IOT DATA LOGGER SYSTEM AND AUTOMATION LIFE BELOW WATER FARMING

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

2021

DECLARATION

I declare that this report entitled "IoT Data Logger System and Automation for Life Below Water Farming" is the result of my own work except for quotes as cited in the references.

Signature :

Author : MUHAMMAD ZIKRI BIN KAMARULZAMAN

Date : 25 JUNE 2021

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature :

Supervisor Name : Ir. Dr. ANAS BIN ABDUL LATIFF

Date : 25 JUNE 2021

DEDICATION

I would like to dedicate this thesis to my beloved parents Kamarulzaman Bin Othman and Norizan Binti Ismail who always support and encourage me through my educational journey. My beloved supervisor, Ir. Dr. Anas Bin Abdul Latiff for guiding me throughout this project and my supportive friends.

ABSTRACT

Fresh water lobsters is a commodity from the ponds, streams, rivers, and lakes resources that have high selling price and already encroaches international market. However, the environmental changes cause the vulnerable to disease, cannibalism, and lower lifespan. To prevent these problem, implementation of an integrated embedded system using internet of things that can monitor the parameters of water and automation system that can control the feeding and water treatment inside the lobsters' ponds. The parameters of water consist of pH water, water temperature and water level. Beside it, this system also equipped with web-based application internet of things (IoT) platform so that the monitoring and control system of the ponds can be accessed everywhere. This project aims to test the accuracy of data from pH sensor, water temperature sensor and water level sensor.

ABSTRAK

Lobster air tawar adalah komoditi dari sumber kolam, sungai, dan tasik yang mempunyai harga jualan yang tinggi dan sudah menembusi pasaran antarabangsa. Namun, perubahan persekitaran menyebabkan kerentanan yang lebih rendah terhadap penyakit, kanibalisme, dan jangka hayat. Untuk mengelakkan masalah ini, perlaksanaan sistem embedded bersepadu menggunakan internet dari hal-hal yang dapat memantau parameter air dan automasi yang dapat mengawal pemberian makan dan rawatan air di kolam lobster. Parameter air terdiri dari pH air, suhu air dan paras air. Di samping itu, sistem ini juga dilengkapi aplikasi berasaskan web Internet of Things (IoT) untuk sistem pemantauan dan kawalan yang dapat diakses di mana saja. Projek ini bertujuan untuk menguji ketepatan data dari sensor pH, sensor suhu air dan sensor paras air.

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ACKNOWLEDGEMENT

First of all, I thank ALLAH for providing me with everything that I required in completing this project. I have taken efforts in this project. However, this project would not have been possible to achieve its objective without the kind support and help of many individuals. I would like to extend my sincere thanks to all of them.

Next, I would like to express my sincere and deepest thanks to my research guide and supervisor, Ir. Dr. Anas Bin Abdul Latiff who has guided me at every stage of my research work and constantly encourage me during this learning process.

Moreover, my profound gratitude to both of my panels Dr. Muhammad Idzhihar Bin Idris and Zarina Baharudin Zamanai for giving ideas and opinions for the improvement of this project with their understanding and patience.

Last but not least, very special thanks to my family and friends for their spiritual support and kind cooperation for the report completion, from beginning until now.

TABLE OF CONTENS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

IP	:	Internet Protocol
SOP	:	Standard of Procedure
IoT	:	Internet of Things
IFTTT	:	If This Then That
IDE	:	Integrated Development Environment
MQTT	:	Message Queuing Telemetry Transport
GUI	:	Graphic User Interface
API		Application Program Interface

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

This project in-line with the united nation's sustainable goals (SDG). There are a few goals that match to this proposed project that called IoT data logger system and automation system for life below water farming. There are 3 goals that match with (SDG) which is goals no.1:no poverty, goals no.2: end hunger, and lastly is goals no.14 life below water.

There are many forms of life below water farming where can find in ocean culture, river culture and pond culture. In this proposed project the lobsters farming is going to be my major consideration as life below water farming. This project aims to help lobsters' farmers to increase their lobster's culture by using this IoT data logger system and automation system for life below water farming. The important to keep the quality of water inside the pond there are few parameters to focus on which is level of pH, water temperature and water level. This is because the freshwater lobsters are live inside the pond with suitable level of pH, water temperature and water level [2]. Besides that, the freshwater lobsters will live longer and disease free by monitor the parameters [5]. To monitor these parameters, there are sensors will be use in this project as my sensing technique and to collect the data of these parameters.

Next is to keep the freshwater lobster's growth by proper feeding the freshwater lobsters on time. The freshwater lobsters consume any type of food to keep their body growth and then freshwater lobster's will eat during the night because at the night, freshwater lobsters are active and then during the day, freshwater lobsters in rest state. Other than that, the excess food inside the pond will make the pond more acidic. The pH level at range 1-7 is acidic, it will cause freshwater lobsters vulnerable to diseases, cannibalism, and lower lifespan [2]. By maintain the level of pH will keep the water in pond in good quality and the freshwater lobsters will survive [5]. At the last, development of automation system it can control a few aspects to be considered which are control the food supply and maintain the level of pH water [9][14].

By introducing this system, it will create modern aquaculture towards IR 4.0 in Malaysia. As a result, it is expected to be able to improve operation cost, while increasing the culture and production. This project will collaborate with the lobster's farmer in Melaka, Malaysia to advise in lobster's farming culture.

1.2 Problem Statement

This project is to help lobsters' farmers to monitor their pond through mobile app by using Cayenne IoT dashboard platform. The aquatic species live inside it will die if the water's pH is too high or too low. Besides that, this aquatic species lives in the ponds with the certain temperature range. The pH level and temperature are very crucial part for the lobsters living, with the optimum pH level and temperature, the lobsters can live without any diseases and help to growing the lobsters in the pond. In order to check this parameter, farmers need to use multiple devices.

Furthermore, for commercial lobsters farming, there a lot of lobster's ponds to take care off. this because farmers need hire the helpers or workers for monitor the lobster's ponds. Besides that, farmers need to be spending a lot of money for that manpower.

Meanwhile, lobster's farmer waste time going back and forth feeding the lobsters and to check the pH level and temperature at the pond. The lobster farmer needs to check pH level and temperature from time to time. The lobster's farmer cannot do other thing of while taking care of lobsters' pond.

1.3 Objectives

To accomplish this project, there are several objectives to achieve as follows: -

1. To analyze the sensing technique for detecting the level of pH water, water temperature, and water level. [R01]
2. To develop the automation system for farming lobsters to maintain the food supply and balance of the pH level water. [R02]
3. To develop IoT data logger system and automation system for lobsters farming which can monitored and controlled via Internet of Thing (IoT) platform. [R03]

1.4 Scope of Work

In order to develop this system, a prototype should be prepared. In order to accomplish it, scope of the project is summarized as table below:

Table 1:1: Scope of Project.

Hardware	• To analyze sensing technique for pH level, water level and water temperature. [R01] • To develop an automation system for smart feeder and smart pH adjustment. [R02] • To assemble the connection the sensor nodes, automation system and microcontroller as a device.
Software	• To program the microcontroller, connect to Cayenne IoT for real-time monitoring and automation system. [R03] • To establish communication between sensor nodes and microcontroller by program it to Arduino IDE. • To program the automation system for smart feeder and smart pH adjustment.
Test	• Set the device system at the pond of farming lobsters. • Collect the data pH value, water temperature and water level. • Control the automation system which is smart feeder and smart pH adjustment.
User	• Farmers monitoring via smart phone.

1.5 Significance of The Project

In this project, it mainly focuses to develop IoT data logger system and automation using NodeMCU-ESP32 with Cayenne IoT as a dashboard platform. Most of the work involves hardware (electronic and mechanical) and programming.

The ability to real-time monitoring the pH water, water temperature and water level in Internet of Thing (IoT) it reduces the effort for farmers from monitor it manually using the separated devices. The Internet of Things (IoT) platform show the data in value and the line graph. Farmers can navigate the data from line graph by minute, hour, day, months, and a year. This system stored data in the cloud storage which farmers can extract the data and analyze the data from time to time. Farmers can monitor it from any place from the web-based application via smart phone and personal computer. Besides that, the sensor for parameter of water is trigger will notify the farmers when the optimum range for this parameter of water out of the optimum range. Farmers also can monitor it live recording by using the portable camera that can access through mobile application via smart phones. The camera application will notify the farmers if the camera detects the motion and recorded it. Farmers can monitor the video in high-definition resolution and camera have 2 mode which is day mode and night mode.

The development the automation system can help farmers feed the lobsters anytime and anywhere with this system by simply click the button on the Internet of Things (IoT) platform. On the internet of things (IoT) platform, farmers can schedule the time for feeding the freshwater lobsters by the day, week, or months. Farmers can control the pH of water by simply click the button of probiotic injection. The probiotic solution is managed for water treatment to stabilize the pH of water and to avoid the freshwater lobsters from being vulnerable to diseases. Farmers can control this automation system which is feed the fish and adjust the pH water via smart phone by access the web-based application.

1.6 Thesis Structure

In this thesis, there will be five chapters to describe the flow project which is a smart aquaculture system and automation system for lobsters farming. The chapters in the thesis will be as follows: Introduction, Literature Review, Methodology, Result, Discussion, and Conclusion.

Chapter 1 - This chapter discussed the background of the study, problem statement, scope of work and objectives of project development.

Chapter 2 - This chapter consists of the background study and research about this project before assembling. Besides, the background study contains the fundamental of the conventional fertigation system and photosynthesis process and previous work that related to this project. Also, in this chapter, the differences between IoT platform Blynk, Cayenne IoT and Thing Speak will be briefly discussed.

Chapter 3 - This chapter involved the process employed during the project development in methodology part, including the equipment, materials used and assemble procedures for the smart aquaculture system and automation system for lobsters farming.

Chapter 4 – This chapter will explain detail about the result and discussion as well as analysis of the project after the assemble is done. Moreover, the sensing technique and automation of the system also will be defined.

Chapter 5 – This is the last chapter which is the conclusion of this project. The conclusion consists of the summary and recommendation for a better development that might be done in future.

CHAPTER 2

BACKGROUND STUDY

This chapter discusses the literature of several related journals, articles, and previous studies on the Data Monitoring system. The progress of the IoT Data Monitoring system is also discussed in this chapter.

2.1 Introduction

Aquaculture is the process of rearing, breeding, and harvesting of aquatic species, both animals and plants, in controlled aquatic environment like the oceans, lakes, rivers, ponds and streams such as freshwater lobsters farming for this project [2]. In Malaysia, freshwater lobsters farming has long been done since 2010. Most of farmers has culture the freshwater lobsters at the ponds and home [15]. The farmers culture the freshwater lobsters because it easy to growth within 7-8 months to achieve the length of body at 30 centimeters [15]. The cost to culture this species is not expensive as expected [15]. That is because the farmers culture this species to get more income or side jobs. A 1 kg of freshwater lobsters can get the around RM 160 [15]. Freshwater lobsters are highly demand in the global market [15].

Furthermore, freshwater lobsters farming is easy to maintain by monitor the parameters which is level of pH, water temperature and water level [15]. This species is polytrophic which is consume all of kind of food from the plants including grains to various types of animals in the waters [2].

There are parameters are needed to discuss which is level of pH, water temperature and water level. For the level of pH, as we known that the freshwater lobsters are live in the average of pH at the ranges 6-7. This range of pH water are the optimum pH for the freshwater lobsters to live. If the range below than that, this species will get diseases such as blister and parasite will grow on the body of this species [5]. Other than that, this species will die, and the ponds will get dirties which effect the other species to get same diseases. Next is the water temperature in the ponds need at the ranges 25-28°C for this species to live [15]. Most of farmers culture this species at home because it suitable in room temperature. Other parameters are water level in the ponds need at the range 20-30 cm for this species survive without electricity [15]. If the ranges below than that, this species will not get enough oxygen in the water and above from that ranges it difficult to monitor this species because the water so murky.

To improve all these parameters, this project will implement the IoT data logger and automation system for farmers to easy monitor from anywhere. For the IoT data logger it will develop real-time monitoring this parameter around the ponds while the automation system is to feed this species and to balance the pH if the pH water below of the ranges this species to live via internet of things (IoT) platform which can access through smart phones. There are sensor and electric components will be use in this project to implement this system to freshwater lobsters farming.

2.2 Sensing Technique for Detecting Level of Ph, Water Temperature and Water Level

2.2.1 Sensing Technique for Detecting Level of Ph Water

The first parameters for monitoring system are the level of pH water. The pH is an important parameter for measuring the water quality, and the pH affects the growth and reproduction of aquatic animals [8] [2] [7].

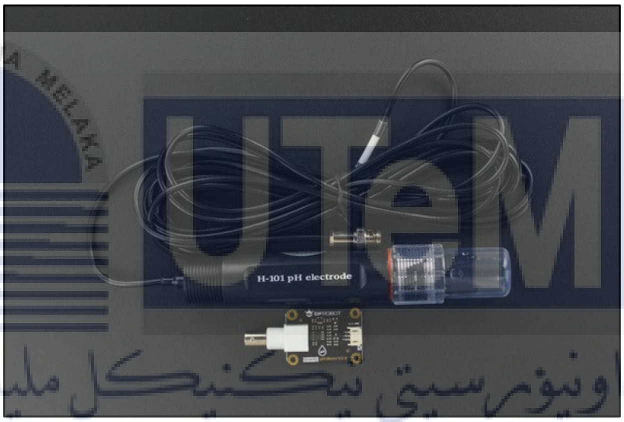

Figure 2.1: pH Sensor.

The pH sensor is analog liquid sensor and use for the to collect the data for IoT data logger system [14]. There are two part of pH sensor are come with the board part and probe part. the board parts usually the same circuit board for connecting the microcontroller. So, the process of setting up and using them is the same for both.

Furthermore, the probe part has different in term of cost and durability. The standard one usually has low life and probe cannot be used continuously. For the pro version, it expensive and the probe can be immersed in liquids for long period time [].

Based on the difference of pH probe between pro and standard, the standard will be use in this project to collect the data of pH level water by monitoring the data via internet of thing (IoT) platform.

2.2.2 Sensing Technique for Detecting Water Temperature

Temperature testing is the process of measuring temperature levels in water. This second parameter is important because aquatic organism depend on temperature ranges for their health [15].

Figure 2.2: DS18B20 Water Temperature Sensor.

For testing the water temperature, the temperature sensor will be used for this project. Water temperature sensor comes usually in two form factors, for the first form factors it comes exactly like an ordinary transistor and second form comes with the waterproof probe style which can measure something far away, underwater or under the ground [4]. In this case, to find the suitable sensor that need to immerse in the water. The waterproof temperature sensor with waterproof probe style will be use in this project for testing and collect the data by monitoring via internet of thing (IoT).

2.2.3 Sensing Technique for Detecting Water Level

To detect the water level at the ponds, the ultrasonic sensor will be used for this project. There are many requirements for measuring the level of water in applications such as flumes, weirs, pipes, tanks, wells, basins, and cooling towers. In operation, the sensor is mounted over the water. to determine the distance to the water, it transmits a sound pulse that reflects from the surface of the water and measures the time it takes for the echo to return [6].

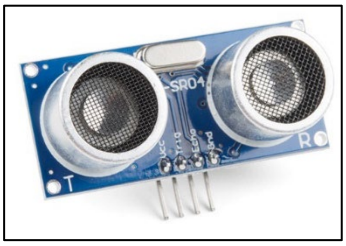

Figure 2.3: Ultrasonic Sensor.

From the observation, this species lives in the ponds not making so much interference. The surface of water less ripple and this sensor will produce echo direct to surface of water to reflect the echo to return it to the trigger and send the signal to the microcontroller which contain the measurement of distance water level. The farmers can monitor the water level from smart phone via internet of things.

2.3 Smart Feeder System

To reduce the manpower and increase the efficiency to feed the freshwater lobsters will be doing this smart feeder system. the problem for farmers is needed to feed this species every day at least once a day for culture this species [16]. If the farmers got no time to feed this species it will eat each other. To avoid this situation, happen the implementation of this system will simplify the workload of those farmers.

This system consists of 2 components which is the mechanical and food case. For the mechanical components will be use the servo motor. Servo motor will be used to control the dispense of the food. This servo will rotate from 0-180 and return to the origin [16]. This servo will attach to the next component which is food case. This food case is special made out from the 3D printing. With the special mounted for servo to control the food dispense and the case act as the food storage. To control the servo this system will be connected to the microcontroller and connected to the internet of things (IoT). The farmers can control via smart phone by sent the input which is press button on the screen smart phone to send the data through microcontroller. The servo will be trigger and the servo start to rotate for food to dispense.

2.4 Smart pH Adjustment

To maintain the pH water back if the amount of ammonia is high inside the ponds will tend to pH water to be drop [2]. It will make the water in the pond's is acidity state. To balance the pH water or adjust the pH water, the farmers need to put the solution inside the ponds. The solution use for farmers to balance the pH is probiotic solution in figure 2.4. To implement the smart pH adjustment in this project some of the components will be used for this project [9]. The components will be use is water pump because it will flow the probiotic solution through the bottle case into the ponds. There is bottle contain with the probiotic solution will connect to the water pump and then water pump starts the process to transfer the probiotic solution to the ponds. This water pump is connected to the microcontroller. The farmers can control the water pump via smart phones through Internet of Things (IoT). The farmer will send the input data in order the water pump to operate. The water pump will trigger once it gets the data from farmer and start the process to balance the pH water.

Figure 2.4: Probiotic Solutions.

2.5 Internet of Thing (IoT) Platform for IoT Data Logger System and Automation System

2.5.1 IoT Infrastructure

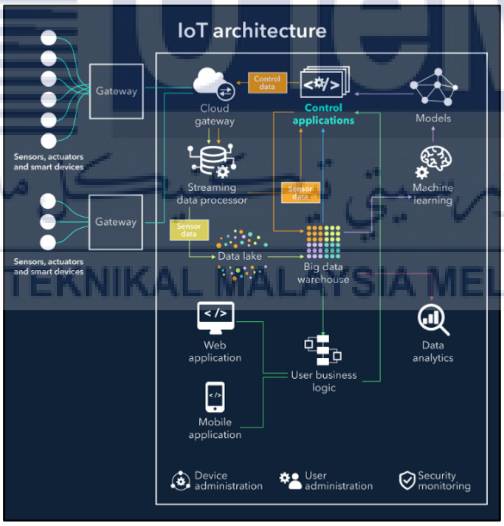

Figure 2.5: IoT Architecture.

The IoT infrastructure can be classified into 3 stages as shown in figure the sensors/actuator, the IoT gateway and data centre/cloud [11].

For the stage 1, the sensors collect data from an object or the environment and turn it into the useful and meaningful data. On the other hand, the actuator changes the physical conditions that generate data. For an instance, shut off a power supply, adjust an air flow valve etc. this stage enables many IoT applications such as camera module in monitoring system, air quality monitoring and temperature control [3]. For the information, the sensors network can be wired or wireless with their strength and limitations, respectively. Since the data is the core of the IoT technology, the data processing is important, and it can occur in all three stages. However, the data processing in sensors are limited by the processing power of the devices that the sensors attached to. Thus, a more extensive processing would be made in stage 2 or stage 3. [11]

Furthermore, for the stage 2, the sensor nodes will send the data to a central location via direct connection to the internet through a Wi-Fi-router. The central location that aggregates the raw data generated by during the stage 1 is called an IoT gateway. The IoT gateway works by receiving data from IoT sensors, which it can then send inwards to the cloud; it also receives information from the cloud which then forward it back to the actuator to help it performs some control functions such as regulating environmental changes. All in formation moving from stage 1 to stage3, or vice versa, goes through the connected IoT gateway. By managing this connection, the gateway can perform security tasks, help manage devices and translate protocols.[11]

Lastly, stage 3 refers to the data centre or cloud. Data that needs more in-depth processing are forwarded to physical data centre or cloud-based systems, where more powerful IT systems can analyze, mange, and securely store the data. Besides that, the integration of the dashboard service with the cloud enables the visualization of those data to the user.[11]

2.5.2 Cayenne IoT

Cayenne is an IoT project builder for developers, designers, engineers, or students and can be used in different IoT applications. It has cloud-based web applications as well as mobile apps for Android and IOS devices. Both the web and mobile apps have a main graphical user interface called dashboard.[3]

The Cayenne mobile apps can be used to monitor, and control remotely located physical devices. The Cayenne dashboard contains widgets that can be configured to visualize data, create rules, schedule events, and make notification rules and more. [3] [13]

The Cayenne platform can be used to connect different kinds of sensors, lights, motors, valves, relay, and generic actuators. It also supports the raspberry pi, Arduino, esp32, Lora devices and other development boards. [3]

The Cayenne IoT cloud uses Cayenne MQTT API to connect devices. This lightweight protocol enables smooth transfer of data. MQTT is designed especially for IoT applications where there is a constraint of computing resources, battery power and bandwidth. [13]

The Cayenne cloud acts as a broker and manages the different sensors and actuators (publishers). The application running on the cloud act as subscribers that will receive data about events that the subscribed to. Figure below shows how the MQTT broker as Cayenne cloud send the data. [13]

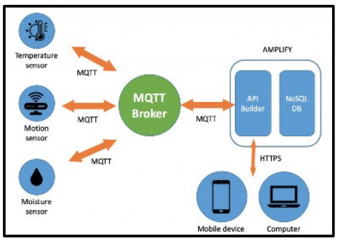

Figure 2.6: MQTT Protocol.

The client devices used in this project interact with the MQTT broker (Cayenne cloud) using the C++. When establishing MQTT connection between devices and the Cayenne cloud, the MQTT credentials; MQTT username, MQTT Password and Client ID are used. The values for each credential need to be included in the code (C++ in Arduino IDE) on the esp32. When the program with the MQTT parameter is compiled and run on the esp32, an MQTT connection is established, and data transfer starts. When new devices are added, these MQTT credentials from online dashboard need to be used again. This ensure that the devices is connected to the correct account. [13]

2.5.3 NodeMCU-ESP32

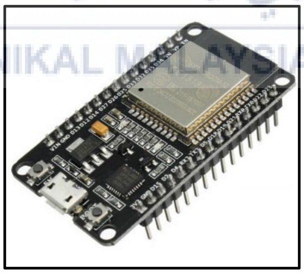

Figure 2.7: NodeMCU-ESP32.

The esp32 is a series of low-cost, low-power system on a chip microcontroller with integrated WI-FI and dual-mode Bluetooth. It acts as an important platform to develop the IoT project.[1]

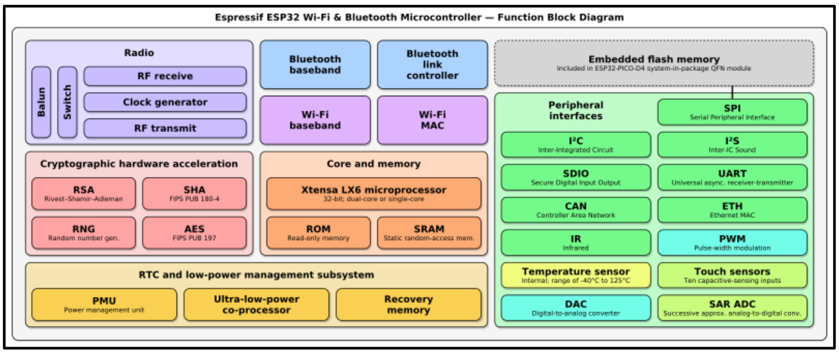

Figure 2.8: NodeMCU-ESP32 Function Block Diagram.

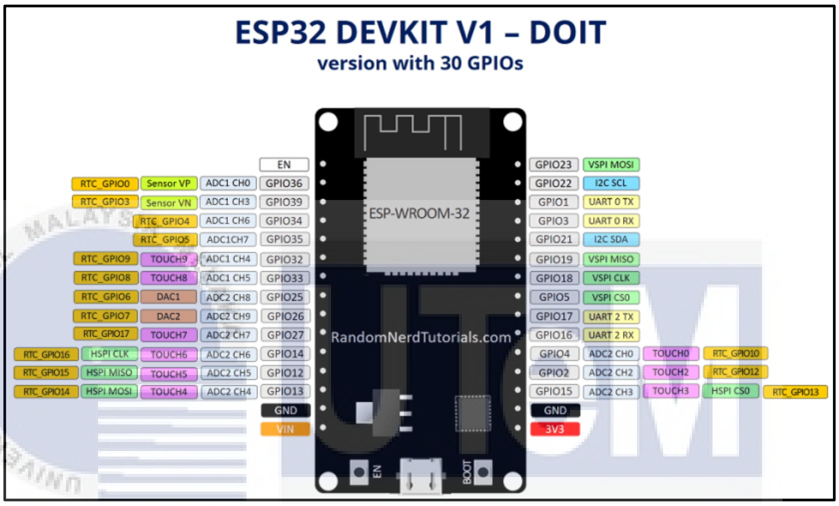

Figure 2.9: NodeMCU-ESP32 GPIO.

The NodeMCU-ESP32 is having 40 GPIO pins. It provides 2.2V~3.6V power DC power. The NodeMCU-ESP32 support many protocols which is ASIO, ESP-MQTT, ESP-TLS, HTTP CLIENT, HTTP SERVER, HTTPS Server, ICMP Echo, Local Control, mDNS, Modbus, Websocket Client, ESP Serial Slave Link, Certificate Bundle, and IP Network Layer. For this project, the protocol will be use is ESP-MQTT. [1]

The Message Queue Telemetry Transport (MQTT) is defined as machine-to-machine(M2M)/internet if things (IoT). The MQTT protocol has client and a broker. MQTT clients subscribe to, and publish on, topics. The MQTT clients communicate to one another through an MQTT Broker, which is primarily responsible for receiving all messages, filtering them, deciding who is interested in it and then sending the message to all subscribed clients [1]. Below is a diagram displaying three clients and a broker. The current temperature is published by the temperature sensor client on the 'temp' issue. Since they subscribed to the "temp" subject, the computer and mobile device clients receive this temperature reading. Connections and message communications are handled by the Broker. [13]

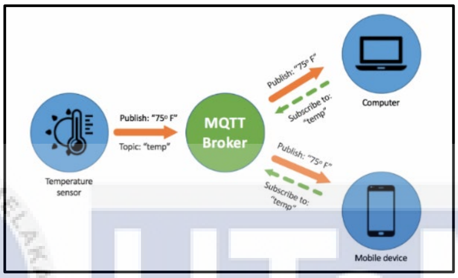

Figure 2.10: MQTT Protocol.

MQTT clients, via the MQTT Broker, connect with each other. However, when the temperature falls below a certain value, one might want to store temperature readings in a database or even send a push notification to a mobile app. [13]

2.6 Review Existing Systems/Applications

2.6.1 Design and Development of Smart Aquaculture System Based on IFTTT Model and Cloud Integration

Based on this research (Dzulqornain, M. I., Al Rasyid, M. U. H., & Sukaridhoto, S. (2018)), this research focus on the monitoring water quality and the way to increase the quality of the water quickly and efficiently [4]. The implementation a real-time monitoring and controlling system for aquaculture based on if this then that (IFTT) model and cloud integration. The data is collected with using smart sensor which is sensor dissolved oxygen, potential of hydrogen, water temperature and water level for real-time monitoring. The aeration system is microcontroller NodeMCU-ESP32 V3, relay, power supply, and propeller that can produce oxygen. The system could set the IFTTT rules for the ideal water condition for the pond in any kinds of aquaculture based on its needs through the web and android application. The experimental result shows that use IFTTT model makes the aquaculture monitoring system more customizable, expandable, and dynamic.

2.6.2 Need of Water Quality Monitoring in Shrimp Culture

Shrimp is an aquatic animal with sensitive habitat. The researcher measure, record and manage the water quality index for shrimp through all four seasons (Mohan Allam, 2015). The changing of the season changes the environment of habitat. By using the parameters such as pH, temperature, dissolved oxygen hardness and ammonia to measure the effect of respiration, feeding metabolism and reproduction of shrimp. The water quality determines the ultimate success and failure of aquaculture. The research using Raspberry pi 3 for microcontroller for collecting and transmit the data. The data will send to the mobile application for tracing and analyses the condition of shrimp.

2.6.3 Temperature and Humidity Monitoring Using DHT22 Sensor and Cayenne API

Based on this research (Adhiwibowo, W., Daru, A. F., & Hirzan, A. M. (2020)), this research designs an automatic monitoring system based on internet of things technology which utilizing the DHT22 sensor and Cayenne API as information retrieval medium to the computer. The processing board that uses in this project is raspberry pi. This device will connect to the internet through wireless connectivity and send the captured information by the sensor to the farmers. The stored data from the cultivation can be exported as a CSV format if the farmers want to check the temperature and humidity statistic. The retrieved information from the sensor also displayed on the LCD attached to the device to ease the information reading near the cultivation.

2.6.4 Implementation of Smart Aquarium System Supporting Remote Monitoring and Controlling of Functions Using Internet of Things

Based on this research (Junaid Khan1 , Onib-Ur-Rehman1 , Zafran Jalil1 , Sikandar Ali1 , Abdul Samad Danish2, (2019)), this research project is the mechanical feed design, fish feeding over the internet and remote monitoring of all the parameters. The parameters include feed level, water temperature, pH, and water level. They can be accessed through a website on a computer or through the app on phone. This task is achieved using NodeMCU v1.0, Cayenne and Arduino mega2560 for the implementation of IoT. This is supposed to reduce human efforts and errors in owning an aquarium full of aquatic animals.

2.6.5 An IoT Based Innovative Real Time pH Monitoring and Control of Municipal Wastewater for Agriculture and Gardening

Based on this research (Khatri, N., Sharma, A., Khatri, K. K., & Sharma, G. D. (2018)), the development of the internal of things (IoT) based innovative real time pH monitoring and control of municipal wastewater for agriculture and gardening application. The green revolution in India, water requirement is increased exponentially in all sectors viz. agriculture, gardening, industry etc. The demand and supply relationship are very essential for every country in present time and is also a big challenge to satisfy this requirement around the world. Regular change in the climate and the urbanization makes the lavish use of the available resources has exhausted the available resources. Water is necessary for the survival of the human being on the earth. So, for the survival the conservation and management of the available water resource are also equally important. The development of interdisciplinary kind work that includes the sample collection and online raw calculation, analysis, control through the chemistry and computer programming. Thus, the water quality for the agriculture and gardening is to maintain the pH of treated municipal wastewater.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter introduced detail for the sensor, automation system and internet of thing (IoT) for the project. The block diagram, flow chart, hardware development and cost. Hence the procedure of the project will be elaborated in this chapter.

3.2 Block Diagram

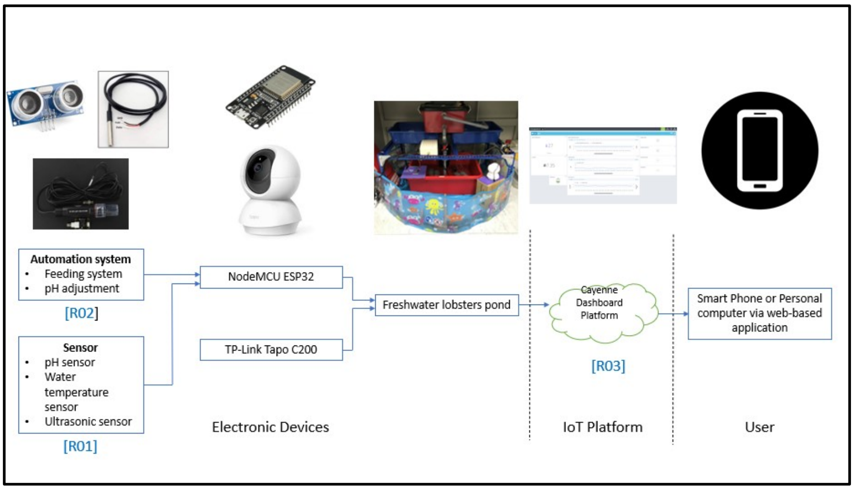

Figure 3.1: Block Diagram.

Shows the functioning block diagram for lobster's pond monitoring system. There are electronic devices used in this research which is sensor part and automation system. For the sensor parts, temperature sensor, pH sensor and ultrasonic sensor will be connected to the NodeMCU-ESP32 board and for automation system will be used servo motor for the automation feeding and pH adjustment will use the water pump to flow the probiotic solution from the bottle to the inside of the ponds is also connect to NodeMCU-ESP32 board. The NodeMCU-ESP32 board with the connection the automation parts and sensor parts are put in the waterproof case near to the ponds to avoid the board exposed of the presence of water. TP-Link Tapo C200 as the monitoring live recording video inside the freshwater lobster's pond. NodeMCU-ESP32 will sent the data as an input and output to the IoT system which use in this project is Cayenne IoT. Cayenne IoT will show the data through the dashboard platform and can be access through smart phone and can control the automation system from the smart phone via web-based application. To communicate the NodeMCU-ESP32 and Cayenne IoT, the board need the internet access to send the data input and output.

3.3 Flowchart

Shows the overall flowchart of project. The main process includes the sensor parts and automation parts. The process shows how the operation conducts for the operation to operate functional.

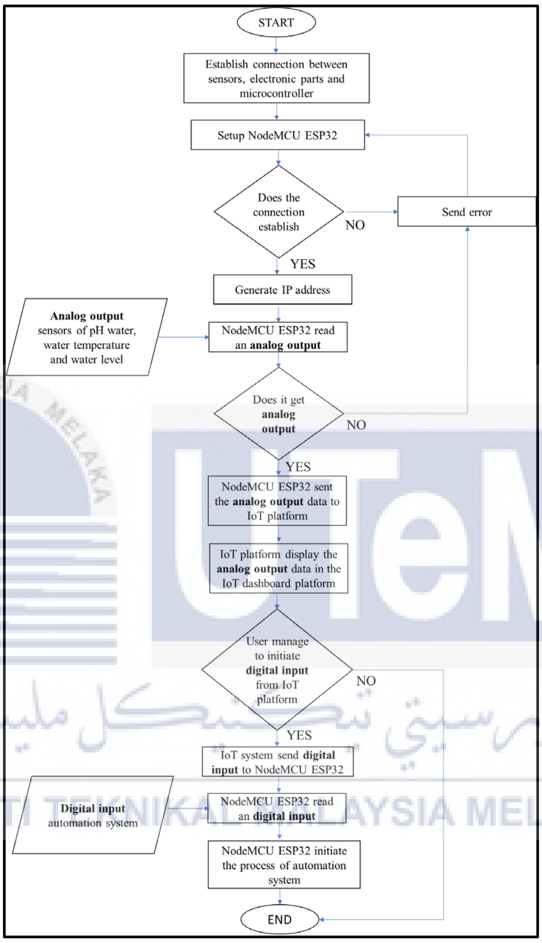

Figure 3.2: Project Flowchart.

For the hardware setup the circuit contain 3 sensors and 2 automation parts which are temperature sensor, pH sensor, ultrasonic sensor, servo motor and dc12v pneumatic water pump that will be connected to NodeMCU-ESP32 board. The functions of the process need to be function as they communicate with each other for transmit the data over the internet of things (IoT).

1. Establish the connection between the NodeMCU-ESP32 and internet connection. Once the connection establishes the ip address is generate.
2. The sensor will collect the data to the NodeMCU-ESP32 and will appear the value of pH value, temperature, and water level.
3. Farmers can monitor and control use the internet of things via smart phone. User can control the water pump and servo by trigger the button on screen. The data will send to microcontroller and start to execute the process.

3.4 Detail Description of The Research Methodology

3.4.1 Research Hardware

The hardware used in this project is described in sub-sections below.

3.4.1.1 NodeMCU-ESP32

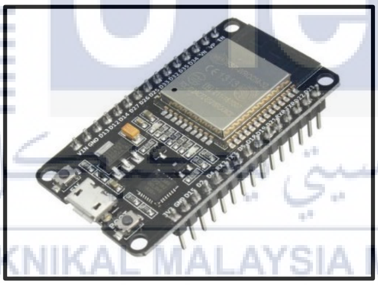

Figure 3.3: NodeMCU-ESP32.

The main controller for this project is NodeMCU-ESP32. NodeMCU-ESP32 is simple circuit platform based on I/O port that implements of processing language. It is programmed by using the Lua scripting language. The platform is based on eLua open-source projects. The platform uses a lot of open-source projects, such as lua-cjson, spiffs. This ESP32 NodeMCU-ESP32 contains firmware that can run on ESP32 Wi-Fi SoC chips and hardware-based on ESP-32S modules. NodeMCU-ESP32 is used for controlling the pH sensor, ultrasonic sensor and temperature sensor for collecting data and store the data.

NodeMCU-ESP32 is an open-source IoT platform. The NodeMCU-ESP32 is open source which can be controlled an analogue and digital in physically control and digitally. The tables below show the characteristics of NodeMCU-ESP32.

Table 3:1: NodeMCU-ESP32 Specification.

Type microcontoroller	Esp-wroom-32 module
Operating voltage	2.2v ~ 3.6v
Operating current	Average:80 ma
Operating temperature	-40~+85
Wifi frequency range	2.4~2.5ghz
Module interface	SD card, UART, SPI, SDIO, I2C, LED PWM, Motor PWM, I2S, IR
	GPIO, capacitive touch sensor, ADC, DAC, LNA pre-amplifier
Flash memory	4Mbyte
Clock speed	40mhz

3.4.1.2 Ultrasonic Sensor

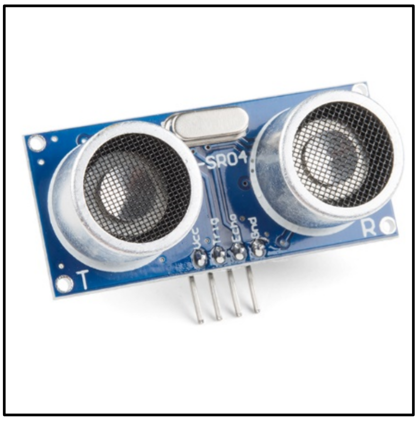

Figure 3.4: Ultrasonic Sensor.

This is the HC-SR04 ultrasonic distance sensor. This economical sensor provides 2cm to 400cm of non-contact measurement functionality with a ranging accuracy that can reach up to 3mm. Each HC-SR04 module includes an ultrasonic transmitter, a receiver and a control circuit.

Table 3:2: Ultrasonic Specification.

Voltage	5v dc
current	15Ma
Measure angle	15°
Ranging distance	2cm-4m

3.4.1.3 Temperature Sensor

Figure 3.5: DS18B20 Water Temperature.

The type of temperature sensor use is DS18B20 model. The process of measuring temperature levels in the water. Temperature affects the dissolved oxygen levels in the water, the rate of photosynthesis, metabolic rates of organisms. The temperature sensor is measuring temperature rates between -55°C to +125°C. The circuit provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function.

Table 3:3: DS18B20 Water Temperature Specification.

Voltage	Usable with 3.0V to 5.5V
Accuracy	±0.5℃ Accuracy from -10℃ to +85℃
Temperature	-55℃ to 125℃
Pin	Uses 1-wire interface- require only one digital pin for communication
Length	90cm
Diameter	4mm

3.4.1.4 pH Sensor

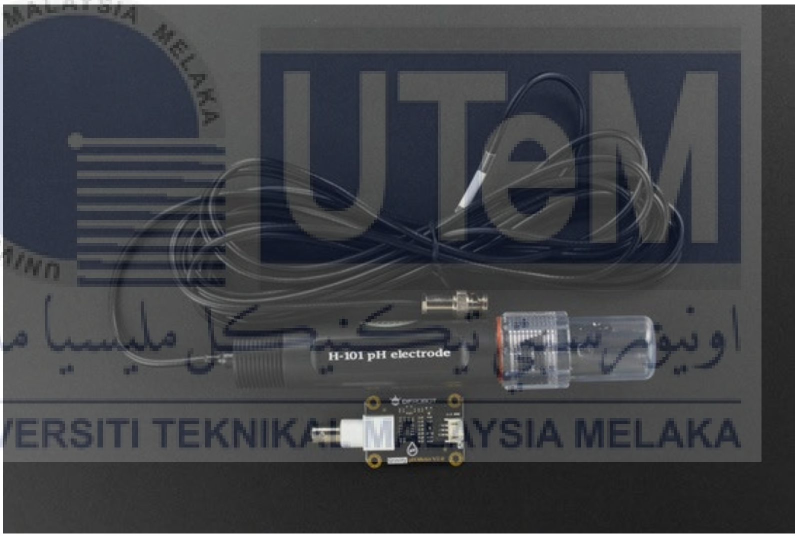

Figure 3.6: pH Sensor.

This Gravity: Analog pH Sensor/Meter Kit V2 is specifically designed to measure the pH of the solution and reflect the acidity or alkalinity. It is commonly used in various applications such as aquaponics, aquaculture, and environmental water testing.

The pH is a value that measures the acidity or alkalinity of the solution. It is also called the hydrogen ion concentration index. The pH is a scale of hydrogen ion activity in solution. The pH has a wide range of uses in medicine, chemistry, and agriculture. Usually, the pH is a number between 0 to 14. Under the thermodynamic standard conditions, pH=7, which means the solution is neutral; pH<7, which means the solution is acidic; pH>7, which means the solution is alkaline.

Table 3:4: Signal conversion board (transmitter)

Supply voltage	3.3~5.5V
Output voltage	0~3.0V
Probe connector	BNC
Signal connector	PH2.0-3P
Measurement accuracy	±0.1@25℃
dimension	42mm*32mm

Table 3:5: pH probe

Protype	Industrial grade
Detection range	0~14
Temperature range	0~60℃
Accuracy	±0.1pH (25℃)
Response time	<1min
Internal resistance	<250MΩ
Cable length	500cm

3.4.1.5 Servo Motor

Figure 3.7: Servo Motor.

Micro size's metal gear RC servo with 1.80kg.cm holding torque (at4.8V). the advantage of RC servo over the DC brush motor is the ability to control its rotation angle. This servo motor use to control the feeding automation. This servo will attach to the feeding case. It can control open/close the food coming out.

Table 3:6: Servo Motor Specification.

Operating voltage	4.8-6V
Speed at 4.80V(no load)	0.1 s/60°
Torque at 4.80V	1.8 kg.cm (~0.1765 N.m)
size	22.3mm*11.8mm*28.3mm
Weight	16g
Rotation angle	180°
Wiring	• brown = GND • Red = 5V • Orange = output/signal

3.4.1.6 DC 12V Pneumatic Diaphragm Water Pump

Figure 3.8: Water Pump.

This DC6-12V MINI Aquarium water Pump is the perfect choice for any project that requires water to be moved from one place to another. When pumping a liquid, the pump runs very quietly. It works quietly with the sound level under 30db. The pump is also capable of pumping air, though when pumping air, the pump is quite noisy in comparison. The pump has a filter inside as well as a suction cup which can help stick it to smooth surfaces tightly. This waterpump use to transfer the probiotic solution to keep the lobster's pond at the optimum range.

Table 3:7: Water Pump Specifications.

Operating voltage	6~12V
Operating current	0.5A~0.7A
size	90mm*40mm*35mm
Outlet diameter	6 mm
External diameter	8.5 mm
Weight	110g
Flow rate	1.5~2L / min
Water flow temperature	Up to 80℃

3.4.1.7 TP-LINK TAPO C200

This product compact with feature and affordable to have. TP-LINK TAPO C200 camera use for monitoring the lobsters' pond via smart phone application. This device comes with the high-definition video quality and audio which is 2-way communication. furthermore, wireless technologies are implemented to this device which is farmers can monitor it anywhere at any anytime. Connection of this devices is Wi-Fi connection. Below are the specification and feature for this device.

Table 3:8: TP-LINK TAPO C200 Specification

Network	Security	128-bit AES encryption with SSL/TLS
	Wireless Rate	• 11Mbps (802.11b) • 54Mbps (802.11g) • 150Mbps (802.11n)
	Frequency	2.4 GHz
	Wireless Security	WPA/WPA2-PSK
Activity notification	Input Trigger	Motion detection
	Output Notification	Push notification
Video	Video Compression	H.264
	Frame Rate	15fps
	Video Streaming	1080p
System	Regulatory Certification	FCC, IC, CE, NCC
	System Requirements	IOS 9+, Android 4.4
Environment	Operating Temperature	0°C~40°C (32°F~104°F)
	Storage Temperature	-40°C~70°C (-40°F~158°F)
	Operating Humidity	10%~90%RH non-condensing
	Storage Humidity	5%~90%RH non-condensing
Hardware	Button	Reset button
	Indicator LED	System LED
	Adapter input	100-240VAC, 50/60Hz, 0.3A
	Adapter Output	9.0V/0.6A
	Dimension (W x D x H)	3.4 x 3.3 x 4.6 in. (86.6 x 85 x 117.7 mm
Camera	Image Sensor	1/2.9“
	Resolution	1080p Full HD
	Lens	F/NO: 2.4; Focal Length: 4mm
	Night vision	850 nm IR LED up to 30 ft
	Video range	360° horizontal, 114° vertical
audio	Audio Communication	2-way audio
	Audio Input & Output	Built-in microphone and speaker

3.4.1.8 Material and Equipment

The materials and equipment used in processing this project are listed below. The table showed that the name of item and price on market.

Table 3:9: Bill of material

Item	Quantity	Price (total)
pH sensor	1	RM 380
Temperature sensor	1	RM 20
Ultrasonic sensor	1	RM 4
Servo motor	1	RM 16
Water pump	1	RM 15
Esp32 module, electronic and mechanical components	-	RM 200

3.4.2 Research Software

The software used in this project is described in sub-sections below.

3.4.2.1 myDevice Cayenne IoT platform

Figure 3.9: myDevices Cayenne IoT platform.

myDevice Cayenne is an online IoT dashboard that takes most of the complication out of creating hardware-oriented programming. myDevice Cayenne allows to quickly design, prototype, and visualize IoT solutions. Can be use Cayenne as a tool to virtualize real-time and historical data, sent over the things network.

3.4.2.2 Arduino IDE

Figure 3.10: Arduino IDE software.

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other opensource software. Arduino consists of both a physical programmable circuit board (microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on computer, used to write and upload computer code to the physical board.

3.4.2.3 Fritzing

Figure 3.11: Fritzing circuit development software.

Fritzing is an open-source hardware initiative that makes electronic accessible as a creative material for anyone. They offer a software tool, community websites and services in the spirit of processing and Arduino, fostering a creative ecosystem that allows users to document their prototypes, share them with others and layout and manufacture professional PCB.

3.4.2.4 Blender

Figure 3.12: Blender design application software.

Blender is a free and open-source 3D computer graphic software toolset used for creating animated films, visual effects, art, 3D printed models, motion graphics, interactive 3D applications, virtual reality and computer games. Blender's features include 3D modelling, UV unwrapping, texturing, raster graphics editing, rigging and skinning, fluid and smoke simulation, particle simulation, sculpting animation, match moving, rendering, motion graphics, video editing, and compositing.

3.4.2.5 Microsoft Excel

Figure 3.13: Microsoft Excel software.

Microsoft Excel is an electronic spreadsheet program that is applied to store, organized, and manipulate data. All data for this research project is imported to the Microsoft Excel to be analyzed.

3.4.2.6 Cura Ultimaker

Figure 3.14: Cura Ultimaker 3D modelling simulation.

Cura is an open-source slicing application for 3D printers. Ultimaker Cura works by slicing the user's model file into layers and generating a printing-specific g-code. Once finished, the g-code can be sent to the printer for the manufacture of the physical object. The open-source software, compatible with the most desktop 3D printers, can work with filles in the most common 3D formats such as STL, OBJ, X3D, 3Mf as well as image file formats such as BMP, GIF, JPG, and PNG.

3.4.2.7 IFTTT

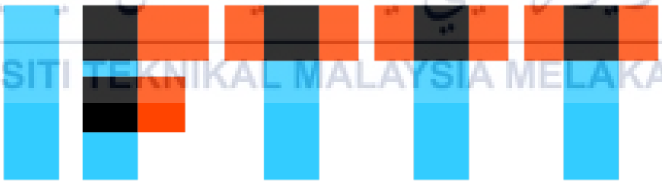

Figure 3.15: IFTTT web-based application.

IFTTT is a freeware web-based service that creates chains of simple conditional statements, called applets. An applet is triggered by changes that occur within other web services. IFTTT is easier to use because of user-friendly and already combine with Webhook. Webhook is a way for an application to provide other applications with real-time information. A Webhook delivers data to other applications immediately.

3.4.2.8 Telegram

Figure 3.16: Telegram application.

Telegram is a freeware, cross-platform, cloud-based instant messaging (IM) software. The service also provides end-to-end encrypted video calling, VoIP, file sharing, webhooks bots, multiple device access and several other features. It can be used for Internet of Things (IoT) services with two-ways interaction for IFTTT implemented within Telegram by integrating the webhooks functionality with IoT provider such as myDevice Cayenne Platform.

3.5 Software Development

The software used in this project is described in sub-sections below.

3.5.1 Arduino IDE

There is software development which been used in this project. Arduino ide software is used to writes and uploads the program for the sensor and automation system to be function. The code is written in c++ and be downloading in the microcontroller chip to be run. This code contains Part of which are for ph sensor, temperature sensor, ultrasonic sensor, servo motor and DC 12V pneumatic diaphragm water pump.

3.5.1.1 Connection between NodeMCU-ESP32 and Cayenne IoT

To achieve the communication between esp32 and Cayenne IoT the code is developed in Arduino IDE. The connection between them must follow the protocol that microcontroller provide. The protocol that uses to establish this the connection between them is MQTT protocol. The protocol must state in the declaration state.

```
//#define CAYENNE_DEBUG
#define CAYENNE_PRINT Serial
#include <CayenneMQTTESP32.h>

// WiFi network info.
char ssid[] = "ssid";
char wifiPassword[] = "wifiPassword";

// Cayenne authentication info. This should be obtained from the Cayenne Dashboard.
char username[] = "MQTT_USERNAME";
char password[] = "MQTT_PASSWORD";
char clientID[] = "CLIENT_ID";


void setup() {
  Serial.begin(9600);
  Cayenne.begin(username, password, clientID, ssid, wifiPassword);
}

void loop() {
  Cayenne.loop();
}

// Default function for sending sensor data at intervals to Cayenne.
// You can also use functions for specific channels, e.g CAYENNE_OUT(1) for sending channel 1 data.
CAYENNE_OUT_DEFAULT()
{
  // Write data to Cayenne here. This example just sends the current uptime in milliseconds on virtual channel 0.
  Cayenne.virtualWrite(0, millis());
  // Some examples of other functions you can use to send data.
  //Cayenne.celsiusWrite(1, 22.0);
  //Cayenne.luxWrite(2, 700);
  //Cayenne.virtualWrite(3, 50, TYPE_PROXIMITY, UNIT_CENTIMETER);
}

// Default function for processing actuator commands from the Cayenne Dashboard.
// You can also use functions for specific channels, e.g CAYENNE_IN(1) for channel 1 commands.
CAYENNE_IN_DEFAULT()
{
  CAYENNE_LOG("Channel %u, value %s", request.channel, getValue.asString());
  //Process message here. If there is an error set an error message using getValue.setError(), e.g getValue.setError("Error message");
}
```

Figure 3.17: NodeMCU-ESP32 connection with Cayenne IoT coding.

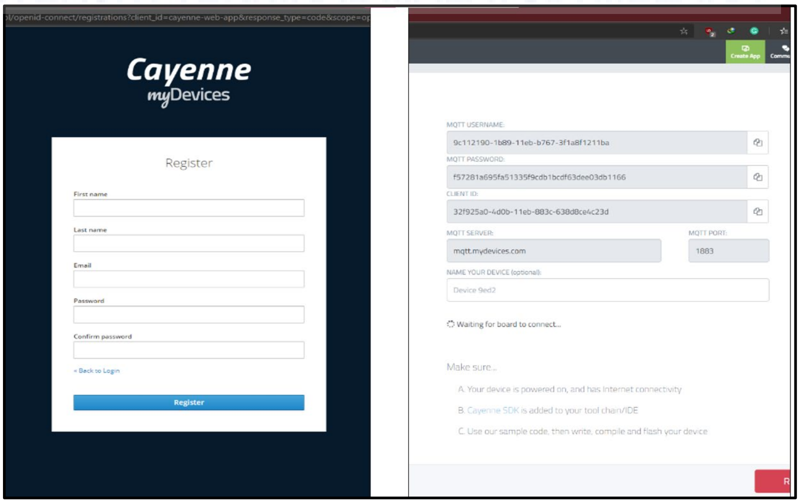

Figure 3.18: Cayenne IoT MQTT_username, MQTT_password and Client ID.

3.5.1.2 pH and Water Temperature Code

The pH sensor and water temperature sensor data are taken for analog data. It will need to be calculated by using the algorithm stated in the code. the virtual channel is set as 6 and will show up in the dashboard platform. The virtual channel for pH sensor is set to 6 while the virtual channel for the water temperature is set to 1 then both pH sensor and water temperature will show up in the myDevices Cayenne platform. The #include <DallasTemperature.h> is stated as temperature type which is DS18B20 and #include <OneWire.h> as the wire input for DS18B20. Temperature sensor is digital sensor, and then the algorithm for the temperature sensor is direct as the data input to be taken form the sensor and display to the application. the virtual channel is set as 1 and will show up in the dashboard platform.

```
#define CAYENNE_DEBUG
#define CAYENNE_PRINT Serial
#include <CayenneMQTTESP32.h>
#include <ESP32Servo.h>
#include "DFRobot_ESP_PH.h"
#include "EEPROM.h"
#define ESPADC 4096.0   //the esp Analog Digital Convertion value
#define ESPVOLTAGE 3300 //the esp voltage supply value
#define PH_PIN 35    //the esp gpio data pin number
#include <OneWire.h>
#include <DallasTemperature.h>
#define VIRTUAL_CHANNEL

const int oneWireBus = 5;
OneWire oneWire(oneWireBus);
DallasTemperature sensors(&oneWire);

DFRobot_ESP_PH ph;

unsigned long int avgValue; //Store the average value of the sensor feedback
float voltage, phValue, temperature = 25;

char ssid[] = "mazeband"; //"TP-Link_41C9";
char wifiPassword[] = "Badin0509"; //"Research_6";

char username[] = "9c112190-1b89-11eb-b767-3f1a8f1211ba";
char password[] = "f57281a695fa51335f9cdb1bcdf63dee03db1166";
char clientID[] = "5b5fd4e0-255f-11eb-883c-638d8ce4c23d";

void setup()
{
 Serial.begin(115200);
 Cayenne.begin(username, password, clientID, ssid, wifiPassword);
 sensors.begin();
 EEPROM.begin(32);//needed to permit storage of calibration value in eeprom
 ph.begin();
}

void loop()
{
  Cayenne.loop();


  static unsigned long timepoint = millis();
  if (millis() - timepoint > 1000U) //time interval: 1s
  {
    timepoint = millis();
    //voltage = rawPinValue / esp32ADC * esp32Vin
    voltage = analogRead(PH_PIN) / ESPADC * ESPVOLTAGE; // read the voltage
    Serial.print("voltage:");
    Serial.println(voltage, 4);

    temperature = readTemperature();  // read your temperature sensor to execute temperature compensation
    Serial.print("temperature:");
    Serial.print(temperature, 1);
    Serial.println("^C");

     phValue = ph.readPH(voltage, temperature); // convert voltage to pH with temperature compensation
     Serial.print("pH:");
     Serial.println(phValue, 4);
  }
  ph.calibration(voltage, temperature);
}

float readTemperature()
{
  sensors.requestTemperatures();
  return sensors.getTempCByIndex(0);
}

CAYENNE_OUT(VIRTUAL_CHANNEL 14)
{
  Cayenne.virtualWrite(VIRTUAL_CHANNEL 14, phValue);
}

CAYENNE_OUT(VIRTUAL_CHANNEL 1)
{
   Cayenne.celsiusWrite(VIRTUAL_CHANNEL 1, sensors.getTempCByIndex(0));
}
```

Figure 3.19: NodeMCU-ESP32 and Water Temperature coding.

3.5.1.3 Ultrasonic Sensor Code

The ultrasonic data is taken for analog data. The data will show as the range in centimeter (cm) where the sensor is face towards the water. The data will show up in the dashboard platform as the GUI (graphical interface unit). the virtual channel is set as 7 and will show up in the dashboard platform.

```
#define CAYENNE_DEBUG
#define CAYENNE_PRINT Serial
#include <CayenneMQTTESP32.h>
#define VIRTUAL_CHANNEL
#include <UltrasonicSensor.h>

UltrasonicSensor ultrasonic(14,12); // Assign Trig PIN 14(D5),Assign Echo PIN 12(D6)

int GIu_Ultrasonic_Dist_CM=0;

char ssid[] = "kamzan@unifi";
char wifiPassword[] = "0104595102@kamzan";

char username[] = "9c112190-1b89-11eb-b767-3f1a8f1211ba";
char password[] = "f57281a695fa51335f9cdb1bcdf63dee03db1166";
char clientID[] = "5b5fd4e0-255f-11eb-883c-638d8ce4c23d";

void setup()
{
 Serial.begin(115200);
 Cayenne.begin(username, password, clientID, ssid, wifiPassword);
 sensors.begin();


 void loop()
{
  Cayenne.loop();
}
CAYENNE_OUT(VIRTUAL_CHANNEL 7)
{
  GIu_Ultrasonic_Dist_CM=ultrasonic.distanceInCentimeters(); // Read ultrasonic distance value in CM or INCH
  Serial.print(GIu_Ultrasonic_Dist_CM);
  Serial.println(" cm" );
  Cayenne.virtualWrite(VIRTUAL_CHANNEL 7, GIu_Ultrasonic_Dist_CM);
}
```


Figure 3.20: NodeMCU-ESP32 and Ultrasonic Sensor coding.

3.5.1.4 Servo Motor Code for Feeding Automation

```
#define CAYENNE_DEBUG
#define CAYENNE_PRINT Serial
#include <CayenneMQTTESP32.h>
#include <ESP32Servo.h>
#define VIRTUAL_CHANNEL
int servoPin = 19;
Servo s1;

char ssid[] = "kamzan@unifi";
char wifiPassword[] = "0104595102@kamzan";

char username[] = "9c112190-1b89-11eb-b767-3f1a8f1211ba";
char password[] = "f57281a695fa51335f9cdb1bcdf63dee03db1166";
char clientID[] = "5b5fd4e0-255f-11eb-883c-638d8ce4c23d";

void setup()
{
 Serial.begin(115200);
 Cayenne.begin(username, password, clientID, ssid, wifiPassword);
 sensors.begin();
 s1.attach(servoPin);

 void loop()
{
  Cayenne.loop();
}
  CAYENNE_IN(VIRTUAL_CHANNEL 4)
{
  // Determine angle to set the servo.
  int position = getValue.asDouble() * 180;
  // Move the servo to the specified position.
  s1.write(position);
}
```


Figure 3.21: NodeMCU-ESP32 and servo motor coding.

The #include <ESP32Servo.h> is stated for declaration and the output port is declared GPIO 19. Servo motors get data from the Cayenne IoT to rotate the motor by press on the dashboard platform. The data will be sent as digital output to trigger the motor to rotate 180°. The virtual channel is set as 4 and will show up in the dashboard platform.

3.5.1.5 Pneumatic Diaphram Water Pump Code for pH adjustment

```
#define CAYENNE_DEBUG
#define CAYENNE_PRINT Serial
#include <CayenneMQTTESP32.h>
#define VIRTUAL_CHANNEL

int DC12Vpump=27;

char ssid[] = "kamzan@unifi";
char wifiPassword[] = "0104595102@kamzan";

char username[] = "9c112190-1b89-11eb-b767-3f1a8f1211ba";
char password[] = "f57281a695fa51335f9cdb1bcdf63dee03db1166";
char clientID[] = "5b5fd4e0-255f-11eb-883c-638d8ce4c23d";

void setup()
{
 Serial.begin(115200);
 Cayenne.begin(username, password, clientID, ssid, wifiPassword);
 sensors.begin();
 pinMode(DC12Vpump, OUTPUT);

 void loop()
{
  Cayenne.loop();
}
CAYENNE_IN(VIRTUAL_CHANNEL 5)
{
  int value = getValue.asInt();
  CAYENNE_LOG("Channel %d, pin %d, value %d", VIRTUAL_CHANNEL 5, DC12Vpump, value);
  // Write the value received to the digital pin.
  digitalWrite(DC12Vpump, value);
}
```


Figure 3.22: NodeMCU-ESP32 and water pump coding.

The water pump is set at the GPIO 27. The data is taken from the IoT and translate to digital data where it triggers the motor to turn on/off. the virtual channel is set as 5 and will show up in the dashboard platform.

3.5.2 Cayenne IoT Dashboard Platform

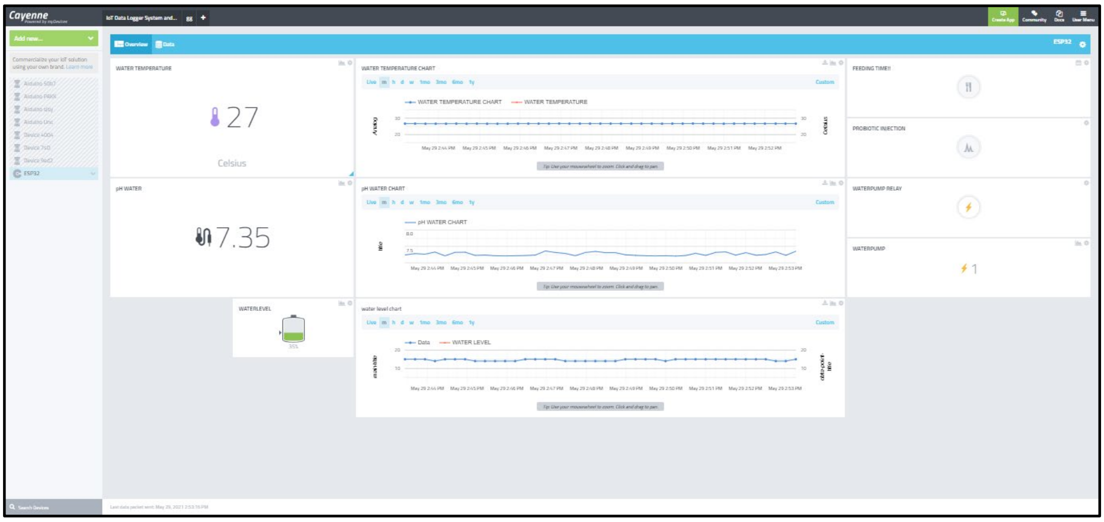

Figure 3.23: Cayenne IoT dashboard platform interface.

The figure shows the dashboard platform of the system. the data shows in multiple virtual channels where it set under void loop stated. Each of the code are provide Cayenne virtual channel where is set in the form of number. For this project, there 5 virtual channels have been set. The Cayenne IoT can show the data from previous day, hour, and minute in the line form graph.

There are 3 virtual channels set as analog output and 2 set as digital input virtual channel. The input virtual channel will show the data from the sensor and the output virtual channel it triggers the automation parts which is water pump and servo motor by click the virtual button on the dashboard platform display. The data for temperature sensor it will show in Celsius. For the ultrasonic it names as water tank level where it set as in centimeter. The pH shows the scale from 0-14 in virtual channel.

3.5.3 Fritzing Circuit Development

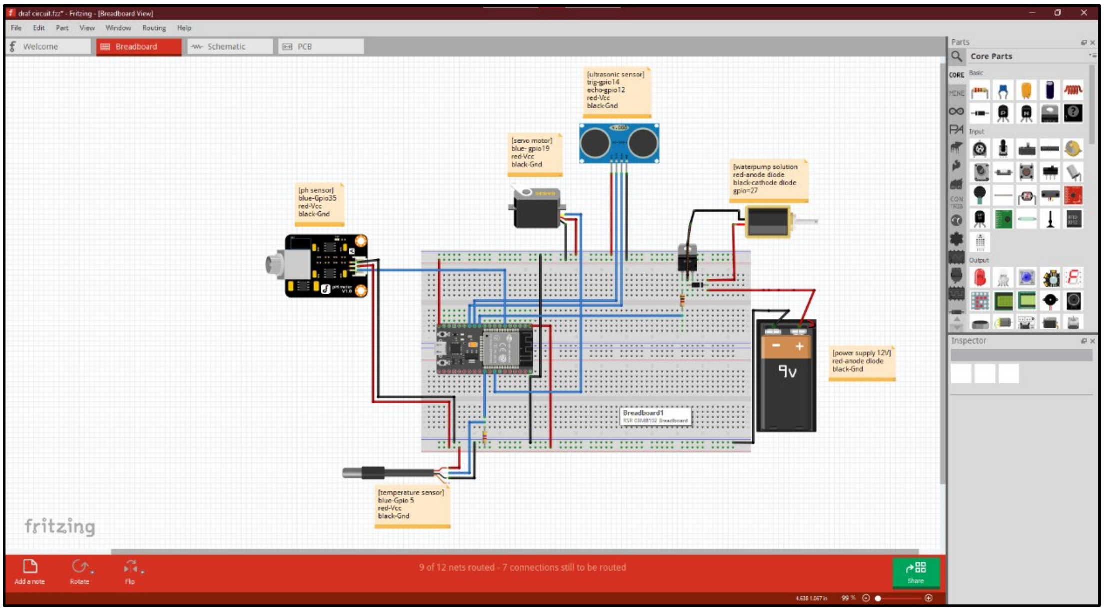

Figure 3.24: Fritzing circuit development.

To develop the circuit the connection of electronic components is organized by using fritzing software. This software is drag and drop from the library where the components can be seen from right panel. It can develop schematic diagram. Furthermore, it easy to refer while connecting electronic part for this project.

3.5.4 Blender 3D Printing of Lobster Feeder Case

Blender software tool is an application to design the smart feeder case. The design is separate into three parts where the first part is use to fill up the lobsters pallet food as a storage case, the second part is call separator where the pallet food from the first part is fall down in this separator then the servo that attached to the separator function to move 180 degree rotation then turn back into 0 degree rotation to fall down the pallet food to the pond and the last part is call opener, the design is to hold the food from falling down into the pond, after the separator manage to rotate 180 degree the food start falling down into the pond. The below is design of the case from part one to part 3. All the part are managed to stack over the part on other part. Below are the figure of the progress of the design for smart feeder system.

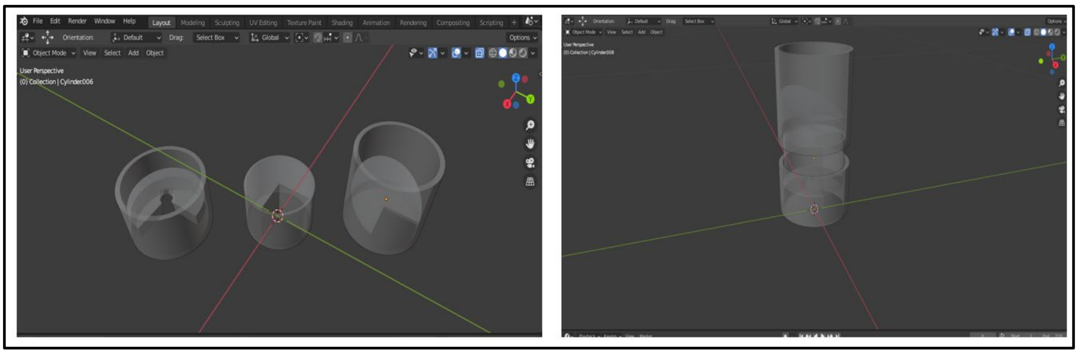

Figure 3.25: 3D modelling from Blender software.

After the designing the smart feeder case is finish, the 3D design need to be export to the sti file. Exporting the 3D design case is required because this design need to transfer to CURA ultimaker software for simulating the printing of this feeder case. Below are the process of exporting file 3D design to STI file.

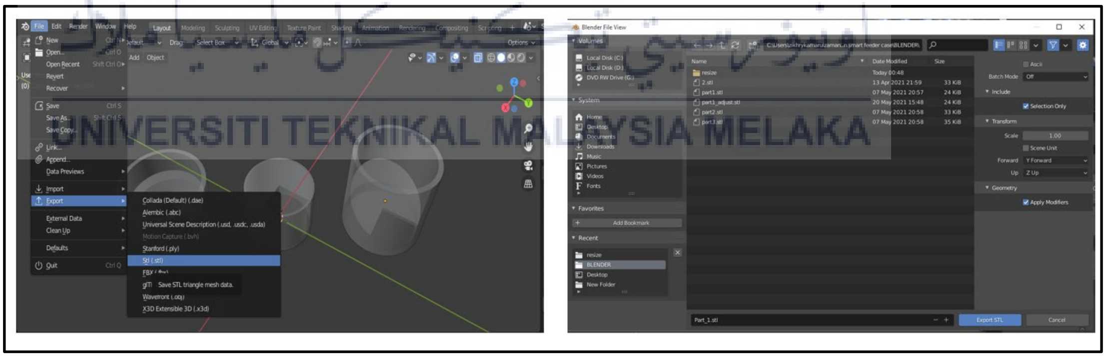

Figure 3.26: 3D modelling file configuration.

3.5.5 Cura Ultimaker

Cura Ultimaker is used to simulate and transfer the file from the blender file. Cura Ultimaker, simulate the process of the 3d printing and estimate the time for the 3d print to finish. the Cura Ultimaker manage to transfer the file from .sti file to. gcode file. to transfer the file into. gcode file the software manage to slice the design. Then, the file. gcode is transfer into micro sd card. the 3d printer ender 3 PRO only use the. gcode file to print the design.

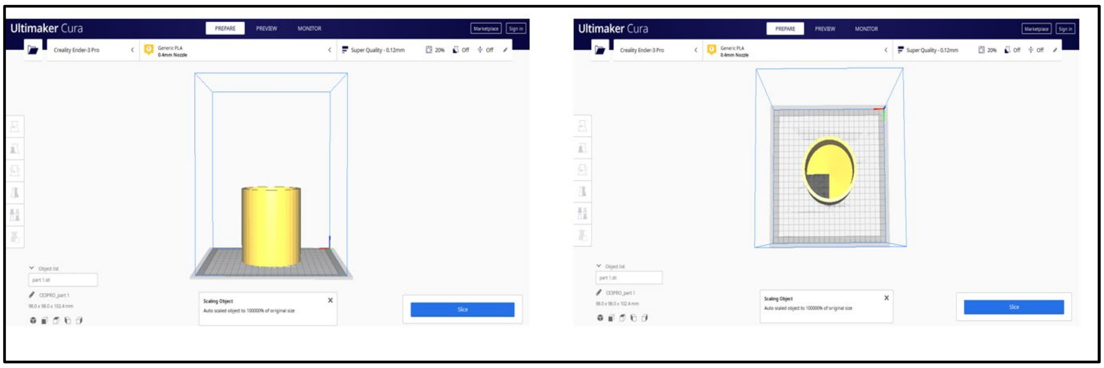

Figure 3.27: Cura Ultimaker 3D modelling

The slice process from this CURA Ultimaker software need to configure the printer setting first before slice the 3D design. Users need to ensure type of material of printer use, for this case the material use is PLA type which is the most popular FDM 3D printing material available, and for good reason. It is relatively inexpensive, a breeze to print with, and comes in hundreds of vibrant colors and blends. The size of the PLA use is 0.2mm while the size of the nozzle from the 3D printer is 0.2mm. Figure 3.28 are the configuration of the print setting for smart feeder case.

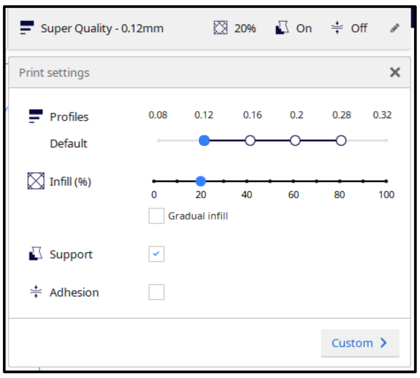

Figure 3.28: Cura Ultimaker configuration.

After the configuration of the print setting, then continue to slice process. Slice the 3D design model means taking the 3D design in. stl format and slicing it into individual layers. The software then generates the tool path (.gcode) the printer will use for printing. Most slicing software will have a print preview function to help prevent print failures. The figure 3.29 shows the print preview function and estimation time for the print process.

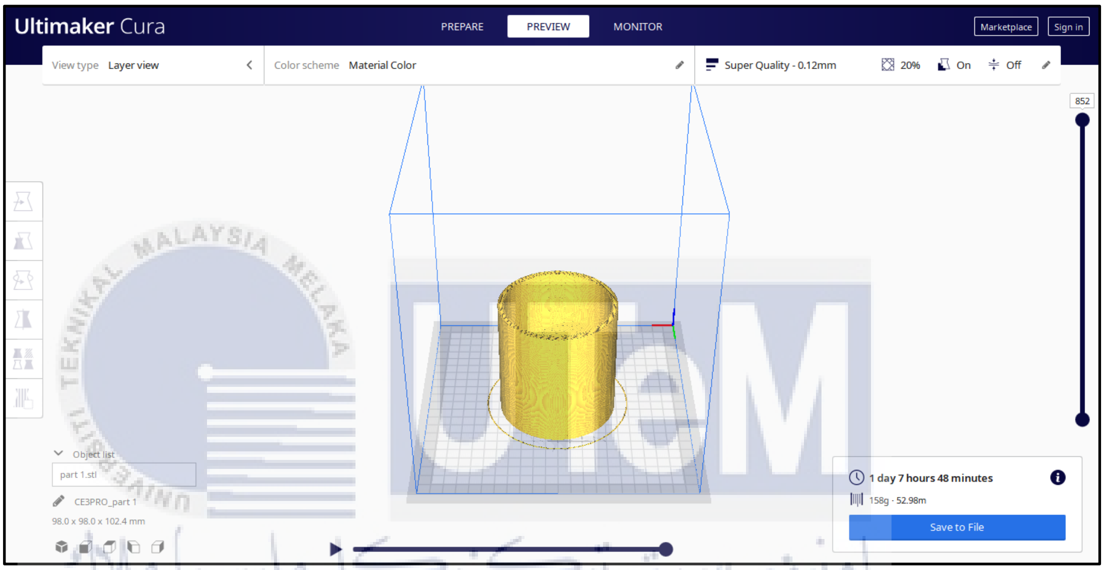

Figure 3.29: Cura Ultimaker slicing

3.5.6 IFTTT

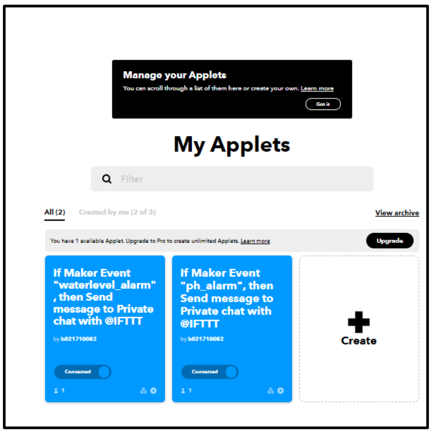

Figure 3.30: IFTTT applets.

In IFTTT, the cloud service acting as a middleman for the system and Telegram or E-mail client. To enable the system to push notification, create the applet with the designated notification or alarm, then obtain the link provided by IFTTT to be use as Webhook in Cayenne IoT Platform.

3.5.7 Webhook

Figure 3.31: Cayenne IoT webhooks configuration.

In Cayenne IoT Platform, enable the push notification by set new trigger in this term of 'if then' statement and this system consist of Temperature Alert and Power Notification. To set the webhooks, pick a sensor from the system in the 'if' statement then set a threshold to trigger the alarm then copy the link to the 'then' statement by obtain the webhook ID link from IFTTT.

3.5.8 Telegram

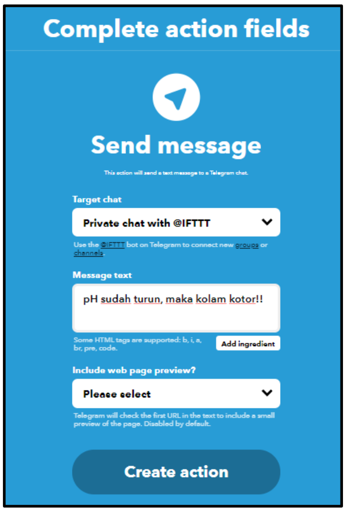

Figure 3.32: Telegram configuration from IFTTT.

By using IFTTT bot in Telegram, the push notification can send alert if ‘if else’ statement triggered at the Cayenne IoT side. This can be achieved by enabling the IFTTT connected with both Cayenne IoT and Telegram bot functionality.

3.6 Research Development

The NodeMCU-ESP32, pH sensor, water temperature sensor, ultrasonic sensor, water pump, and servo motor were used to construct this project. This test's entire output is a real-time experiment and real-time implementation monitoring. To collect data, the experiment is set up in an indoor lobster pond and operated for months to collect measurements and comparisons.

3.6.1 Project Circuit

This system circuit connects to a single IoT Data Logger.

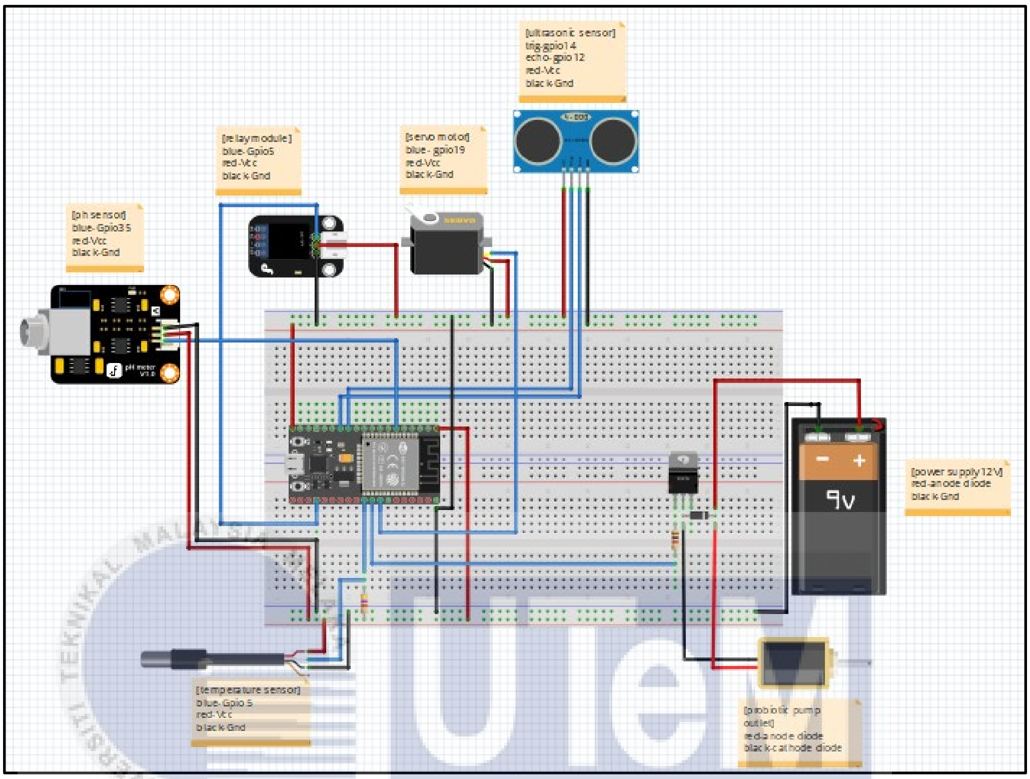

Figure 3.33: Circuit design.

The sensor nodes are pH sensor, DS18B20 temperature sensor and ultrasonic sensor are connected to microcontroller NodeMCU-ESP32. The automation system which is servo motor and water pump connected to NodeMCU-ESP32. All the connection is labelled.

3.6.2 Project Hardware

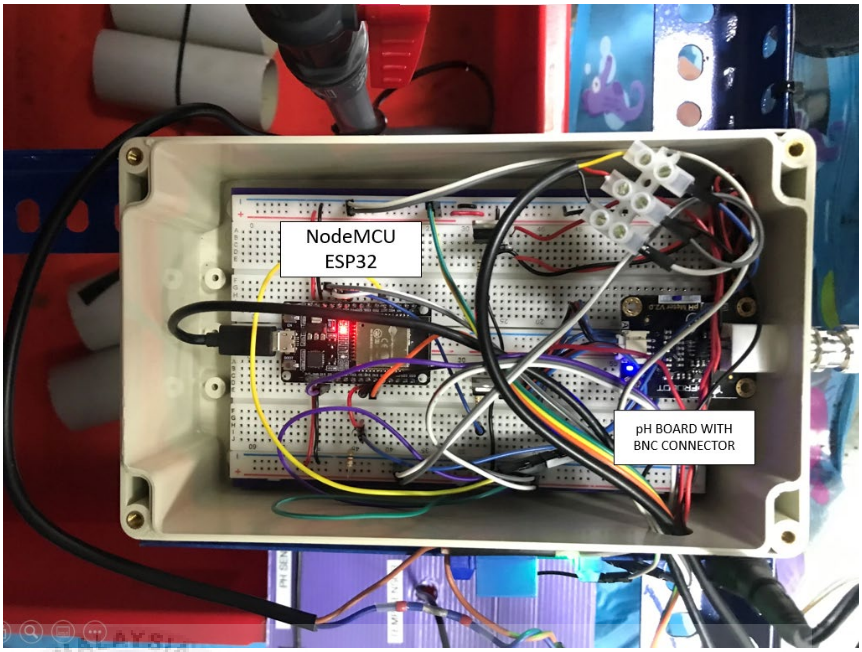

Figure 3.34: NodeMCU-ESp32 and pH board

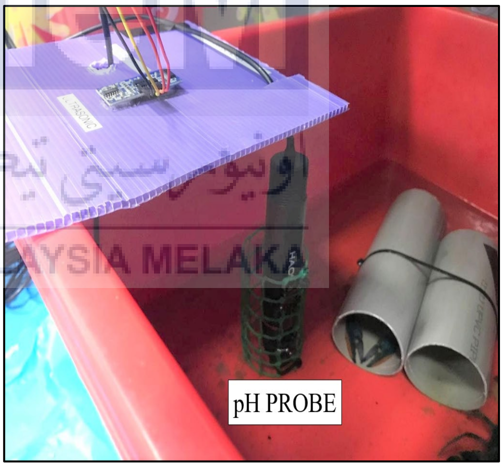

Figure 3.35: Sensor nodes

Figure 3.36: Bottom view sensor nodes

Figure 3.37: Smart Feeder case

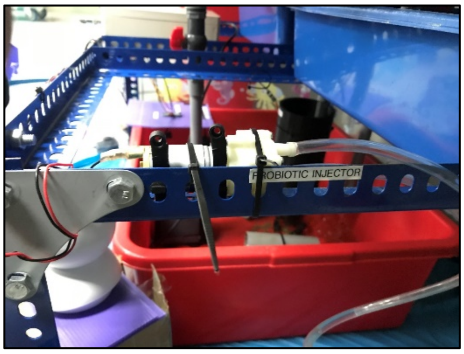

Figure 3.38: Water pump for probiotic injection

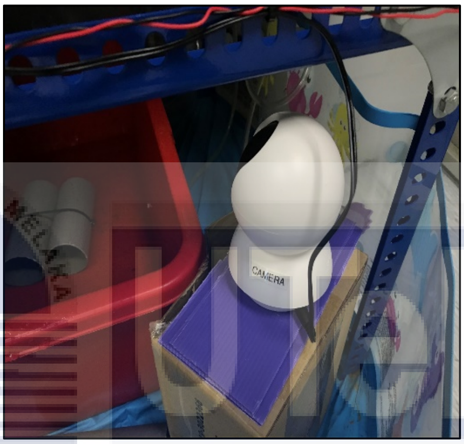

Figure 3.39: Portable camera

All the connection sensor nodes and automation are connected to NodeMCU-ESP32. The NodeMCU-ESP32 is placed inside the waterproof box with the circuit and the pH circuit board shown in figure 3.35. The sensor nodes are placed together as shown in figure 3.36. The servo motor is attached at the bottom of feeder case. The water pump is zip-tied along to the rack. The camera system is for real-time live and recorded monitoring inside the ponds using portable camera.

3.6.3 Project Location

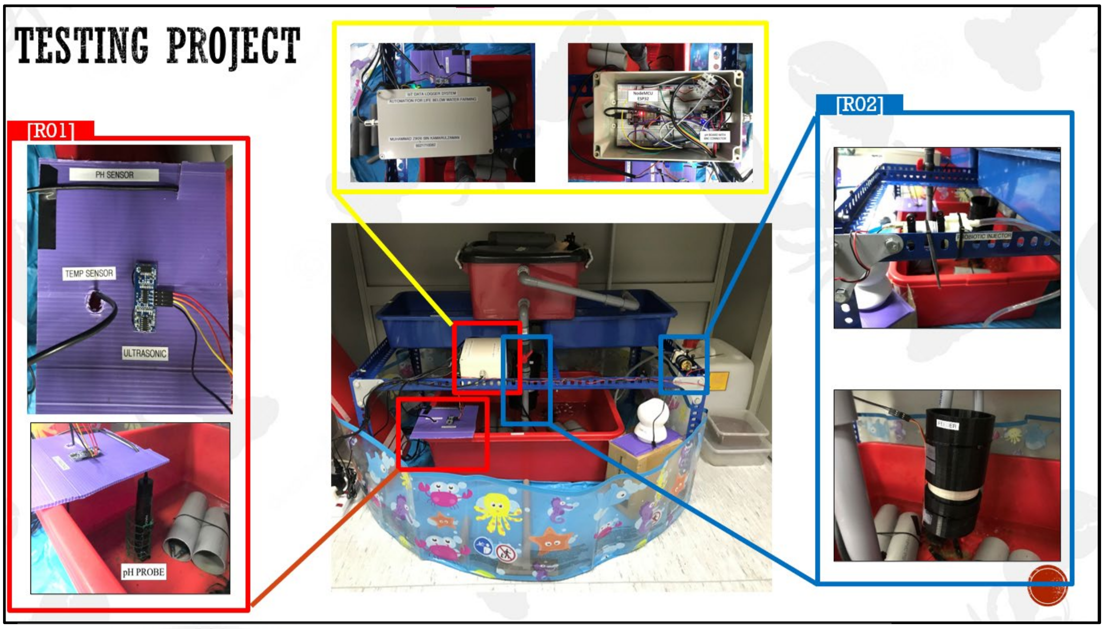

Figure 3.40: Lobsters Pond project testing.

This project testing at the paralon pipe shelter which is indoor type farming method. The shelter mostly using the PVC parts such as the ponds, the filter, the pipe. All the work involve drilling, cutting, and screwing until the shelter for freshwater lobsters is done. This lobster's pond is placed at the research laboratory for testing and monitoring by students and supervisor.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter will analyze and discuss the data collected from the project carried out according to the result. All data were tabulated, and designed graph showed a different of the data display. The data analyzed and discussion will be explained further throughout this chapter.

4.2 Testing The Sensor

4.2.1 pH Sensor Testing

This testing is conducted to show the result between the pH sensor and pH meter devices. The data from pH sensor shown in Arduino IDE and pH meter data shown in display devices. Both of devices are testing on the buffer solution which is pH 4 and pH 7.

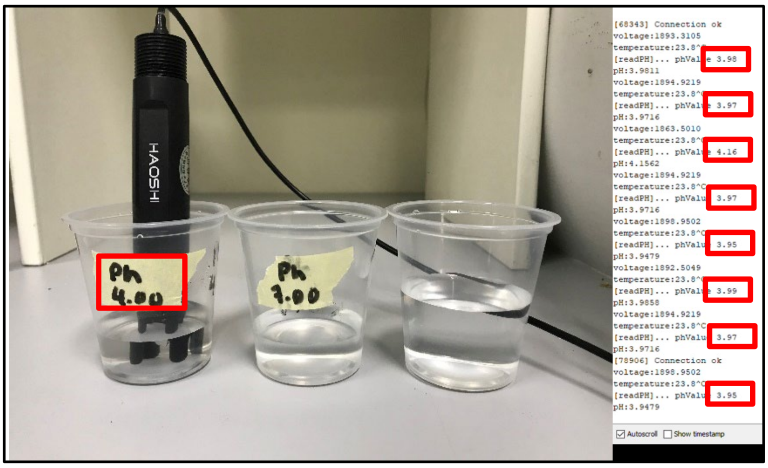

Figure 4.1: Result pH Sensor Testing in Buffer Solution pH 4.

Based on the observation above the pH sensor probe is immersed in pH 4 buffer solution. The result shown the pH value in Arduino IDE range from 3.95 to 4.16 at water temperature 24°C. Based on the pH probe specification the accuracy of this pH probe is ±0.1 accuracy at temperature 25°C. So, the accuracy of this pH probe depends on the water temperature.

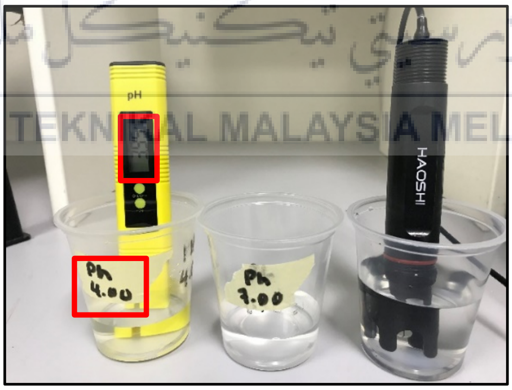

Figure 4.2: Result pH Meter Testing in Buffer Solution pH 4.

Based on the observation above the pH meter is immersed in pH 4 buffer solution. Before the data taken a few calibrations is conducted. After that, the result is taken, and it shown the pH value is 3.95. So that, the pH meter depends on consistency in calibration made for pH meter devices may show the accurate data.

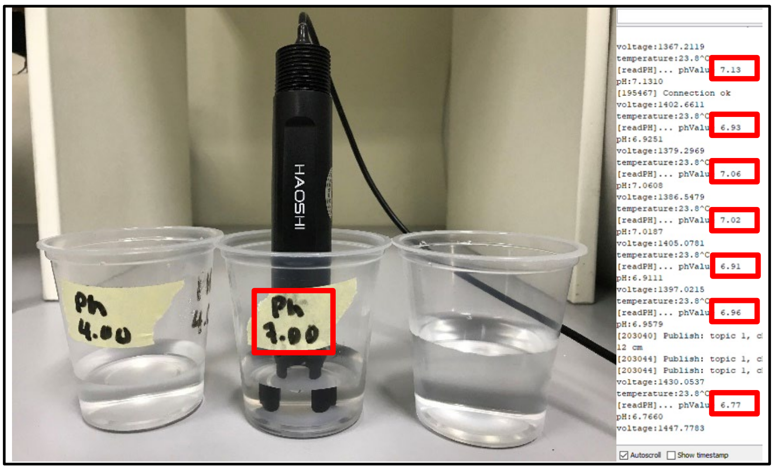

Figure 4.3: Result pH Sensor Testing in Buffer Solution pH 7.

Based on the observation above the pH sensor probe is immersed in pH 4 buffer solution. The result shown the pH value in Arduino IDE range from 6.77 to 7.13 at water temperature 24℃. Based on the pH probe specification the accuracy of this pH probe is ±0.1 accuracy at temperature 25℃. So, the accuracy of this pH probe depends on the water temperature.

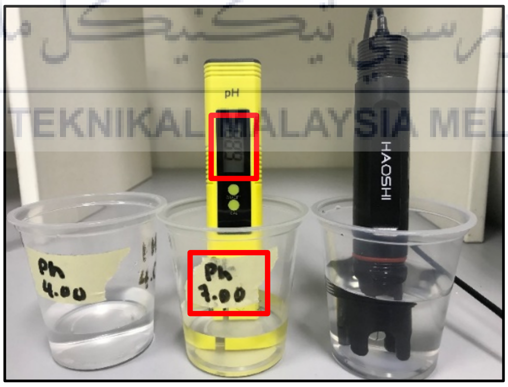

Figure 4.4: Result pH Meter Testing in Buffer Solution pH 7.

Based on the observation above the pH meter is immersed in pH 7 buffer solution. Before the data taken a few calibrations is conducted. After that, the result is taken, and it shown the pH value is 6.8. So that, the pH meter depends on consistency in calibration made for pH meter devices may show the accurate data.

4.2.2 Water Temperature Sensor Testing

This testing is conducted to compare the result between the water temperature sensor (ds18b20) and water temperature devices. The data from water temperature sensor shown in Arduino IDE and water temperature devices data shown in display devices.

Figure 4.5: Result Between Water Temperature Sensor and Water Temperature Device.

Based on the observation above, both of device immersed in the cup of water. The data taken simultaneously for water temperature. The white devices are water temperature device. The result for water temperature devices shown in display of the devices. It shown the water temperature is 21.6°C. the water temperature sensor () shown in Arduino IDE at the range value 21.50°C - 21.75°C. The different between both devices ±0.1 accuracy. The water temperature may increase due to heat dissipation around the environment of the laboratory.

4.2.3 Water Level Sensor Testing

This testing conducted by measuring the accuracy of the distance in centimeter (cm) between the ultrasonic sensor and the ruler meter. The measuring method is to measure the object A with the specific distance. The data from ultrasonic sensor shown in Arduino IDE while ruler meter data shown in centimeter (cm).

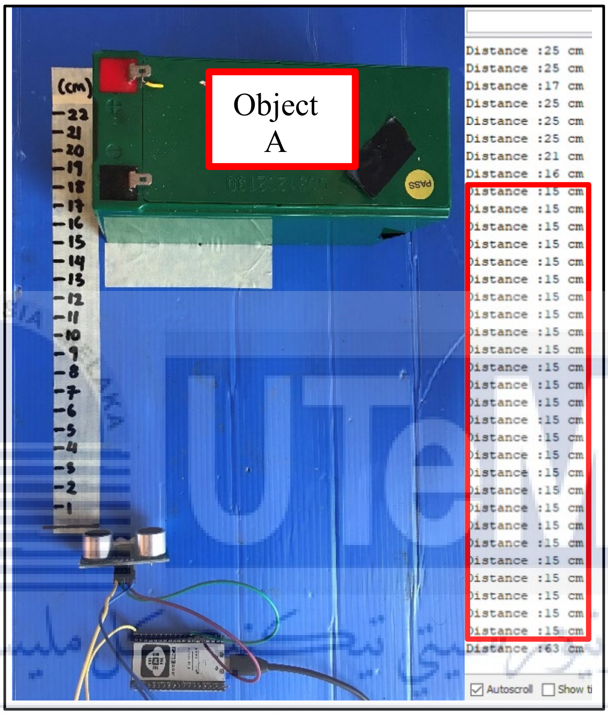

Figure 4.6: Ultrasonic Testing Result Detecting Object A.

Based on the above observation, the distance object A result for both measurement methods is 15 cm. There are multiple distance measurements of object A made, and the results for both measuring methods are identical.

4.2.4 Push Notification System

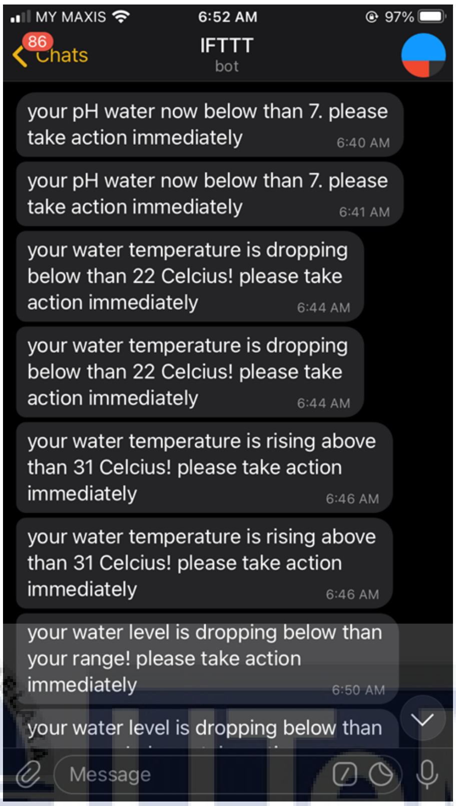

Figure 4.7: Push Notification from Telegram Application.

According to the figure 4.7, if the pH limit established in the Cayenne IoT platform trigger function is exceeded, the push notification sends a text message to the users. This function is also available for water temperature and water level. This may be accomplished by connecting IFTTT to Cayenne IoT and Telegram bot capability.

4.3 Automation System Functionality

The functioning of the automation system for the lobster pond will be explained in this section. The smart feeding system and the smart pH injection are two automation systems.

4.3.1 Smart Feeding System

The smart feeding system is automation system for feeding the lobsters by control it through smart phone via Cayenne IoT web-based application. The smart feeding enclosure was created using blender software and printed on an Ender 3 Pro 3printer.

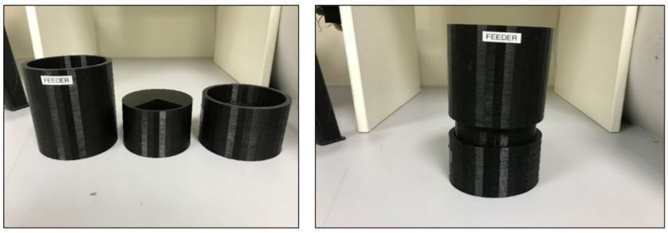

Figure 4.8: Smart Feeder Case

The figure 4.8 shown that, there are 3 part of case is 3D printed. The 3 part is combined as one case as figure 4.8 shown. The first part is a food container, the second part is attached to a servo motor that rotates 180^0 the food from the first part to the third part hole, and the third part is a hole where the food falls into the lobsters pond.

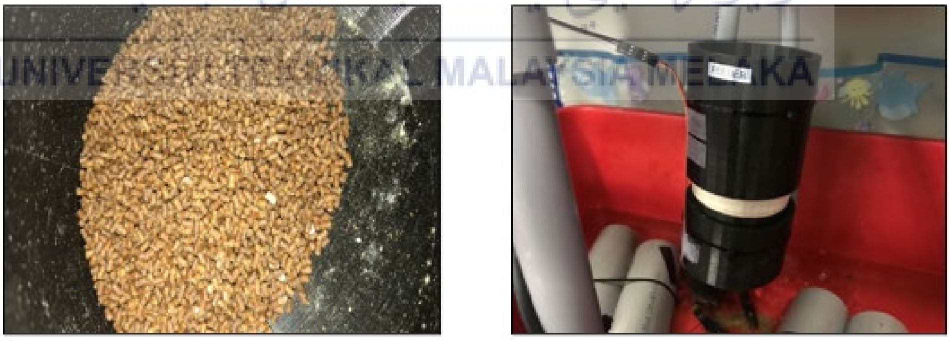

Figure 4.9: Smart Feeder System

The food palette for lobsters is shown in the figure 4.9. This smart feeder case can carry around a week's worth of food if fed once a day. The case is zip tied to the PVC pipe that runs across the middle of the lobster ponds.

4.3.2 Smart pH Adjustment (Probiotic Injection)

The smart pH adjustment system is an automation system that regulates the pH of the water in the lobster pond using a smart phone and the Cayenne IoT web-based application.

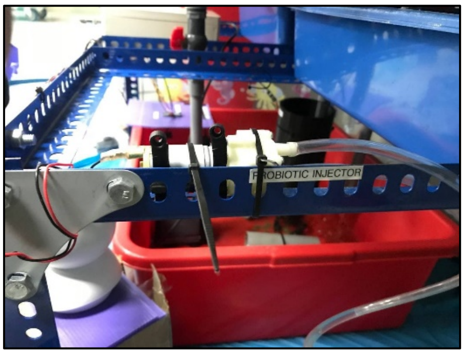

Figure 4.11: Water Pump

Figure 4.10: Probiotic Solution

According to the figure 4.11, the smart pH adjustment works by sucking in the probiotic solution from the case in the figure. The probiotic solution is used to keep the pH of the water in the lobster's pond in balance. Aside from that, the probiotic solution is used to distribute beneficial bacteria around the pond and protect the lobster from disease.

Figure 4.12: Water Flow of Probiotic Inside the Lobsters' Ponds.

The water pump can be controlled through smart phone via the Cayenne IoT web-based application, as shown in the diagram. Every few months, the water pump runs to keep the water quality and pH in the right range.

4.3.3 Scheduling System Using IoT Platform

Cayenne IoT has a scheduling system capability that allows it to govern the project's output, which is an automation system. This scheduling system generates the output automatically by configuring the devices.

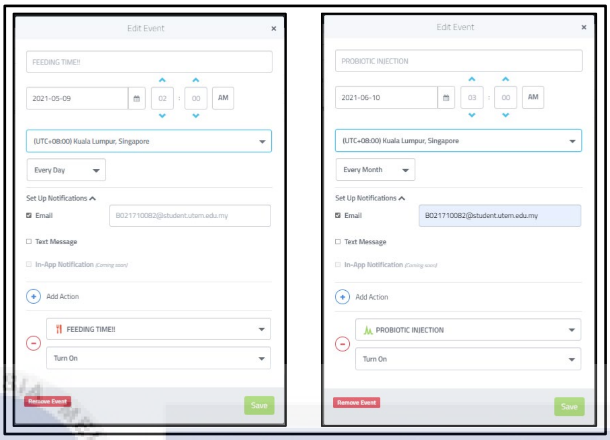

Figure 4.13: Configuration for Automation System.

The configuration of the smart feeding system and smart pH adjustment is indicated in the figure 4.13. The smart feeding system configuration is based on left, whereas the smart pH adjustment configuration is based on right.

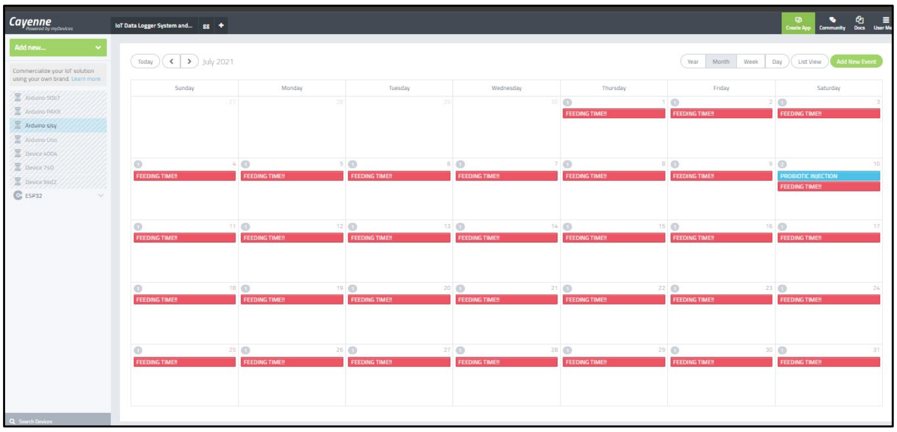

Figure 4.14: Schedule for Automation System.

Following the configuration, the Cayenne IoT will display a calendar with the setup for both automation systems.

4.4 IoT – myDevices Cayenne Platform

The Cayenne IoT platform is used to monitor sensor input and automation system output. The data from the NodeMCU-ESP32 microcontroller is transferred to the Cayenne IoT cloud through a wireless internet connection.

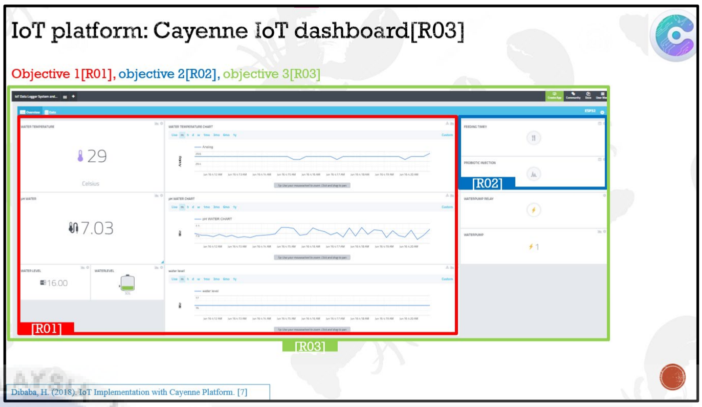

Figure 4.15: Cayenne IoT Real-Time Monitoring Interface.

The Cayenne IoT dashboard platform is described in figure 4.15, with the sensor input labelled as [R01]. The sensor displayed the current water parameter within the lobsters' platform. Every minute, hour, day, month, and year, the data in the line graph can be monitored. Furthermore, the [R02] labelled output system for automation system shows the display button to control the output offered for smart feeding and smart pH adjustment systems from this Cayenne IoT platform.

Figure 4.16: QR Code Real-Time Monitoring

Aside from that, the figure 4.16 shows that other users can monitor the circumstance in real time by scanning the QR code. The Cayenne IoT dashboard platform will be displayed.

4.5 Data Measurement and Comparison

Data is obtained from various measurements through sensors, instruments, and other data collection devices. The information is extracted, compared, then tabulated in Microsoft Excel for easier reading. In each part, a graph is presented for comparison.

4.5.1 pH Value

The pH value data is gathered using an IoT platform, pH meter devices, and the Arduino IDE. The data is acquired and then compared. For two days, data is collected every hour.

Table 4:1: Data Compare Between pH Sensor and pH Meter.

Timestamp	Cayenne IoT Value	Arduino IDE Value	pH meter Value	Timestamp	Cayenne IoT Value	Arduino IDE Value	pH meter Value
7/5/2021 12:00 AM	7.19	7.19	6.84	**8/5/2021 12:00 AM**	7.59	7.59	7.47
1:00:00 AM	7.24	7.24	6.99	1:00:00 AM	7.59	7.59	7.33
2:00:00 AM	7.31	7.31	7	2:00:00 AM	7.61	7.61	7.27
3:00:00 AM	7.36	7.36	7.12	3:00:00 AM	7.61	7.61	7.36
4:00:00 AM	7.39	7.39	7.12	4:00:00 AM	7.60	7.60	7.14
5:00:00 AM	7.41	7.41	7.15	5:00:00 AM	7.61	7.61	7.22
6:00:00 AM	7.40	7.40	7.14	6:00:00 AM	7.61	7.61	7.24
7:00:00 AM	7.41	7.41	7.25	7:00:00 AM	7.61	7.61	7.19
8:00:00 AM	7.43	7.43	7.21	8:00:00 AM	7.60	7.60	7.28
9:00:00 AM	7.47	7.47	7.33	9:00:00 AM	7.60	7.60	7.36
10:00:00 AM	7.48	7.48	7.27	10:00:00 AM	7.60	7.60	7.24
11:00:00 AM	7.49	7.49	7.36	11:00:00 AM	7.61	7.61	7.17
12:00:00 PM	7.50	7.50	7.14	12:00:00 PM	7.63	7.63	7.36
1:00:00 PM	7.54	7.54	7.22	1:00:00 PM	7.64	7.64	7.51
2:00:00 PM	7.54	7.54	7.24	2:00:00 PM	7.63	7.63	7.52
3:00:00 PM	7.56	7.56	7.19	3:00:00 PM	7.64	7.64	7.49
4:00:00 PM	7.57	7.57	7.28	4:00:00 PM	7.64	7.64	7.47
5:00:00 PM	7.59	7.59	7.36	5:00:00 PM	7.64	7.64	7.33
6:00:00 PM	7.58	7.58	7.24	6:00:00 PM	7.63	7.63	7.27
7:00:00 PM	7.58	7.58	7.17	7:00:00 PM	7.62	7.62	7.36
8:00:00 PM	7.60	7.60	7.36	8:00:00 PM	7.63	7.63	7.14
9:00:00 PM	7.60	7.60	7.51	9:00:00 PM	7.64	7.64	7.22
10:00:00 PM	7.59	7.59	7.52	10:00:00 PM	7.64	7.64	7.24
11:00:00 PM	7.61	7.61	7.49	11:00:00 PM	7.65	7.65	7.19

Given the table 4.1, this project collected three values: Cayenne IoT, Arduino IDE, and pH meter. This data was taken every hour from the lobster pond. Due to the transmit data from the ESP32 to the Cayenne IoT cloud, the data for Cayenne IoT and Arduino IDE are nearly same.

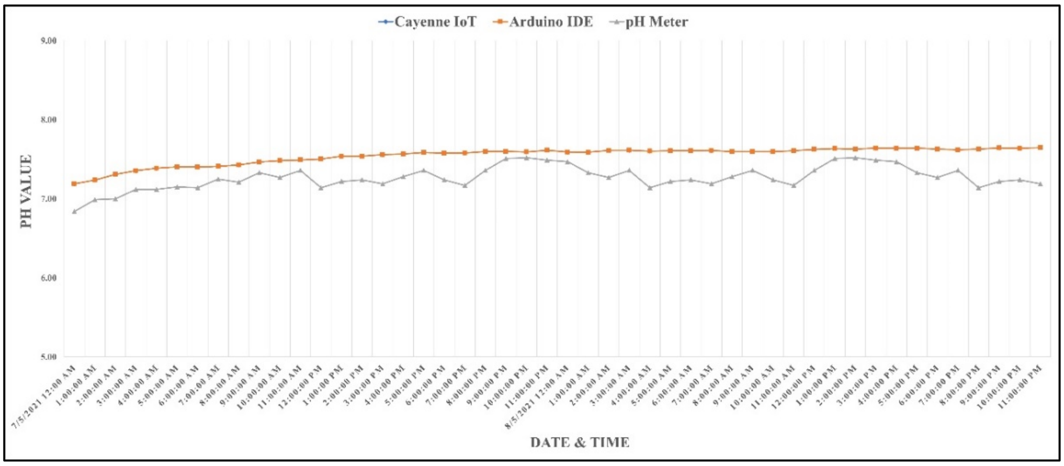

Figure 4.17: Line Graph Between pH Sensor and pH meter.

The line graphs for Cayenne IoT and Arduino IDE are the same as shown in the figure 4.17. As a result, the line graphs for Cayenne IoT and pH meter differ slightly. In comparison to the pH meter, the line graph for Cayenne IoT and Arduino IDE is reliable. Due to the environment around the room, the line graph Cayenne IoT and Arduino IDE slightly increases. At 25 degrees Celsius, the pH sensor has an accuracy of $\pm$0.1 accuracy. The accuracy may reduce until $\pm$0.5 accuracy but not more than $\pm$1 accuracy if the temperature is too high or too low. The pH meter's line graph revealed that the data was inconsistent. It displayed the increase and reduction in value for each hour.

4.5.2 Temperature

Water temperature data is collected using an IoT platform, water temperature meter devices, and the Arduino IDE, and then compared. Every hour for two days, data is collected.

Table 4:2: Data Compare Between Water Temperature Sensor and Water Temperature Meter.

Timestamp	Cayenne IoT value	Arduino IDE value	Temperature meter value	Timestamp	Cayenne IoT value	Arduino IDE value	Temperature meter value
7/5/2021 12:00 AM	25.18	25.18	25.01	8/5/2021 12:00 AM	24.62	24.62	24.39
1:00:00 AM	25.29	25.29	25.03	1:00:00 AM	24.80	24.80	24.58
2:00:00 AM	25.36	25.36	25.06	2:00:00 AM	24.95	24.95	24.64
3:00:00 AM	25.43	25.43	25.37	3:00:00 AM	25.08	25.08	25.38
4:00:00 AM	25.52	25.52	25.48	4:00:00 AM	25.19	25.19	25.39
5:00:00 AM	25.56	25.56	25.59	5:00:00 AM	25.32	25.32	25.45
6:00:00 AM	25.61	25.61	25.66	6:00:00 AM	25.44	25.44	25.55
7:00:00 AM	25.63	25.63	25.72	7:00:00 AM	25.50	25.50	25.68
8:00:00 AM	25.55	25.55	25.85	8:00:00 AM	25.58	25.58	25.91
9:00:00 AM	24.95	24.95	25.37	9:00:00 AM	25.64	25.64	25.99
10:00:00 AM	24.14	24.14	24.08	10:00:00 AM	25.74	25.74	26.05
11:00:00 AM	23.50	23.50	23.35	11:00:00 AM	25.80	25.80	26.09
12:00:00 PM	23.14	23.14	22.98	12:00:00 PM	25.87	25.87	26.14
1:00:00 PM	22.93	22.93	22.76	1:00:00 PM	26.04	26.04	26.25
2:00:00 PM	22.94	22.94	22.71	2:00:00 PM	26.08	26.08	26.25
3:00:00 PM	22.75	22.75	22.63	3:00:00 PM	26.22	26.22	26.36
4:00:00 PM	22.44	22.44	22.61	4:00:00 PM	26.34	26.34	26.56
5:00:00 PM	22.36	22.36	22.57	5:00:00 PM	26.48	26.48	26.57
6:00:00 PM	22.69	22.69	22.31	6:00:00 PM	26.63	26.63	26.63
7:00:00 PM	23.10	23.10	23.8	7:00:00 PM	26.63	26.63	26.31
8:00:00 PM	23.51	23.51	23.92	8:00:00 PM	26.73	26.73	26.53
9:00:00 PM	23.87	23.87	23.93	9:00:00 PM	26.77	26.77	26.6
10:00:00 PM	24.15	24.15	24.03	10:00:00 PM	26.77	26.77	26.83
11:00:00 PM	24.42	24.42	24.2	11:00:00 PM	26.81	26.81	26.87

Based on the table 4.2, there are 3 values collected from this project which are from Cayenne IoT, Arduino IDE and water temperature meter. This data collected from the lobsters' pond every hour. The data for Cayenne IoT and Arduino IDE mostly same due to the transmit data from ESP32 to Cayenne IoT cloud. There are slightly different in value for water temperature meter and Cayenne IoT.

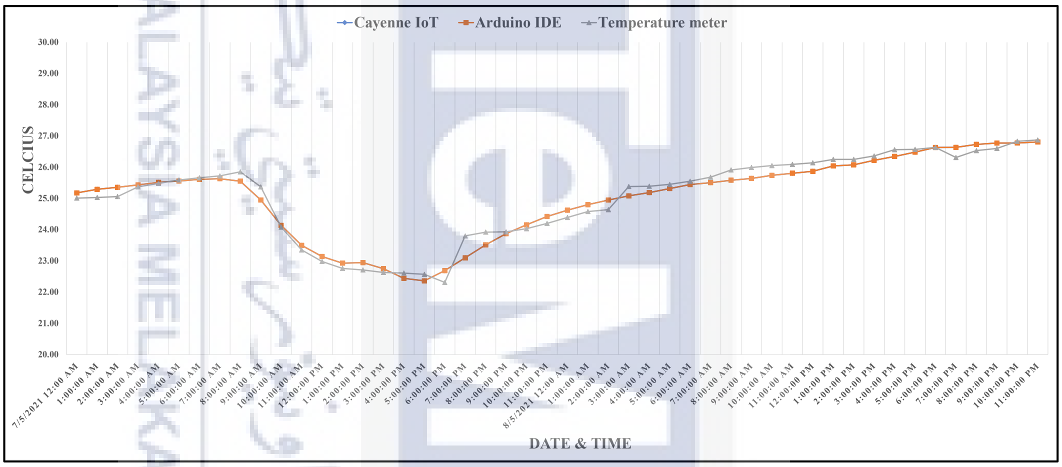

Figure 4.18: Line Graph Between Water Temperature Sensor and Water Temperature Meter.

The line graphs for Cayenne IoT and Arduino IDE are the same as displayed in the figure 4.18. As a result, the line graphs for Cayenne IoT and water temperature meter differ slightly. When compared to a water temperature meter, the line graph for Cayenne IoT and Arduino IDE is reliable. The line graph Cayenne IoT with Arduino IDE tends to drop the temperature from 25°C to 22°C because the laboratory is air-conditioned from 8 a.m. to 6 p.m. The line graph for the water temperature meter then showed conflicting line graphs when compared to the line graphs of Cayenne IoT and Arduino IDE.

4.5.3 Water Level

Water level data is gathered using Cayenne IoT platform, a ruler meter, and the Arduino IDE. The information is taken and then compared. For two days, data is collected every hour.

Table 4:3: Data Compare Between Ultrasonic Sensor and Measuring Devices.

Timestamp	Cayenne IoT value	Arduino IDE value	Ruler meter value	Timestamp	Cayenne IoT value	Arduino IDE value	Ruler meter value
7/5/2021 12:00 AM	12	12	12	**8/5/2021 12:00 AM**	12	12	12
1:00:00 AM	12	12	12	1:00:00 AM	12	12	12
2:00:00 AM	12	12	12	2:00:00 AM	12	12	12
3:00:00 AM	12	12	12	3:00:00 AM	12	12	12
4:00:00 AM	12	12	12	4:00:00 AM	12	12	12
5:00:00 AM	12	12	12	5:00:00 AM	12	12	12
6:00:00 AM	12	12	12	6:00:00 AM	12	12	12
7:00:00 AM	12	12	12	7:00:00 AM	12	12	12
8:00:00 AM	12	12	12	8:00:00 AM	12	12	12
9:00:00 AM	12	12	12	9:00:00 AM	12	12	12
10:00:00 AM	12	12	12	10:00:00 AM	12	12	12
11:00:00 AM	12	12	12	11:00:00 AM	12	12	12
12:00:00 PM	12	12	12	12:00:00 PM	12	12	12
1:00:00 PM	12	12	12	1:00:00 PM	12	12	12
2:00:00 PM	12	12	12	2:00:00 PM	12	12	12
3:00:00 PM	12	12	12	3:00:00 PM	12	12	12
4:00:00 PM	12	12	12	4:00:00 PM	12	12	12
5:00:00 PM	12	12	12	5:00:00 PM	12	12	12
6:00:00 PM	12	12	12	6:00:00 PM	12	12	12
7:00:00 PM	12	12	12	7:00:00 PM	12	12	12
8:00:00 PM	12	12	12	8:00:00 PM	12	12	12
9:00:00 PM	12	12	12	9:00:00 PM	12	12	12
10:00:00 PM	12	12	12	10:00:00 PM	12	12	12
11:00:00 PM	12	12	12	11:00:00 PM	12	12	12

Based on the table 4.3, this project has three values: Cayenne IoT, Arduino IDE, and ruler meter. Every hour, data was collected from the lobster pond. The data indicates that the value for all measurements is 12 cm.

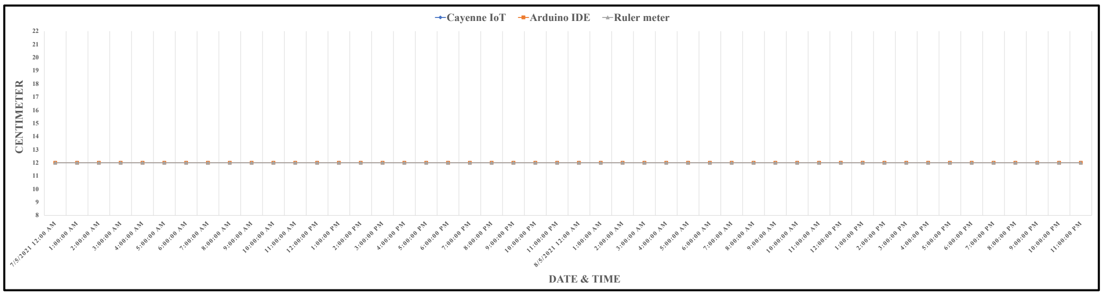

Figure 4.19: Line Graph Between Ultrasonic Sensor and Ruler Meter.

The line graph shown for all distances between Cayenne IoT, Arduino IDE, and ruler meter is the same value, which is 12 cm, as seen in the figure 4.19. The value represents the distance between the ultrasonic sensor and the water's surface. So, here is how to figure out how much water height inside the lobster pond is worth:

$$Height\ of\ water = the\ height\ of\ lobsters\ pond - the\ value\ of\ ultrasonic\ sensor$$

For example:

The height of lobster pond is 22 cm and the ultrasonic sensor detect the surface of the water is 12 cm.

$$Height\ of\ water = 22\ cm - 12\ cm$$

$$Height\ of\ water = 10\ cm$$

Equation 4.1: Water Level Inside Lobsters' Ponds.

4.6 Dataset Cayenne IoT

Cayenne IoT cloud provided this dataset. For easier viewing, the data is exported to Excel. Data is gathered for at least three months. Water temperature, pH, and water level are the variables in the dataset.

4.6.1 Water Temperature

Table 4:4: Data Water Temperature from Cayenne IoT.

Timestamp	DeviceID	Channel	SensorName	SensorID	DataType	Unit	Value
1/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	25
2/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	25
3/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	25
4/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
5/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
6/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
7/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
8/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
9/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
10/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	25
11/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	25
12/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	25
13/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	27
14/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	25
15/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	27
16/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
17/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
18/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	25
19/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
20/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
21/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
22/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
23/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	23
24/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	27
25/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	28
26/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	26
27/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	25
28/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
29/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	25
30/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
1/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	26
2/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	27
3/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	26
4/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	25
5/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
6/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
7/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	26
8/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	26
9/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	26
10/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	25
11/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	25
12/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	25
13/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	27
14/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	28
15/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	29
16/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	29
17/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	26
18/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	25
19/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
20/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
21/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
22/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	26
23/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	27
24/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	28
25/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	32
26/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	24
27/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	27
28/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	28
29/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	27
30/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	28
31/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	29
1/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	30
2/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	30
3/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	30
4/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	30
5/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	30
6/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	30
7/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	30
8/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	30
9/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	30
10/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	30
11/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	30
12/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	30
13/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	30
14/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	30
15/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	30
16/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	27
17/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	28
18/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	28
19/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	1	WATER TEMPERATURE CHART	4bb24540-358c-11eb-b767-3f1a8f1211ba	analog_sensor	c	28

The data for the water temperature sensor is gathered for at least three months, according to the table 4.4. This table shown that, depicts the water temperature in the laboratory throughout a 24-hour period. In Microsoft Excel, the data is sorted by day. This dataset contains all data, including the date and time, sensor ID, virtual channel used in Cayenne IoT, device ID, data type, unit, and water temperature value.

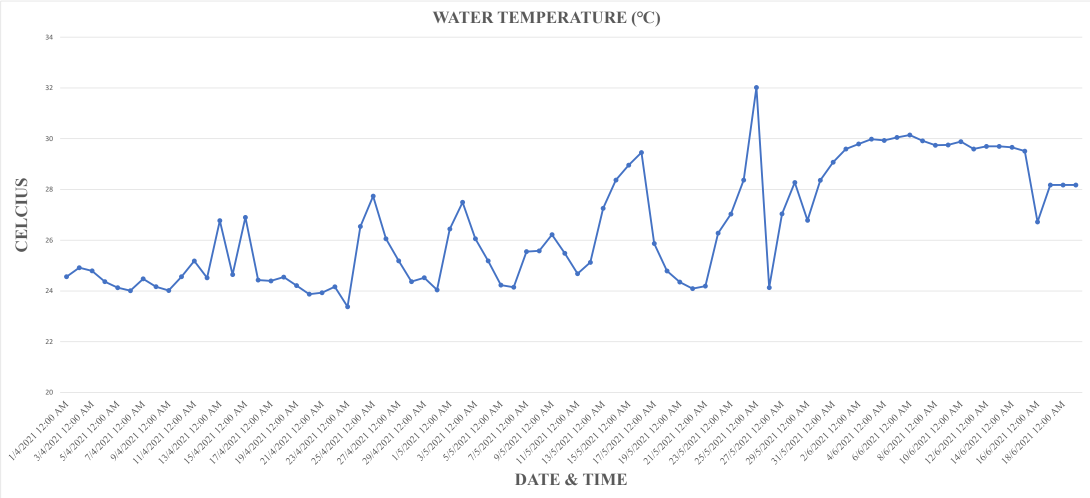

Figure 4.20: Line Graph Water Temperature.

The line graph for water temperature for each day over three months is depicted in the figure 4.20. The water temperature is increasing and decreasing on a daily basis, as shown in this line graph. It demonstrates that the temperature of the water in the lobster ponds changes every day as a result of the laboratory environment. The maximum temperature recorded in the water is 32°C, while the lowest is no more than 23°C. This temperature is within the optimal range of water temperature. The water temperature is 27°C on average.

4.6.2 pH Water

Table 4:5: Data pH Water from Cayenne IoT.

Timestamp	DeviceID	Channel	SensorName	SensorID	DataType	Unit	Value
1/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	8.2
2/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	8.2
3/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	8.9
4/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	8.6
5/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	8.2
6/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	8.3
7/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	8.4
8/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	8.4
9/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.3
10/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	8.3
11/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	8.2
12/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.5
13/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.7
14/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.9
15/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.9
16/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.7
17/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
18/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.7
19/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.7
20/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.7
21/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.7
22/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.7
23/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.7
24/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.7
25/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.7
26/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
27/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
28/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
29/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
30/4/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
1/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
2/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
3/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
4/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.7
5/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.7
6/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.7
7/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
8/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.7
9/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
10/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.4
11/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.4
12/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.5
13/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.5
14/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.5
15/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
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17/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
18/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
19/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
20/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
21/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
22/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
23/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
24/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.5
25/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.5
26/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
27/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
28/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
29/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
30/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
31/5/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
1/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.5
2/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.5
3/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
4/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
5/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
6/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
7/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
8/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
9/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
10/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
11/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
12/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
13/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
14/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
15/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
16/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
17/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
18/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6
19/6/2021 3:00 PM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	14	pH WATER CHART	aa890350-8bf0-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	7.6

The data for the pH sensor is gathered for at least three months, according to the table 4.5. This table shown that, depicts the pH water in the laboratory throughout a 24-hour period. In Microsoft Excel, the data is sorted by day. This dataset contains all data, including the date and time, sensor ID, virtual channel used in Cayenne IoT, device ID, data type, unit, and pH water value.

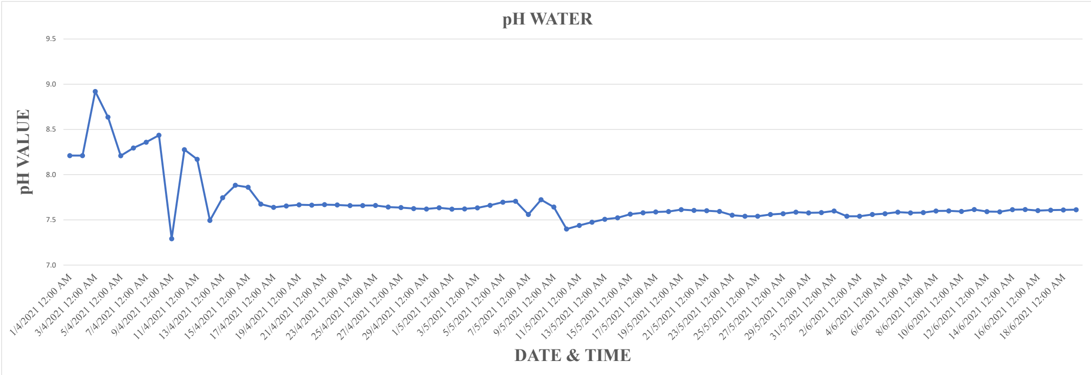

Figure 4.21: Line Graph pH water.

The figure 4.21 shows a line graph of pH water temperature for each day over three months. During the early months of testing this pH sensor, there were few limits. During the first few months, a laboratory-grade pH sensor is used. The pH sensor laboratory grade is not suited for real-time monitoring after a few days of monitoring since it cannot be used for a long time. Then, for real-time monitoring, an industrial-grade pH sensor is used. As a result, the line graph shows a consistent value from the middle of the April to the end of the three months. The average pH of the water for the three months of real-time monitoring is 7.6, which is in the ideal range for lobsters living in ponds.

4.6.3 Water Level

Table 4:6: Data Water Level from Cayenne IoT.

Timestamp	DeviceID	Channel	SensorName	SensorID	DataType	Unit	Value
1/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
2/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
3/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
4/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
5/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
6/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
7/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	12
8/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	13
9/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	13
10/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	13
11/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	13
12/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	13
13/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	13
14/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
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20/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
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22/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
23/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	11
24/4/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	11
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1/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	13
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19/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
20/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
21/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
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23/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
24/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
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26/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
27/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
28/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
29/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
30/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	14
31/5/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	15
1/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	15
2/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	15
3/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	15
4/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	15
5/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	15
6/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	15
7/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	15
8/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	15
9/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	15
10/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	15
11/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	15
12/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	16
13/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	16
14/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	16
15/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	16
16/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	16
17/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	16
18/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	10
19/6/2021 8:00 AM	5b5fd4e0-255f-11eb-883c-638d8ce4c23d	7	water level	0ec5dd20-cc6a-11eb-b767-3f1a8f1211ba	analog_sensor	undefined	9

The data for the ultrasonic sensor is gathered for at least three months, according to the table 4.6. This table shown that, depicts the water level in the laboratory throughout a 24-hour period. In Microsoft Excel, the data is sorted by day. This dataset contains all data, including the date and time, sensor ID, virtual channel used in Cayenne IoT, device ID, data type, unit, and water level value.

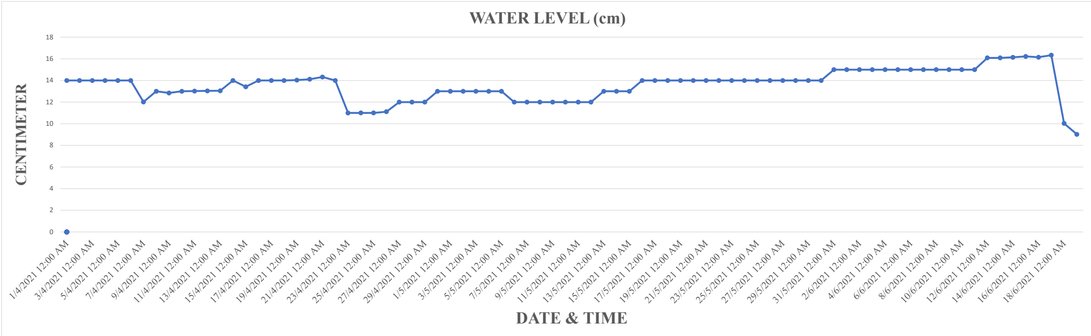

Figure 4.22: Line Graph Water Level.

The figure 4.22 shows a line graph of water level for each day over three months. The line graph for water temperature for each day over three months is depicted in the figure. The water level shows the consistency drop of water level. According to the line graph, the highest water level indicates a decrease in water inside the lobster ponds, whilst the lowest water level indicates an increase in water level. As the water temperature drops, a high temperature surrounds the lobster ponds, causing the water to evaporate. For the three months of real-time monitoring, the average water level is 14 cm. After subtracting the height of lobster ponds, the result is 8 cm because the ultrasonic detects the water's surface, which is in the appropriate range for lobsters dwelling in ponds.

4.7 The Rate of Growing Lobsters

The length of lobsters is one of the key reasons for their high price. Aside from that, the length of lobsters shows the lobsters' life span.

Table 4:7: Data Measuring Lobsters Length.

DATE	Length of Lobsters value(cm)
12/3/2021	11.5
19/3/2021	11.5
26/3/2021	11.5
2/4/2021	11.51
9/4/2021	11.51
16/4/2021	11.51
23/4/2021	11.51
30/4/2021	11.51
7/5/2021	11.51

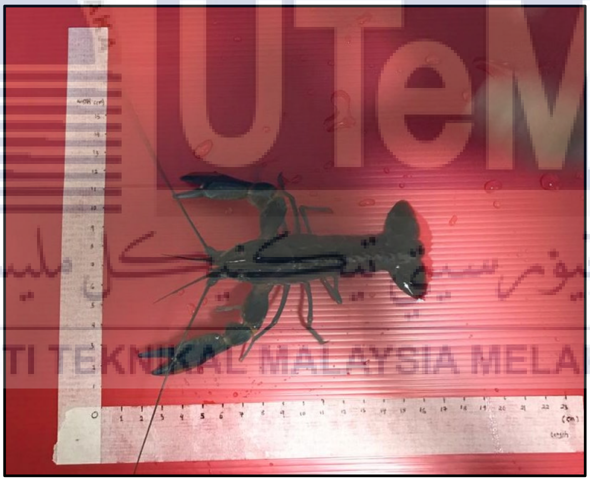

Figure 4.23: Measuring Lobsters Length.

The data is collected every week for around two months, as shown in the table 4.7. The lobsters' starting farm, with a length of about 11.5 cm. After a few months of cultivating the lobsters inside the lobster pond, the lobsters have grown to a length of 12.5 cm. Lobster length was determined based on the age of the lobsters, which was around 4 months.

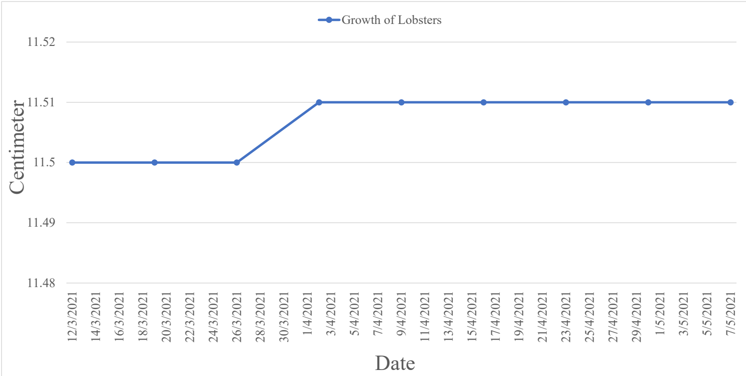

Figure 4.24: Line Graph for Lobsters Length.

The line graph above shows the lobster length is increasing from 12/3/2021 to 7/5/2021, as depicted in the graph above. This demonstrates that this system is capable of monitoring and treating for lobsters from anywhere using a smart phone or laptop via the Cayenne IoT web-based application.

4.8 Discussion

The project's goals were eventually met. In the end, the project succeeded by analyzing the water sensing technique parameters of pH, temperature, and level. After that, the Cayenne IoT platform's automation and monitoring systems performed admirably during the project's testing. This technique can assist lobster growers in enhancing their lobster farming operations.

Besides that, the limitation of this project is about the connectivity of internet connection. The networking needs of IoT projects are well prepared on a regular network depending on the nature of IoT projects. A connectivity provider must be able to support large and developing device networks in a variety of environments. When the Wi-Fi connection was not reliable, it was sometimes difficult to run the devices. Apart from that, the Cayenne IoT web-based application for this project can only connect through Wi-Fi using the local server IP address.

CHAPTER 5

CONCLUSION AND FUTURE WORKS

5.1 Conclusion

As a conclusion, the project IoT data logger and automation system for life below water farming has been done successfully designed and tested. The system has been developed by integration of hardware and software. In addition, the hardware and software architecture of the system is designed to improved previous system of aquaculture for lobsters farming. NodeMCU-ESP32, sensors nodes and electronic parts can be operated functionally by collecting the data from analog output (pH sensor, water temperature sensors and ultrasonic sensors) and digital input (servo motor and water pump) for monitoring and controlling from IoT platform. Cayenne IoT platform is used as dashboard to monitor, control and store the data from NodeMCU-ESP32 and the were displayed in the dashboard platform. The objectives that were set in the beginning of this project were successfully achieved which are analyzing sensing technique for detecting the level of pH water, water temperature and water level [R01], develop the automation system for lobsters farming to maintain the food supply and balance of the pH water [R02], develop IoT data logger system and automation system for lobsters farming which can monitored and controlled via Internet of Things (IoT) platform.

5.2 United Nation Sustainable Development Goals

Consideration to the sustainable Development goals is crucial in developing and producing on IoT data logger and automation system life below water farming because it is very important to debate about sustainability when developing country in consideration of implication in nature and society.

The united nation sustainable development goals for this project is goal 1 end poverty. This project is in line with goal 1 because it is to help the all group especially b40, can do multiple job while taking care of lobsters pond by real-time monitoring the lobsters pond through smart phone via web-based application. furthermore, this project in line with goals 2 end hunger. This project in line with goals 2 because of it is to increase the good quality of protein source in the global market by manage the food supply and good quality of water improve the protein source from lobsters. Lastly, this project in line goals 14 life below water. This project in line with goals 14 it manages to conserve and sustainably use the oceans, seas and marine resources for sustainable development by maintain the ecosystem without compromising by implement this project as smart aquaculture system.

Figure 5.1: 14 Goals from Sustainable Developments Goals.

5.3 Future Works

There is a few changes and improvement that can be implemented to this project.

These improvements are:

1. Implementation solar power
   - Implementation solar power to this system can decrease electricity consuming by using renewable energy.
2. Improving the scale of smart feeder case.
   - Improving the scale of smart feeder case by increasing the size scale of feeder case can hold up the storage of food supply over a month.

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APPENDICES

Appendix A: Monitoring system and automation system Cayenne IoT coding.

```
#define CAYENNE_DEBUG

#define CAYENNE_PRINT Serial

#include <CayenneMQTTESP32.h>

#include <ESP32Servo.h>

#include "DFRobot_ESP_PH.h"

#include "EEPROM.h"

#define ESPADC 4096.0   //the esp Analog Digital Convertion value

#define ESPVOLTAGE 3300 //the esp voltage supply value

#define PH_PIN 35    //the esp gpio data pin number

#include <OneWire.h>

#include <DallasTemperature.h>
```

```
#define VIRTUAL_CHANNEL

#include <UltrasonicSensor.h>



UltrasonicSensor ultrasonic(14,12); // Assign Trig PIN 14(D5),Assign Echo PIN 12(D6)

int FloatSensor=4;

int RelayModule1=15;

int buttonState = 1;

int servoPin = 19;

int ValveSolenoid1=18;

int ValveSolenoid2=27;

int GIu_Ultrasonic_Dist_CM=0;

const int oneWireBus = 5;

OneWire oneWire(oneWireBus);

DallasTemperature sensors(&oneWire);

Servo s1;

DFRobot_ESP_PH ph;
```

```
unsigned long int avgValue; //Store the average value of the sensor feedback

float voltage, phValue, temperature = 25;



char ssid[] = "TP-Link_41C9"; //"mazeband";

char wifiPassword[] = "Research_6"; // "Badin0509";



char username[] = "9c112190-1b89-11eb-b767-3f1a8f1211ba";

char password[] = "f57281a695fa51335f9cdb1bcdf63dee03db1166";

char clientID[] = "5b5fd4e0-255f-11eb-883c-638d8ce4c23d";



void setup()

{

 Serial.begin(115200);

 //Cayenne.begin(username, password, clientID, ssid, wifiPassword);

 sensors.begin();
```

```
pinMode(ValveSolenoid1, OUTPUT);

pinMode(ValveSolenoid2, OUTPUT);

pinMode(FloatSensor, INPUT_PULLUP);

pinMode (RelayModule1, OUTPUT);

s1.attach(servoPin);

EEPROM.begin(32);//needed to permit storage of calibration value in eeprom

ph.begin();

}

void loop()

{

 Cayenne.loop();

 static unsigned long timepoint = millis();

 if (millis() - timepoint > 1000U) //time interval: 1s

 {
```

```
timepoint = millis();

//voltage = rawPinValue / esp32ADC * esp32Vin

voltage = analogRead(PH_PIN) / ESPADC * ESPVOLTAGE; // read the voltage

Serial.print("voltage:");

Serial.println(voltage, 4);



temperature = readTemperature();  // read your temperature sensor to execute
temperature compensation

Serial.print("temperature:");

Serial.print(temperature, 1);

Serial.println("^C");



phValue = ph.readPH(voltage, temperature); // convert voltage to pH with
temperature compensation

Serial.print("pH:");

Serial.println(phValue, 4);

}

ph.calibration(voltage, temperature);
```

```
}

float readTemperature()
{
  sensors.requestTemperatures();
  return sensors.getTempCByIndex(0);
}

CAYENNE_OUT(VIRTUAL_CHANNEL 14)
{
  Cayenne.virtualWrite(VIRTUAL_CHANNEL 14, phValue);
}
CAYENNE_OUT(VIRTUAL_CHANNEL 7)
{
  GIu_Ultrasonic_Dist_CM=ultrasonic.distanceInCentimeters();          // Read
ultrasonic distance value in CM
  Serial.print(GIu_Ultrasonic_Dist_CM);
```

```
  Serial.println(" cm" );
  Cayenne.virtualWrite(VIRTUAL_CHANNEL 7, GIu_Ultrasonic_Dist_CM);
}
CAYENNE_IN(VIRTUAL_CHANNEL 4)
{
  // Determine angle to set the servo.
  int position = getValue.asDouble() * 180;
  // Move the servo to the specified position.
  s1.write(position);
}
CAYENNE_OUT(VIRTUAL_CHANNEL 1)
{
   Cayenne.celsiusWrite(VIRTUAL_CHANNEL1,
sensors.getTempCByIndex(0));
}
```