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Design Methodology
Farm Assistor

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EN2160 - Electronic Design Realization

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Contents

1 Introduction

The farm assistor, is a reliable tool for measuring the moisture level, temperature level and general fertility level of the soil. Our product can be used across diverse and specialized fields, including green house cultivation and research applications. And this tool helps users make informed decisions about watering practices, soil management, and plant care, resulting in healthy and thriving plants. Therefore, our soil monitoring and management product helps farmers achieve exceptional yields and quality. Our flexible soil moisture monitoring and management systems enable farmers to respond intelligently to changing conditions so they can apply the correct amount of water and fertilizer to their crops at exactly the right time. There is no guesswork, no unnecessary applications, and a lot less waste.

2 Review Progress

Reviewing the progress of our project we did an analysis of the work done in this area by numerous companies . Understanding current approaches, innovations, and technology was intended to provide as a basis for the project that was being suggested. YouTube videos, product brochures from relevant manufacturers, and research articles .
Here is a detailed overview of our progress so far:

- **Sensor Integration:** We successfully interfaced two capacitive moisture sensors and one RS485 moisture,temperature and conductivity sensor with our microcontroller. This integration allows us to measure soil moisture and nutrient levels accurately.
- **Data Collection:**The microcontroller has been programmed to read data from the sensors every 30 minutes. This frequent data collection ensures that we have up-to-date information on soil conditions.
- **Data Storage:**To store the collected data, we implemented an SD card module with a data logger. This setup ensures that all readings are saved for future analysis, even if there is a temporary loss of power or connectivity.
- **Wi-Fi Connectivity:**Our system connects to Wi-Fi, enabling it to transmit data to a cloud-based application once every 3 hours. This connectivity ensures that users can access necessary data from anywhere, providing flexibility and convenience.
- **Mobile Application:** We developed a mobile application that displays the data collected by the sensors. Users can view soil moisture and in real-time and receive updates once every 3 hours.
- **Threshold Alerts:** The system includes a feature to set threshold values for soil moisture and nutrient levels through the app. When these thresholds are crossed, the app sends notifications to alert users, enabling timely interventions.
- **System Reliability:**We focused on ensuring the system's reliability by using high-quality components.
- **User Interface:**The mobile app is designed to be user-friendly with intuitive navigation. Users can easily set up the system, view data, and configure alerts without needing technical expertise.
- **Environmental Considerations:**Our design prioritizes sustainability by using low-power components and efficient data transmission methods. This consideration helps minimize the environmental impact of our system.

- **Future Enhancements:**We are planning further enhancements, including expanding the sensor network, integrating more advanced data analytics, and improving the app's user interface based on user feedback.

3 Stake holder map

The stakeholder map diagram organizes project stakeholders into different categories based on their levels of interest and influence. stakeholders are strategically placed according to their engagement and impact on project outcomes. This systematic classification aids in stakeholder management by anticipating their needs, ensuring thorough engagement with key stakeholders, and maintaining regular communication channels with those most critical. By aligning engagement strategies with stakeholders' levels of interest and influence, projects can effectively manage stakeholders to optimize outcomes.

- **Design team:** As the design team success of this project is crucial for the learning process.
- **University of Moratuwa:** As this is an academic project done under the guidance of a staff member of the university, the university also becomes a stakeholder.
- **End users:**
  Farmers: Our main end users will be famers with large to medium scale greenhouses. Their main interest lies in the quality of our product to meet their Industrial requirements.
  Agricultural research institutes: They are interested in accurate and reliable data for research purposes. University of Peradeniya and Sri Lanka Council for Agricultural Research Policy (CARP) are the main stakeholders in this area.
- **Competitors:** Companies which provide similar solutions will be affected by our product. Therefore, they are also considered as major stakeholders.
  - IMKO Micromodultechnik GmbH, Germany
  - Sentek Technologies, Australia
  - Spectrum Technologies, USA
  - Irrometer Company, Inc., USA
  - Davis Instruments, USA
  - Delta-T Devices Ltd, UK
- **Agricultural extension services:** Agricultural Extension Services are essential for educating and supporting farmers in adopting new technologies. They act as a bridge between innovation and practical implementation in agriculture. The Sri Lankan Department of Agriculture's Extension division is a major stakeholder, crucial for the project's success in implementing soil monitoring solutions.
- **Government Agencies:** The Department of Agriculture in Sri Lanka is a key stakeholder as they regulate agricultural practices and environmental impact. our product design needs to comply with their regulations for market acceptance.
- **Environmental NGOs:** These organizations advocate for sustainable farming and support products that promote soil health and conservation. Their endorsement can boost our project's environmental credentials.
- **Suppliers:** Suppliers, offering hardware, software, and connectivity resources, that are necessary for proposed soil monitoring systems
- **Investors and Funding Agencies:** To develop product further, we'll need financial backing. Investors and funding agencies will consider market potential, scalability, and expected returns before providing support.

- **Distribution and Retail Partners:** Partnering with agricultural equipment retailers can significantly increase market reach. Their established networks can help connect with potential farmers.
- **Industry Associations:** These associations represent the collective interests of the agricultural community. Their endorsement can significantly enhance our product's credibility among farmers.

Figure 1: Stake holder map

Power / Interest	High	Low
High	Design team, University of Moratuwa, Competitors, Users, Agriculture extension service	Investors, Environmental NGOs
Low	Government, Industry Association,Distribution partners	Suppliers

4 User requirements

By carefully observing the needs and expectations of the farming community we have identified greenhouse farmers as the primary users of our product. By evaluating the existing market products and their reviews we were able to identify the main expectations of the users for a soil condition monitoring device.

- **Soil Health Monitoring**
  - The system must provide accurate monitoring of key soil health parameters including moisture levels, temperature, and general nutrient levels.
  - Ability to set thresholds and receive alerts when levels are too high or too low.
  - Compatibility with various soil types and conditions found in greenhouses or farms.
  - Ability to recommend solutions and insights based on the measured parameters.
- **User Interface and Data Visualization**
  - User-friendly interface for easy access to soil data and analytics.
  - Visual representation of soil parameters through charts, graphs, or heat maps.
  - Ability to view historical data and trends for better decision-making.
- **Remote Monitoring and Accessibility**
  - Access to soil data and analytics from remote locations or mobile devices.

  - Updates and notifications for critical soil conditions.

- **Durability and Reliability**
  - Robust and weather-resistant hardware suitable for greenhouse or outdoor farm conditions.
  - Low maintenance requirements and long battery life.
  - Reliable data transmission and storage to prevent data loss.

- **Scalability and Expandability**
  - Ability to expand the system to monitor multiple greenhouse sections or farm plots.
  - Compatibility with additional sensors or monitoring devices for other parameters (e.g., water quality, pest detection)
  - Flexible integration with existing or future agricultural technologies.

- **Ease of Installation and Use**

- **Cost-Effectiveness and Return on Investment**

5 Observe Users

In this section, Use Cases and User Scenarios of soil monitoring system is discussed.

- **Soil Moisture Monitoring**
  - **IMKO:** Their PICO-BT, HD2, and TRIME series offer various soil moisture sensors with diverse features and communication protocols.
    Brochure
  - **IRROMETER:**A pioneer in this field, IRROMETER provides the IRROcloud IC-10 system for comprehensive soil moisture monitoring.
    IRROMETER introduction
    IRROcloud IC-10 Full System Overview
  - **Delta-T Devices:**For several decades Delta-T Devices has helped its customers to design and create highly effective soil moisture sensor systems and networks. Their sensor networks are built centered around their SDI-12 compatible GP2 Data Logger and Controller. Delta-T Sensor Networks

Figure 2: Delta-T Network Example 1

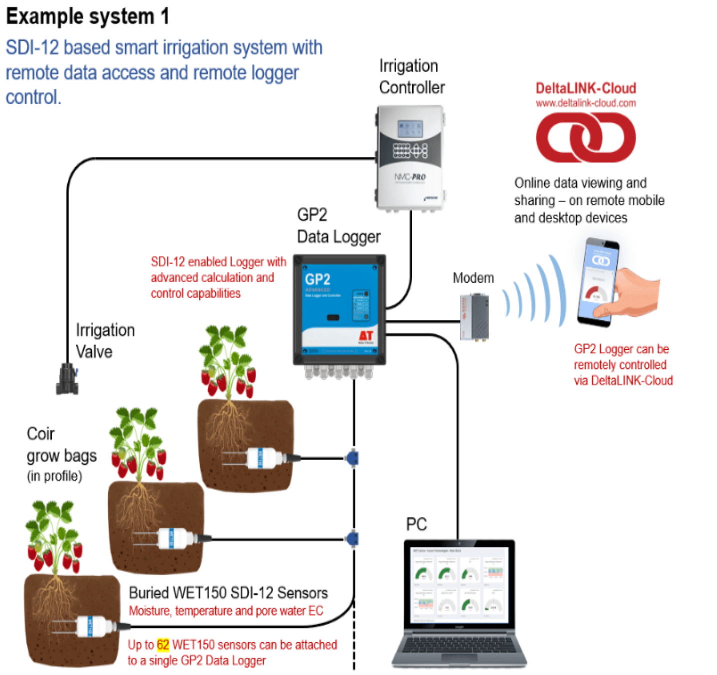
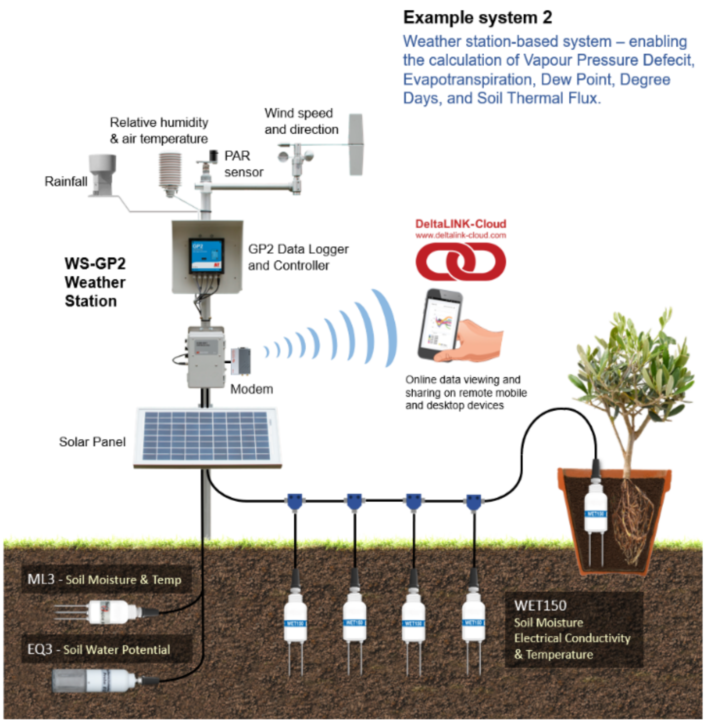


Figure 3: Delta-T Network Example 2



- **Comprehensive Monitoring Systems**
  - **Davis Instruments:**Their Enviromonitor system captures a broader range of agricultural data, offering a more holistic approach. Davis Enviromonitor
- **Additional Resources:**We reviewed relevant research articles to stay updated on the latest advancements in IoT-based soil health monitoring and wireless sensor networks for smart agriculture.

  A Self-Powered, Real-Time, LoRaWAN IoT-Based Soil Health Monitoring System
  IoT enabled plant soil moisture monitoring using wireless sensor networks A low power IoT network for smart agriculture

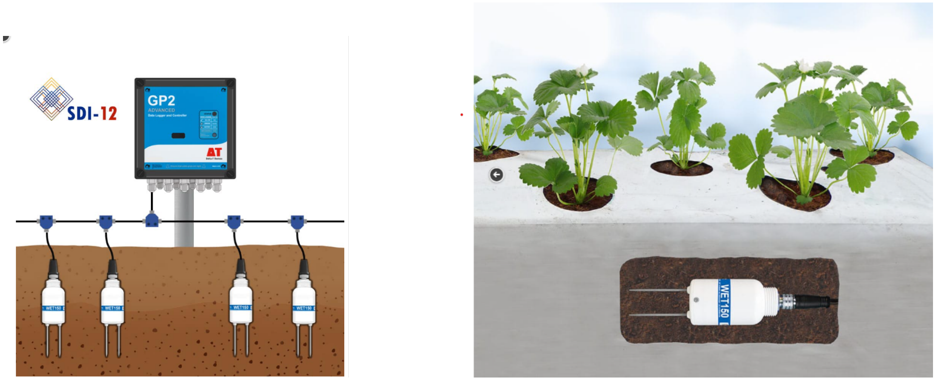


Figure 4: Soil Moisture Monitoring

6 Design Criteria

When developing a new product, it's crucial to consider key aspects to ensure its success and effectiveness. First and foremost is functionality and performance. The product should work well and consistently, even under tough conditions.
Usability and user experience are also vital. A good product should be easy to use and navigate, making users happy and more likely to recommend it.
Durability and reliability matter too. A product that lasts and performs well over time will be preferred by consumers.
Cost-effectiveness is another important factor. Finding the right balance between production costs and affordability for customers is key.
Lastly, environmental sustainability is increasingly important. Using eco-friendly materials and methods can reduce the product's impact on the environment.

7 Conceptual Design

In this section presents the conceptual design for Farm assistor. Within these pages,can find sketches and block diagrams that outline the vision and structure of the project. Designed to provide a clear understanding of our objectives and approach, this section serves as a foundational resource for stakeholders involved in the development process.

7.1 Conceptual Design 1

In this design, we plan to directly display the information on a handheld monitor. This will be a battery powered design which is plugged into the soil when we want to measure the values. This device will be able to give soil moisture, temperature, PH, conductivity.

7.1.1 Hand Sketch 1

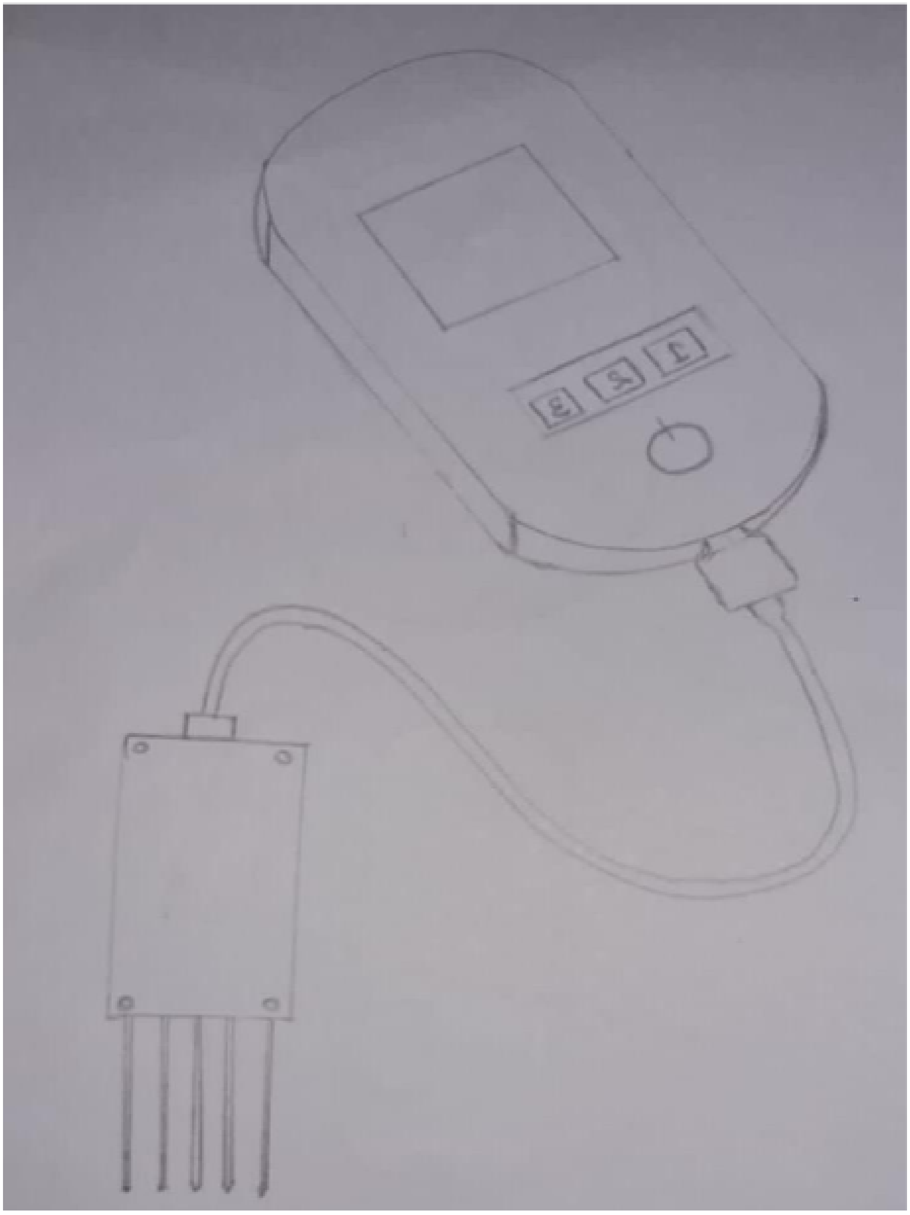


Figure 5: Hand sketch 1

7.1.2 Functional block diagram 1

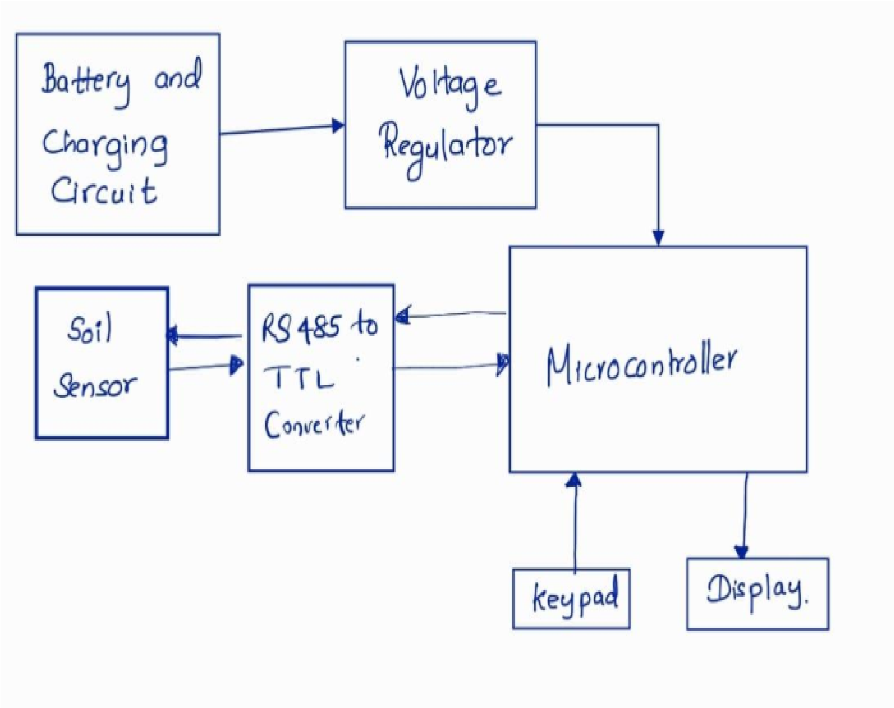


Figure 6: Functional block diagram 1

7.2 Conceptual Design 2

In this design, we plan to use three separate sensors to measure different soil parameters. And two separate sensors will be used to measure soil temperature and moisture levels. We also plan to use a Wi-Fi module and transmit real time data to an app so that we can monitor the soil conditions remotely.

7.2.1 Hand sketch 2

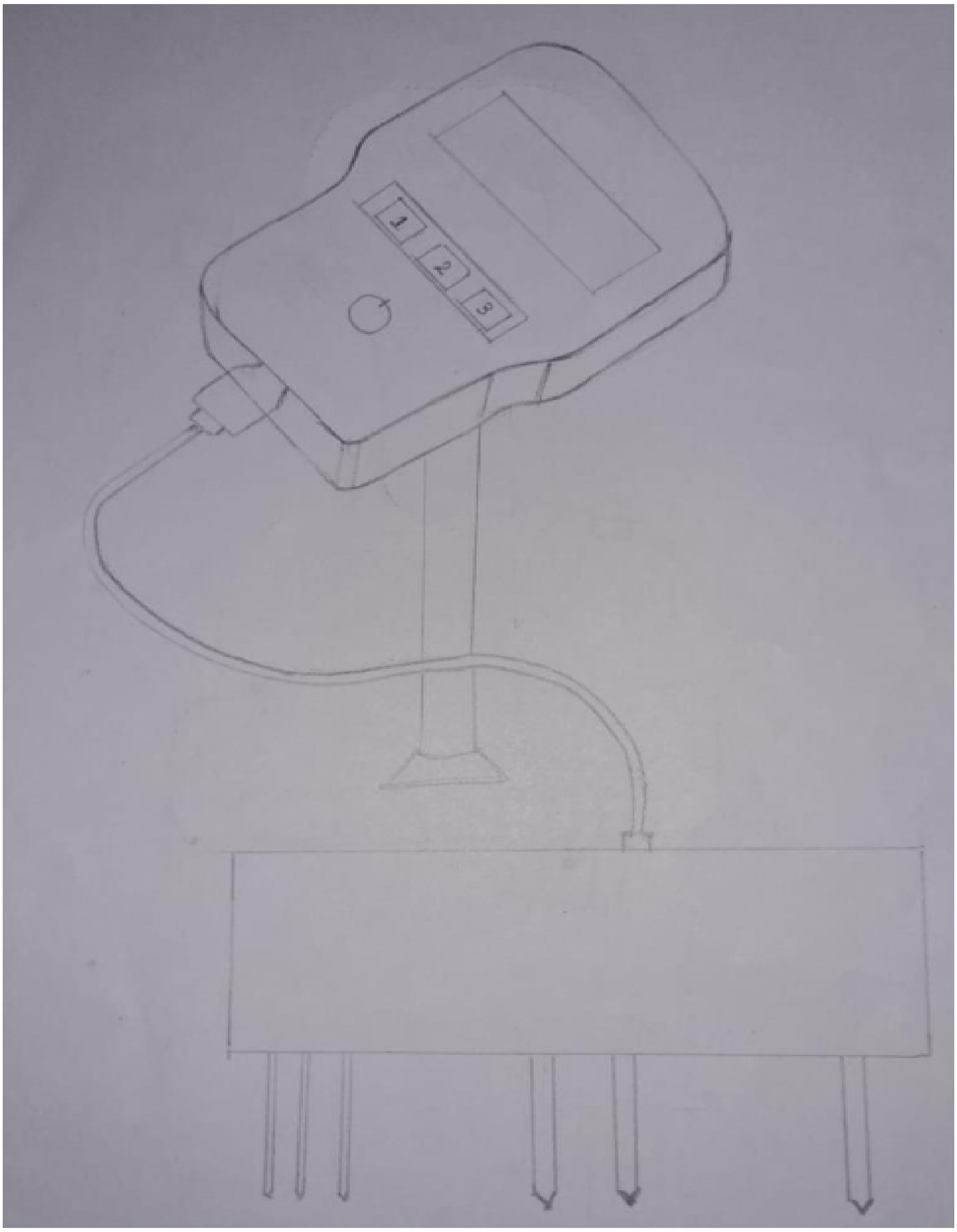


Figure 7: Hand sketch 2

7.2.2 Functional block diagram 2

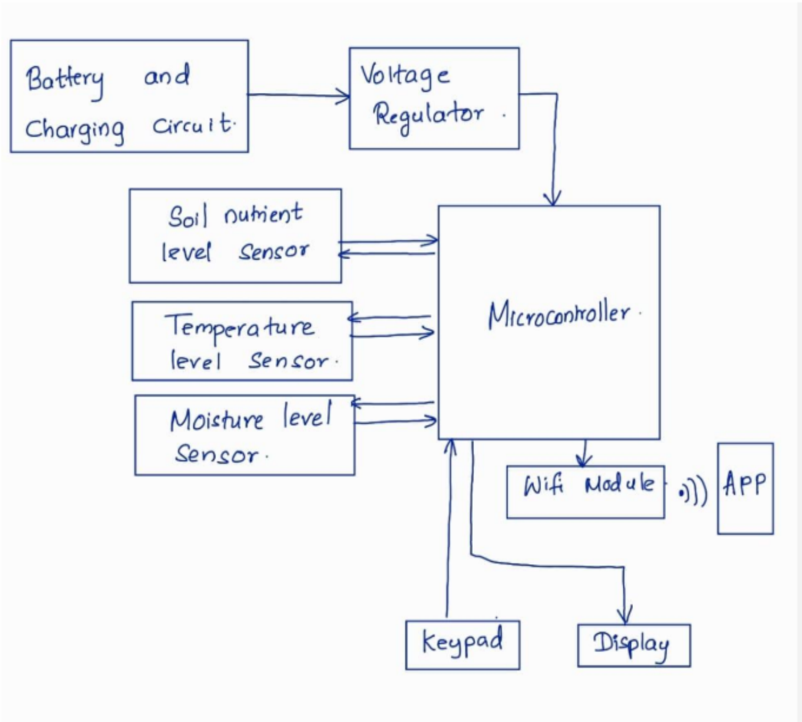


Figure 8: Functional block diagram 2

7.3 Conceptual Design 3

In this design we plan to use a centralized monitoring device to which we can plug in 3 sensors to monitor soil parameters of three different places. We plan to use a single RS485 sensor which can measure soil moisture, temperature, PH, conductivity. We will use a Wi-Fi module to monitor the conditions remotely through an app. In this design we thought of introducing a data logger and to store the data with a timestamp and transmit only about once per six hours to save battery power.

7.3.1 Hand sketch 3

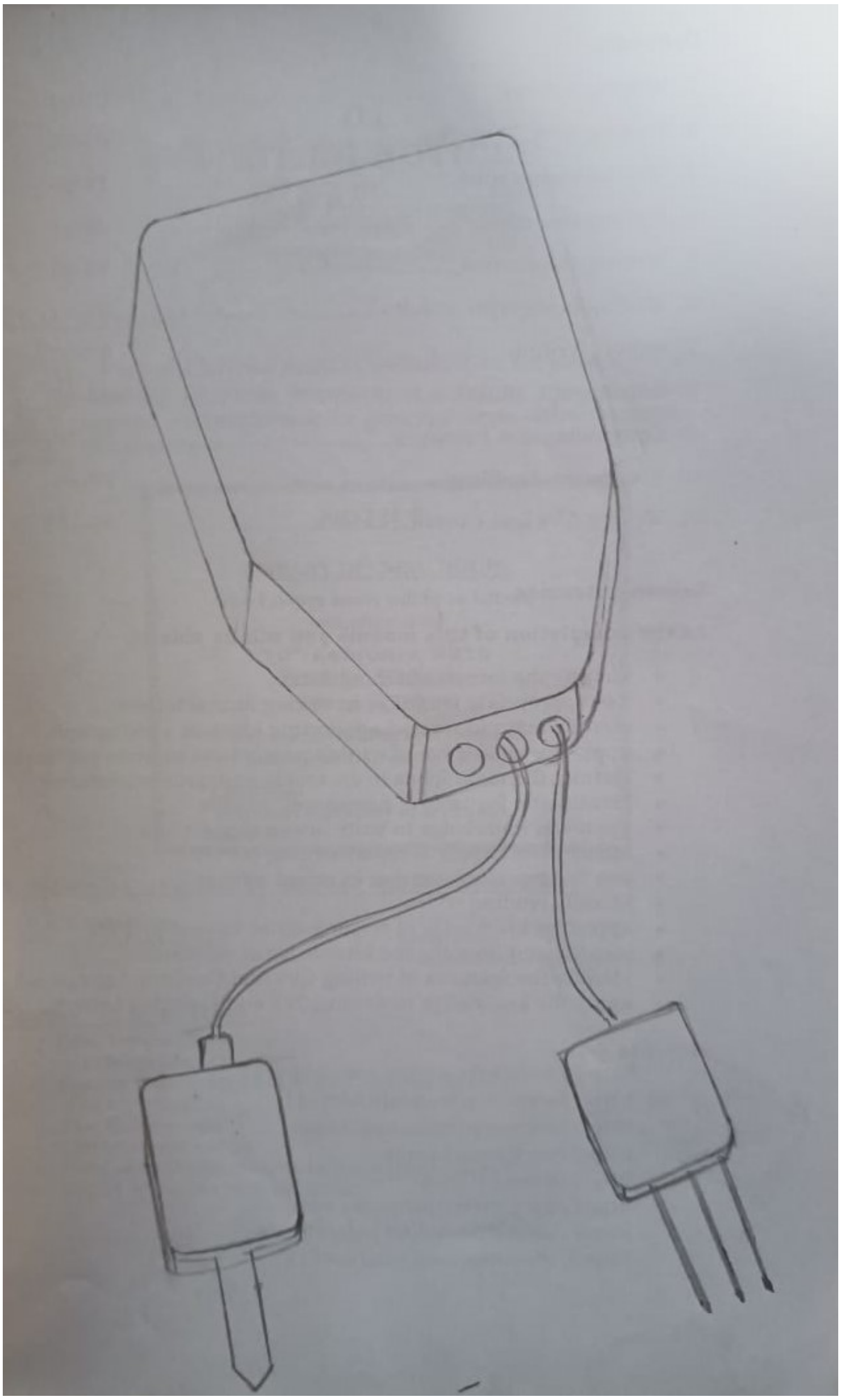


Figure 9: Hand sketch 3

7.3.2 Functional block diagram 3

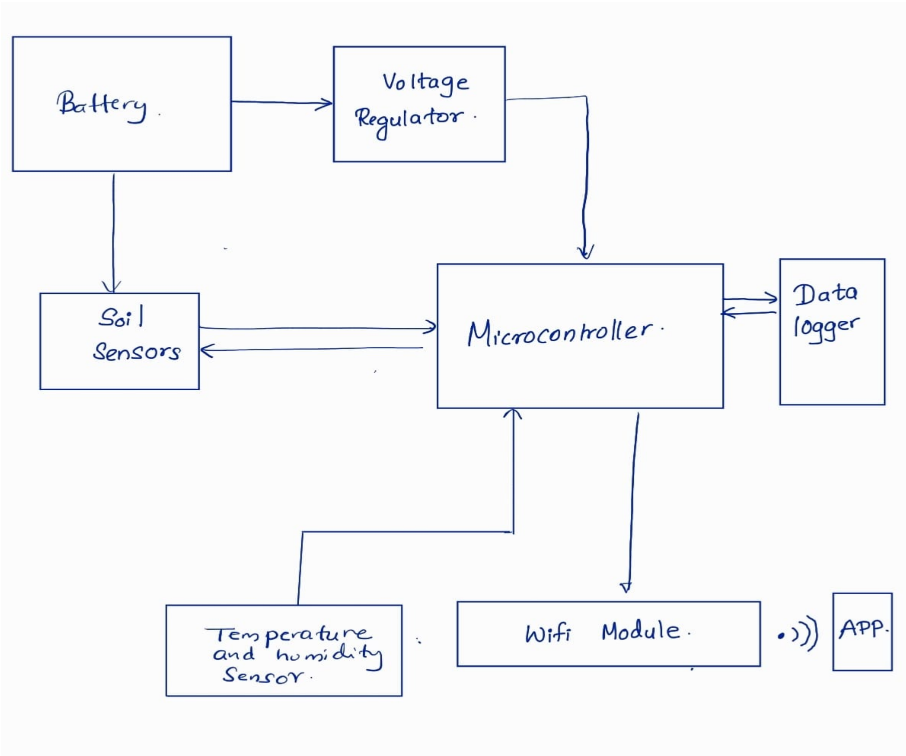


Figure 10: Functional block diagram 3

8 Evaluation of Conceptual Design

8.1 Enclosure Design Criteria

- **Functionality:**How well the design supports the main functionalities?
- **Aesthetics:** Is the design eye-catching and overall appeal of the user?
- **Ergonomics:**Does the design consider human factors and optimize usability?
- **Feasibility:**Is the concept technically feasible and realistic to implement?
- **Durability:**How well does the design withstand impacts and environmental conditions?
- **Innovation:**How unique and creative is the concept?
- **Market Differentiation:** Does the design offer unique features that differentiate it from existing products?
- **Scalability:** Can the design be scaled up or down to accommodate different product variations?
- **Manufacturing Efficiency:**: How well does the design optimize the manufacturing process in terms of production time, cost, and resources?
- **Safety:** Does the design prioritize the safety of users, considering factors such as electrical safety, sharp edges, stability, and protection against potential hazards?

8.2 Functional Block Diagram Criteria

- **Functionality:** Does circuit design function as intended?
- **User experience:**How intuitive and user-friendly is the interaction?
- **Cost:**Evaluate the overall cost effectiveness for the provided functionality
- **Performance:**Evaluate the accuracy of the results by comparing them with real results.
- **Future proofing:**To what extent does the design allow for easy replacement or upgrade of individual components?
- **Power Efficiency:** How effectively does the device manage power consumption?

9 Comparison

Criteria	Design 1	Design 2	Design 3
Newly added features	Portable	Using three separate sensors to measure npk, temperature and moisture level. Ability to connect to Wi-Fi Observe condition through an App	Using a single industrial grade RS485 sensor to obtain data.
Enclosure Design			
Functionality	7	8	9
Aesthetics	9	8	8
Ergonomics	8	8	8
Simplicity	8	8	8
Durability	8	8	9
Innovation	7	8	9
Market Differentiation	7	8	8
Scalability	6	8	9
Manufacturing efficiency	8	8	9
Safety	9	9	9
Functional Block Diagram			
Functionality	7	8	9
Accuracy	8	7	9
User experience	7	9	9
Cost	8	9	7
Performance	8	8	10
Future proofing	7	7	8
Power efficiency	8	7	9
Total	130	136	147

Figure 11

The Sketch 3 of the conceptual designs which received highest score (147) were selected as the final sketches for enclosure considering the marks obtained under the criteria evaluated by the team members.
For the functional block diagram, some modifications extracted from the user need survey were added to the functional block diagram 3 which scored highest (147) under the conceptual design criteria evaluated by team members.

10 Design Selection

After analyzing the design driven innovation sketches and user need design sketches, the following sketches are selected for the design after the first iteration of conceptual design cycle. This could be further modified after several cycles of “Explore”, “Create” and “Evaluate”.
We plan to use two 3.7V Lithium ion batteries to power the circuit. We plan to use an ATmega328P microcontroller with a Wi-Fi module to achieve the required IoT functionality. We will make the prototype with 3 sensors, one RS485 industrial grade moisture, temperature and conductivity sensor and two capacitive moisture sensors to measure the soil parameters. Our device will measure the soil parameters once every 30 minutes, store the data in a data logger and transmit that data through Wi-Fi once every three hours. The user will be able to remotely view the soil parameters and recommendations through an app and make informed decisions.

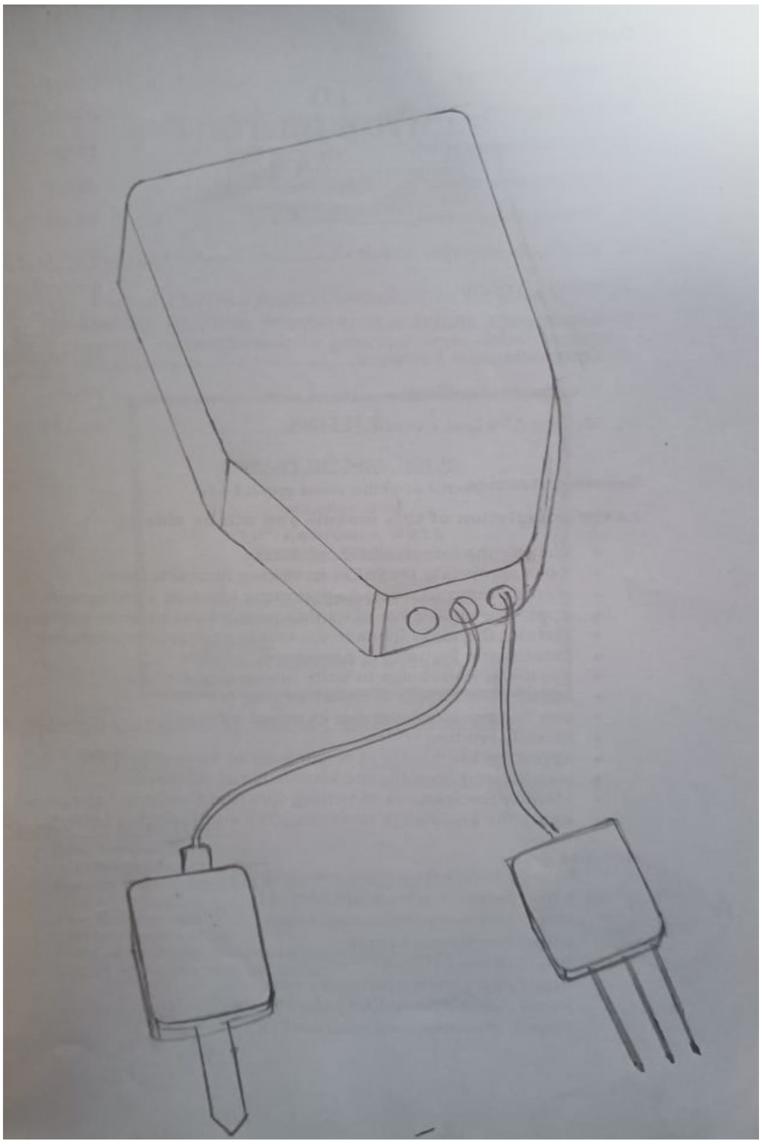


Figure 12: Hand sketch

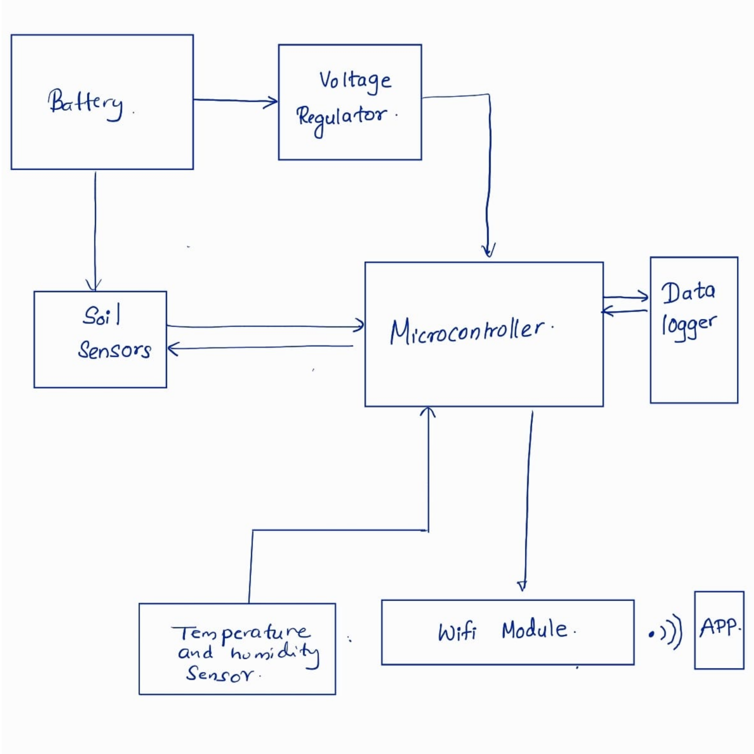


Figure 13: Functional block diagram

From the results of the user need survey, we were able to get an understanding about the expectations of users on a Soil moisture meter. Most of the users were really interested in using this product in their greenhouses and they were happy about selecting it and developing it as an Engineering design project. User need survey suggestions were very helpful to further modify the enclosure and functional block diagrams to meet the user requirement.

11 Features and Specifications

- **Rechargeable battery:** The device is equipped with a rechargeable battery.
- **Soil moisture sensor:** Measures the moisture content of the soil and displays it on the Farm assistor app.
- **humidity:**Measures the humidity level of the environment displays it on app.
- **conductivity:**Measures the humidity level of the soil displays it on app.
- **Temperature sensor:**Measures the temperature of the environment and displays it on the app.
- **Moisture measurement range:**The value ranges from 0% to 100% with an accuracy of $\pm 2\%$
- **Humidity measurement range:** The value ranges from 0% to 100% with an accuracy of $\pm 2\%$
- **Temperature measurement range:**-10% to 70% with an accuracy of $\pm 0.5\%$
- **Material:**Made with durable, water resistant material for long-term use

12 Schematic

The following is the schematic of the product. A hierarchical design has been used. Separate sheets were used for the microcontroller unit, Sensor inputs and their relevent ICs, Power unit and data logger unit.

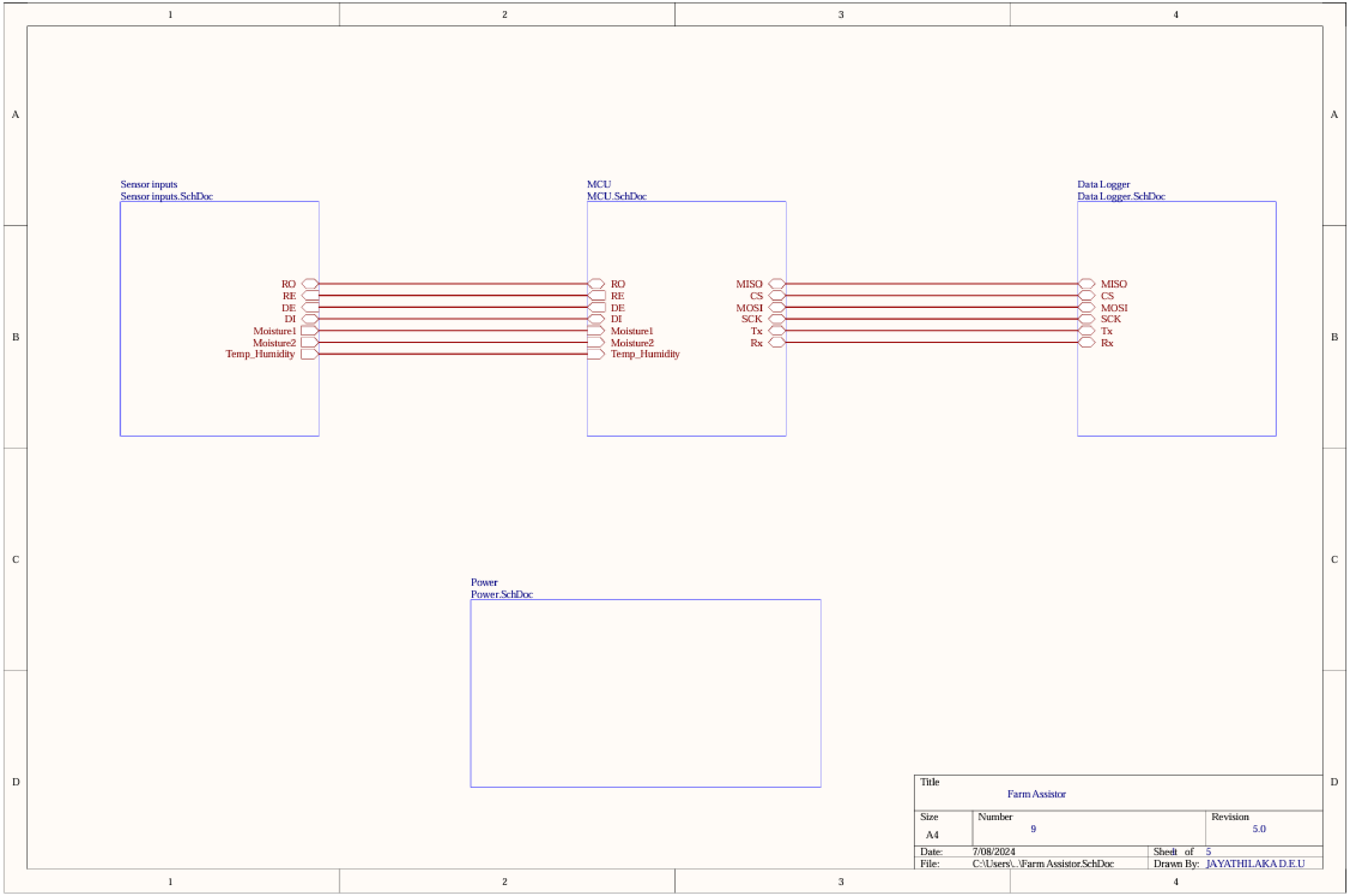


Figure 14: Block Diagram

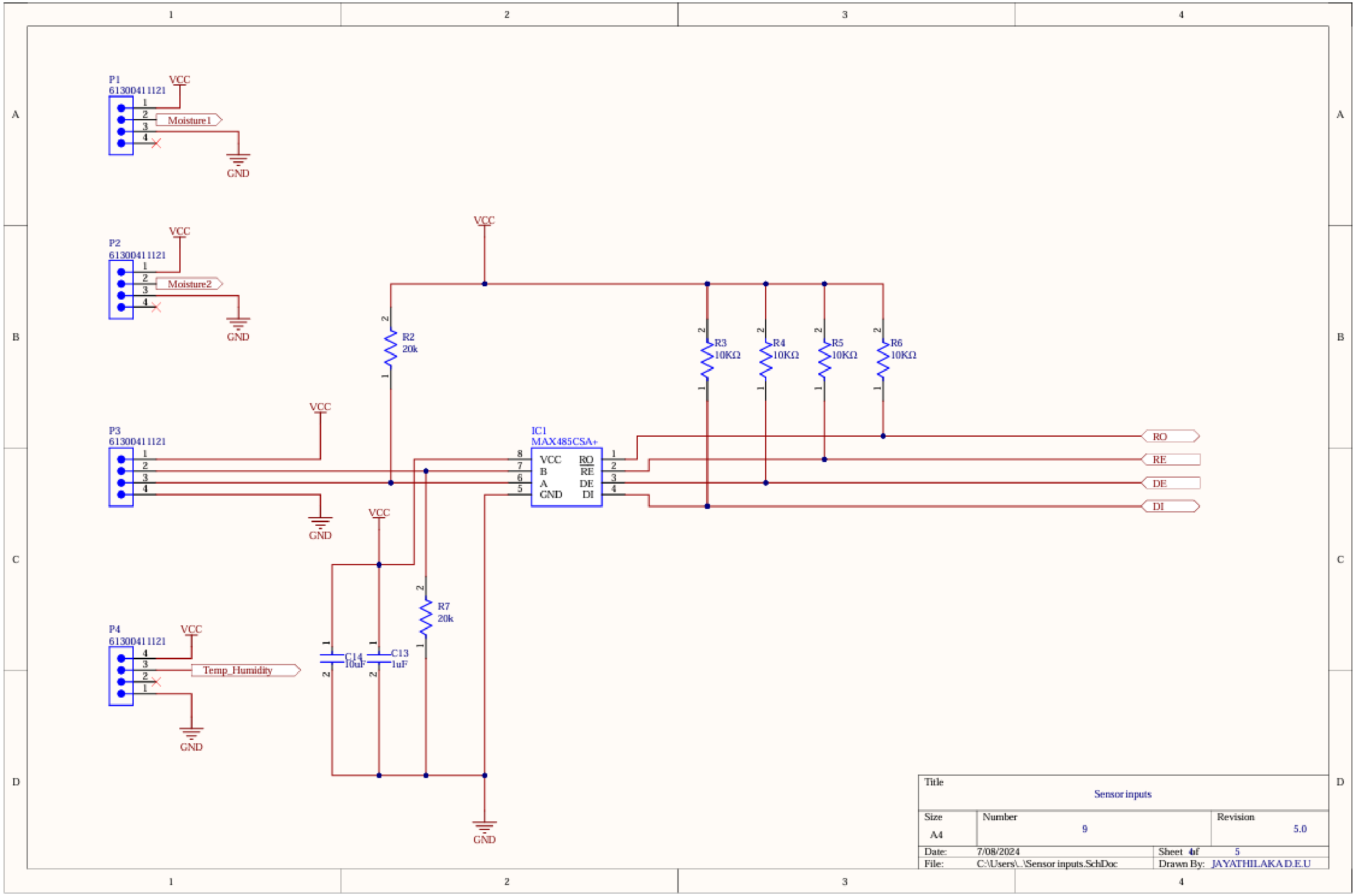


Figure 15: Sensor inputs

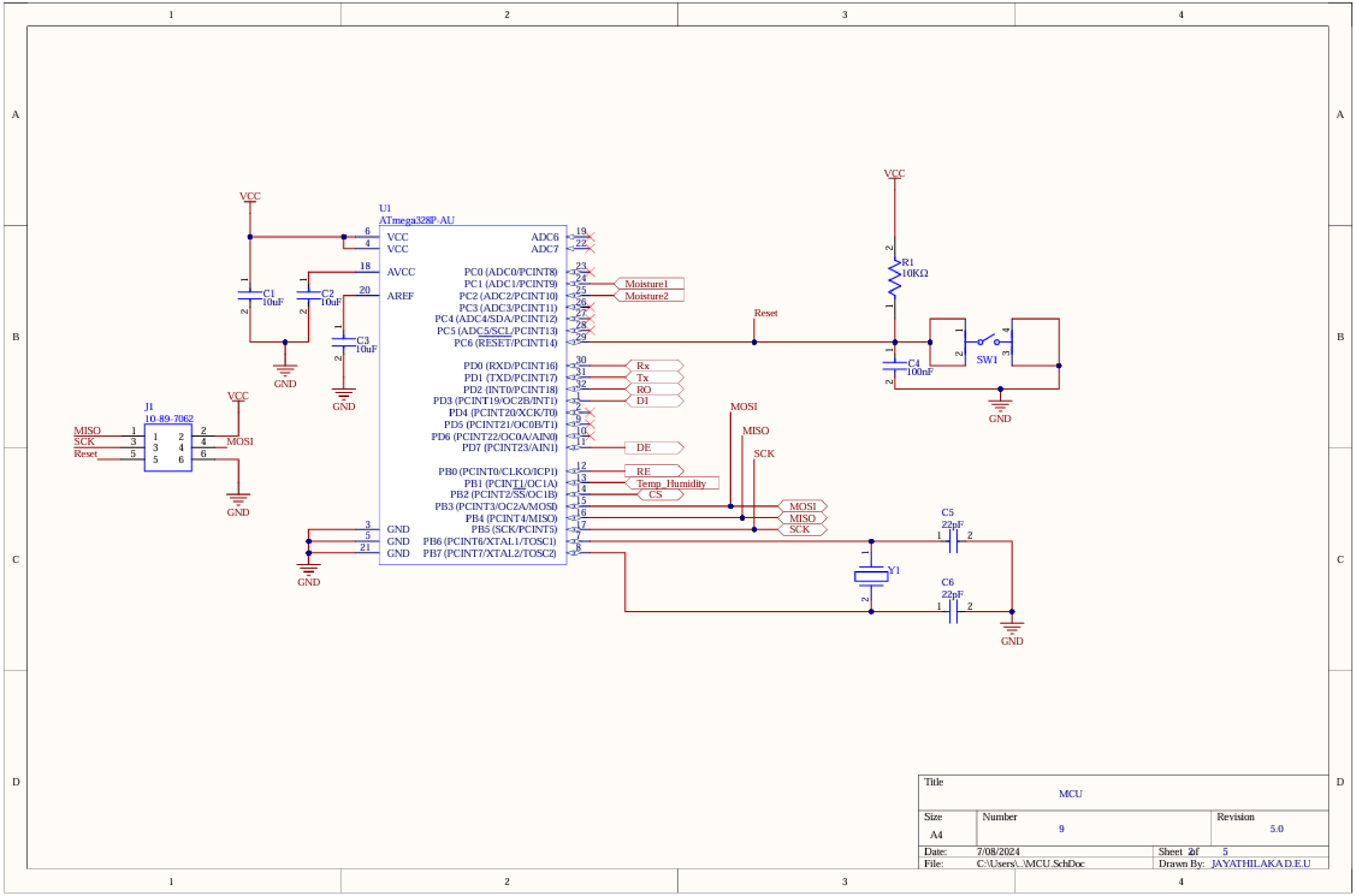


Figure 16: Microcontroller Unit

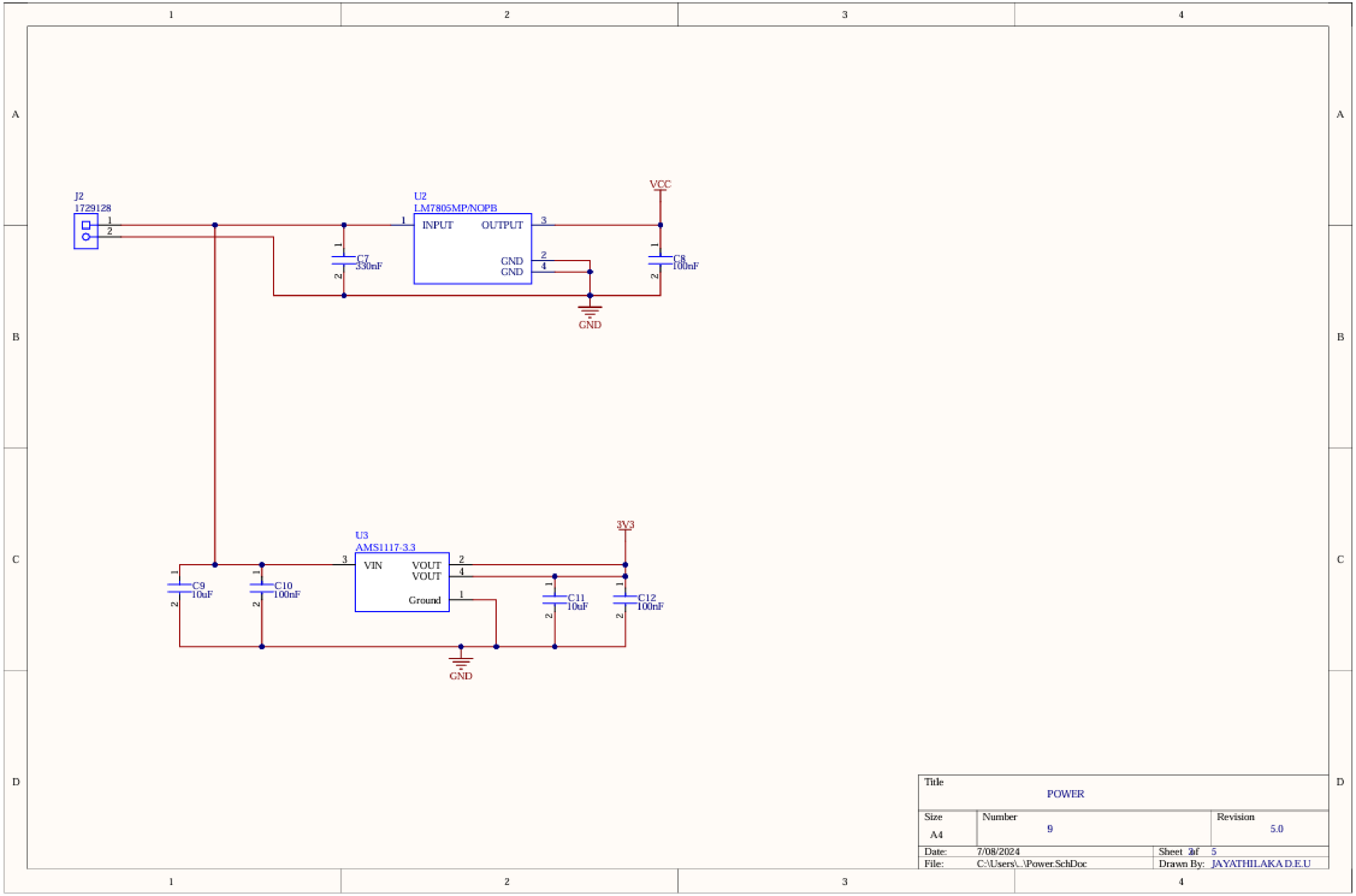


Figure 17: Power Circuit

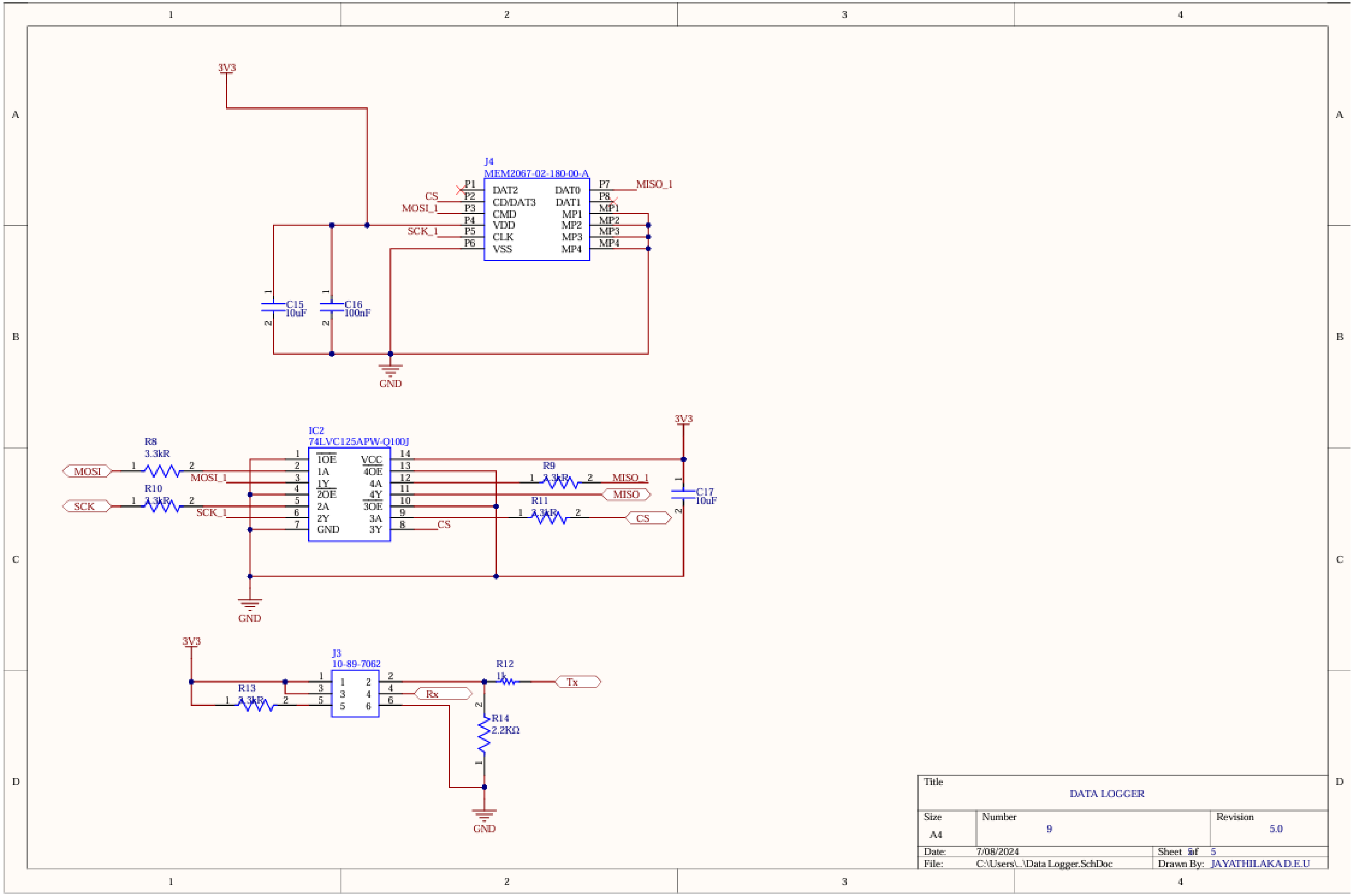


Figure 18: Data Logger

13 Printed Circuit Board

The following is the printed circuit board of the product. It is designed to be able to be manufactured by JLC PCB in China.

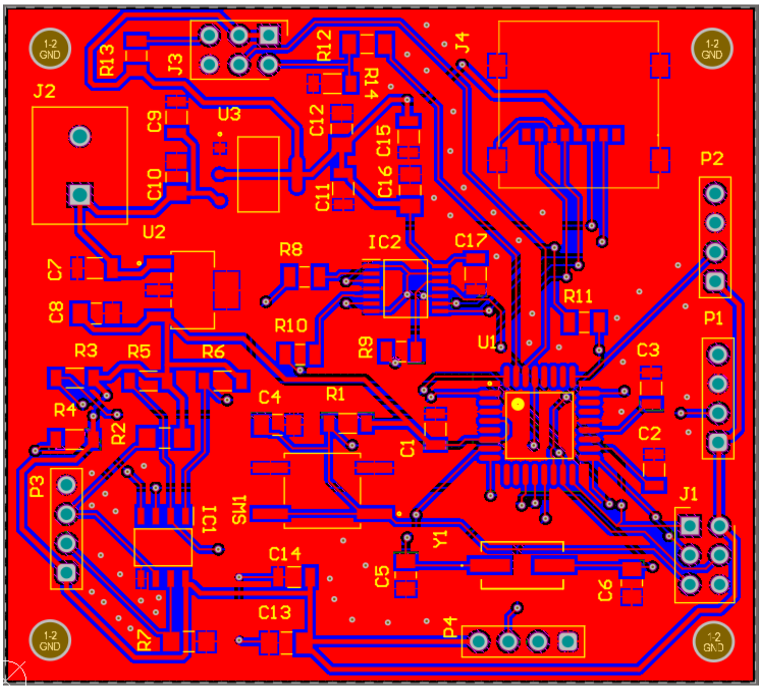


Figure 19: Top layer

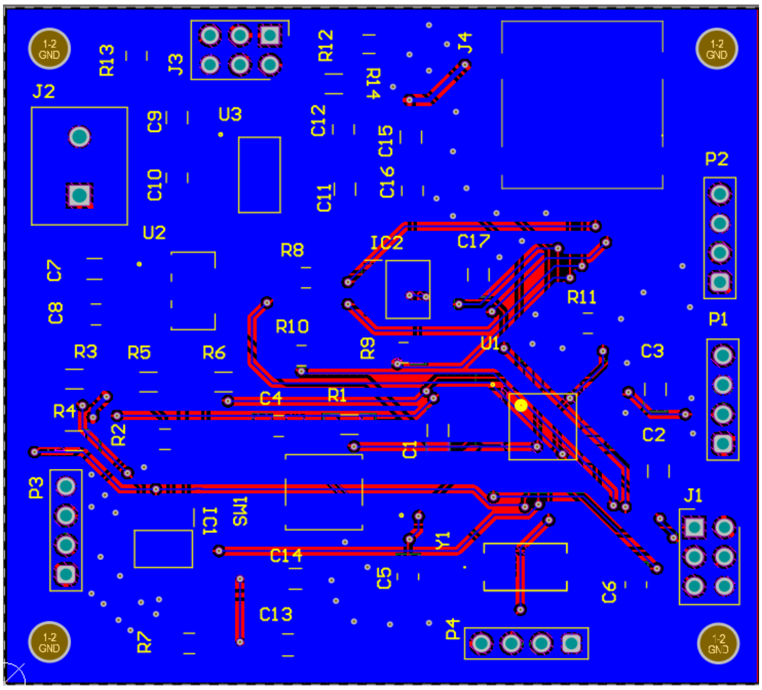


Figure 20: Bottom layer

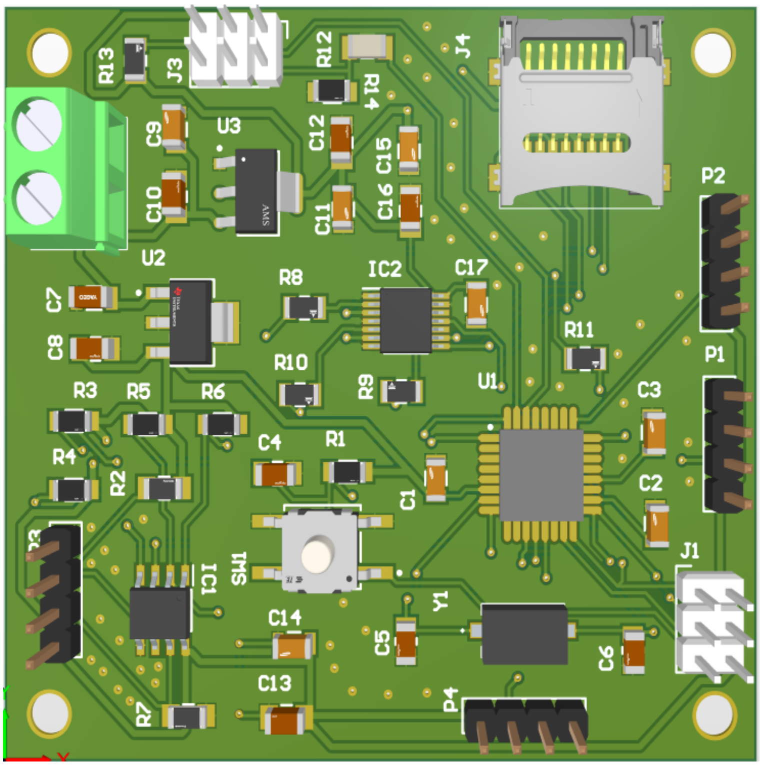


Figure 21: 3D view

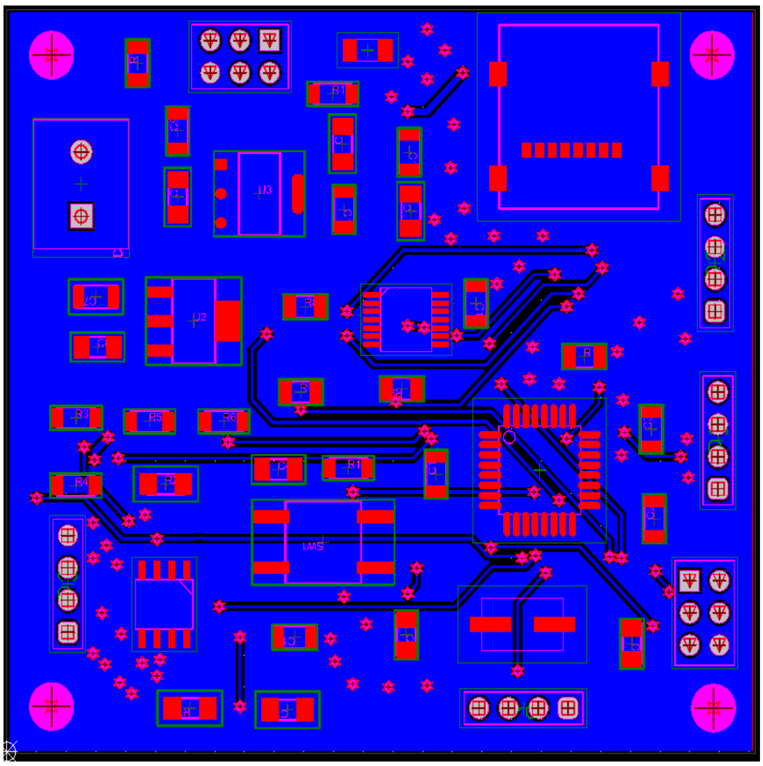


Figure 22: Gerber file

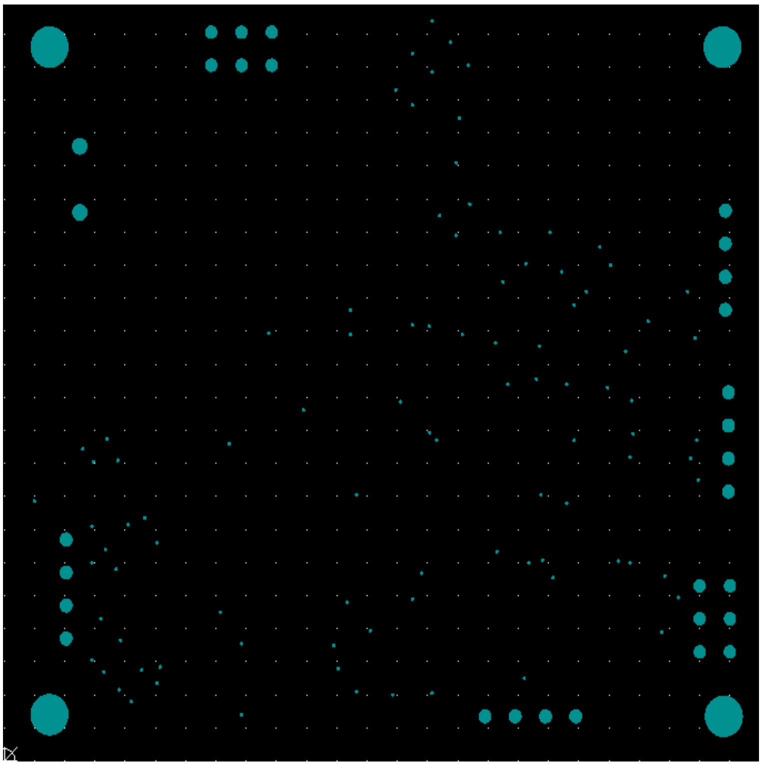


Figure 23: NC Drill file

14 Enclosure

The enclosure will be designed to be portable, lightweight, and compact with a smarter look. The manufacturing materials for the enclosure will be selected considering the durability and rough use. In this way, the enclosure will be designed to be aesthetically pleasing and easy to assemble.

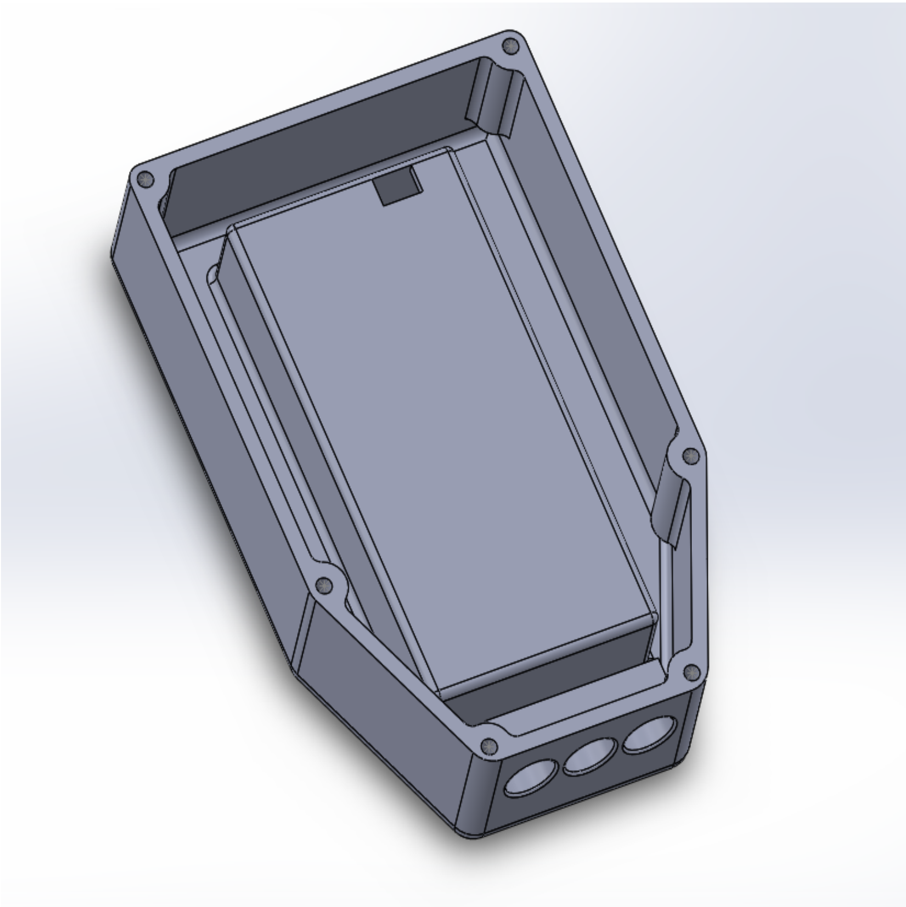


Figure 24: Top lid inside

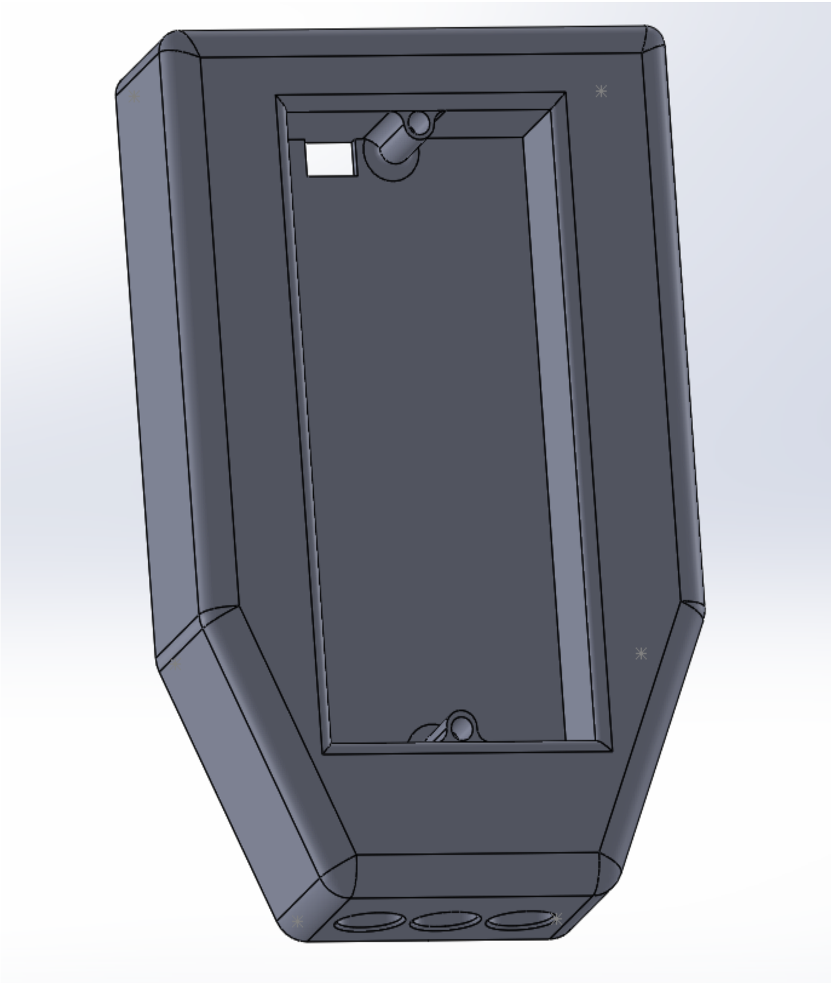


Figure 25: Top lid

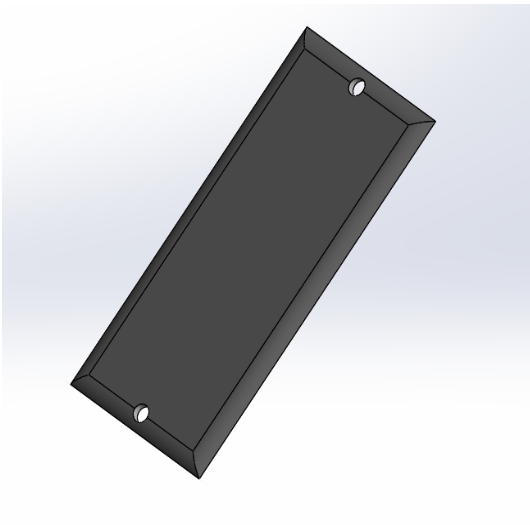


Figure 26: Battery lid

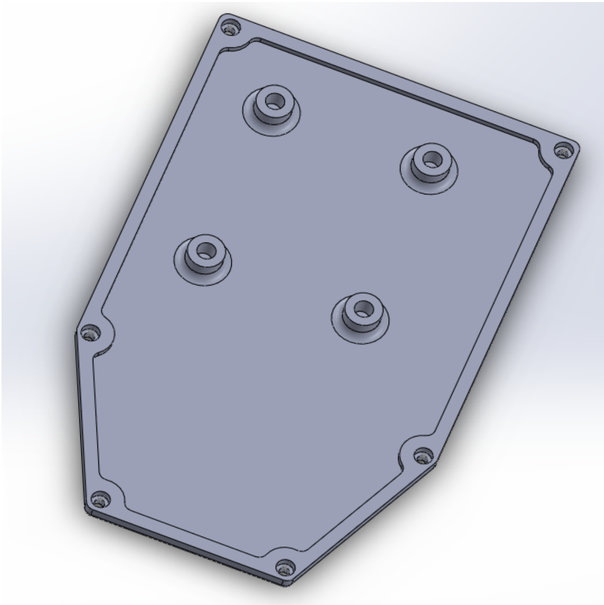
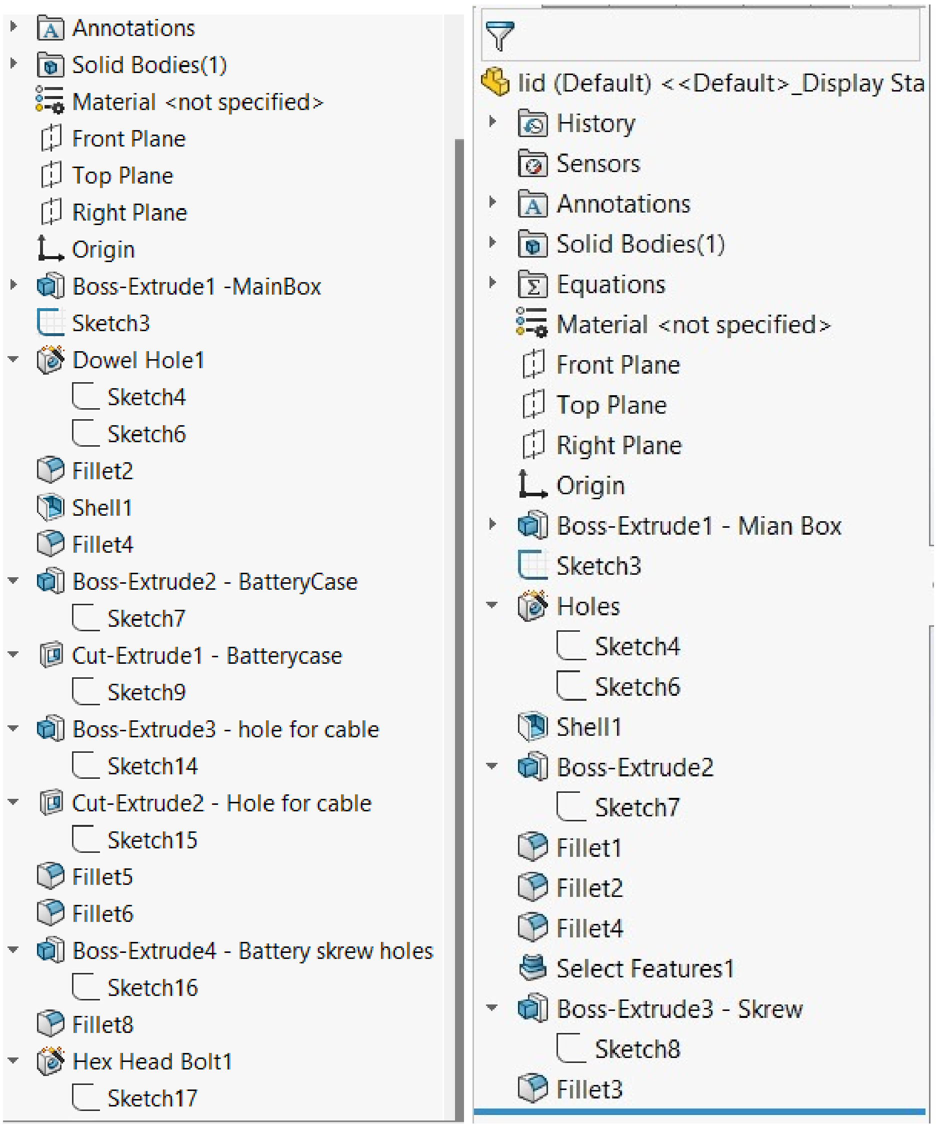


Figure 27: Bottom lid

Figure 28: After assembly



(a) (b)

Figure 29: Model trees

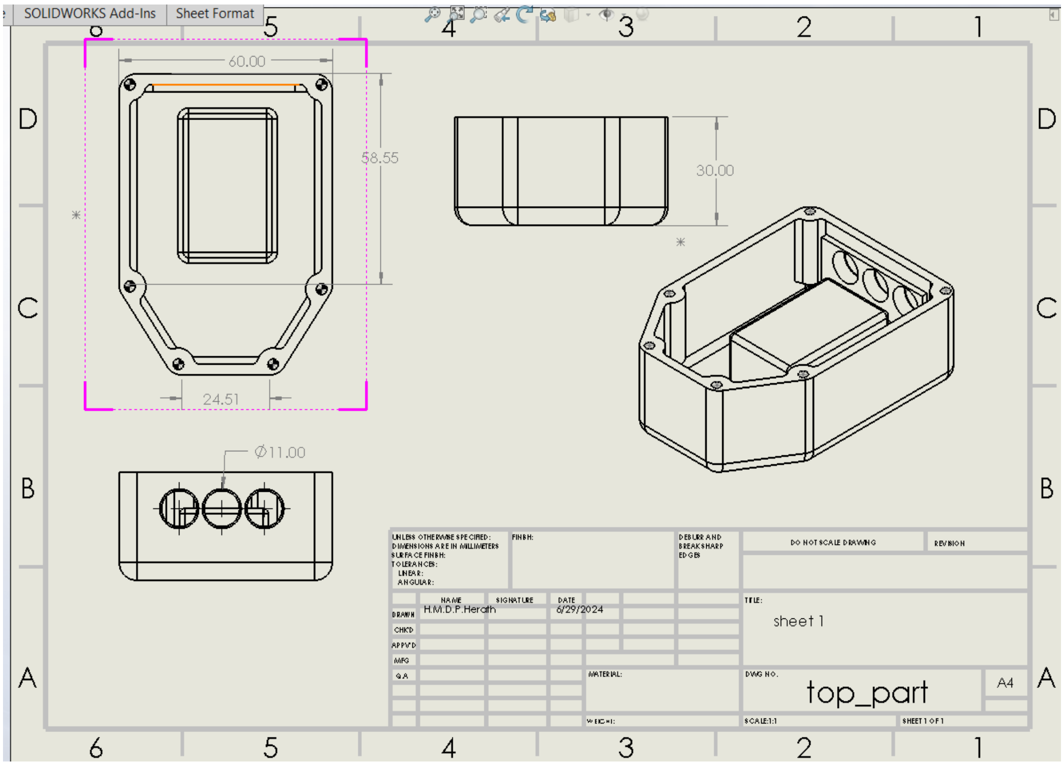


Figure 30

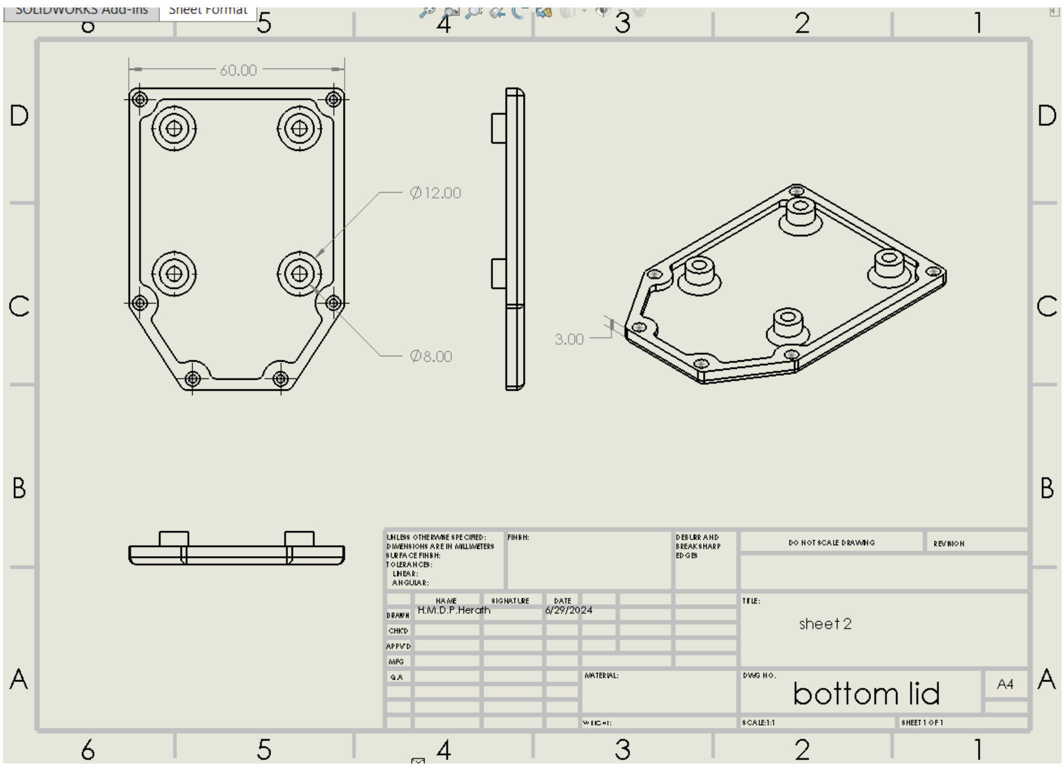


Figure 31

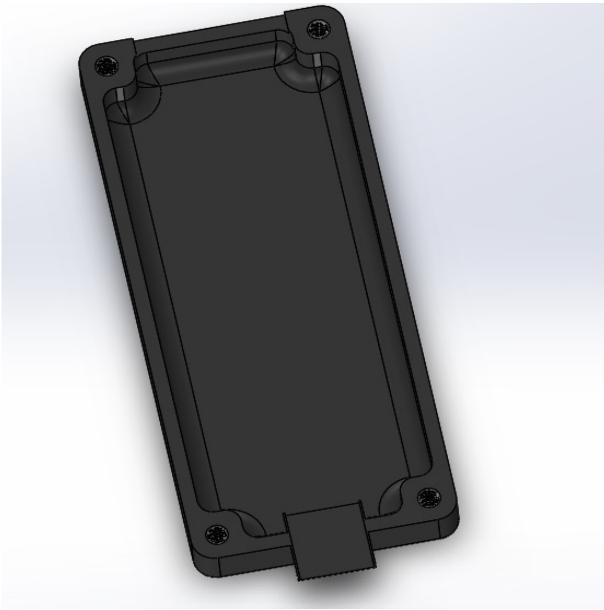


Figure 32: Sensor top

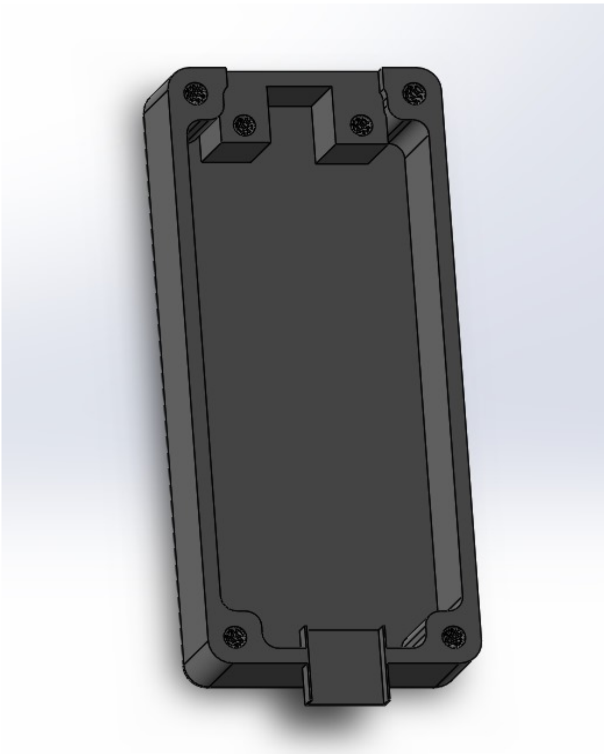


Figure 33: Sensor bottom

Figure 34: Assembly

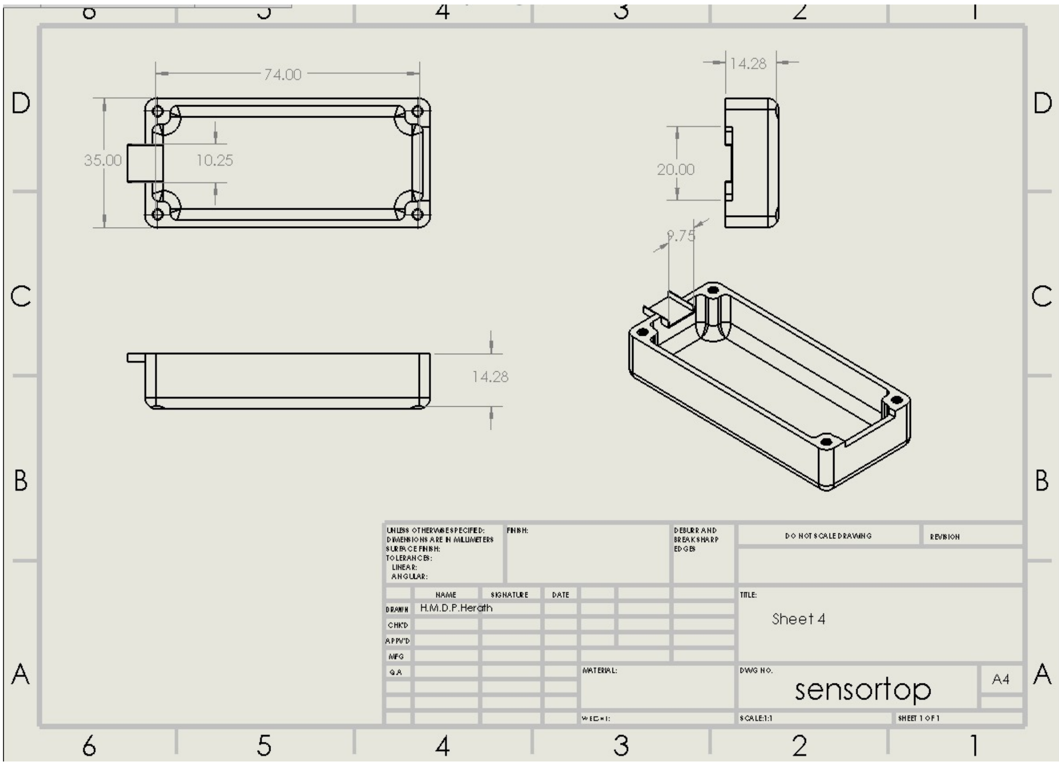


Figure 35: Sensor top

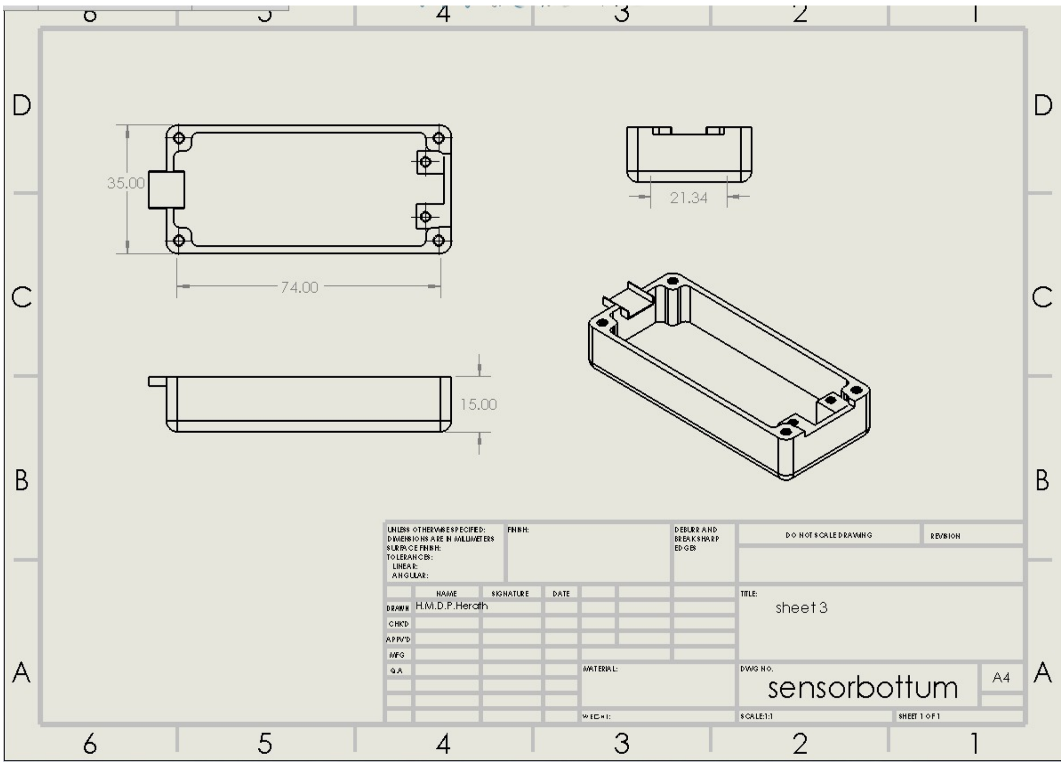
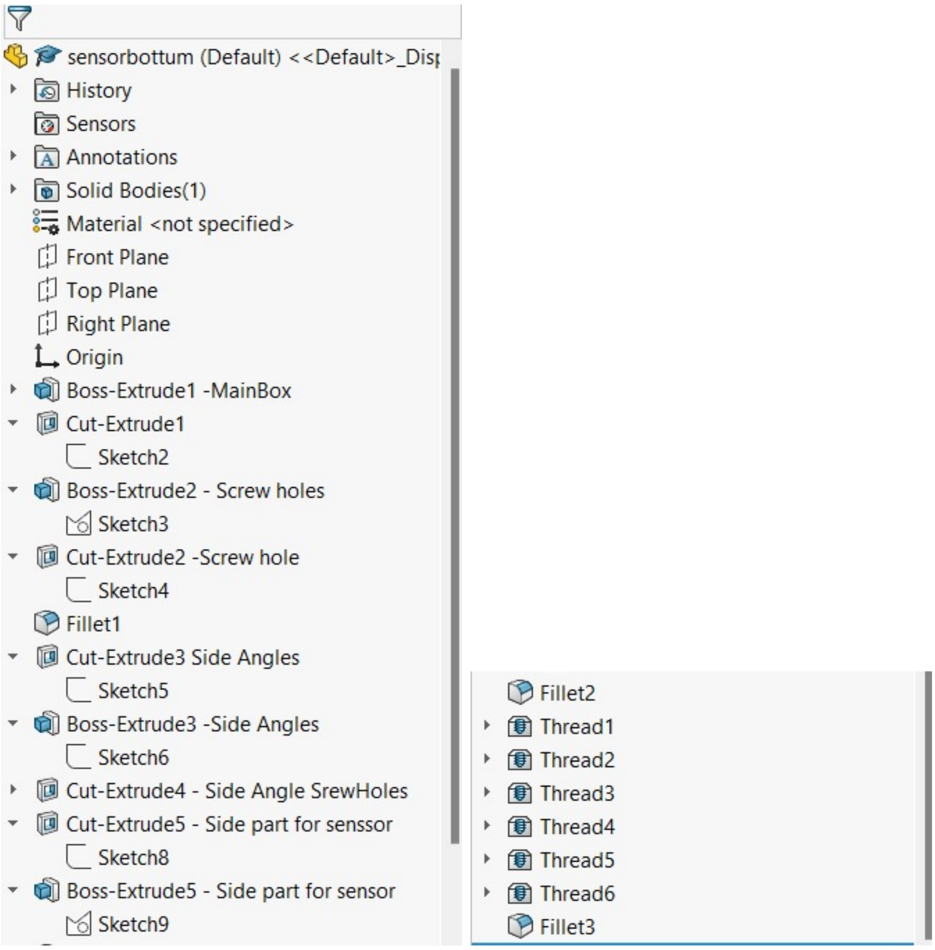


Figure 36: Sensor bottom



(a) (b)

Figure 37: Model trees of sensor bottom part

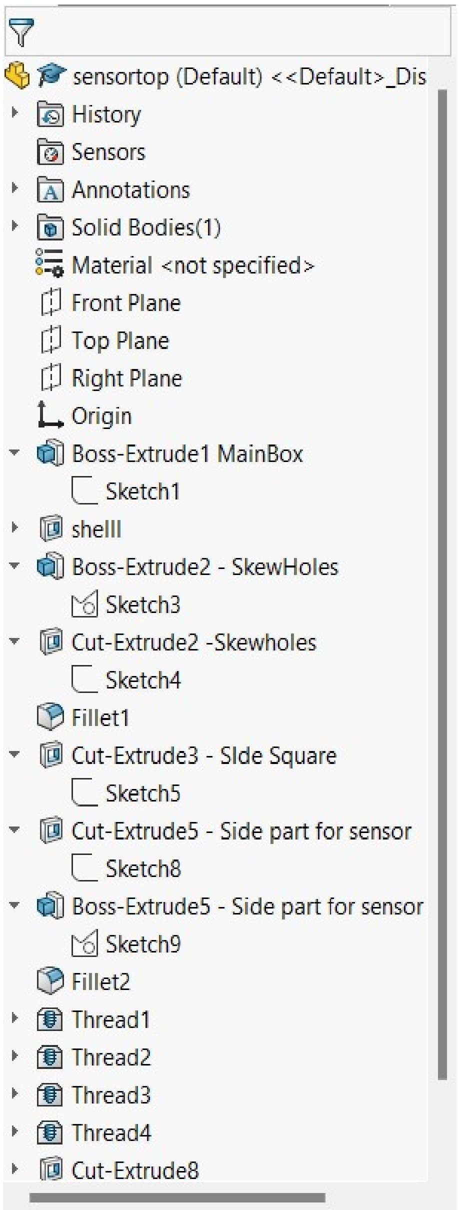


Figure 38: Sensor top model tree

Figure 39: Overall view of product

15 Instructions For assembling

- **Gather Components:** Begin by gathering all necessary components and tools required for the assembly process. This includes the PCB, enclosure, soil moisture sensor, temperature and humidity sensors, microcontroller , resistors, capacitors, connectors, and other required electronic components.
- **PCB Assembly:**Solder the electronic components onto the PCB, starting with smaller components like resistors and capacitors, and then moving on to larger components such as connectors and sensors. Ensure you double-check the component values and orientations to prevent errors.
- **Sensor Integration:**Attach the soil moisture, temperature, and humidity sensors to their designated positions on the PCB. Follow the datasheets or guidelines provided for each sensor to ensure proper connections.
- **Microcontroller (if applicable):**If a microcontroller is part of your design, integrate it onto the PCB at this stage. Program the microcontroller with the necessary firmware before soldering it in place.
- **Power Supply:**Install the power supply components and make sure to follow safety guidelines for power connections. Inspect for any short circuits or incorrect connections that could damage the circuit.
- **Testing:**Before moving forward, conduct thorough tests to verify the functionality of the assembled circuit. Test the soil moisture, temperature, and humidity sensors for accuracy, systems operate correctly.
- **Enclosure Assembly:** After verifying the PCB assembly, place it carefully inside the enclosure. Ensure that all necessary holes for connectors, buttons, and displays align properly with the PCB and components.
- **Secure the PCB:**Use appropriate mounting hardware to secure the PCB inside the enclosure. This prevents any movement that could cause damage during usage or transportation.
- **Final Connections:**Connect any external interfaces, such as USB ports, power jacks, or display modules, according to the design requirements. Double-check all connections for accuracy and stability.
- **Final Testing:**Perform a final functional test of the fully assembled Soil Moisture Meter. Ensure that all components work together seamlessly and meet the desired specifications.

16 Mobile Application

16.1 Requirements

- User should be able to login or sign up and access all the records relevant to that user.
- User should be able to add a newly bought device to the database and access its relevant parameters using a unique device Id.
- User should be able to view the latest data in the database which they are authorized to.
- Data should be presented in a simple, effective graphical manner.
- Database should separate devices that belong to different users.
- It should separately identify data sent from each device and update the relevant entries in the database.
- User should be able to add or delete records but not modify them using software. Only device transmissions should be able to modify data in existing records.

16.2 Architecture Overview

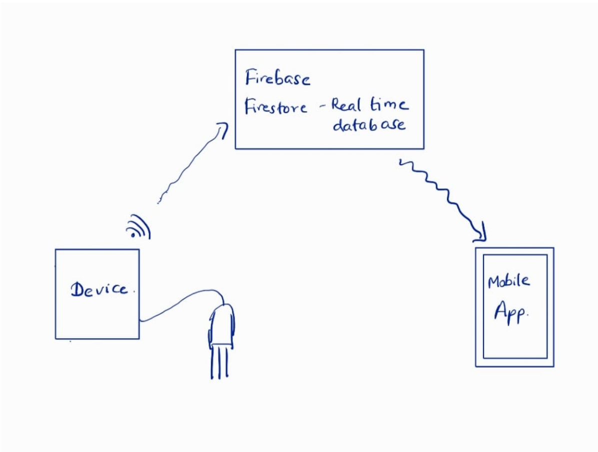
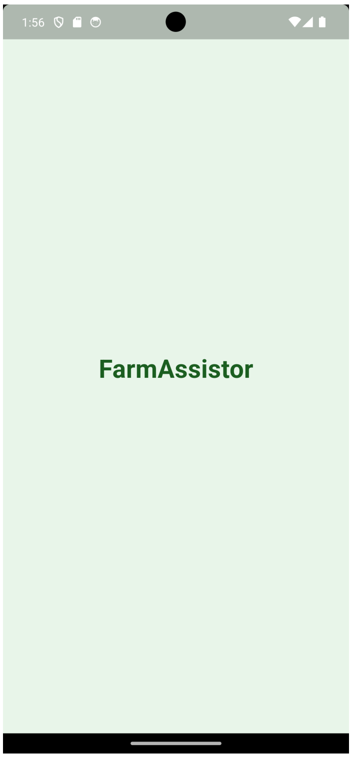


Figure 40: Architecture overview

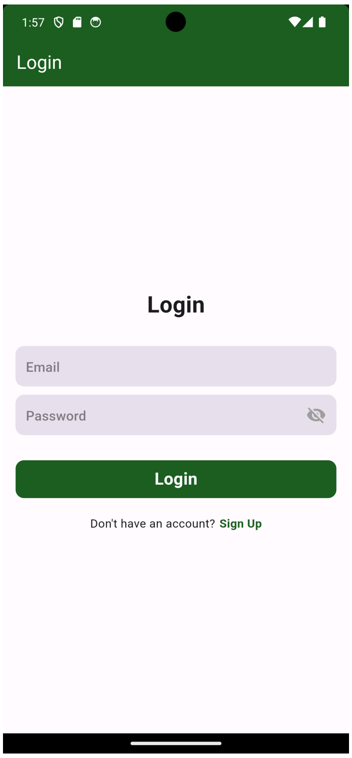
For our app development, we selected Firebase, a platform by Google to host the real-time database and authentication system. We chose Flutter, a framework based on the Dart language, for developing the user interface. Detailed guidelines for setting up required environments is given in the appendix comprehensive design details section.

16.3 Final Application Structure

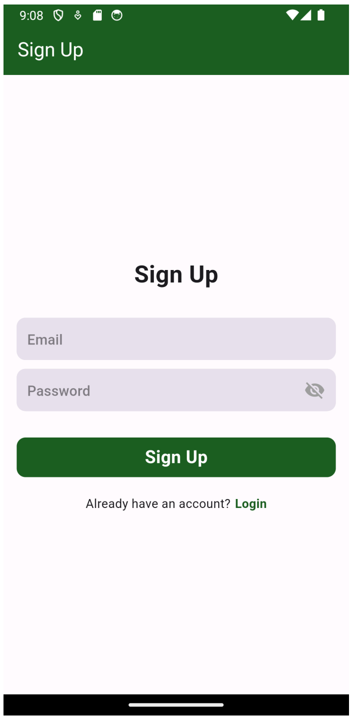
We have designed the final application structure to satisfy the identified requirements in the most efficient manner.



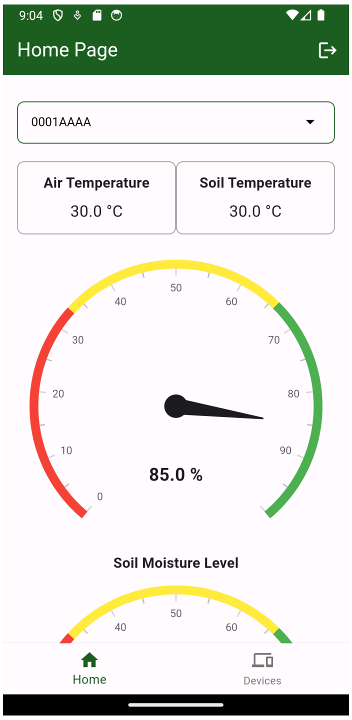
(a) Splash Screen



(b) Login Page

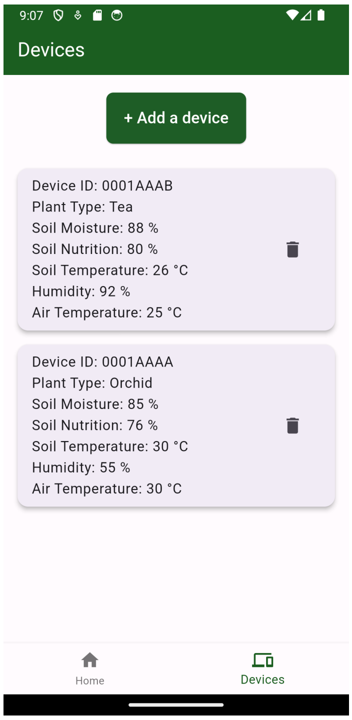


(c) Sign Up Page

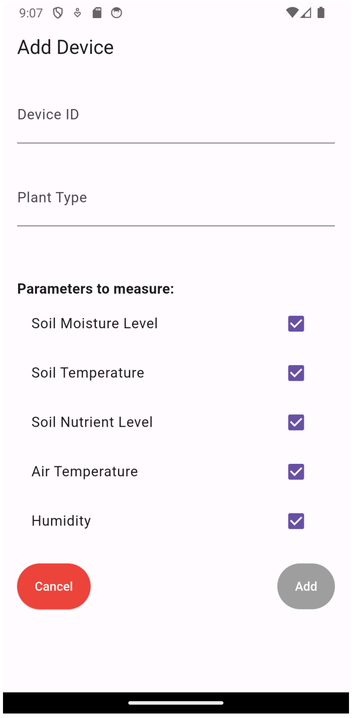


(d) Home Page

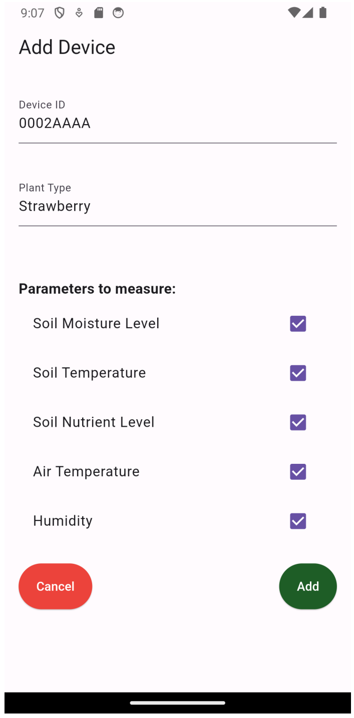
(e) Home Page



(f) Devices Page



(a) Add Device unfilled



(b) Add Device filled

Figure 42: Application Structure

This report was reviewed by,

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