REAL TIME SYSTEM AND INTERNET OF THINGS FINAL PROJECT REPORT
DEPARTMENT OF ELECTRICAL ENGINEERING
UNIVERSITAS INDONESIA

AquaSenseHub

GROUP A9

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PREFACE

In the ever-evolving landscape of technology, the rise of the Internet of Things (IoT) has bestowed upon us the ability to reimagine the way we interact with our environment. As we introduce "AquaSenseHub" to the world, we embark on a journey to leverage IoT principles and redefine the relationship between humanity and water ecosystems.

Water, the essence of life, is a resource that demands careful monitoring and sustainable management. The AquaSenseHub project emerges as a response to this imperative, seeking to revolutionize the way we perceive, understand, and conserve water resources. By integrating cutting-edge IoT technologies, we aim to create a hub of intelligence capable of monitoring water quality, managing consumption, and contributing to the broader conversation on environmental stewardship.

This document serves as a guide through the conceptualization, development, and implementation phases of the AquaSenseHub project. From the initial spark of inspiration to the practical intricacies of sensor integration and data analytics, each section provides a glimpse into the collective efforts of a dedicated team passionate about the intersection of technology and environmental sustainability.

The name "AquaSenseHub" encapsulates the essence of our mission – to bring heightened awareness and intelligent solutions to water-related challenges. Through this project, we strive to empower individuals, communities, and organizations with the tools they need to make informed decisions about water usage, conservation, and overall environmental impact.

Depok, December 10, 2023

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CHAPTER 1

INTRODUCTION

1.1 PROBLEM STATEMENT

In traditional aquarium management, periodic checks and manual measurements often result in inconsistent oversight, potentially overlooking critical parameter fluctuations. To address this, AquaSenseHub introduces continuous, real-time monitoring through various sensors, ensuring the prompt detection and resolution of changes in temperature, pH levels, water clarity, and other crucial factors.

Fluctuations in aquarium conditions pose a significant risk to the health of its inhabitants, leading to stress, diseases, and other issues for the fish. AquaSenseHub actively mitigates this risk by monitoring and controlling parameters like temperature, pH levels, and water clarity. This proactive approach creates a stable environment conducive to the overall well-being of the aquarium's occupants.

Manual feeding practices can be inconsistent, impacting both fish health and water quality. AquaSenseHub tackles this challenge by incorporating an automatic feeding system, ensuring precise and timely feeding based on predefined schedules or triggered events. This feature promotes a consistent and controlled feeding regime, contributing significantly to the overall health of the aquarium and its inhabitants.

1.2 PROPOSED SOLUTION

The AquaSenseHub project utilizes a variety of sensors to monitor the aquarium's conditions and ensure the well-being of the fish. The DHT11 temperature sensor is employed to check the temperature, the pH sensor measures acidity levels, the water level sensor observes water height, and the Total Dissolved Solids (TDS) sensor assesses water clarity. The automatic feeding system involves actuators that can be controlled manually or automatically, connected to the ESP32. Smart notifications are sent via the MQTT protocol through WiFi when parameters deviate from normal limits. The entire connectivity utilizes WiFi to link the ESP32 with the Blynk application and transfer data through the MQTT protocol. Through this integration, AquaSenseHub provides accurate monitoring and responsive notifications, making aquarium maintenance and management easier.

1.3 ACCEPTANCE CRITERIA

The acceptance criteria of this project are as follows:

1. Able to Monitor Temperature, pH, Turbidity, and Water Level

   The system must accurately measure and provide real-time updates on the aquarium's temperature, pH levels, turbidity, and water level, ensuring a comprehensive understanding of the aquatic environment.

2. Show the Monitored Data to the Application

   The AquaSenseHub system should seamlessly integrate with a user-friendly application, allowing aquarium enthusiasts to remotely visualize and interpret the real-time data gathered from the aquarium sensors.

3. Connect with WiFi

   Stable and secure WiFi connectivity is essential for the AquaSenseHub system, enabling consistent communication and data transmission, as well as facilitating remote access and control from external devices.

4. Automatically Feeding the Aquarium

   Implementing an automated feeding mechanism using a servo motor, the AquaSenseHub system provides users with the flexibility to schedule and customize fish feeding intervals while allowing manual control through the application interface.

1.4 ROLES AND RESPONSIBILITIES

The roles and responsibilities assigned to the group members are as follows:

Roles	Responsibilities	Person
Project Leader	Lead the project	Abdul Fikih Kurnia

Staff	- Involved in the software development process - Testing the functionality of the sensors - Writing Report, User guide and Readme.md	Eriqo Arief Wicaksono
Staff	Help the project leader	Leonardo Jeremy P. M.
Staff	Help the project leader	Bintang Marsyuma Rakhasunu

Table 1. Roles and Responsibilities

1.5 TIMELINE AND MILESTONES

			PHASE ONE										PHASE TWO									
			WEEK 1					WEEK 2					WEEK 3					WEEK 4				
TASK TITLE	START DATE	DUE DATE	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F
Hardware Design completion	27/11/2023	10/12/2023	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Software Development	27/11/2023	10/12/2023	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Integration and Testing of Hardware and Software	27/11/2023	10/12/2023	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Final Product Assembly and Testing	27/11/2023	10/12/2023	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

CHAPTER 2

IMPLEMENTATION

2.1 HARDWARE DESIGN AND SCHEMATIC

Fig 2.1.1. Hardware Design.

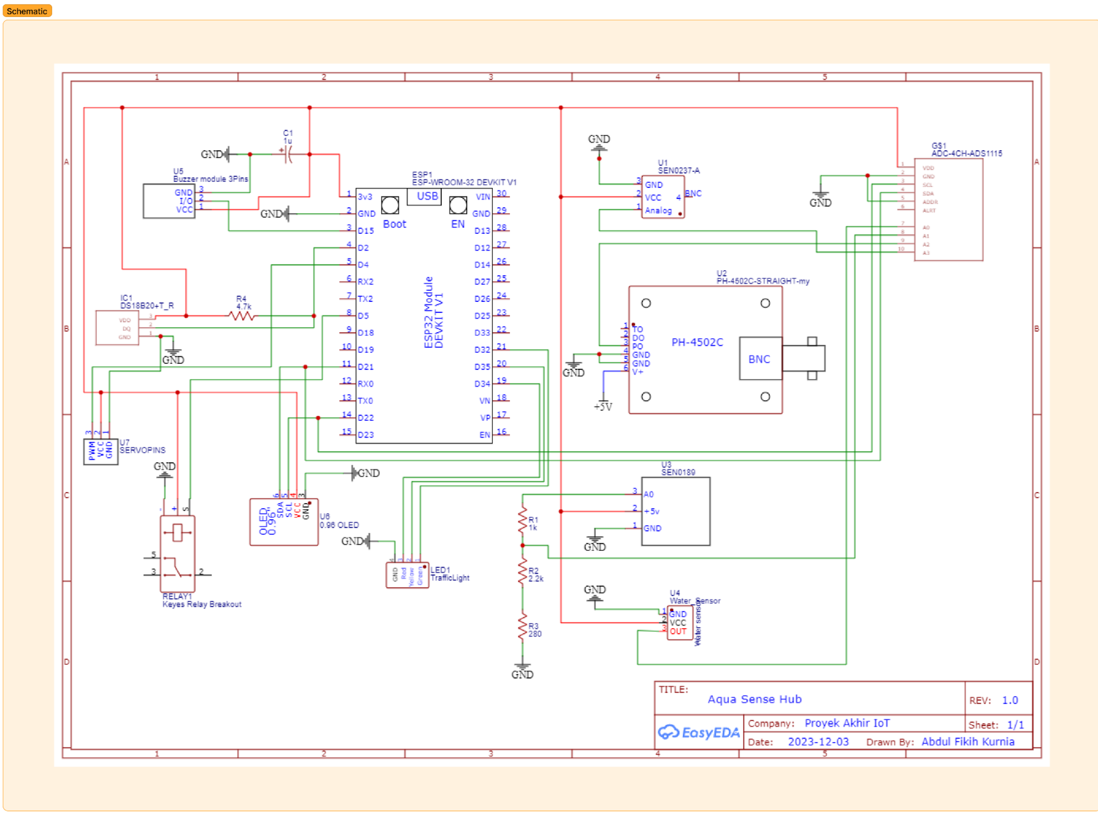

Fig 2.1.2. Hardware Schematic.

2.2 SOFTWARE DEVELOPMENT

The AquaSenseHub code intricately orchestrates an aquarium monitoring and control system through the implementation of an ESP32 microcontroller. Its architecture is a testament to a comprehensive integration of diverse hardware components, including sensors, an OLED display, Blynk for remote control functionalities, and a servo motor for automating the fish feeding process. The code's structure is thoughtfully organized into distinct tasks, meticulously coordinated by the FreeRTOS multitasking library, ensuring concurrent execution of operations.

The pivotal role of Blynk in this system cannot be overstated. The initiation of the Blynk connection through Blynk.begin(auth, ssid, password) establishes a seamless communication channel with the Blynk server, leveraging a specific authentication token and Wi-Fi credentials. The BLYNK_WRITE(V4) function, functioning as a Blynk callback, actively listens for user input on Virtual Pin 4. Upon detecting the designated input, it promptly triggers the activateServo() function, thereby facilitating users to exert manual control over the servo's actions through the Blynk application.

The AquaSenseHub further integrates a multitude of sensors to meticulously monitor the aquarium environment. Tasks such as taskWaterTemp, taskWaterLevel, taskTurbidity, and taskPhSensor orchestrate the collection of data from sensors including the Dallas Temperature sensor (sensors), water level sensor (WaterLevelPin), turbidity sensor (TurbiditySensorPin), and pH sensor (PhSensorPin). Executing independently as FreeRTOS tasks, they ensure the efficient parallel processing of data, guaranteeing real-time insights into the aquarium's vital statistics.

The taskOled function takes on the responsibility of managing the OLED display, presenting users with dynamic and real-time information concerning the aquarium's prevailing conditions. Employing a modular paradigm, this function adeptly negotiates access to shared resources – sensor data – via semaphores, creating a seamless flow of information that enriches the user's on-site monitoring experience. Servo control is executed with finesse through the ESP32 Servo library. The activateServo() function orchestrates the servo motor's precise movements, mimicking the automated feeding of fish within the aquarium. Adding a layer of user interactivity, the Blynk integration allows users to manually manipulate the servo's actions via the Blynk app. A sophisticated timer mechanism, actualized through FreeRTOS functions such as xTimerCreate and xTimerStart, culminates in the creation of servoTimer. This timer, when activated, triggers the servoTimerCallback function at consistent intervals, precisely every 5 seconds. Consequently, the servo motor is set into motion, delineating an automated and scheduled feeding regimen for the aquarium's inhabitants.

In essence, the AquaSenseHub code serves as an exemplary model of a sophisticated and modular approach to aquarium monitoring and control. By seamlessly integrating sensor data, Blynk for remote accessibility, an OLED display for on-site insights, servo control for automating fish feeding, and a meticulously crafted timer mechanism for scheduled tasks, the AquaSenseHub stands as a powerful, versatile, and extensible solution. It encapsulates the pinnacle of software development for aquarium enthusiasts, offering an advanced and automated system that redefines the paradigms of aquarium management.

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2.3 HARDWARE AND SOFTWARE INTEGRATION

In this chapter, we delve into the software development of AquaSenseHub, an advanced aquarium monitoring system utilizing the ESP32 microcontroller. The system is designed to comprehensively monitor crucial parameters within the aquarium environment, offering real-time data visualization and control through the Blynk platform.

AquaSenseHub adopts a multitasking approach facilitated by the FreeRTOS real-time operating system. Distinct tasks are meticulously crafted to manage diverse responsibilities, such as collecting sensor data, presenting information on an OLED screen, and orchestrating servo motor control. Semaphores play a pivotal role in ensuring the integrity of shared resources, preventing conflicts during concurrent access to critical sections of the code. The seamless integration of the Blynk IoT platform is a hallmark feature of AquaSenseHub, enabling aquarists to remotely monitor and control their aquariums. Leveraging the Blynk library, the ESP32 establishes a secure connection to the Blynk server via Wi-Fi. Virtual pins within the Blynk app are strategically assigned to receive and display data from the ESP32. Notably, a dedicated virtual pin is allocated to initiate actions involving the servo motor through the Blynk app.

Temperature monitoring is executed using a Dallas Temperature sensor, with readings regularly transmitted to Blynk for users to monitor temperature variations in their aquarium. Analog water level sensors gauge the water level, and the acquired data is relayed to Blynk, providing visual insights into water levels. Turbidity, indicative of water clarity, is tracked through an analog turbidity sensor, contributing to a comprehensive understanding of aquarium conditions. The pH level, crucial for aquatic health, is assessed using a pH sensor, with real-time data seamlessly sent to Blynk for remote monitoring. Local monitoring is facilitated by an OLED screen displaying real-time data, offering aquarists on-site insights into their aquarium. Additionally, the servo motor integration enables specific control actions. Triggered by signals from Blynk, users can remotely initiate actions such as feeding the fish or managing water circulation. Importantly, the servo motor is equipped with a timer mechanism, ensuring timely and automated fish feeding. However, users retain the flexibility to manually control the feeding process through Blynk, providing a seamless blend of automation and user control.

To ensure precise execution of tasks and scheduled actions, a timer mechanism is implemented using FreeRTOS, orchestrating regular activations of the servo motor for feeder fish. This feature enhances automation within the aquarium, contributing to a streamlined and efficient management system. In summary, AquaSenseHub, the ESP32-based Aquarium Monitoring System, boasts a robust software architecture blending sensor integration, multitasking capabilities, and seamless communication with the Blynk IoT platform. This advanced system not only offers real-time monitoring but also empowers users with remote control, elevating the aquarium management experience. The adoption of FreeRTOS and Blynk establishes AquaSenseHub as a scalable, connected solution for modern aquarium enthusiasts seeking a sophisticated and user-friendly monitoring system. The addition of a servo motor for automated fish feeding, controlled by both a timer and manual inputs through Blynk, further enhances the system's versatility and user engagement.

CHAPTER 3

TESTING AND EVALUATION

3.1 TESTING

In the testing phase of developing the smart aquarium system, we first establish connections to the four sensors: pH, water level, temperature, and turbidity, linking them to the ESP32 device. Through the Serial Monitor, we monitor the numerical readings from each sensor to ensure that the data received by the ESP32 is accurate and aligns with real environmental conditions.

This next testing phase delved into the WiFi connectivity and Blynk integration aspects of the smart aquarium system. The evaluation rigorously examined the establishment and stability of the WiFi connection, emphasizing key indicators such as connection status and signal strength. Simultaneously, the Blynk integration was scrutinized, assessing the device's seamless interaction with the Blynk platform for remote monitoring and control. Screenshots and visuals captured success indicators, including Blynk app interfaces and relevant logs, ensuring that the smart aquarium could reliably transmit sensor data and provide a user-friendly experience. The positive outcomes of this test signify a robust foundation for the system, enhancing its reliability and user accessibility as it moves forward in the development and refinement process.

```
21:36:52.163 -> Connecting...
21:36:52.163 -> Connected to WiFi
21:36:52.163 -> [16176] Connecting to abdul
21:36:52.662 -> [16693] Connected to WiFi
21:36:52.662 -> [16693] IP: 192.168.137.206
21:36:52.662 -> [16694]
21:36:52.662 ->     ___  __          __
21:36:52.662 ->    / _ )/ /_ _____  / /__
21:36:52.662 ->   / _  / / // / _ \/  '_/
21:36:52.662 ->  /____/_/\_, /_//_/_/\_\
21:36:52.707 ->         /___/ v1.3.2 on ESP32
21:36:52.707 ->
21:36:52.707 ->  #StandWithUkraine    https://bit.ly/swua
21:36:52.707 ->
21:36:52.707 ->
21:36:52.707 -> [16704] Connecting to blynk.cloud:80
21:36:53.204 -> [17215] Ready (ping: 42ms).
21:36:54.924 -> Timer created successfully
```

Fig 3.1.1. WiFi and Blynk Test.

```
21:37:04.968 -> Temp:          29.00
21:37:04.968 -> Water Level:   17
21:37:04.968 -> Turbidity:     1168.00
21:37:04.968 -> pH Level:      6.30
```

Fig 3.1.2. Sensors Reading Test.

After confirming the success of sensor connections and readings, the next step in the testing process is to evaluate the OLED module used. The OLED module serves as the user interface by displaying sensor readings in a more intuitive and user-friendly manner. This testing involves verifying the display of sensor data on the OLED screen, ensuring data completeness, and assessing ease of use for end users.

By involving the OLED module in the initial testing phase, we can ensure that the information presented to end users is accessible and easily understood. This is a crucial step in ensuring the functionality and usability of the developing smart aquarium system. This testing process serves as the foundation for the initial evaluation before moving on to further testing phases for the entire system as a whole.

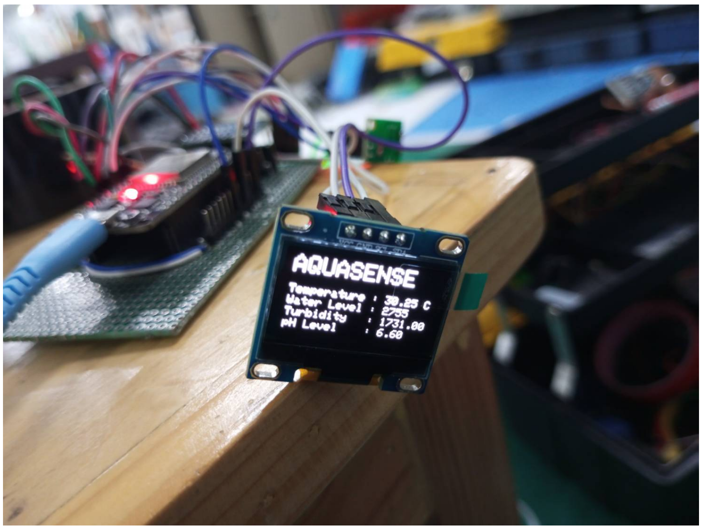

Fig 3.1.3. OLED Module Testing.

3.2 RESULT

In Fig 3.1.3, the successful integration and functionality of the OLED module within the smart aquarium system are shown. The OLED display shines brightly, presenting a clear and organized layout that showcases the real-time readings from all four sensors—pH, water level, temperature, and turbidity. Each parameter is neatly arranged on the screen, providing a comprehensive overview of the aquarium's current conditions. The OLED module successfully translates complex sensor data into an easily understandable format, ensuring a user-friendly experience. The number displayed on the screen validates the accurate reception and processing of data by the ESP32, affirming that the smart aquarium system is working correctly.

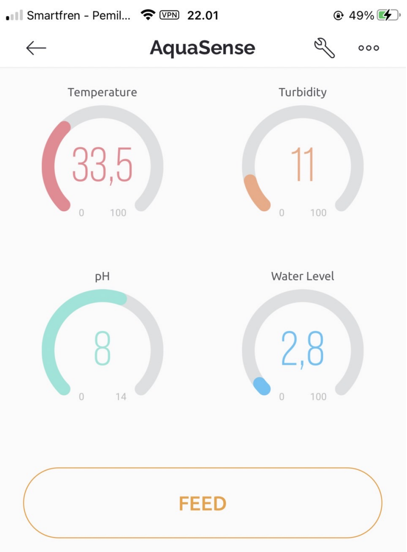

Fig 3.2.1. Blynk Mobile UI.

Blynk user interface for the smart aquarium system is prominently featured, offering a comprehensive view of the real-time data from all four sensors. The graphical representation on the Blynk app provides an intuitive display, allowing users to monitor the aquarium conditions at a glance. Each sensor reading is visibly presented on the interface, offering a clear insight into the aquatic environment.

Additionally, a notable feature on the Blynk app is a strategically placed button designed to activate a servo mechanism forcefully. This button serves the purpose of initiating the fish feeding process, and its inclusion in the interface highlights the interactive and user-controlled nature of the smart aquarium system. The servo's ability to dispense fish food is a practical and hands-on aspect of the system's functionality, emphasizing the integration of automation with user engagement.

Fig 3.2.2. Final Assembly.

In the physical assembly, when we put everything together for the smart aquarium, we make sure all the wires are neat and not all over the place, and we stick the pieces inside the fish tank setup securely. The finished thing is a mix of the tech stuff and the way it looks – it's all set up to help keep an eye on your fish tank in a smart way.

With all components in place, the ESP32 microcontroller serves as the central hub, orchestrating communication between all of the sensors. Each sensor is carefully connected to the ESP32, ensuring seamless data acquisition and processing. The OLED module, acting as the user interface, is integrated to display real-time readings in an easily understandable format. This graphical representation enhances user interaction, providing a visual snapshot of the aquarium's vital parameters. Users can effortlessly monitor and interpret the data, fostering a user-friendly experience.

3.3 EVALUATION

After the successful assembly of the smart aquarium device, the evaluation phase is crucial in gauging its overall performance, reliability, and user-friendliness. This section outlines the key criteria used to assess the effectiveness of the system, considering both technical functionality and user experience.

The evaluation begins with a focus on the accuracy and responsiveness of the sensors integrated into the smart aquarium. The pH sensor's precision is assessed by comparing its readings against calibrated measurements, ensuring that it provides reliable data for maintaining optimal water conditions. Similarly, the water level sensor undergoes testing to confirm its responsiveness to changes in water levels, critical for accurate monitoring.

The user interface, comprising the OLED module and the Blynk app, is a key component influencing user satisfaction. Feedback from users interacting with the system is collected to evaluate the clarity and intuitiveness of the displayed information. The goal is to ensure that users can easily comprehend the real-time sensor readings and efficiently navigate the interface.

The robustness of the hardware and software integration is scrutinized during prolonged use. The system is subjected to varying environmental conditions to identify any potential issues or vulnerabilities. This evaluation aims to ensure that the smart aquarium device maintains consistent functionality over time, providing a reliable solution for continuous monitoring.

CHAPTER 4

CONCLUSION

In conclusion, the AquaSenseHub project represents a sophisticated and integrated solution for aquarium monitoring and control. By leveraging the capabilities of the ESP32 microcontroller and a variety of sensors, the system adeptly captures crucial data points such as temperature, pH levels, turbidity, and water level, offering aquarium enthusiasts a comprehensive overview of their aquatic environment. The seamless integration with the Blynk platform enhances user experience by providing remote access and control through a user-friendly application. The modular design of the code, organized into different FreeRTOS tasks, ensures efficient parallel execution and scalability. The inclusion of an OLED display further enriches the on-site monitoring experience by presenting real-time information. A notable feature of the AquaSenseHub is the incorporation of a servo motor for automated fish feeding. The system allows users to schedule feeding intervals and provides manual control through the Blynk app, offering a customizable and convenient solution for maintaining optimal conditions within the aquarium. The implementation of a timer mechanism, facilitated by FreeRTOS functions, ensures timely and regular activation of the servo motor, providing a reliable automated feeding process.

The project's acceptance criteria, including the ability to monitor critical parameters, display data in the application, establish WiFi connectivity, and automate aquarium feeding, are effectively met. The AquaSenseHub demonstrates a comprehensive and extensible solution for aquarium enthusiasts, embodying a harmonious blend of sensor technology, remote accessibility, and automation. This project serves as a testament to the potential of integrating hardware and software components for creating advanced and user-friendly systems in the realm of aquarium monitoring and control.

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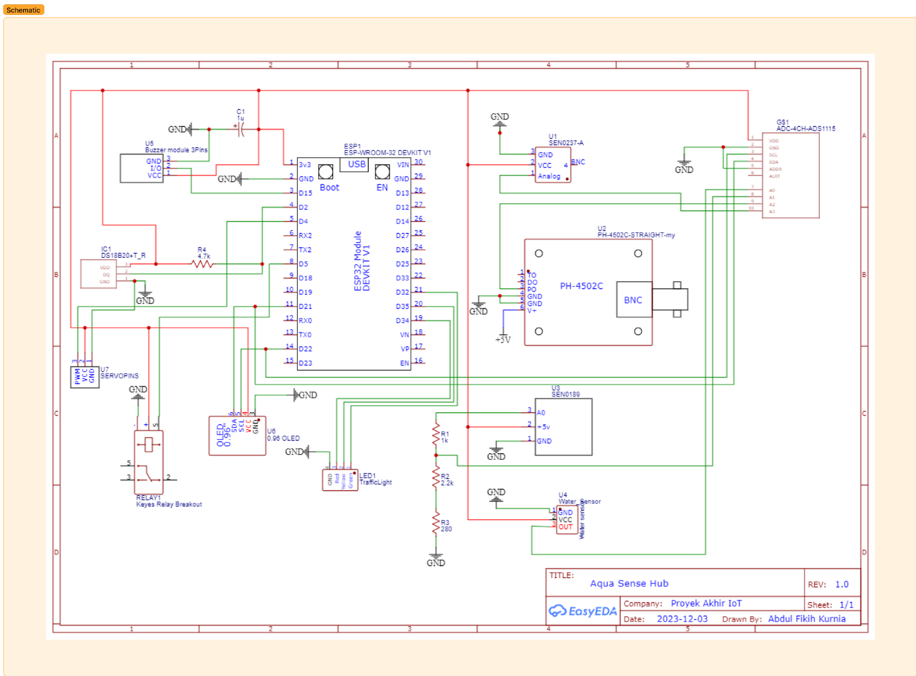
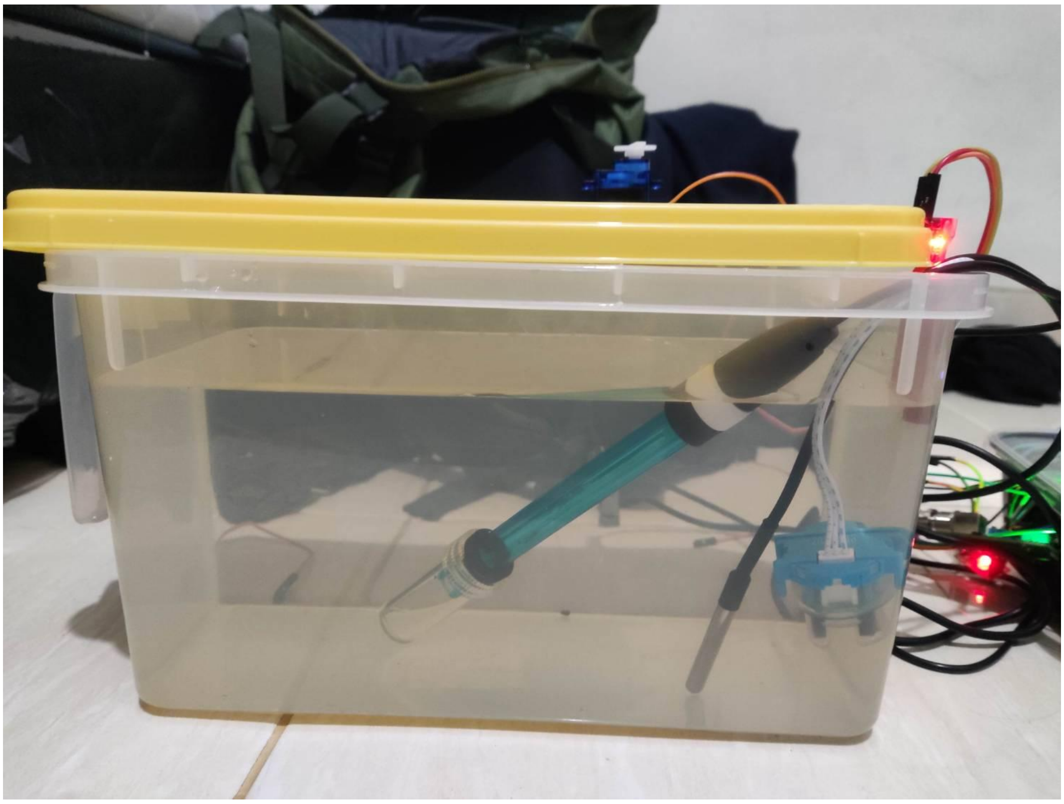
APPENDICES

Appendix A: Project Schematic



Appendix B: Documentation

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