

PUMPED

Critical Design Review Presented by Group 14



OUR TEAM



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Electrical Engineer



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MOTIVATION & BACKGROUND



- Our sponsors, Victoria and Matthew, are full-time working parents who are committed to providing the best care for their baby. They want to ensure their child continues to receive the nutritional benefits of breastmilk, even when mom is at work or when feeding is handled by dad or another caregiver.
- Breastmilk is often pumped for future use, requiring accurate labeling of the volume, date, and time.
- Sleep-deprived mothers may struggle to consistently track and record this information during or after pumping.
- Current storage bags rely on handwritten labels, which can be inconvenient—especially when caring for a newborn.
- Our goal is to simplify this process by automating the tracking and labeling of breastmilk, reducing mental load and improving accuracy.



GOALS



Basic Goals

- Help mothers manage breastmilk by designing a device that measures and prints a label for pumped breastmilk
- Create a user-friendly interface for mothers to access information

Advanced Goals

- Optimize design for portability, offer customizable labeling
- Help mothers by monitor milk inventory
- Design a physical guide system to minimize milk spillage while providing a visual feedback on system status

Stretch Goals

- Provide insights to help mothers make informed dietary decisions
- Implement multi-user access with varying levels of permission



OBJECTIVES



Accurate Measurement & Labeling:

- Device will measure and log milk volume using a built-in sensor
- Labels will include date, time, weight, and optional dietary/allergen restrictions, adhering to milk bank/hospital requirements
- Mobile app will allow manual editing of details

Portability:

- Device will be compact, lightweight, and battery-operated for on-the-go use
- LEDs will provide low battery alerts

Smart Inventory Management

- Accompanying software will manage inventory, track expiration dates, and provide various notifications
- User-friendly app will analyze patterns (feeding frequency, baby's age, stored amount) to anticipate future milk needs.



SPECIFICATIONS

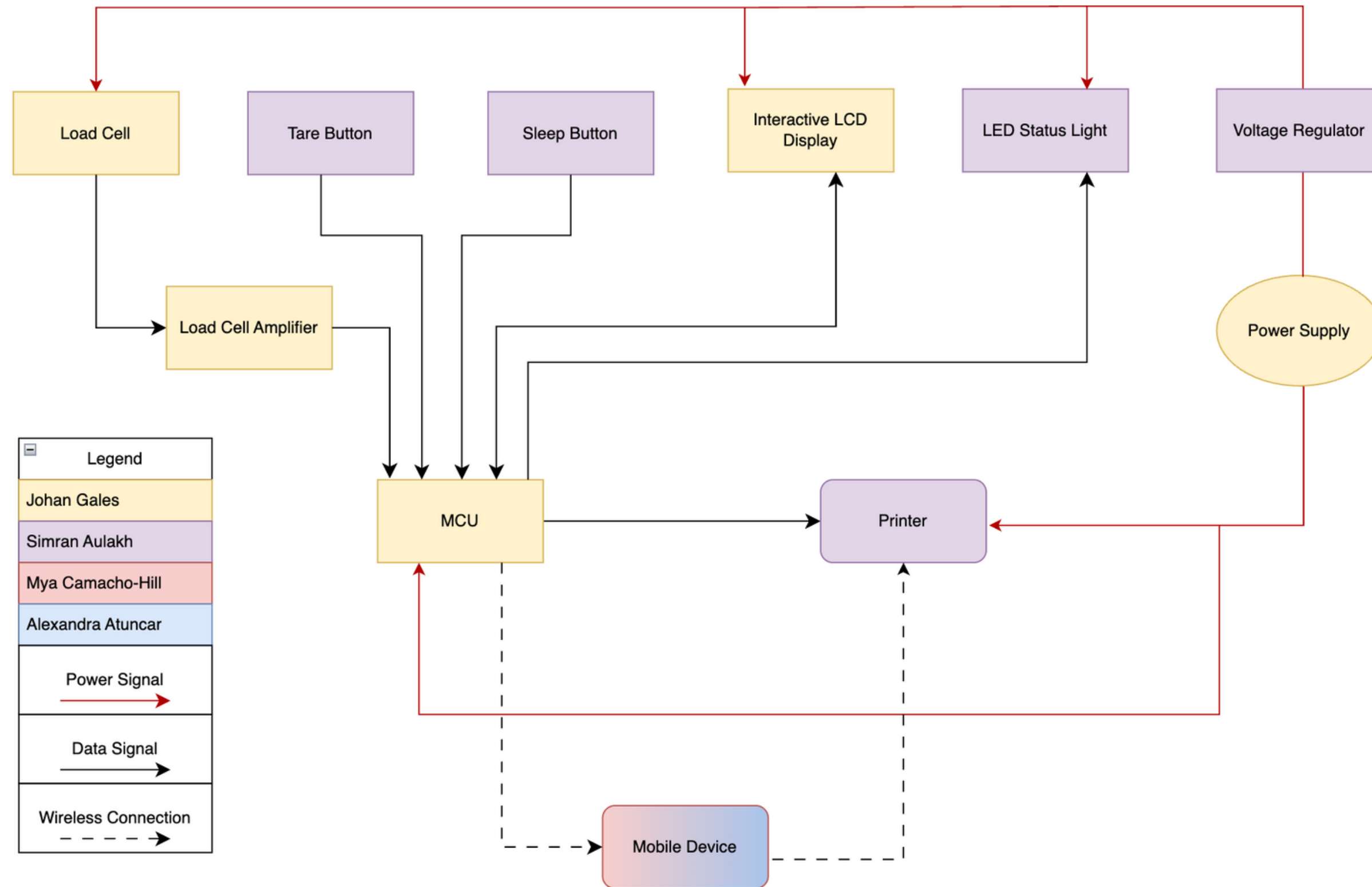


Parameter	Description	Value
Weighing Accuracy	Accuracy of weight sensor's detection	±0.005 – 0.02 oz
Maximum Weight Capacity	Maximum amount of weight the scale can hold	1-3 lbs.
Label Dimensions	FDA compliant, has date/time/dietary restrictions	2 x 3 inch labels
Wireless Connection Range	Range of Bluetooth connection between product and mobile device	30 feet
Software Response Time	Response time to see data from hardware device to mobile applications	< 5 seconds
Printing Time	Time it takes to print one label after button is pressed	< 5 seconds
Weight	Weight of the product	1-3 lbs.
Storage Capacity	Total logs of milk bags that can be stored in data inventory	1200 entries





HARDWARE BLOCK DIAGRAM



HARDWARE SELECTION: MCU



Microcontroller	Architecture	Operating Voltage	RAM	I/O Interfaces	Connectivity	Power Consumption
MSP430	16-bit	1.8-3.6V	2-8 KB	UART, SPI, I2C, ADC	None	Ultra-low power
Arduino Uno R3	8-bit	5V	2 KB	UART, SPI, I2C, ADC	None	Moderate
ESP32 - WROOM32	32-bit	2.2-3.6V	520 KB	UART, SPI, I2C, ADC, DAC, PWM	Wi-Fi, Bluetooth	Higher Power Consumption
Raspberry Pi Pico	32-bit	1.8-3.3V	264 KB	UART, SPI, I2C, ADC, PWM	None	Low Power
STM32F411	32-bit	1.7-3.6V	128 KB	UART, SPI, I2C, ADC, DAC, PWM	None	Low Power

- Built-in Bluetooth & Wi-Fi features are crucial to our project
- Operates within a voltage range that works with our other selections



HARDWARE SELECTION: LOAD CELL



- The SparkFun SEN-13329 is compact & lightweight
- Has high accuracy which is needed for breastmilk weight measurement
- Good for small scale usage
- Easily available and good for prototyping

Model	Load Cell Type	Max Capacity	Material	Output Sensitivity	Excitation Voltage
SparkFun SEN-13329	Single-Point	10 KG	Aluminum	0.9-1.1mV/V	5V
CZL635	Single-Point	10 KG	Aluminum	0.85 - 1.15 mV/V	5V-10V
Bosche H30A	Bar-Type	60 KG	Stainless Steel	2.0 mV/V	5V-12V
Vishay Tedea – Huntleigh 1042	Bar-Type	50 KG – 200 KG	Stainless Steel	2.0mV/V	5V-12V
Vishay Tedea – Huntleigh 614	S-Type	100 KG – 500 KG	Nickel-Plated Alloy Steel	3.0mV/V	5V-15V



HARDWARE SELECTION: LOAD CELL AMPLIFIER



- The specific load cell amplifier we have chosen is the SparkFun SEN-13879
- It is directly compatible with the SparkFun SEN-13329 load cell
- Supports 3.3V, which works with our ESP32
- Has community support which provides example schematics and designs

Amplifier	Type	Power Supply	Interface
ADS1232	Digital ADC	5V	SPI
NAU7802	Digital ADC	5V	SPI
HX711	Digital ADC	3.3V / 5V	I2C
NAU7802	Digital ADC	3.3V / 5V	I2C
INA125	Digital ADC	Analog Instrumentation Amplifier	2.7V - 15V



HARDWARE SELECTION: PRINTER



- TTL Serial Interface
- Supports label printing
- Has a good trade-off between cost and functionality

Printer	Print Speed	Power Type	Connectivity	Label Size Supported
Primuz Micro Thermal Printer	60 mm per second	Wired power, no batter	TTL Serial	57 x 30 mm
MUNBYN ITPP941	150 mm per second	Wired power, no battery	USB	Various sizes
Bixolon SPP-R310	80 mm per second	24-hr standby battery life	Bluetooth, WLAN, USB	3 inches
Zebra ZQ620/ZQ520	114.3 mm per second	Battery powered	Bluetooth, USB	3-4 inches
Brother RJ-2035B	101.6 mm per second	Long lasting battery	Bluetooth, NFC, USB	2 inches



HARDWARE SELECTION: DISPLAY SCREEN



- Using an LCD screen over an OLED screen due to lower cost & no burn-in risk
- Has SPI interface and 3.3V-5V range
- Fits within 4'-5' inch size

Screen	Resolution	Display Type	Interface	Supply Voltage	Touchscreen Options
ILI9488 TFT Display	320 x 480	TFT LCD	Multiple including SPI	3.3V - 5V	Resistive
DT050BTFT – 5" Color TFT LCD Display	800 x 480	IPS TFT LCD	SPI/RGB	3.0V - 3.6V	Resistive or Capacitive
NHD-4.3-480272FT-CSXP-T (4.3" TFT LCD Display)	480 x 272	IPS TFT LCD	SPI	3.0V - 3.6V	Resistive



HARDWARE SELECTION: VOLTAGE REGULATOR



- The LM2576 has been highly recommended due to reliability
- 3.3V supports our ESP32, touchscreen, and load cell amplifier components
- Can handle a wide range of voltage inputs as well
- Cost effective

Voltage Regulator	Type	Output Voltage Range	Max Output Current	Efficiency
LM2576	Buck	3.3V, 5V, 12V (Fixed) or 1.23V - 37V (Adjustable)	3A	~77-80%
LM2679	Buck	3.3V, 5V, 12V (Fixed) or 1.23V - 37V (Adjustable)	5A	~85%
LM2596	Buck	3.3V, 5V, 12V (Fixed) or 1.23V - 37V (Adjustable)	3A	~80-85%
MP1584	Buck	0.8V - 20V (Adjustable)	3A	~90%
XL4015	Buck	1.25V - 36V (Adjustable)	5A	~96%



HARDWARE SELECTION: POWER SUPPLY



- The TalentCell's 12V output satisfies our printer's power requirement while simultaneously
- Has built-in safety features, such as overcharge, overdischarge and short-circuit protection
- Uses wall adapter plugged into standard AC outlet

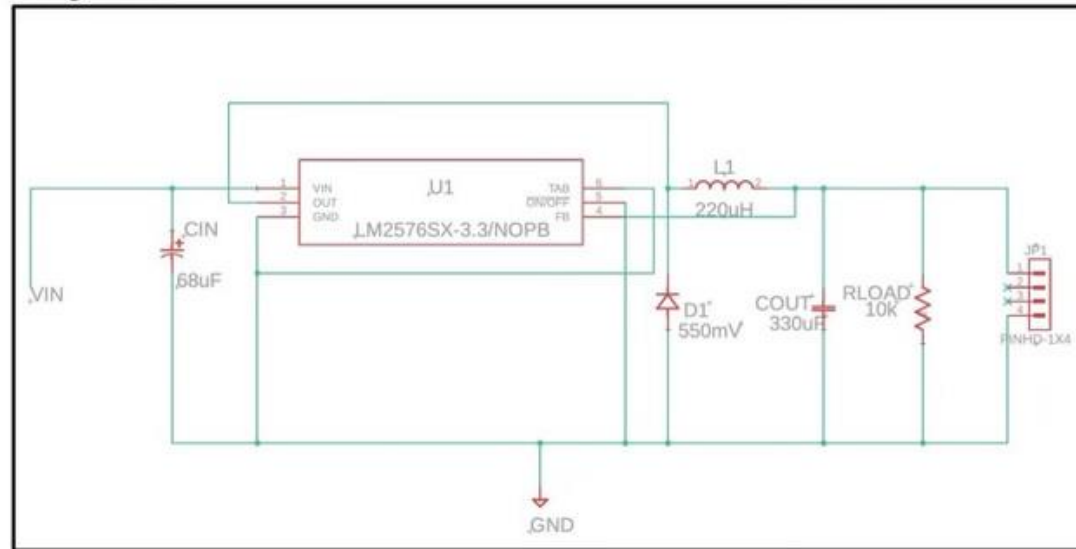
Brand Model	Input	Output	Capacity	Weight
TalentCell (YB1206000)	12.6V	12V/5V	6000mAh	380g
Rapthor	12.6V	12V/5V	6500mAh/13000mAh	380g
Melasta	12.6V	12V/9V/5V	5200mAh	400g



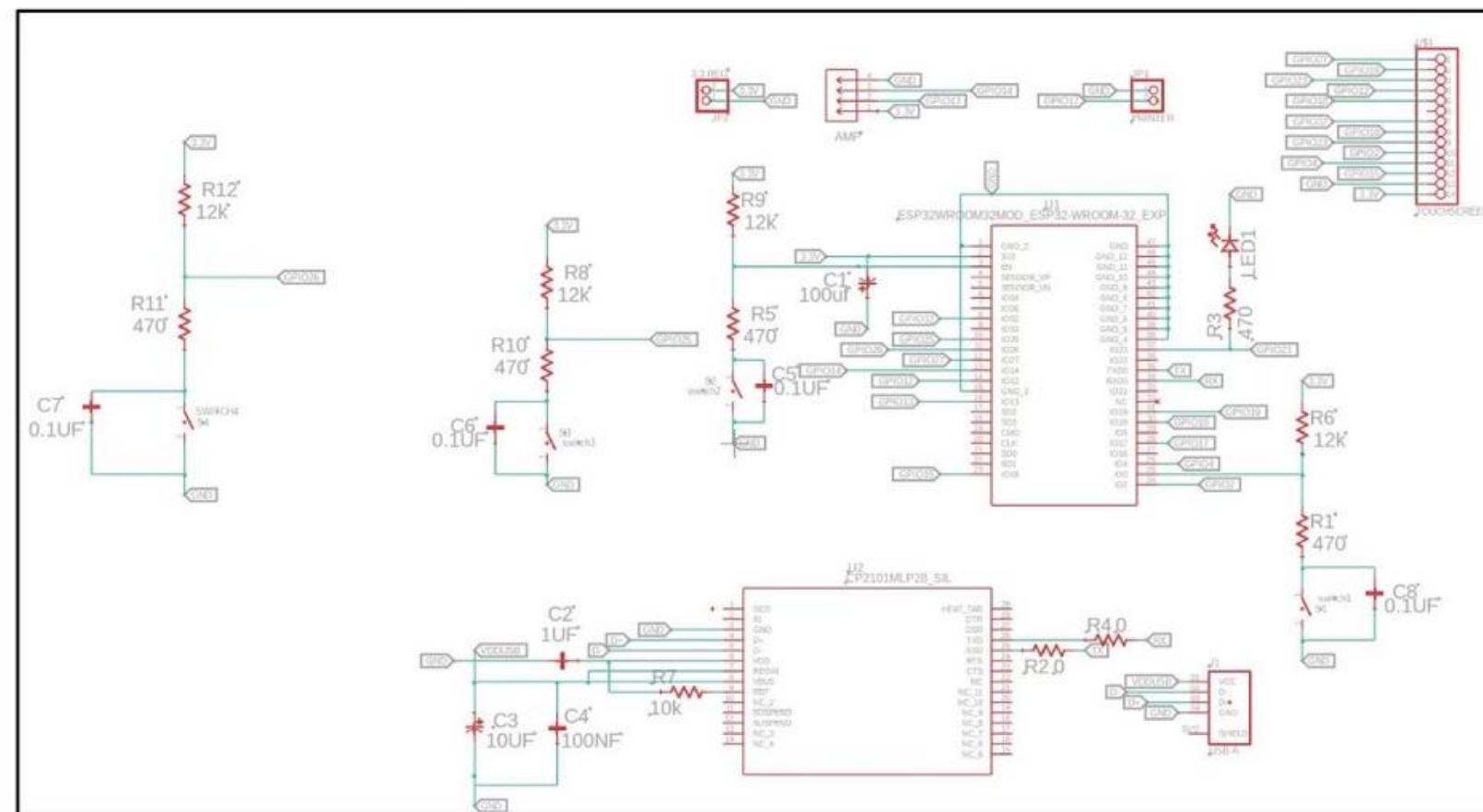
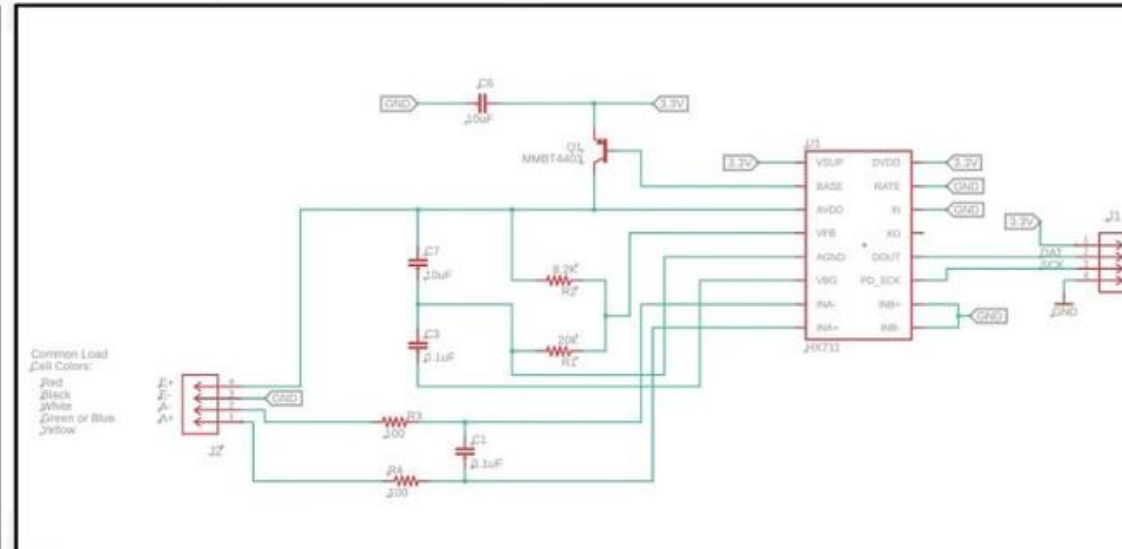
OVERALL SCHEMATIC



Regulator

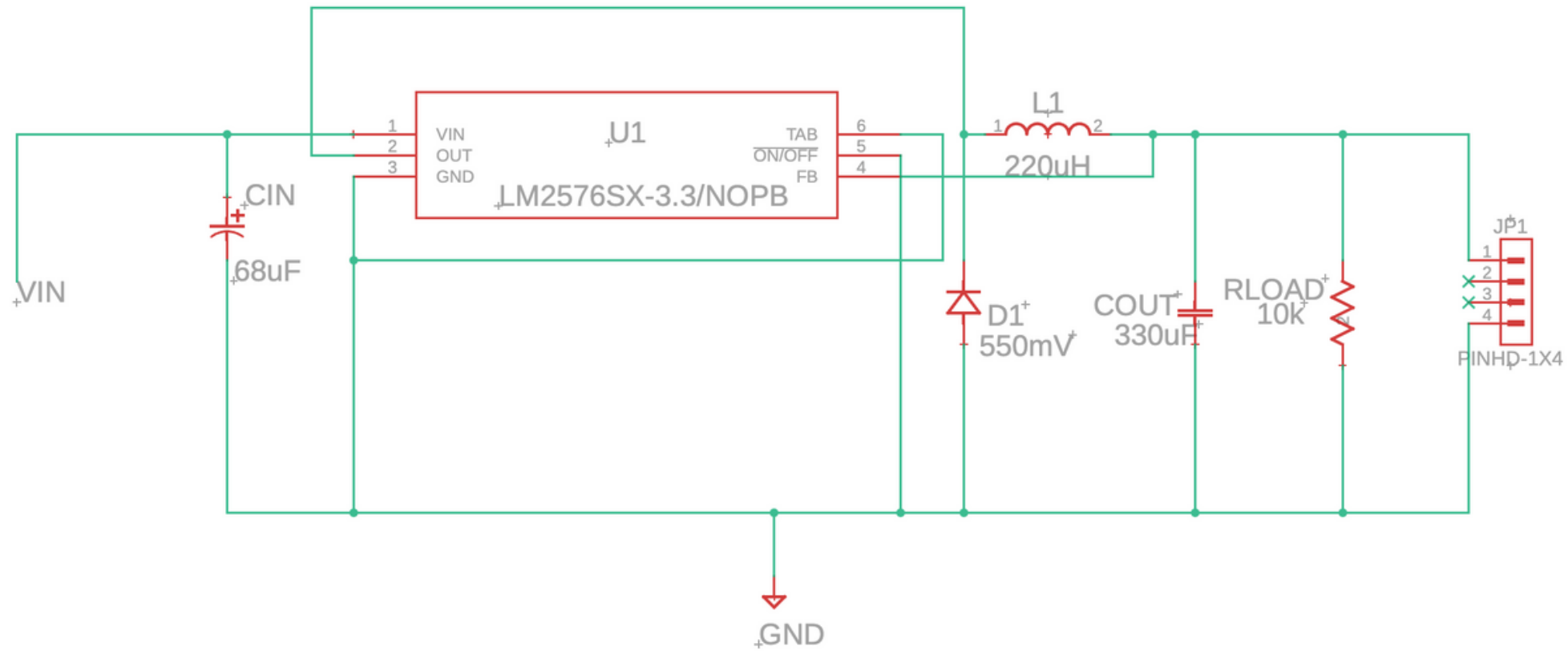


Load Cell Amplifier



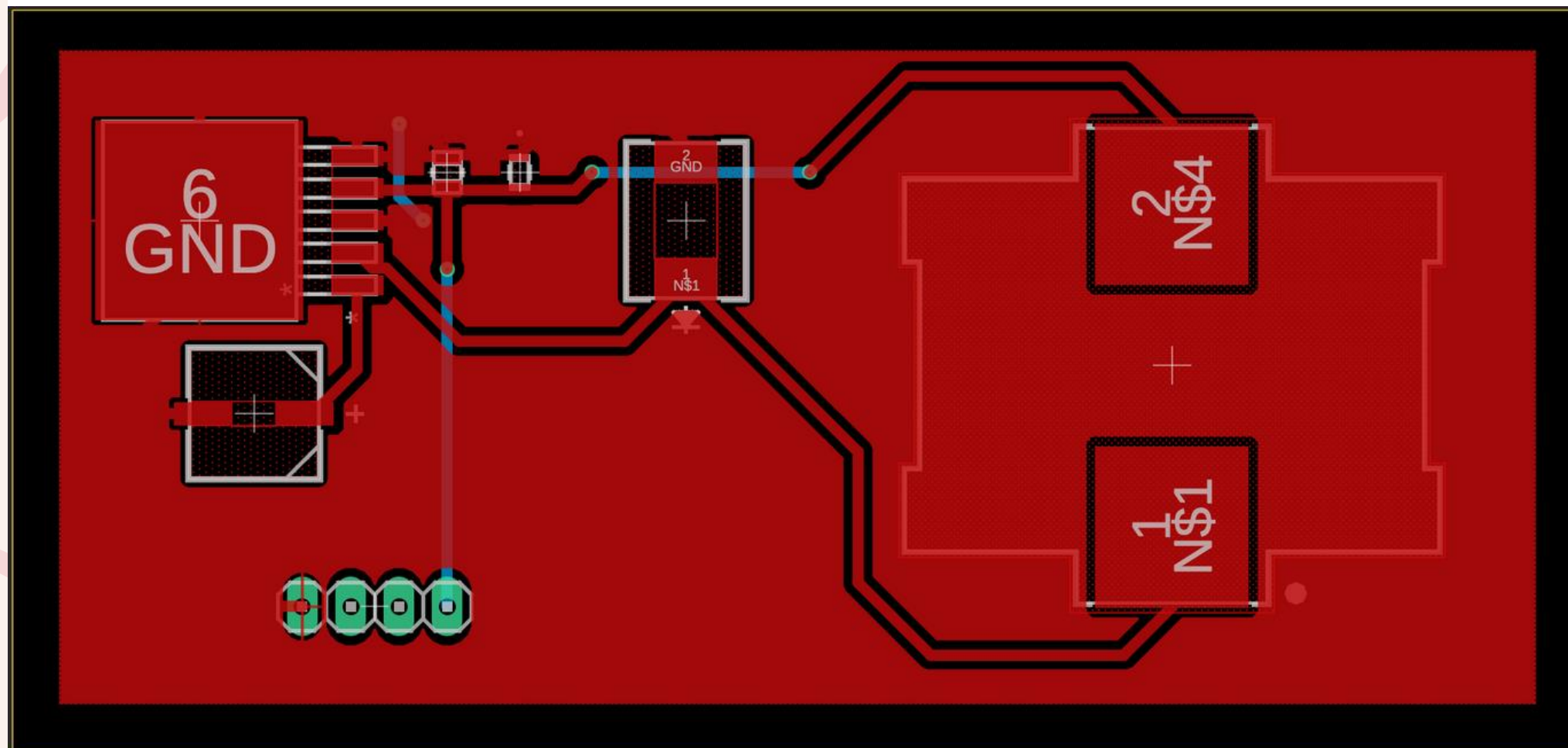
MCU



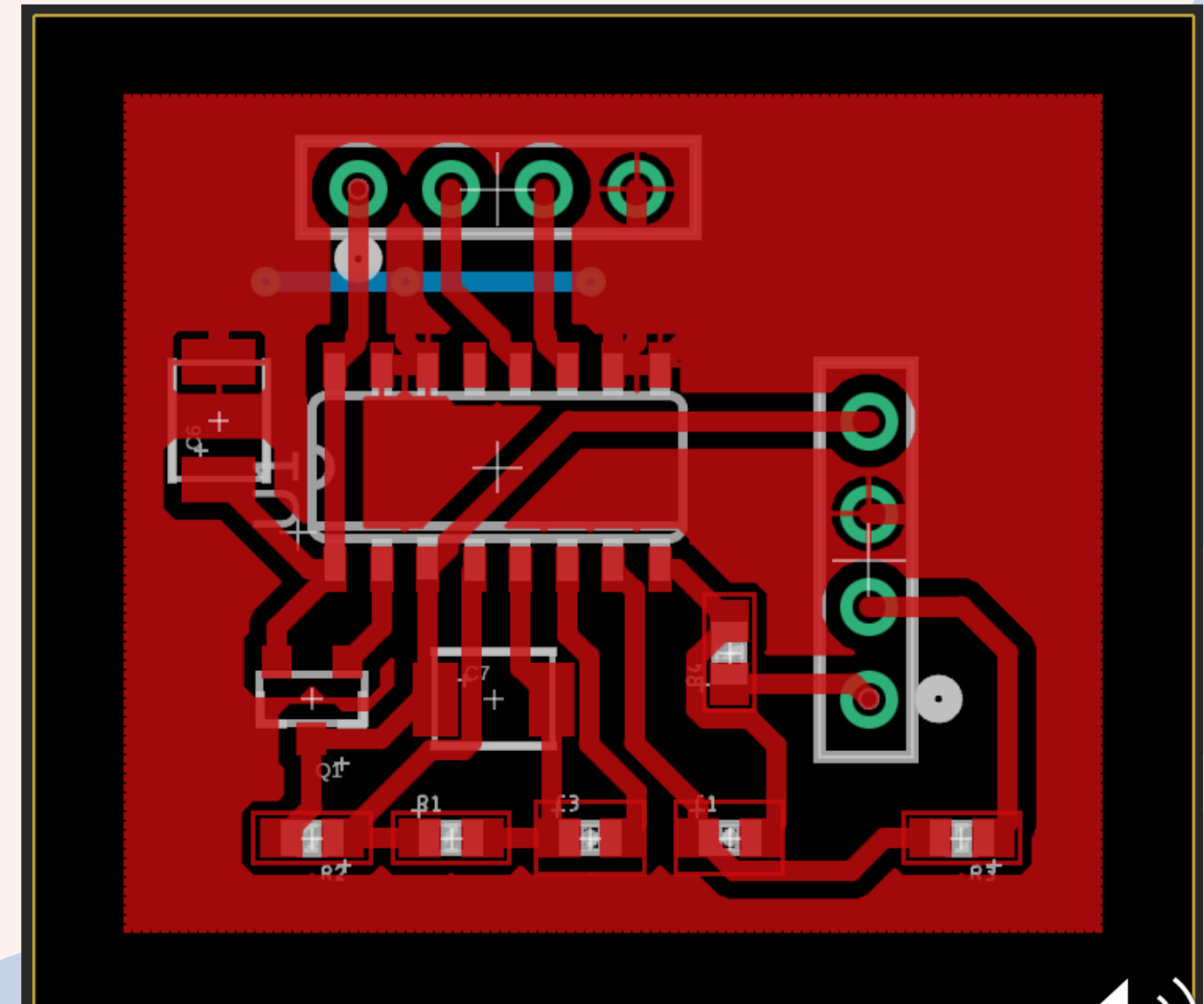


3.3V REGULATOR

- Provides 3.3V to our subsystems
- Schematic was generated using WeBench



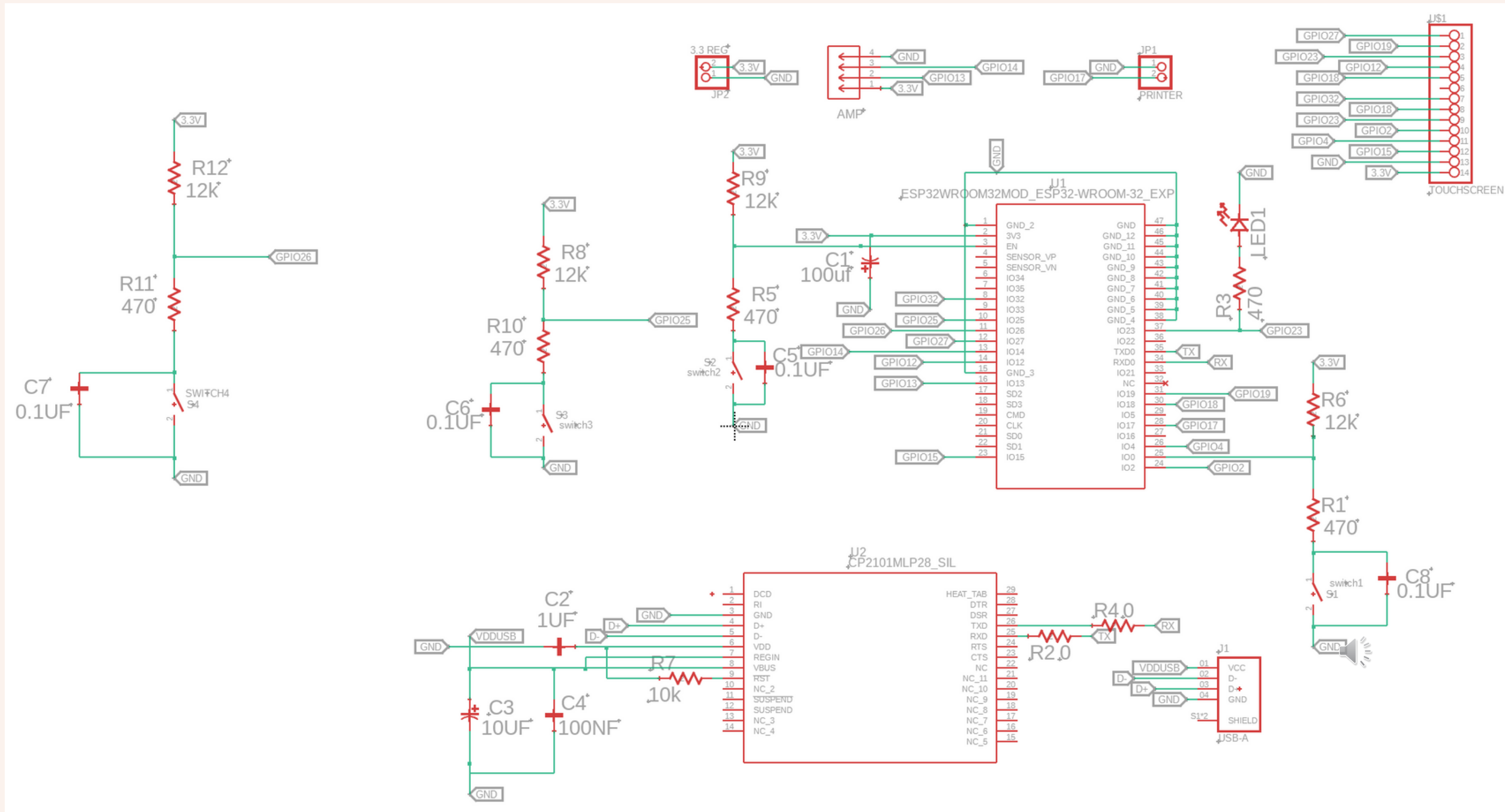
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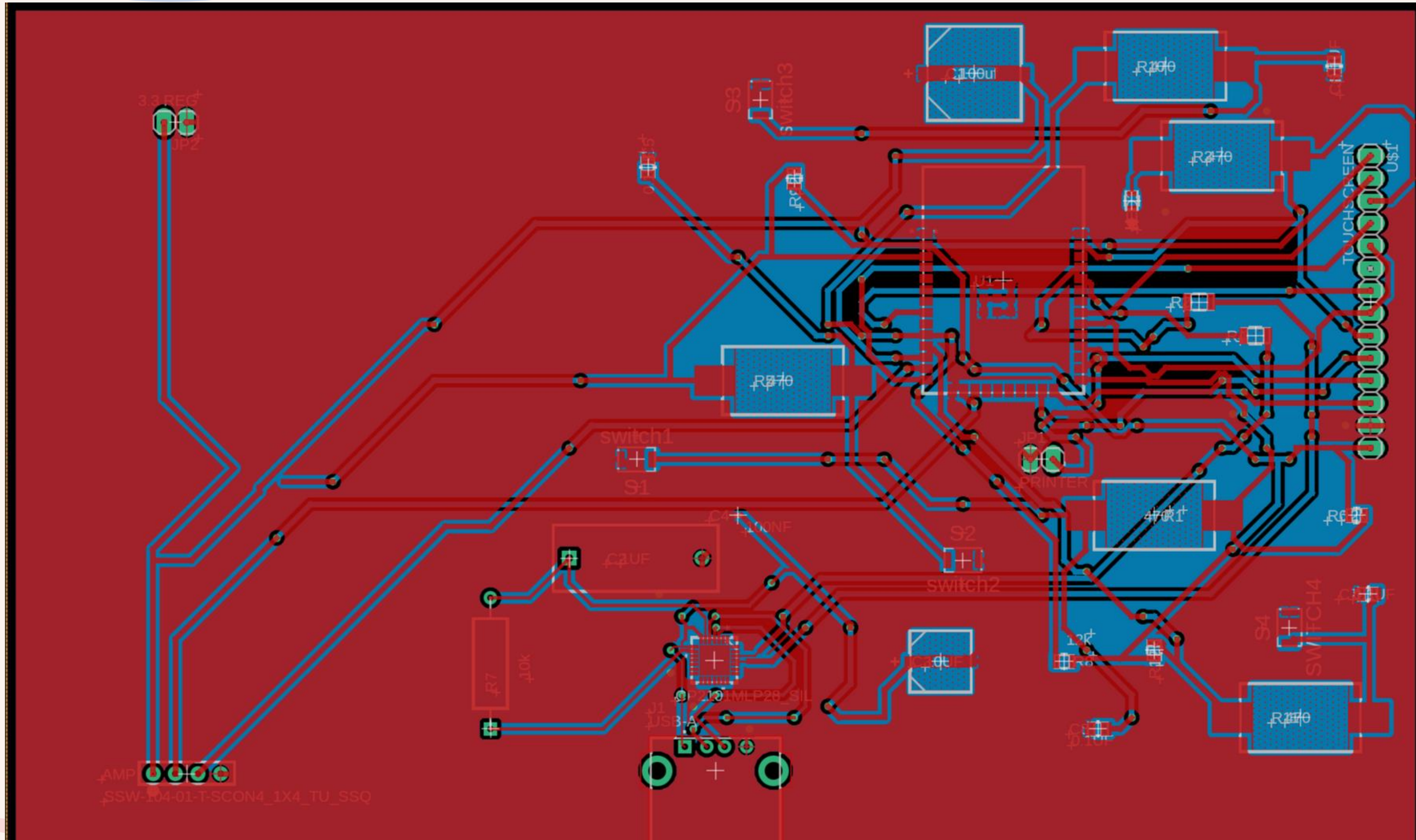
MCU DESIGN



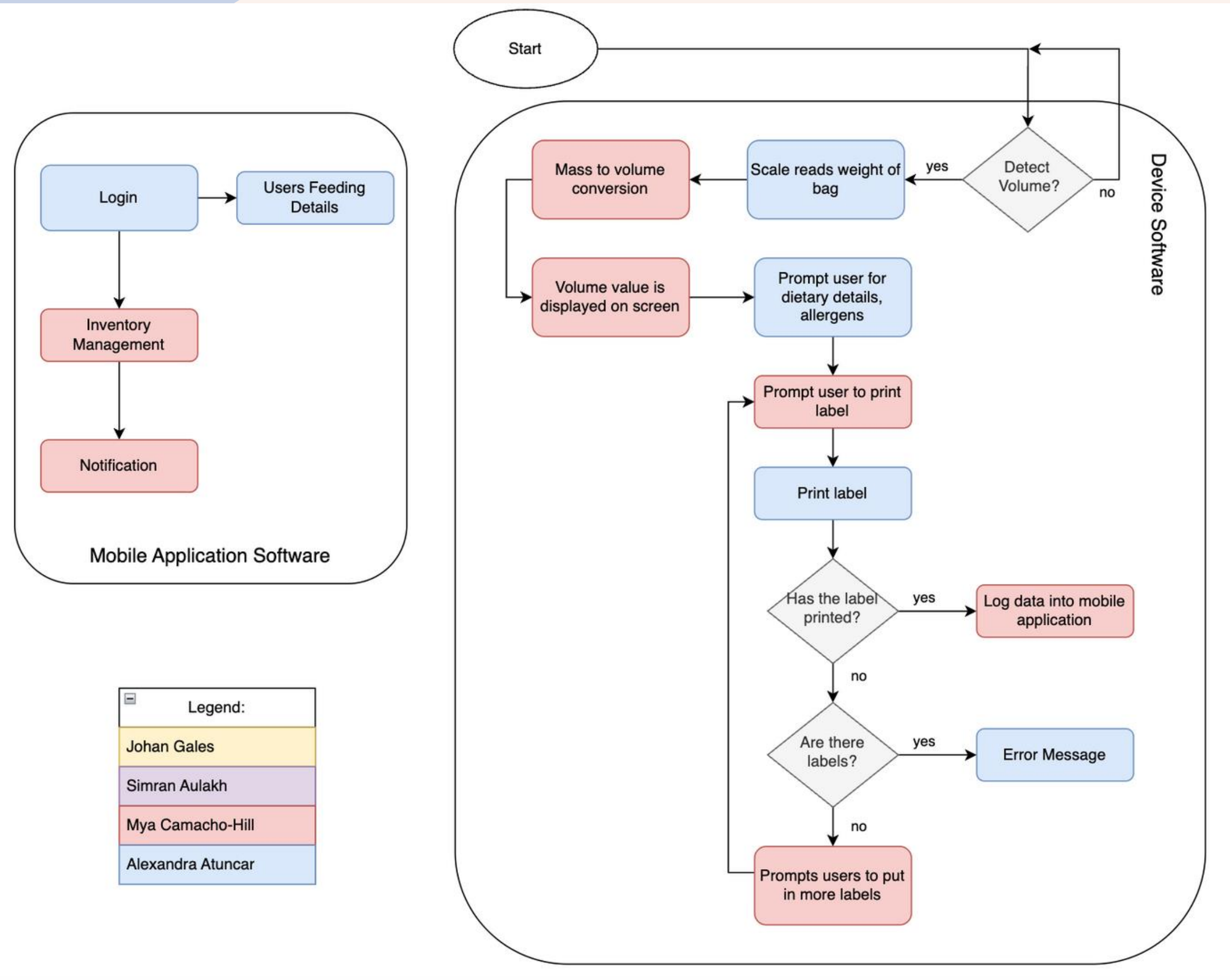
- System is centered around the ESP32
- CP2102N provides a USB-to-UART Bridge
- Several Peripherals are connected to the ESP32



MCU DESIGN



SOFTWARE FLOWCHART



SOFTWARE SELECTION: MICROCONTROLLER INTERFACE



- In our project, we decided to utilize three microcontroller interfaces to ensure smooth and compatible communication between our components and the microcontroller.
- UART: Printer Communication
- SPI: Touchscreen Communication
- I2C: Load Cell Amplifier Communication

Interface	Speed	Wires Needed	Usage	Compatible Components
PWM	Variable	1 per channel	Backlight, motor control feedback audio	LCD backlight, servos, buzzers and DC motors
ADC/DAC	Variable	Analog input/output	Sensor reading, audio output	Load cells, temperature sensors, microphone speakers
UART (Universal Asynchronous Receiver Transmitter)	Up to 1 Mbps	2 (TX, RX)	Debugging and communication with modules	GPS modules, Bluetooth modules, RFID readers
SPI (Serial Peripheral Interface)	Up to 50 Mbps	4 (MOSI, MISO, SCLK, CS)	Display communication and high-speed data transfer	TFT LCDs, SD cards, flash memory and high-speed ADCs
I2C (Inter-Integrated Circuit)	Up to 3.4 Mbps	2 (SDA/SCL)	Sensors, memory and low-power devices	OLED displays, EEPROMs, IMUs and environmental sensors



SOFTWARE SELECTION: DEVELOPMENT ENVIRONMENT



Environment	Ease of Use	Language Support	Board Support	Debugging	Compiler	Firebase Integration
Arduino-IDE	Beginner Friendly (Simple UI)	C/C++ with Arduino API	Arduino, ESP32, Uno, Mega, etc.	Serial Monitor only	Moderate	Easy via Arduino Firebase Client
PlatformIO	Intermediate (Advanced features)	C/C++, embedded Python (Including Micropython)	Extensive support: ESP32, STM32, AVR, RP2040, etc.	Integrated debugging (JTAG, GDB)	Moderate	Easy via Arduino Firebase Client
ESP-IDF	Advanced (Experts use with steep learning curve)	Mainly C with C++, Rust, and Python support	ESP framework (ESP32, ESP32-S, ESP32-C series)	Full debugger support	Optimized	Manual implementation with REST/HTTP

We chose PlatformIO as our development environment because:

- Integrated debugging superior to the Arduino IDE
- Better library management and faster development cycle
- Easy to use with advanced features



SOFTWARE SELECTION: DATABASE



We chose

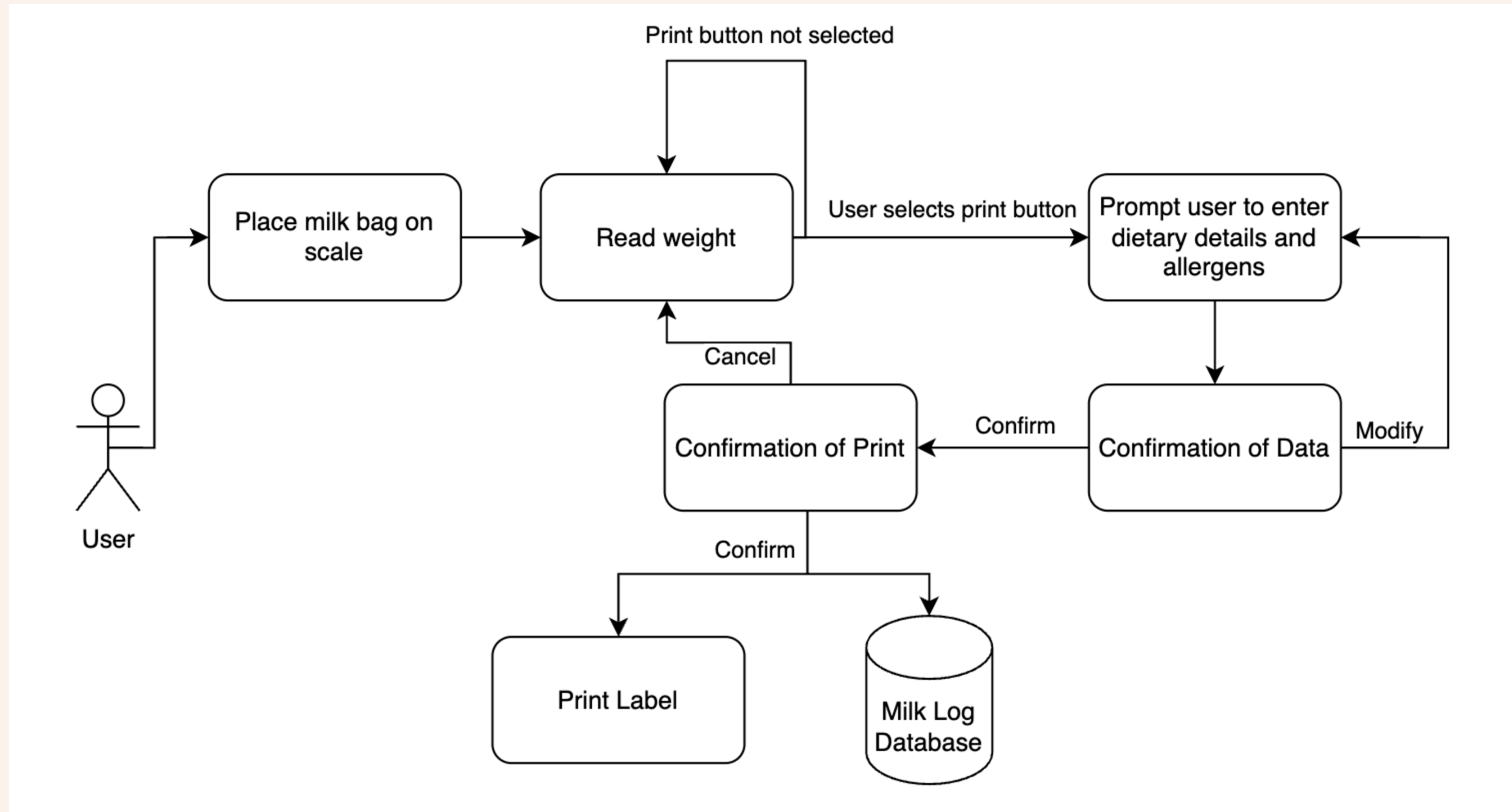
Firestore Realtime Database because:

- User-friendly setup and cloud-hosting enable real-time data synchronization
- Native SDKs for Flutter
- It has built-in offline caching

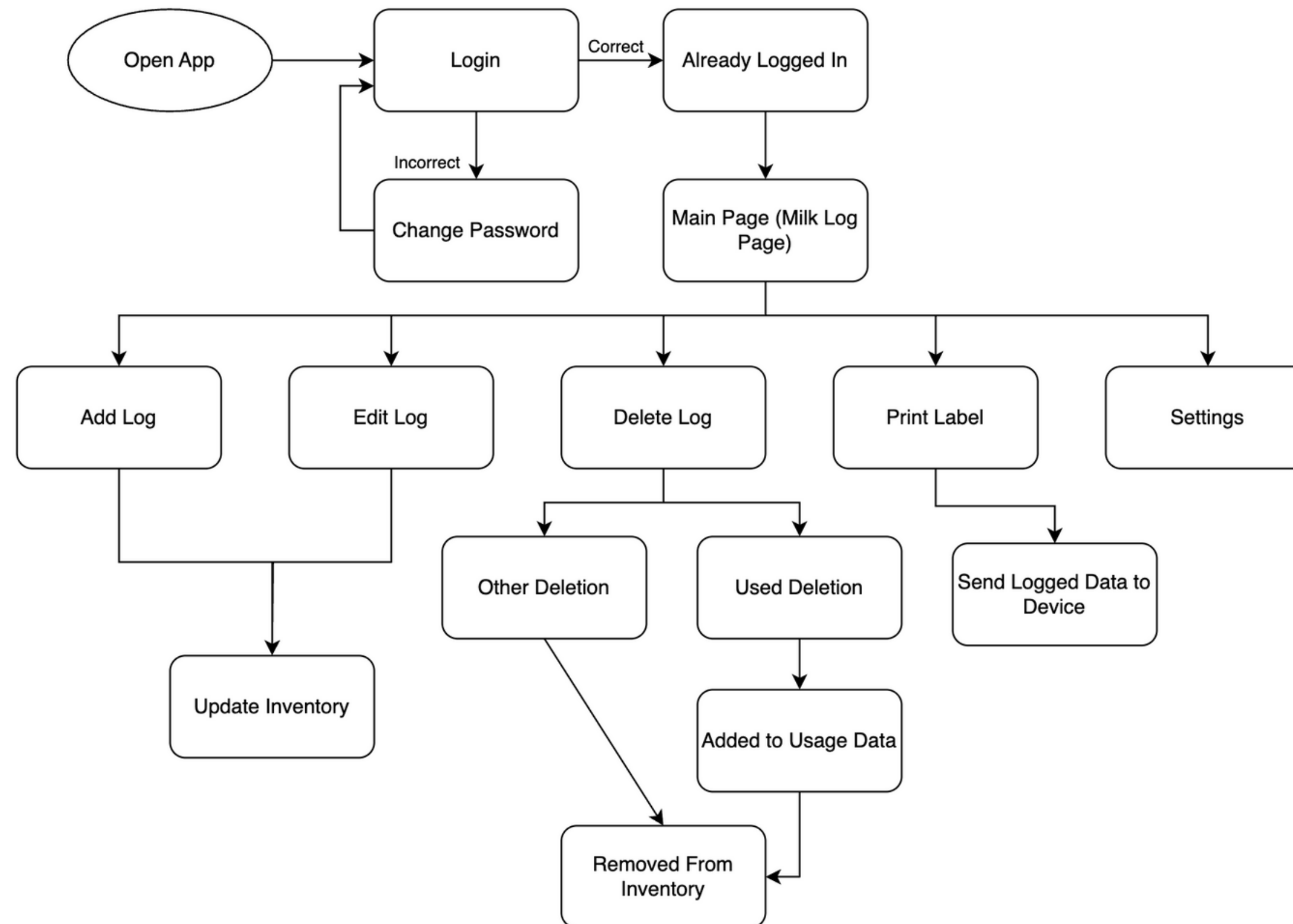
Database	Ease of Setup	Type	Hosting	ESP Compatibility	Realtime Sync	Mobile Integration	Offline Support
SQLite	Easy	Embedded relational DB	Local (on-device/mobile)	Not ideal	No native support	Good (Android Room)	Excellent
MySQL Database	Moderate	Relational (SQL)	Requires external server	Needs HTTP/REST or intermediate app	No native support	Requires REST API or middleware	Not Ideal
Firestore Realtime Database	Easy	NoSQL (key-value, tree-structured)	Cloud-hosted by Google	Direct support via REST/Arduino SDK	Built-in real-time sync	Native SDKs (Flutter, Android, iOS)	Excellent (Built-in offline cache)
MongoDB	Moderate	NoSQL (document-based)	Cloud/self-hosted	Needs REST API or MQTT bridge	Requires custom setup	Requires third-party libraries	Moderate (Manual configuration needed)



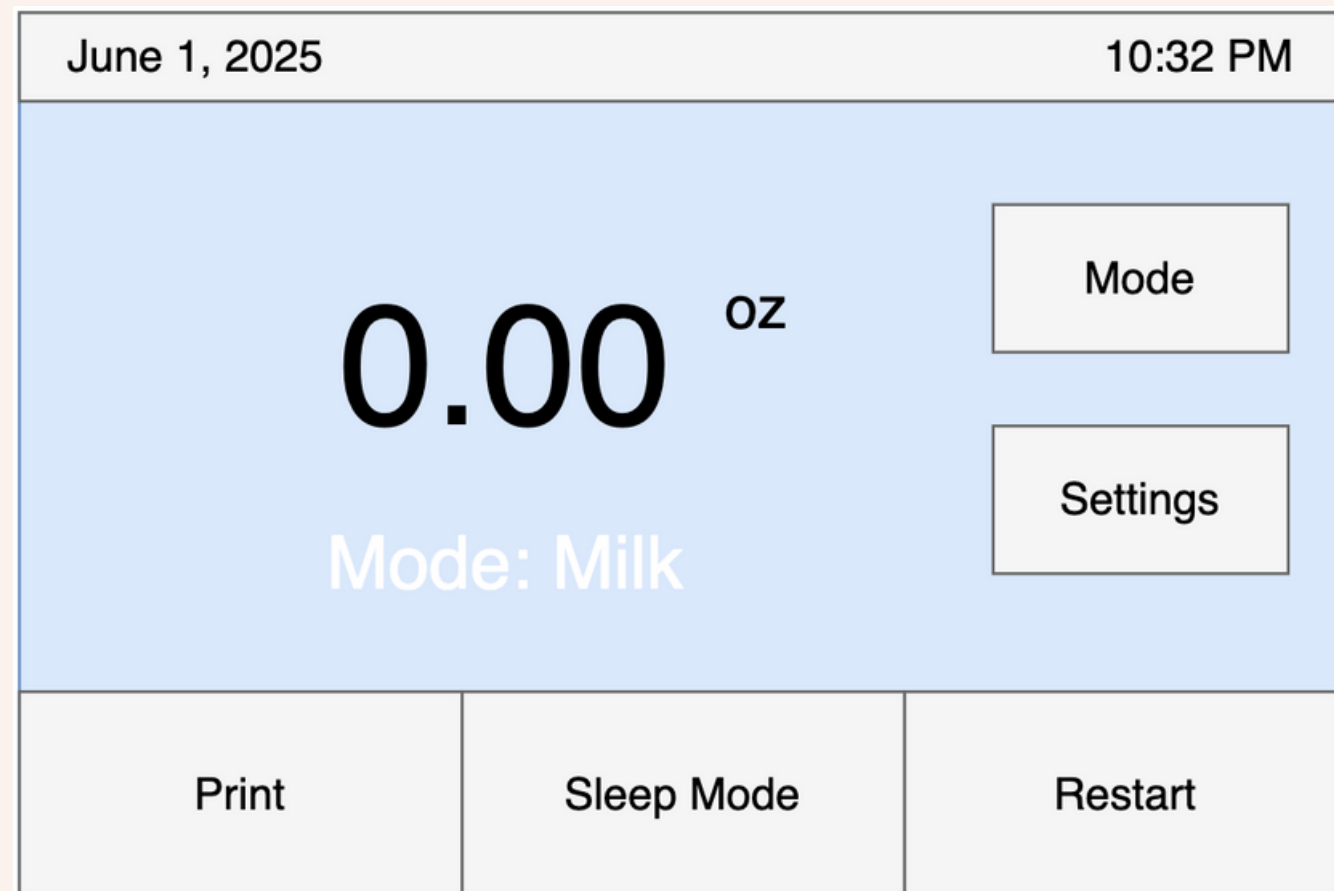
USE CASE DIAGRAM



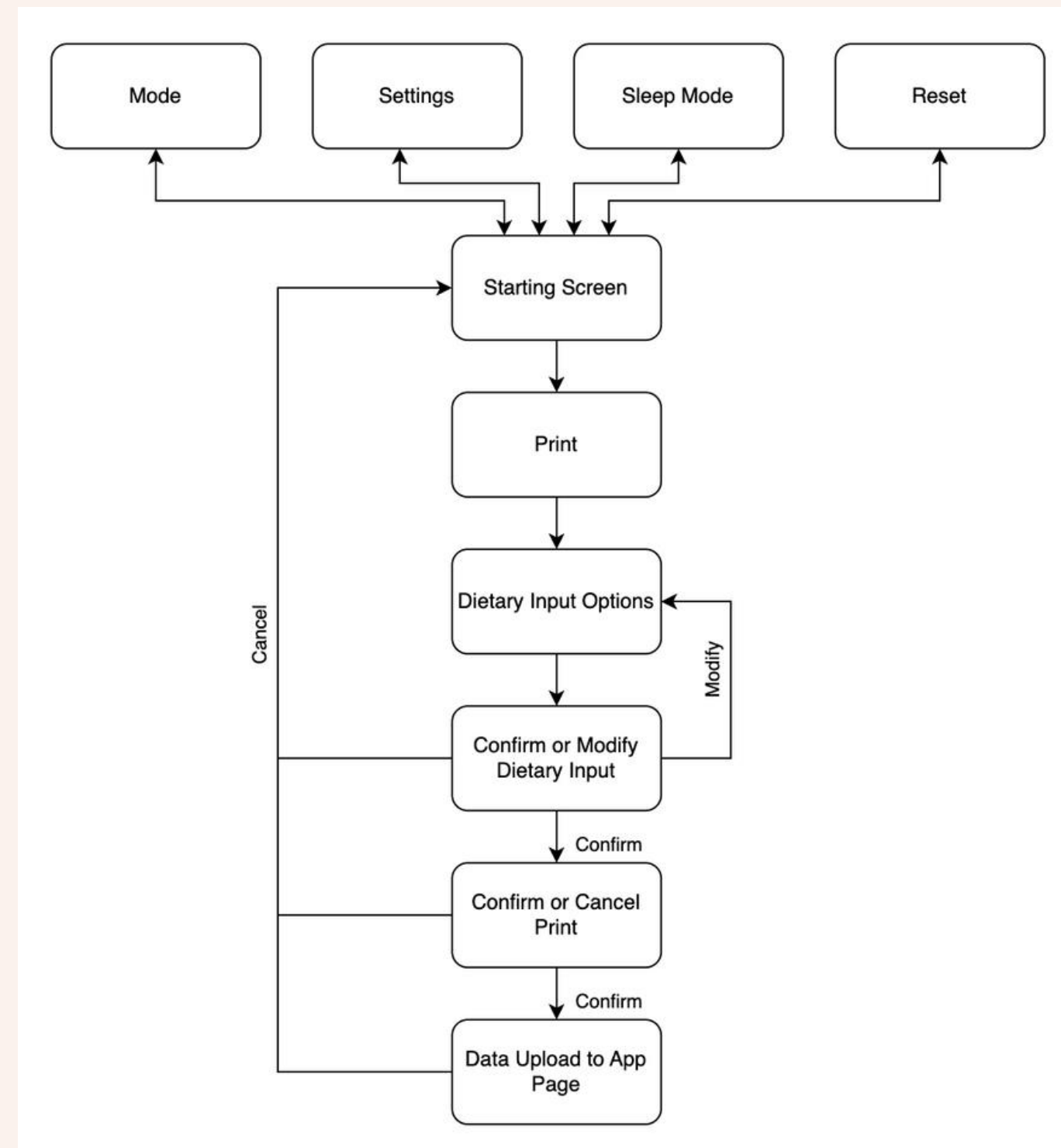
APPLICATION FLOWCHART



GRAPHICAL USER INTERFACE



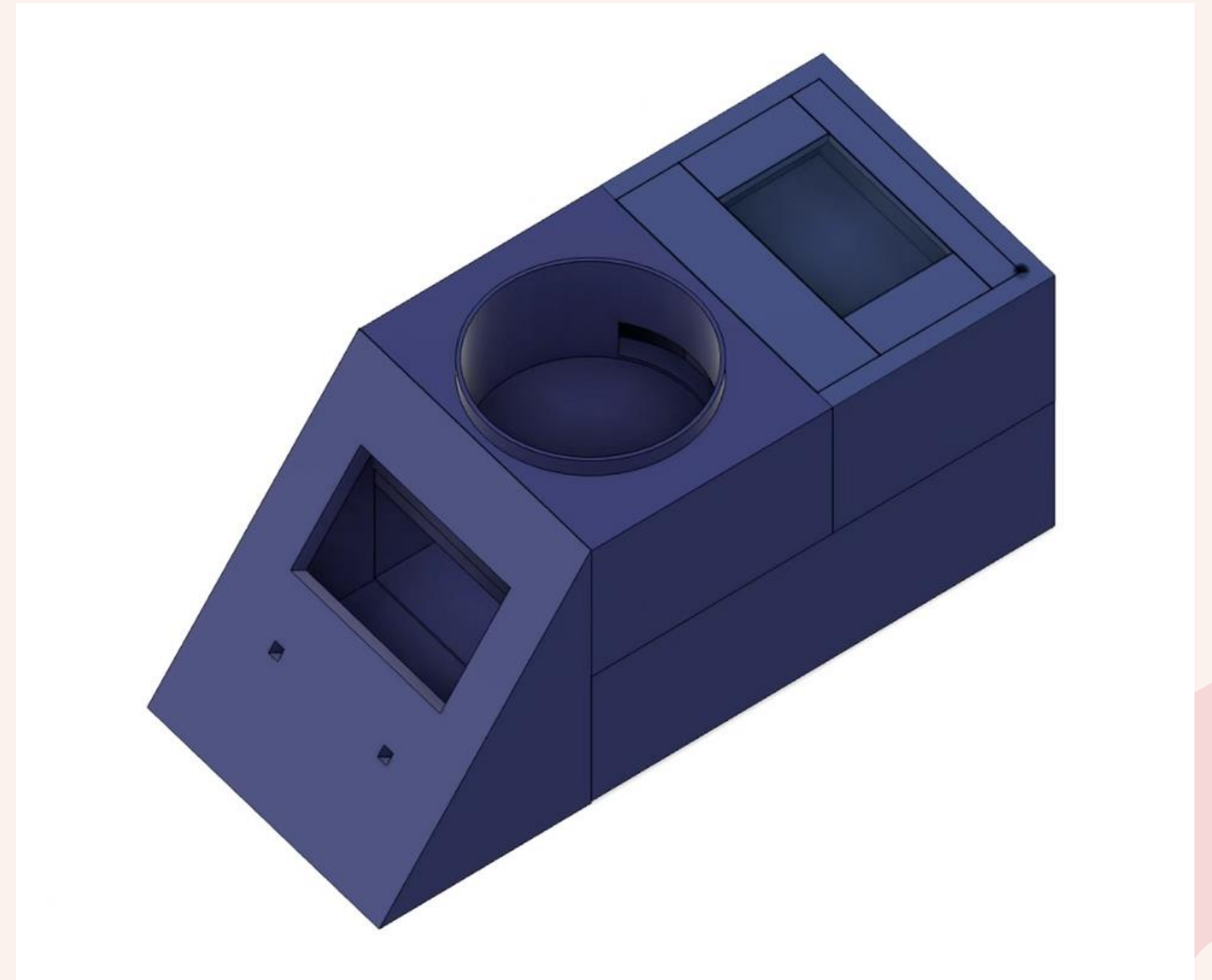
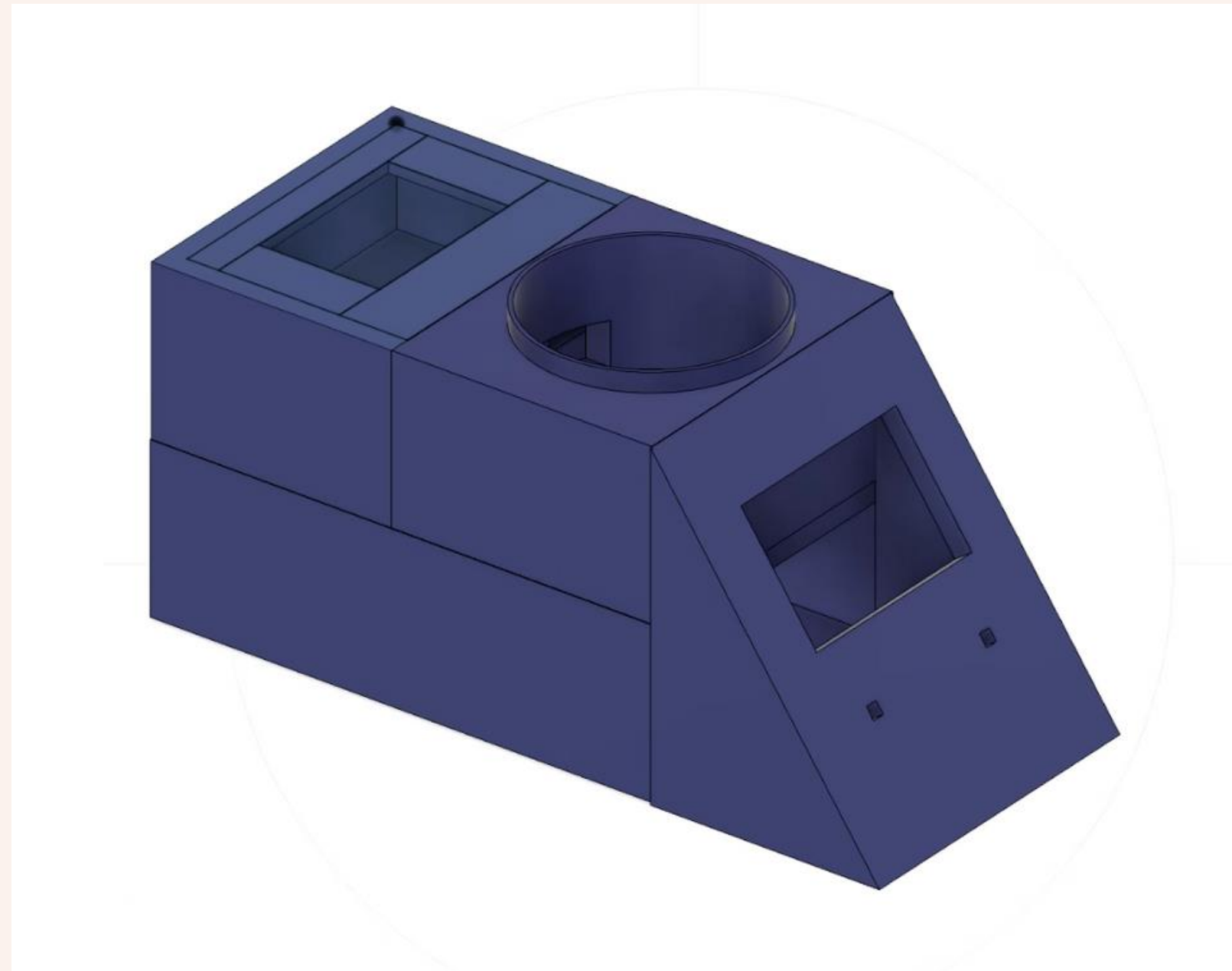
Homepage Draft



Touchscreen Flowchart



ENCLOSURE



Built in Fusion360

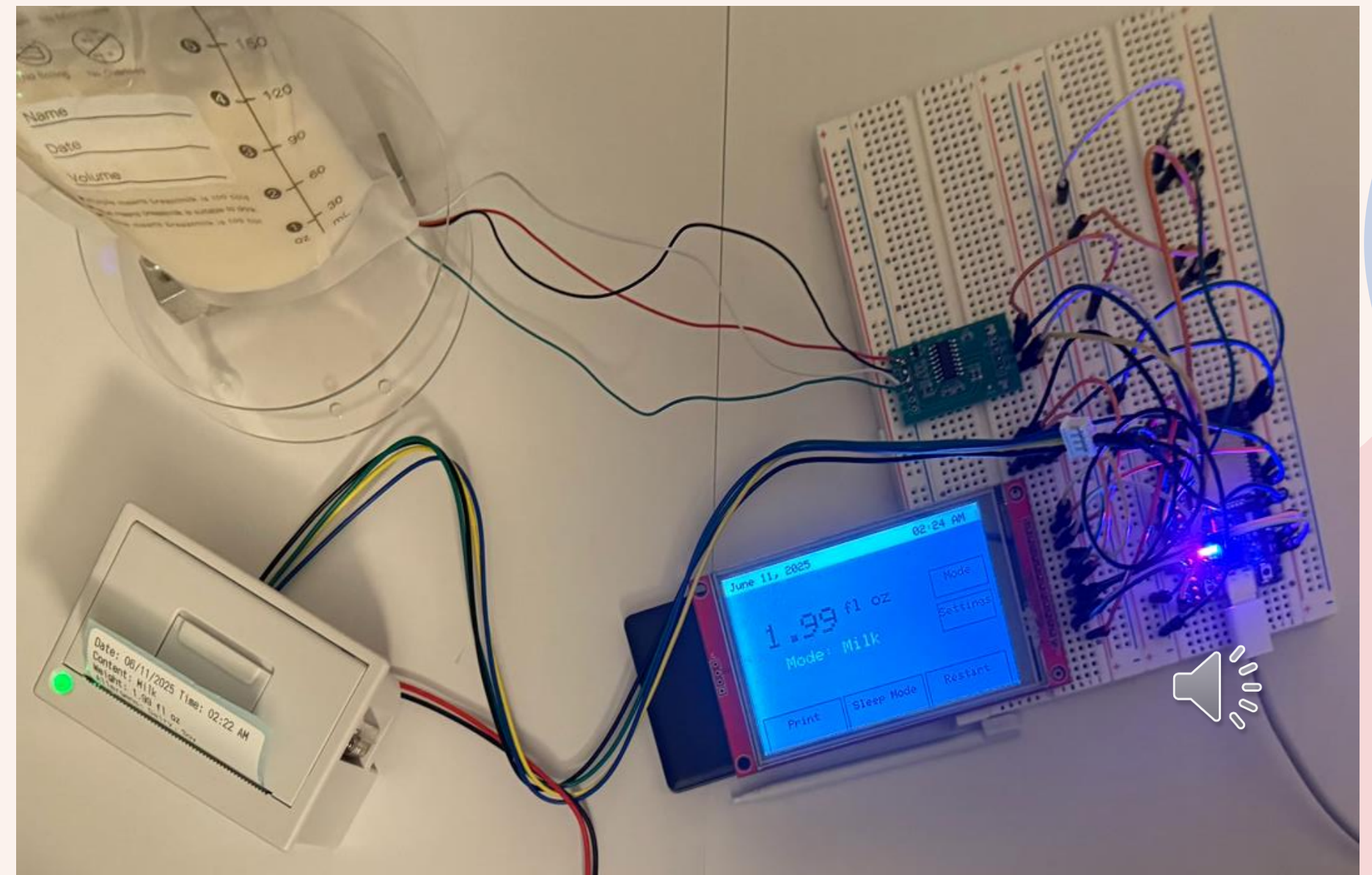
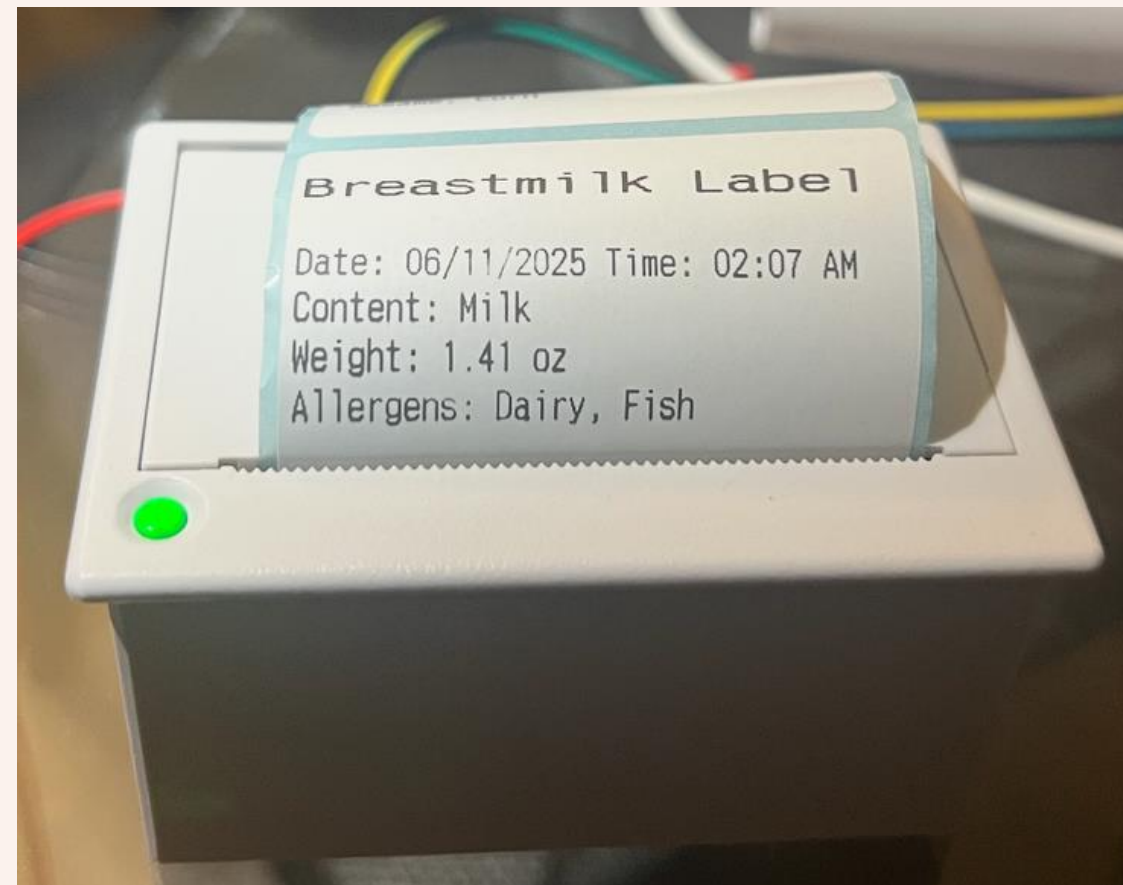


PROTOTYPING



```
Confirm Print button touched. Label printed and Firebase upload attempted.  
Touch detected at X: 81, Y: 319  
Touchscreen Print button touched. Entering allergens selection screen.  
Touch detected at X: 133, Y: 213  
Allergen 'Fish' toggled. State: Selected  
Touch detected at X: 178, Y: 157  
Allergen 'Dairy' toggled. State: Selected  
Touch detected at X: 417, Y: 311  
Touch detected at X: 426, Y: 300  
Next button touched (Allergens). Proceeding to allergen confirmation.  
Touch detected at X: 137, Y: 278  
Confirm button touched (Allergens Confirmation). Proceeding to final print confirmation.  
Touch detected at X: 184, Y: 289  
Attempting to print label...  
Print commands sent. Printer put to sleep.  
Attempting to upload data to Firebase...  
Data uploaded successfully to Firebase:  
-OSS_naD5L04GLW92Bkr  
Confirm Print button touched. Label printed and Firebase upload attempted.
```

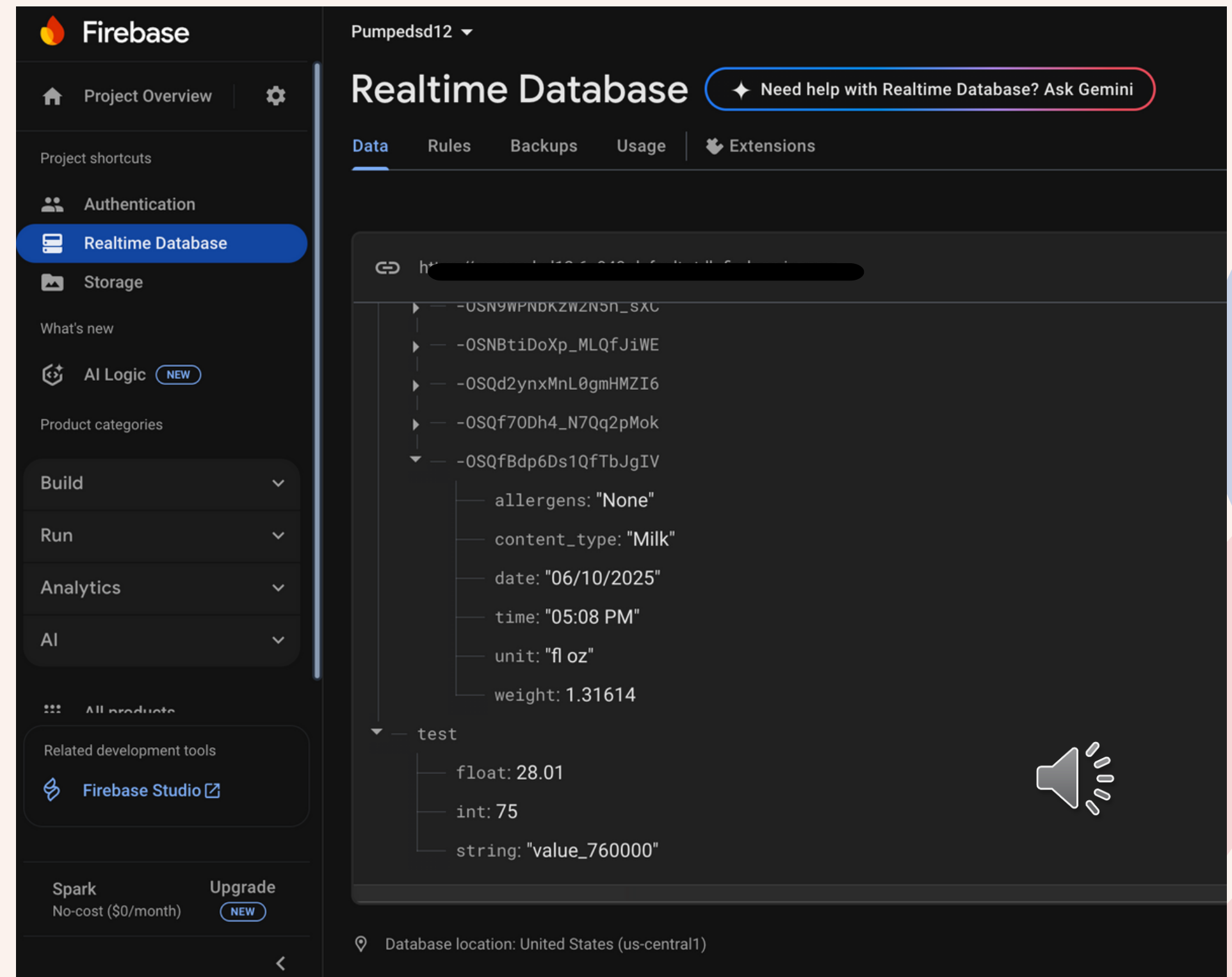
Serial Monitor: Showcases the user going through the process of printing the label and the information being sent to the database



PROBLEMS & SOLUTIONS

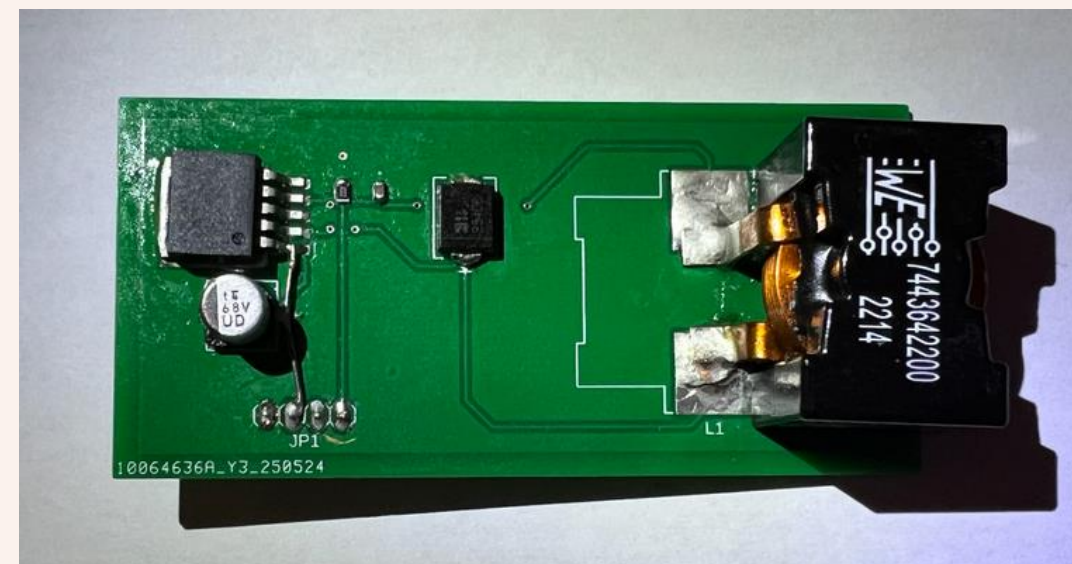


- **Load Cell Data Issues:** The initial SparkFun HX711 amplifier failed to communicate properly with the ESP32.
- **Solution:** Replaced it with an HX711 module from Amazon, which resolved the communication issue.
- **Printer Challenges:** The first printer used RS232 and did not print in English.
- **Solution:** Switched to a TTL-compatible printer, which aligned with ESP32's supported communication.
- The second printer stopped working after being accidentally set to label mode while adjusting label spacing.
- **Solution:** Reverted to a previously tested TTL printer that was easier to configure for the label size.
- **ESP32 Connections:** Faced difficulties interfacing the ESP32 with the amplifier, touchscreen, and printer.
- **Solution:** Integrated each component individually using a trial-and-error approach.
- **Mobile App Development:** The initial challenge was determining the most effective starting point for development.
- **Solution:** We established a solid foundation by setting up the database and creating the API files to support core app functionality.



SUCCESSSES

- Successfully developed a working prototype that accurately reads weight from the load cell.
- Designed a functional and user-friendly touchscreen interface with features such as sleep mode, restart, and on-screen printing, along with physical buttons for taring and toggling sleep mode on and off.
- Added a customizable measurement mode feature, allowing users to switch between milk, water, and units such as grams (g), ounces (oz), fluid ounces (fl oz), and milliliters (ml) directly through the touchscreen interface.
- Implemented Firebase database integration that stores confirmed print data — including date, time, weight, and selected unit of measurement.
- 3.3V regulator has been soldered and tested to be fully functional



BUDGET



Product Name	Expected Cost	Actual Cost
Microcontroller	\$10-\$35	\$40.26
Load-Cell	\$6-\$10	\$20.33
Touchscreen Display	\$20-\$60	\$16.99
Thermal Label Printer	\$30-\$120	\$151.91
Thermal Label Paper	\$10-\$30	\$13.67
Power Supply	\$20	\$10.64
PCBs + Tariffs	\$80-\$150	\$254.10
LEDs	\$0.10-\$0.70	\$15.68
Load-Cell Amplifier	\$40-\$50	\$21.90
Rechargeable Battery	\$9-\$20	\$41.68
Prototyping	\$100-\$150	\$139.51
Total Cost		\$726.67



WORK DISTRIBUTION



Requirement	Primary Member	Secondary Member
Fusion360 Shell Design	Johan	Simran
Mobile Application Design Development	Mya	Alexandra
Device Software Design & Implementation	Alexandra	Mya
Printed Circuit Board Design	Simran	Johan
Weight Sensor Design & Implementation	Alexandra	Mya
Mobile Application Debugging	Alexandra	Mya
Battery Integration & Management	Johan	Simran
LED Control System	Simran	Mya
Display Integration	Mya	Alexandra
Wireless Communication	Mya	Alexandra
Thermal & Durability Testing	Simran	Johan
Testing & Debugging	All	



PLAN FOR COMPLETION



Present CDR Presentation

- Regulator board is fully functional
- MCU & Load cell amplifier boards are in the process of being soldered and tested
- App foundation is being built & Embedded software is being finalized

In 3 Weeks Midterm Demo

- All PCBs will be soldered & tested
- 3 major engineering specifications will be met
- App should be able to receive information
- Touchscreen is fully functional

In 6 Weeks Week Before Live Demo

- All PCBs should be successfully working
- App should be completed
- All testing will be in the final debugging phase



**THANK
YOU!**

