Smart Water Tank Level Monitoring and Alert System in Labuan

by

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my on except as specified in the references and acknowledgements, and that the originalwork contained herein have not been undertaken or done by unspecified sources or persons.

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ABSTRACT

This project seeks to tackle the urgent problem of frequent water disruptions in Labuan by creating an Internet of Things (IoT) water level monitoring and alarm system specifically designed for residential water tanks. The persistent obstacles encountered by inhabitants, particularly in remote regions, require a novel strategy. The project is in line with Sustainable Development Goals (SDGs) 6 (Clean Water and Sanitation), 9 (Industry, Innovation, and Infrastructure), and 11 (Sustainable Cities and Communities). The scope of the project includes the villages of Labuan, with a specific focus on enhancing the stability of the water supply. A complete process entails utilising a survey form consisting of 15 questions to collect user insights. The development process adheres to a cyclical approach, integrating research and ongoing improvement. The survey serves as a guiding framework for the research methodology, while the development methodology advances from initial requirements to the creation of a prototype. Throughout this process, user feedback is included to make incremental improvements. The expected results encompass better precision in monitoring, prompt notifications through the mobile application which is Blynk application, and enhanced management of water resource for the user since they are able to get the insights of the data. The suggested system is in line with the requirements of Labuan, hence enhancing the resilience and efficiency of the water delivery infrastructure.

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1.0 INTRODUCTION

1.1 Background of Study

Unpolluted and safe water is not any simple accessory, it is rather an elementary right that serves as the basis of the people's health protection and general wellbeing. Sadly, Malaysia is no exception because water shortage as well as water pollution are rampant worldwide. Unique to Labuan is the problems faced in the Malaysia region's water supply infrastructure. The problems include unpredictable supply breaks frequently, serious shortages especially in the remote areas, and big delays in informing affected customers about the interruptions. While the health risks are obvious, other consequences include financial hardships and social problems that can affect the entire community.

There has been an increased desire to tap on IoT technology to develop sustainable water management solutions due to the increasing needs associated with water consumption. Water monitoring devices based on the Internet of Things technology are very progressive as they provide immediate data about water level, quality, and trends. The above-mentioned technologies have proven effective in mitigating water related issues through proper water management practices and unnecessary waste reduction. Also, IoT-based technologies could be important in informing people promptly of water interruptions that are yet to occur. It is used as a preventative measure to minimize the adverse outcomes of these occurrences.

To this end, IoT water level monitoring and alarm system that is designed purposely to accommodate Labuan in Malaysia should be developed and implemented. Therefore, a proposed system shall be designed to strategically install water levels sensor in village water tanks and link the network for real-time communication. Upon analysis, it promptly gives alerts about water levels that fall below pre-established criteria. The initiative aims at empowering villagers and focuses on being localized and user friendly.

1.2 Problem Statement

In June 2023, over 60,000 residents in Labuan experienced a water disruption due to damage to the Pulau Enoe main pump. The disruption affected more than 20 villages and residential areas and lasted for several days. In May 2023, hot weather and power outages exacerbated the impact of unscheduled water disruptions on the island. Residents faced difficulties in accessing clean water for essential needs, and businesses were forced to close, leading to economic losses.

Labuan, a region in Malaysia, grapples with persistent challenges in its water supply system, particularly evident in the rural areas where households predominantly rely on individual water tanks. This reliance introduces a series of issues, with the most pressing being the unpredictability of water availability. Residents of these areas frequently encounter sudden and unanticipated water shortages, leading to not only inconvenience but also a fundamental inability to plan for effective water storage. The resulting shortages contribute to disruptions in daily routines and economic activities, exacerbating the challenges faced by the residents and hindering their overall quality of life.

On top of this problem, the current water supply system's sluggish response time adds to the issue of effectively communicating disruptions. The lack of real-time information means that residents only become aware of the water shortage when it directly impacts them. This delay in communication not only leads to further frustration but also leaves residents without an efficient means to plan and prepare for water shortages effectively. Consequently, this inadequacy in the communication system significantly hampers the residents’ ability to adapt to and mitigate the impact of water disruptions in their daily lives.

In summary, the primary problems facing Labuan’s water supply system revolve around the unreliable nature of water availability, especially in the rural areas reliant on water tanks. This unreliability not only disrupts the daily lives of residents but also underscores the critical need for timely information and alerts regarding water shortages. The summaries of problem statement in points as below:

- Frequent Water Supply Issues in Labuan
- Sudden Water Shortages in Rural Area
- Delayed Communication of Water Disruption

1.3 Objectives

The main objective of this project is to create an economical Internet of Things (IoT) system specifically intended for monitoring water levels in domestic water tanks. The primary objective is to create a system that guarantees precise identification of water levels, facilitating prompt alarms and messages to users. The system's objective is to improve users' capacity to efficiently oversee and control water resources, hence promoting sustainable water utilisation practises.

Once the core purpose is achieved, further attributes will be considered to enhance the system's performance. Furthermore, endeavours will be focused on enhancing the precision of the system in identifying imminent water scarcities, while reducing the frequency of erroneous alerts.

The specific objectives for this project are as follows:

1. To design a IoT-Based Water Level Monitoring System:

Create an all-encompassing system architecture and design that is specifically tailored for household water tanks. This entails the careful selection of suitable sensors and communication modules, while also prioritising power efficiency at every stage of the design process.

2. To implement Real-Time Data Collection and Processing:

Ensure that the system can accurately acquire real-time data from household water tanks during the implementation phase. This includes the integration of sensors, establishment of communication protocols, and implementation of algorithms for data processing.

3. To enable Immediate Alerts and Notifications:

Create a notification system component for the project that is specifically designed to give timely notifications to inhabitants. This entails developing a user-friendly interface to facilitate comprehension and facilitate smooth interaction between the system and people.

The aims of this project are to develop an effective and dependable water level monitoring and alarm system using IoT technology. This system will help enhance water resource management and increase user awareness.

1.4 Scope of Study

The primary purpose of this project is to create an affordable Internet of Things (IoT) water level monitoring and warning system that is especially tailored for household water tanks. The central element of the system is the ESP-32, chosen for its adaptability and cost-effectiveness. The device utilizes ultrasonic sensors for instantaneous monitoring of water levels in the water tank. Then, a Water Flow Sensor detects the water flow into the water tank. Additional crucial elements include jumper wires, LED lights, a 12C LCD Display, water pump and buzzer, DC power supply, Dc female jack for exhibiting the present water level.

The initiative primarily targets residential areas in Labuan with a specific focus on the water disruption that can affect their daily life routine. The technology operates by continuously monitoring water levels, and users will promptly receive messages on their smartphones when the water level drops or increase to a certain level such as Full, High, Average, Low and Empty.

The objective of this project is to design an IoT- based water level monitoring and alert system by providing users with precise and timely information regarding their household water levels. This concept stands out from previous monitoring systems by selecting IoT components and emphasizing residential areas. It specifically caters to the demands of families in efficiently managing water resources whenever they know the capacity of the water level in the water tanks and if there is any water flow into the water tanks.

2.0 LITERATURE REVIEW

2.1 Technology Approached

2.1.1 Implementation of IoT

The incorporation of Internet of Things (IoT) technology has led to substantial breakthroughs in water level monitoring and alarm systems. The application of IoT in water management has emerged as a central focus for both researchers and practitioners, providing cutting-edge technologies for the gathering and transmission of real-time data.

The primary aim of this study was to create a "faucet add-on device" that tracks water consumption and delivers up-to-date information via audio-visual alerts (Dutta & Dontiboyina, 2016). The implemented system incorporates an LCD display in conjunction with switches to promote user engagement. In recent years, there has been a noticeable surge in the interest of researchers towards the implementation of Internet of Things (IoT) systems. This heightened interest is primarily attributed to the capability of these systems to enable sensors to collectively gather data and provide various services autonomously, eliminating the need for direct human involvement (Al-Fuqaha et al., 2015).

In contrast, Azid et al. (2015) employed a pressure sensor for consistent monitoring of water levels, identifying any deviations from user-set thresholds. When water levels surpass the predetermined threshold, a text message alert is promptly dispatched to homeowners, offering timely warnings to facilitate immediate action (Azid et al.,2015). Their proposed system utilizes an ultrasonic sensor for gauging water levels.

Johari et al. (2011) were pioneers in introducing Internet of Things (IoT) technology to water level monitoring systems. They presented a system for monitoring tank water levels, utilizing a Global System for Mobile Communications (GSM) network. This system facilitated remote monitoring and reporting of water-related applications through SMS alerts, laying the groundwork for the integration of IoT technology (Johari et al., 2011).

Zhou and Jiang (2020) developed a sophisticated water tank monitoring system incorporating IoT concepts. Their system not only provided real-time data visualization but also allowed for remote-control capabilities, showcasing the potential of IoT in enhancing water resource monitoring and management (Zhou and Jiang, 2020). Advancing the field further, Kulkarni et al. (2020) implemented an intelligent water level monitoring system utilizing the Internet of Things (IoT). Their solution integrated machine learning algorithms to analyze water use trends, yielding valuable insights for effective resource management (Kulkarni et al., 2020).

The proposed project aligns with the advancements in IoT-based water monitoring systems, with a specific focus on monitoring home water tanks. The system aims to deliver real-time data on water levels to individual residences by leveraging IoT components such as ultrasonic sensors, Wi-Fi modules, and microcontrollers. This customized approach is vital for empowering users with timely information, enabling them to effectively manage water resources.

To summarize, the utilization of IoT in water level monitoring systems has seen substantial advancements. This study adds to this progression by offering a specific system for residential water tanks that integrates IoT components to enable accurate and efficient data collecting.

2.1.2 Blynk as a platform for alert and monitoring

The system utilized in this study offers distinct advantages over these two systems, as it enables prompt, direct, and rapid notification delivery to users, in fact, it is the fastest method available. Notifications are received by users via a dedicated application called the Blynk Application, which is installed on each user's smartphone. Employing the latest Internet of Things (IoT) technology, this system demonstrates remarkable wireless information transmission capabilities (Hasbullah et al., 2020).

Blynk is a modern platform that allows users to develop interfaces primarily on iOS and Android devices, facilitating tracking and monitoring of desired applications (Parihar, 2019). If the communication network connection is not detected, the process begins anew, starting with inspecting sensor placement until the communication network connection issue is resolved. Subsequently, the collected data undergo analysis and are utilized for data visualization to provide updates on air quality conditions. Finally, the information results are transmitted via Wi-Fi for thorough monitoring by end-users.

2.1.4 Water Tank Level Monitoring using mobile Application.

Rajeshwari et al. (2019) presented a real-time water tank monitoring and control system utilizing a Raspberry Pi and an Android app. This system employs ultrasonic sensors to measure water levels and transmits the data to the Android app, enabling users to monitor water levels in real time. Additionally, the system provides notifications when water levels reach predetermined thresholds, alerting users to potential water scarcity or excessive consumption.

Besides that, Islam et al. (2021) proposed a water tank level monitoring and control system using an Arduino microcontroller and an Android app. This system utilizes ultrasonic sensors to measure water levels and an Arduino board to control a water pump. The Android app provides a user-friendly interface for monitoring water levels, receiving notifications, and controlling the water pump remotely, ensuring efficient water management.

Furthermore, Singh et al. (2022) introduced an IoT-based smart water tank monitoring and control system using an ESP32 microcontroller and an Android app. This system leverages ultrasonic sensors to measure water levels and an ESP32 board to connect to the internet, facilitating the transmission of data to the Android app. The app provides real-time water level data, notifications, and remote control of the water pump, promoting informed water usage decisions.

Not only that, Kumar et al. (2023) presented the design and implementation of a water level monitoring and control system using a NodeMCU microcontroller and an Android app. This system employs ultrasonic sensors to measure water levels and a NodeMCU board to connect to the internet, enabling the transfer of data to the Android app. The app provides real-time water level data, notifications, and remote control of the water pump, empowering users to effectively manage water usage.

Lastly, Patel et al. (2023) described the development of a water tank monitoring and control system using an ESP8266 microcontroller and an Android app. This system utilizes ultrasonic sensors to measure water levels and an ESP8266 board to connect to the internet, facilitating the transmission of data to the Android app. The app provides real-time water level data, notifications, and remote control of the water pump, enabling users to proactively manage water consumption.

2.2 Benefit of Water Level Monitoring System

2.2.1 Efficient Water Management

Water level monitoring systems play a crucial role in ensuring efficient water management by providing real-time data on water consumption and availability (Johari et al., 2011; K et al., 2018; Hidayat et al., 2019). This real-time information empowers water management authorities and individuals to make informed decisions regarding water usage and conservation strategies. By continuously monitoring water levels, potential issues such as water scarcity or excessive consumption can be identified promptly, allowing for timely interventions to prevent water shortages and wastage.

The availability of real-time water level data enables water managers to implement water conservation measures proactively. For instance, if water levels in reservoirs or tanks are observed to be declining at a faster rate than anticipated, water managers can initiate measures such as demand-side management strategies to reduce overall water consumption (Johari et al., 2011). These strategies may include public awareness campaigns promoting water conservation practices, implementing water restriction measures, or adopting water-efficient technologies (K et al., 2018).

Additionally, real-time water level monitoring systems can help identify areas of potential leakage or overuse within water distribution networks (Hidayat et al., 2019). By analyzing water consumption patterns and identifying anomalies, water authorities can pinpoint locations where water losses may be occurring due to leaks or inefficient usage practices. This enables targeted maintenance efforts to address these issues and prevent further water wastage.

2.2 Reduced Water Wastage

Monitoring water levels is an essential aspect of conserving our precious water resources. By employing advanced technologies such as water level monitoring systems, valuable insights can be gained into consumption patterns and potential areas of water waste or excessive usage (Johari et al., 2011; K et al., 2018; Hidayat et al., 2019). These systems facilitate continuous monitoring, enabling the detection of any irregularities in water usage, which can then be investigated to determine their root causes. This proactive approach is crucial in preventing undetected water losses and ultimately contributing to the conservation of water resources.

In addition to detecting potential leaks, water level monitoring systems also play a critical role in identifying areas where water is being used excessively or inefficiently (Johari et al., 2011). By closely examining water consumption patterns, water managers can pinpoint specific sectors or locations where high-water usage is occurring (K et al., 2018). Armed with this knowledge, targeted solutions can be implemented, such as promoting water-efficient practices or upgrading water infrastructure, to address wastefulness in these identified areas (Hidayat et al., 2019).

The installation of water level monitoring systems is a cornerstone of effective water management and minimizing water wastage. With their ability to provide up-to-date information, these systems enable early detection of water scarcity and assist in identifying areas where water may be lost. Their vital role in preserving this invaluable resource for future generations cannot be overstated.

2.3 Hand Phone Survey

2.3.1 Smartphone ownership

According to the Malaysian Communications and Multimedia Commission (MCMC) (2021), the percentage of smartphone ownership can be seen drastically increased from 76.4% to 91.5% compared to the HPUS 2018, where its growth obviously by 15.1%. Therefore, there is a huge number that is increasing from year to year due to the advancement of the technology that requires variety of ages that access to the smartphones.

2.3.2 Smartphone that accesses the internet.

The statistics illustrate that there were growing trend in smartphone Internet usage in Malaysia. Since 2012, there has been a obvious increase 30.5% of the percentage of smartphone users that were accessing the Internet through their devices with an annual growth rate of 6.3% (Malaysian Communications and Multimedia Commission, 2021). According to the HPUS 2021, a major 99.3% of smartphone users fully utilized their phones for online activities in 2021 were compared to the IUS 2020, which reported only 98.7% of Internet users using smartphones to access the Internet.

3.0 METHODOLOGY

3.1 Chapter Introduction

In this chapter it will discuss the methodology employed to conduct the research and develop the Smart Water Tank Level Monitoring and Alert System in Labuan. This chapter will be divided into two sections which are Research Method and Prototype Method. The research method section outlines the process of conducting a survey to gather numerical data on the user perspective and preference regarding the water supply disruptions. It also discussed the survey questionnaire's design and pilot testing. On the other hand, the Prototype Method explains the development process where it uses the prototype model process methodology. Plus, it also describes the hardware and software requirements, prototype design, user evaluation and testing and the installation process. From the installation process, it also gives insights into the components that are installed in the prototype such as ESP-32, Ultrasonic sensor HC-SR04, LED lights, Buzzer, 12C LCD Display, Water Flow Sensor Detector, Blynk and Arduino IDE. Lastly, flowcharts, schematic diagram, Gantt charts for FYP 1 and FYP 2 are also included in this chapter.

3.2 Research Method

For this research method, I have conducted a survey by using Google Form for the respondents to fill up. The survey was conducted during Phase 2 during my FYP 1. The study aims to collect numerical data through a structured survey questionnaire to comprehensively analyze user perceptions and preferences related to water supply disruptions. The target population includes residents of Labuan, specifically those residing in areas prone to water supply disruptions.

The structured survey questionnaire comprises fifteen questions designed to capture essential variables such as the frequency of water supply disruptions, user satisfaction with current communication methods, awareness of water shortages, and interest in adopting an IoT-based system for water monitoring. The questionnaire includes scale items, providing respondents with options ranging from frequency levels to satisfaction levels.

Prior to the main survey, a pilot test will be conducted to refine the questionnaire based on feedback and improve its clarity and relevance. Ethical considerations will be prioritized, ensuring participants receive detailed information about the study and provide informed consent. Anonymity and voluntary participation will be maintained throughout the research process**.** The questionnaire in the survey of the data as below:

1. How frequently have you experienced water supply disruptions in Labuan in the past year?
2. Do you live in a rural or urban area of Labuan?
3. Have you faced unexpected water shortages that disrupted your daily routines?
4. How satisfied are you with the current communication of water disruptions in Labuan?
5. Are you aware of water shortages before they occur in your area?
6. Have you ever received timely notifications about water availability during shortages?
7. Are you interested in using an IoT-based system (Internet of Things) for real-time water level monitoring and immediate alerts?
8. Do you think adaptive thresholding for alerts, tailored to your household's needs, would be beneficial?
9. Would you like the ability to remotely monitor and control your household water tank using such a system?
10. How important do you believe enhanced water resource management is for Labuan's water supply stability?
11. Do you believe that an IoT-based water monitoring system could help you conserve water more effectively?
12. Have you ever experienced loss or damage to property due to unexpected water supply disruptions?
13. How well do you understand how IoT (Internet of Things) technology works for water level monitoring and immediate alerts?
14. What is your opinion on the importance of online water monitoring for improving the quality of life in Labuan?
15. Do you think an IoT-based water monitoring system could help Labuan reduce water supply disruptions and maintain a more stable supply?

3.3 Prototype Method

In a project centered around the development of a functional prototype utilizing Internet of Things (IoT), the prototyping model emerges as the most fitting approach for the System Development Life Cycle (SDLC) methodology. Diverging from the linear progression and predefined stages of development observed in the waterfall SDLC methodology, the prototyping model embraces a dynamic trial-and-error approach. This iterative method continues until the final software or system aligns precisely with the specified requirements. This model establishes a robust foundation for the prototype, subjecting it to testing and successive refinement, particularly well-suited for projects demanding continual incorporation of new insights and updates throughout the development journey.

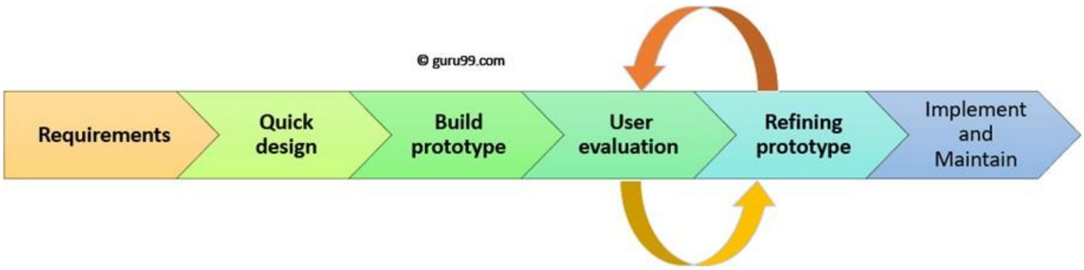


Figure 1: Prototype model process.

3.3.1 Requirements

The project's primary objective is to design and implement a Smart Water Tank Level Monitoring and Alert System, leveraging Internet of Things (IoT) technology. The system aims to provide real-time monitoring of water levels in household tanks and deliver immediate alerts to users when levels fall below a certain threshold. The project encompasses two key phases which are the hardware configuration and software development, aligning with the principles of IoT.

Hardware requirements

1. ESP-32
2. Ultrasonic Sensor – HC-SR04 (Generic)
3. Breadboard (Generic)
4. 5mm LED: Green
5. 5mm LED: Orange
6. 5mm LED: Red
7. Buzzer
8. Male to Female Jumper Wires
9. Male to Male Jumper Wires
10. Female to Female Jumper Wires
11. 9V Battery
12. USB-A to B cable
13. YF-S201 Water Flow Sensor Detector
14. LCD 1602 Yellow (12C)
15. 5V DC Power Supply
16. 5V Water Pump
17. DC Female

Software requirements

1. Arduino Integrated Development Environment (IDE)
2. Blynk Application

3.3.2 Prototype Design

In the initial phase of hardware development, the Smart Water Tank Level Monitoring and Alert System incorporates essential components such as the Arduino UNO microcontroller, Bolt IoT Wi-Fi Module (ESP8266), Ultrasonic Sensor HC-SR04, Adafruit RGB Backlight LCD 16x2, LED lights, and jumper wires. The Arduino UNO serves as the central processing unit, enabling control over various outputs, while the Bolt IoT Wi-Fi Module facilitates internet connectivity for real-time monitoring. The Ultrasonic Sensor accurately measures water levels, and visual indicators, represented by three LED colors, convey different water levels, enhancing user awareness. The Adafruit RGB Backlight LCD provides a clear interface for real-time information. This carefully curated hardware configuration forms the foundation for subsequent phases of integration and calibration, ensuring the system's effective operation. The initial of the schematic diagram during the initial phase of hardware development during Final Year Project 1 (FYP 1) as below:

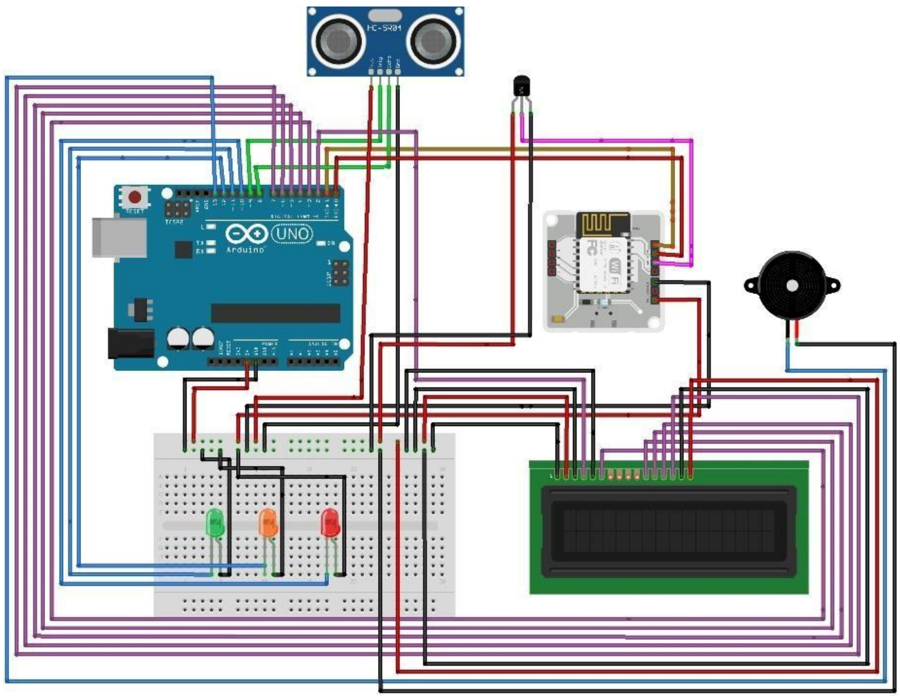


Figure 2: Schematic diagram of proposed methodology.

3.3.3 User evaluation and testing

To help with the visualizing the idea of the proposed smart water tank level monitoring and alert system, a model of a small water tank will be connected to the prototype model which will be used to present the water tank situations. The aim of this evaluation is to determine and test whether the system can function properly to determine which water level correctly instead inaccurate and false alarm. The other challenge of this implementation is whether the system can send out the notification to user mobile device due to absence of the internet connection or poor internet connectivity.

Other than that, to test out the flow and the effectiveness of the Smart Water Tank Level Monitoring and Alert System, the system will be tested according to the prototype model. The water sensor which is the (Ultrasonic Sensor – HC-SR04 (Generic) will detect the water level whether it's increasing or decreasing in the water tank. The data will be processed, and it will be sent out to the Blynk App to alert the user via mobile notifications. The LED lights and buzzer will be switched on based to the 5 levels of water level which are Empty, Low, Average, High and Full.

3.3.4 Installation

3.3.4.1 ESP-32

For novice individuals embarking on microcontroller projects, we will be employing the ESP32, which is one of the leading microprocessor boards available in the industry. The ESP32, created by Espressif Systems, is well regarded for its adaptability and strong performance, making it an exceptional option for educational and industrial uses. Due to its comprehensive documentation and broad adoption in the last 10 years, the ESP32 provides a dependable framework for acquiring real-time data from sensors and sending it to mobile devices.

The ESP32, being an IoT-enabled device, allows for effortless data interchange with other devices over networks, enabling the generation of data logs, visualization graphs, event triggers, and automation procedures. Therefore, there is no requirement for supplementary components like the Bolt Wi-Fi or NodeMCU ESP8266, as the ESP32 is capable of independently managing data transfer with high efficiency. The ESP32 is equipped with a robust ESP32 processor, a wide range of input/output pins, built-in USB connectivity, analogue input pins, an ICSP header, and a reset button. These features make the ESP32 well-suited for a variety of project needs.

The pinout of ESP-32 are as follows:

Pin Number	Pin Name	Function	Type	Description
1	EN	Enable	Power	Enable pin for the ESP32
2	VP	General-purpose I/O	Digital I/O	General-purpose I/O pin
3	VN	General-purpose I/O	Digital I/O	General-purpose I/O pin
4	GND	General-purpose I/O	Digital I/O	Ground
5	GPIO34	General-purpose I/O	Digital I/O	General-purpose I/O pin
6	D35	General-purpose I/O	Digital I/O	General-purpose I/O pin
7	D32	General-purpose I/O	Digital I/O	General-purpose I/O pin
8	D33	General-purpose I/O	Digital I/O	General-purpose I/O pin
9	D25	General-purpose I/O	Digital I/O	General-purpose I/O pin
10	D26	General-purpose I/O	Digital I/O	General-purpose I/O pin
11	D27	General-purpose I/O	Digital I/O	General-purpose I/O pin
12	D14	General-purpose I/O	Digital I/O	General-purpose I/O pin
13	D12	General-purpose I/O	Digital I/O	General-purpose I/O pin
14	D13	General-purpose I/O	Digital I/O	General-purpose I/O pin
15	GND	General-purpose I/O	Digital I/O	Ground
16	D23	General-purpose I/O	Digital I/O	General-purpose I/O pin
17	D22	General-purpose I/O	Digital I/O	General-purpose I/O pin
18	D21	General-purpose I/O	Digital I/O	General-purpose I/O pin
19	D19	General-purpose I/O	Digital I/O	General-purpose I/O pin
20	D18	General-purpose I/O	Digital I/O	General-purpose I/O pin

21	D5	General-purpose I/O	Digital I/O	General-purpose I/O pin
22	TX12	General-purpose I/O	Digital I/O	General-purpose I/O pin
23	RX2	General-purpose I/O	Digital I/O	General-purpose I/O pin
24	D4	General-purpose I/O	Digital I/O	General-purpose I/O pin
25	D0	General-purpose I/O	Digital I/O	General-purpose I/O pin (Bootstrapping and Reset)
26	D2	General-purpose I/O	Digital I/O	General-purpose I/O pin (Bootstrapping and Reset)
27	D15	General-purpose I/O	Digital I/O	General-purpose I/O pin (Bootstrapping and Reset)
28	RX0	General-purpose I/O	Digital I/O	General-purpose I/O pin (Bootstrapping and Reset)
29	TX0	General-purpose I/O	Digital I/O	General-purpose I/O pin (Bootstrapping and Reset)
30	3V3	3.3V Power Supply	Power	3.3V power supply
31	GND	Ground	Power	Ground
32	VIN	Input Voltage	Power	Input voltage (5V recommended)

Table 1: ESP-32 Pinouts

In order to commence working with the ESP32 board, it is important to establish a connection between it and the computer by utilizing a micro-USB cable. Verify if the cable is capable of data transfer, as certain cables are specifically designed for charging only. Subsequently, procure the suitable driver for the ESP32 in order to establish communication with the computer. After safely connecting the micro-USB cable, confirm the connection in the Device Manager to ensure that the computer recognizes it successfully.

Figure 3: ESP-32 inside packaging.

To validate the functionality of the ESP32, we can start by running a simple code example in the Arduino IDE, such as the blink function. Once the ESP32 is confirmed to be functioning correctly, we can proceed with prototype development, connecting it to various hardware components using jumper wires. By interfacing the ESP32 with ultrasonic and temperature sensors, LEDs, and a buzzer, we can conduct thorough testing to ensure seamless integration and functionality of the entire system.

3.3.4.2 Ultrasonic Sensor HC-SR04

The HC-SR04 Ultrasonic Sensor employs a pair of ultrasonic transducers to gauge distance. The device functions by generating ultrasonic waves into the surrounding environment and subsequently measuring the duration it takes for these waves to reflect. One of the transducers acts as a transmitter, transforming electrical signals into ultrasonic sound pulses with a frequency of 40KHz. The second transducer acts as a receiver, detecting the reflected pulses.

When the TRIGGER pin is activated, the transmitter releases eight sequences of ultrasonic pulses that endure for 10µs apiece. These pulses are specifically engineered to be discernible from surrounding ultrasonic waves. While these pulses travel through the air, the receiver, which is attached to the ECHO pin, remains in a state of readiness to detect any signals that bounce back. If a signal is not received within a duration of 38 milliseconds, the receiver pin will transition to a low state, indicating the lack of an object in the sensor's vicinity.

In contrast, when a signal is detected, the ECHO pin decreases in voltage, resulting in the generation of a pulse with a width that varies between 150µs and 25ms. The length of this pulse is directly proportional to the distance separating the sensor from the observed object. The distance can be determined by multiplying the speed of the signal by the time it takes to reflect, according to the formula: Distance = Speed x Time.

Figure 4: Ultrasonic HC-SR04 sensor pinouts.

PIN	FUNCTION
VCC	Connected to 5V5 pin of the ESP-32. Supplies power to ultrasonic sensor
Trig	Trigger pin will be set to HIGH for 10 and send ultrasonic sound pulses
Echo	HIGH when the ultrasonic pulses are transmitted until the sensor detects the reflected signal and then goes LOW. The time taken for the Echo pin during HIGH state will be used to calculate the distance
GND	Ground pin will be connected to GND pin of the ESP-32

Table 2: Ultrasonic HC-SR04 sensors pinout

The sensor can detect distances ranging from 2cm to 400cm, with a precision of 3mm. It will be connected to the ESP-32 using the following pin configuration:

- VCC pin connected to VIN pin of ESP-32
- Trig pin connected to pin 19
- Echo pin connected to pin 18
- GND pin of the sensor to GND pin of the ESP-32

For the ultrasonic sensor, The Echo pin connected to pin 19 while the Trig needed to be connected to pin 18. The GNG and VCC are connected to GNG 5V5 respectively. Then, the Ultrasonic sensor is installed to be tested by the code from the Arduino IDE if it's functioning properly. After that, the sensor is installed at the prototype model which at behind the water tank cover. The sensor will detect the water level whether it is increasing or decreasing.

Figure 5: Ultrasonic sensor HC-SR04 (front view)

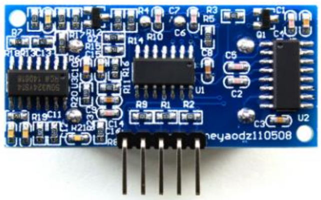


Figure 6: Ultrasonic sensor HC-SR04 (back view)

Figure 7: Ultrasonic sensor HC-SR04 placed under the water tank model cap.

Figure 8: Ultrasonic sensor HC-SR04 (view it its closed)

3.3.4.3 LED Light and Buzzer

To differentiate between the difference of the water level in the water tank such as Empty, Low, Average, High and Full, the prototype also consists of LED lights and buzzer that have been implemented as for the output alerts which will parallel based on the difference water level. The Empty level is when the water level has reached the closeness to the base of the water tank which ranging from 0% to 9%, Low level from 10% to 40%, Average level from 41% to 75%, High level from 76% to 90% and Full level from 91% to 100%. Not only that but the prototype also has 5 LED lights and 3 types of colour. The first colour is Green where it is uses for Full and High level, Orange is for Average level and Red is for Low and Empty level. There is a little bit different where for the Empty level, two Red LED bulb will be switched on different from Low where only one Red LED bulb will be switched on. For the High Level, it one Green LED light will be switched on whereas for the Full level, two bulbs of Green LED light will turn on.

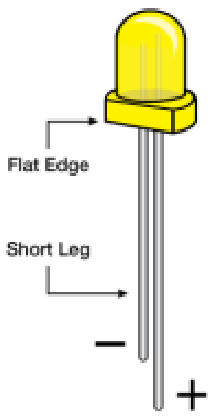


Figure 9: LED lights legs (positive and negative)

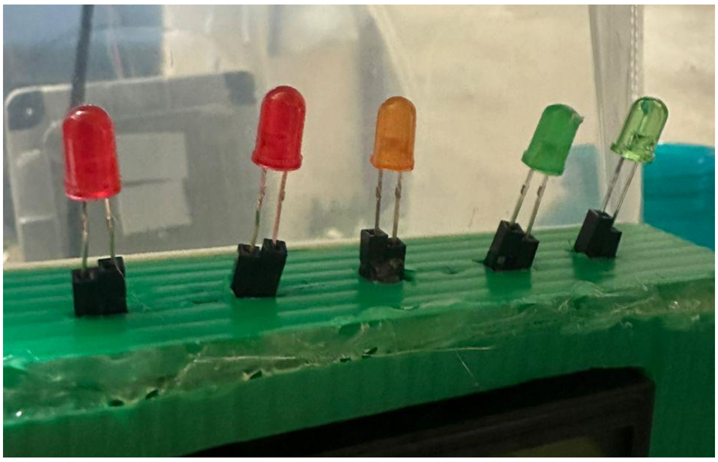


Figure 10: LED lights with 3 color on the prototype model

The LEDs (light-emitting diodes) consists of two legs, the positive and negative. Both the legs can be visually differentiated according to their length with the negative leg being shorter. The negative leg (-) of an LED will be connected to the GND pin of the ESP-32 while the positive leg will be connected to any of the GPIO pins of the board. The positive leg will serve as voltage source to the LEDs. For the prototype the negative legs of all the LEDs are connected to the GND pin while the Green LED positive leg (Full level) is connected to pin 4 on the board whereas for (High level) is connected to pin 5, Orange (Average level) connected to pin 12 and Red (Low Level) is connected to pin 13 and for the (Empty Level) is connected to pin 14. After successful wiring, the pin connected to the LEDs are defined further in the Ardunio IDE.

Figure 11: Piezo Buzzer

Known as Active Piezo buzzer, this small hardware runs on DC 3-24V power supply and produces continuous alarm sound to 87dB. The Buzzer has wires attached to the main body, the positive and negative. The positive wire will be connected to pin 8 on the ESP-32 and the negative wire will be connected to the GND pin. For the prototype, during Low and Empty level alert, the Buzzer produces sound longer so that the user or the household are able to identify when it comes to the red zone.

Figure 12: Piezo Buzzer on the prototype model.

3.3.4.4 12C LCD Display

Instead of using a conventional 16x2 LCD Display, one can choose to use an I2C LCD Display. An I2C LCD display necessitates only two I/O pins, which can be utilised in conjunction with other I2C devices. It does not belong to the set of 14 digital input/output pins. On the other hand, a standard LCD display requires a connection to seven out of the 14 digital pins that are accessible on an Arduino. This means that it uses up half of the available input pins. The I2C LCD Display consists of a display utilising HD44780 technology and an I2C adaptor located at the rear. These LCD variants are appropriate for displaying a maximum of 32 ASCII characters on a 16x2 display, spread over two rows. The character display consists of a 5x8 pixel grid, which creates small rectangles. The adapter utilises an 8-bit I/O expander chip, namely the PCF8574, to take data from the Arduino and transform the I2C data into a parallel display on the LCD.

Figure 13: 12C LCD Display

An 12C Display consist of four pins and each of the pinout act as below:

PIN	FUNCTION
VCC	Supplies power to the 12C LCD Display
GND	Ground pin
SDA	Data pin for 12C
SCL	Clock pin for 12C

Figure 14:12C LCD Display pinouts.

After successfully connecting the 12C Display to the ESP-32 board according to its perspective pins, the system is tested using the Arduino IDE software. The display of the LCD executes smoothly based on the different alert levels. The display output "Water Level Percentage: " will based on the value for each categories of water level which for the Empty is from 0%-9%, Low from 10% to 40%, Average from 41% to 75%, High from 76% to 90% and Full from 91% to 100%. For the second row in the LCD display is the water level status where it will display "Water Lvl:" and it will display the water level status based on the water level percentage.

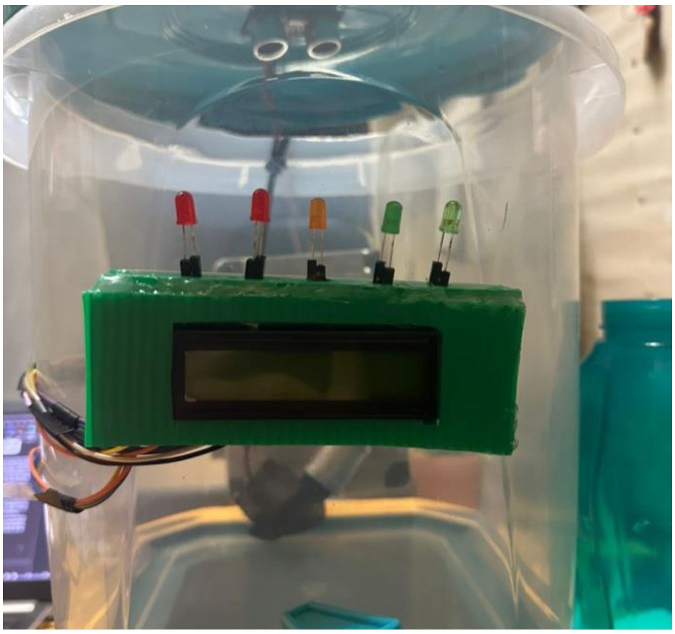


Figure 15: 12C LCD Display on the prototype model.

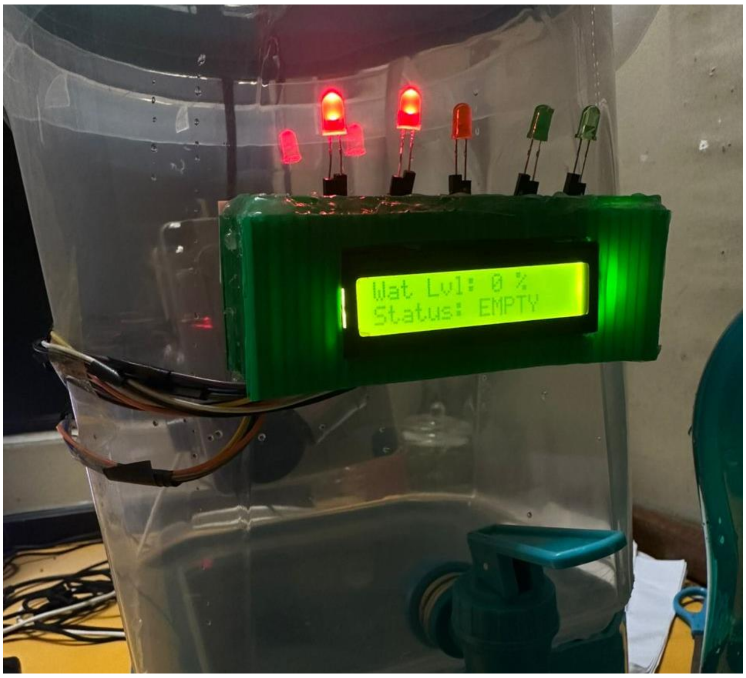


Figure 16: 12C LCD Display on the prototype model (switched on)

3.3.4.5 Water Pump and 5V DC Power Supply

Figure 17: 5V Water Pump

The 5V water pump is a small and effective device specifically engineered for the purpose of moving water in a wide range of uses. With a low voltage of 5 volts, this device is compatible with microcontroller platforms like as Arduino and Raspberry Pi. The 5V water pump is well-suited for applications that necessitate accurate water circulation due to its compact size and noiseless operation.

The 5V DC power supply is an apparatus that converts alternating current (AC) voltage from a wall socket into a consistent output of 5 volts direct current (DC). This power supply is commonly used to provide constant and reliable power to electronic devices and components that require a 5V DC input. A typical configuration comprises a transformer, rectifier, voltage regulator, and filtering components to ensure a reliable and uniform output voltage. The 5V DC power supply is widely employed in several applications, including the provision of power to microcontrollers, sensors, LEDs, and other electronic circuits operating at low voltages.

Figure 18:5V DC Power Supply

The 5V water pump wires which is the positive and negative wire will be connected directly to the DC Jack Female. Then the 5V DC Power Supply will be connected to the DC Jack Female as a power source. This will visualize as the automation of the water pump that connected to the household pipe that always automatically pump and refill the water tank whenever it hits minimum level.

Figure 19:5V DC power supply connected to power source

Figure 20:5V Water pump connected to 5V DC Power Supply

3.3.4.6 YF-S201 Water Flow Sensor Detector

The YF-S201 Water Flow Sensor Detector is a small and effective gadget utilised to quantify the rate at which water flows through a pipeline. This sensor normally comprises three pins for connection: VCC for power input, GND for ground connection, and OUT for signal output. Its design is straightforward yet efficient. When water passes through the sensor, it activates the internal mechanism, causing it to produce electrical pulses. The frequency of these pulses is directly correlated with the rate of water flow. This sensor is extensively used in diverse industries such as home automation, industrial operations, and environmental monitoring, where accurate measurement and control of water flow are crucial.

Figure 21: YF-S201 Water Flow Sensor Detector

PIN	FUNCTION
VCC	Provides power to the flow sensor. Typically requires a voltage of 5V DC
GND	Ground connection for the sensor. Completes the circuit and provides a reference voltage
OUT	Outputs a square wave signal proportional to the flow rate of the water passing through the sensor

Table 3: YF-S201 Water Flow Sensor Detector pinouts

For the Water Flow Sensor Detector, the out pin is connected to pin 26 at the ESP-32 board, while the VCC and GND are connected to the GND 5V5 respectively. Plus, this sensor will detect the water flow if there is water flowing into the sensor from the 5V water pump 1m pipe. It will read the water flow rate in millimeters (ml). The Water Flow Sensor Detector will be submerged into the water tank.

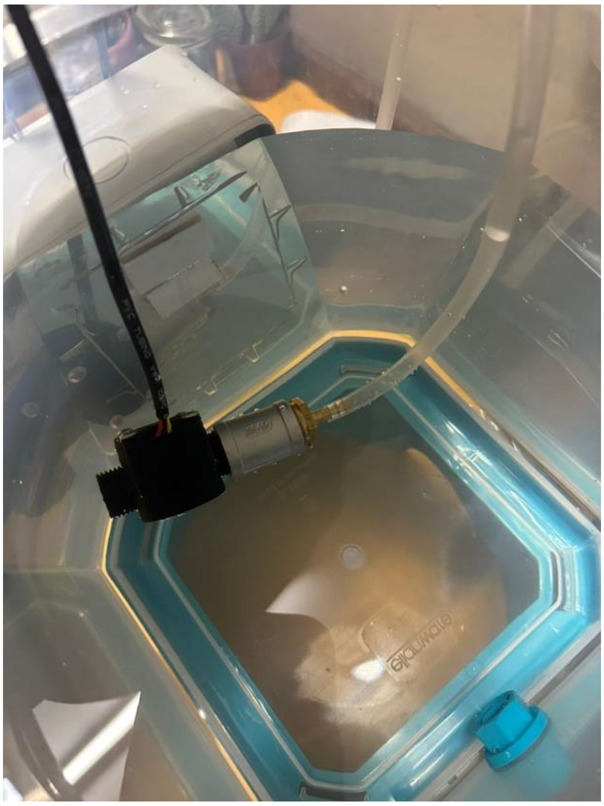


Figure 22: YF-S201 Water Flow Sensor Detector on prototype model.

3.3.4.7 Blynk

Blynk is a modern platform that enables users to create interfaces largely from iOS and Android devices. It allows them to track and monitor certain programmes. Blynk has been a popular choice among developers who want to incorporate IoT technologies into their projects due to its easy-to-use interface and flexible capabilities. Blynk's user-friendly interface and powerful capabilities allow users to effortlessly link their devices, retrieve live data, and manage a wide range of IoT-enabled devices remotely, positioning it as a crucial tool in the field of Internet of Things (IoT) development.

For the Blynk, we need to create dashboards whether in the website for laptop or desktop interface or Mobile display. For this project, there are several widgets that had been placed in the dashboard such as gauge widget, label widget, and chart widget. There are two-gauge widgets which are for the capacity of water level and for the water flow rate in the water tank. The label widgets are for another reading that display the output of both gauge widgets which are the additional display. Then, the chart graphs are for the reading for both variables which are the water level capacity and the water flow rate in the water tank. It will display the line chart where the changing for the water level and the water flow rate. Therefore, the user are able to view the live data of the system.

Not only that, but Blynk also can implement the trigger by an event where it sends the notifications to the user where it alerts the user of the current water level, water tank refilling and detected water flow.

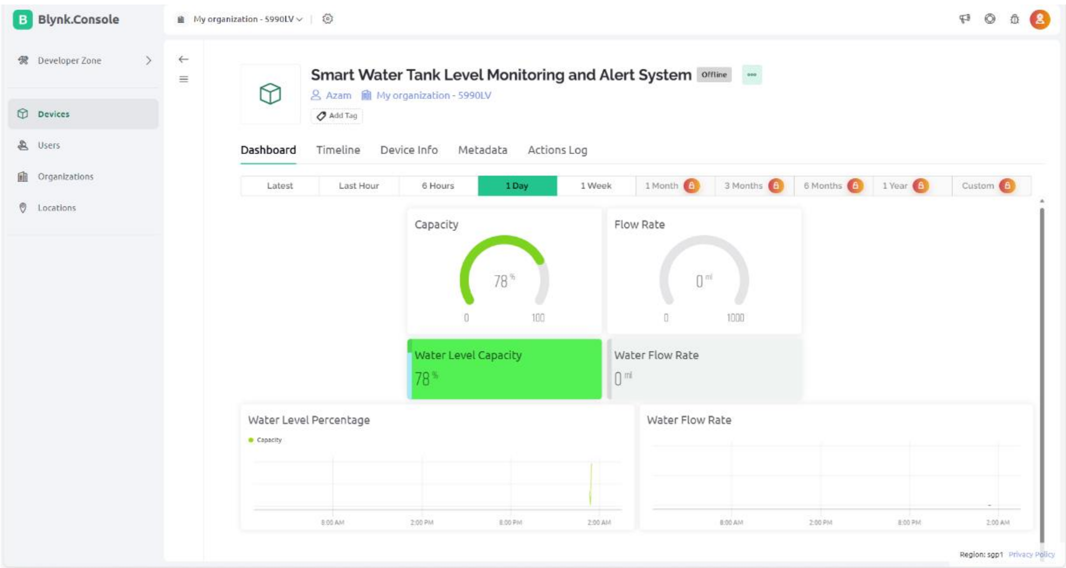


Figure 23: Smart Water Tank Level Monitoring and Alert System Dashboard in Blynk (Dekstop view)

Figure 24: Smart Water Tank Level Monitoring and Alert System Dashboard in Blynk (Mobile device view)

3.3.4.8 Arduino IDE

The Arduino Integrated Development Environment (IDE) is a software tool specifically created for programming and uploading code to Arduino microcontroller boards. It is designed to be user-friendly and easy to use. The software provides a user-friendly interface that is easy to understand and operate. It includes a variety of tools, including as a text editor, compiler, and uploader, which greatly assist in the creation of embedded projects. These features cater to the needs of both novice and proficient users. Arduino IDE is an essential tool for makers and hobbyists as it provides a large collection of pre-written code samples and comprehensive documentation. This allows users to efficiently create and implement various electronic projects.

For this project, all the components are connected to the breadboard including the ESP-32 processor. From ESP-32 is connected to the laptop via USB cable. In order for the components and the processor can functioning properly, it needed to write the code for each component. Then, it verifies the code whether there is an error or not and once the system already verifies the code, it uploads the code into the ESP-32.

The example image of the Smart Water Tank Level code as below:

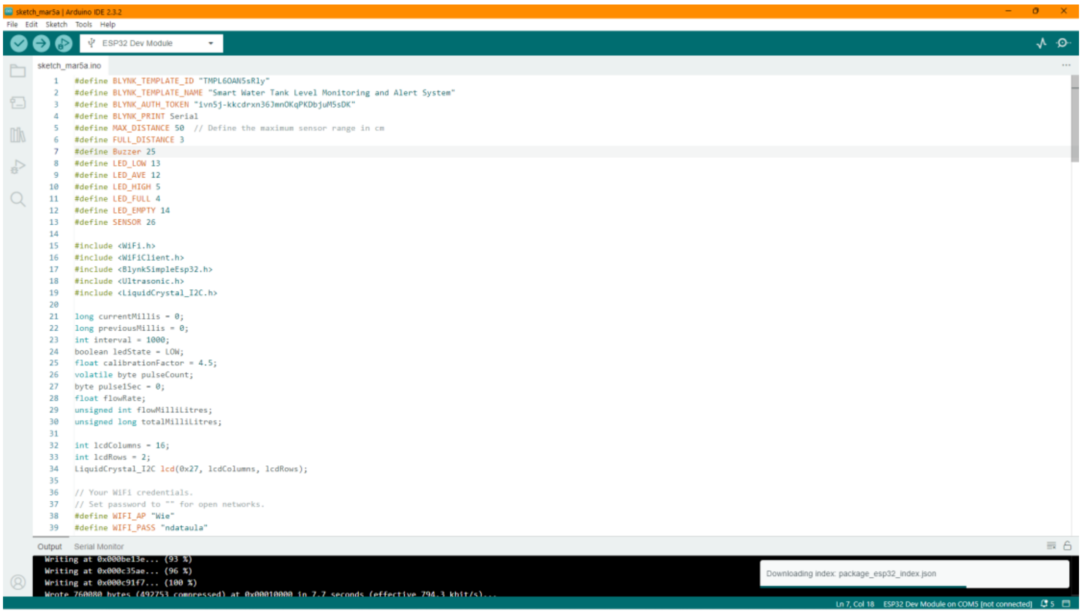


Figure 25: Code in Arduino IDE

Below is the uploading part into the ESP-32 processor:

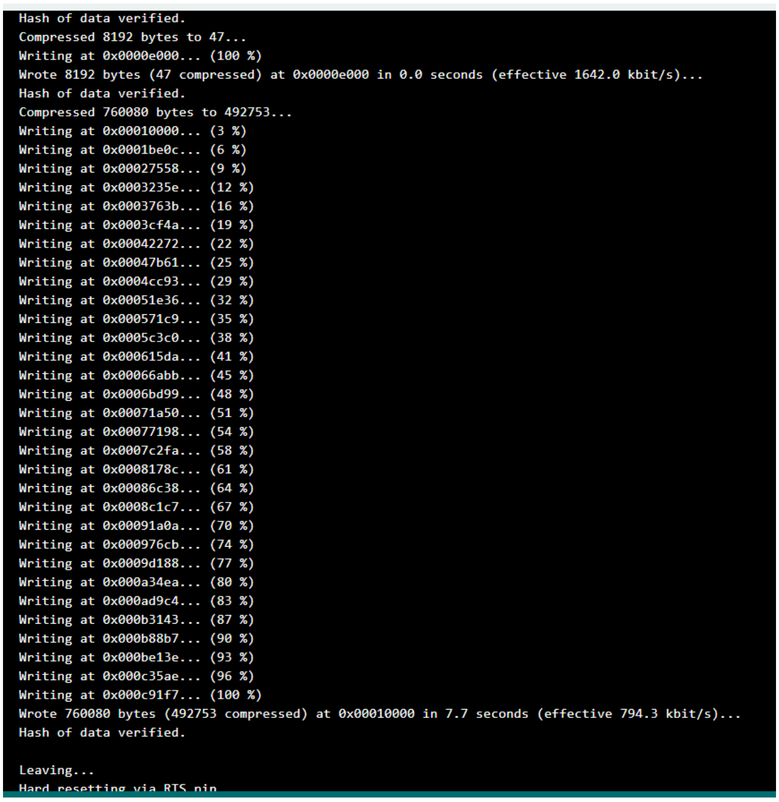


Figure 26: Uploading process in Arduino IDE into ESP-32 board.

The output at the serial monitors in Arduino IDE as below:

```
Water is FULL!
Water Pump OFF wlevel == 100!
Water is FULL
Flow rate: 0L/min       Output Liquid Quantity: 7690mL / 7L
Distance in CM: 3
100%
Buzzer OFF!
Water is FULL!
Water Pump OFF wlevel == 100!
Water is FULL
Flow rate: 0L/min       Output Liquid Quantity: 7690mL / 7L
Distance in CM: 3
100%
Buzzer OFF!
Water is FULL!
Water Pump OFF wlevel == 100!
Water is FULL
Flow rate: 0L/min       Output Liquid Quantity: 7690mL / 7L
Distance in CM: 3
100%
Buzzer OFF!
Water is FULL!
Water Pump OFF wlevel == 100!
Water is FULL
Flow rate: 0L/min       Output Liquid Quantity: 7690mL / 7L
Distance in CM: 3
100%
Buzzer OFF!
Water is FULL!
Water Pump OFF wlevel == 100!
Water is FULL
Flow rate: 0L/min       Output Liquid Quantity: 7690mL / 7L
Distance in CM: 3
100%
Buzzer OFF!
Water is FULL!
Water Pump OFF wlevel == 100!
Water is FULL
Flow rate: 0L/min       Output Liquid Quantity: 7690mL / 7L
Distance in CM: 3
100%
```

Figure 27: Output view (Serial Monitor) in Arduino IDE

3.4 System Architecture

3.4.1 Flowchart

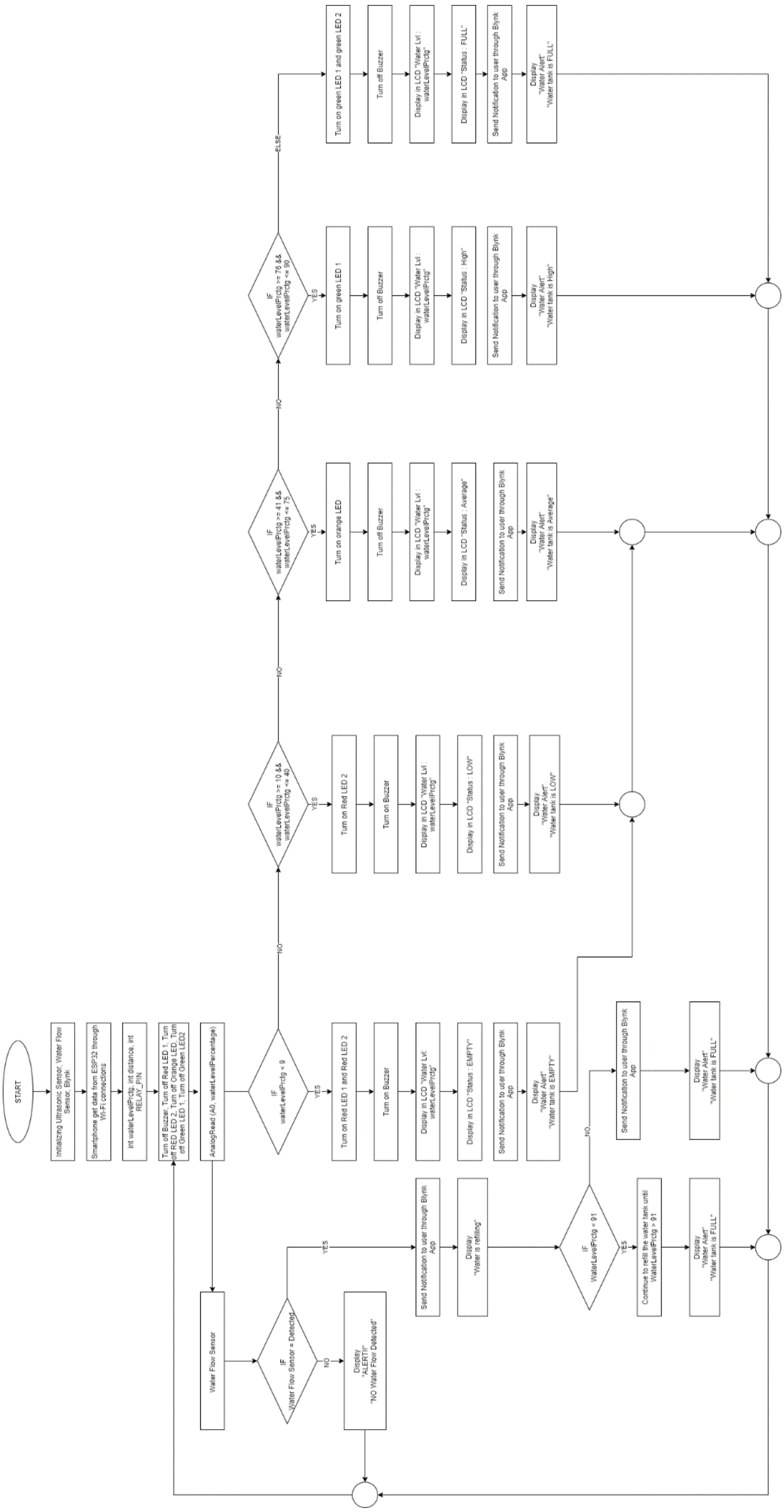


Figure 28: Flowchart of the system.

3.4.2 Schematic Diagram

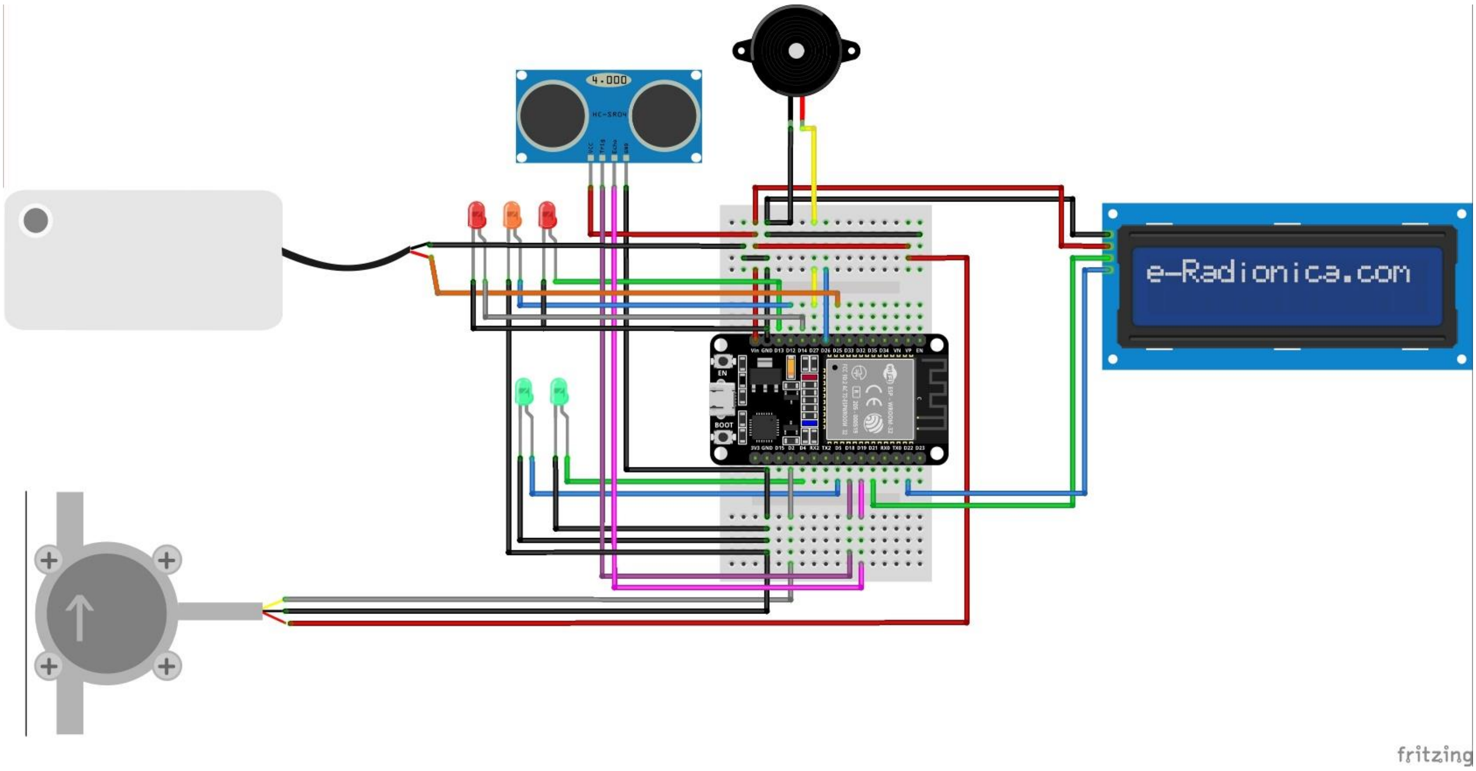


Figure 29: Schematic diagram of system.

During phase 3 of the FYP2, the feedback and testing had been considered and decided to change and add a few of the components. For instance, the replacement components are Arduino Uno board had been changed to ESP-32 board. Then additional components such as 5 LED lights in total to indicate various water level in the water tank and the water flow sensor detector use to detect the water flow from the water pump into the water tank. The main reason for changes of the components is because it is more suitable and easier to configure and build the prototype.

3.5 Gantt Chart

3.5.1 Gantt Chart for FYP1

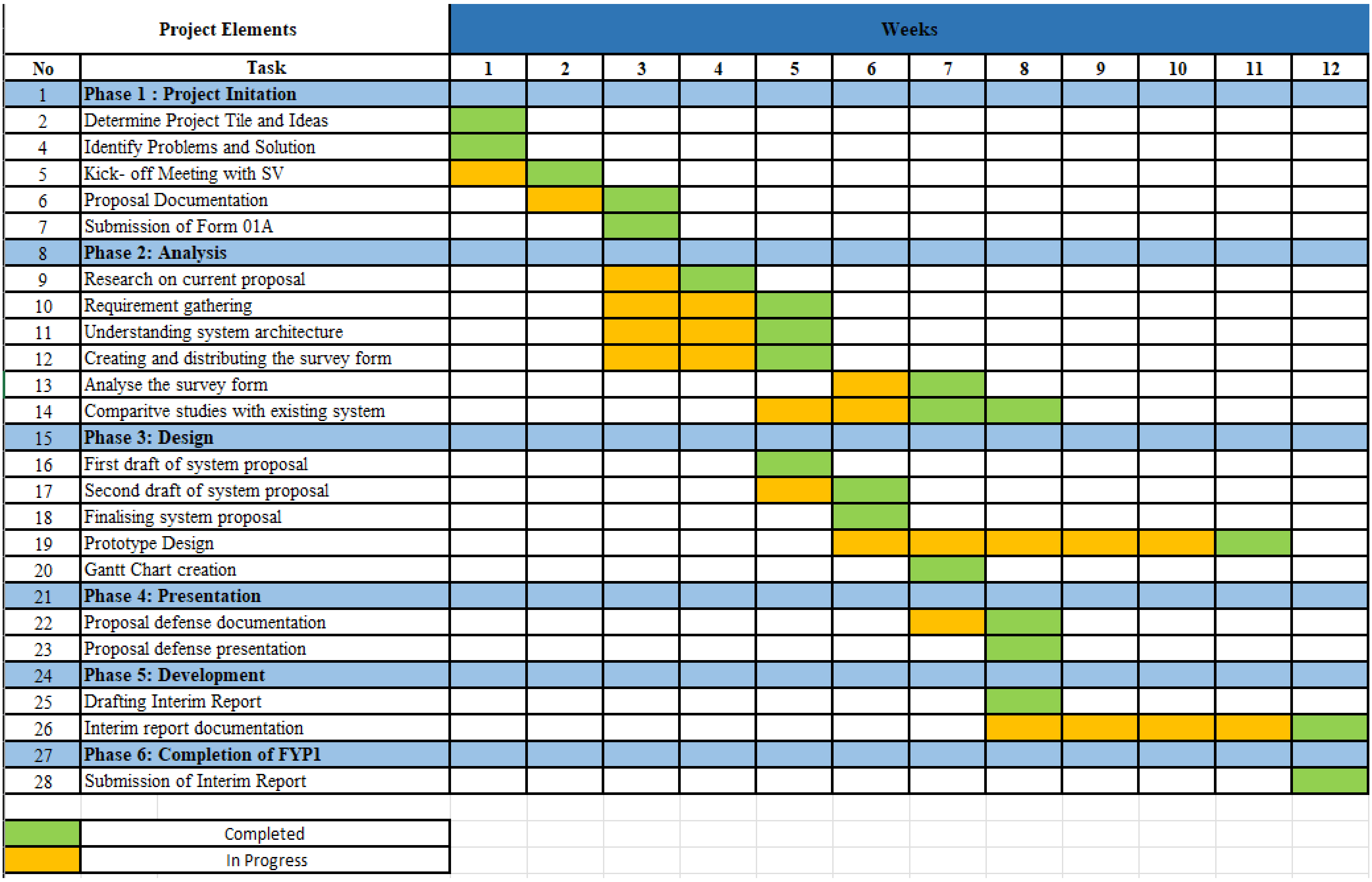


Figure 30: Gantt Chart during FYP 1

3.5.2 Gantt Chart for FYP2

Figure 31: Gantt Chart during FYP

3.6 Chapter Summary

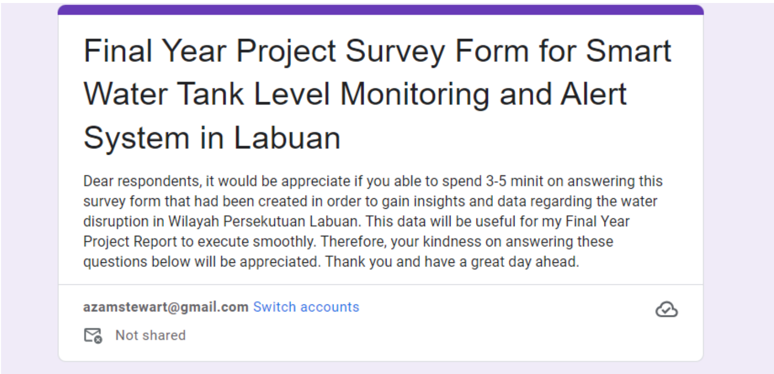
In this chapter, the methodology for conducting the research and developing the prototype is discussed. The research method involves surveying Labuan residents to gather data on water supply disruptions. A pilot test will refine the survey questionnaire, ensuring ethical considerations. The prototype development method employs a prototyping model within the Prototype model process to create a Smart Water Tank Level Monitoring and Alert System using IoT technology. Detailed descriptions of hardware components, installation procedures, and testing methods are provided. Additionally, a Gantt chart outlines the project timeline for both phases of FYP 1 and FYP 2.

4.0 RESULT AND DISCUSSION

4.1 Chapter Introduction

In this chapter, it will be delved into the result and discussion from the survey form which consists of 15 questions on the Smart Water Tank Level Monitoring and Alert System in Labuan where it provides a comprehensive understanding about the Labuan residents situation and impact from the water disruption. Besides that, this section also explores the development and its functionality of the prototype model where it highlights the changes of the water level in the water tank such as Full, High, Average, Low and Empty by alerting to the user via notification. Lastly, it also can be monitored virtually through mobile device where it will be visualized and displayed in the Blynk dashboard.

4.2 Survey Result


Final Year Project Survey Form for Smart Water Tank Level Monitoring and Alert System in Labuan

Dear respondents, it would be appreciate if you able to spend 3-5 minit on answering this survey form that had been created in order to gain insights and data regarding the water disruption in Wilayah Persekutuan Labuan. This data will be useful for my Final Year Project Report to execute smoothly. Therefore, your kindness on answering these questions below will be appreciated. Thank you and have a great day ahead.

azamstewart@gmail.com Switch accounts

Not shared

Figure 32: Smart Water Tank Level Monitoring and Alert System in Labuan Survey

Based on figure 1 above, this online survey regarding the Smart Water Tank Level Monitoring and Alert System in Labuan by using Google Form. The total number of respondents for this survey is 99 respondents who took part in answering the form. The survey consists of 15 questionnaires for the respondent to answer.

Figure 33: Question 2 of the survey result.

Based on figure 2, it can be seen that the water disruptions are very frequently occur in the past year which consist of 40.4% (40 respondent) and for the frequent which only 29.3% (29 Respondent). For the other type which are occasionally and rarely only 17.2% (17 respondents) and 13.1% (13 respondents). This visualizes that the water disruption in Labuan often occurred.

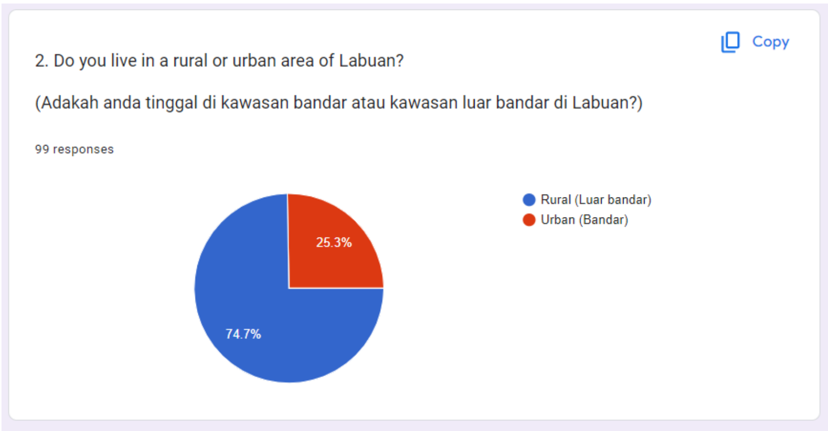


Figure 34: Question 3 of the survey result.

According to figure 3, most of the respondents live in the rural area which consists of 74.7% (74 respondents) and the rest are from urban areas 25.3% (25 respondents). From the figure, the most respondents who took part in the survey are from rural areas.

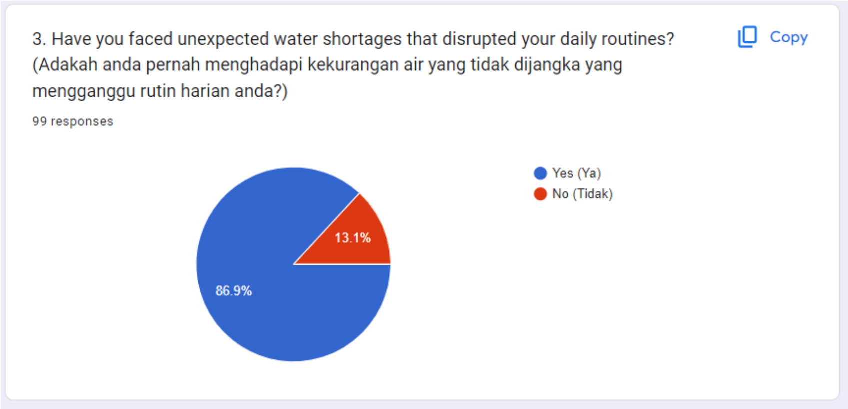


Figure 35: Question 3 of the survey result.

The chart in figure 4 shows above represents 86.9% of the respondents said Yes that the water shortages can disrupt their daily life routine and only 13.1% (13 respondents) said no. This can be seen when it comes to water shortages, it can disrupt their routine and make it burden for them to live alone.

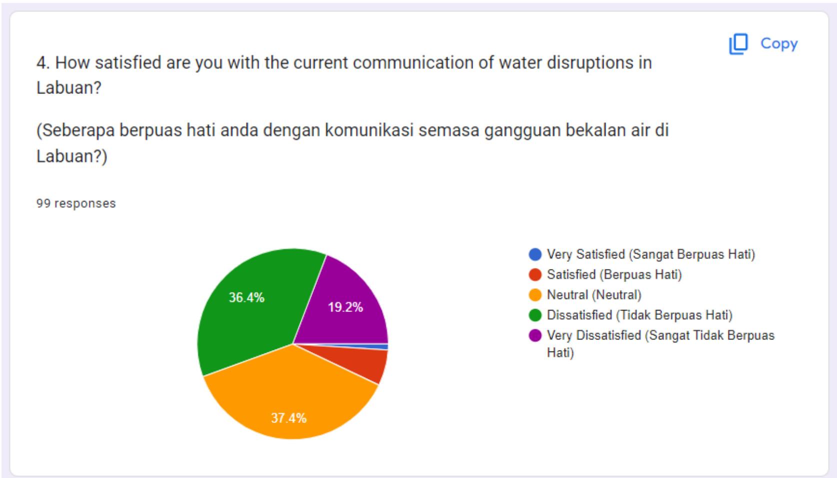


Figure 36: Question 4 of the survey result.

According to the chart in the figure 5 above, the question is asking about the "How satisfied are you with the current communication of water disruptions in Labuan?" and there are several type of choice of answer which are very satisfied, satisfied, neutral, dissatisfied, and very dissatisfied. This can be seen when the largest choice of answer would be Neutral with 37.4% (37 respondents), followed by Dissatisfied with 36.4% (36 respondents), 19.2% (19 respondents) for Very dissatisfied and the rest just a small percentage.

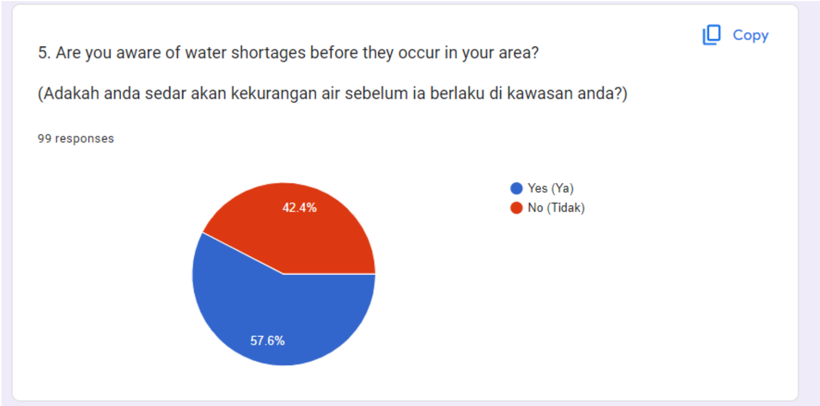


Figure 37: Question 5 of the survey result.

Figure 6 above shows that 57.6% (57 respondent) of respondents were aware of the water shortages before it occurred and only 42.4% (42 respondent) of respondents answered no which they are not aware of the water shortages. This can be seen when, the group of people who did not aware of the water shortages may face difficulties because they did not prepare anything before it happened.

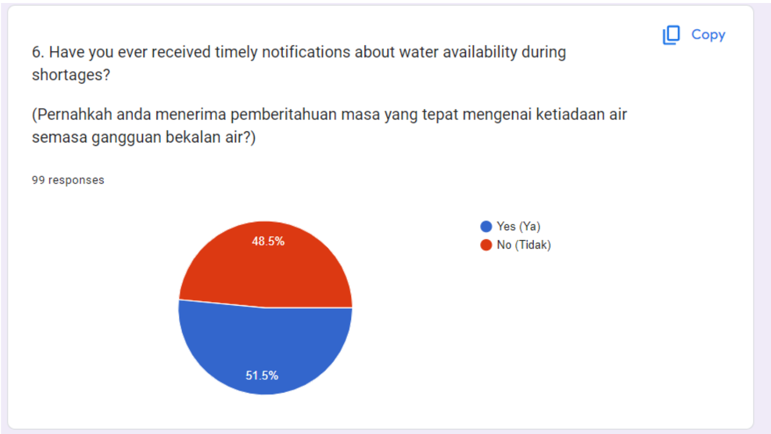


Figure 38: Question 6 of the survey result.

With the number of 51.5% (51 respondents) received timely notification regarding the availability of the water shortage and about 48.5% (48 respondents) were unable to receive timely notification. This can be seen when there is an issue regarding the notification that had been sent out to the people from received the information before the water shortages.

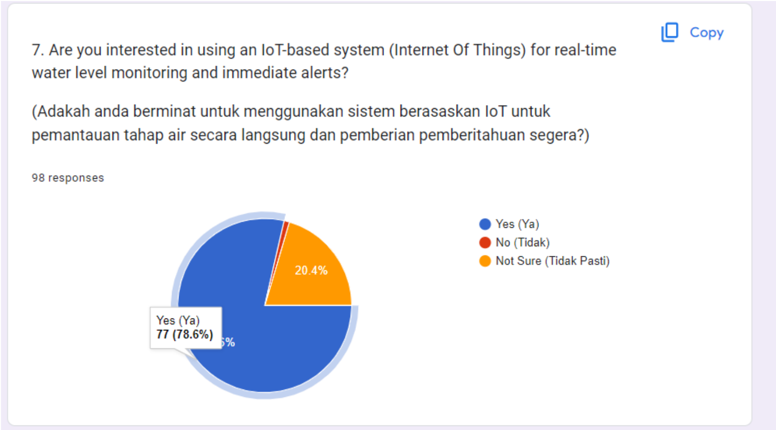


Figure 39: Question 7 of the survey result.

With a majority of 78.6% (78 respondent) said yes to the interested in using IoT based system (Internet of Things) for real-time water level monitoring and immediate alerts. Respondent who chooses "Not sure" answered with consist of 20.4% (20 respondents) might did have the knowledge regarding the uses of IoT or what is IoT all about.

Figure 40:Question 8 of the survey result.

Based on figure 9 above, 65.7% (65 respondents) agreed with a choice of answer "Yes" to the adaptive thresholding for alerts and only 31.3% (31 respondents) choose "Not sure". There are only 3% who voted for "No". This suggests that it would be beneficial for the water tank by implementing a threshold into it.

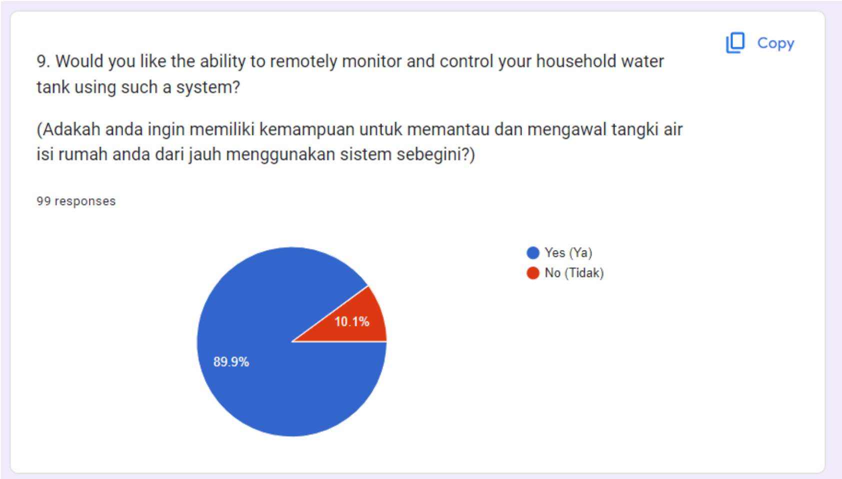


Figure 41: Question 9 of the survey result.

With the huge number of 89.9% (89 respondents) agreed and interested to be able to remote monitor and control their household water tank using a system and only 10.1% (10 respondent) choose "No". From here, we can see that they are more likely to control and monitor virtually rather than need to continuously check-up their water tank physically.

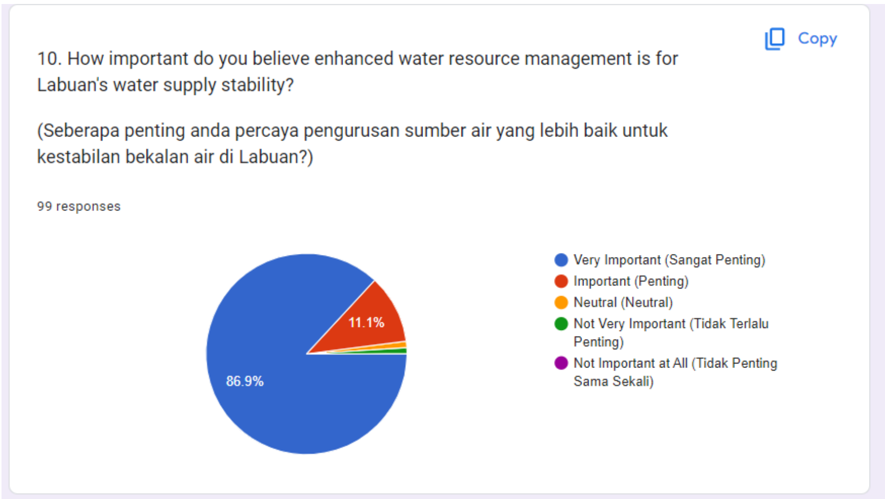


Figure 42: Question 10 of the survey result.

From the chart in figure 11 above, the respondents who believe the enhancement water resource management is for Labuan's water supply stability were 86.9% (86 respondent) choose "Very important" and 11.1% (11 respondent choose "Important". The chart did not display the percentage of the other categories such as "Neutral"," Not very important" and "Not important at all" were either not present or negligible.

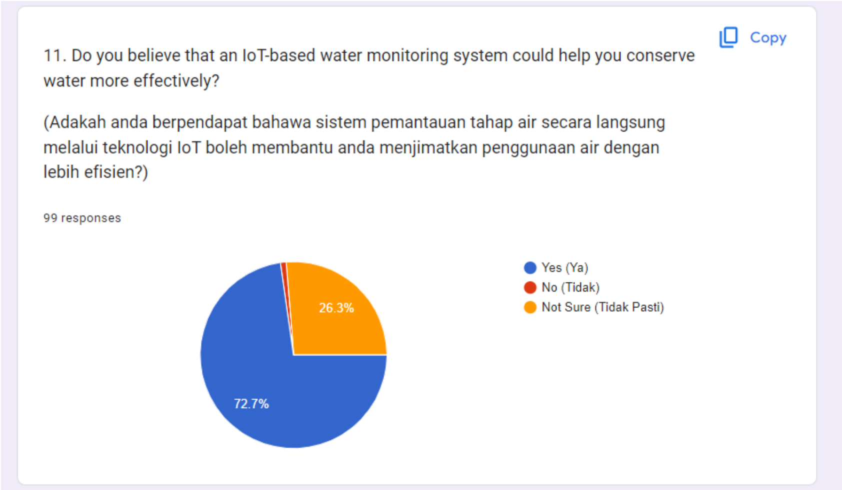


Figure 43:Question 11 of the survey result.

From the chart in figure 12 above, respondents agreed that the IoT water monitoring system could help them conserve water more effectively with 72.7% (72 respondents) choose “Yes” whereas 26.3% (26 respondents) choose “Not sure”. This data can be portrayed that the respondents believe by having a system that can monitor and alert will help them to save water more effectively.

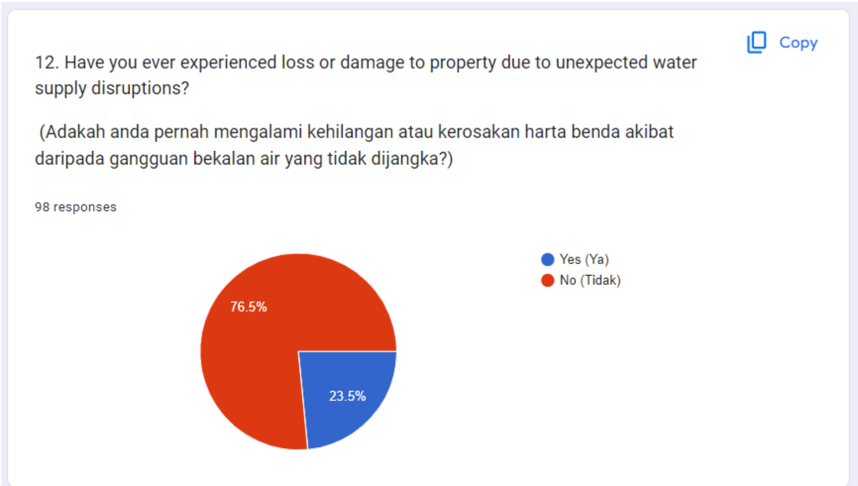


Figure 44: Question 12 of the survey result.

Based on figure 13 above, 76.5% voted “No” which they never experienced any loss or damage to property due to unexpected water supply disruptions and for the “Yes” only 23.5% who voted for it. This can be seen when even there is water supply disruptions, majority of the respondents didn’t have the difficulties or loss that needed them to buy the new items.

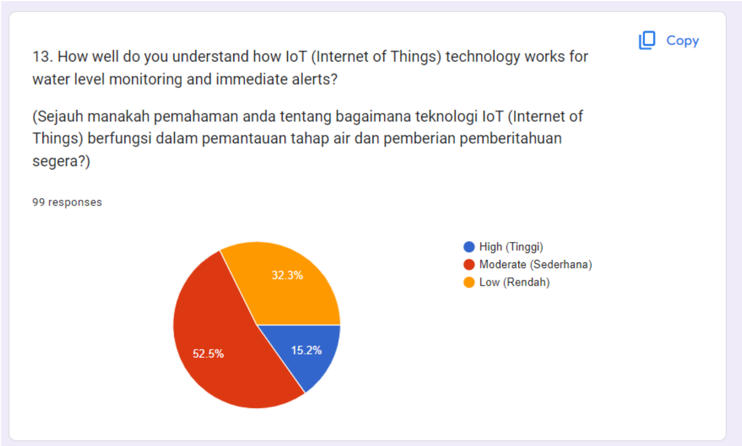


Figure 45:Question 13 of the survey result.

With a percentage of 52.5% (52 respondents) voted “Moderate” for the understanding on how the IoT works for water level monitoring and immediate alerts. For the others, 15.2% (15 respondents) voted for “High” which they can perform understand on the IoT functions and 32.3% for the “Low” understand. Therefore, by having a tutorial and instructions on how the monitor and alert works, It will boost the respondent knowledge regarding the IoT.

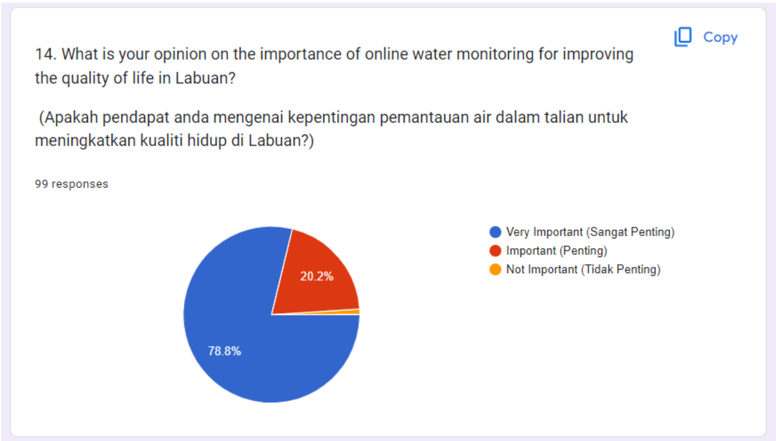


Figure 46:Question 14 of the survey result.

From the chart in figure 15 above, the total percentage for the people who voted “Very important” is 78.8% (78 respondents) for the opinion on the importance of online water monitor in order to improve the quality of life in Labuan. Where on the other hand, only 20.2% (20 respondents) voted “Important”. This can be seen when both of the choices of answer indicate that they really agreed for the online water monitoring can boost quality of life among the residents in Labuan.

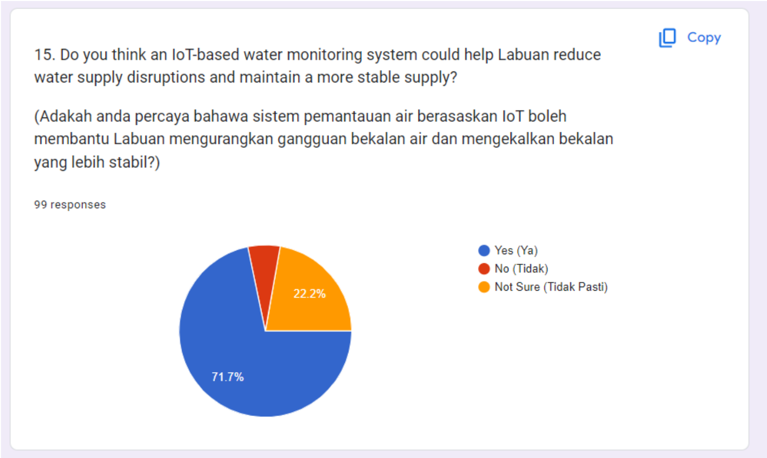


Figure 47:Question 15 of the survey result.

With a percentage of 71.1% (71 respondents) are agreed by voting "Yes" about the IoT water monitoring can help the Labuan residents to reduce the water supply disruptions and maintain a more stable water supply. Whereas only 22.2% (22 respondents) were not sure and 6.1% (6% respondents) voted for No. This can be seen when the IoT has the potential to overcome the problems of the water disruption in Labuan.

4.3 Prototype Model.

Finished prototype module of the Smart Water Level Monitoring and Alert System

Figure 48: Finished prototype model (Front view)

Figure 49: Finished prototype model (Back view)

The finished and complete prototype model was created by using a 9L water jar, and a box to put the IoT in it. The model represents a water tank level that is in the household area especially in the rural area such as in Labuan. All the sensors, hardware and display are attached to the prototype as well and it's connected to the ESP-32 which will be placed in a box that is attached to the model. When it connected to the Arduino IDE, the sensors such as the Water Flow Sensor Detector and the Ultrasonic Sensor are functioning properly with the LEDs lights, buzzer automatically switched on based on the condition of the water level capacity in the water tank, the 12C LCD Display displaying the different water level status and water level percentage. The live data will be sent through the Blynk App where it will aggregate and visualize either in the mobile device such as Androids or iOS or on the website. When the water level reaches a certain level in the water tank, an action will be triggered that had been coded in the Arduino IDE to send a notification to the user as an info (green zone), warning (orange zone) or alert (red zone). The prototype model has been tested and it is functioning properly,

The model currently Sensor Consist of:

- YF-S201 Water Flow Sensor Detector to detect the water flow that fills the water tank.
- Ultrasonic Sensor HC-SR04 to detect the water level capacity.
- LED lights to display different warning colours level.
- ESP-32 board as a main microprocessor component for the project.
- Buzzer emits a sound when it reaches low water level and below.
- 12C LCD Display to display water level status and water level percentages in the water tank.
- 5V Water Pump as a pump to fill in the water tank.
- 5V pump will be directly connected to the 5V DC Power Supply.

4.3.1 Water Level Monitoring and Alert.

i. Full Water Level

When it reaches this water level, the Ultrasonic Sensor HC-SR04 will determine and read the current water level in the water tank. Both green LED lights will be turned on to represent the current water level status is “FULL”. The buzzer will not emit any alarm tones since it is not at a crucial level. The 12C LCD Display will display the output text on the screen of it such as “Wat Level: “that ranging from 91% to 100% and “Status: FULL”. The 5V water pump is connected to the DC Female and the DC female will be connected directly to the 5V DC Power Supply. For the water flow sensor detector, it will not detect any water flow since the water pump is OFF. The live data can be checked through the Blynk website as well as in the mobile device application.

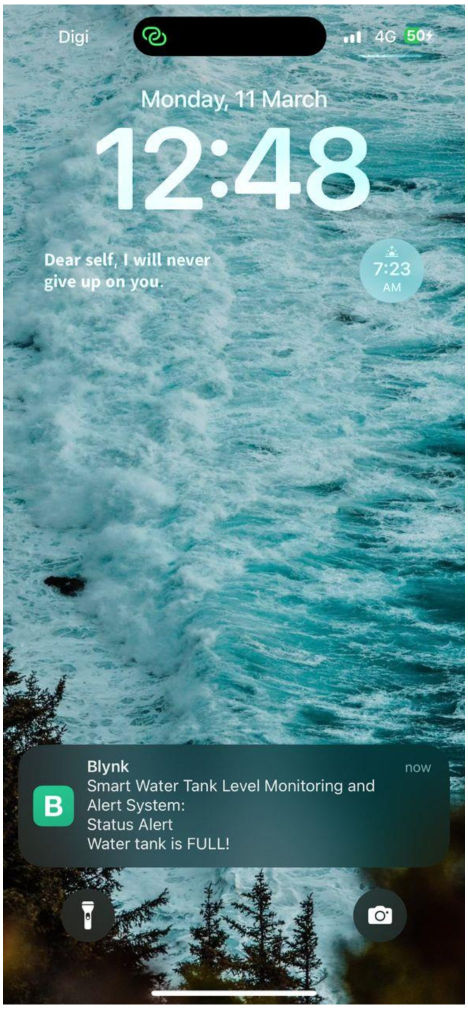


Figure 50: Water Level Full notification alert

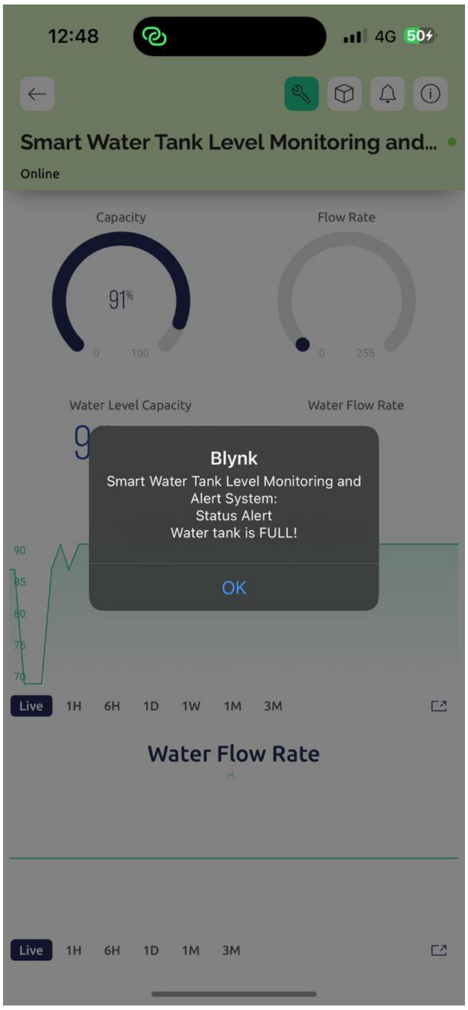


Figure 51: Alert notification in the Blynk Dashboard

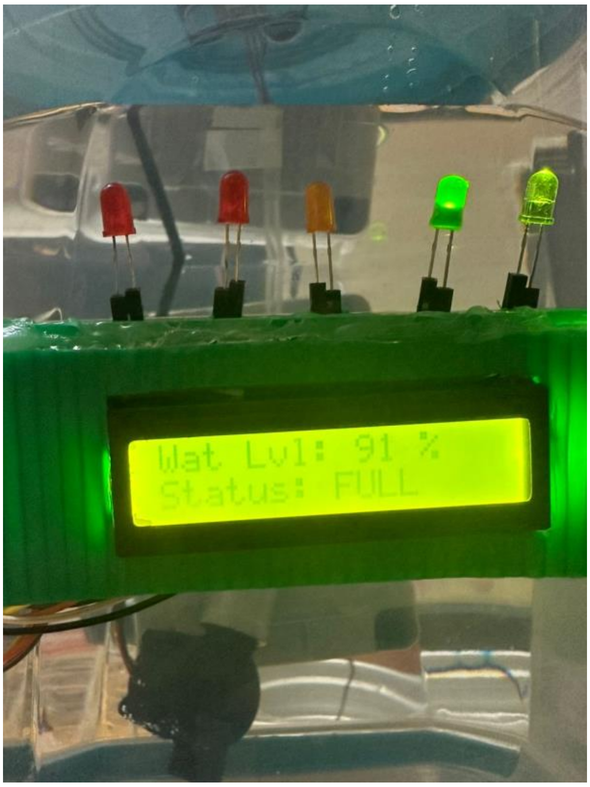


Figure 52: LCD display output for Full Level

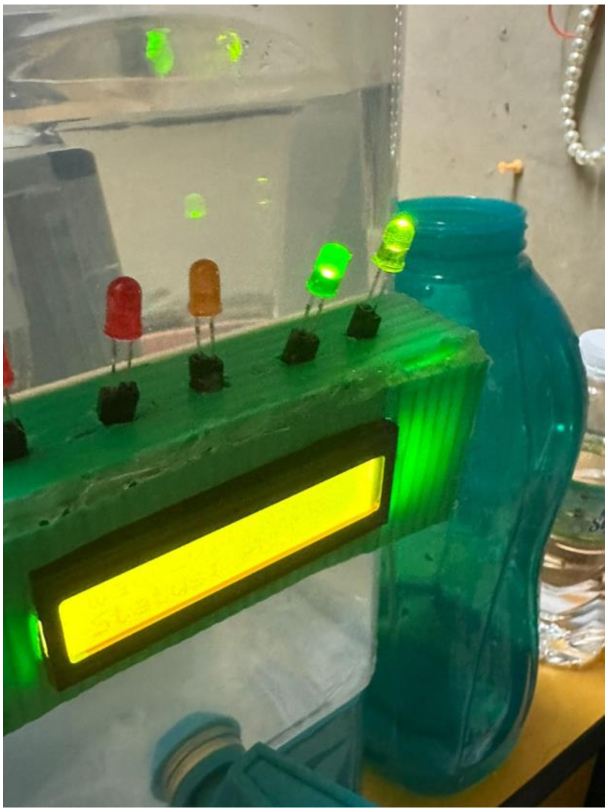


Figure 53: LED lights for both green switched on

ii. High Water level.

For the high-water level, the water level percentage ranges from 76% to 90%. Therefore, the Ultrasonic sensor HC-SR04 will calculate and determine the current water level in the water tank. When it lies in this condition, one of the green LED lights will be switched on. Differ from the full water level that both green LED lights will be switched on. The buzzer still will not emit any alarm tones since it is still in the High-water level status. The 12C LCD Display will display the "Wat Level:" of the percentage range in this condition and the "Status: High". The water pump that connected to the DC Power Supply will remain switched off. Then, the water flow sensor still will not detect any of the water flow since the water pump is OFF. When the Ultrasonic sensor reached this this water level status, it will send the notification to the user via the Blynk Apps which the output of the notification "Water Alert, Water is HIGH". The notification will send through the user mobile device which will ease them to monitor and view the visualize data in term of charts and widget.

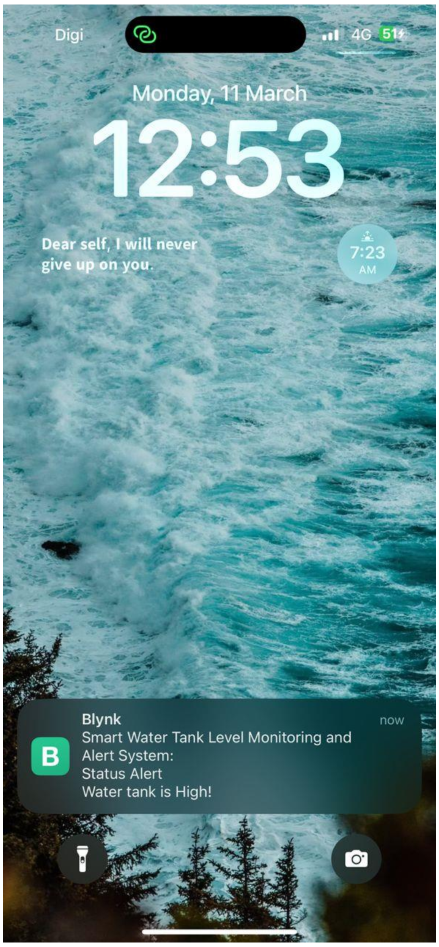


Figure 54: Notification alert for the High-Level

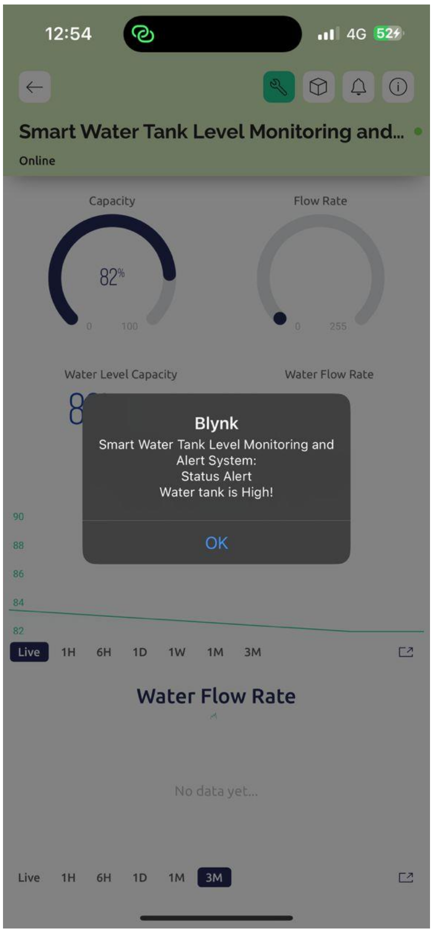


Figure 55: Pop-up notification alert in the Blynk Dashboard

Figure 56: Visualisation view in Blynk Dashboard

Figure 57: LCD display the output of the water level percentage and status.

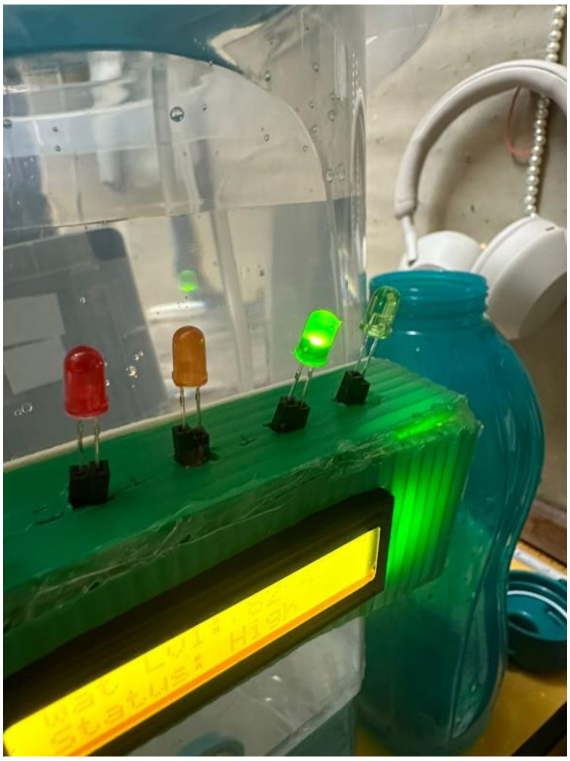


Figure 58: One of the green LED Lights switched on.

iii. Average Water Level

During this water level, the Ultrasonic Sensor HC-SRO4 has detected the current capacity of the water level in the water tank is in “Orange Zone” which indicated in the average water level. The water level percentage for this condition is between 41% to 75%. The orange LED light will be turned on which indicates “Average Water Level”. During this stage, the buzzer still will not emit any alarm tone. The 12C LCD Display an output text which “Wat Level” based on the current capacity and the “Status: Average.” For this stage, the DC power supply that is connected to the water pump will be switched in order to refill the water tank. The water pump symbolized as a pump that connected to the water tank and it will automatically refill when the water level percentage less than and equal to 75 and below. Then, the hose from the water pump will be connected to a water flow sensor which will detect the water flow. From there, the sensor can detect if there is any water flowing into the water tank. For the notification, the processor will send it to the Blynk and from Blynk, it will notify the user via notification. If there is a water flow rate flowing into the water tank, the system sends a notification to the user which shows “Water Alert, Water Tank is Refilling”. Else, if the water pump is on, but there is no water flowing into the water tank, that means there is no water supply and it will send the notification to the user "Water Alert, "Warning! No Water Flow Detected!". The water pump will continuously refill the water tank until it reaches the water tank percentage equals to 100. The condition lies for the water level to pump is when the water level percentage less than and equal to 75% and below.

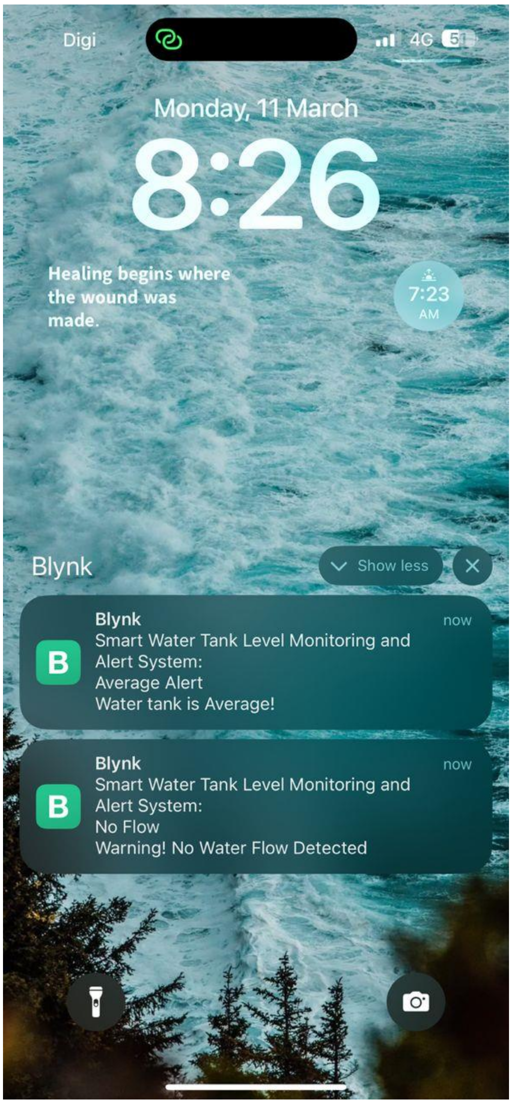


Figure 59: Notification of average water level and No water flow detection

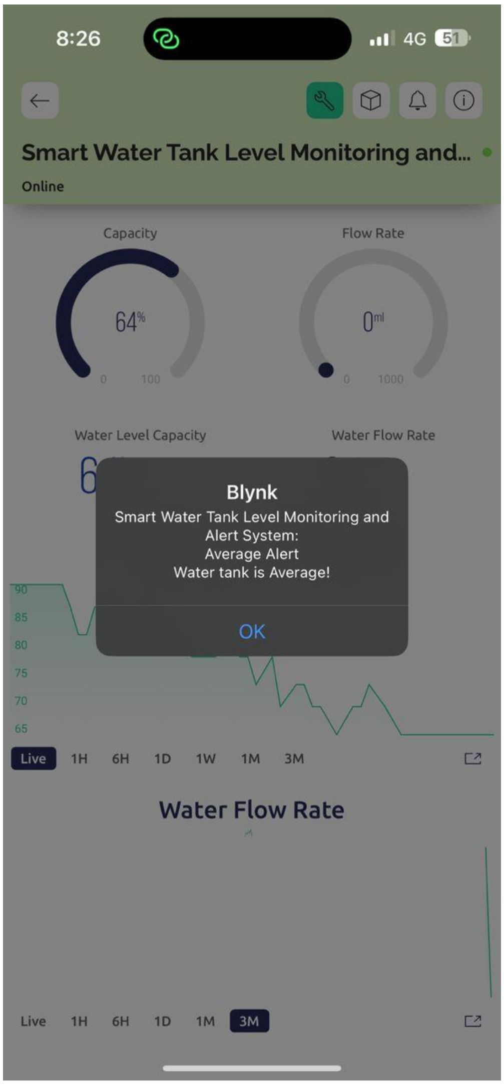


Figure 60: Pop-up notification in the blynk dashboard status.

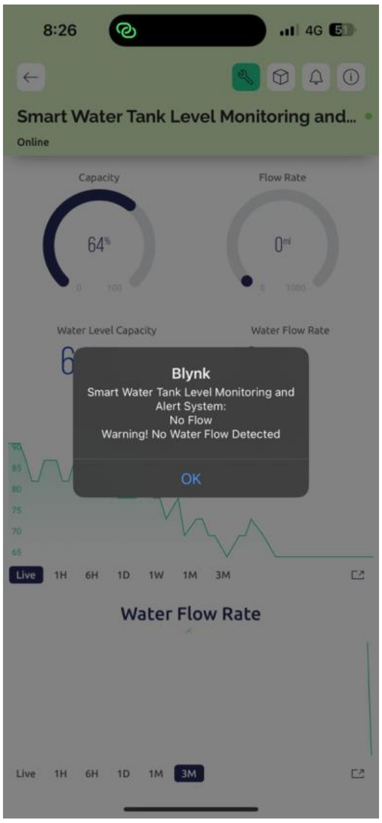


Figure 61: Pop up notification (no water flow)

Figure 62: Notification of water refilling (water flow presence)

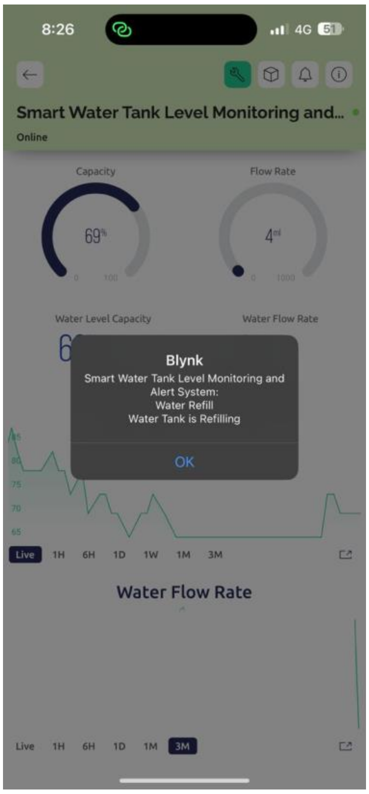


Figure 63: Pop up notification in blynk dashboard (water refilling)

Figure 64: Data visualisation in the blynk dashboard.

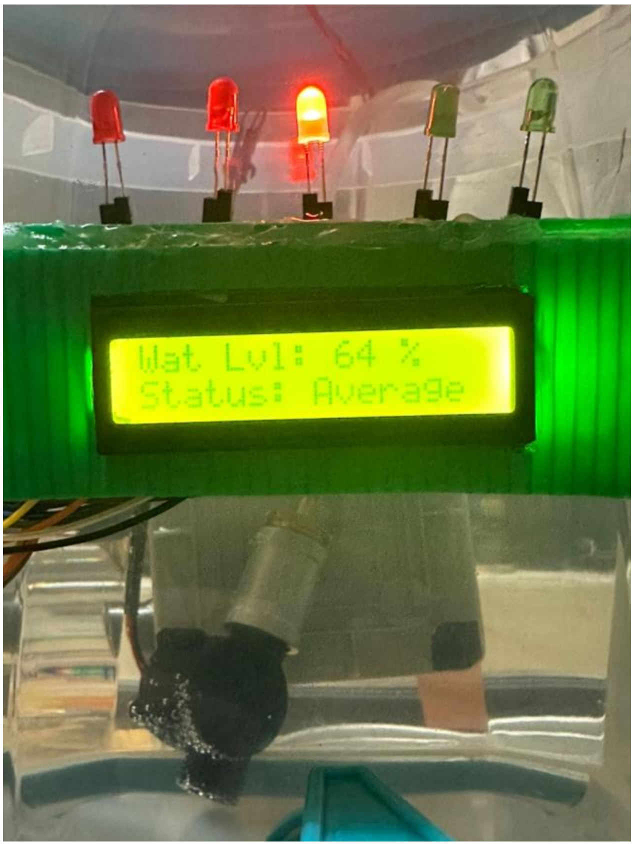


Figure 65: Orange LED switched on and LCD Display the output of the water level percentage and water status.

iv. Low Water Level.

Next stage is Low Water Level where the percentage is raging from 10& to 40%. The LED lights for this condition, one of the red LED lights will be switched on. The buzzer will emit an alert tone which indicates the water level is already in the red zone (Low Level). The 12C LCD Display will display an output text which are "Wat Level:" the current capacity water level percentage and the "Status: LOW". The system also sends the notification to the user via Blynk App in the mobile phone which" Water Alert, Water Level is LOW!". The 5V DC Power Supply still uses the same condition as in the Average Level where will be switched on when the water level percentage is less than and equal to 75 and below. With the presence of the water flow, it will calculate the water flow rate and it will still send the same notification as the previous stage. The visualization widget and graph can be seen at the Blynk dashboard.

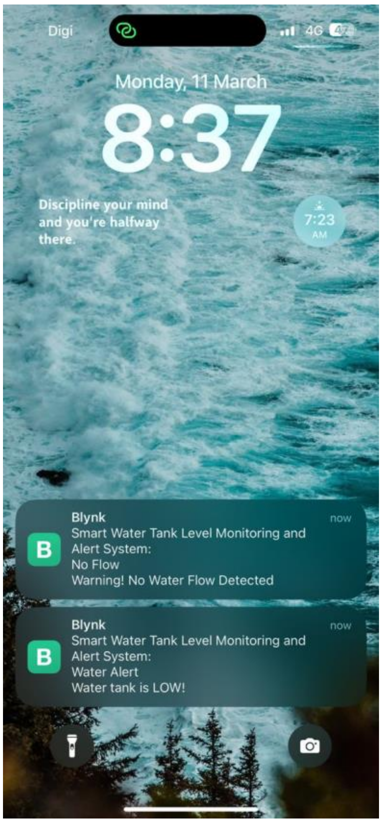


Figure 66: Notification for Low water level

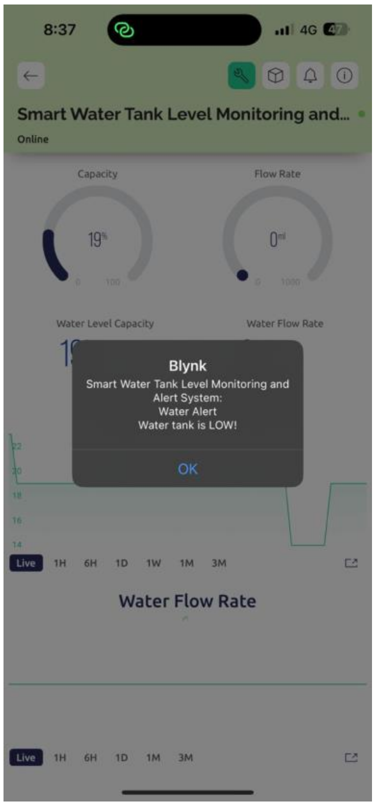


Figure 67:Pop up notification in blynk dashboard (Low water level)

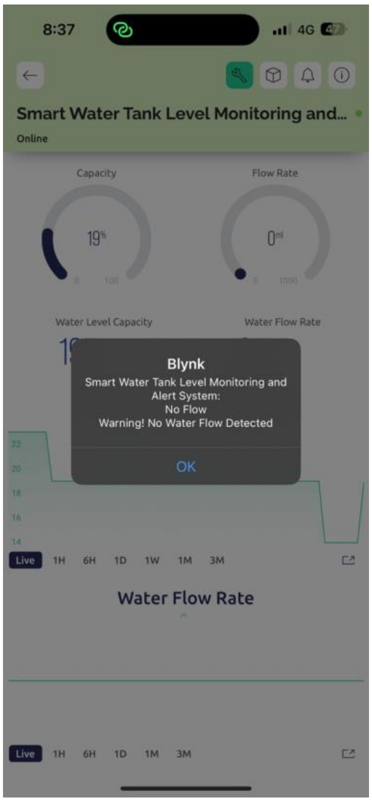


Figure 68: Pop up notification (No water flow)

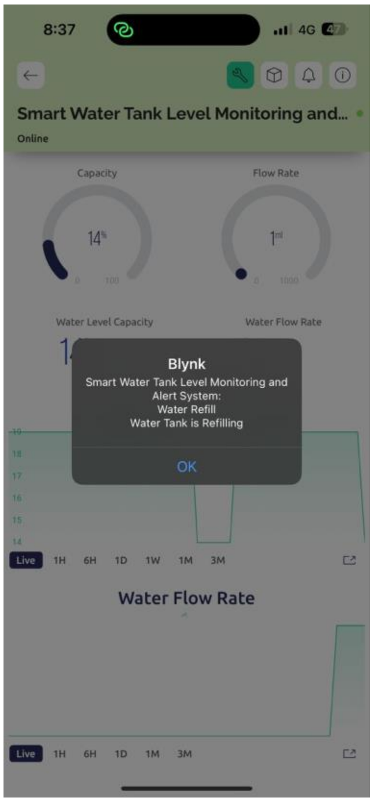


Figure 69: Pop up notification (water refilling)

Figure 70: Data visualisation in dashboard (Low Level)

Figure 71: One of the red LED lights switched on and LCD Display the output.

v. Empty Water Level

The last condition is Empty Water Level where it is ranging from 0% to 9%. Both red LED Lights will be switched on which indicate the water level is in the red zone (Empty level). Then, the buzzer will continuously emit the alarm tone since the low water level. The Ultrasonic sensor HC-SR04 will calculate the capacity water percentage in the water tank and it will send the data to the Blynk app for the visualization at the dashboard. The dashboard in the Blynk app also consist of widget and graph which represent for the water flow rate and water level capacity. The Blynk app as well will send the notification to the user as well where it shows the capacity of the water tank level " Water Alert, Water is EMPTY!". Then the water pump also applies the same condition as previous average and low level where it will be turn on when the water level percentage is less than and equal to 75% and below.

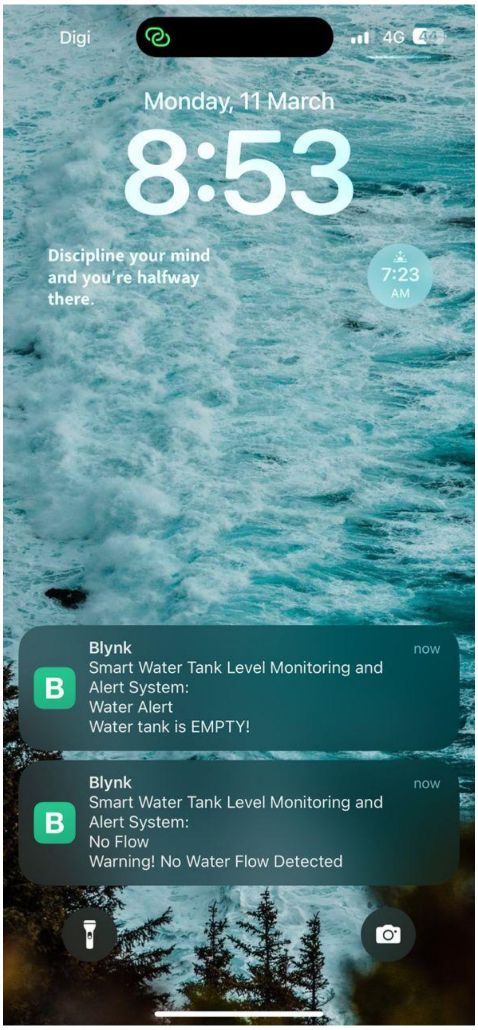


Figure 72: Alert notification for the Empty water level

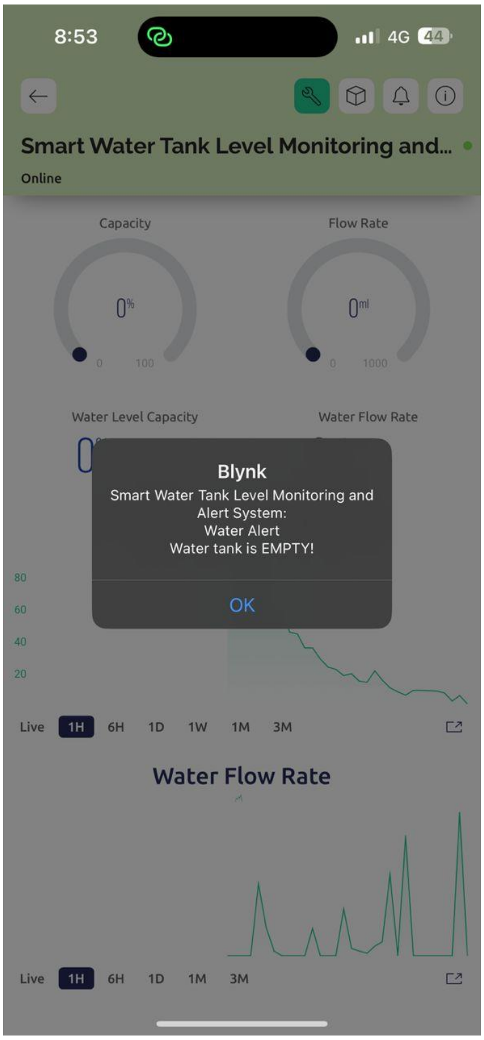


Figure 73: Pop up notification (Water level Empty)

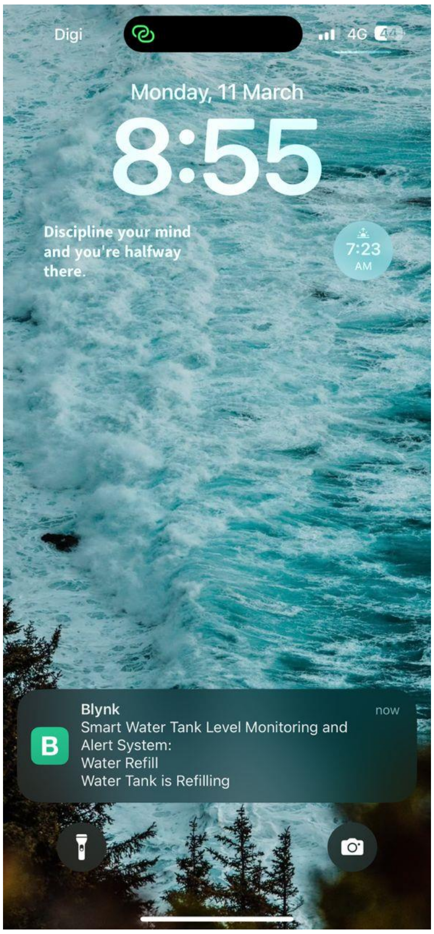


Figure 74: Notification for the water refilling

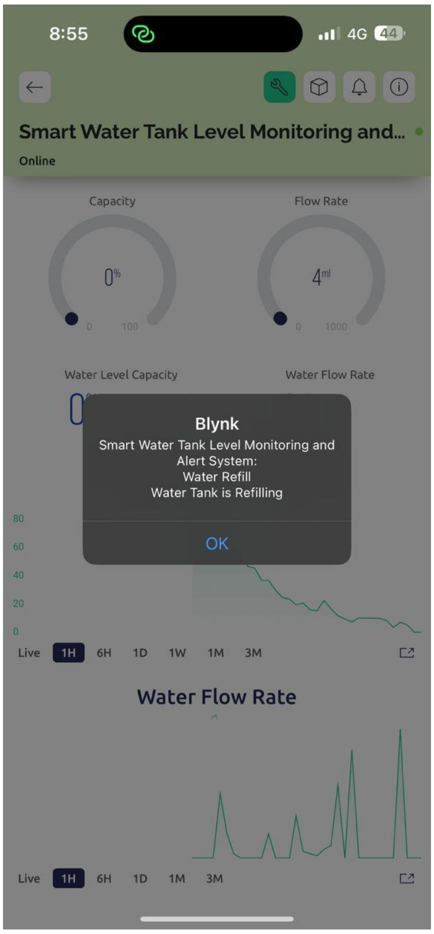


Figure 75: Pop up notification (water refilling)

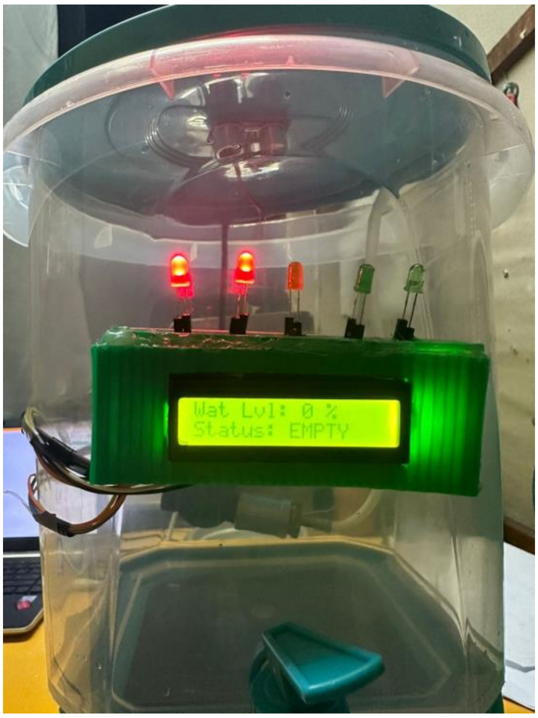


Figure 76: LCD Display (level percentage and level status)

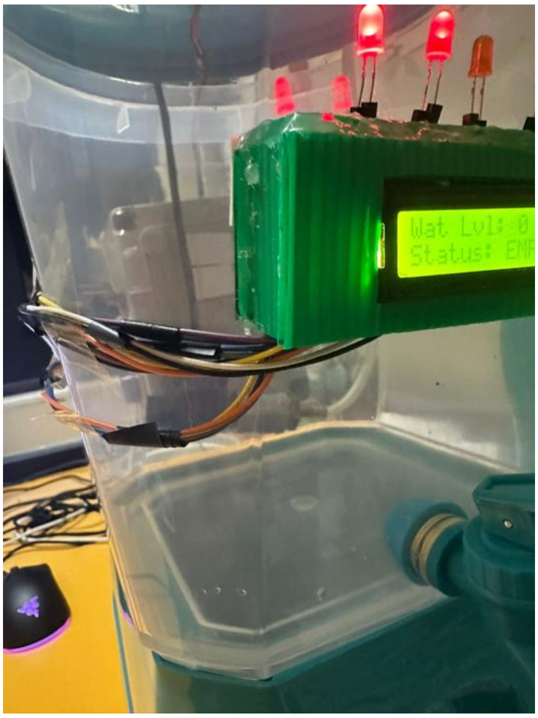


Figure 77: Both red LED lights switched on

4.4 Chapter Summary

This chapter discussed the survey results regarding the Smart Water Tank Level Monitoring and Alert System in Labuan where it gets 99 respondents to answer the survey, unveiling an insight into the frequency water disruption occurred, interest in IoT solutions and the community demographics. Moreover, the development and functionality of the prototype model also had been discussed where it demonstrated its effectiveness in simulating the different water level scenarios and provide the timely notifications to the user. The implementation of the water level monitoring and alert system displayed its ability to respond to the water level from full to empty water level. Therefore, the users can improve their water management by monitoring their household water tank level.

5.0 SUMMARY AND FUTURE WORK

5.1 Summary

The Internet of Things (IoT) is a flexible and economical idea that has been utilized in a variety of projects, including home automation. The Internet of Things (IoT) provides creative solutions to common problems by facilitating the connection and data sharing between digital devices and individuals. This technological integration enables effortless communication and interaction between people and everyday objects that are outfitted with sensors, microcontrollers, and receivers. The utilization of IoT to monitor and control from abruptly situation has considerable potential for growth. Implementing mitigation measures can be costly, but using this approach can help decrease those expenses. Additionally, it can enhance the ability to monitor virtually rather than physically and prepare from unwanted situations happened.

As a summary, the objectives on this project had been achieved. The first objectives is to design a IoT- based water level monitoring system. From the water tank prototype and components, there were several sensors that had been implemented such as ultrasonic sensor HC-SR04 to calculate and detect the water level capacity in the water tank and water flow sensor which to detect the water flow into the water tank if it is refilling or not. The other components such as LED Lights, 12C LCD Display, ESP-32 as well as buzzer also implemented in this project prototype. The second objectives are to implement real-time data collection and processing. It can be seen when the data been sent out directly from the sensors through Arduino IDE to the Blynk app to visualize the output of the data. Then the last objectives are to enable immediate alert and notification. This can be seen when the user is able to get timely notification when the water level capacity either drop or increase to the certain level. Not only that, but the user also gets the notification whether if theres is a water flow into the water tank or not and the buzzer also emit a tone to indicate the water tank level is on red zone (Low and Empty) level. Therefore, the system will be able to help the residents of Labuan to be aware and alert about their water tank which they can prepare from water shortage that might happened in the future.

5.2. Future Work

Future work needs to be focused on the development of the prototype of the smart water tank level alert and monitoring system. As for now, the project is in requirement phase of analysing the required hardware and software configuration to be implemented. After confirmation of the requirements, the project will begin with the first iteration of the smart water tank level monitoring and alert prototype, continued with further refinements of the system. The focus of the project is two main ideas which are the architecture of the system and the increasing the accuracy of the system. The system needs to be able to function properly since it will use for the long-term period so that it will make sure will withstanding from rain, strong wind blows and drought season that can affect the quality of it. Secondly, there needs to be additional inputs from the surrounding area to the system such as more sensors implemented to increase the accuracy of detecting a water level, the temperature of the water and humidity to detect water scarcity, the quality of the water, the automation of the pump control and so on.

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7.0 APPENDICES