-speed applications	Load Cells	Embedded applications
Cost	~$11.00	~$1.00	Tied to the esp32 price

Hardware Block Diagram



Visual Key

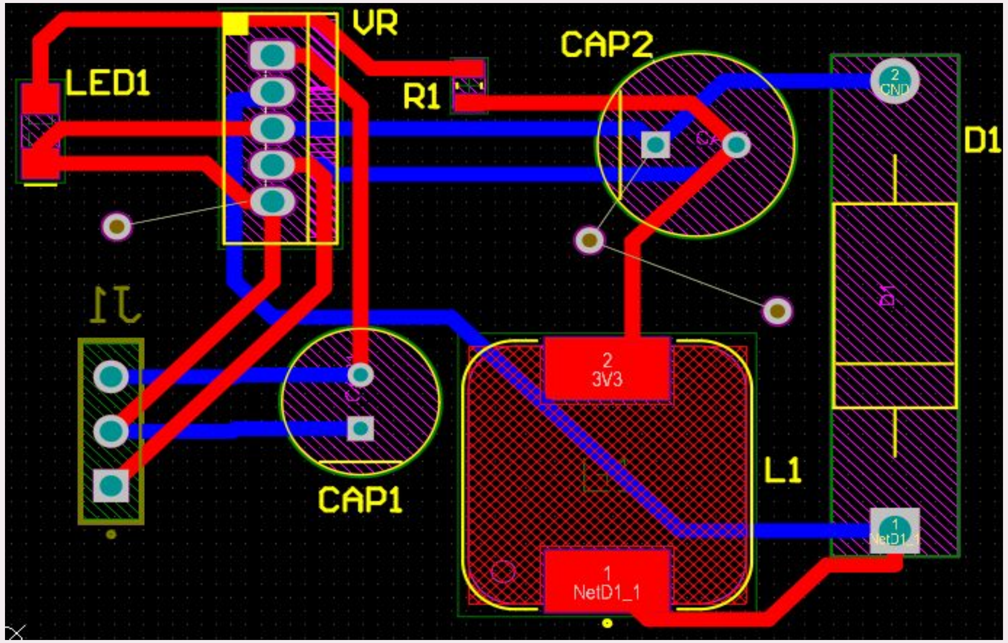
- Wireless Connection
- Power
- Communication
- INPUTS
- OUTPUTS

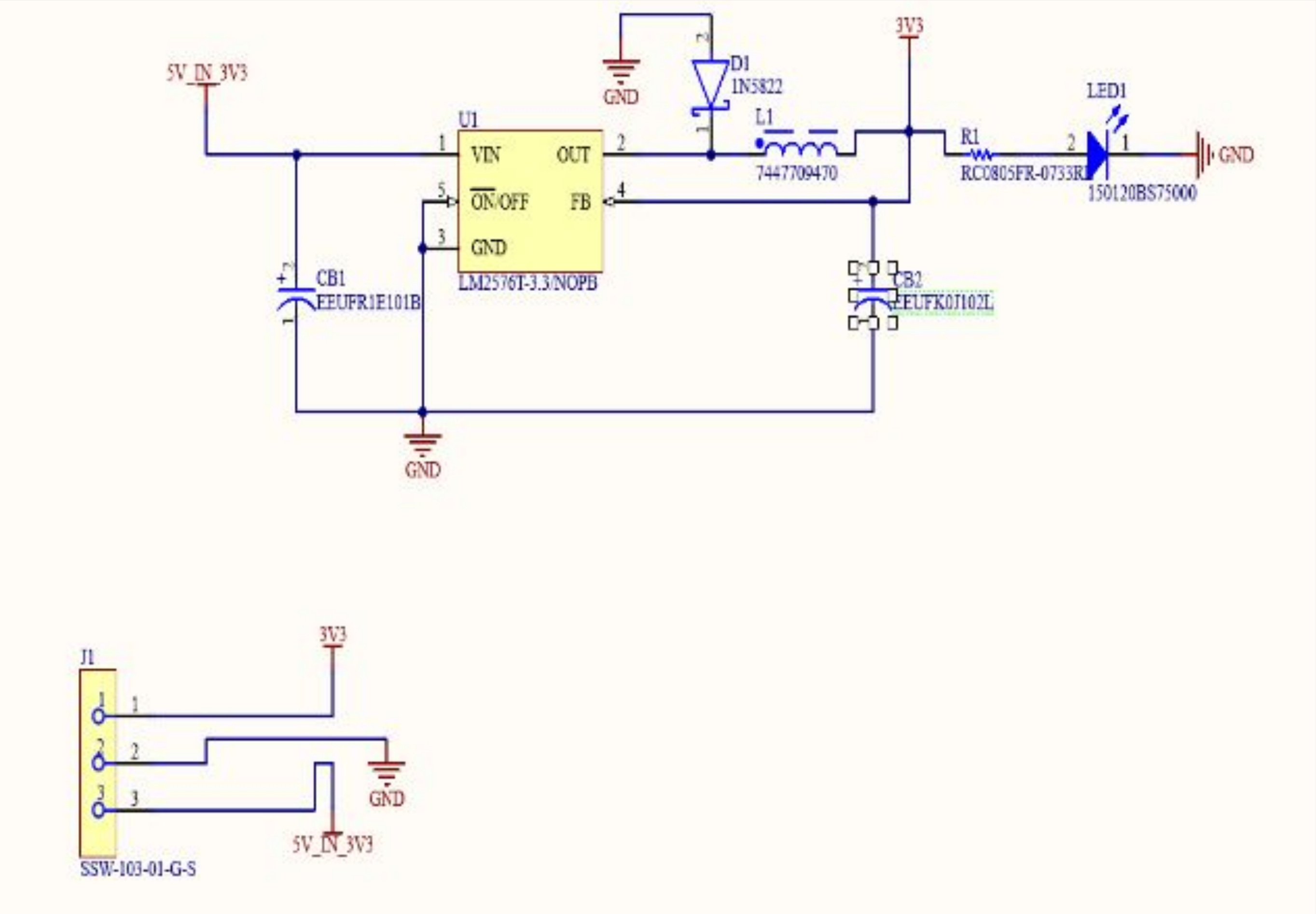
Scope Distribution

- Kevin Fernandez
- Eric Hernandez
- Agustin Rodriguez
- Jimmie Rawls

3.3 Voltage Regulator PCB Schematic

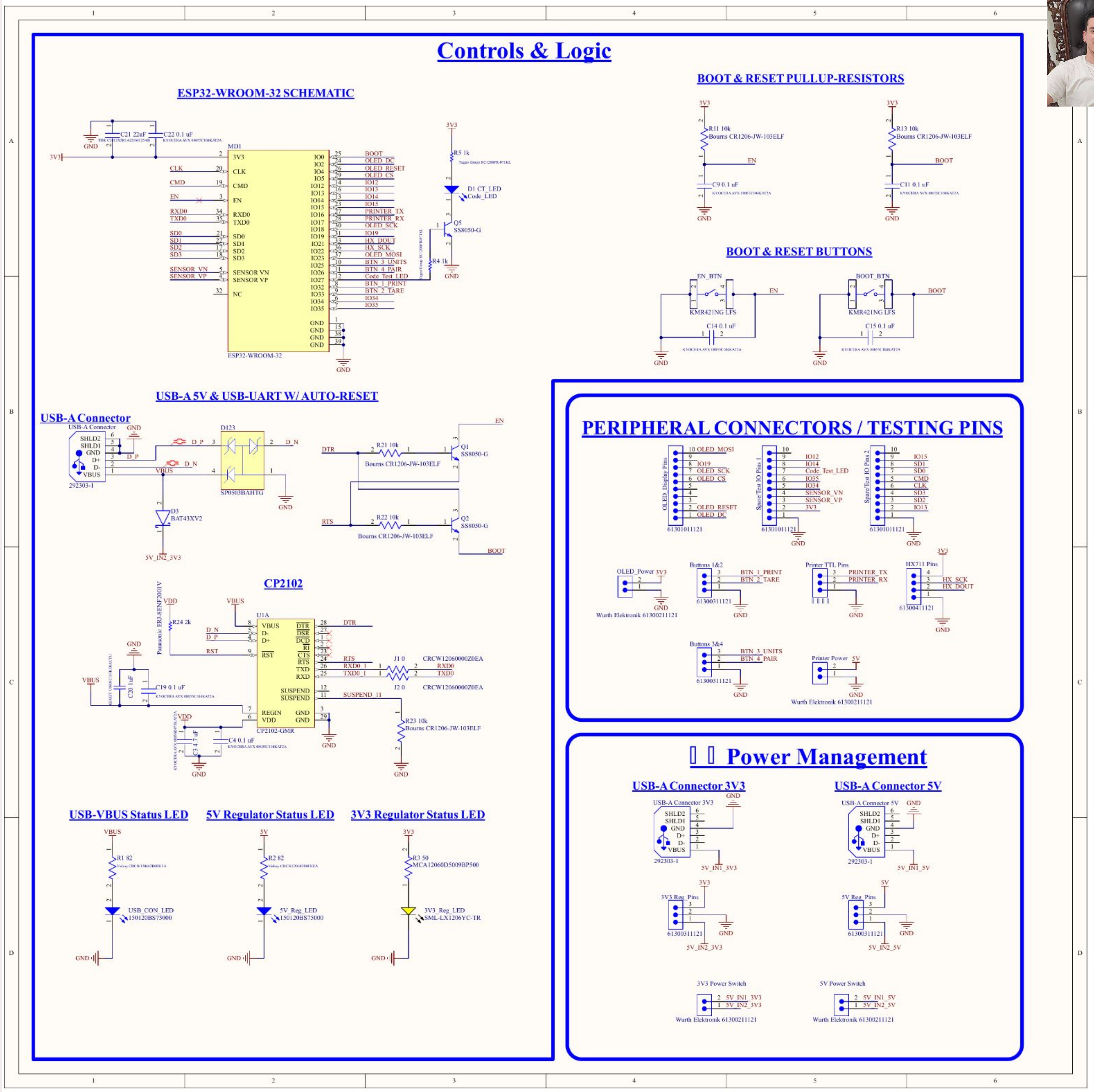
Design from Texas Instruments LM2576xx series datasheet





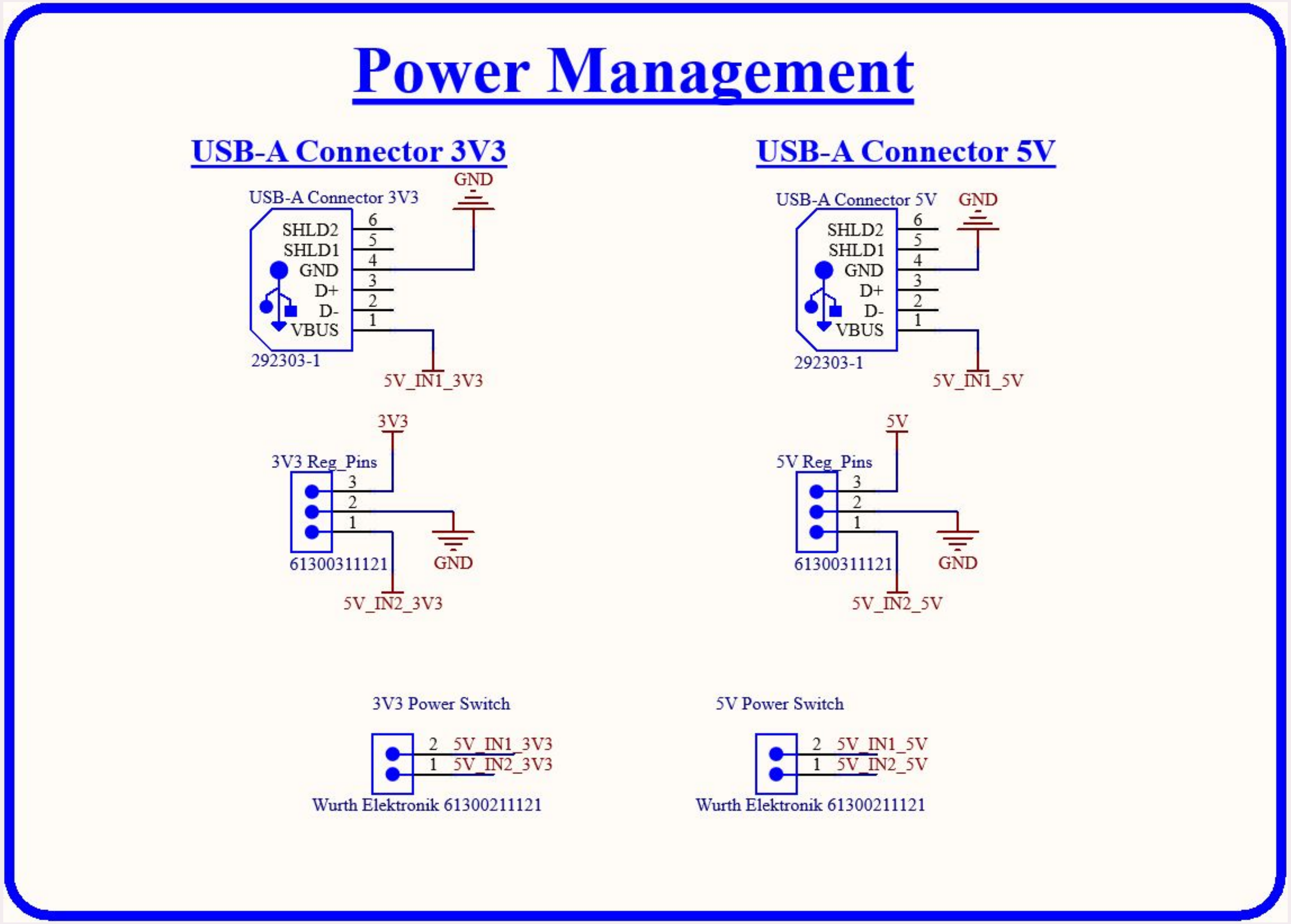
PUMPED MCU Schematic Overview

- **Power Management**
  - Headers for Off/On Switch
  - Modular 3.3V regulator
- **Controls & Logic**
  - ESP32-WROOM-32 microcontroller
  - CP2102 USB-to-UART interface
  - Power Status LEDs
  - IO controlled LED
- **Peripherals:**
  - Load cell with HX711 amplifier
  - OLED display (SPI)
  - Embedded thermal printer
  - Four user interface buttons
  - Battery Percentage Indicator
- **Testing & Expansion**
  - Spare/test IO headers



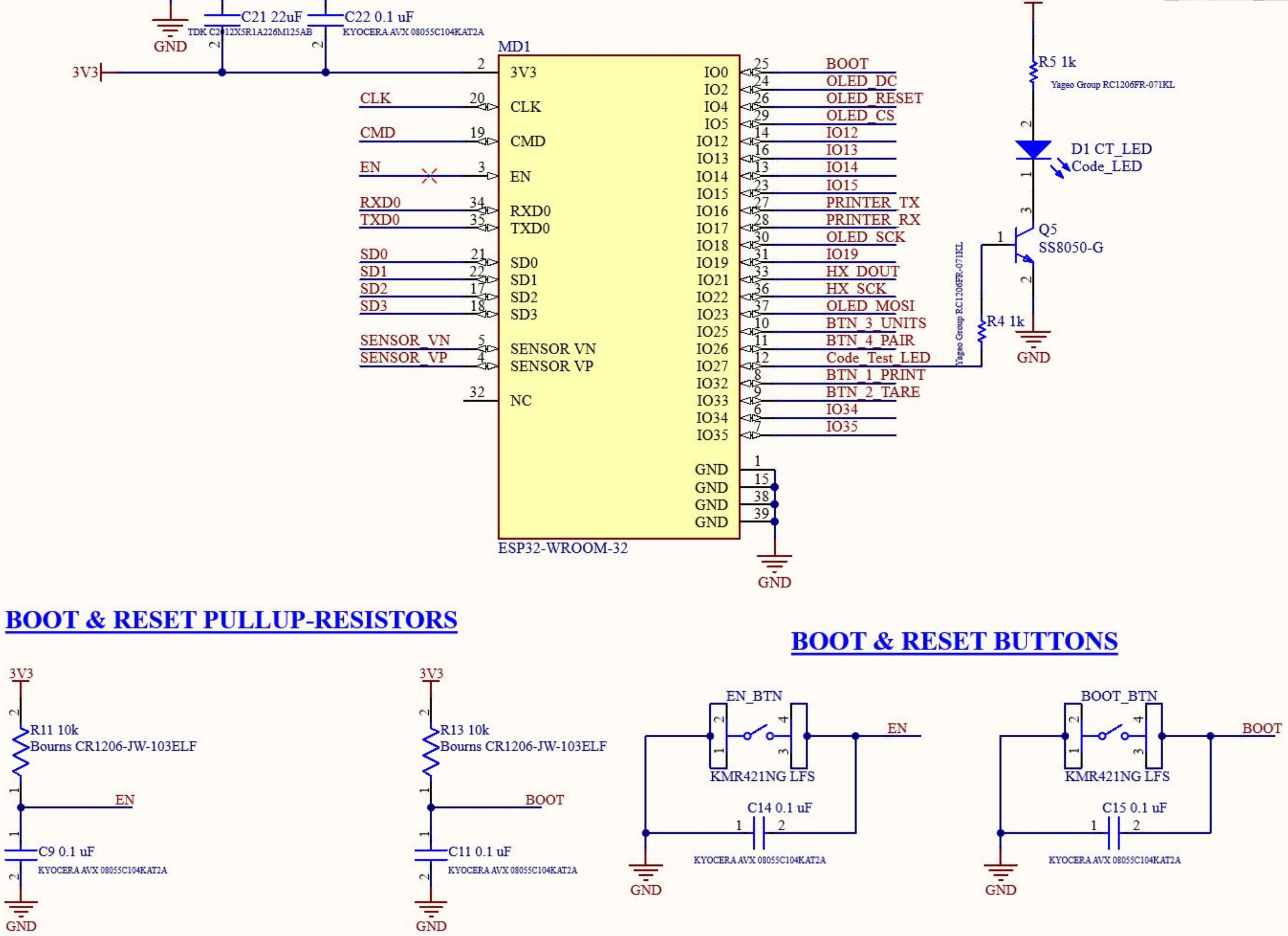
Schematic: Power Management

- **Power Input**
  - System powered by two USB-A inputs using USB-A to USB-A cables from the ROMOSS Battery Bank.
  - Avoids possible noise induced by high current draw from the Printer.
- **ON/OFF Switch**
  - Power rails are cut off at individual headers which will be connected to a DPDT Switch.
- **Modular Voltage Regulator**
  - Includes 3 pin header connectors that the 3.3V



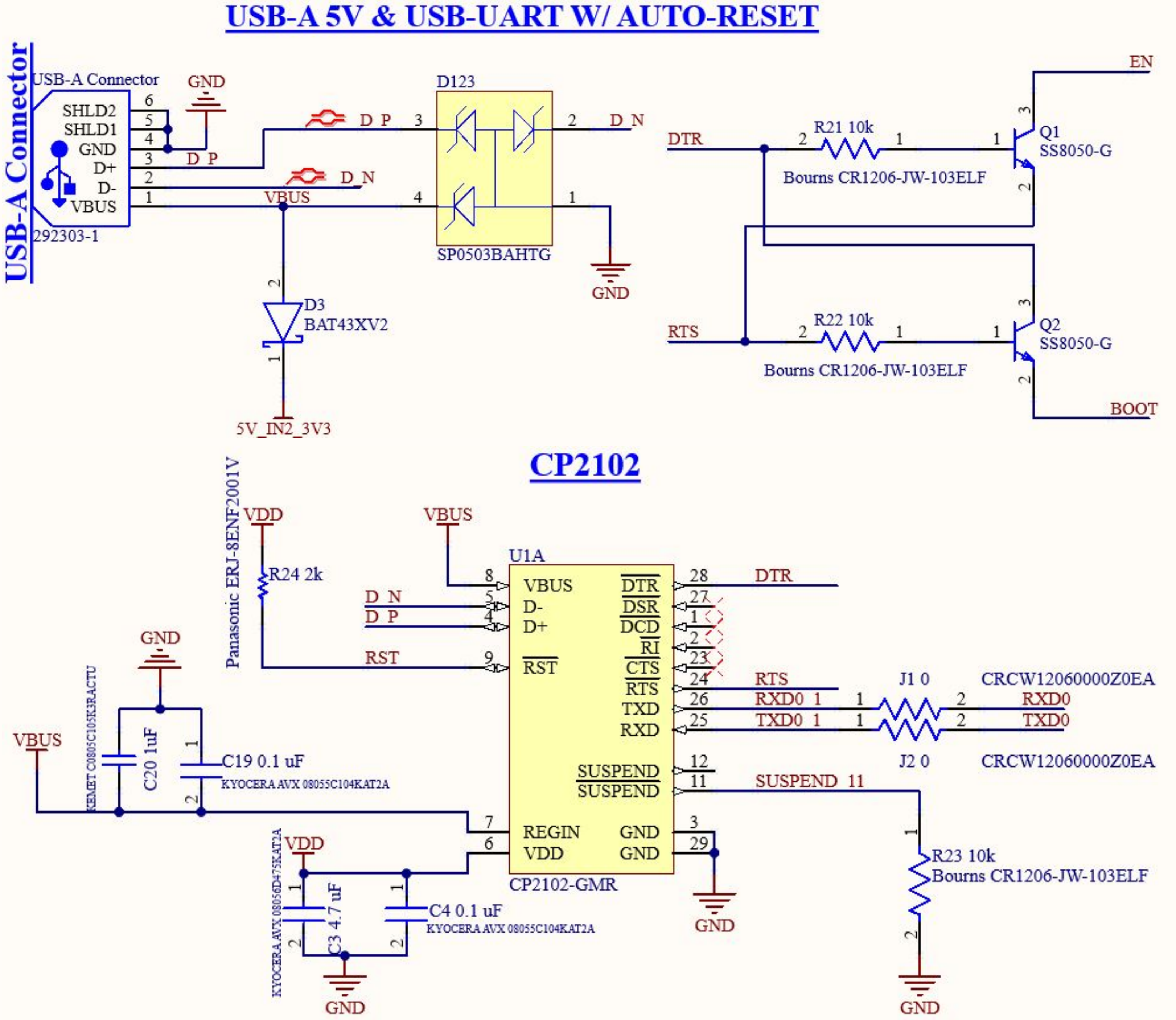
Schematic: Controls & Logic 1/3

- **MCU (ESP32-WROOM-32)**
  - Central processor for all system functions/Peripherals
  - Powered by 3.3V with 22μF and 0.1μF capacitors for voltage stability and noise filtering
  - Interfaces with CP2102 for programming
  - Includes a Code Status LED on IO27, toggled by an NPN transistor.
- **Boot & Reset Circuitry**
  - Pull-up resistors on BOOT and EN pins ensure proper startup
  - When the BOOT button is pressed it enters the MCU into FLASH mode
  - When the EN button is pressed the MCU is manually reset.



Schematic: Controls & Logic 2/3

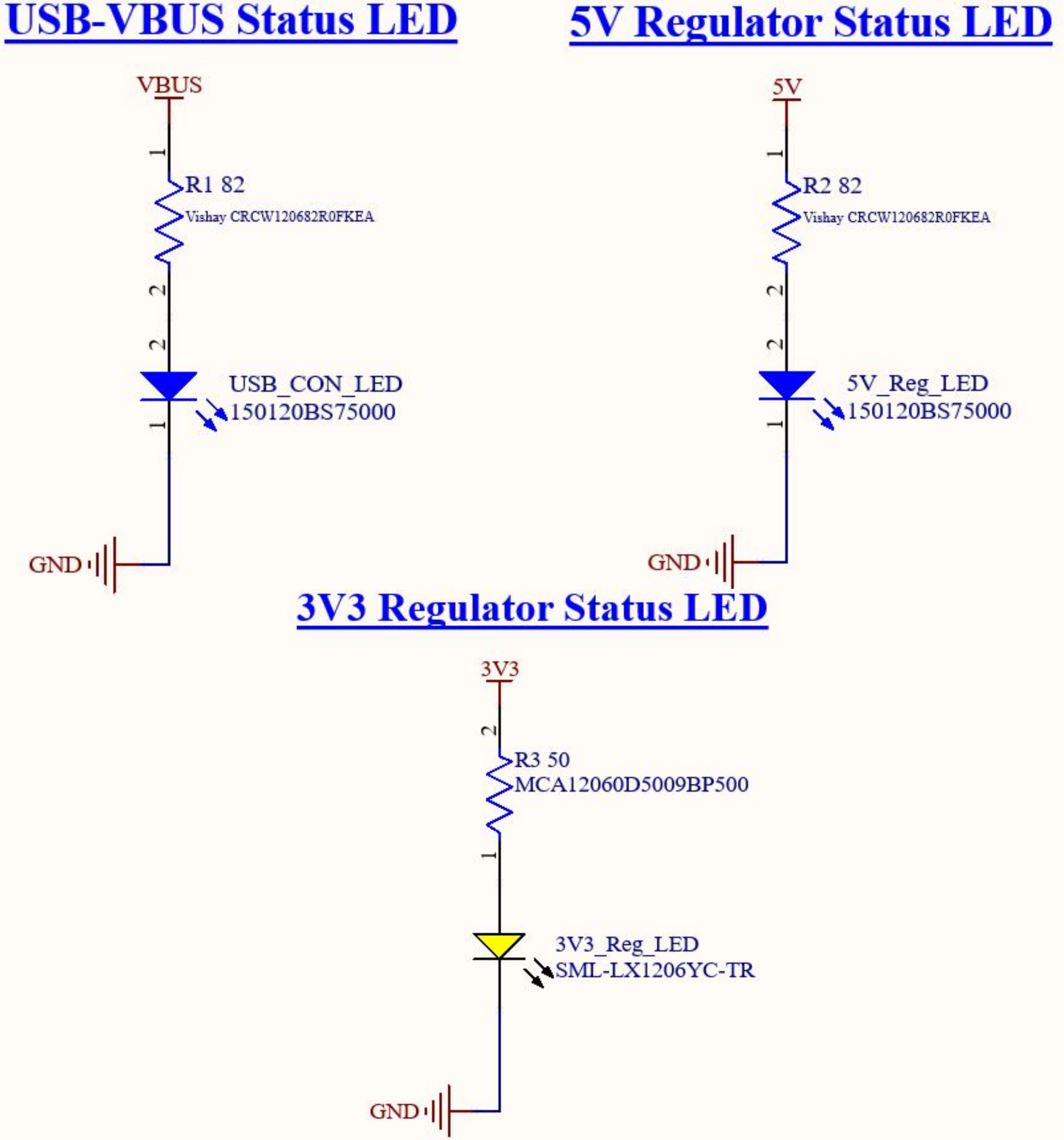
- **USB-A Input**
  - Used to power the CP2102.
  - D- and D+ lines provide the USB data connection.
  - Data lines connected to a TVS diode (SP0503BAHTG) for ESD protection.
- **CP2102 USB-to-UART**
  - Handles serial communication and programming for the ESP32.
  - REGIN input and VDD output are stabilized/smoothed by capacitors.
  - Reset pin is pulled up with a 2k Ohm resistor.
  - Suspend pin is pulled down with a 10K Ohm resistor.
  - 0 Ohm resistors on the TX and RX lines are used for debugging or possible isolation.
- **Auto Reset Circuitry**
  - Allows the ESP32 to automatically enter reset and boot modes during code uploads.
  - Uses two NPN transistors controlled by DTR and RTS from the CP2102.



Schematic: Controls & Logic 3/3

Power Status LEDs

- **USB-VBUS LED**
  - Uses an 82 Ohm resistor to bias a blue LED with a forward voltage of 3.2V and a forward current of 30mA
  - Used to indicate that our VBUS when programming the MCU is active.
- **5V Line LED**
  - Same circuitry as the USB-VBUS LED
  - Used to indicate that our 5V regulated power output from the battery bank is working.
- **3.3V Regulator LED**
  - Uses a 50 Ohm resistor to bias a yellow LED with a forward voltage of 2.0V and a forward current of 30mA.
  - Used to indicate that our power output from the 3.3V regulator is working.



Schematic: Peripherals & Expansion

10-Pin Female Headers (x3)

- OLED display Header
  - SPI Interface for connecting the OLED Screen
- Spare IO Pins Header 1
  - Contains additional IOs for future use (Is now being used for the battery level indicator)
  - Has an extra connection to 3.3V and a ground. (Used to power the Battery Level Indicator PCB)
- Spare IO Pins Header 2
  - Also Contains additional IOs for future use.
  - Contains an additional connection to 5V and a ground.

4-Pin Female Header (x1)

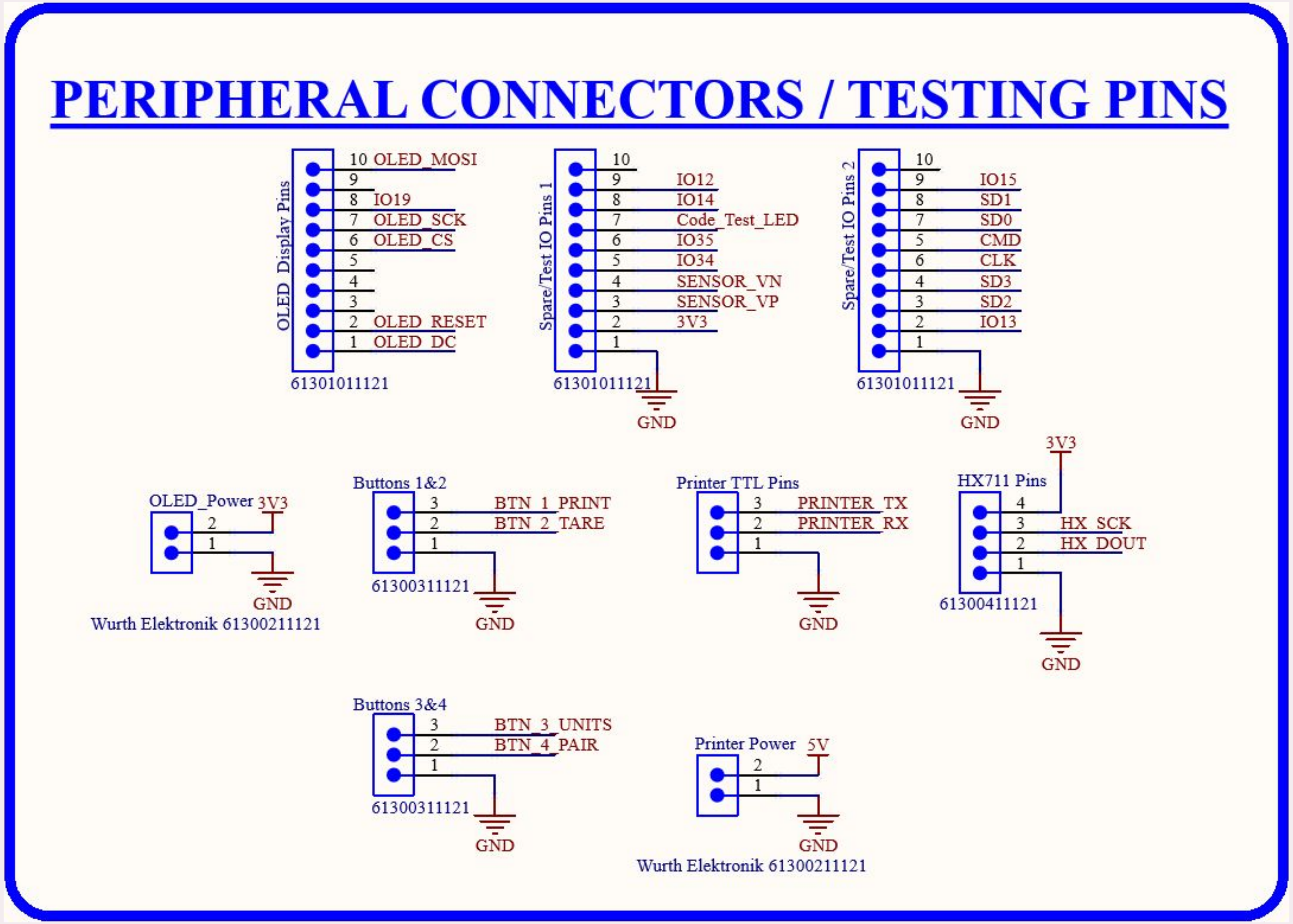
- HX711 Header
  - Direct plug in for the HX711 that includes 3.3V, GND, and its communication connections.

3-Pin Female Headers (x3)

- Buttons 1-2 Header and Button 3-4 Header
  - Both contain 2 connections to IO pins, and a ground (pulls IOs low when pressed)
- Printer TTL Header
  - Includes the RX and TX lines to communicate to/from the ESP32 and a GND pin.

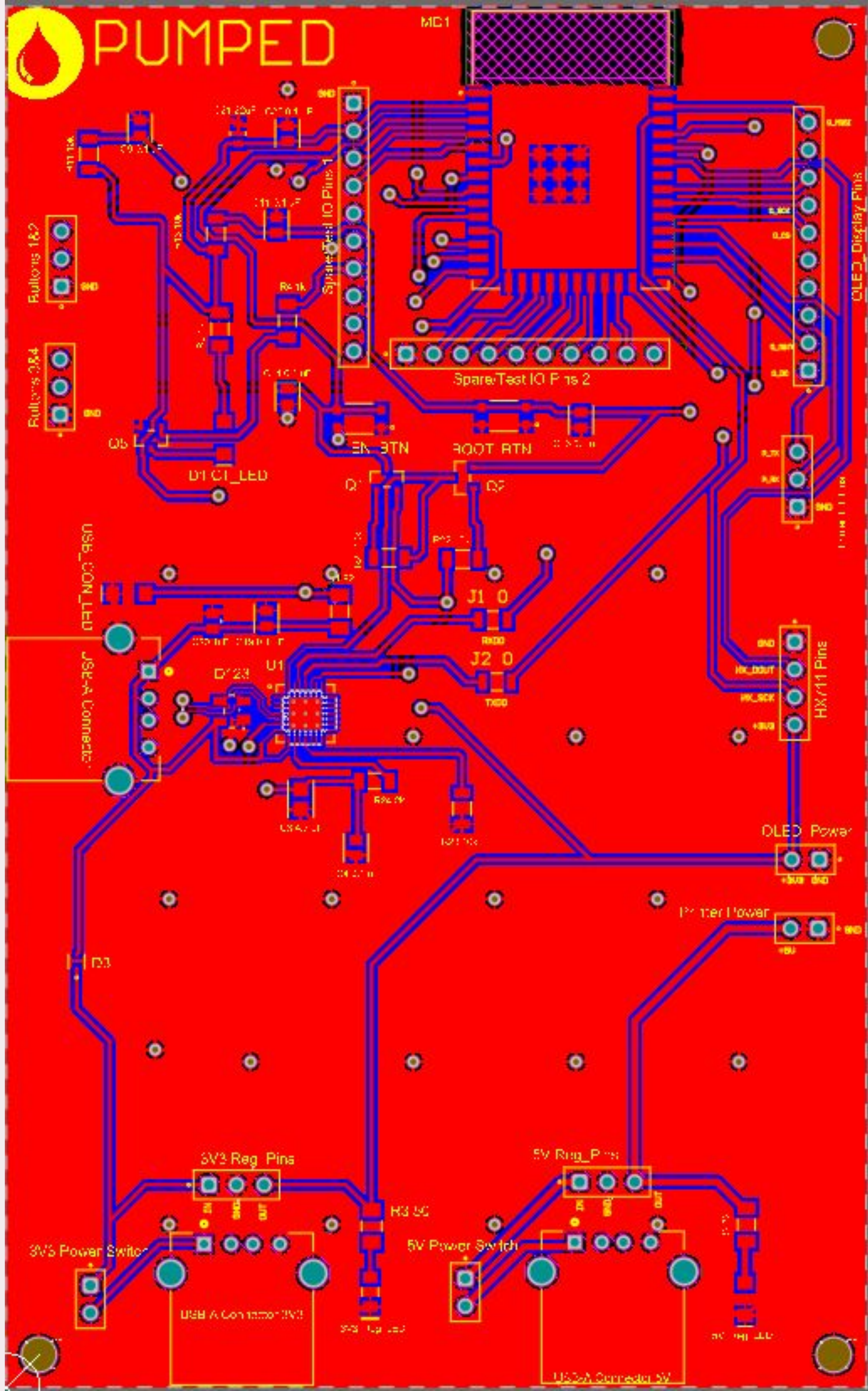
2-Pin Female Headers (x2)

- OLED Power Header
  - Supplies 3.3V and a ground pin
- Printer Power Header
  - Supplies 5V and a ground pin



PUMPED MCU PCB Overview

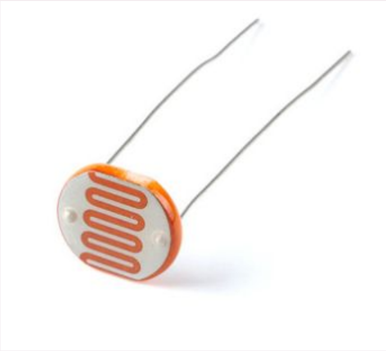
- **USB-A Connector Placement**
  - Both USB-A power inputs are located at the bottom edge of the board and are near the status LEDs along the voltage regulator headers.
  - The USB-A for programming the ESP32 is placed on the left side of the board and the CP2102 circuitry is placed closely to it to reduce signal noise and data errors.
- **ESP32 Antenna Cutouts**
  - The ground plane underneath the ESP32's antenna has been removed in both the top and bottom layers.
  - This helps mitigate interference and improves wireless signal performance.
- **Trace Sizing**
  - 32 mil trace was used for the printers trace lines so that they could withstand the 2 amps of current the printer peaks at.
- **Mounting holes**
  - Added mounting holes to some corners to secure the PCB to the inside of the devices enclosure.



Battery Percentage Indicator (1/2)

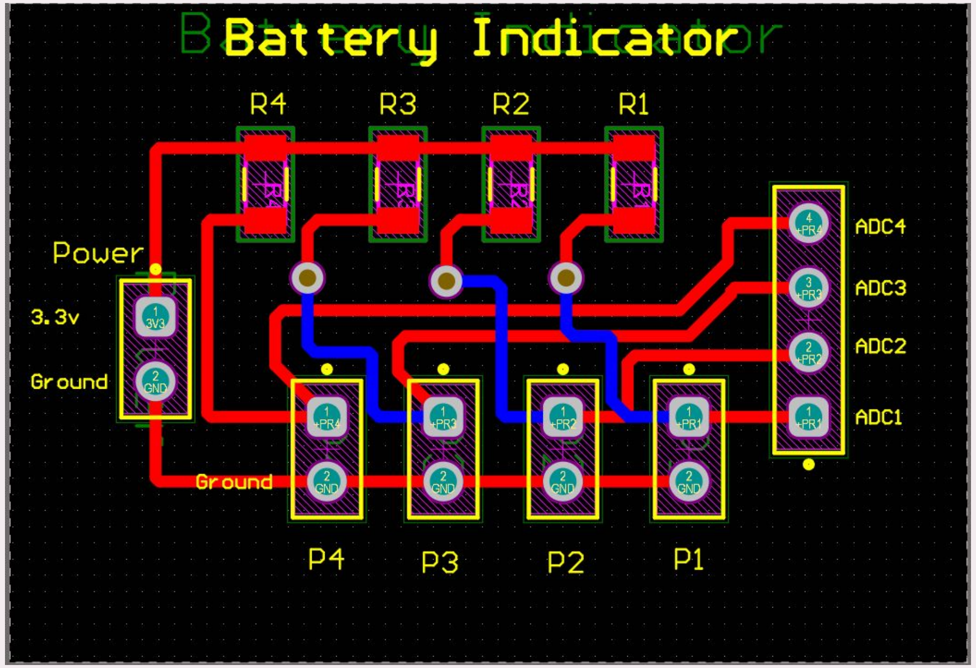
We decided to go with the ROMOSS Sense 8+ (30,000mAh) over regular batteries. This was a great opportunity for us to create a well rounded portable device that had the capability of being rechargeable without any concerns. We ran into an issue on how the consumer was going to determine what the battery percentage was going to be, but we knew that the battery bank was capable of illustrating the battery through 4 LED lights. Dr. Weeks and the group came up with an idea.

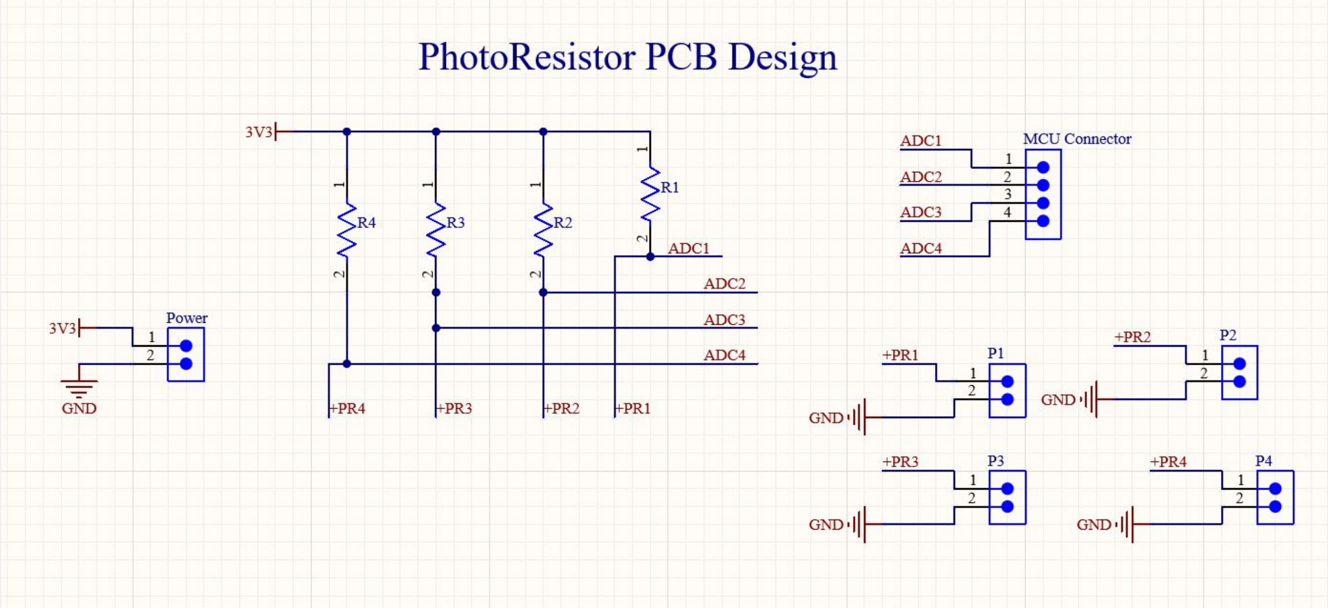
Using Photoresistors to determine the battery percentage based on the LEDs on the battery bank. The way photoresistors work is that the material has high resistance when in the dark, and lower resistance when in light. We are going to sync this up with the ESP32, and we are going to be able to determine the battery amount based on the amount of LEDs (out of 4) that are on and off.



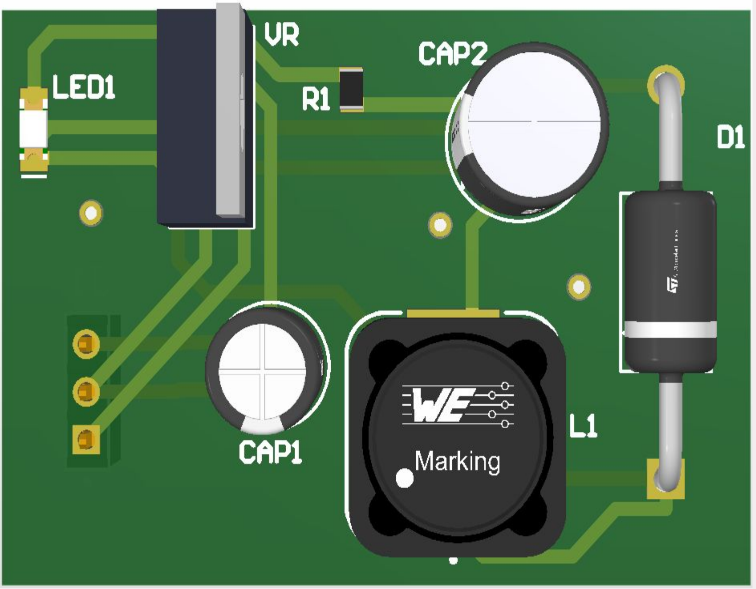
Battery Percentage Indicator (2/2)

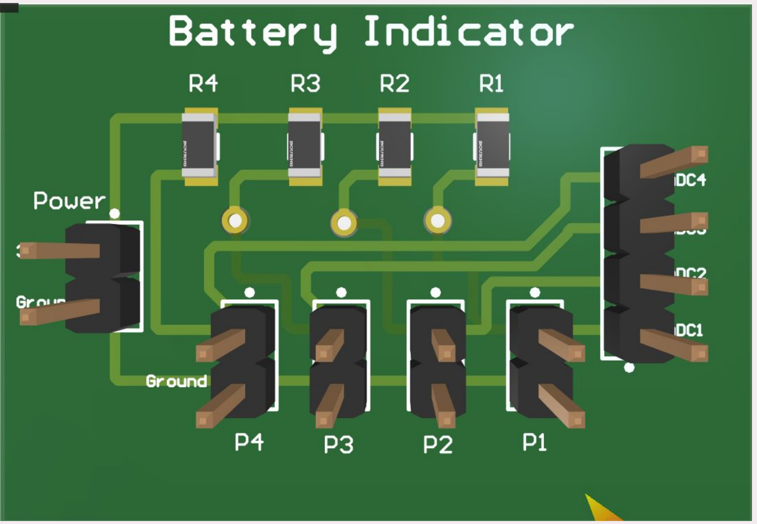
After Speaking with Dr. Weeks he gave us an idea to use Photodiodes to measure the battery, but we didn't need to measure high light speed. That is when we came up with an idea to use 4 photoresistors (1 for each LED). They would be directly attached on top of the battery bank via a compartment, it will then be connected to the MCU via an ADC connection, and then the MCU will transmit it onto the display.

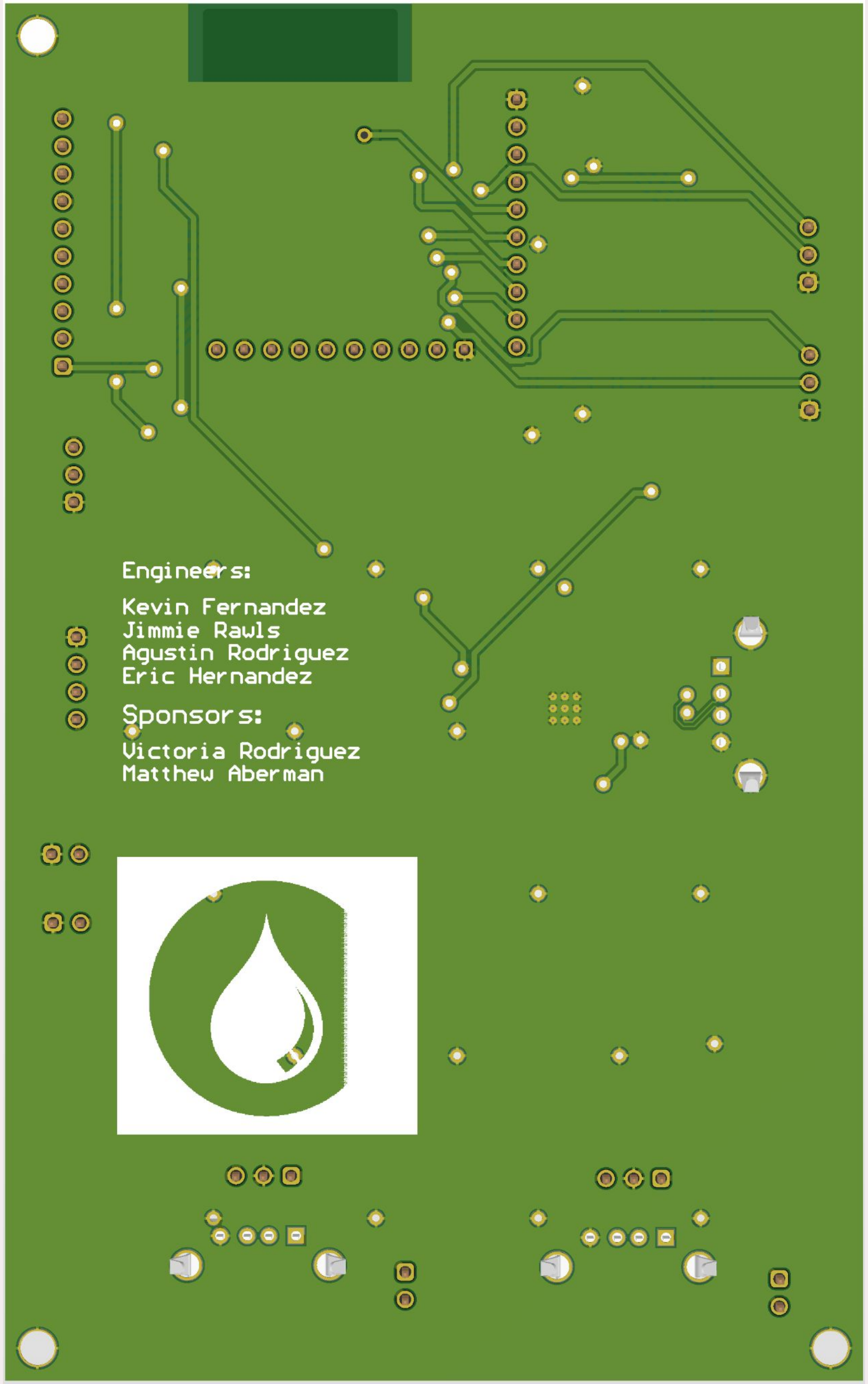


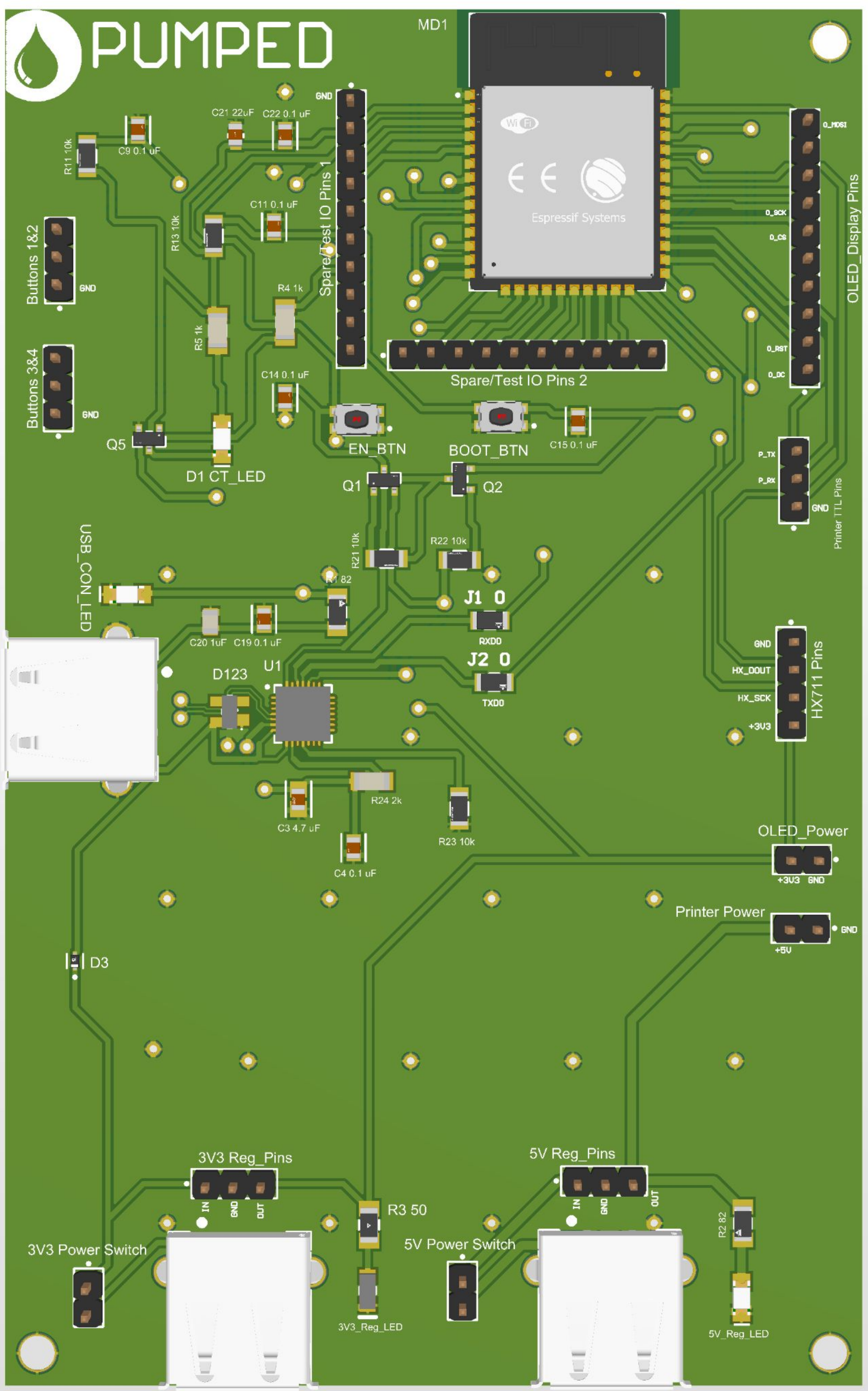


Overall PCB 3D View

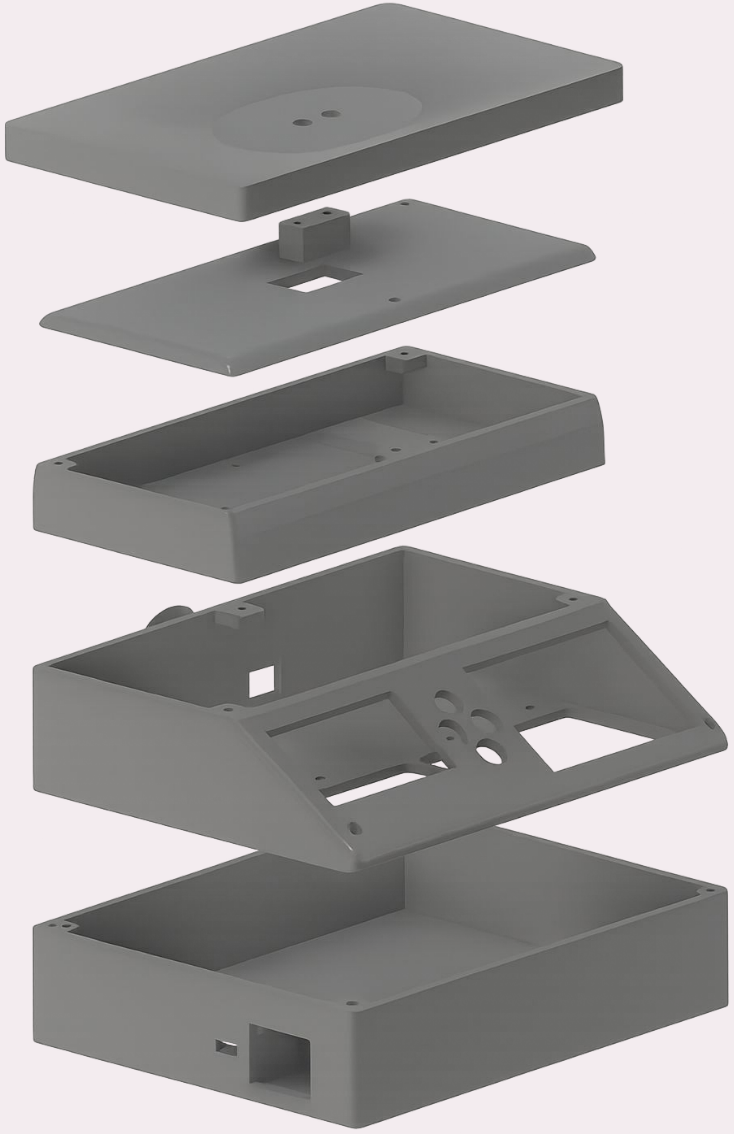






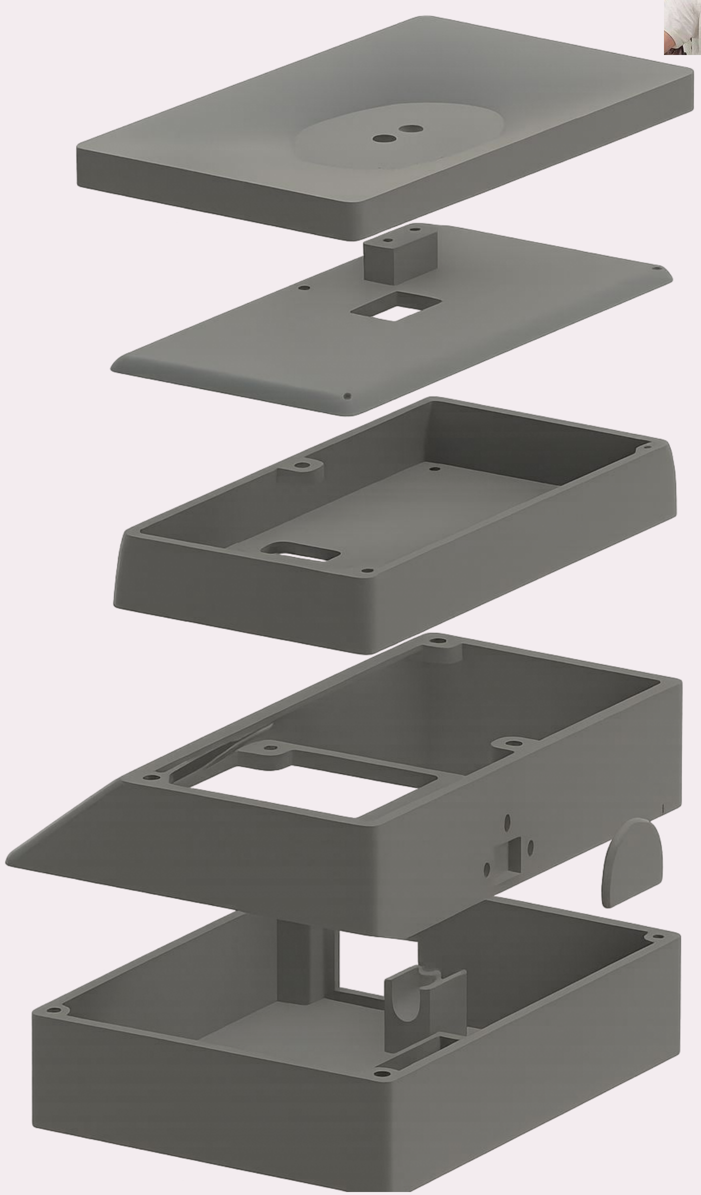


PUMPED Enclosure Overview

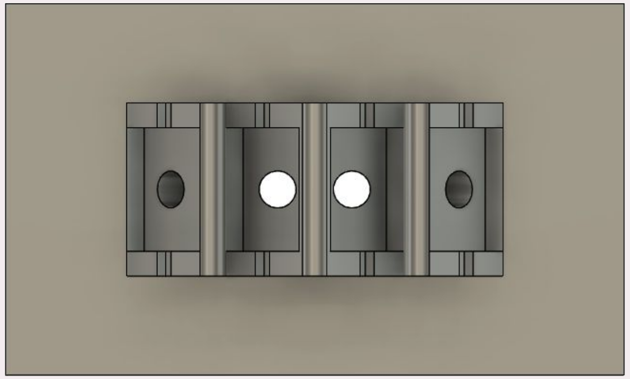


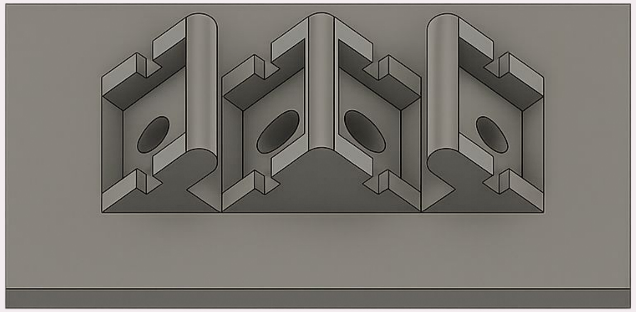
Enclosure Features

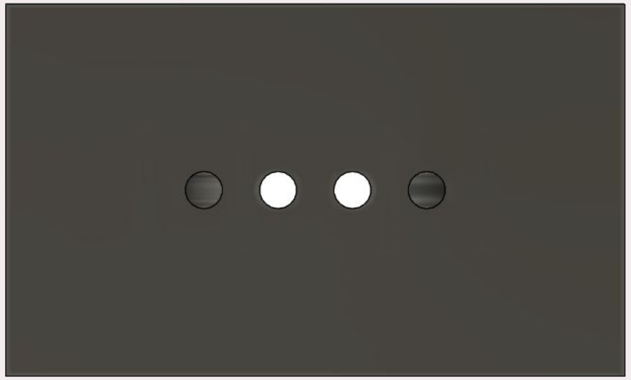
- Dimensions (LxWxH) : 8″ x 6.5″ x 5.25″
- Designed as multi-part assembly optimized for 3D printing. All parts oriented to print flat on the bed for easy printing.
- Weight plate sealed with rubber O-rings to prevent liquid intrusion
- Custom load cell base raised 3mm off the bottom
- Load cell connected through lid using extender.
- Threaded insert holes included for durable fastening
- Counterbored holes to hide screws (minimal visible fasteners)
- Rear access port for ESP32 programming, covered by magnetic hatch
- USB-C extension mount for external battery charging



Photoresistor (Battery Indicator) Mount Overview



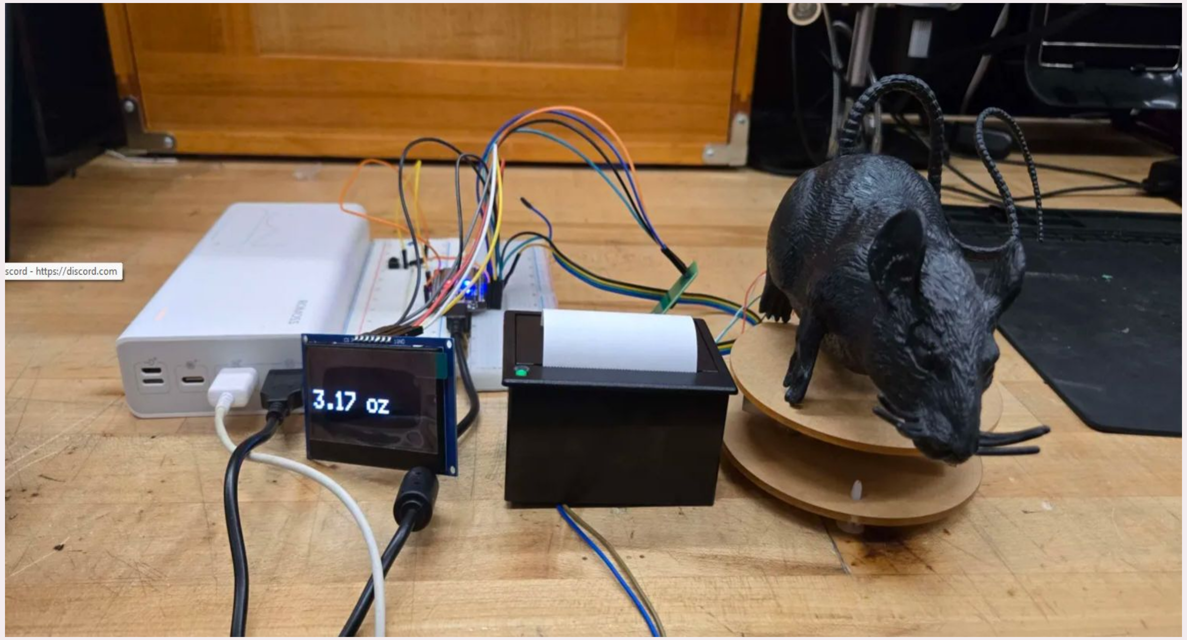




Photoresistor Mount Features

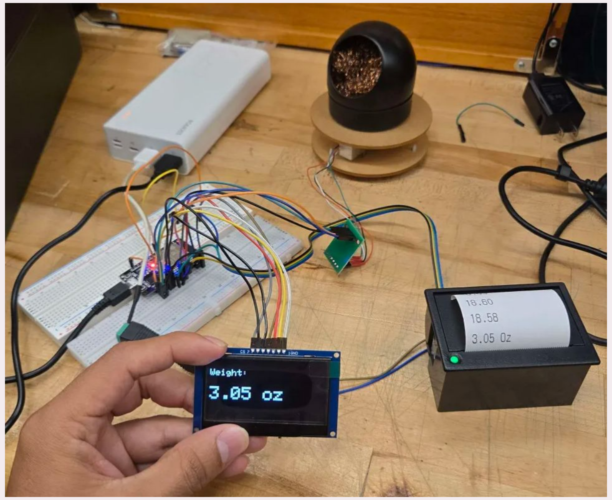
- Dimensions (L×W×H):
  0.98” × 0.59” × 0.14”
  (25 mm × 15 mm × 3.61 mm)
- Designed to read battery level using the power bank's built-in LED indicators
- Holds 4 photoresistors angled at 45°
- Angled design avoids width interference between sensors
- Compact design to fit over battery bank LEDs
- Wider base allows secure attachment using adhesive
- Safe, non-invasive workaround for displaying charge status on screen

Prototype



When working with our prototype we were able to get all of the subsystems to work together to produce a label with a printed weight on it.

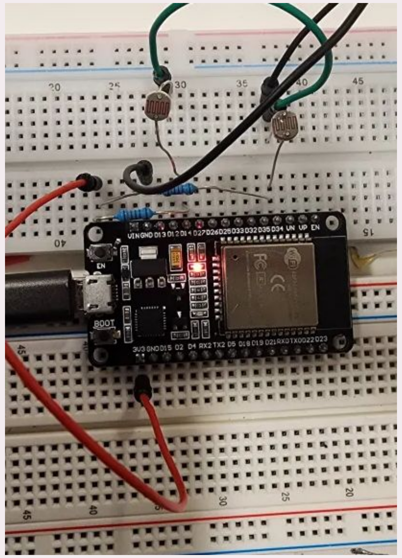

```
#include "HX711.h"
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
#include <Pushbutton.h>

// HX711 circuit wiring
const int LOADCELL_DOUT_PIN = 2;
const int LOADCELL_SCK_PIN = 3;
```



Output   Serial Monitor ×

Message (Enter to send message to 'ESP32-WROOM-DA Module' on

```
GPIO34: 1907     ||     GPIO14: 1456
GPIO34: 2702 --> Battery 50%     ||     GPIO14: 2032
GPIO34: 3120 --> Battery 50%     ||     GPIO14: 2288
GPIO34: 3186 --> Battery 50%     ||     GPIO14: 2335
GPIO34: 3212 --> Battery 50%     ||     GPIO14: 2323
GPIO34: 3194 --> Battery 50%     ||     GPIO14: 2341
GPIO34: 3188 --> Battery 50%     ||     GPIO14: 2347
GPIO34: 3206 --> Battery 50%     ||     GPIO14: 2336
GPIO34: 3195 --> Battery 50%     ||     GPIO14: 2343
GPIO34: 3175 --> Battery 50%     ||     GPIO14: 2354
```



Prototype Troubleshooting

Problem:
One issue we came across when building the prototype was brought on by the first thermal printer we wanted to use. In the datasheet the printer was rated for 5 volts to 20 volts at 1 amp but when we tested the printer we found that it would only print legibly when its input voltage was at 17 volts or above. This was an issue because in our proposed design we were not anticipating needing a power supply that could produce more than 12 volts.

Considered Solution:
Replace the battery with one that could meet the printers voltage requirement.

Solution:
We decided to switch out the thermal printer with a different brand that is rated for 5 to 9 volts at 2 amps. This printer worked as intended with our power supply even with the increased current requirement.

Problem:
Originally, we planned to use a second voltage regulator in our final design to step down the battery voltage to 5 volts for the thermal printer, but when we measured the output from this regulator the voltage was about 4.3 volts. This caused the prints to become blurrier and less readable. This issue was caused by the, port we designated as the thermal printer connection. That port is rated to supply 12 volts but only supplies 5 volts during printer operation. The regulator then can't maintain the 5 volts in the output.

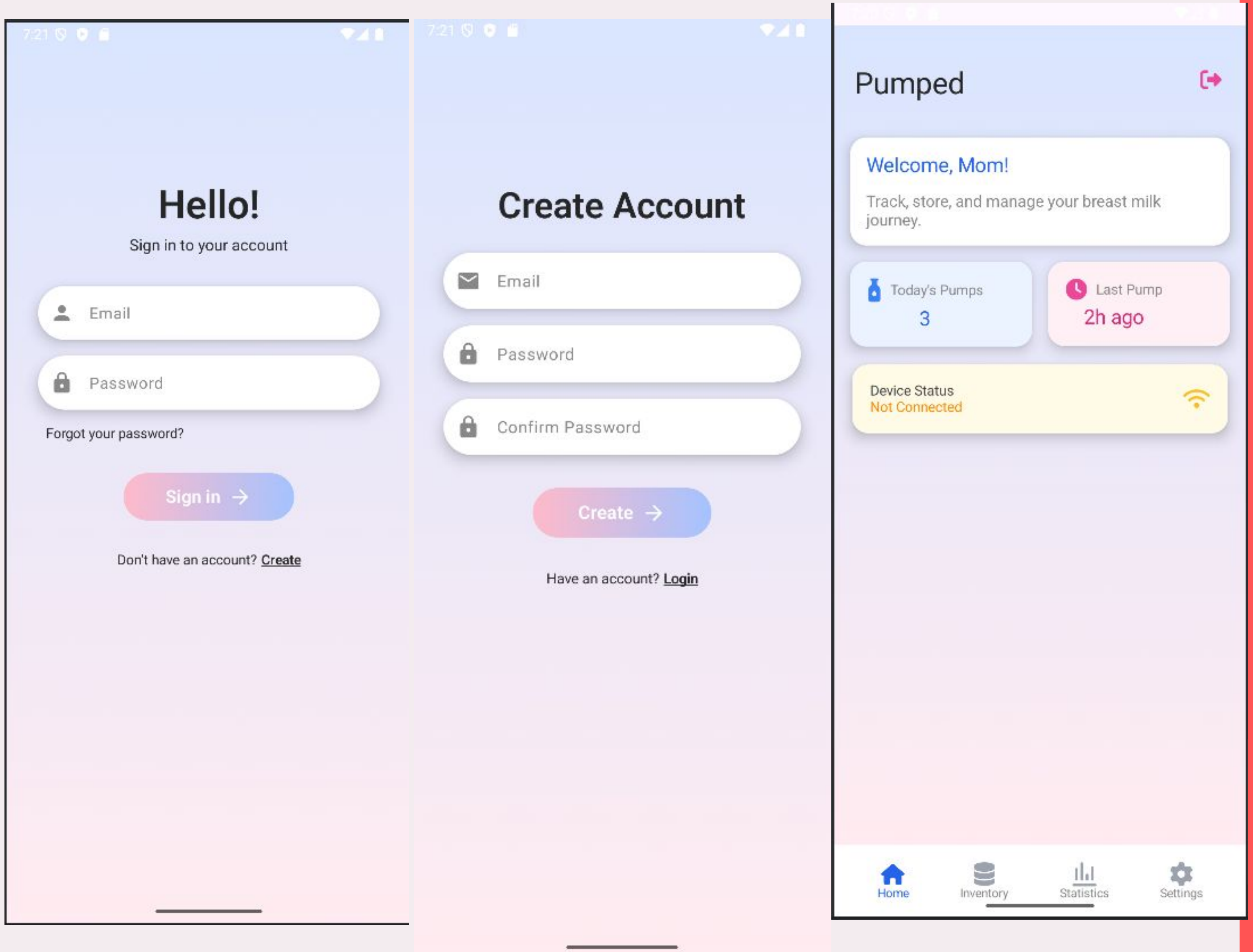
Considered Solution:
A different battery was considered but at the point we were at in SD2 it would been a significant time loss.

Solution:
We decided to remove the voltage regulator from the connection between the battery and the thermal printer. This change fixed the clarity in the thermal prints.

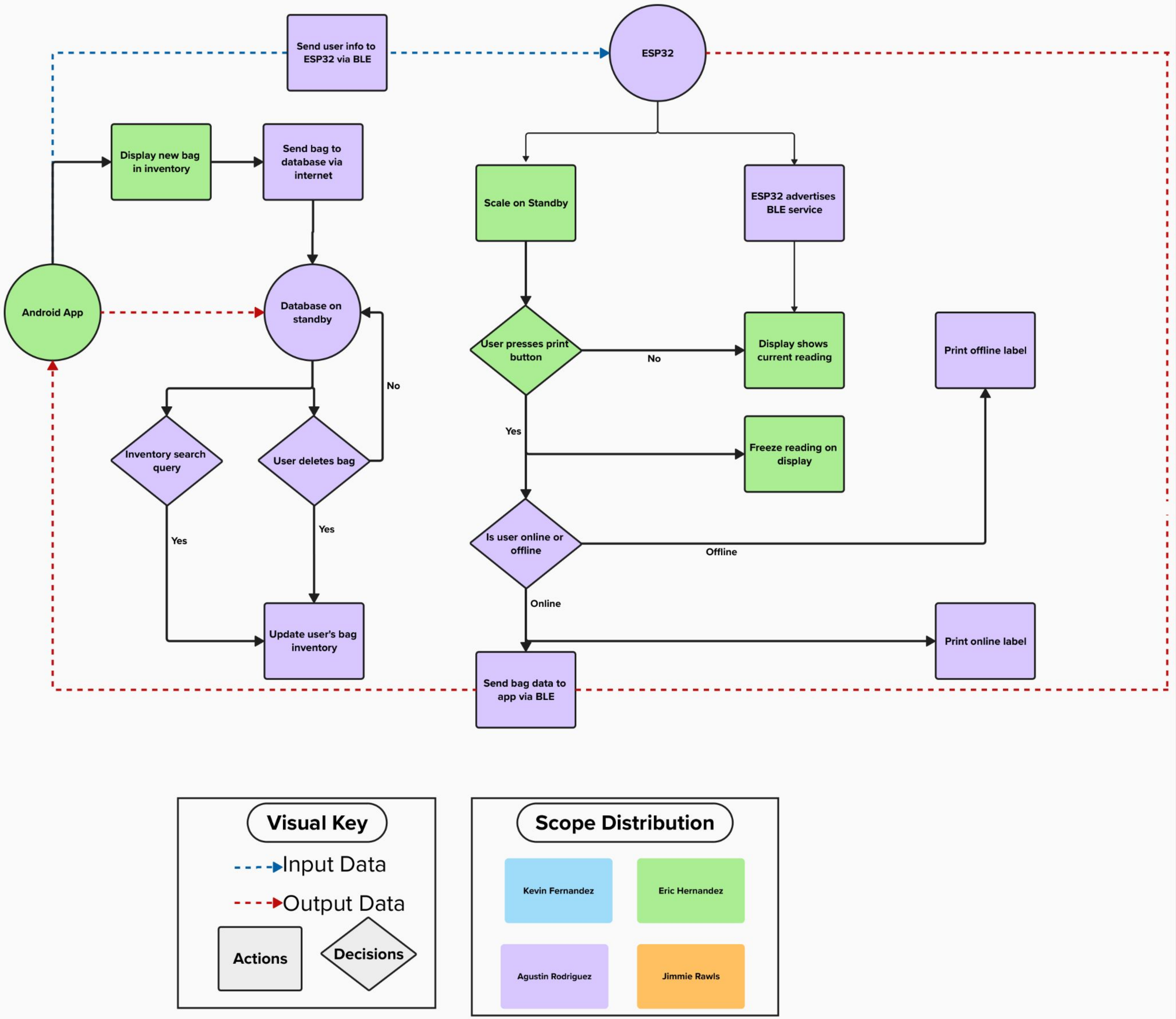
Mobile Application

The automatic label printer device will have an associated Android mobile app.

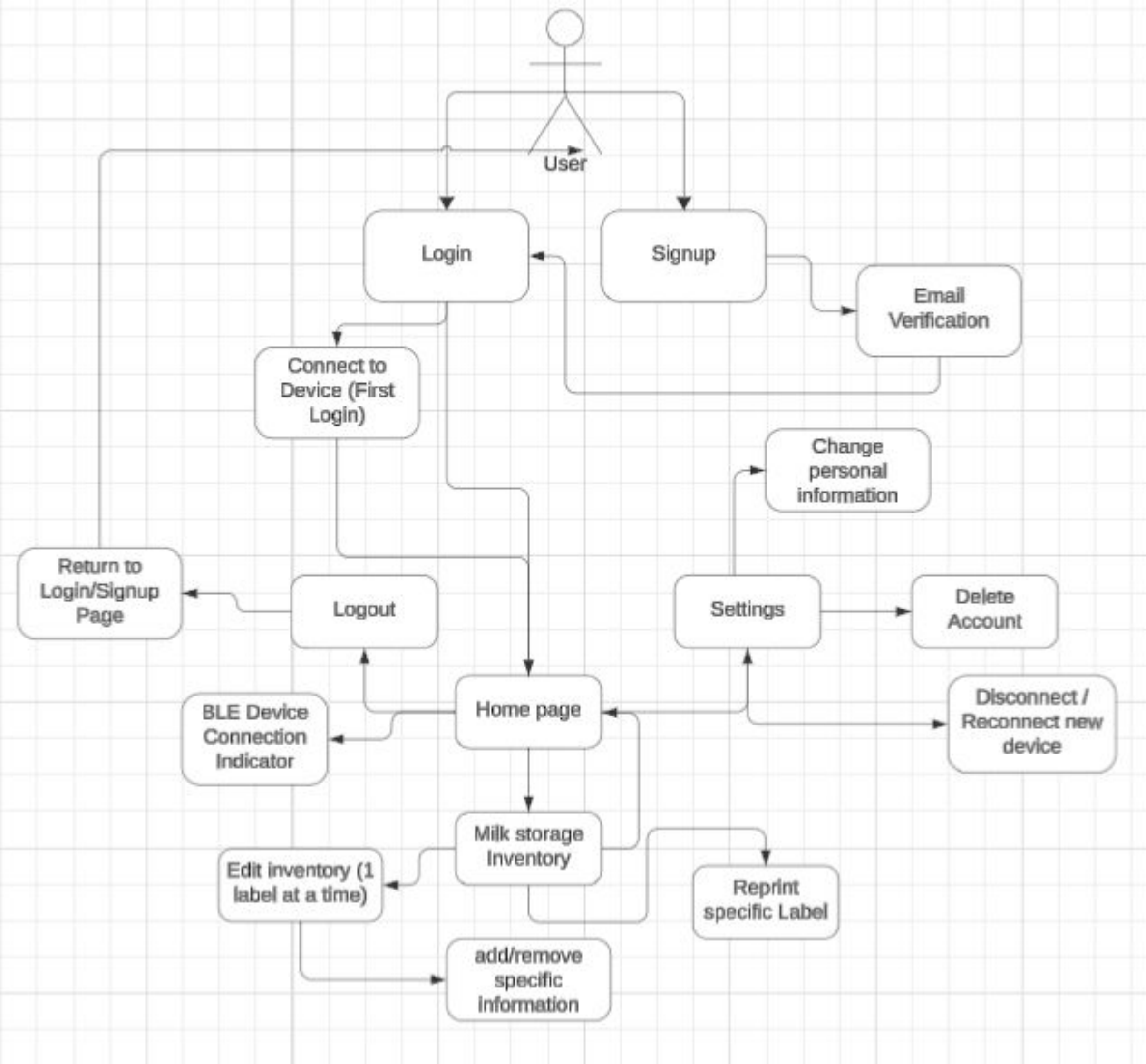
- Built in Android Studio using Kotlin + Jetpack Compose for the UI.
- App is connected to Firebase Realtime Database.
- The app sends and receives data from the ESP32 via a BLE connection.



Software Block Diagram



Mobile App Block Diagram



Frontend Comparison and Selection

- Flutter
- React Native
- XML
- Jetpack Compose

Front End Framework	
Framework	Description
Flutter	• Cross platform (Android, IOS, Web) • Dart Language • Widget Based UI • Growing rapidly • Android Studio, VSCode
React Native	• Cross Platform (Android, IOS) • JavaScript/TypeScript, CSS • Component Based UI • Mature, huge communities and libraries • VSCode Android Studio, WebStorm
XML	• Not Cross Platform (Android only UI) • XML + Java/Kotlin for logic • Layout files, Separate code UI • Legacy layout, not recommended to be used in new projects, only used to maintain older projects. • Mature Community • Android Studio
Jetpack Compose	• Not Cross Platform (Android only) • Kotlin (Similar to Java, classes and functions) • Function Based UI • Built in Live Preview & Live updates • Growing • Modern features • Android Studio • Tight integration with modern Android APIs. • Seamless integration with jetpack libraries. • Positioned by google as the future of Android UI Development. • We wanted to solely focus on Android and not IOS because we have previously run into issues with connections and development using a cross-platform framework. We also wanted to get the best features that Android Studios and Jetpack Compose have to offer.

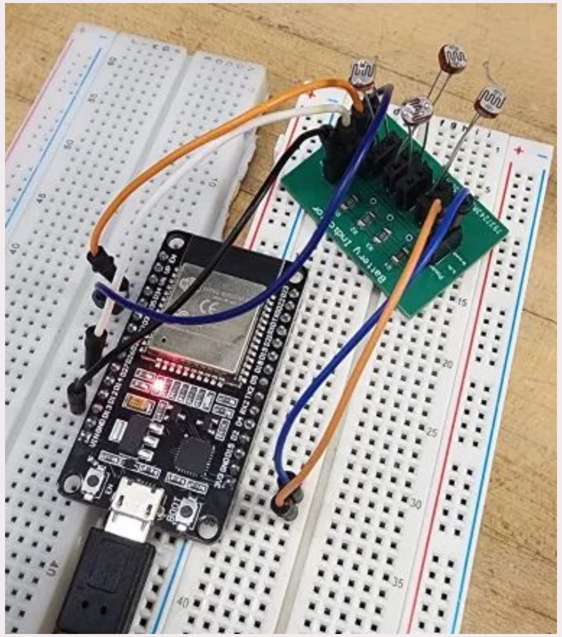
Backend Comparison and Selection

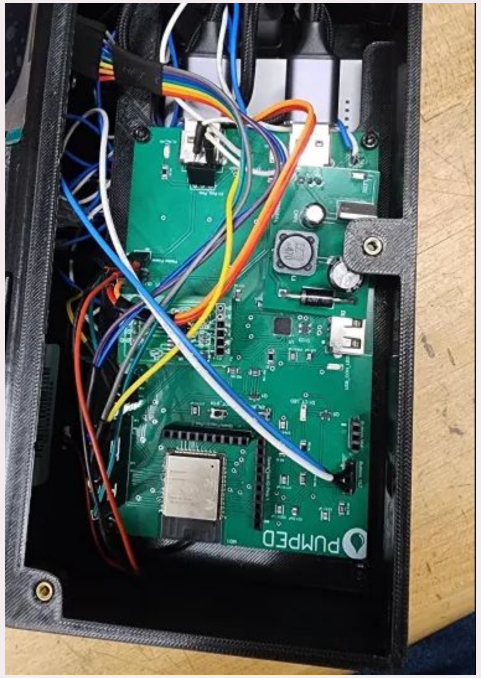
Among the options available for software's backend we decided on using Firebase. Firebase is a backend as a service (BaaS) owned and maintained by Google. We choose it for various reasons including:

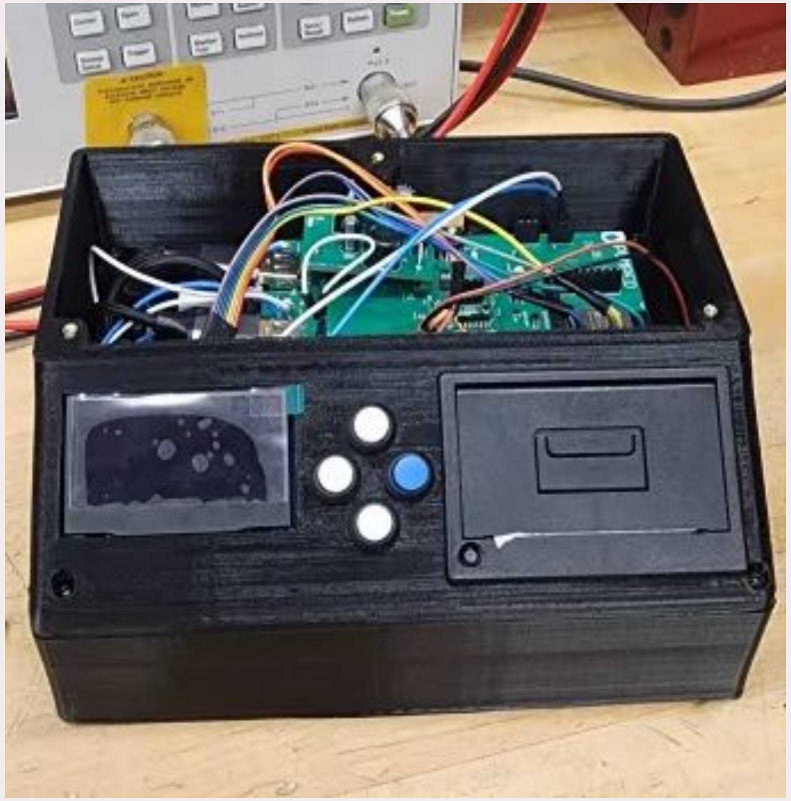
- Provides real time database to ensure minimum latency for device.
- Ease of use thanks to many backend features being prebuilt.
- Generous free tier that we are unlikely to exceed.
- Provides our sponsors the ability to scale this device if they choose.

Backend	Built-in Android Studio Compatibility	Previous Experience	Cost
Node.js + Express.js	No	Yes	Self-hosted
Ktor	No	No	Self-hosted
Firebase	Yes	No	Free* (under certain level of usage)

Testing







Budget Provided by Sponsors: $500

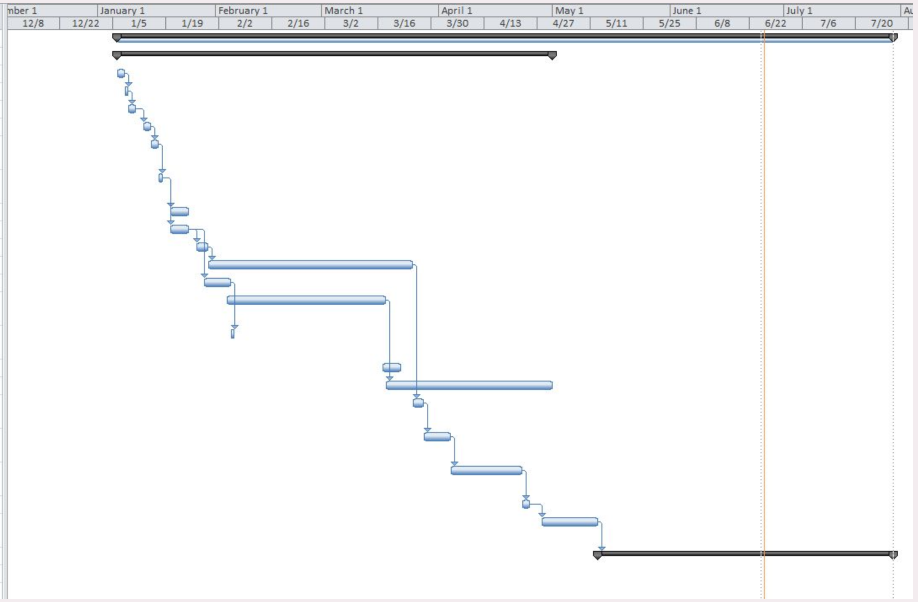
Group 15 Senior Design Expenses		
Purchased By	ITEM	COST
Jimmie R.	10 kg load cell + platform	$9.99
Jimmie R.	3x ESP 32	$13.88
Jimmie R.	HX711 + load cell	$6.99
Jimmie R.	10 PCs Thermal Paper	$14.98
Kevin F.	PCB + Stencil Order (Main & Regulator)	$80.14
Kevin F.	ROMOSS Power Bank + DC Jack Connectors	$30.10
Kevin F.	USB-A Cables (2-Pack)	$9.10
Kevin F.	USB-A Angled Connectors (4-Pack)	$6.37
Kevin F.	USB-C Angled Cable	$5.62
Kevin F.	DPST Power Switch (2-Pack)	$3.72
Kevin F.	Dual Color PLA Filament	$19.16
Kevin F.	Momentary Push Button SPST (24 Pack)	$8.51
Agustin R.	DFRobot Thermal Printer (didn't meet specs)	$53.00
Agustin R.	Maikrt Thermal Printer (used)	$49.93
Agustin R.	Maikrt Thermal Printer (backup)	$49.93
Agustin R.	22 components of varying quantities for PCBs	$77.21
Agustin R.	Male and female pin heads	$11.70
Agustin R.	Calibrations Weights & 3x ESP32s	$31.91
Agustin R.	Padlock	$6.38
Eric H.	OLED Display	$18.09
Eric H.	ESP32s 3 Pack	$14.78
Eric H.	Photo Resistors	$5.59
Eric H.	USB-A to USB-A	$7.07
Eric H.	Sticky Labels (USING FOR FINAL DEMO)	$7.44
Eric H.	Anti-Scratch Pads for device	$2.97
Eric H.	PCB + Stencil (Battery Indicator)	$33.50
	TOTAL:	**$578.06**

Work Distribution

Name	Work Assigned
Kevin Fernandez Secondary: Jimmie Rawls	• Main MCU PCB design, soldering, and troubleshooting • Photoresistor prototype programming and testing • Photoresistor Enclosure 3D modeling and Printing • PUMPED Enclosure 3D modeling and Printing
Jimmie Rawls Secondary: Kevin Fernandez	• Regulator PCB design, soldering, and troubleshooting • Load cell calibration and troubleshooting • ADC implementation • General troubleshooting and programming
Eric Hernandez Secondary: Agustin Rodriguez	• Team Leader • Battery Percentage Indicator Design, soldering, and troubleshooting • Front End development for the mobile application. • OLED Display UI
Agustin Rodriguez Secondary: Eric Hernandez	• ESP32 Printer Driver • ESP32 BLE Connectivity • Android Development • Backend Development

Schedule for SD1 + SD2

ID	Task Mode	Task Name	Duration	Start	Finish	Resource Names
1		**Senior Design Schedule**	**147 days**	**Mon 1/6/25**	**Tue 7/29/25**	
2		**Senior Design 1 Scope**	**83 days**	**Mon 1/6/25**	**Wed 4/30/25**	
3		Group Formation	2 days	Mon 1/6/25	Tue 1/7/25	
4		Group Meeting	1 day	Wed 1/8/25	Wed 1/8/25	
5		Brainstorming Ideas	2 days	Thu 1/9/25	Fri 1/10/25	
6		Choosing Project	2 days	Mon 1/13/25	Tue 1/14/25	
7		Begin Communication With our Project Sponsor	2 days	Wed 1/15/25	Thu 1/16/25	
8		Scheduled First in Person Meeting With Sponsor	1 day	Fri 1/17/25	Fri 1/17/25	
9		Divide & Conquer Report	5 days	Mon 1/20/25	Fri 1/24/25	
10		Committee Formation	5 days	Mon 1/20/25	Fri 1/24/25	
11		Divide & Conquer Meeting	3 days	Mon 1/27/25	Wed 1/29/25	
12		Midterm Report	38 days	Thu 1/30/25	Mon 3/24/25	
13		Website Formation	5 days	Wed 1/29/25	Tue 2/4/25	
14		Beginning Requisition of Components	30 days	Tue 2/4/25	Mon 3/17/25	
15		Upload D&C Report onto Website	1 day	Wed 2/5/25	Wed 2/5/25	
16		Sprink Break	5 days	Mon 3/17/25	Fri 3/21/25	
17		Prototype Testing	32 days	Tue 3/18/25	Wed 4/30/25	
18		Midterm Report Group Meeting	3 days	Tue 3/25/25	Thu 3/27/25	
19		Added Changes + Upload of Midterm Report onto Website	5 days	Fri 3/28/25	Thu 4/3/25	
20		Final Report + Mini Demo Video	13 days	Fri 4/4/25	Tue 4/22/25	
21		Second Meeting w/ Sponsor	2 days	Wed 4/23/25	Thu 4/24/25	
22		Scheduled Break Before Summer Term	11 days	Mon 4/28/25	Mon 5/12/25	
23		**Senior Design 2 Scope**	**56 days**	**Tue 5/13/25**	**Tue 7/29/25**	



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22		Scheduled Break Before Summer Term	11 days	Mon 4/28/25	Mon 5/12/25	
23		**Senior Design 2 Scope**	**56 days**	**Tue 5/13/25**	**Tue 7/29/25**	
24		ABET Lecture #1 + #2 Fridays	6 days	Fri 5/16/25	Fri 5/23/25	
25		CDR Classes	6 days	Fri 6/6/25	Fri 6/13/25	
26		Midterm Demo	3 days	Mon 6/30/25	Wed 7/2/25	
27		PCB Drafting	9 days	Tue 5/13/25	Fri 5/23/25	
28		PCB Ordering	5 days	Mon 5/26/25	Fri 5/30/25	
29		Components Ordering	5 days	Mon 5/26/25	Fri 5/30/25	
30		PCB Assembly + Troubleshooting	16 days	Mon 6/2/25	Mon 6/23/25	
31		Front end Mobile App Development	36 days	Tue 5/13/25	Tue 7/1/25	
32		Back-End Mobile App Development	39 days	Tue 5/20/25	Fri 7/11/25	
33		Simultaneous sync of both Device and Mobile App	15 days	Wed 6/25/25	Tue 7/15/25	
34		Encasing Drafting	8 days	Mon 6/9/25	Wed 6/18/25	
35		3d Printing Shell	3 days	Thu 6/19/25	Mon 6/23/25	
36		Shell Assembly	4 days	Tue 6/24/25	Fri 6/27/25	
37		Correcting Minor Errors / Polishing Project	4 days	Wed 7/16/25	Mon 7/21/25	
38		D-Day	3 days	Tue 7/22/25	Thu 7/24/25	
39		Final Documentation	1 day	Tue 7/29/25	Tue 7/29/25