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Automated Aquaculture Tank Monitoring System
Methodology Report

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EN 2160 Electronic Design Realization

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Abstract

Our process was guided by the Cambridge EDC model, encompassing three phases:

1. Explore
2. Create
3. Evaluate

During the exploration phase, we examined existing products and engaged with stakeholders to gather insights. In the creation phase, we developed conceptual designs that integrated our findings and addressed identified needs. Finally, in the evaluation phase, we rigorously assessed our designs to ensure they met our objectives and provided significant improvements over current market offerings. This comprehensive and iterative process enabled us to refine our ideas and develop a product that is both innovative and aligned with the needs of the aquaculture industry.

Figure 1: Cambridge modle for product design

1 General Specifications

1.1 Review progress and plan next steps

Review progress

Reviewing the progress of our project, we conducted a comprehensive analysis of existing work in this field by various companies. Our focus on understanding current approaches, innovations, and technology aimed to lay the groundwork for the proposed project. We utilized sources such as YouTube videos, product brochures from relevant manufacturers, and research articles to gather insights and inform our approach moving forward. This comprehensive review provided valuable insights into the state-of-the-art technologies and practices, guiding the development of our project towards addressing specific needs in the aquaculture industry effectively.

Plan next steps

outline of the specific actions and milestones that are planned for the project's progression.

- **Stakeholder Engagement**
  - Conduct surveys and interviews with aquaculture farmers and industry experts to gather feedback on our design and features.
  - Organize focus groups to discuss the practical aspects of system implementation and maintenance.
- **Prototype Refinement**
  - Incorporate feedback from stakeholders into the prototype design.
  - Enhance the system's software to improve user interface and functionality.
- **Hardware Implementation**
  - Source and assemble the necessary hardware components for the monitoring system.
  - Integrate sensors and other hardware components with the prototype to ensure seamless operation.
  - Conduct thorough testing of hardware components to ensure durability and reliability.
- **Software (Coding) Implementation**
  - Develop and refine the control software for the monitoring system, ensuring all functionalities are correctly implemented.
  - Optimize the code for efficiency and responsiveness, particularly in real-time monitoring scenarios.
  - Perform rigorous testing and debugging of the software to eliminate any issues and ensure smooth operation.
- **Field Testing**
  - Deploy the prototype in various aquaculture settings to test its performance under real-world conditions.
  - Collect data to assess the system's accuracy, reliability, and ease of use.
- **Regulatory Review**

  - Investigate and comply with local and international regulations relevant to aquaculture monitoring systems.
  - Prepare documentation and certifications required for product launch.

- **Continuous Monitoring and Evaluation**
  - Regularly review project progress and adjust plans as necessary.
  - Monitor the effectiveness of our solutions in meeting stakeholder needs, based on data from the field tests.

By addressing these steps systematically, we aim to ensure the successful development and deployment of our aquaculture monitoring and management system, ultimately contributing to the sustainability and efficiency of the industry.

1.2 Identification of need

What is Aquaculture? Aquaculture is the farming of aquatic organisms such as fish, mollusks, crustaceans, and aquatic plants. This is a vital industry contributing to global food security and economic growth. In Sri Lanka, aquaculture plays a significant role in both ornamental fish breeding and consumer fish farming sectors.

What does our product do?
Our comprehensive monitoring and management system addresses a critical need within the aquaculture industry by providing real-time monitoring of crucial parameters such as pH levels, temperature, and total dissolved solids (TDS) in fish tanks and pools. Furthermore, this has a feeder integrated into the system as well. This system is designed to benefit ornamental fish breeders and consumer fish farms alike, where maintaining optimal conditions is essential for fish health and growth.

Why is it needed in the industry?

- **Ensuring Fish Health:**

Our monitoring system plays a vital role in ensuring the well-being of fish populations by continuously tracking essential parameters such as pH levels, temperature, and total dissolved solids (TDS). Maintaining optimal conditions in these parameters is crucial for promoting fish health and growth in both ornamental and consumer-based fish breeding operations. Fluctuations beyond acceptable ranges can induce stress, weaken immune systems, and render fish susceptible to diseases, ultimately leading to mortality. By providing real-time monitoring and alerts, our device empowers farmers to intervene promptly, mitigating potential risks and safeguarding the health of their fish stocks.

- **Improving Efficiency:**

Our monitoring system plays a vital role in ensuring the well-being of fish populations by continuously tracking essential parameters such as pH levels, temperature, and total dissolved solids (TDS). Maintaining optimal conditions in these parameters is crucial for promoting fish health and growth in both ornamental and consumer-based fish breeding operations. Fluctuations beyond acceptable ranges can induce stress, weaken immune systems, and render fish susceptible to diseases, ultimately leading to mortality. By providing real-time monitoring and alerts, our device empowers farmers to intervene promptly, mitigating potential risks and safeguarding the health of their fish stocks.

- **Enhancing Productivity:**

Our monitoring system goes beyond merely tracking parameters; it provides farmers with actionable insights to optimize farm operations. By delivering real-time data on water quality parameters,

including pH levels, temperature, and TDS, our product empowers farmers to make informed decisions regarding feed management, water treatment, and other aspects of fish farming. Armed with this valuable information, farmers can adjust feeding schedules, implement targeted treatments, and optimize resource allocation, leading to improved productivity and resource utilization. Additionally, access to historical data enables farmers to identify trends and patterns, facilitating long-term planning and continuous improvement in farm management practices.

Therefore, the need for our monitoring and management system stems from the imperative to ensure optimal conditions for fish health and growth in aquaculture environments. By addressing this need, our product contributes to the sustainability and success of both ornamental fish breeding and consumer fish farming sectors in Sri Lanka.

1.2.1 Need list

- Continuous monitoring of pH levels, temperature, and total dissolved solids (TDS).
- Instantaneous data updates to ensure current status is always available.
- **Accuracy and Precision:**
  - High accuracy in measuring pH, temperature, and TDS to ensure reliable data.
  - Minimal error margins to maintain optimal conditions for fish health.
- **Alerts and Notifications:**
  - Immediate alerts for parameter deviations beyond acceptable ranges.
  - Notification system (SMS, email, or app notifications) to inform farmers of critical changes.
- **Data Logging and Analysis:**
  - Historical data storage for trend analysis and long-term planning.
  - User-friendly interface for reviewing past data and identifying patterns.
- **Integration with Feeder System:**
  - Automated feeding schedules based on real-time data.
  - Ability to manually adjust feeding times and quantities through a control interface.
- **User Interface:**
  - Intuitive and easy-to-use interface for monitoring and control.
  - Mobile and web applications for remote access and management.
- **Durability and Reliability:**
  - Weather-resistant and robust hardware suitable for various environmental conditions.
  - Long-lasting performance with minimal maintenance requirements.
- **Scalability:**
  - Ability to scale the system for different farm sizes, from small ornamental fish breeders to large consumer fish farms.
  - Modular design allowing for the addition of more sensors or feeders as needed.
- **Power Efficiency:**
  - Low power consumption to reduce operational costs.
  - Backup power options to ensure continuous operation during power outages.

- **Cost-Effectiveness:**
  - Affordable initial setup and maintenance costs.
  - Cost-saving benefits through improved fish health and optimized resource usage.
- **Compliance and Safety:**
  - Adherence to industry standards and regulations for aquaculture equipment.
  - Safe for use in aquatic environments without harming the fish or water quality.
- **Customer Support and Training:**
  - Comprehensive support services including installation, troubleshooting, and maintenance.
  - Training materials and resources to help users understand and effectively use the system.

1.3 Stake holder map

The stakeholder map for our product categorizes stakeholders based on their level of interest and influence. This strategic organization enables effective stakeholder management by anticipating needs, engaging with key stakeholders, and maintaining open communication channels. By aligning engagement strategies with stakeholders' interests and influence levels, we ensure thorough involvement and optimize project outcomes.

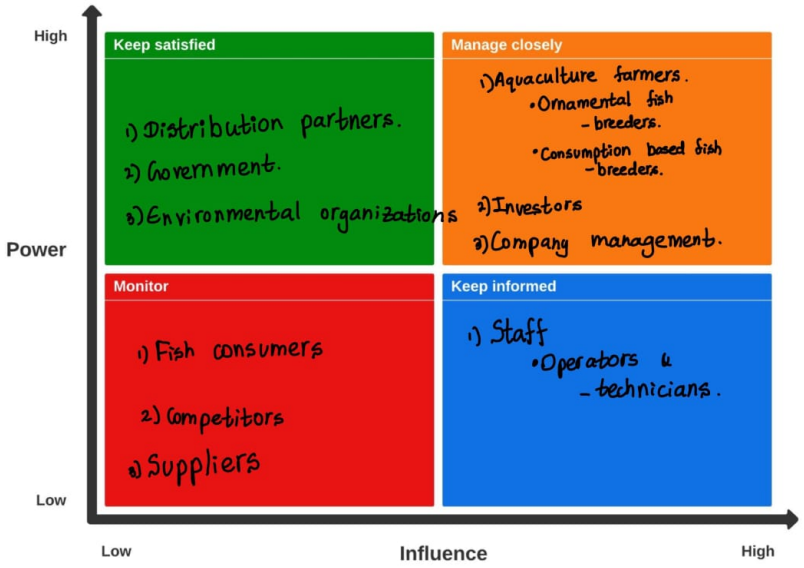


Figure 2: Stake holder map

1. **Fish Breeders and Farmers:** Individuals or organizations engaged in breeding and farming fish, striving to ensure the health and productivity of their fish populations for both ornamental and consumption purposes.
2. **Government Agencies and Regulatory Bodies:** Responsible for overseeing aquaculture practices and enforcing regulations, these entities prioritize technologies that facilitate compliance, promote environmental sustainability, and foster economic growth in the industry.
3. **Research Institutions and Academia:** Universities, research institutes, and academic researchers actively contribute to aquaculture studies and innovation. They collaborate on research projects, provide expertise, and utilize technology for academic and scientific purposes.

4. **Competitors:** Entities offering comparable solutions will be impacted by our product, thus categorizing them as significant stakeholders.
5. **Suppliers:** Providers of hardware, software, and connectivity resources essential for the proposed soil monitoring systems.
6. **Investors and Funding Organizations:** Securing additional financial support is crucial for advancing our product. Evaluating market potential, scalability, and projected returns will be key considerations for potential investors and funding agencies.

1.4 Observe users

Our product targets the aquaculture industry, particularly ornamental and consumer fish breeding farms, aiding in the breeding, raising, and harvesting of fish, shellfish, and aquatic plants for consumption and ornamental purposes.

Ornamental Fish Breeding:
Ornamental fish farming involves breeding and raising a variety of colorful species for commercial purposes, including livebearers like guppies and egg layers such as tetras and catfish.
Fish that are bred for ornamental purposes:

1. Guppies
2. Swordtails
3. Platys
4. Barbs
5. Tetras

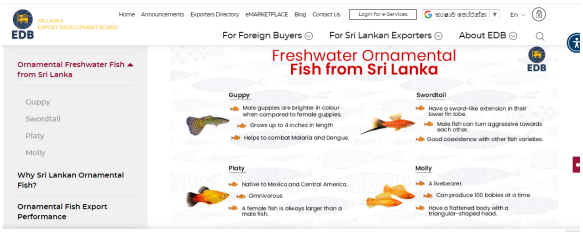


Figure 3: Ornamental fish breeds in SriLanka

Some companies which breed and sell ornamental fish in Sri Lanka who could be our potential customers:

1. Oscar Fish Farm (Pvt) Ltd. in Homagama
2. PERERA Fish Farm And Hatchery in Negambo

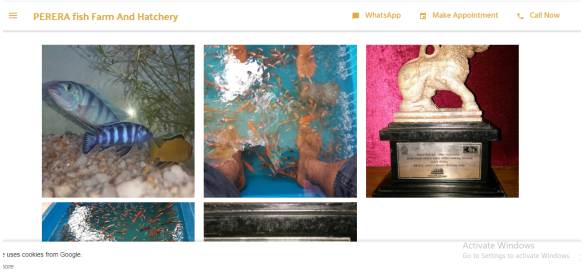


Figure 4: An ornamental fish breeder

Consumer based fish farming:
Consumer-based fish farming in Sri Lanka involves the breeding and cultivation of fish species primarily for human consumption. Fish for consumptions are commonly farmed in controlled environments such as ponds, tanks, and raceways.
Fish that are bred for consumption:

1. Trout

2. Thilapia
3. Catfish
4. Sea cucumber

Some companies which breed and sell consumer based in Sri Lanka who could be our potential customers:

1. Sri lankan Thilapia farm in Katunayaka
2. Sea cucumber farms in JaffnaHatchery in Negambo
3. Finefish Hatchery In Batticoloa

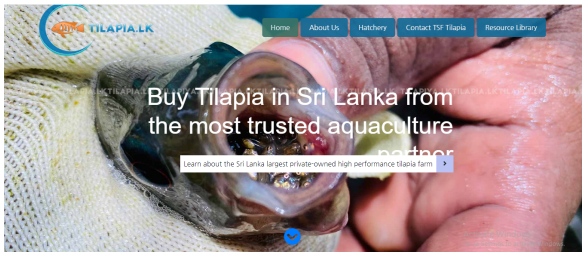


Figure 5: Thilapia farm

1.5 Review of Existing Products

2. YSI 5200A

Figure 6: YSI 5200A

This product boasts a multiparameter monitoring system, encompassing vital parameters like dissolved oxygen, temperature, conductivity, pH, ORP, and salinity. It offers versatile connectivity options, event logging for calibrations, and advanced features such as conditional feed timers and network integration for up to 32 instruments per communication port. The intuitive interface with a graphic, backlit LCD ensures swift and reliable system status checks, complemented by included Feed Smart software for enhanced functionality.

3. Kactoily

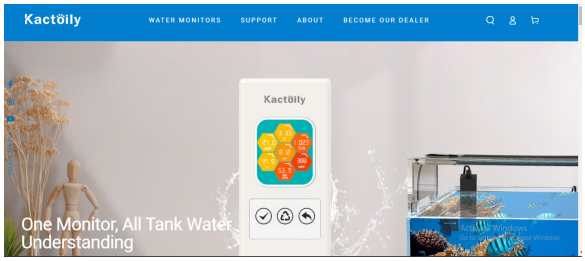


Figure 7: Kactoily

This product excels in precision measurement, encompassing pH, TDS, EC, salinity, temperature, specific gravity, and ORP parameters. Offering simultaneous data display, it ensures seamless monitoring, backed by industrial-grade probes for extended durability. With round-the-clock surveillance and automated calibration, it guarantees accurate detection data, providing peace of mind.

Observations regarding the existing products:

Observations highlight a variety of features across existing aquaculture monitoring products, covering parameters vital for management. However, notable gaps include the absence of integrated feeding systems in certain products and the lack of specific features like conditional feed timers in others. Despite offering accurate measurement and continuous monitoring, some products fall short in automation features. There's a discernible market void for locally tailored, integrated monitoring systems with feeding capabilities, especially in Sri Lanka, where manual systems prevail. Additionally, most existing solutions are sourced from overseas, underlining the need for localized options. Notably, IoT integration is a prevalent feature in many aquaculture monitoring products.

1.6 Simulate ideas

To stimulate ideas for our comprehensive monitoring and management system, we employed a structured approach involving mind mapping and brainstorming sessions to identify the essential needs of users in the aquaculture industry. We analyzed existing products in the market, examining their key features and pinpointing areas for improvement. Additionally, we explored additional functionalities that could be valuable to users, ensuring our product addresses a wide range of needs.

We also engaged in discussions with other groups whose goals and needs aligned with ours, even if their product ideas differed. This exchange of ideas provided valuable insights and perspectives. We shared our concepts with them and actively listened to their feedback, enriching our ideation process.

During our idea simulation, we encountered the following questions:

1. How can we ensure the accuracy and reliability of real-time monitoring for pH, temperature, and TDS levels in diverse aquaculture environments?

2. What features can we integrate to make the system user-friendly for both small-scale ornamental fish breeders and large-scale consumer fish farms?

3. How can we design the feeder mechanism to be both efficient and flexible enough to accommodate different types of fish feed and feeding schedules?

4. What methods can we use to waterproof and protect the enclosure, ensuring durability in various weather conditions and aquaculture settings?

5. How can we leverage connectivity and data analytics to provide actionable insights that help farmers optimize their operations and improve fish health and growth?

By addressing these questions, we aimed to create a robust, versatile, and user-centric product that meets the diverse needs of the aquaculture industry.

1.7 Design Criteria

When crafting a novel product, it's essential to evaluate fundamental elements to ensure its efficacy and success. Primary among these is **functionality and performance**, necessitating consistent operation, even in challenging circumstances. Additionally, **usability and user experience** are crucial, requiring intuitive navigation and ease of use to enhance user satisfaction and promote recommendations. **Durability and reliability** are also significant, as products that endure and consistently perform well are favored by consumers. **Achieving cost-effectiveness** is another essential consideration, striking a balance between production costs and affordability to cater to customer needs. Lastly, **environmental sustainability** has emerged as a pivotal factor, prompting the adoption of eco-friendly materials and practices to minimize the product's ecological footprint.

1.8 Conceptual Design

Introduction:

This report delves into the development of an Electronic Fish Tank Maintenance Device, crucial for the aquaculture industry. We present alternative conceptual designs and functional block diagrams for key components, including the fish feeder, sensor probes, and user interface. Additionally, we evaluate each design option based on criteria such as efficiency, reliability, and user-friendliness. This thorough evaluation process guides the selection of the most suitable design solutions, ensuring optimal fish tank management in diverse aquaculture settings.

1.8.1 Conceptual Design 1

• In the first design, three sensors are utilized, each dedicated to sensing TDS values, pH values, and temperature. Additionally, for the feeder in the initial design, a servo motor is incorporated to slide a small flap at the bottom of the feeder for food dispensing. Here the Microcontroller has a built-in WiFi Module to get real time. All three probes are connected to a main unit and will be submerged in the water. A buzzer is included for warning alerts, triggered by deviations in monitored parameters such as temperature, TDS levels, and pH levels.

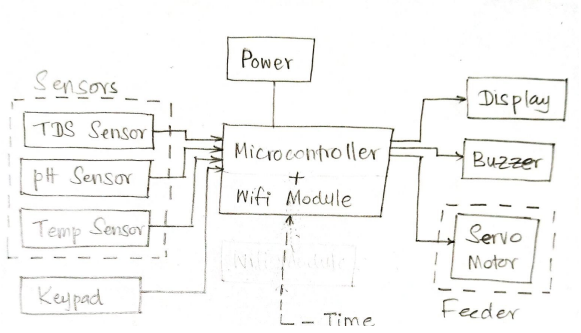


Figure 8: Block diagram of design 1

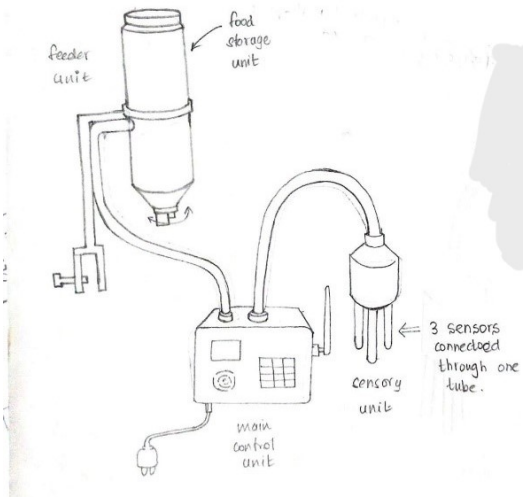


Figure 9: Caption for Image 1

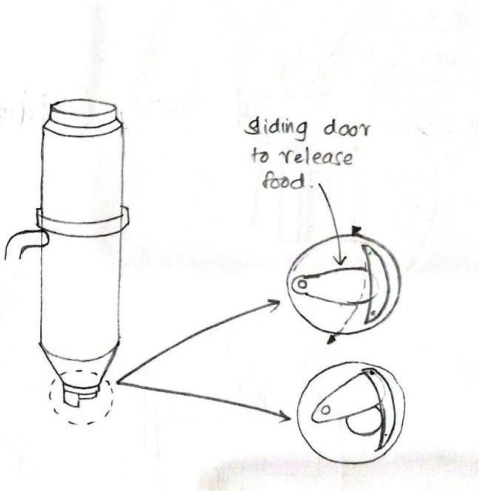


Figure 10: Sketch of design 1

1.8.2 Conceptual Design 2

• In the second design, communication with the user is facilitated through an external WiFi module, allowing data transmission via an accompanying app. A servo motor operates the feeder, which is designed in an L-shape for improved functionality. In this model, three separate probes are suggested, each individually connected to the main unit to gather tank data including temperature, pH values, and TDS values.

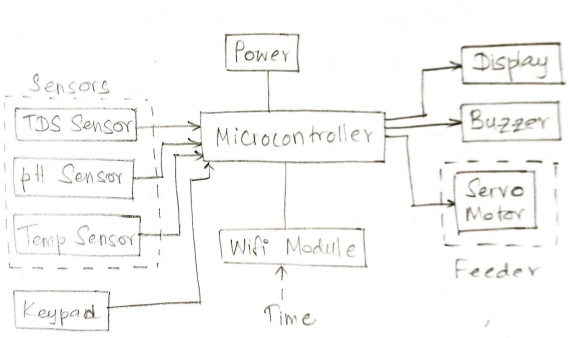


Figure 11: Block diagram of design 2

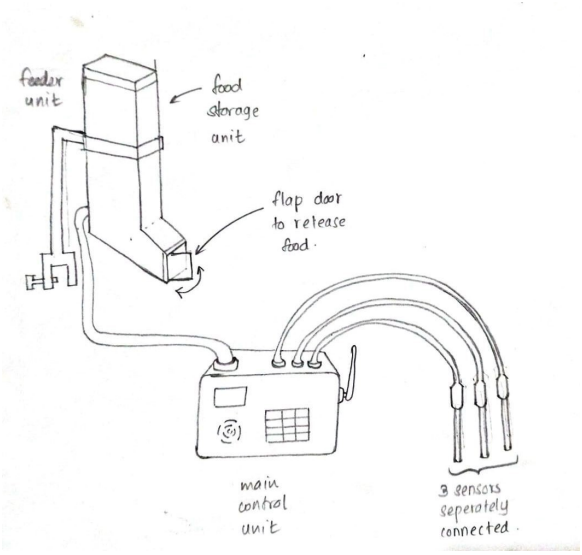


Figure 12: Sketch of design 2

1.8.3 Conceptual Design 3

• In the third device, a DC motor is integrated with a screw conveyor, ensuring a streamlined and efficient feeding solution. The rotation of the screw conveyor, driven by the motor, facilitates precise and consistent feeding. Additionally, an external WiFi module is incorporated to connect to a server, enabling users to easily set and control feeding times and durations through an intuitive interface. This connectivity allows for real-time synchronization of feeding schedules, ensuring optimal performance and convenience.

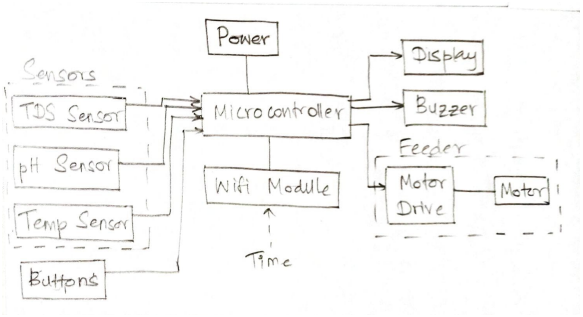


Figure 13: Block diagram of design 3

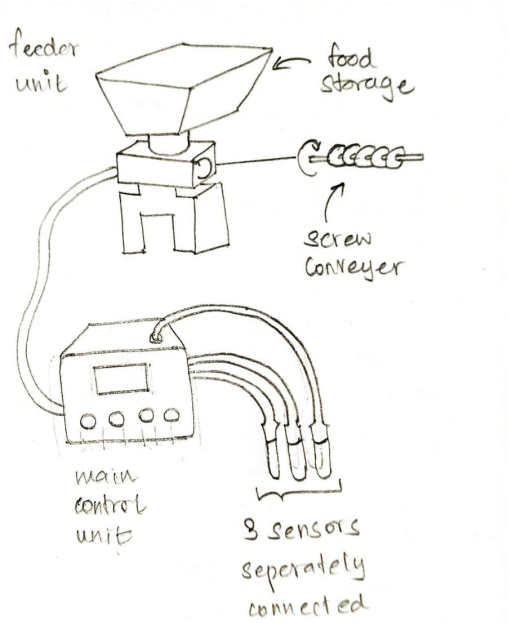


Figure 14: sketch of design 3

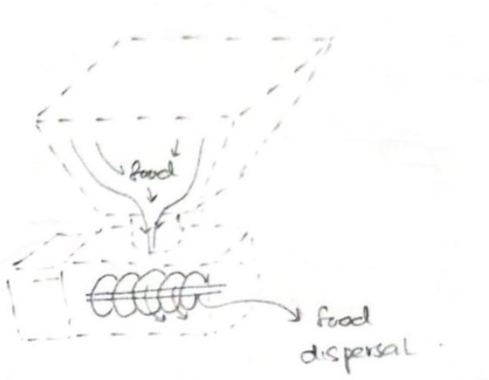


Figure 15: Screw conveyer

1.9 Evaluation of conceptual designs

Enclosure evaluation criteria

1. **Functionality:** Does the design function as intended?
2. **Durability:** Does the product have an appropriate lifespan?
3. **Ergonomics:** Does the design consider human factors and optimize usability?
4. **Assembly and serviceability:** Does the design incorporate modular components and accessible access points to facilitate streamlined assembly and serviceability, allowing for efficient maintenance and repairs with minimal downtime?
5. **Scalability:** Can the design be scaled up or down to accommodate different product variations?
6. **Simplicity:** Does the design achieve simplicity through straightforward assembly methods and intuitive user interfaces, enhancing usability and ease of operation?
7. **Manufacturing Feasibility:** How well does the design optimize the manufacturing process in terms of production time, cost, and resources?
8. **Safety:** Does the design prioritize the safety of users, considering factors such as electrical safety, sharp edges, stability, and protection against potential hazards?

Functional Block diagram evaluation criteria

1. **User experience:** How intuitive and user-friendly is the interaction?
2. **Cost:** Evaluate the overall cost effectiveness for the provided functionality.

3. **Performance:** Does the design ensure reliable and efficient functioning? Are there any potential bottlenecks?
4. **Future proofing:** To what extent does the design allow for easy replacement or upgrade of individual components?
5. **Power Efficiency:** How effectively does the device manage power consumption?

		Conceptual design 1	**Conceptual design 2**	**Conceptual design 3**
Newly added features		Micro controller with Built-in Wi-Fi module Flipping door-based feeding mechanism Tube shaped feeding dispenser 3 in one sensory unit	External Wi-Fi module for the micro controller Flapping door-based feeding mechanism L shaped feeding dispenser	Screw conveyer feeding mechanism DC motor with motor controlling circuit 3 sensors separately connected
Removed features		Sliding door at the bottom of dispenser.	Micro controller with Built-in Wi-Fi module 3 in one sensory unit	Servo motor L shaped and tube-shaped feeding dispenser
Enclosure design criteria comparison	Functionality	7	5	9
	Durability	5	7	9
	Manufacturing Feasibility	7	8	8
	Assembly and serviceability	8	6	7
	Simplicity	5	6	8
	Scalability	7	8	9
	Safety	9	9	9
	Ergonomics	7	8	8
	User experience	5	6	9
Functional block design criteria comparison	Power Efficiency	8	8	7
	Future Proofing	7	7	9
	Cost	6	8	8
	Performance	5	7	9
Total		86	93	109

Figure 16: Comparison of conceptual designs

1.9.1 Design Selection

According to the above evaluation criteria third conceptual design has been chosen to develop.

We chose the design with the motor-powered screw conveyor for easier and uniform feed dispensing due to its efficiency and reduced strain on components. Unlike flipping doors, flaps, or sliding mechanisms, which may experience wear and tear over time, the screw conveyor design minimizes mechanical stress and ensures consistent dispensing without relying on fragile components like hinges.

Furthermore, the motor-driven screw conveyor offers enhanced versatility and adaptability, catering to varying tank sizes and configurations while optimizing feeding processes for improved fish health and productivity. Its ease of adaptability ensures seamless integration into existing fish farming setups, minimizing disruptions and simplifying the transition to automated feeding systems.

2 PCB Documentation

2.1 Schematic Diagrams

The schematic diagrams of the PCB are organized as follows:

Figure Number	**Schematic Page Number**	**Caption**
17	1	Block Diagram
18	2	Power Regulator
19	3	MCU
20	4	User Interface
21	5	pH Sensor Module
22	6	TDS Sensor Module
23	7	Water Temperature Sensor Module
24	8	Motor Driver and Switch

Table 1: Schematic Diagrams of the PCB

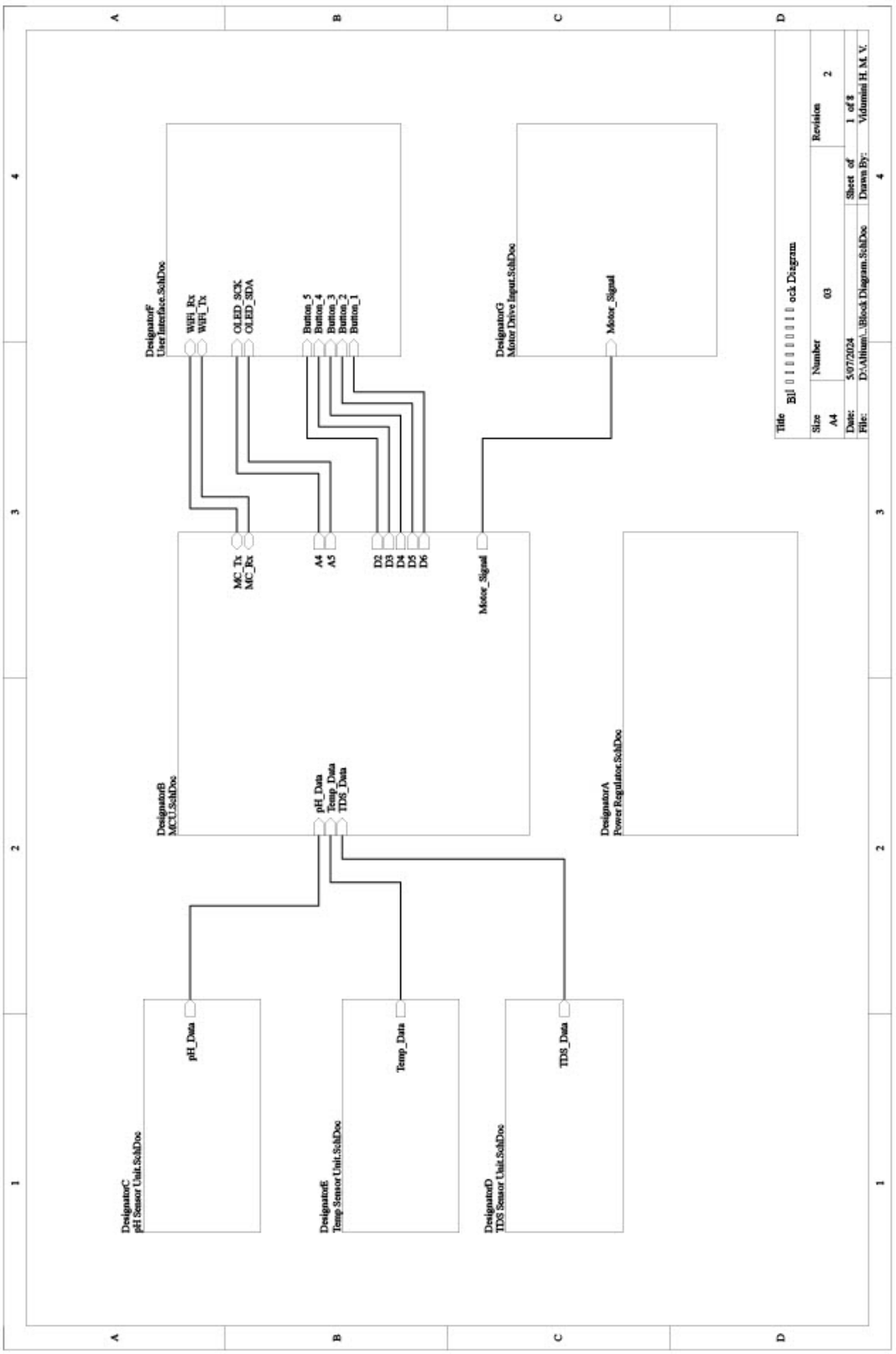


Figure 17: Schematic - Page 1

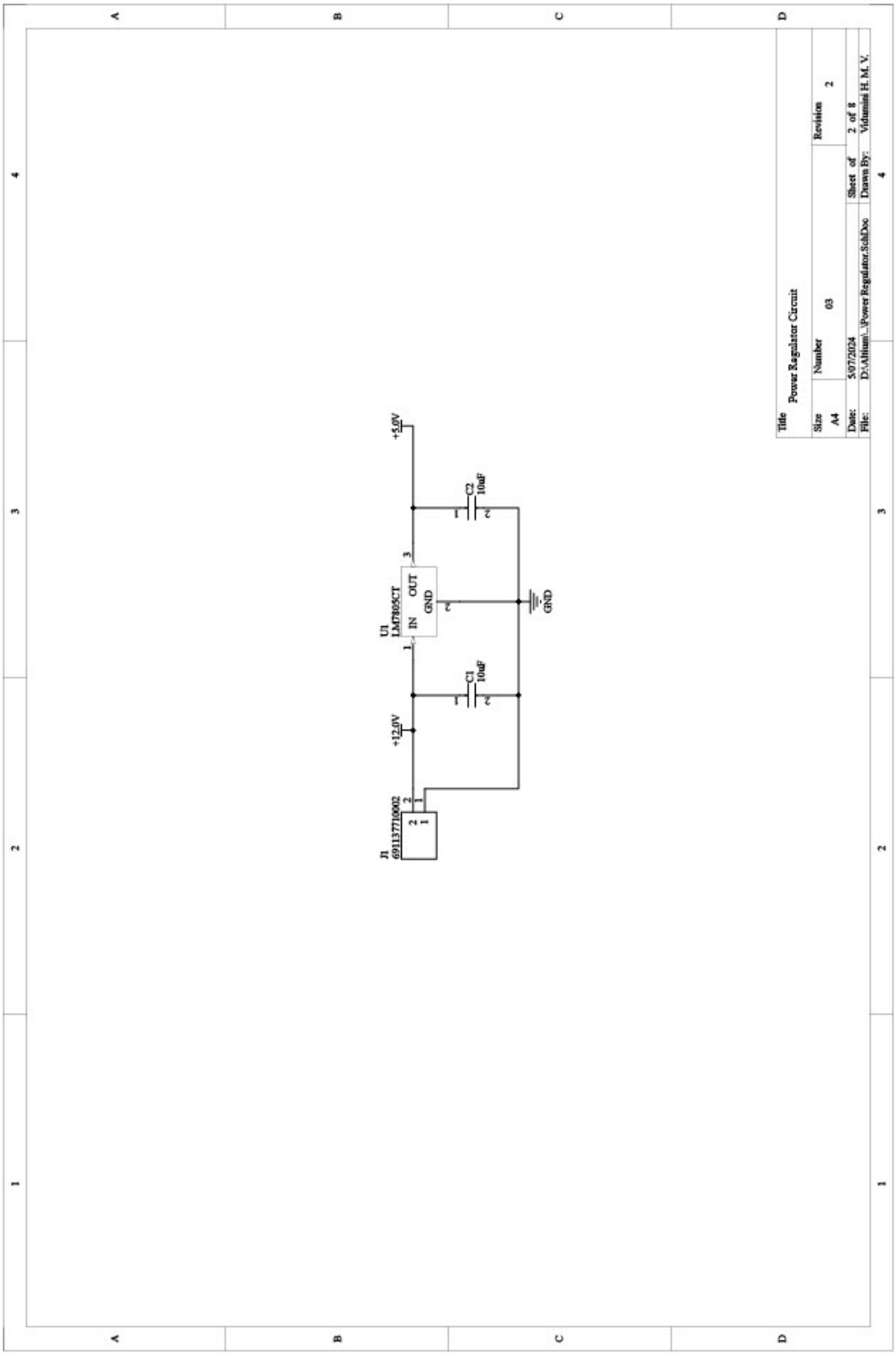


Figure 18: Schematic - Page 2

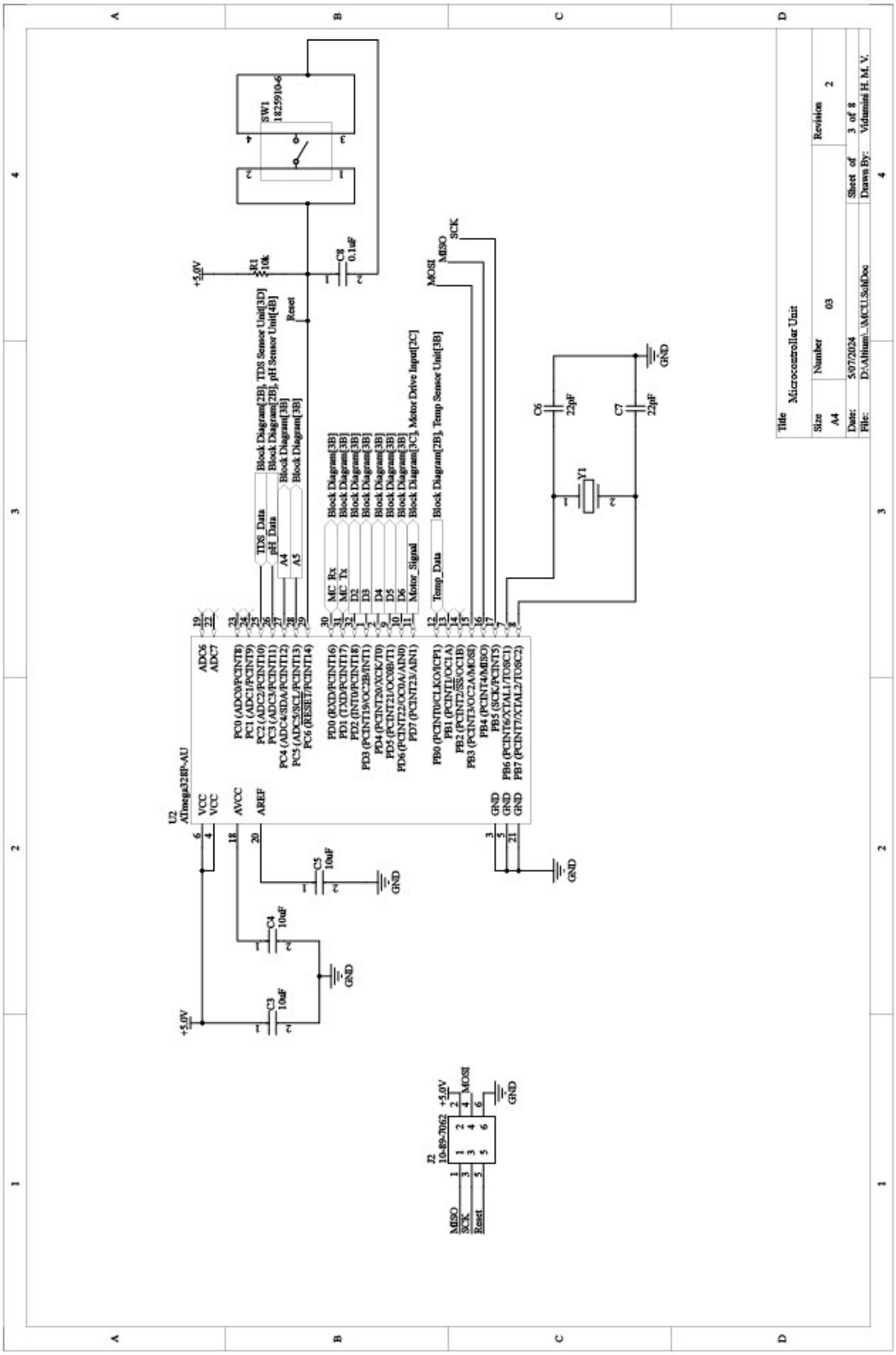


Figure 19: Schematic - Page 3

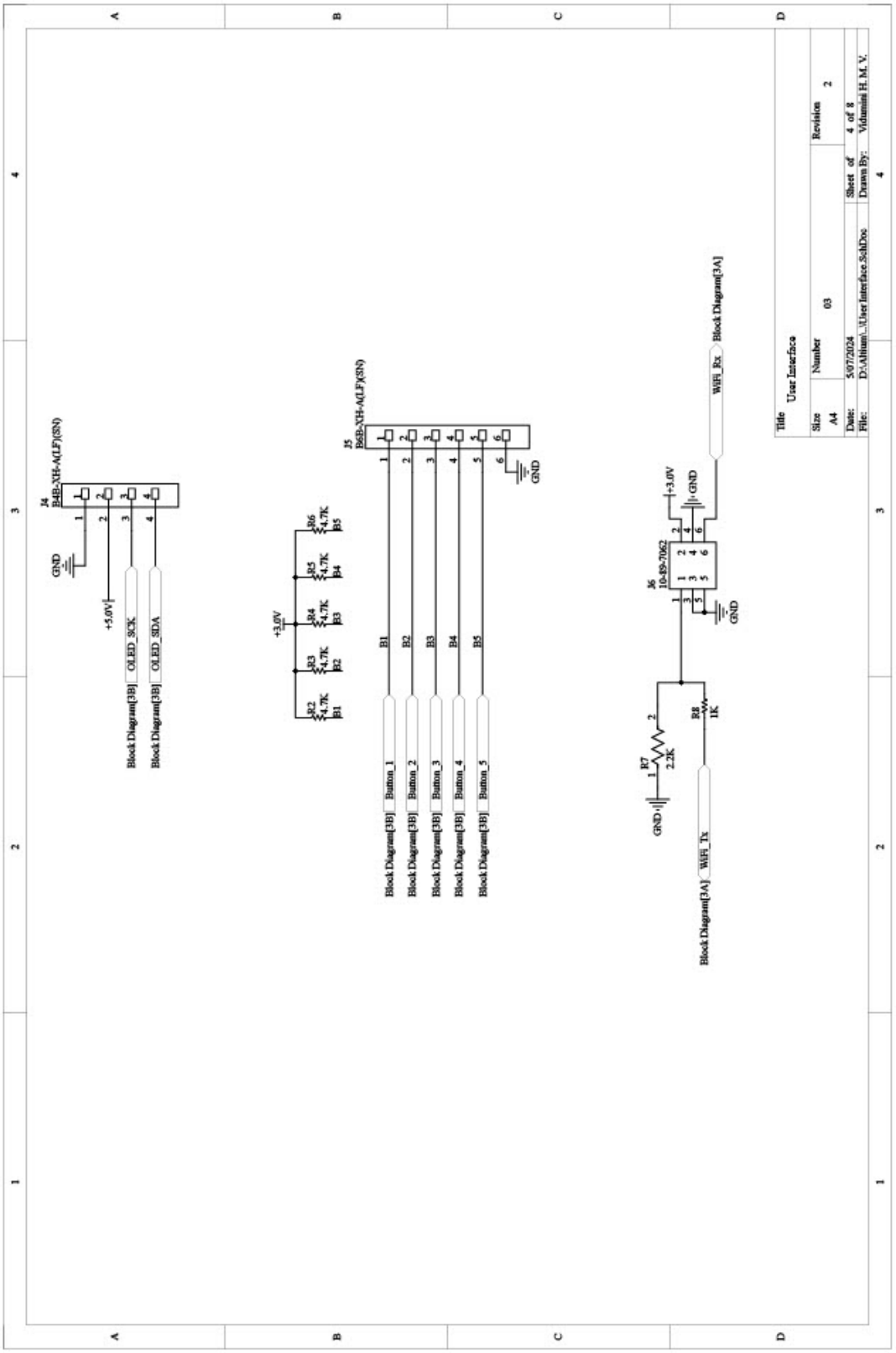


Figure 20: Schematic - Page 4

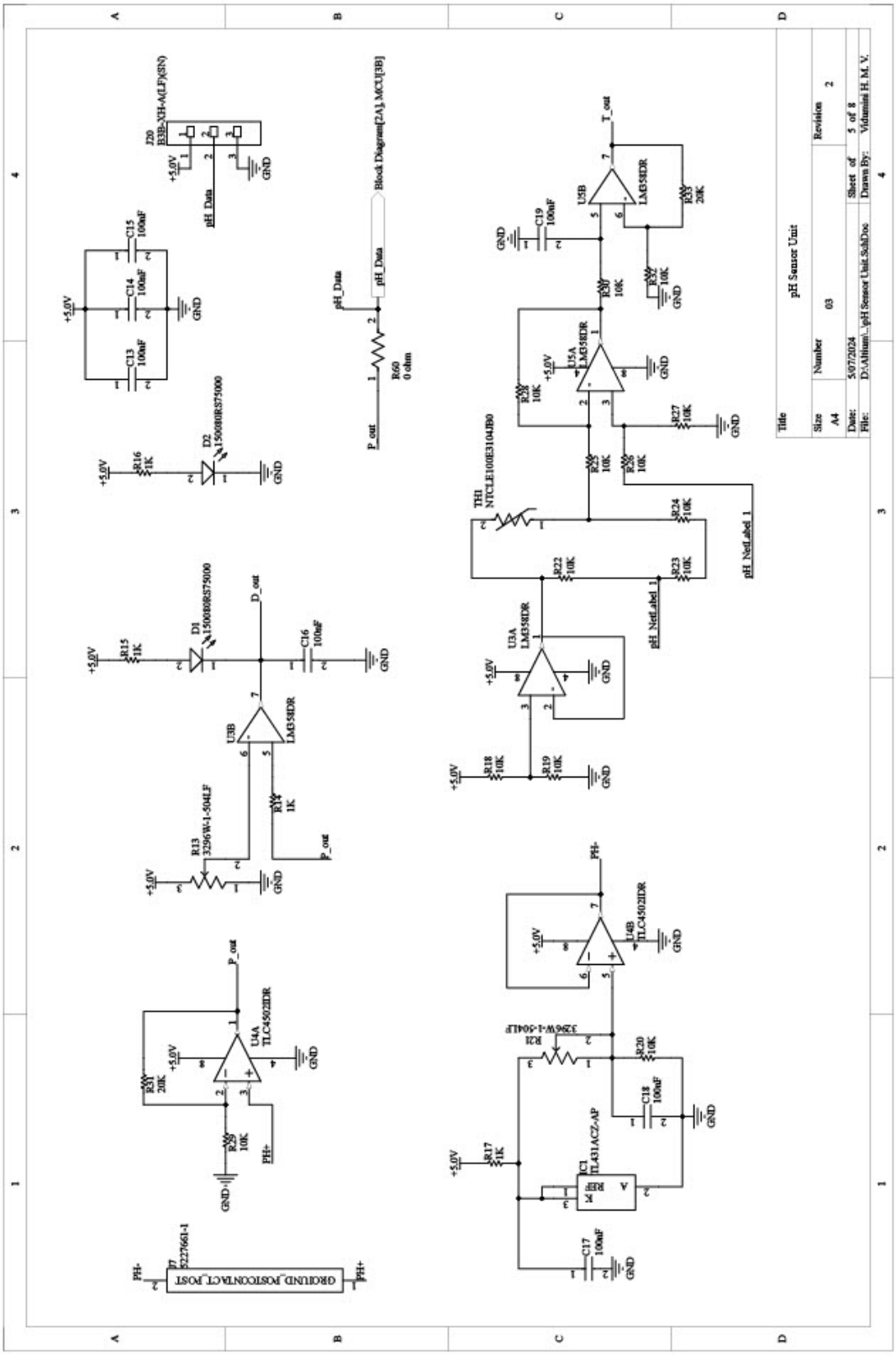


Figure 21: Schematic - Page 5

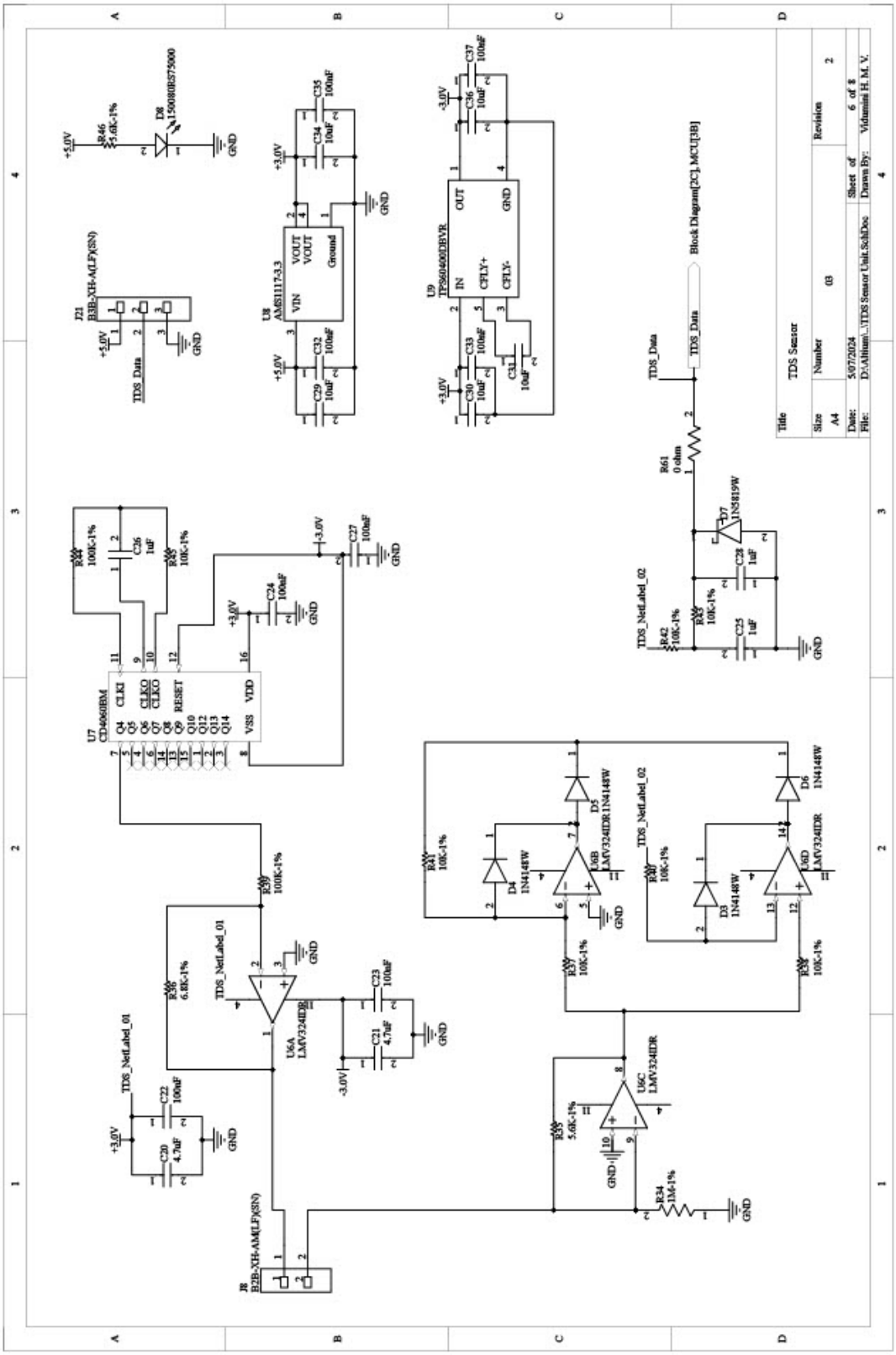


Figure 22: Schematic - Page 6

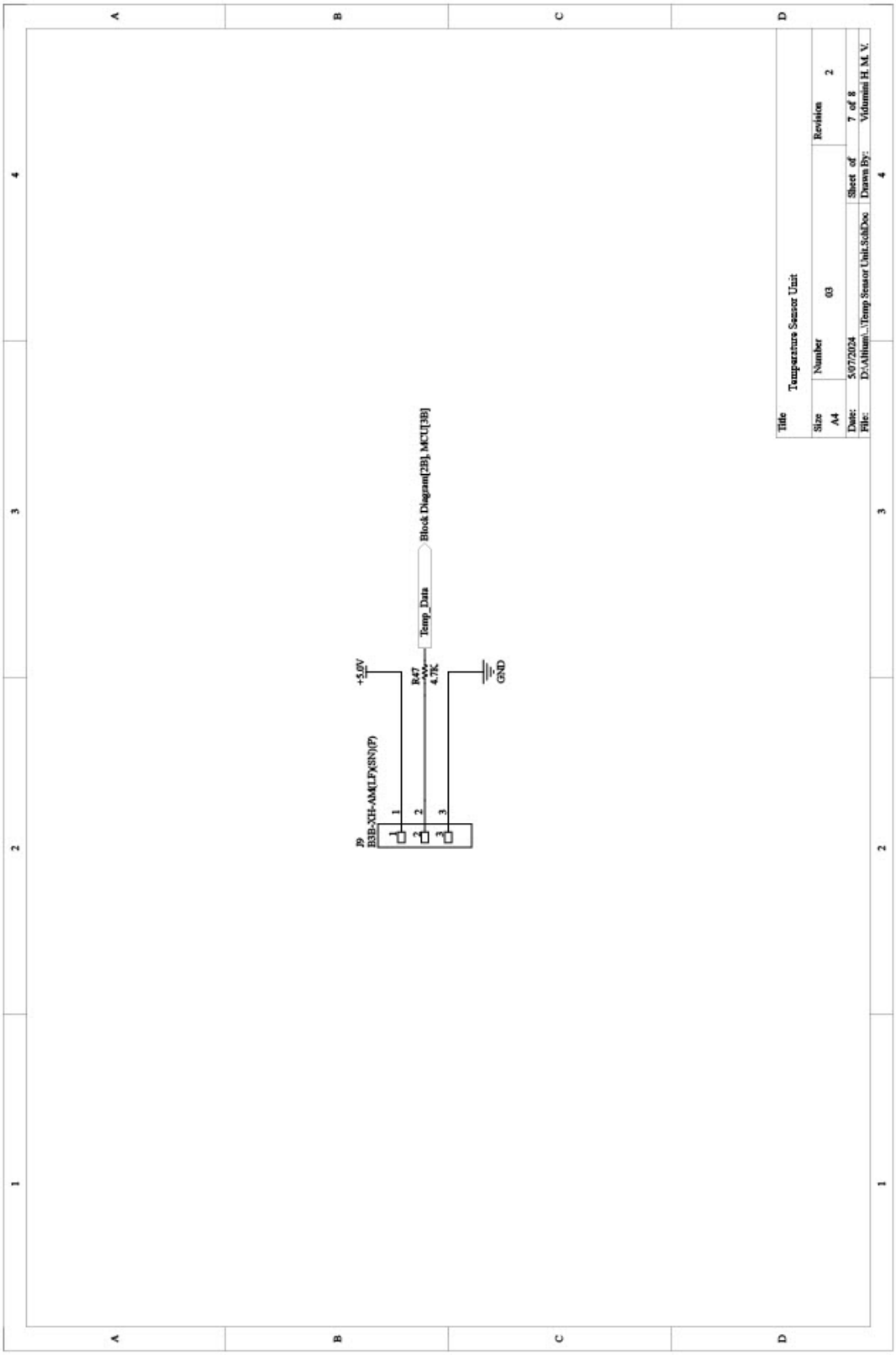


Figure 23: Schematic - Page 7

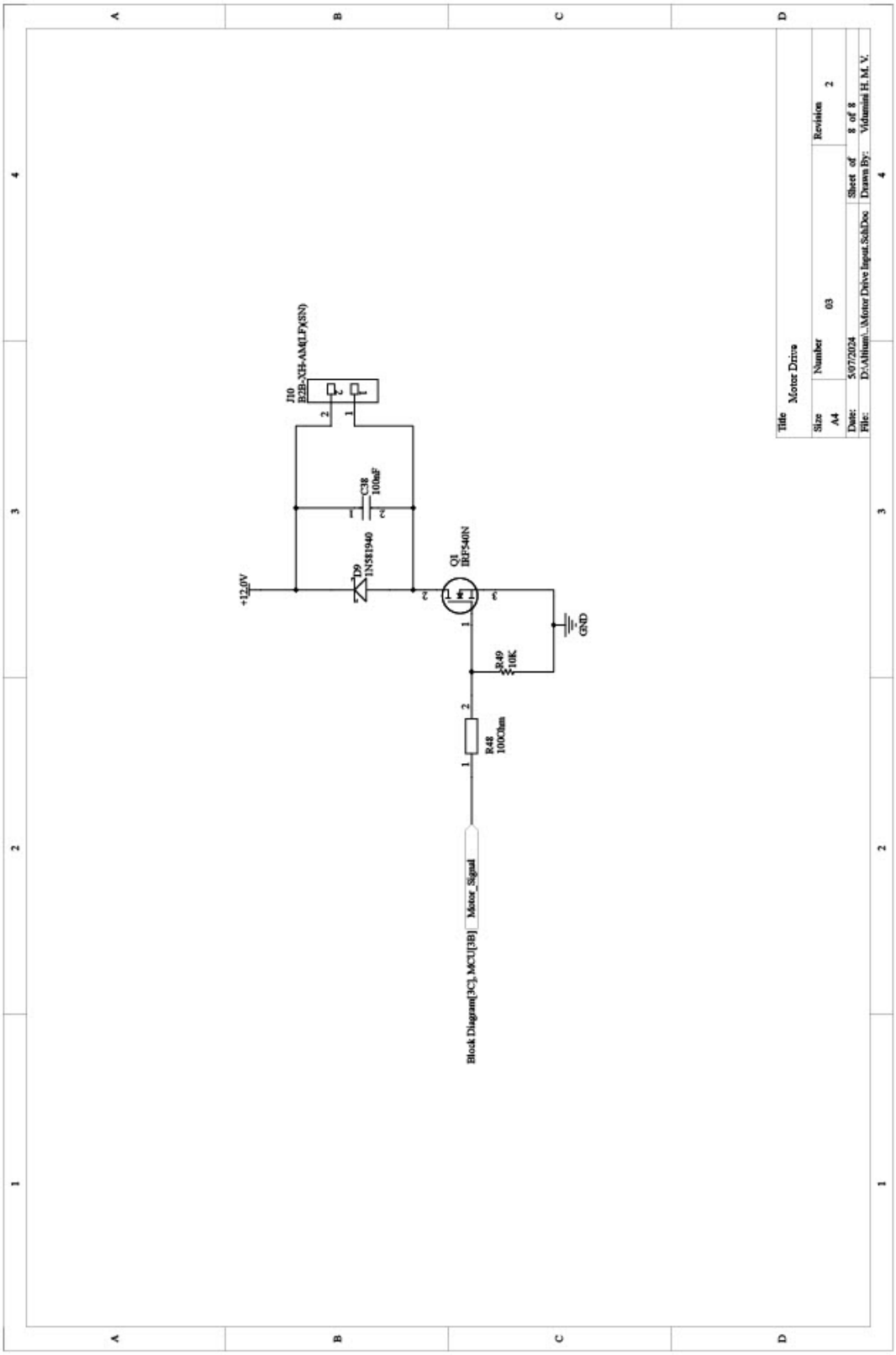


Figure 24: Schematic - Page 8

2.2 Layout of the PCB

2.2.1 3D Views

The 3D views provides a three-dimensional visualization of the bottom side of the PCB with all its components. This view allows for a thorough inspection of the bottom side, checking the placement and orientation of components, and ensuring proper clearance and fit. Like the top view, it is also valuable for confirming the design and for presentations. These are crucial for visualizing the final product before manufacturing, helping to identify any potential issues in component placement or board design.

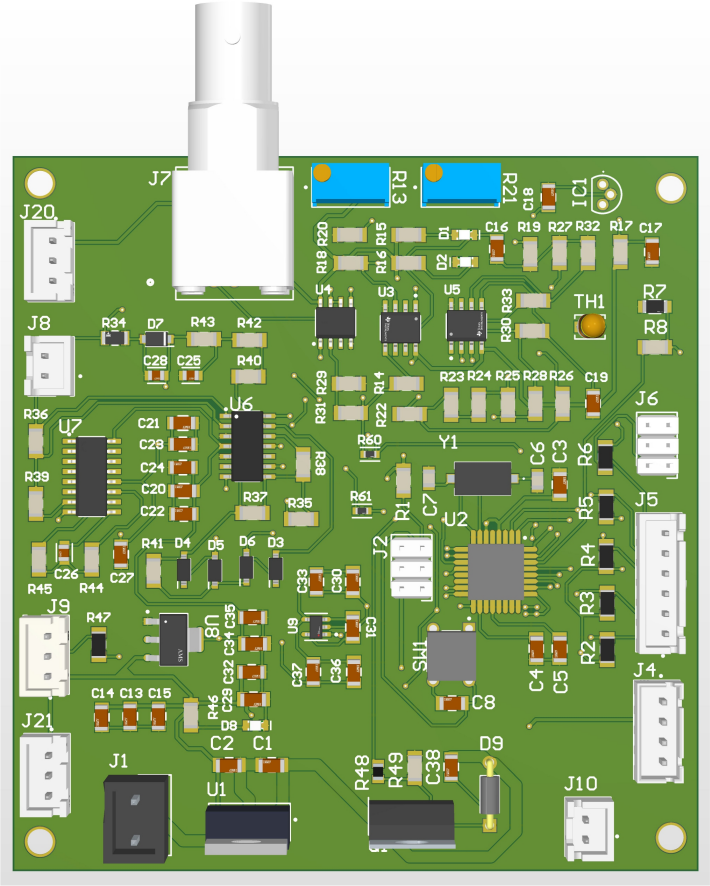


Figure 25: 3D view - Top Layer

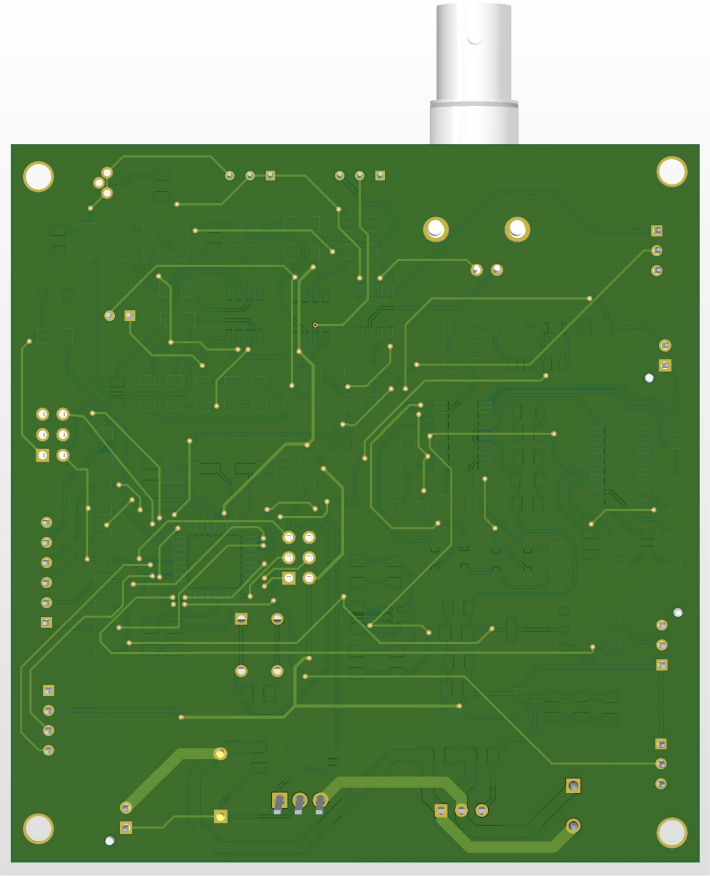


Figure 26: 3D view - Bottom Layer

2.2.2 Top Layer

The top layer of the PCB contains the copper traces and pads on the top side of the board. It shows the electrical connections between the components placed on the top side of the PCB.

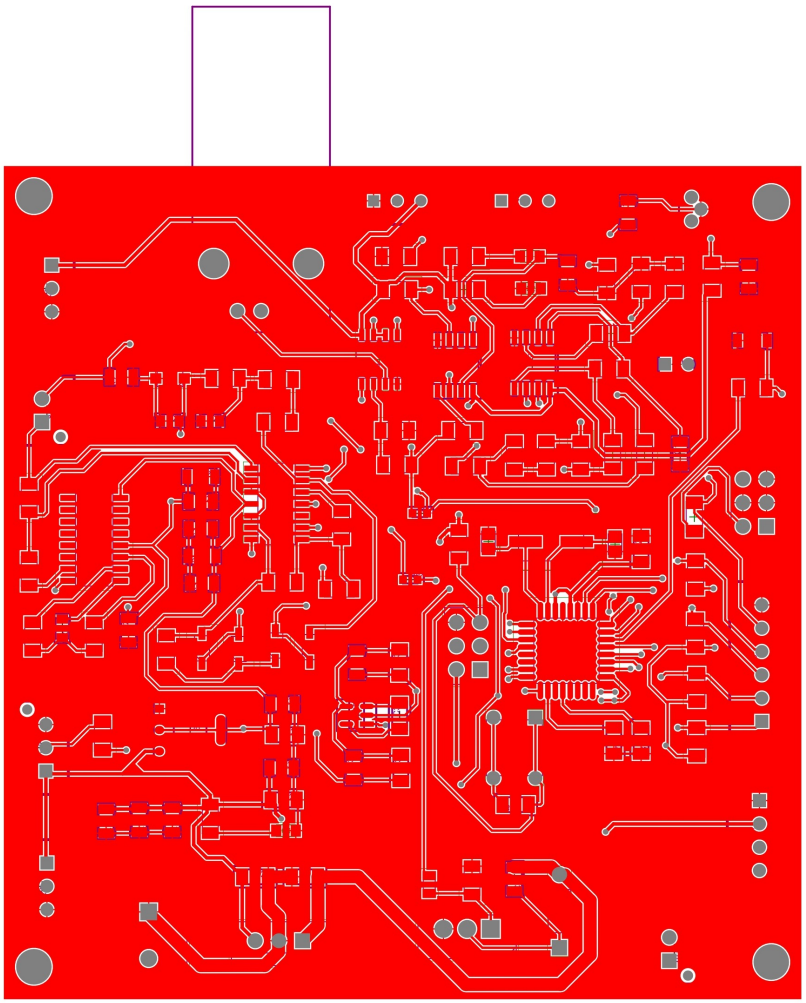


Figure 27: Top-Layer

2.2.3 Bottom Layer

The bottom layer of the PCB contains the copper traces and pads on the bottom side of the board. It shows the electrical connections between the components placed on the bottom side of the PCB.

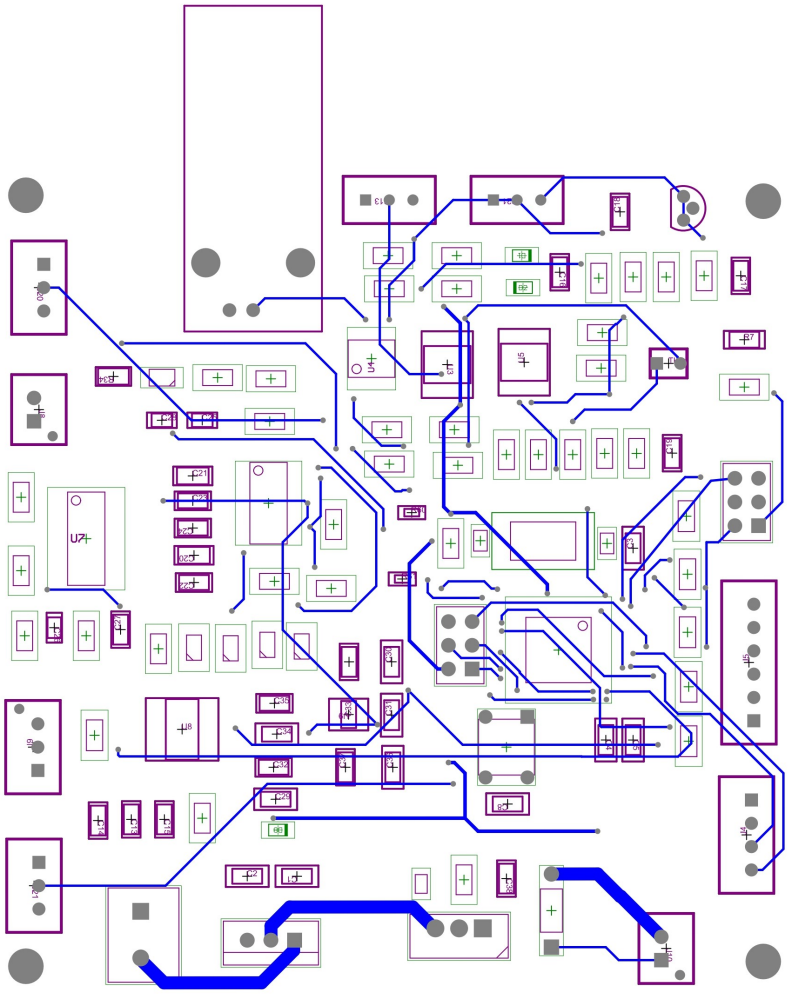


Figure 28: Bottom Layer

2.3 Photographs of PCB

2.3.1 Photographs of the unsoldered PCB

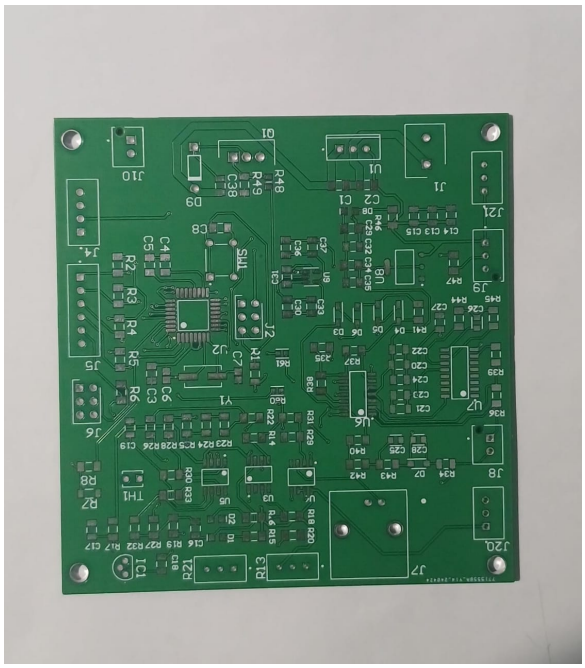


Figure 29: Unsoldered PCB - Top View

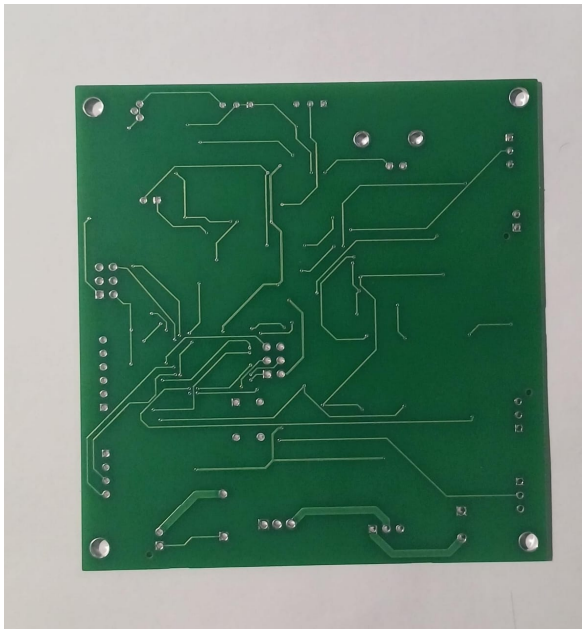


Figure 30: Unsoldered PCB - Bottom View

2.3.2 Photograph of Soldered PCB

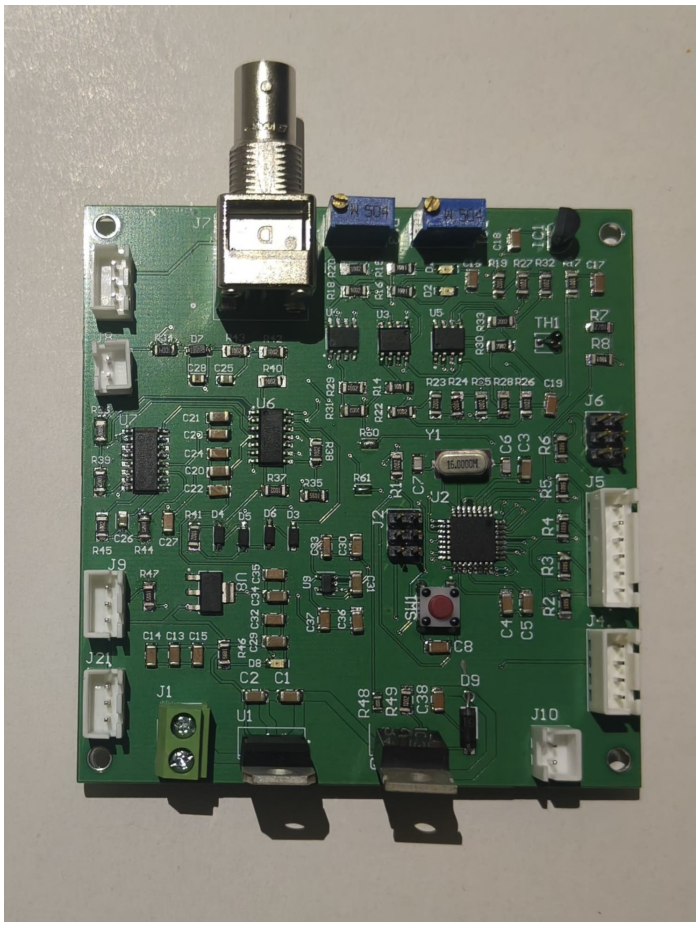


Figure 31: Bottom Layer

3 Solid works design

Our product consists of two primary enclosures designed to enhance the functionality and ease of use for aquarium enthusiasts.

1. User Interface Enclosure (Control Unit Housing)

The interface enclosure serves as the user's primary interaction point. It features:

- LCD display showing pH, TDS (Total Dissolved Solids), and temperature readings of the fish tank
- Built-in buzzer for alerting users of parameter warnings
- Intuitive pushbuttons for navigation, value input, and manual feeder control
- PCB (Printed Circuit Board) for seamless integration of all functionalities
- Secure attachment to the tank's rim using hooks connected to its lid

2. Feeder Enclosure

The feeder enclosure is specifically designed for dispensing fish feed at user-defined intervals. It features:

- User interface button on the control unit for manual operation
- Screw conveyor driven by a DC motor for precise feed dispensing
- Sturdy metal stand for stable attachment to the tank's rim

Conclusion

Our product combines comprehensive monitoring capabilities with efficient feeding mechanisms, making it an essential tool for aquarium management and ensuring the well-being of aquatic life.

3.1 Interface Enclosure (Control Unit Housing enclosure)

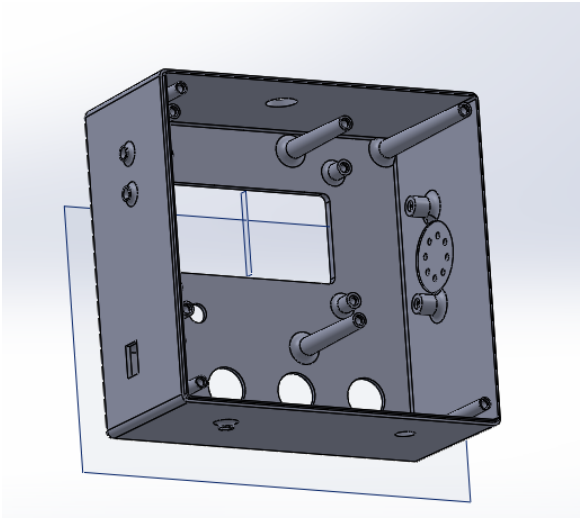


Figure 32: Interface enclosure

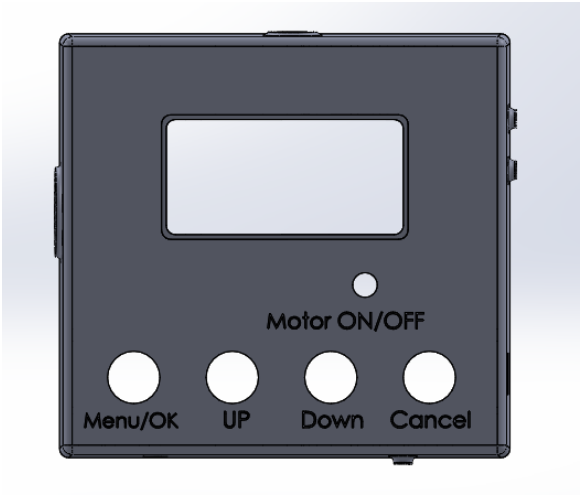


Figure 33: Interface enclosure (front)

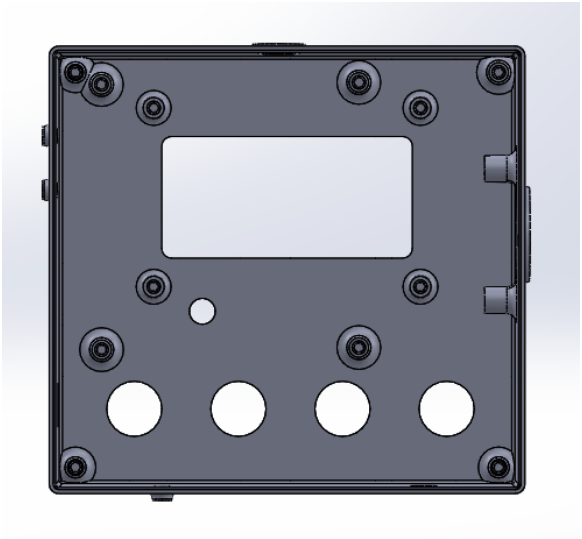
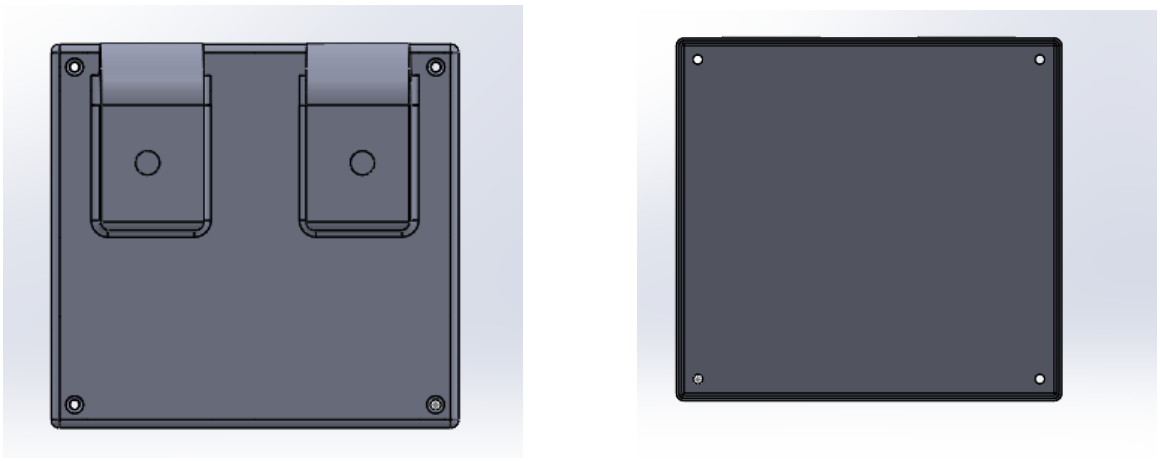


Figure 34: Interface enclosure (back)

3.1.1 User Interface Enclosure (Control Unit Housing enclosure) lid



(a) Interface Enclosure lid back

(b) Interface Enclosure lid interior

Figure 35: Images of the Two Enclosures

3.1.2 Assembly

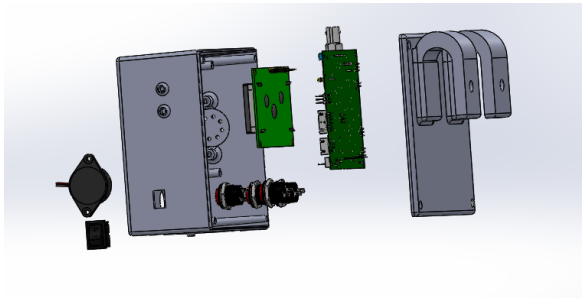


Figure 36: Interface enclosure (Assembled)

3.2 Feeder

3.2.1 Screw conveyor

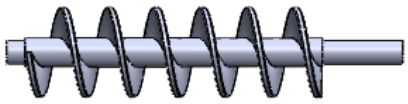


Figure 37: Screw conveyor)

3.2.2 Main body that houses the screw conveyor and the DC motor

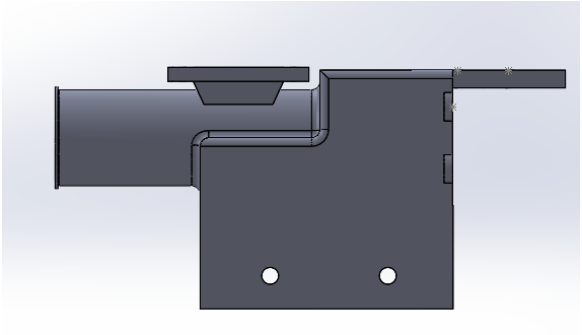


Figure 38: Main body that houses the screw conveyor and the DC motor)

The lid of the main body

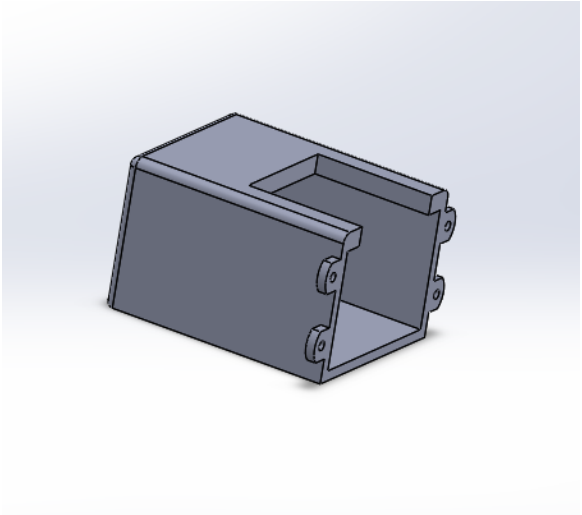


Figure 39: Main body lid

3.2.3 Feed reservoir

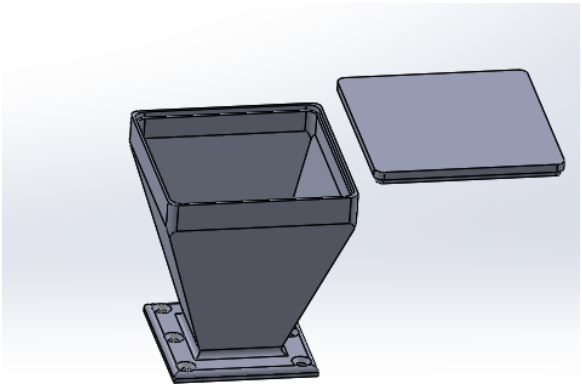
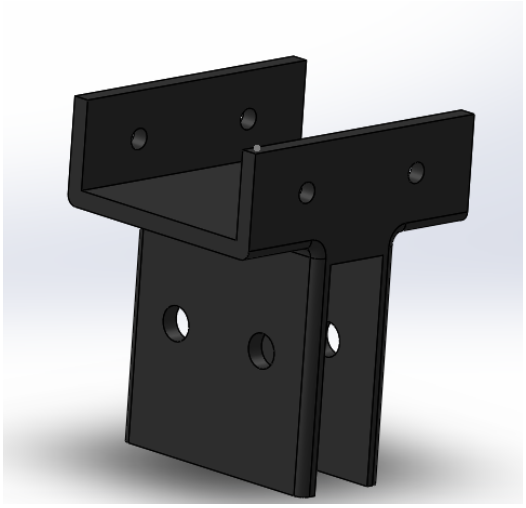
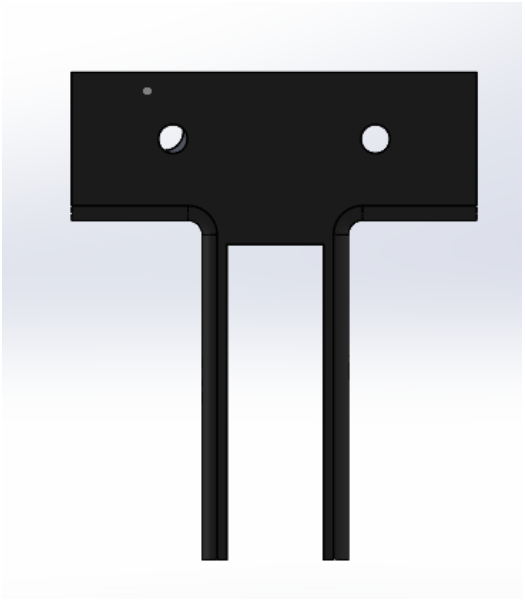


Figure 40: Feed reservoir and lid

3.2.4 Stand



(a) Metal stand



(b) Metal stand

Figure 41: The stand which holds the device and fixes it to the rim of the fish tank

3.2.5 Assembly

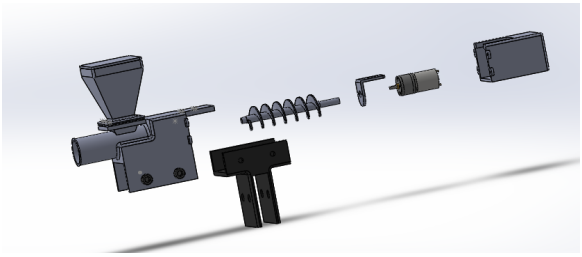


Figure 42: Feeder Assembly

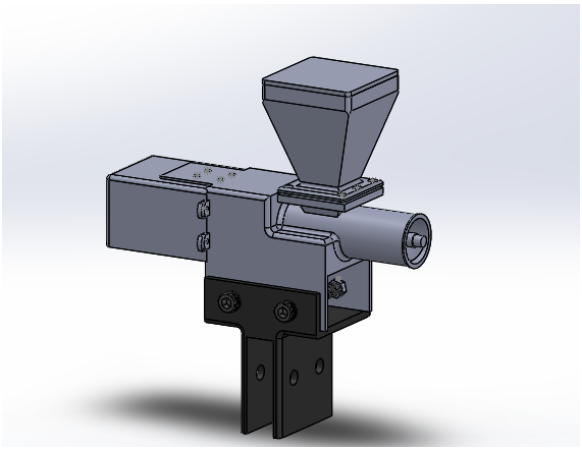


Figure 43: Feeder Assembly

4 References

1. **Concept design process: Overview / Cambridge University:**
   - https://www.inclusivedesigntoolkit.com/GS_overview/overview.html
2. **Quad link (a similar product to our device):**
   - https://www.quadlink-tech.com/en/a4-11108-14327/Aquadlink%C2%AESmart-Aquaculture-Application-System.html
3. **YSI 5200A (a similar product to our project):**
   - https://www.ysi.com/5200a
4. **Sri Lankan ornamental fish industry:**
   - https://www.srilankabusiness.com/aquarium-fish/ornamental-freshwater-fish.html

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