DEVELOPMENT OF REAL-TIME WIRELESS MONITORING SYSTEM FOR AQUACULTURE INDUSTRIES

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ABSTRACT

Traditionally, the water quality detection especially for aquaculture industries like shrimp aquaculture has been carried out manually wherein the water samples are collected and taken to the laboratories for analysis. Since these methods fail to deliver real time data, we propose a real time water quality monitoring system based on wireless sensor network which helps in continuous and remote monitoring of the water quality data. The application of wireless sensor network (WSN) for a water quality monitoring is composed of a number of sensor nodes with a networking capability that can be deployed for an ad hoc or continuous monitoring purpose. The parameters involved in the water quality determination such as the pH level, conductivity, dissolve oxygen and temperature is measured in the real time by the sensors that send the data to the base station or control/monitoring room. The use of wireless system for monitoring purpose will not only reduce the overall monitoring system cost in term of facilities setup and labour cost, but will also provide flexibility in term of distance or location. In this project, the fundamental design and implementation of WSN featuring a high power transmission Zigbee based technology together with the IEEE 802.15.4 compatible transceiver is proposed. The water quality data will be display using visual studio platform as graphical user interface (GUI).

ABSTRAK

Secara tradisional, pengesanan kualiti air terutama untuk industri akuakultur seperti akuakultur udang telah dilakukan secara manual di mana sampel air dikumpulkan dan dibawa ke makmal untuk dianalisis. Oleh kerana kaedah ini gagal memberikan data masa nyata, kami mencadangkan sistem pemantauan kualiti air masa nyata berdasarkan rangkaian sensor tanpa wayar yang membantu dalam pemantauan data kualiti air secara berterusan dan jarak jauh. Aplikasi rangkaian sensor tanpa wayar (WSN) untuk pemantauan kualiti air terdiri dari sejumlah simpul sensor dengan kemampuan jaringan yang dapat digunakan untuk tujuan pemantauan secara ad hoc atau berterusan. Parameter yang terlibat dalam penentuan kualiti air seperti tahap pH, kekonduksian, oksigen terlarut dan suhu diukur secara real time oleh sensor yang mengirim data ke stesen pangkalan atau ruang kawalan / pemantauan. Penggunaan sistem tanpa wayar untuk tujuan pemantauan tidak hanya akan mengurangi keseluruhan biaya sistem pemantauan dari segi penyediaan kemudahan dan biaya tenaga kerja, tetapi juga akan memberikan fleksibilitas dari segi jarak atau lokasi. Dalam projek ini, reka bentuk dan pelaksanaan asas WSN yang menampilkan teknologi berasaskan Zigbee transmisi kuasa tinggi bersama-sama dengan transceiver serasi IEEE 802.15.4 dicadangkan. Data kualiti air akan dipaparkan menggunakan platform studio visual sebagai antara muka pengguna grafik (GUI).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

IoT	Internet of Things
GUI	Graphical User Interface
IDE	Integrated Development Environment
GSM	Global System for Mobile Communication
DO	Dissolve Oxygen
VB	Visual Basic

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Aquaculture farm is one of the activities that can boost our country economy. The reason aqua farming activity is very popular among our citizens because of higher demand from many industry especially food and hotel industry. This because taste of shrimp is delicious, it can be cook in various way depends on people taste. Aqua farming activities is very popular nowadays. However, there are many problems regarding aqua farming activities in term of aqua care. How to make sure that aqua that we farm can survive and grow healthy?

Water quality for aqua farm is very important part for aqua to survive and grow healthy. There are many parameters that we need to alert such as temperature and ph. Ph needs to be maintained in range 6 to 8[a1][MKMN2] based on journal Lab-Scale Zero Exchange Shrimp Aquaculture [1]. If below or higher than that threshold, it will affect shrimp growth and concentration of dissolve oxygen. Dissolve oxygen needs to stay in higher concentration because it will affect shrimp's antibody. Temperature also needs to be control as it will affect dissolve oxygen concentration cause of double usage of dissolve oxygen if temperature is too high. The question is how to maintain these water quality parameters? Many aquaculture farmers still use traditional method which is collect water samples and send those samples to laboratory. This way is good but it takes time to know the condition of water quality at their pools. Nowadays, they start using sensor manually. For example, shrimp farmer will measure ph of pools using ph sensor at certain points and record manually. If there are 2 parameters, they will use two sensors at those points. This method also good for collecting and analyzing data faster and shrimp farmer can take action from data immediately. However, there is better solution for this problem which using collecting and analyzing data samples wirelessly.

Hereby, we managed to design a prototype of water quality monitoring system using wireless sensor network at shrimp pools in order to solve this problem. Sensors based on parameters are placed on the pools to measure parameters given. It connected with microcontroller and wireless transmitter. Microcontroller use to control the system which is control data from input sensor and wireless transmitter function is to transmit data to another microcontroller which is act as main system. Main system use microcontroller, wireless receiver, GSM then connected to computer. It has graphical user interface (GUI) which function to control and display data to the user in certain time. GSM act as alert system which created alarm to tell user that parameter has reached its threshold and send alarm message to user to make it efficient. So, user can take immediate action to do some maintenance to his pools. This method is better idea of how to collect and analyze data efficiently.

1.1 PROBLEM STATEMENT

Based on introduction section above, the problem of shrimp farmers will face to ensure their shrimps will survive and undergo rapid growth. Traditional method that they use is very tiring because they need to visit all of their pools and take water samples manually. They also need to spend cost to pay the workers to take samples for all pools. If they send the water samples to laboratory, they have to spend another cost for laboratory work. This method is very unreliable, not efficient and very costly for long term.

There is a problem that observe based on real situation which is how to monitor water quality simultaneously and automatic. For example, police department in United States monitor their road and grid even control traffic light using their monitoring system which is using security camera as their main devices.

Nowadays, wireless system is very popular and used in many activities and devices. Wireless system makes transmit and received data become efficient and easy to user. In our case, the question is how to collect and gather data from all pools wirelessly at the same time. Wireless implementation is needed in this system.

1.2 OBJECTIVES

This project focuses on the objective that concern about development of water quality monitoring system at aquaculture farm. On the other hand, the research should concentrate on these following aspects;

- To develop prototype of water quality monitoring system based on aquaculture farm which is automatic and real-time
- Implementation of wireless system which can display data from pools in one graphical user interface (GUI)
- Implementation of GSM as alert system when data reading above threshold value.

1.3 SCOPE OF PROJECT[a3][MKMN4]

The scope is to design specifications in order to perform water quality monitoring system using wireless sensor network based on objectives. These sets of requirements are intended to fully describe all the stages in hardware and software design as well as the interfacing of the device with a personal computer. There are work scopes that need to follow until the prototype system is completed;

- Design prototype hardware and research the suitable material use for build the prototype farm. (Hardware part)

- Build the prototype farm and researching hardware specification includes microcontroller, sensors, wireless module and GSM Hardware part.

- Develop system by program the microcontroller to sync with sensors and wireless module and deliver data real-time. (Software part).

- Develop interface that will display data according to specification which is classification of data and timing to collect data from pools. It also includes synchronization with alarm system (GSM). (Software part)

- Troubleshooting and analysis part.

CHAPTER 2

LITERATURE REVIEW[a5][MKMN6]

2.1 INTRODUCTION

This chapter covers a series of literature review that was conducted throughout the entire project in order to deepen and widen the knowledge fields while accomplishing the project. Basically the fundamental sources to obtain the information are came from journals, articles or books that published on Internet or selling on the market. This chapter is examined the past projects and those resources which related to this project. It is essential to understand how precisely the system function by doing fine analysis on the previous projects or researches.

2.2 METHOD OF MONITORING WATER QUALITY

There 2 methods have been using by shrimp farmers to monitor their water quality;

- Traditional method
- Developing method

2.2.1 Traditional Method

Based on Food and Agriculture Organization of United Nations on Water Quality Management journal [5], this method is usually using manual effort and laboratory experiments to get all those parameters[a7] and usually takes a week to get the result. First, they take water samples from all of their pools and undergo a few experiments. For temperature test, they using thermometer based on figure 2.1 to detect temperature of their samples.

Figure 2.1: Thermometer[a8]

For ph test, they usually used ph paper as shown in figure 2.2 to observe ph of their water samples. However, this method is proved not accurate for monitoring water quality because this method is not practical and unreliable.

Figure 2.2: Ph Paper

Based on [5], they are using colorimetric method based on figure 2.3 which is practical experiment method to detect ph. Colorimetric method makes use of comparators such as lovibond which is a scale for measuring colour which is placed in tintometer. The samples will add with other indicators and compared with coloured solution known as ph.

Figure 2.3: Colorimetric method process

For measuring concentration of dissolve oxygen, they are using experiment method which is wrinkle titration method based on figure 2.4 which is generally conducted in lab.

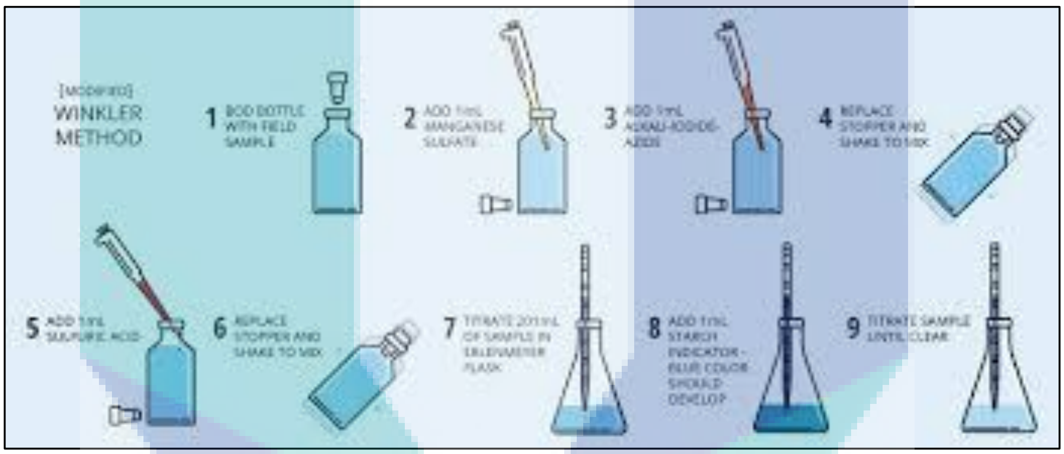


Figure 2.4: Wrinkler titration method process

2.2.2 Developing Method[a9][MKMN10]

Kasnir.M, Harlina, and Rosmiati has studied of water quality analysis for the feasibility of shrimp culture in Takalar Regency, Indonesia [3]. According to this article, most of shrimp farmers using sensor to detect parameters for their water quality. Different sensors were used which is ph sensor, temperature sensor and dissolve oxygen sensor. This section shows that some of the shrimp farmer develop the technique of monitoring by using equipment like sensor. Table 2.1 shows the method that they used to monitor water quality of shrimp pool.

Table 2.1: Water quality measurement shrimp farm in Takalar Regency, Indonesia[a11][MKMN12] [3]

No	Water quality parameter	Equipment	Note
1	Water temperature	YSI	Insitu
2	Ph	YSI	Insitu
3	Dissolve Oxygen	YSI	Insitu

2.2.3 Development of water quality that already exist[a13][MKMN14]

There is a system that already performing the water quality at shrimp pool using LabVIEW which invented by University of Michigan's researcher. Based on Daniel Nguyen studies on Lab-Scale Zero Exchange Shrimp Aquaculture journal [1], parameters limit that used to monitor shrimp pool are to ensure that shrimp can undergo rapid growth and survive. Main idea of the system is to consistently monitor and record the water quality parameters including the water temperature, pH value, ammonia level, dissolve oxygen level and salinity. It also ensure that that the water quality parameters are maintained at a certain level. Example of GUI that used in the system as shown in figure 2.5. In conclusion, this section shows that there is a development method to monitor water quality besides the methods that mentioned earlier which can monitor water quality real-time and display it on GUI.

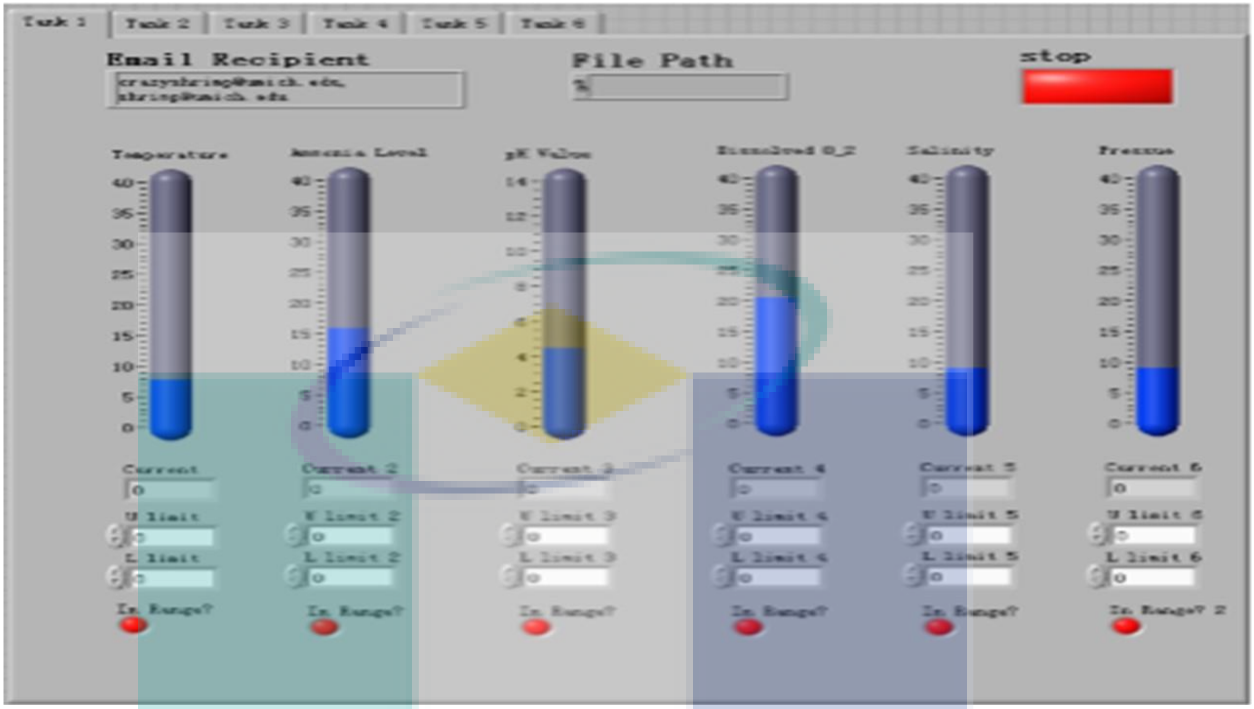


Figure 2.5: Interface of LabVIEW monitoring code

2.3 WATER QUALITY PARAMETERS

Parameter plays very important role in monitoring system. Before we developed this system, we need to study about what is the parameter that important in order to ensure that shrimp will survive and growth healthy. Based on various journal which are Shrimp Aquaculture [1], Study on Water and Soil Quality Parameters of Shrimp and Prawn Farming in the Southwest Region of Bangladesh [2], and Water Quality Assessment of a Shrimp Farm: A Study in a Salinity Prone Area of Bangladesh [4] study about parameters for measuring water quality that suitable for shrimp in different region and area. These data and analysis are very helpful to decide the suitable parameters which are ph, temperature and DO for Malaysia region. Table 2.2 shows data collected from shrimp farm at Southwest Region of Bangladesh during dry and wet season.

Table 2.2: Parameter's data for shrimp farm at Southwest Region of Bangladesh [2]

No	Water quality parameter	Wet season	Dry season
1	Temperature (°C)	31.67 ± 0.68	32.67 ± 0.88
2	pH	7.30 ± 0.15	8.33 ± 0.61
3	Dissolve Oxygen (ppm)	5.33 ± 0.34	9.67 ± 1.68

2.3.1 Temperature

Temperature plays important role in regulating the activities of cultured animal. Best temperature maintain for shrimp farm is below ±30°C

2.3.2 Ph

Fertility and potential productivity depend on PH value. 7.5 to 9.0 is suitable for shrimp farm

2.3.3 DO

Dissolve oxygen very important for shrimp growth and survival. Optimum DO range is from 4.5 mg/L to 8 mg/L

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

When it comes to monitoring system, real-time concept must be implemented to ensure that our system is efficient and reliable. Based on Kanakka Juvva on Real Time Systems journal [6], real-time system can be decomposed into a set of subsystems include the controlled object, the real-time computer system and the human operator. A real-time computer system must react to stimuli from the controlled object (or the operator) within time intervals dictated by its environment.

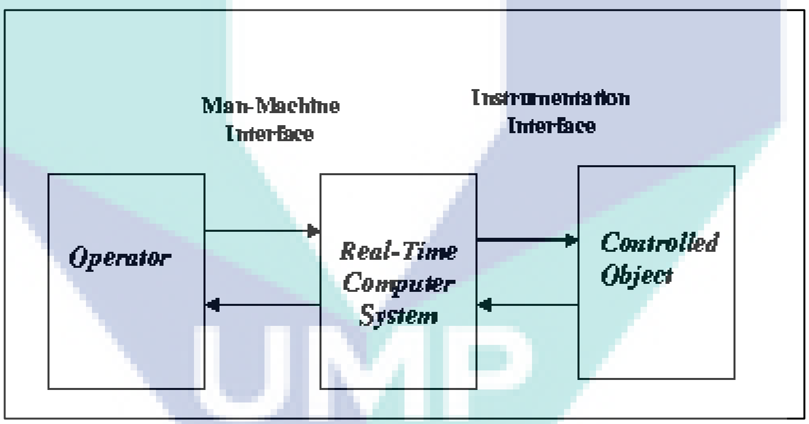


Figure 3.1: Definition of real-time system

We have studied how the real time system works based on figure 3.1 and try to implement it to our system. First, we need to identified which is controlled object or what are we controlling. In our case, we need to control data of sensors in from different pools which include few types of process which is collecting, gathering, and transmitting data to main system. Controlling time for system to transmit the data also is the important part. Microcontroller is needed as our embedded system that can manipulate data. After that, we need to identify what is our main system. Computer is needed in this project as our main system. Main system function as receiver of all data gathered from other microcontroller. Graphical user interface (GUI) is needed for few process such as logging data, classification and display data to the user. Main system also controlling the limit or threshold for parameters that we measured and identified whether the parameters are safe or vice versa to the shrimps. For safety purposes, we try to implement alarm system which is consist of Global System for Mobile Communication (GSM) and displaying alert status on GUI. The status will appear as the parameter that we measured is unsafe while GSM as one of the alternative which can message the user about condition of the pools based on parameters.

3.2 DESIGNING SYSTEM AND PROTOTYPE

We intend to propose a prototype system which has two pools represented as case study for this system. Designation of the system is consists of two parts;

- Slave system
- Main system

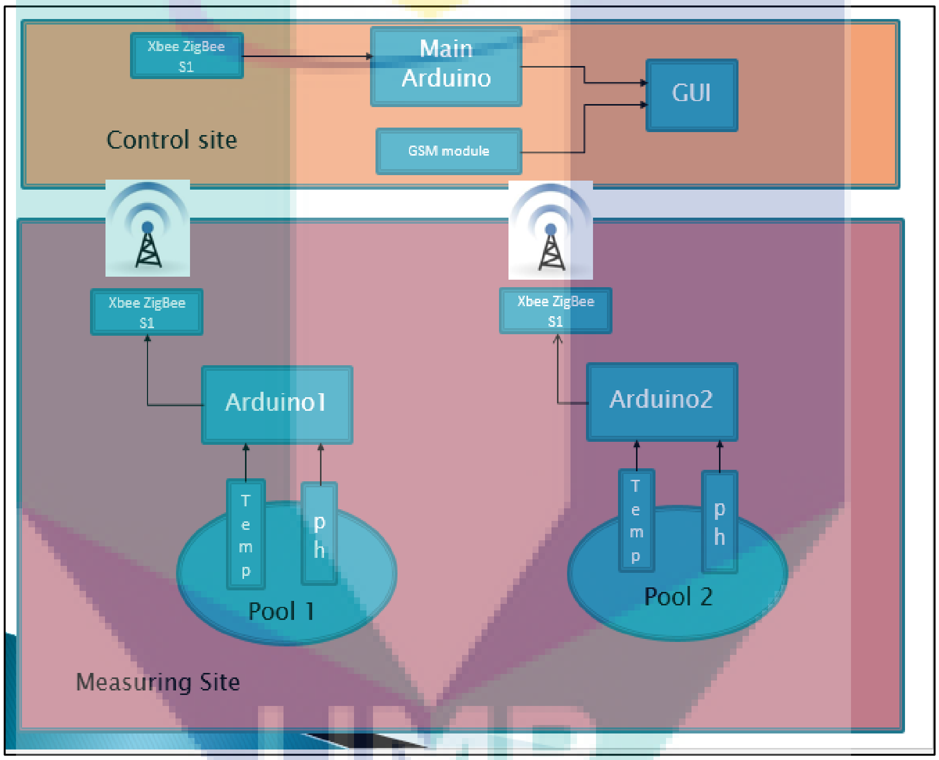


Figure 3.2: Block diagram of overall concept of the system

- Slave system

For this project, slave system is located at prototype hardware which is consists of two pools act as our case study. Based on figure 3.2, each pool consists of two sensors which is temperature sensor, and ph sensor. These sensors will collected data and act as input in our system. It connected with one microcontroller act as controlling data and set wireless transmitter as output which function to transmit data to main system.

- Main system

Based on figure 3.2, master system consists of microcontroller, wireless receiver and GSM which are connected to computer. Wireless receiver act as input in microcontroller which function as receive signal data from transmitter. Data will be program to computer which simulate by GUI to display the data. GSM act as output of the system.

For this system, our objective is to visualize the functionality of the system to target user. Thus, there is a design of prototype hardware represents as shrimp pools and run the system using it. The design is sketched using SolidWorks software as shown in figure 3.3.

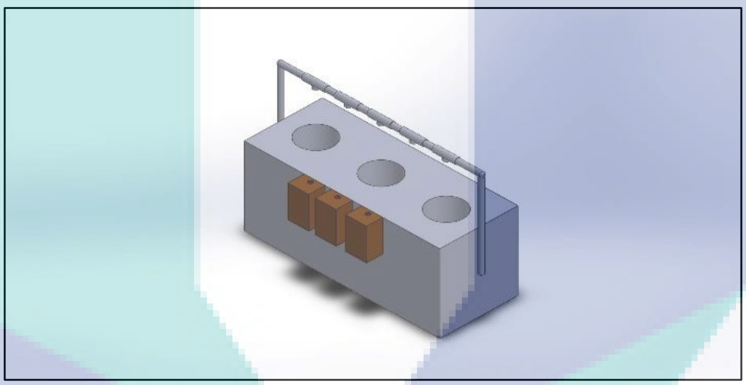


Figure 3.3: Early design of prototype hardware

In order to work on this prototype, we need to study on material that we may use to build it. Based on dimension of design in figure 3.3, the materials that use are as listed below;

- 12mm[a15][MKMN16] Plywood
- 15 mm diameter of PVC pipe (for wiring installation)
- 10.5 cm container
- IP65 waterproof box

3.3 HARDWARE DESIGN

3.3.1 Introduction

Majority of this system involving the development of hardware prototype. This section will explain about the characteristics or specifications of hardware components that the system needs in order to function as expected in this project. Design system and prototype that mentioned in section 3.2 will be implemented using these hardware components. It consists of temperature sensor, ph sensor, Arduino NANO board and Zigbee Xbee S1 (transmitter and receiver). The ph and temperature data that acquired from these components would be displayed and analyzed. All of the data are measured from water as test subject. In other word, it is called water quality. The system will cooperated with other Arduino Nano and Zigbee which act as receiver to receive data and interpret it to GUI that display at the computer. GUI will be invented using Microsoft Visual Studio 2015 software. GSM also connected to computer that will sync up with GUI to send alert message if the parameter values exceed its limit.

3.3.2 Sensors

Data acquisition of monitored parameters like water quality will be done using specific sensors. Temperature sensor will be used to monitor temperature of the water in pools or monitoring area. This sensor is able to monitor up to boiling point and down to freezing point of temperature as it is very accurate to measure temperature in water. In addition, ph sensor is used to measure ph of the water at monitoring area as it can measure all the ph solution. The selection of sensor depends on it specifications.

3.3.2.1 Temperature Sensor

In this project, DS12B80 Temperature sensor is used to measure temperature of the water at monitoring area. This sensor consists of three wire. The three wire from the sensor are input 5V voltage, sensor pin for output voltage GND for ground. The sensor as shown in figure 3.4. Table 3.1 also shows the specifications of this sensor.

Figure 3.4: DS12B80 Temperature sensor

Table 3.1: Technical specification of DS12B80 Temperature sensor

Specification	Description
Power	5V
Accuracy	± 0.5
Interface	Use 1-Wire interface – required only one digital pin for communication
Wire	• Red wire - VCC • Black wire - GND • Yellow wire - DATA
Material	Stainless steel tube 6mm diameter by 35mm long
Thermal time constant	10s

Basic test circuit is shown in figure 3.5. The sensor is powered by 5V voltage supplied from Arduino NANO. Red wire will connected to 5V pin. Black wire will connected to ground. Yellow wire will connected to 4.7K ohm resistor then connected to digital pin 2 on Arduino.

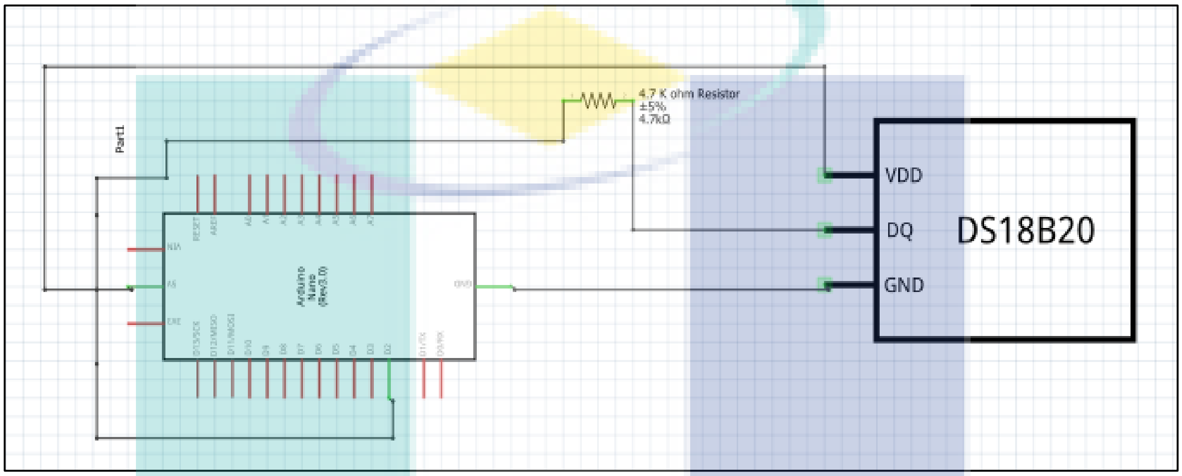


Figure 3.5: Schematic circuit for DS18B20 Temperature sensor

3.3.2.2 Ph sensor

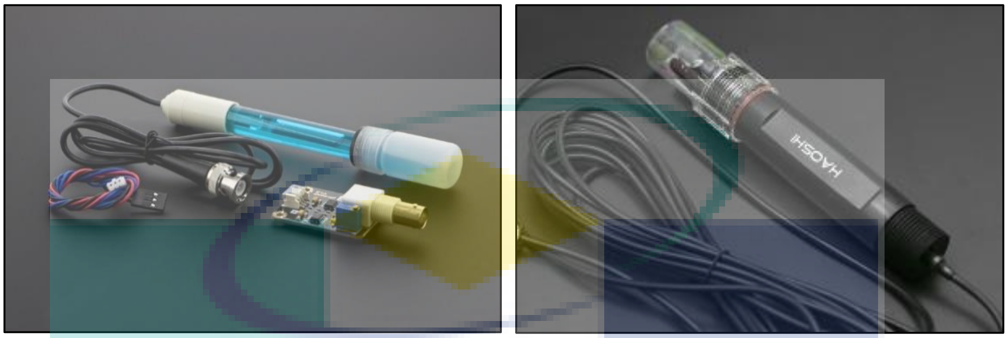


Figure 3.6: SEN 0161 Analog Ph meter (left) and SEN0169 Analog Ph meter (right)

In this project, both type of ph meter kits based on figure 3.6 are chosen to monitor ph of water at monitor area. I used two different type of sensors in order to compare which one is more suitable with the system and project. Figure 3.7 below shows the schematic circuit of sensor interface with Arduino NANO.

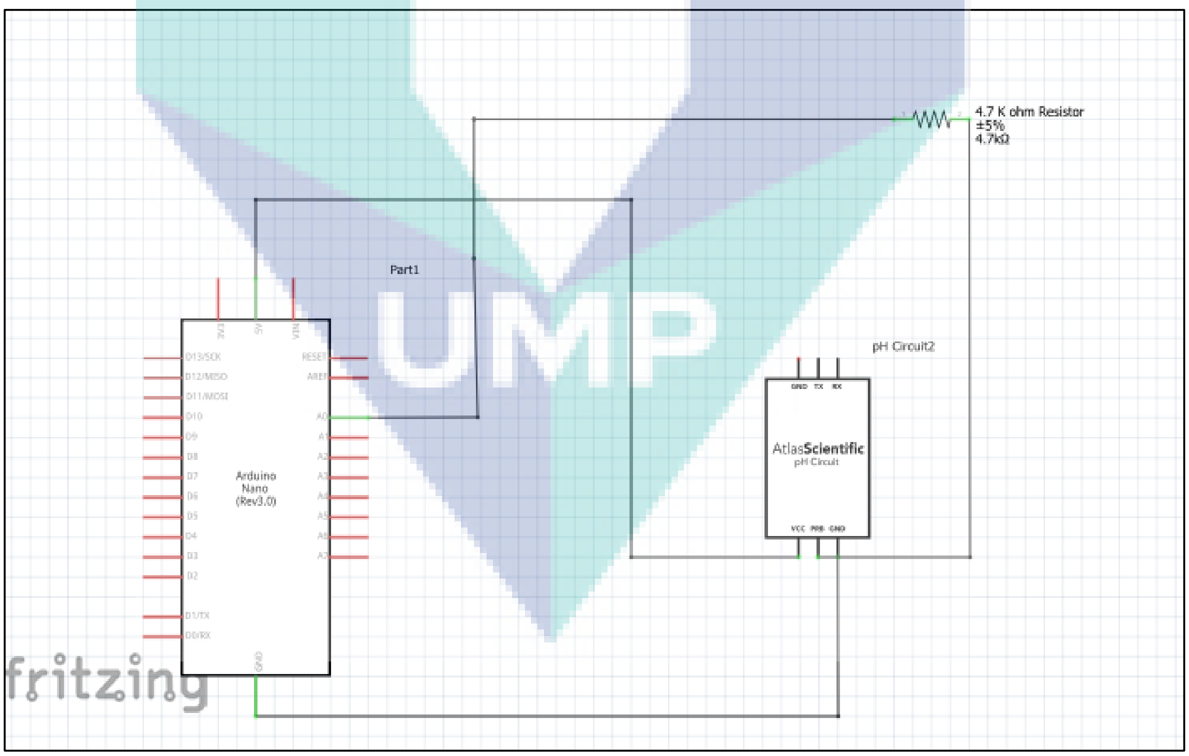


Figure 3.7: Schematic circuit of ph meter interface with Arduino

Both of sensors are analog type. Sensors are connected to Analog pin on Arduino which is A0 act as data communication pin. Both of sensors have almost similar in specifications but have few differences in feature. Table 3.2 shows the specifications of both type of sensors.

Table 3.2: Specifications for Both pH Sensors[a17][MKMN18]

Specification	**Description**
Module Power	5V
PH measuring range	0 – 14
Measuring Temperature	0-60 ℃
Accuracy	± 0.1pH (25 ℃)
Response Time	≤ 1min

Although the specifications are almost the same, there are differences between these ph sensors which are;

- **Long**[a19][MKMN20]**-Firing Operation**: SEN0169 afford to support it while SEN0161 cannot immerse in water for continuous testing.
- **Life Span**: In continuous testing, SEN0169 can work much longer than SEN0161
- **Waterproof**: SEN0169 can be immersed fully into water while SEN0161 can only immerse front part of the probe.
- **Strongly Acid and Alkali**: SEN0169 preferred for strongly acid and alkali testing while SEN0161 is preferred for ph range 6 – 8.

3.3.3 Xbee Zigbee S1 Module

Xbee module is the radio device that uses ZigBee or 802.15.4 protocol. It send and receive data via the 2.4GHz or 900MHz band at a relatively low power and can be used to set up simple point-to-point links or complex self-healing networks spread over quite large areas. Two modules are needed to complete this project which is acting as a transmitter and receiver respectively. Xbee S1 operated within specific range 90 meters. The wireless range of this module is measured in open area without obstacle. This wireless range may reduce if it was placed at indoor places which the signal blocked by obstacle. The specification of Zigbee Xbee S1 is shown in table 3.3 below.

Table 3.3: Technical Specification for Zigbee Xbee S1 Module

Range	300 Ft
Power consumption	50mA @ 3.3v
Frequency	2.4GHz
Protocol	802.15.4
Tx Power	1mW
Data Rate	250kbps
Antenna	Wire

All parameter that acquired from the sensor reading are transferred to the other Zigbee receiver which located at main system to interface with GUI in the computer wirelessly. Figure 3.8 below shows the picture of Zigbee Xbee S1 module. On the other hand, figure 3.9 shows the schematic circuit on how the wireless module interface with Arduino.

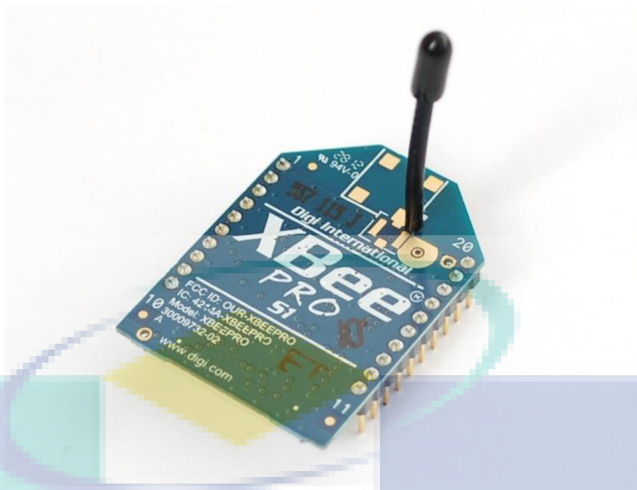


Figure 3.8: Zigbee Xbee S1 Module

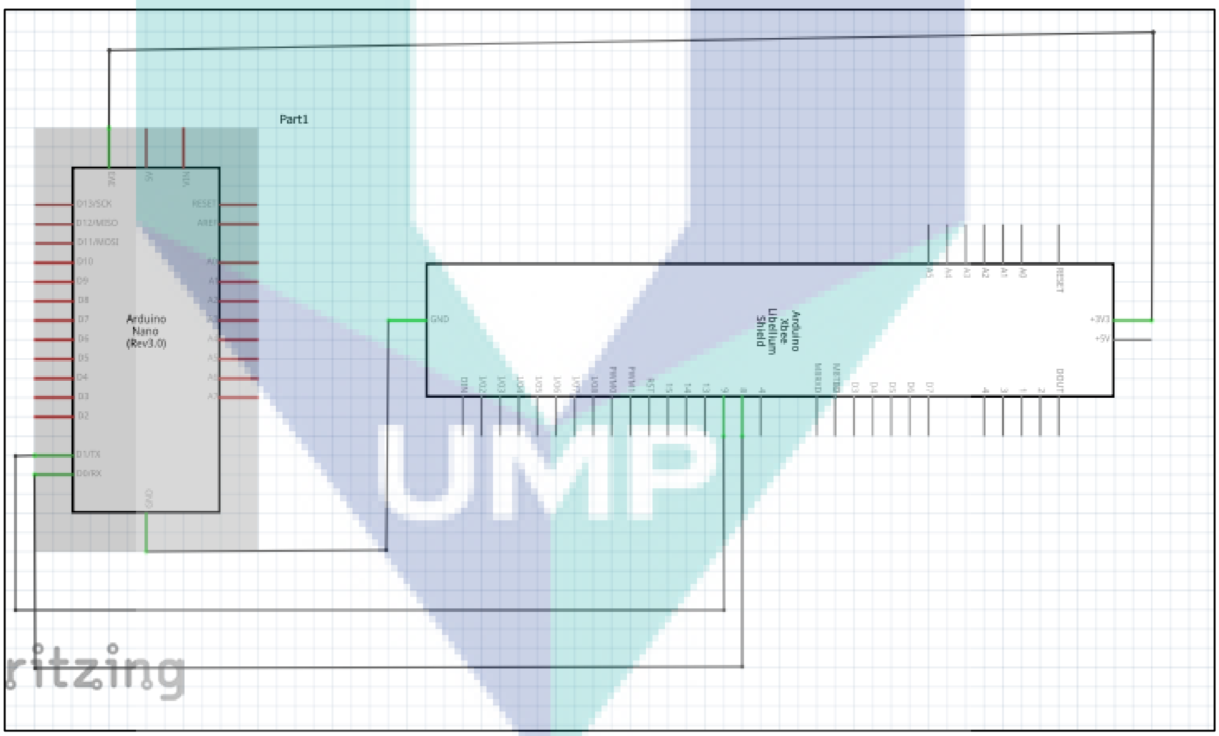


Figure 3.9: Schematic circuit of wireless module connected to Arduino

For the connection, we use digital pin to connect Zigbee with Arduino which is pin 8 for connect to RX (receiver) while pin 9 connect to TX (transmitter). For Zigbee, it use 3.3 V supply from Arduino. Thus, V3.3 must connect to 3.3V on Arduino and it must be grounded.

3.3.4 Arduino NANO Board

Arduino is microcontroller based with ATMEL microcontroller, ATmega328. It consists of fourteen digital I/O pins, eight analog inputs, a 16 MHz crystal oscillator and USB connection. It contains everything needed to support the microcontroller which simply connects it to a computer with a USB cable to get started. Arduino also can be powered via a power bank. The power source is switching based on decision of the user. However, NANO boards does not compatible with Xbee Shield as we need connect it on one board and connect using jumper wire. In this project, the Arduino board is communicate with Zigbee Xbee S1 by placed it on circuit board and connect it using wrapping wire method for wireless data transmission. Figure 3.10 below shows the whole connection of Arduino board. The analog to digital converter specification and its relation with range of analog inputs is studied and shows in later sections.

. This project will applied the power bank as the power source for mobility. The specification of Arduino NANO board shows in Table 3.4.

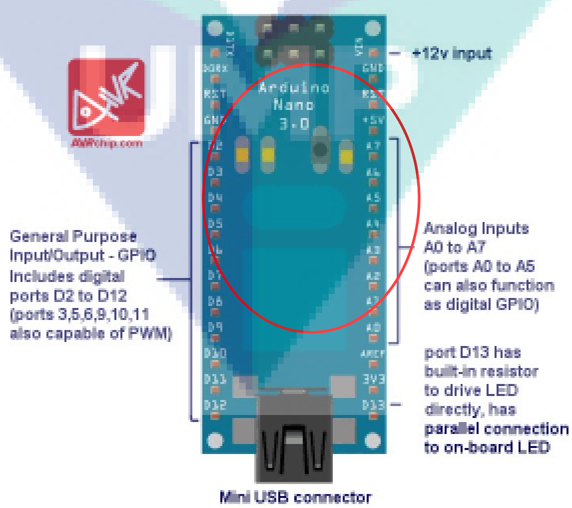


Figure 3.10: Arduino NANO with pins and configurations

Table 3.4: Arduino NANO Specification

Microcontroller	Atmel ATmega168 or ATmega328
Operating Voltage (logic level)	5 V
Input Voltage (recommended)	7-12 V
Input Voltage (limits)	6-20 V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	8
DC Current per I/O Pin	40 mA
Flash Memory	16 KB (ATmega168) or 32 KB (ATmega328) of which 2 KB used by bootloader
SRAM	1 KB (ATmega168) or 2 KB (ATmega328)
EEPROM	512 bytes (ATmega168) or 1 KB (ATmega328)
Clock Speed	16 MHz
Dimensions	0.73″ x 1.70″
Length	45 mm
Width	18 mm
Weight	5 g

3.3.5 GSM Module

Arduino GSM shield allows an Arduino board to connect to the internet, calling or receive call and sending or receiving text message. Arduino shield uses a radio modem M10 by Quectel which is possible to communicate with the board using AT command. This shield uses digital pins 2 and 3 for software serial communication with the M10. Thus, pin 2 connected to TX pin while pin 3 connected to RX pin.

M10 that I mentioned earlier is a Quad-band GSM/GPRS modem that works at frequencies GSM850MHz, GSM900MHz, DCS1800MHz and PCS1900MHz. It supports TCP/UDP and HTTP protocols through a GPRS connection. Figure 3.11 shows the GSM shield connected with Arduino UNO.

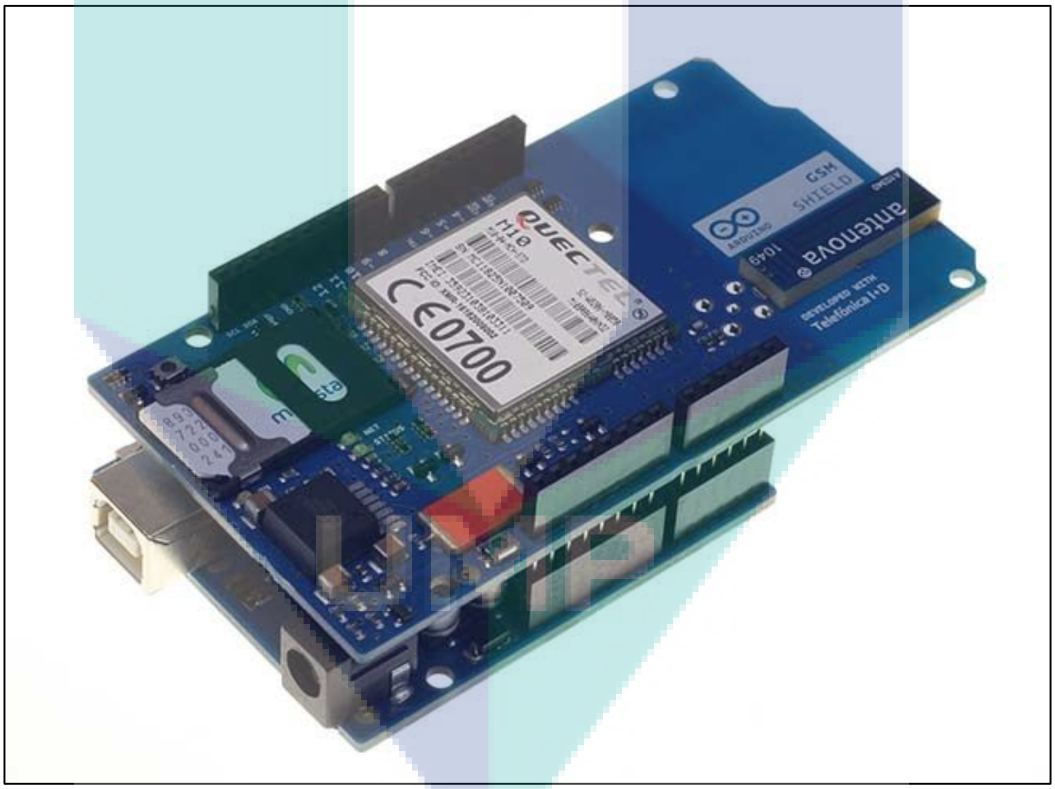


Figure 3.11: Arduino GSM Shield connected with Arduino UNO

3.3.6 Power Supply

In this project, power supply that used for turn up the Arduino is power bank. Arduino NANO has no power plug to supply power except USB connection. Thus, power bank is important to supply 5V to turn on Arduino. Based on table 3.5, power bank that used has 20 000 mAh to ensure that it can supply Arduino much longer. It also can save cost as it has two USB connector which can supply two Arduino at the same time as shown in figure 3.12.

Table 3.5: Pineng Power Bank PN-999 Specification

Input	DC, 5V, 2A
Output	5V, 1.0 A ; 5V, 2.1 A
Built-in battery capacities	3.7V, 20000 mAh, 37 Wh
Battery type	Lithium Ion Battery
Charge Retention	>5000hrs
Cycle life of charging	500 times
Net weight	292g
Size	140 X 62 X 23 mm
Cost	RM 65.00

Figure 3.12: Pineng Power Bank PN-999 view

3.4 SOFTWARE DESIGN

3.4.1 Arduino Software[a21][MKMN22]

Arduino Software is used to program Arduino NANO and Arduino UNO board. It can be downloaded through Arduino official website. The latest version of Arduino 1.8.1 is being used to program the board. Arduino software act as main system for whole the project. It will reads the serial values from the sensors inputs, then processing it with calculation designed to convert raw data into processed data with standard unit. Then, it will transmit data wirelessly using Zigbee Xbee S1 module. Figure 3.13 shows the flowchart of the system based on Arduino function.

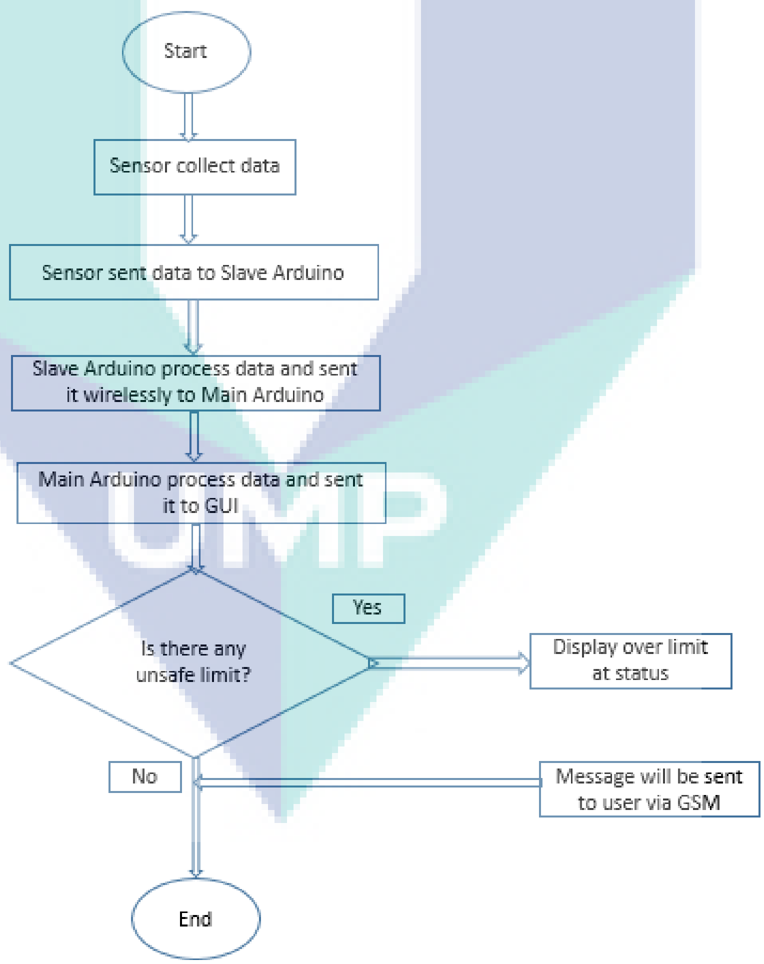


Figure 3.13: Flowchart of the system

3.4.1.1 Temperature Calculating Process

Temperature calculating process is simpler process as Arduino has its own library to sync up with DS12B80 Temperature sensor to get real temperature value. Firstly, declaration of #include OneWire library onto the code must be done to sync up with the system. Then, it need to declare digital pin that connected on hardware process which I connected to pin 2. We can get temperature by declaring getTempCby index on Arduino to make change value of voltage onto value of temperature.

3.4.1.2 Ph Calculating Process

First step to measure ph using ph sensor on Arduino is to identify the specification of sensor. Based on sensor specification on hardware topic, we can see that sensor need 5V supply to turn on and work to measure ph in water. Then, we need to analyze the relationship between voltage and ph value in ph electrode characteristics as shown in table 3.5.

Table 3.6: Relationship between Voltage and pH Value in pH Electrode

VOLTAGE (mV)	pH value	VOLTAGE (mV)	pH value
414.12	0.00	-414.12	14.00
354.96	1.00	-354.96	13.00
295.80	2.00	-295.80	12.00
236.64	3.00	-236.64	11.00
177.48	4.00	-177.48	10.00
118.32	5.00	-118.32	9.00
59.16	6.00	-59.16	8.00
0.00	7.00	0.00	7.00

Since ph sensor is connected to analog pin, analog read value must be used as part of the ph calculation. When ph sensor measures the ph water, it will use voltage that supply from the Arduino. Arduino will detect amount of voltage used based on ph of water. For example, more acidic the water, more voltage that will used to indicate the water as shown at table 3.5. For analog pin, the value of voltage indicates by analog read value which 0-1063. There is calculation that I used to indicate ph of water as shown below

$$\text{Sensor Value} = (\text{Analog Read} / 815) \times 14 \qquad \text{(Equation 3.1)}$$

From this equation 3.1, the calculation is used to program the indication of ph which this calculation will indicate ph value then display on monitor.

3.4.2 Graphical user interface (GUI) Development

Microsoft Visual Studio is an Integrated Development Environment (IDE) from Microsoft. Figure 3.13 shows the icon of Visual Studio. It is software can develop computer programs as well as website apps and mobile phone apps. It is a development application that consists of set of tools for acquiring, analyzing, displaying and storing data. In this project, Visual Studio is designed to display water qualities which include temperature and ph value in water that can easily monitor by user wirelessly.

Figure 3.14: Icon of Visual Studio[a23][MKMN24]

For Visual Studio, it can use two languages to program this software which is #C language and VB language. VB is used to program this GUI because it is easier and tend to use library while using it. Purposes of using this software are to build a GUI that can fulfill the expectation of the functionality of this system. From GUI, data can be received from Arduino and can be display based on our design. Next, it can be program to control the limit value for parameters that the system measure. It also can display the status of the pool when the parameters value exceed its range and can communicate with GSM to trigger alert message to the user. Lastly, the monitoring data can be saved into a file. There are steps to start the software as shown below.

Step 1: Open Microsoft Visual Studio 2015 IDE[a25][a26][MKMN27]

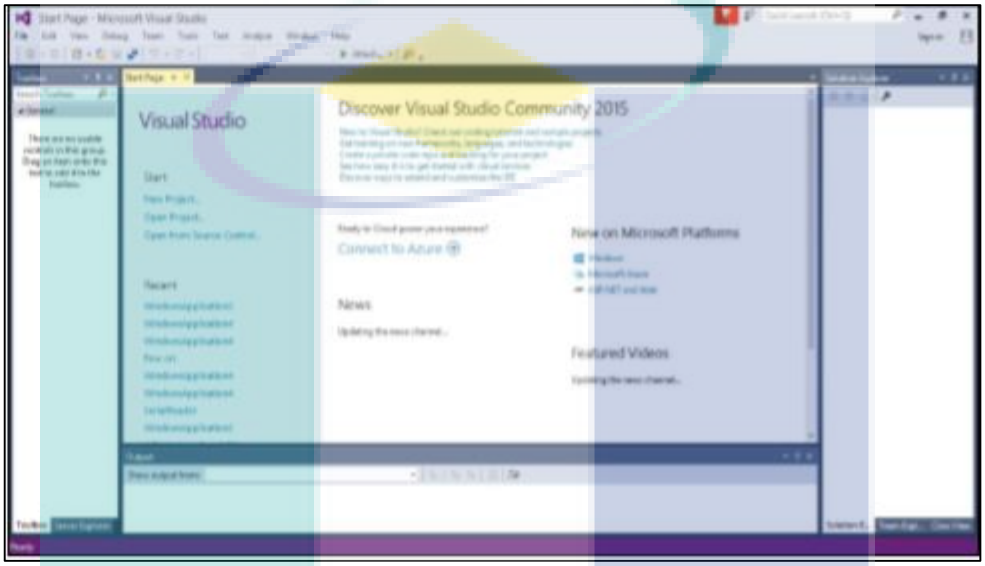


Figure 3.15: Startup of Microsoft Visual Studio 2015

Step 2: Choose the Windows Application form to develop GUI in Visual Basic language

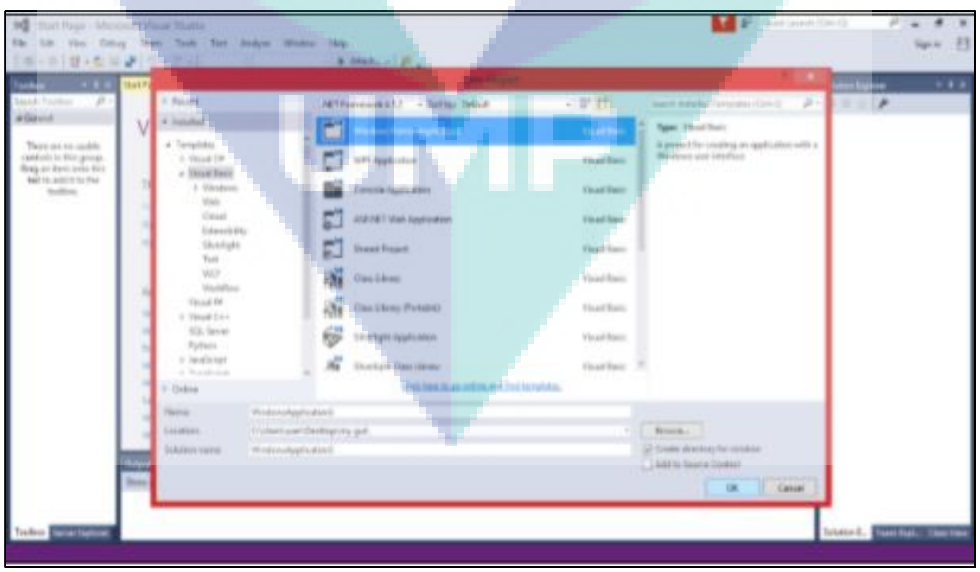


Figure 3.16: Windows Application Form selectio

Step 3: Designing GUI

Figure 3.16 shows an early design of GUI after step 2. Firstly, this GUI contain many tools that used from Visual Studio which is textbox, Rich Textbox, button and label. Each of the tools act as different function. It also contain serial ports which is serial port 1 and serial port 2. Serial port 1 function as communication system between GUI and Main Arduino while serial port 2 function as communication system between GUI and GSM. Besides, it also contain timers which is timer 1 and timer 2. Timer 1 used as displaying date and time while timer 2 used as time stamp for displaying data.

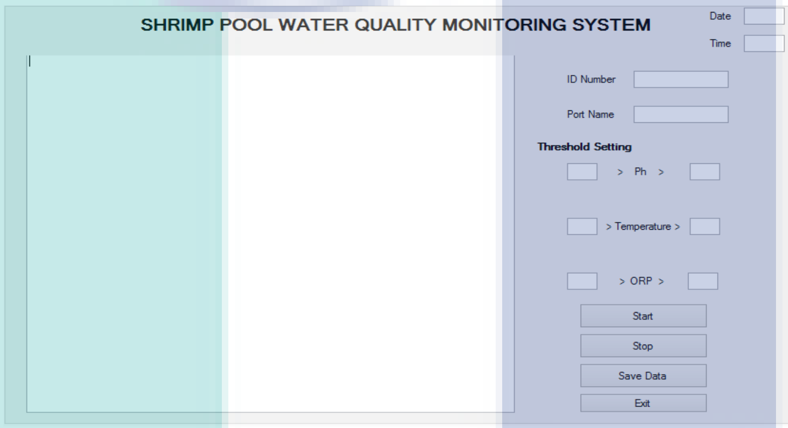


Figure 3.17: First sketching of GUI

Step 4: Program code for GUI

Program code section as shown in figure 3.17 is the section that use to program each function of the tools.

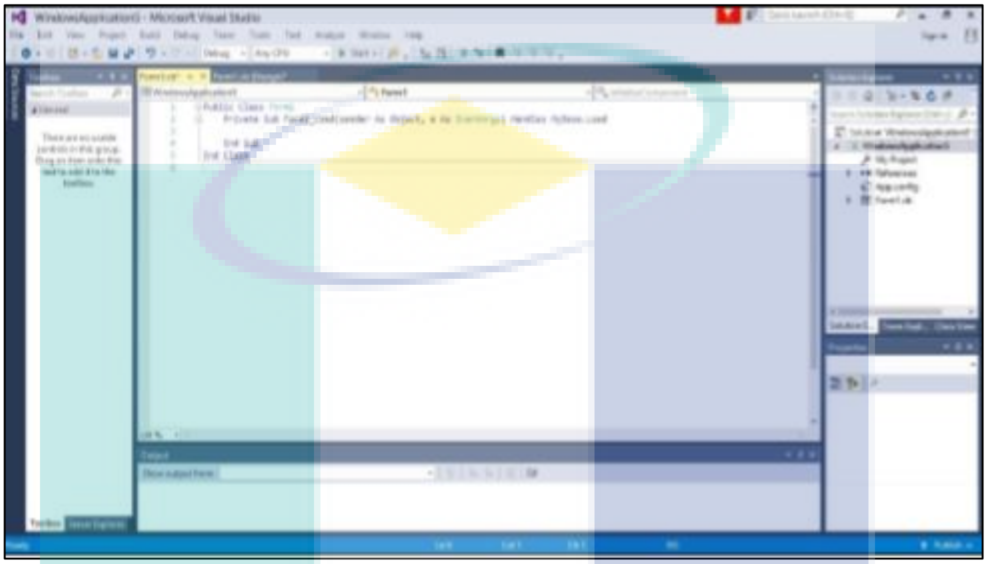


Figure 3.18: Programming form

Step 5: Finalize GUI

There are some improvement of GUI design as show in figure 3.18. The GUI design is finalizes well as program code. Function and effect of GUI will be shown at results.

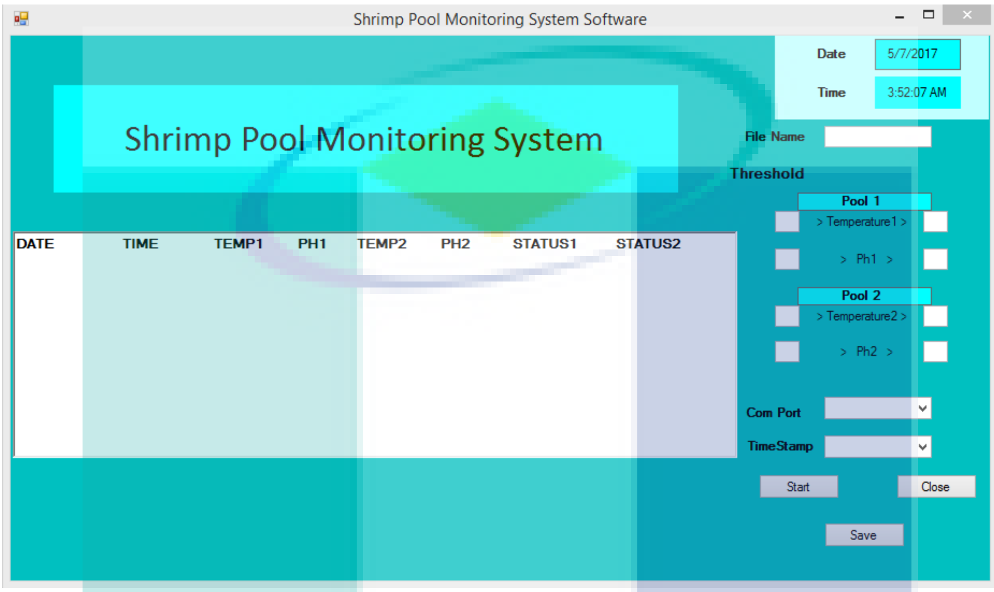


Figure 3.19: Final GUI sketching

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter specifically discuss about the results obtained from previous chapter regarding functionality of this system from hardware to software which include GUI display. Analysis part which will be discussed in discussion part. It will elaborate the data analysis was done based on the data acquired from these results. The data obtained was calculating and researching about the actual theoretical values and then compared with the results acquired.

4.2 RESULTS

Figure 4.1 shows complete prototype design for this system. There 2 holes consider as shrimp pools connected with 2 type of sensors each which is ph and temperature sensor. Ph and temperature are used as parameters to detect quality of water in pools. Board on the protoype box is slave circuit which connection of Arduino Nano with ph sensor, temperature sensor and Zigbee S1.

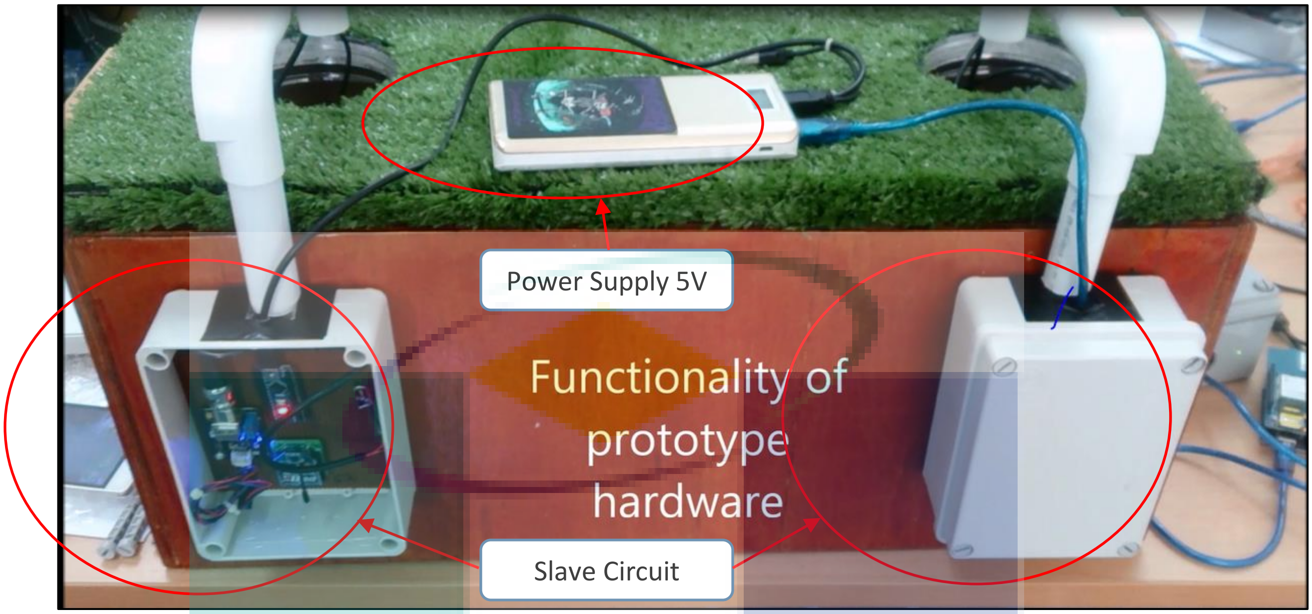


Figure 4.1: Complete Prototype Hardware

Combination of component in one circuit as shown in Figure 4.2 is cover by using IP95 box which function as slave. Function of slave is to collect data and transfer it to main which is connected to laptop. Blue LED on slave's circuit board will light up when ph sensor is connected while red LED light up when Arduino is connected to power source which is power bank that gives 5V power supply.

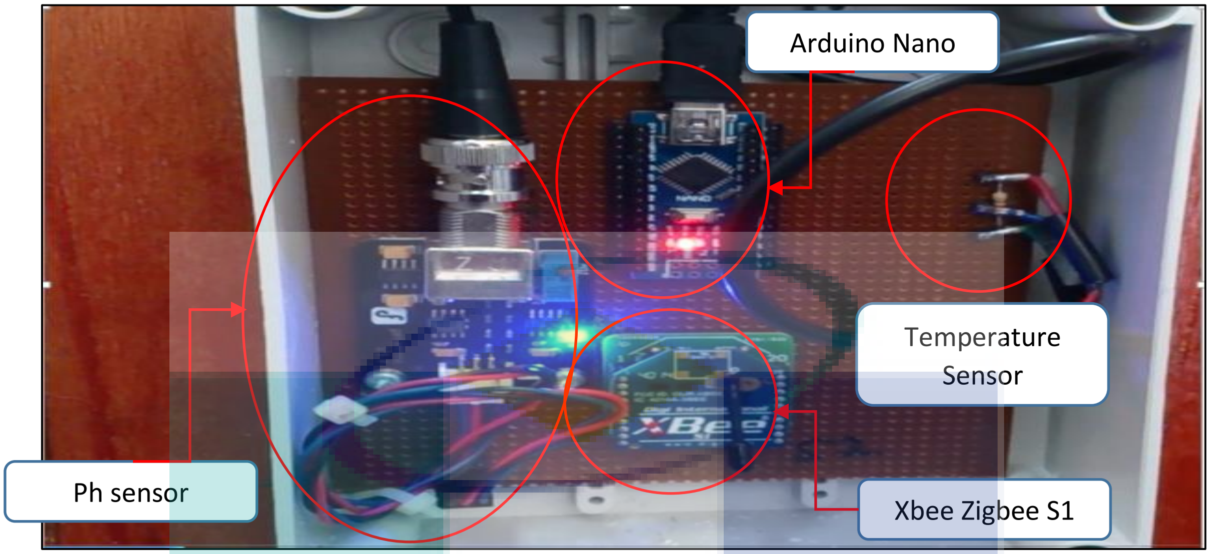


Figure 4.2: Connection on slave's circuit board

Prototype hardware that mentioned earlier is consisting of two pools which can be justified as real shrimp pool. These pools function as measurement area which both sensors that we used are placed onto the pool. These pools will be filled by water as measurement subject. Figure 4.3 shows how the sensors are placed onto the pools when measurements occur.

Figure 4.3: Sensors Placement

Data sent from slaves will be transmit wirelessly to main controller which is Arduino Nano that connected with Xbee Zigbee S1 then connected to computer. From computer, it will display through GUI that made up using Visual Studio 2015 as shows in Figure 3.18

Based on figure 4.4, there are textbox on GUI which is file name that we need to fill up in order to name it on save data which will be shown later. Besides, user can set limit value for parameter given based on types of shrimp. Therefore, there are textbox to fill up limit value for each pool. Next, user must select communication port which is main controller port. This communication port that allow data received from slaves controller display on GUI. Communication port may be different based on computer used. Lastly, user can select time stamp for data to be display on GUI. Then press start button and connect.

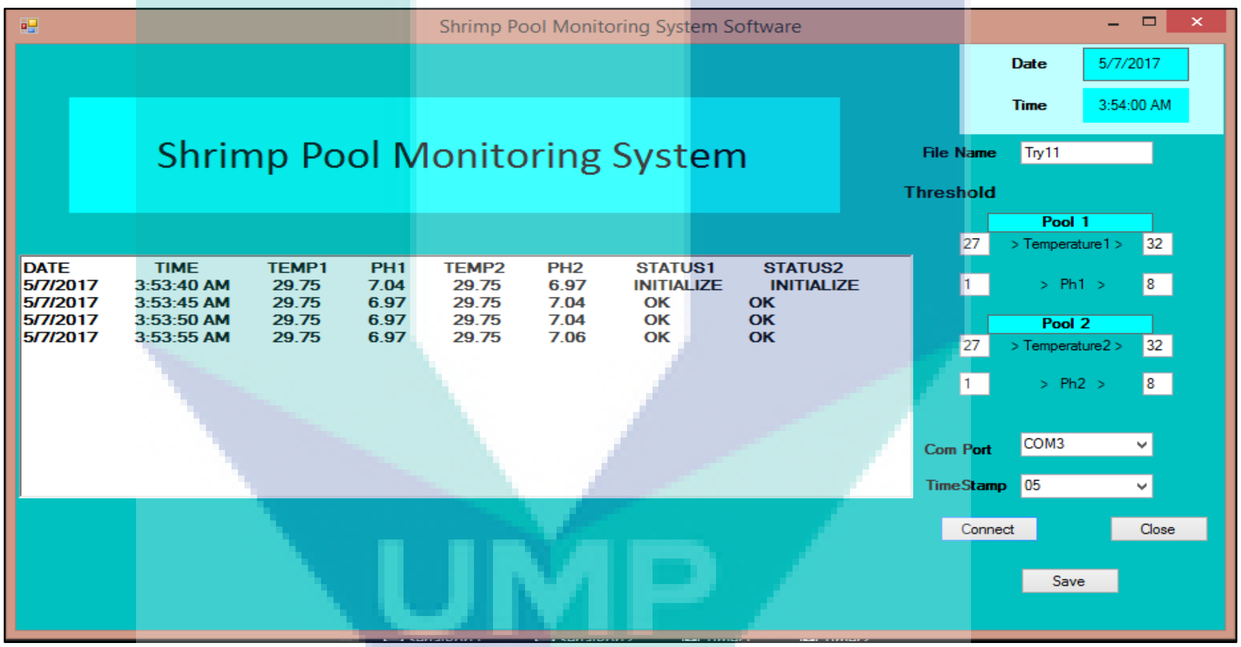


Figure 4.4: GUI display when monitoring occur

Status 1 and status 2 will trigger if reading of water exceeds or lower than range value that set by user. It functions as warning system to the user if the situation occur and user can take immediate action to control the water quality. Figure 4.5 and 4.6 will show the status display when limit value exceeds range given for both pools.

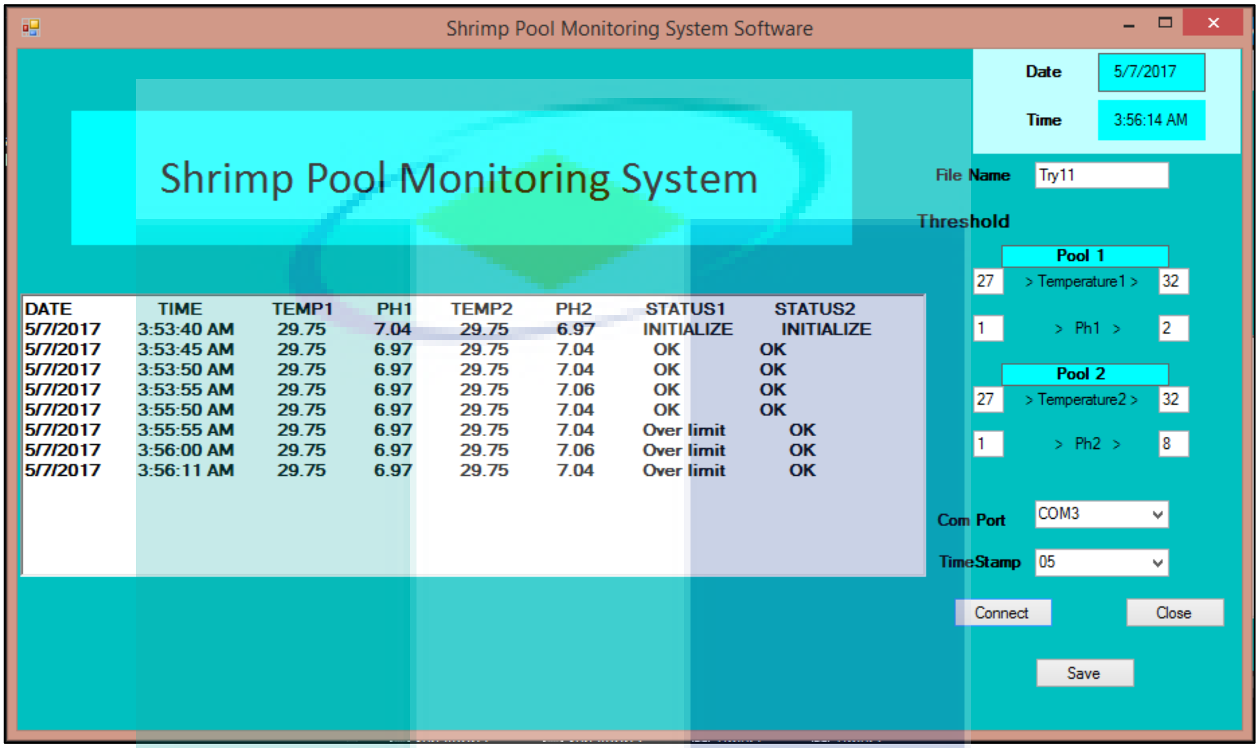


Figure 4.5: GUI display when ph value from pool 1 exceed limit value

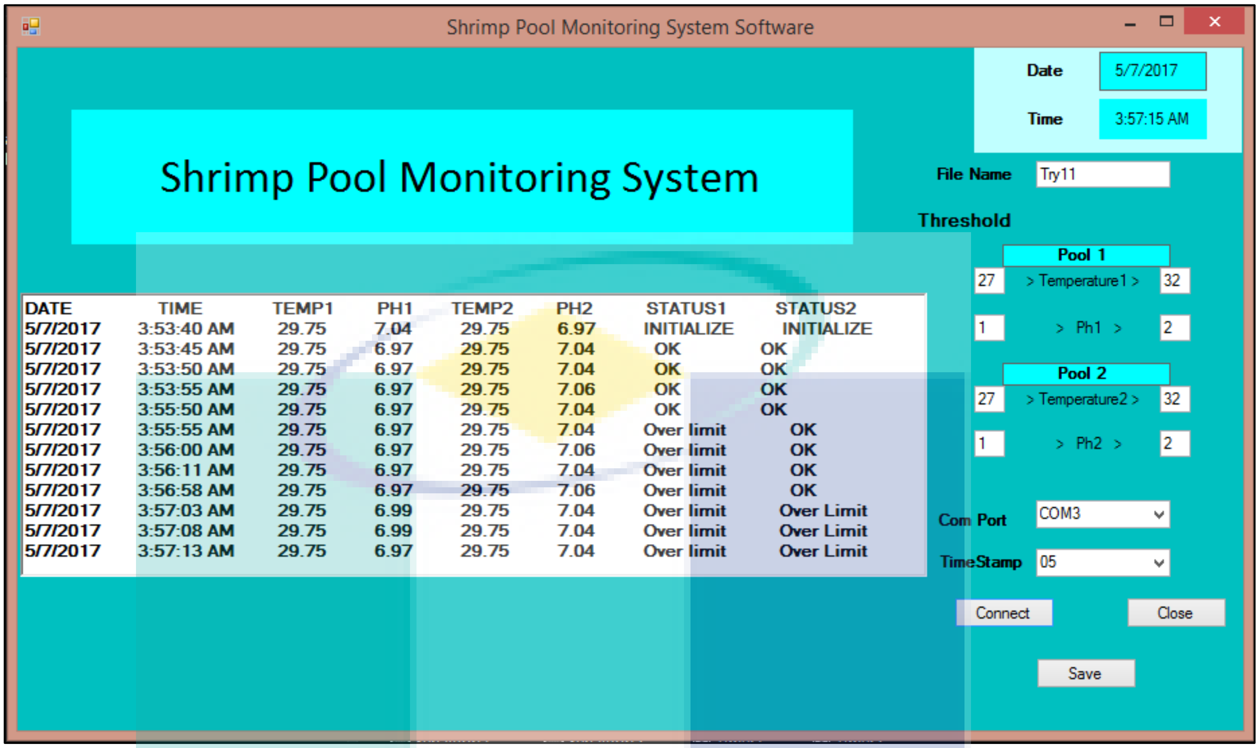


Figure 4.6: GUI display when ph value from both pool exceed limit value

The system also has another warning system that will trigger user to take immediate action if reading value exceed its range which is alert message will be sent to the user using GSM Shield V2. Therefore, user will get a notification if the incident as mentioned occur even though the user not monitor the GUI as shown in figure 4.7.

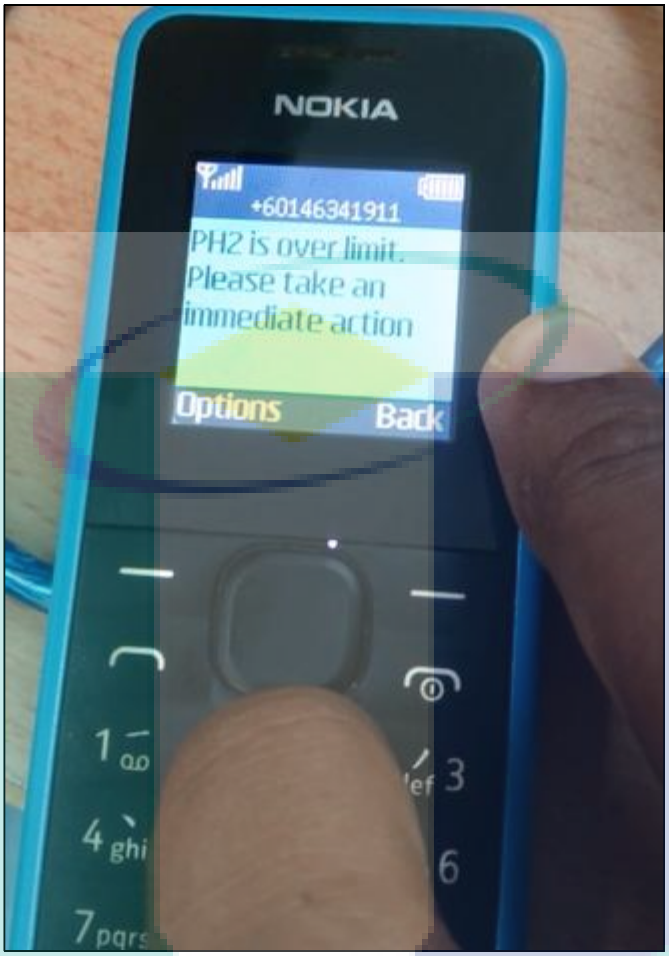
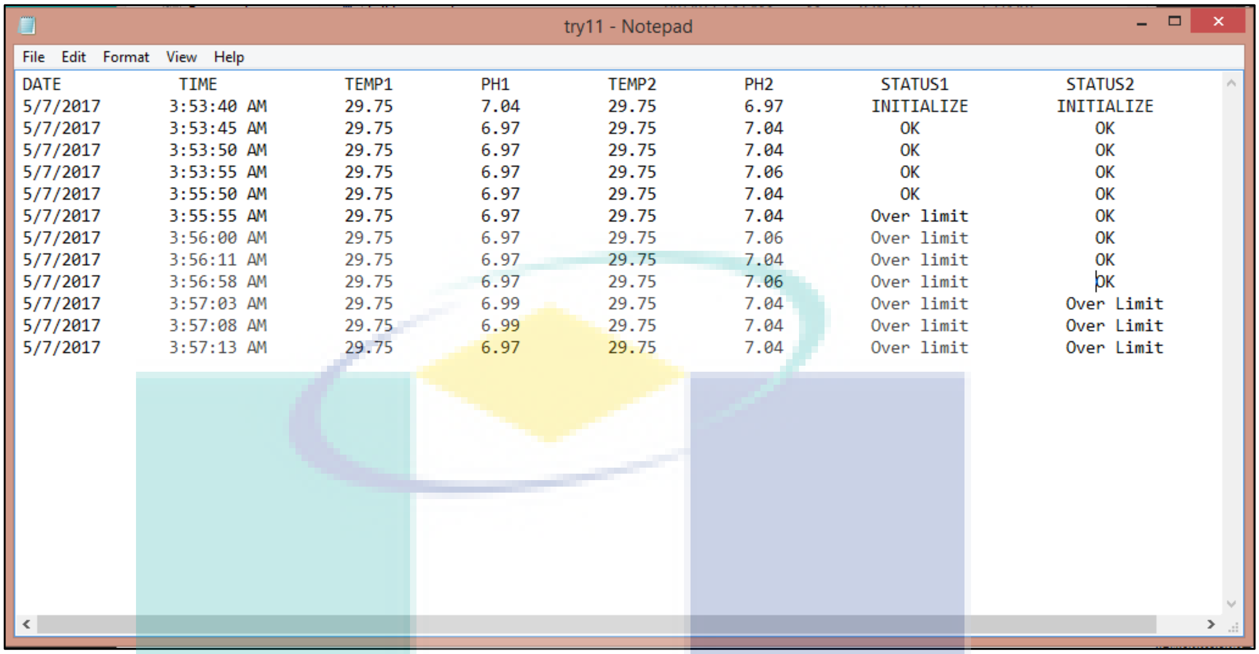


Figure 4.7: Alert message for user

This system also provide save function to save all the monitoring data that we run into monitoring file. The data will be saved once the user click save button. It will automatically save inside computer as TXT file, which will be opened using Notepad afterward as shown in Figure 4.8.



DATE	TIME	TEMP1	PH1	TEMP2	PH2	STATUS1	STATUS2
5/7/2017	3:53:40 AM	29.75	7.04	29.75	6.97	INITIALIZE	INITIALIZE
5/7/2017	3:53:45 AM	29.75	6.97	29.75	7.04	OK	OK
5/7/2017	3:53:50 AM	29.75	6.97	29.75	7.04	OK	OK
5/7/2017	3:53:55 AM	29.75	6.97	29.75	7.06	OK	OK
5/7/2017	3:55:50 AM	29.75	6.97	29.75	7.04	OK	OK
5/7/2017	3:55:55 AM	29.75	6.97	29.75	7.04	Over limit	OK
5/7/2017	3:56:00 AM	29.75	6.97	29.75	7.06	Over limit	OK
5/7/2017	3:56:11 AM	29.75	6.97	29.75	7.04	Over limit	OK
5/7/2017	3:56:58 AM	29.75	6.97	29.75	7.06	Over limit	OK
5/7/2017	3:57:03 AM	29.75	6.99	29.75	7.04	Over limit	Over Limit
5/7/2017	3:57:08 AM	29.75	6.99	29.75	7.04	Over limit	Over Limit
5/7/2017	3:57:13 AM	29.75	6.97	29.75	7.04	Over limit	Over Limit

Figure 4.8: Data stored automatically inside file

Data that shows detail information include date and time which specifically on monitoring activity occur. Therefore, user is able to monitor the previous stored data anytime if they missed. Thus, further analysis can be done using collected data to provide suitable precaution step if the limit value exceed the range.

4.3 ANALYSIS AND DISCUSSION

There are few analysis that can be done from this system. Firstly, temperature and ph readings for both pools is taken in order to verify the accuracy of the sensor. It needs two conducted experiment to verify the accuracy of the sensor used.

4.3.1 Temperature Accuracy Test

In this test, two respective temperature was set as constant variable which is boiling point temperature and freezing point temperature. For boiling point temperature, cup of distilled water was boiled and measure it using laboratory thermometer. At the same time, system is running by placed temperature sensor onto the water to get the reading. For freezing point, experiment is conducted using latent heat of fusion experiment where bucket of ice is put and pour some warm water on it. Temperature measurement using thermometer and temperature sensors. Measurement data is recorded and shown in Table 4.1.

Table 4.1: Measurement Data for Temperature

Time(s)	Thermometer	Temp sensor 1	Temp Sensor 2	Thermometer	Temp Sensor 1	Temp Sensor 2
0	94	95.01	94.97	0	0	0.02
5	94	94.89	94.78	0	0.03	0.05
10	94	94.81	94.73	0	0.14	0.1
15	94	94.32	94.32	0.3	0.21	0.19
20	93	94.08	94.15	0.4	0.34	0.27
25	93	93.77	93.88	0.4	0.42	0.36
30	93	93.56	93.73	0.5	0.49	0.45
35	93	93.1	93.29	0.7	0.65	0.59
40	92	92.97	93.01	1	0.93	0.83
45	92	92.85	92.91	1.2	1.19	0.99
50	92	92.68	92.73	1.3	1.27	1.18
55	92	92	92.59	1.5	1.46	1.37
60	91	91.9	92.08	1.6	1.55	1.51

The readings of thermometer are constant variable for this experiment. From result above, graph were plotted to be analyzed as shown in Figure 4.10. The graph shows that reading of sensor 1 and 2 were almost equal to actual value.

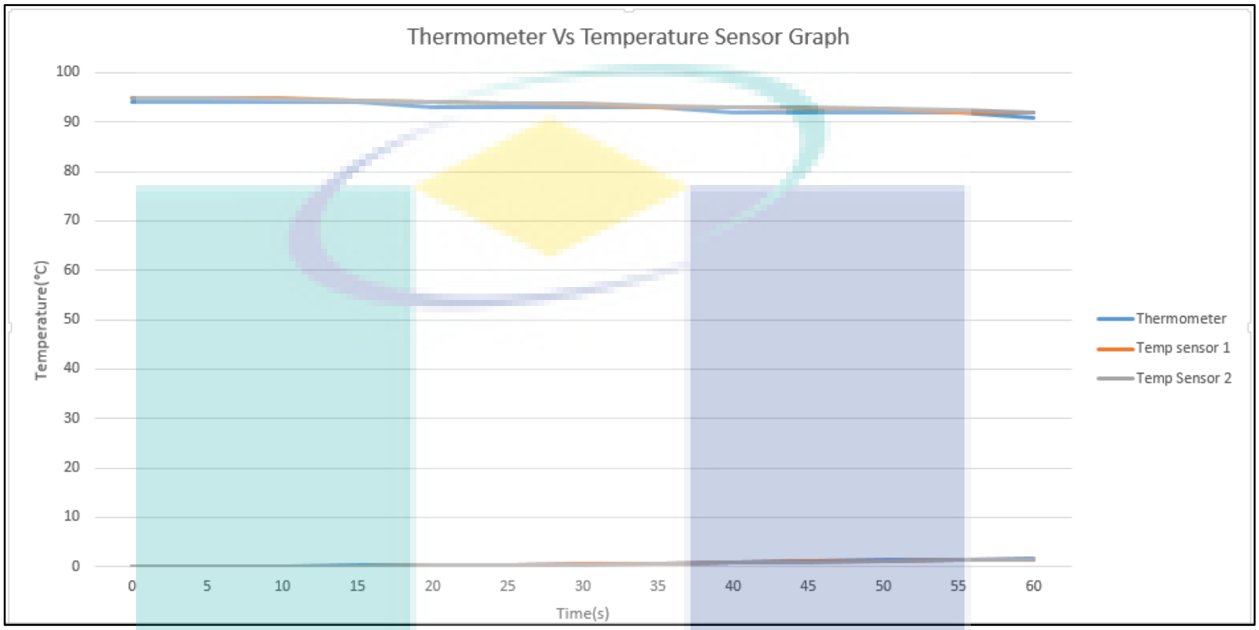


Figure 4.9: Graph of comparison between thermometer and temperature sensor readings

Result from graph were being analyzed by calculating percentage error by using formula ((actual value – calculated value) / (actual value)) X 100%. Actual value for this experiment, I am using constant variable which is thermometer reading while calculated value is temperature sensor. Table 4.2 shows the sum of percentage error for both sensor. Based on the result, it shows that both of the sensor are very accurate. All of the error are below 10 % which is shows the accuracy of the sensors.

Table 4.2: Percentage Error for Both Temperature Sensors

Ph buffer	**Average Error 1**	**Average Percentage Error 1 (%)**	**Average Error 2**	**Average Percentage Error 2 (%)**
4.01	0.05	1.27	0.30	7.5
7.01	0.16	2.27	0.15	2.21
10.01	0.10	1.02	0.15	1.50

4.3.2 Ph Accuracy Test

In this test, it use three different ph buffer solutions which are set as constant variable. It use three different ph which are ph 4, ph 7 and, ph 10 to test error in accuracy of two ph sensor that I use in this project. Table 4.3, 4.4 and 4.5 show 13 measurement that recorded in 60 seconds for three reading using both sensors.

Table 4.3: Measurement using Ph Buffer Solution 4.01

Time (s)	Ph buffer	Ph Sensor 1	Ph Sensor 2
0	4.01	4	3.71
5	4.01	3.99	3.68
10	4.01	3.99	3.71
15	4.01	3.97	3.69
20	4.01	3.99	3.71
25	4.01	3.95	3.69
30	4.01	3.97	3.71
35	4.01	3.95	3.71
40	4.01	3.95	3.71
45	4.01	3.93	3.71
50	4.01	3.93	3.73
55	4.01	3.93	3.73
60	4.01	3.92	3.71

Table 4.4: Measurement using Ph Buffer Solution 7.01

Time (s)	Ph buffer	Ph Sensor 1	Ph Sensor 2
0	7.01	6.82	6.87
5	7.01	6.82	6.85
10	7.01	6.84	6.87
15	7.01	6.84	6.85
20	7.01	6.85	6.87

25	7.01	6.84	6.84
30	7.01	6.85	6.85
35	7.01	6.85	6.85
40	7.01	6.87	6.87
45	7.01	6.85	6.85
50	7.01	6.87	6.85
55	7.01	6.87	6.85
60	7.01	6.89	6.85

Table 4.5: Measurement using pH Buffer Solution 10.01

Time (s)	Ph buffer	Ph Sensor 1	Ph Sensor 2
0	10.01	9.98	9.74
5	10.01	10	9.98
10	10.01	9.89	9.79
15	10.01	9.72	9.83
20	10.01	9.75	9.74
25	10.01	9.83	10.01
30	10.01	10.01	9.72
35	10.01	9.95	10.05
40	10.01	9.87	9.69
45	10.01	9.91	10.05
50	10.01	9.93	9.62
55	10.01	9.98	9.95
60	10.01	9.98	10.01

From the results above, graph were plotted to be analyzed as shows in figure 4.10. The graph shows that measured values are almost same as actual values for all three ph solution.

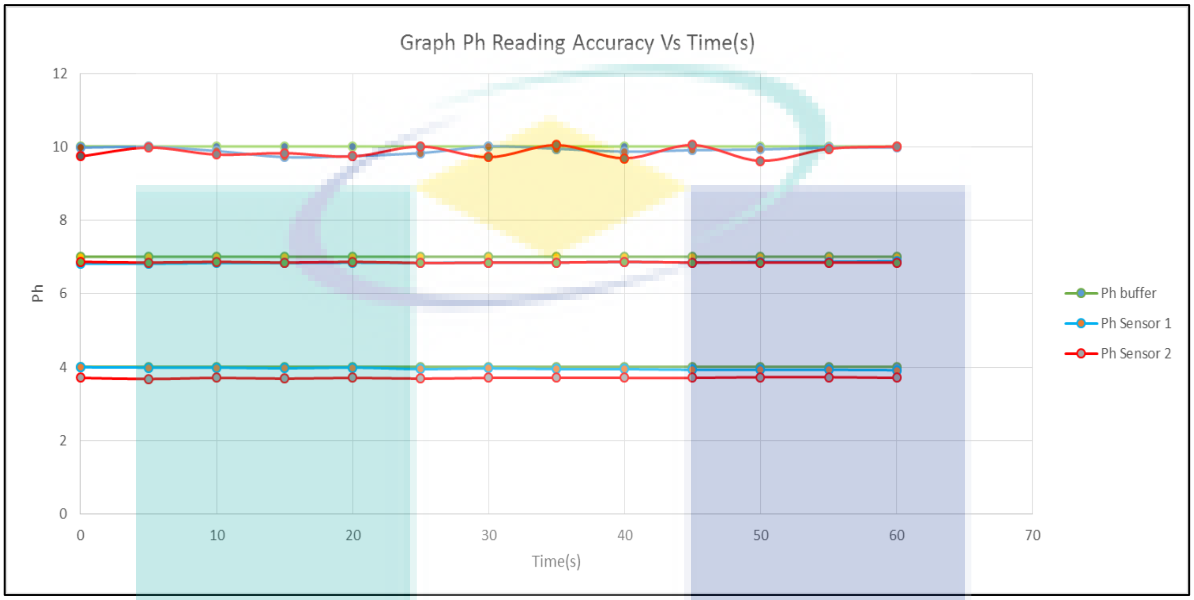


Figure 4.10: Graph of comparison between value of pH solution and ph sensors

Result from graph were being analyzed by calculating percentage error by using formula ((actual value – calculated value) / (actual value)) X 100%. Actual value for this experiment, constant variable that used is ph buffer solution while calculated value is ph sensor. Table 4.6 shows the sum of percentage error for both sensors. Based on the result, it shows that both of the sensor are very accurate. All of the error are below 10 % which is shows the accuracy of the sensors.

Table 4.6: Percentage Error for Both pH Sensors

Ph buffer	Average Error 1	Average Percentage Error 1 (%)	Average Error 2	Average Percentage Error 2 (%)
4.01	0.05	1.27	0.30	7.5
7.01	0.16	2.27	0.15	2.21
10.01	0.10	1.02	0.15	1.50

4.3.3 Continuity and Stability Data Test

In this test, it want to prove that this system has the capability to maintain their monitoring system in such a long time per day which it keep receiving data from pools and display it on GUI. Therefore, system was ran for 9 hours per day and the system is test in 3 days. Table 4.7 and 4.8 show the recorded data for temperature and ph value in that particular time with its mean calculation.

Table 4.7: Temperature Sensors Data in 3 days

Time (hour)	Temperature 1	Temperature 2	Temp1 mean	Temp1 mean square	Temp2 mean	Temp2 mean square
0	29.81	29.87	-0.87	0.76	-0.86	0.74
1	29.81	29.87	-0.87	0.76	-0.86	0.74
2	29.94	29.94	-0.74	0.55	-0.79	0.62
3	29.81	30.06	-0.87	0.76	-0.67	0.44
4	30.00	29.94	-0.68	0.46	-0.79	0.62
5	30.06	30.12	-0.62	0.38	-0.61	0.37
6	29.94	30.12	-0.74	0.55	-0.61	0.37
7	30.12	30.12	-0.56	0.31	-0.61	0.37
8	30.19	30.12	-0.49	0.24	-0.61	0.37
9	31.25	31.19	0.56	0.32	0.46	0.21
10	31.19	31.31	0.50	0.25	0.58	0.34
11	31.31	31.19	0.62	0.39	0.46	0.21
12	31.19	31.19	0.50	0.25	0.46	0.21
13	31.19	31.19	0.50	0.25	0.46	0.21
14	31.31	31.25	0.62	0.39	0.52	0.27
15	31.31	31.31	0.62	0.39	0.58	0.34
16	31.00	31.19	0.31	0.10	0.46	0.21
17	30.87	31.19	0.18	0.03	0.46	0.21
18	30.87	30.87	0.18	0.03	0.14	0.02
19	30.87	31.00	0.18	0.03	0.26	0.07
20	31.00	31.00	0.31	0.10	0.26	0.07
21	3100	30.87	0.31	0.10	0.13	0.02

22	30.87	30.87	0.18	0.03	0.13	0.02
23	30.87	31.00	0.18	0.03	0.26	0.07
24	30.87	31.00	0.18	0.03	0.26	0.07
25	30.94	31.00	0.25	0.06	0.26	0.07
26	30.87	30.94	0.18	0.03	0.20	0.04

Table 4.8: Ph Sensors Data for 3 Days

Time(hour)	**Ph1**	**Ph2**	**ph1 mean**	**ph1 mean square**	**ph2 mean**	**ph2 mean square**
0	6.94	6.84	-0.07	0.01	-0.17	0.03
1	6.94	6.84	-0.07	0.01	-0.17	0.03
2	6.82	6.94	-0.19	0.04	-0.07	0.01
3	6.84	6.94	-0.18	0.03	-0.07	0.01
4	7.12	6.92	0.10	0.01	-0.09	0.01
5	6.84	6.84	-0.17	0.03	-0.17	0.03
6	6.94	6.94	-0.07	0.01	-0.07	0.01
7	6.84	6.92	-0.17	0.03	-0.09	0.01
8	6.84	6.94	-0.17	0.03	-0.07	0.01
9	6.85	6.77	-0.16	0.02	-0.24	0.06
10	6.79	6.85	-0.22	0.05	-0.16	0.02
11	6.85	6.77	-0.16	0.02	-0.24	0.06
12	6.85	6.79	-0.16	0.02	-0.22	0.05
13	6.85	6.77	-0.16	0.02	-0.24	0.06
14	6.85	6.85	-0.16	0.02	-0.16	0.02
15	6.77	6.85	-0.24	0.06	-0.16	0.02
16	6.79	6.77	-0.22	0.05	-0.24	0.06
17	6.87	6.79	-0.14	0.02	-0.22	0.05
18	6.85	6.77	-0.16	0.02	-0.24	0.06
19	7.51	7.28	0.49	0.24	0.26	0.06
20	7.3	7.51	0.28	0.08	0.49	0.24

21	7.28	7.49	0.26	0.07	0.47	0.22
22	7.51	7.28	0.49	0.24	0.26	0.06
23	7.49	7.3	0.47	0.22	0.28	0.08
24	7.28	7.51	0.26	0.07	0.49	0.24
25	7.3	7.49	0.28	0.08	0.47	0.22
26	7.3	7.49	0.28	0.08	0.47	0.22

Blue highlighted line at Table 4.7 and 4.8 represent the separate days of conducting this test which is 9 hours per day in 3 days. Firstly, calculate average value using formula;

Average Value = (Total Measured Value / Sample) (Equation 4.1)

Then, calculated the mean from the data using formula;

Mean = Σ (Measured Value – Average Value) (Equation 4.2)

From the data given, graph were plotted to analyze the pattern shown based on the situation of pools when the system was running which show in Figure 4.11 and 4.12.

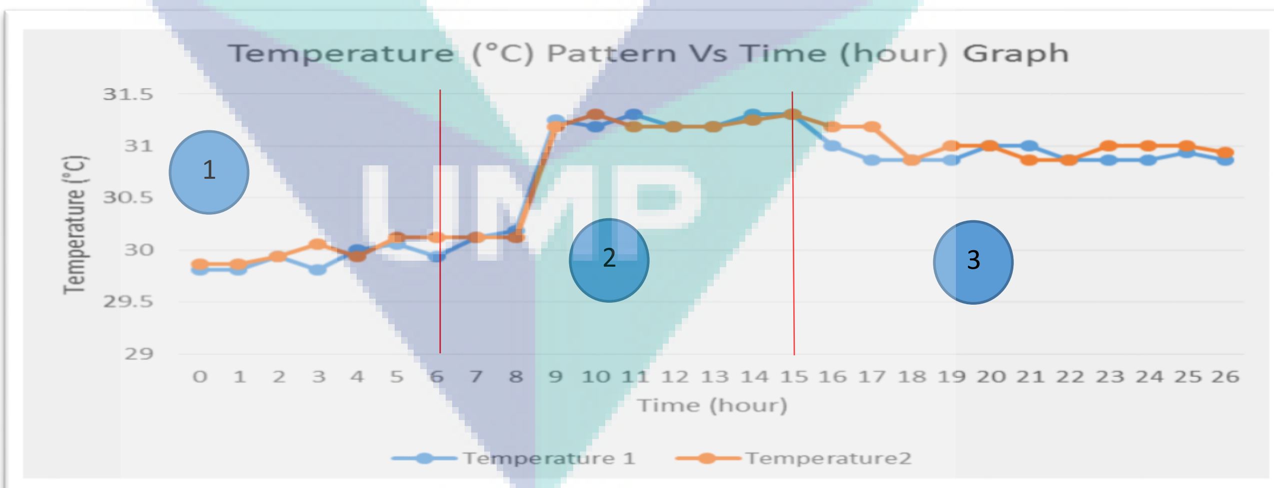


Figure 4.11: Graph of Temperature Data Pattern

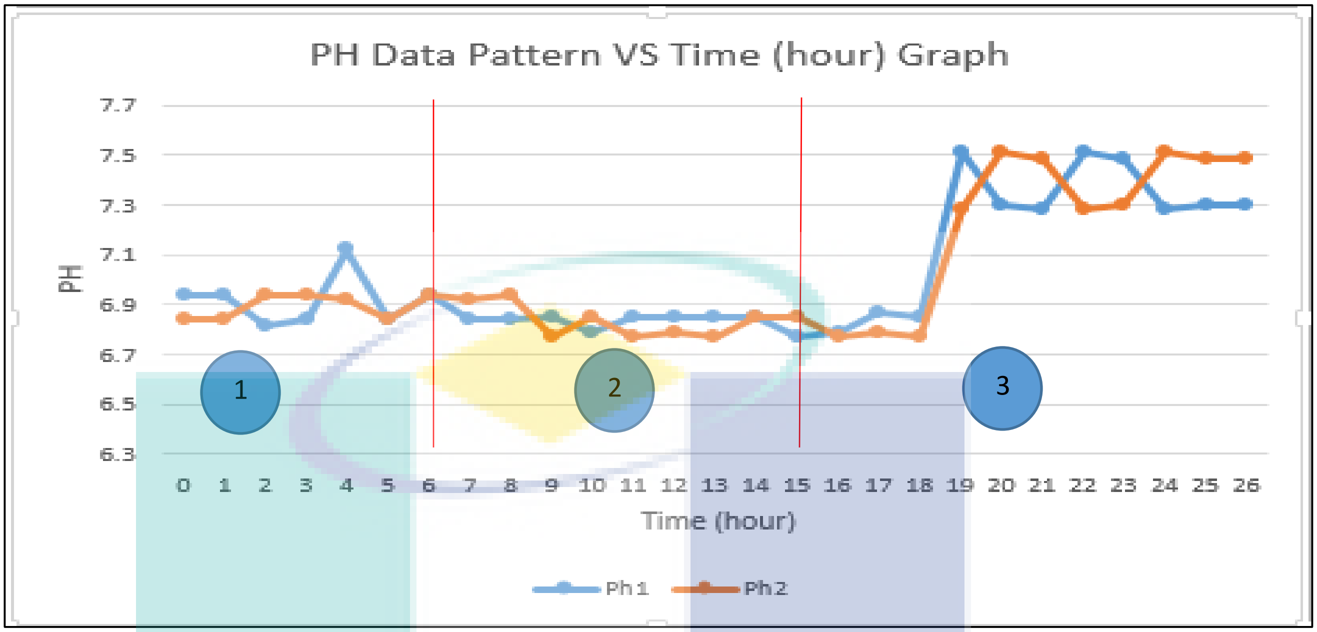


Figure 4.12: Graph of Ph Data Pattern

From the graphs, its show that the pattern of the data display on GUI in 3 days as label on the graphs. It is proved that the system can be run in such a long time and the continuity of the system can be done. It is important for the system to run in a long time to ensure water quality of the pools in a safe state. From the calculation that I calculated earlier, I can calculate variance and standard deviation value using formula;

$$\text{Variance } (\sigma^2) = \Sigma\, ((\text{Mean})^2 / \text{Sample} - 1) \qquad \text{(Equation 4.3)}$$

$$\text{Standard Deviation } (\sigma) = \sqrt{(\text{Variance})} \qquad \text{(Equation 4.4)}$$

Standard Deviation is a measure of how spreads out the numbers are. Table 4.9 shows the value of variance and standard deviation of all the sensors. The value shows that their standard deviations are small and the numbers is not too spread out through the data. Therefore, it concludes that this system is stable as the data is not too differ from each other as I run system using same water which is lake water for these 3 days and in close area.

Table 4.9: Value of Variance and Standard Deviation of All Sensors

	Temperature 1	Ph 1	Temperature 2	Ph 2
(σ^2)	0.29	0.06	0.28	0.07[a28] [MKMN29] [MKMN30]
(σ)	0.54	0.25	0.53	0.27

CHAPTER 5

CONCLUSION AND RECCOMENDATION

5.1 INTRODUCTION

This chapter concluded about the summary of the overall project and considerate recommendation for the project in future. Achievement of the project also has been conclude based on objective that set at the beginning of the project. Besides, suggestion also been given for future development of this project in order to overcome the weaknesses of the system and make this system more user friendly.

5.2 CONCLUSION

In conclusion, this project was successful as it achieve all of the objectives that listed at the beginning of the project. The water quality monitoring system using wireless sensor network at shrimp pool was designed and fabricated with temperature and ph sensors. The system was capable to monitor the parameters that important for shrimp to grow and survive which are temperature and ph and display the data on GUI developed. Wireless concept is implemented on this system to transmit data from the pools to the GUI. The system displaying the value is equipped with precaution systems which are it display the status of water quality whenever the parameter value exceeds it limit. The system also triggered alert message to the user as the status display over limit.

The system was developed by using wireless technology, known as Zigbee transmission together to transmit and received data in particular distance which can monitor all of the pools in one place at the same time. The data also can be saved as the user can use the data as daily report. This project is a new era of monitoring technology as it is real-time, wireless and provided the alert system. This system can improve the quality of the shrimp that growth and increase the profit of the users as they can take immediate action whenever water quality of their pools are in danger state. In other word, this system improve on how monitoring system been done and increase the productivity on shrimp farming.

5.3 RECOMMENDATION

This monitoring can be said a new technology of monitoring system based on its function and the system equipped. However, there is an improvement can be done on this project as the data can be upload to the cloud thus implementation of Internet Of Things (IOT). From this improvement, users can monitor their pool anytime and anywhere as they can monitor it through their smartphone. Besides, another improvement can be done on this project is to add another sensor that important for water quality of shrimp pools which is Dissolve Oxygen (DO) sensor. Dissolve oxygen sensor is an important parameter to detect level of oxygen in pool which is crucial for respiration of the shrimp. Based on all of these improvement, it will take the monitoring system for water quality at shrimp pool to the new level of technology and increase the productivity of shrimp farmer all over the world.

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ATTACHMENT A

Universiti Malaysia PAHANG

CITREx CREATION, INNOVATION, TECHNOLOGY & RESEARCH EXPOSITION (CITREx)

Certificate of Award

SILVER MEDAL

This Certificate of Award is presented to

Dr. Airul Sharizli Bin Abdullah, Mohd Faifazli Bin Mat Jusof, Dr. Ahmad Syahiman Bin Mohd Shah, Dr. Mohamad Shaiful Bin Abdul Karim, Mohd Shawal Bin Jadin, Dr. Ruhaizad Bin Ishak

For The Invention Entitled

Development of Real-Time Wireless Monitoring System for Aquaculture Industries.

CREATION, INNOVATION, TECHNOLOGY & RESEARCH EXPOSITION 2018
7th – 8th February 2018, Universiti Malaysia Pahang

PROFESSOR DATO' DR. MASHITAH MOHD. YUSOFF
DEPUTY VICE CHANCELLOR (RESEARCH & INNOVATION)
UNIVERSITI MALAYSIA PAHANG

ATTACHMENT B

Chapter 1

Development of Real-Time Wireless Monitoring System for Aquaculture Industries

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Universiti Malaysia Pahang

Abstract

Aquatic farming activity is most interesting part because shrimp can generate income and economy for our country progressively. Water quality for shrimp pool is most critical part in shrimp farming and monitoring issues need to develop in order to maintain shrimp production. Water quality monitoring system using wireless sensor network for shrimp pool give the information about water quality condition based on its parameters in real time. We are developing a prototype of system consist of two mini pools. Each pool consists of two sensors which are ph and temperature sensor. These two sensors and Zigbee Xbee S1 module (wireless module) will connect to Arduino NANO (microcontroller). Data will transmit to another wireless module and PC display. Microsoft Visual Studio (graphical user interface) is equipped in PC to display water quality condition based on sensor detection in set time stamp. Alarm system will be equipped as parameters are higher than their threshold and message will be delivered to person in charge. This system will be useful for sampling and collecting data faster and give user time to troubleshoot and maintain water quality.

Introduction

The aquaculture sector has recorded an annual growth rate of about 20 percent in the last 5 years. It has now grown into a lucrative and sustainable industry, associated with the culture of high value species, mainly shrimp, marine fish and high value freshwater fish. Malaysia, a country with around 29 million people in 2015, fish food is always the necessary source of animal protein to their community. Fisheries sector is responsible in providing food security to the growing population. Malaysia, surrounded by South China Sea and the Strait of Malacca, coupled with development of aquaculture industry, this country is rich in fish resource.

Commercial aquaculture in many countries, including Malaysia has been prompted due to increasing demand of international market (Ismail and Abdullah, 2013). Therefore, aquaculture industry is playing increasingly important role in Malaysian economy. In the Third National Agricultural Policy (NAP3), Malaysian government has promoted brackish water shrimp culture under taking a number of initiatives (Ministry of Agriculture Malaysia, 2003). Targeted shrimp production in 2010 was set at 180,000 metric tons or RM 4.3 billion (Islam et al., 2011). However, the targeted volume of supply was not materialized.

Water quality is a critical factor when culturing any aquatic organism. Optimal water quality varies by species and must be monitored to ensure growth and survival. The quality of the water in the production systems can significantly affect the organism's health and the costs associated with getting a product to the market. Water quality parameters that are commonly monitored in the aquaculture industry include temperature, dissolved oxygen, pH, alkalinity, ammonia, and nitrites. Some