Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF IOT-BASED AUTOMATIC RAIN GAUGE USING NODEMCU FOR RAINFALL MEASUREMENT

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Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

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DEVELOPMENT OF IOT-BASED AUTOMATIC RAIN GAUGE USING NODEMCU FOR RAINFALL MEASUREMENT

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in partial fulfillment of the requirements for the degree of
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DECLARATION

I declare that this project report entitled "Development of Iot-based Automatic Rain Gauge using Nodemcu for Rainfall Measurement" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date : 9 JANUARY 2022

APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Telecommunications) with Honours.

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Date : 09 Jan. 2022

Signature :

Co-Supervisor :

Name (if any)

Date :

DEDICATION

This study is wholeheartedly dedicated to our beloved parents for our source inspiration and our strength when we thought to giving up, who always provide their moral, emotional and financial support.

To our brother, sisters, friends, classmates and my supervisor for shared their opinion, guidance and idea to encouragement to finish this study.

Lastly, to our Almighty God for giving us healty life and strength. All of these will not finish without permission.

ABSTRACT

Meteorologists and hydrologists use a type of instrument to collect and measure the amount of liquid within period of time which is called as rain gauge. Before technology evolved, measurement was carried out through manual method of conventional rain gauge or standard rain gauge. Basically, when measurement is obtained, the water in container is measured in height using stick measure. After measurement are collected, the water needs to be discarded manually. Sometimes the accuracy of measurement may be incorrect and erroneous. Furthermore, it is also convenient if the data from rain gauge can be automatically collected. Therefore, an Internet of Things (IoT) based rain gauge system is developed to solve such issues. Nodemcu ESP8266 microcontroller is used to interface between input and outputs. It also has built in Wi-Fi capability, so the result can be transferred from the microcontroller to the phone app. The accumulated water is measured using water flow sensor where it allows the water to flow and directly discarded. Therefore, this ensure a more advanced and smooth measurement process. Solar panel and batteries are used as power source for the rain gauge system. The measurement result will be displayed on the LCD that is connected to the rain gauge system. In addition, the data will also be shown and stored on the Blynk application.

ABSTRAK

Ahli meteorologi dan ahli hidrologi menggunakan sejenis alat untuk mengumpulkan dan mengukur jumlah cecair dalam jangka masa yang dikenali sebagai tolok hujan. Sebelum teknologi berkembang, pengukuran telah dilakukan melalui kaedah manual alat tolok hujan konvensional atau alat tolok hujan standard. Pada asasnya, apabila ukuran tersebut diperoleh, air di dalam bekas disukat ketinggiannya menggunakan kayu ukur. Setelah ukuran air telah dikumpulkan, ianya perlu dibuang secara manual. Selalunya, ketepatan pengukuran mungkin tidak betul dan salah. Tambahan pula, ia juga mudah jika data tersebut dapat dikumpul secara automatik oleh tolok hujan. Oleh itu, sistem tolok hujan berasaskan "Internet of Things (IoT)" dilakukan untuk menyelesaikan isu tersebut. Mikropengawal Nodemcu ESP8266 digunakan untuk menghubungkan antara input dan output. Ia juga mempunyai keupayaan Wi-Fi yang terbina didalamnya, maka output tersebut boleh dipindahkan daripada mikropengawal ke aplikasi telefon. Air yang terkumpul diukur menggunakan sensor aliran air dimana ia membolehkan air mengalir dan terus dibuang. Oleh itu, ia dapat memastikan proses pengukuran lebih maju dan lancar. Panel solar dan bateri digunakan sebagai sumber tenaga kepada sistem tolok hujan. Hasil pengukuran akan dipaparkan pada LCD yang disambungkan kepada sistem tolok hujan. Sebagai tambahan, data itu juga akan dipaparkan dan disimpan pada aplikasi Blynk.

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My highest appreciation goes to my parents and family members for their love and prayer during the period of my study. An honourable mention also goes to myself for all the motivation and understanding.

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LIST OF SYMBOLS

mm	-	Milimeter
ml	-	Mililitre
cm^2	-	Surface area in centimetre
l	-	Litre
mm/min	-	Milimeter per minute
mm/h	-	Milimeter per hour
%	-	Percentage
cm	-	Centimeter
π	-	3.14159

LIST OF ABBREVIATIONS

IoT	-	Internet of Thing
LCD	-	Liqiud Crystal Display
WSN	-	Wireless Sensor Network
GPRS	-	General Pocket Radio Services

CHAPTER 1

INTRODUCTION

1.1 Background

Rain gauge is an instrument to measure rainfall rate in a certain period of time by meteorologists and hydrologists. For the conventional method it is usually carried out manually to record the data. It works by catching the rainfall through the funnel-shaped collector that attached with measuring tube at the wide and open area where it can receive the rain. Automatic rain gauge is rain gauge electronically work to record the data by measuring the rainfall which will be displayed on mobile phone. The measurement of rainfall uses technology to enable physical world to be linked to computer-based system. In our daily life, the technology is important that can be sensed everywhere surrounding us. The innovation of project makes improvements in terms efficiency, accuracy and benefits in economy.

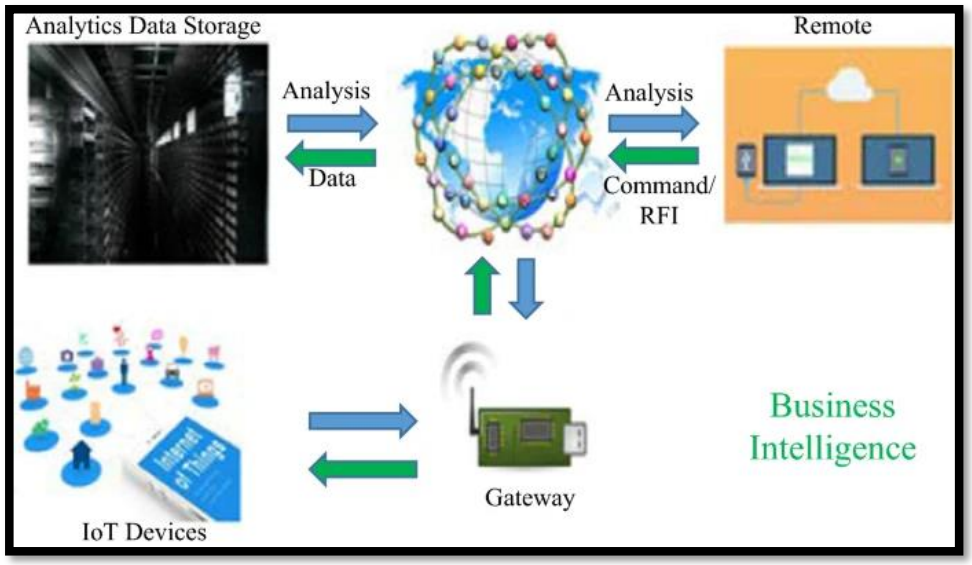


Figure 1.1 Internet of Things (IoT)

This project aims to develop IoT-based Automatic Rain Gauge using Nodemcu for Rainfall Measurement. Figure 1.1 shows the IoT (Internet of Thing) can be accessed worldwide, anytime it is required. All the physical devices can be connected and obtain the data for analyzing of some applications. The Internet of Things (IoT) provides a wide variety of connectivity with different application qualities. In development of IoT, the technology of Wi-Fi provides a platform for remarkable amount of IoT solutions.

The Wi-Fi in this project is used in microcontroller nodemcu ESP8266. ESP8266 contains crucial element of a computer including networking Wi-Fi, so it is suitable for doing Internet of Things (IoT) projects. To measure the rainfall, water flow sensor will be used and installed through tubes, which allows the sensor to detect the rain that flow and feed the signal to the microcontroller. The water will not be collected as usual because this project will be easier than the conventional method. Solar panel and batteries are used as power sources for the rain gauge system.

From this project, the measurement results will be displayed on LCD rain gauge system while in Blynk app the data will also shown and can be stored. The system will run automatically and it is very helpful for meteorologists and hydrologists to obtain the data measurement of rainfall. This project is also convenient and advantageous because the water will flow through the tubes without being collected conventionally.

1.2 Problem Statement

Rain gauge is one of the meteorological equipment that has been widely used for measuring point rainfall due to its accuracy and cost efficiency. However, the conventional method for recording the data of rainfall from typical rain gauge needs to be carried out manually, which can be tedious and also leads to inaccuracy. To overcome such a limitation, it needs to be incorporated with an automatic data reading and operational to improve the

efficiency, using Internet of Things (IoT) capabilities. The reading of accumulated rainfall will be carried out automatically and the data will be sent to mobile phone or cloud. Then, the water will flow ongoing through the tube and it will not to be discarded as conventionally. So it is advanced for this project.

1.3 Project Objective

The main aim of this project is to develop automatic rain gauge by using nodemcu microcontroller for rainfall measurement. Specifically, the objectives are as follows:

a) To develop an automatic rain gauge that is able to read accumulated rainfall data automatically using nodemcu microcontroller.

b) To measure and record the data of the rainfall into cloud.

c) To display the data from the application Blynk.

1.4 Scope of Project

The scope of this project are as follows:

a) The accumulated rainfall will be measured using water flow sensor.

b) The data will be collected from the cloud.

c) The system will be assisted by solar panel and batteries.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Nowadays, there are many types of rain gauge worldwide which have the same function of measuring the rainfall. Every type of rain gauge differs in how rainfall is measured based on the component used. This chapter will review the past articles to know every different process.

2.2 Type of Rain Gauge

There are three major types of rain gauges which are standard rain gauge, weighing rain gauge and tipping bucket rain gauge. Each type differs in its use and in its involving component. From the conventional type to automatic type, the accuracy in measurement also improves.

2.2.1 Standard of Rain Gauge/Conventional Rain Gauge

Standard rain gauge or conventional rain gauge are being used in this article[1] to measured amount of the rainfall collected in tube. For manual rain gauge there are usually errors in calculating and measuring of the rainfall amount.

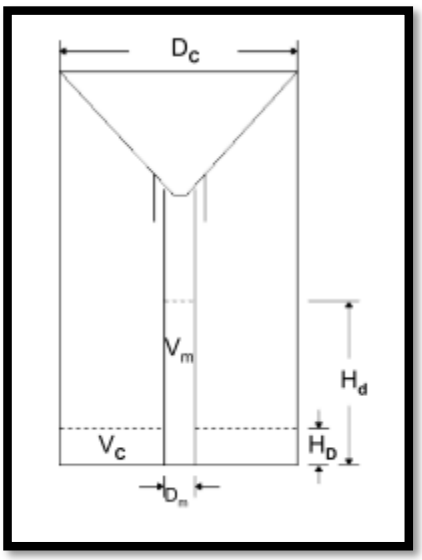


Figure 2.1 Rain gauge with measuring tube[1]

Figure 2.1 above shows conventional rain gauge that are still used to supply the data to weather stations. Since rainfall is measured manually, formulas are used to get the exact value. The conventional rain gauge is simple and easy to constructed. In certain period, this system may easily overflow and the data measurement will be incorrectly as mentioned in this journal [2].

2.2.2 Weighing Rain Gauge

Weighing rain gauge is operated to record the amount of water collected and measure the weight of that rain water. The authors in this article [3] stated that to measure the rain fall magnitude and all weather conditions, weighing rain gauge are used. This system is selected because bad weather condition causes difficulty of forecasting when flood happens. Weighing rain gauge, measures when water is collected in bucket. Journal [4] mentioned that weighing rain gauge is operated to weigh rainwater collected by the device.

2.2.3 Tipping Bucket Rain Gauge

Tipping bucket rain gauge is most common type that is always used in this field. In this journal [2] , it was mentioned that tipping bucket rain gauge which measures in snowfall is inefficient as the solid ice have to melt first, thus delaying the process and the time taken for the measurement may be incorrect. In this article [5], tipping bucket was used to analyze the stability of water flow rate that was measured. The weakness of this system is the water that flows between pair of tipping buckets is not measured thus the inaccuracy may increase. Figure 2.2 below shows the design of tipping bucket of rain gauge.

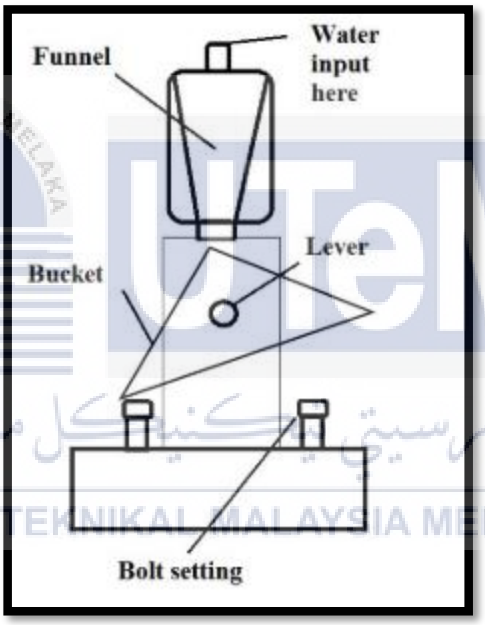


Figure 2.2 Tipping bucket of rain gauge[5]

2.3 Methods for Rain Measurement

Every research will have different method to measured the rainfall and also the component that is used. In conventional rain gauge, mostly the method will collected rainfall through funnel-shaped collector attached together with measuring tube. The record data will take only once in a day means 24 hours because it is manually recorded. The measurement of rainfall be obtained from the cylinder using stick or ruler to read the value. After the data

is recorded, the water will be discarded by flip the tube and make sure there is no water in cylinder tube.

2.3.1 Rain Gauge Development Employing Bluetooth and RF Modem

In this article [6] was discussed that the method which uses Bluetooth and RF-FSK enables data to be read easily and promptly. The amount of rain was captured by the sensor and sent to the microcontroller. The data was accepted and sent by Bluetooth and RF Modem. Figure 2.3 below shows the block diagram of the rain gauge system.

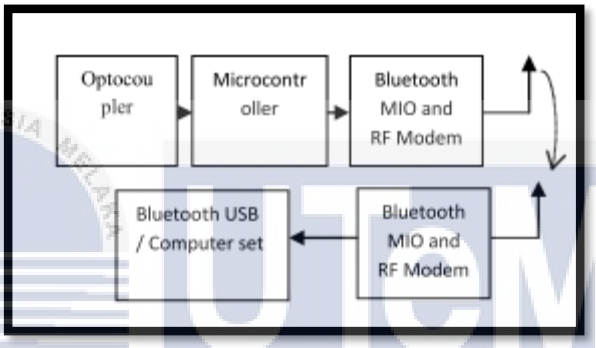


Figure 2.3 Block diagram of the system[6]

For Bluetooth and RF Modem, there are different distance between rain system set and computer set. Table 2.1 shows the measurement results. Optocoupler is an electronic device which function is to transfer electrical signals between two isolated circuits by using lights.

Table 2.1 The results of measurement[6]

MEASUREMENT RESULT			
No	Water volume	I_{manual} (mm)	$I_{automatic}$ (mm)
1	50ml	2,5	2,269108
2	100ml	5	4,538217
3	500ml	25	24,392914
4	1000ml	50	49,76114

2.3.2 Development of Rain Gauge using Measurement for Microwave Network

In this paper[7], which discussed the use of load cell to sense the weight of water in a container. The weight of the accumulated water in the container will be detected by load sensor. Since load cell has analog signal data, the data should be converted to the digital form by ADC module. Then, the Arduino will read the data and display it on the screen. In order to empty the container from water, this paper used DC motor to discard the water. The data accumulated of rainfall in mm/h. Figure 2.4 shows the system of rain gauge.

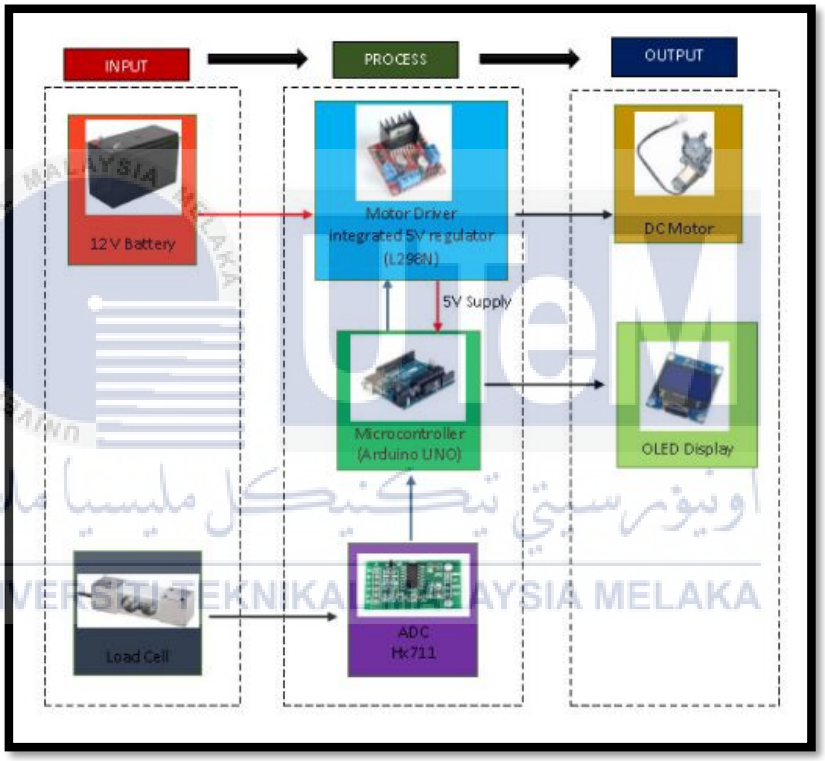


Figure 2.4 Rain gauge process[7]

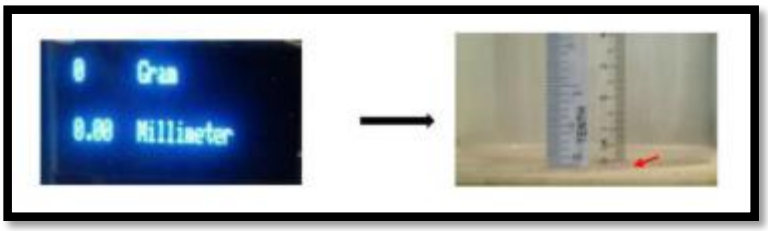


Figure 2.5 When container water empty[7]

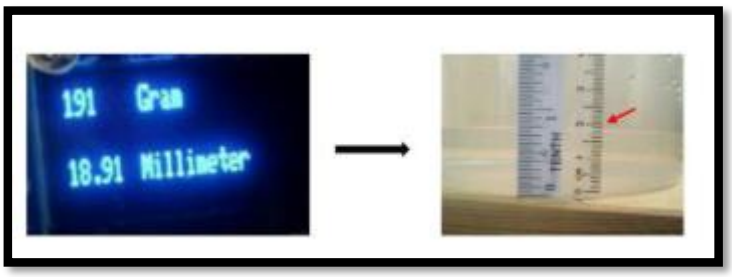


Figure 2.6 First result conversion[7]

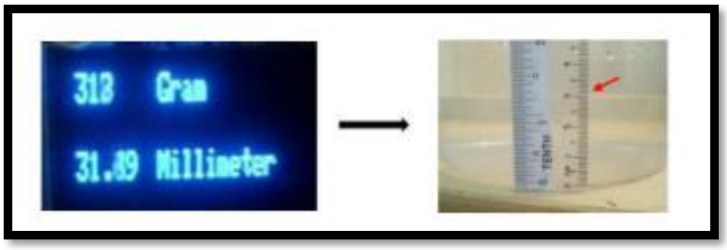


Figure 2.7 Second result conversion[7]

Figure 2.5, 2.6 and 2.7 aboves shows the measurement results of rain gauge.

2.3.3 Weighing Type Rain Gauge with Weather Monitoring System

The paper presented by [3] discussed how rainfall is measured by using arduino Atmega328P microcontroller from the HX711 load cell amplifier. The accumulated water in bucket will measure weight of water by using load cell. The data will be sent to web server using Ethernet shield. The circuit diagram of the system is shown in Figure 2.8 while the result from ThingSpeak is shown in Figure 2.9.

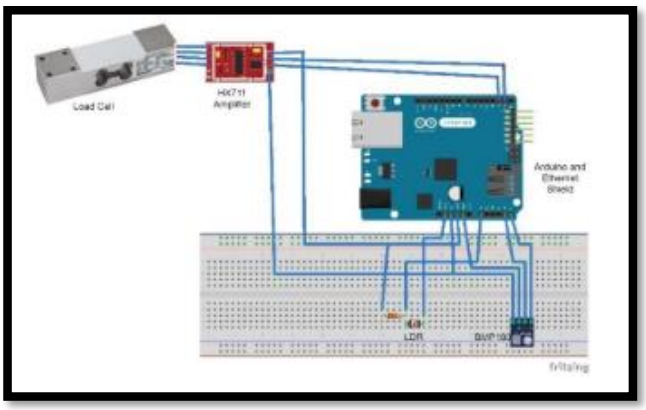


Figure 2.8 Circuit diagram[3]

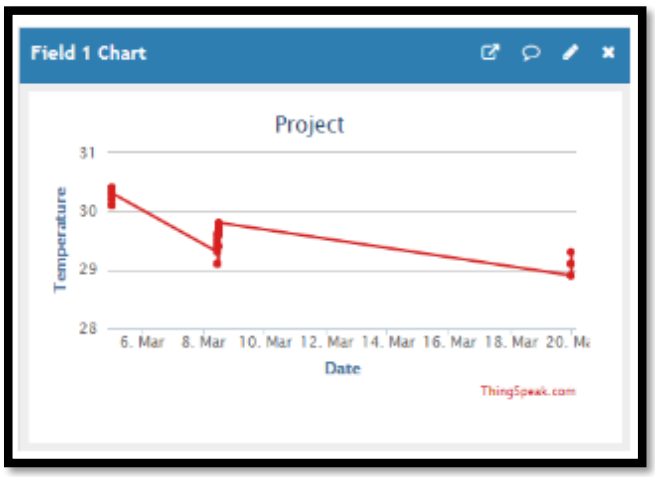


Figure 2.9 ThingSpeak graph result[3]

2.3.4 Iot based Rain Gauge using Arduino

The author of this paper [8] discussed the system used Internet of Things (IoT) for tipping bucket rain gauge to obtain the data through internet or the data could monitored remotely and can be integrated with other application. This system use microcontroller Arduino Uno as processor and ESP8266 module and Wi-Fi network as gateway to get the data. The data from rain gauge collector will be detect by IR sensor. The result of data will display in Blynk server. This system can read the rainfall intensity in maximum 50mm/min. This system also can read the data rainfall in small detection limit 0,788mm and 0,788 for large detection limit of rainfall. Figure 2.10 below shows the block diagram of rain gauge sytem.

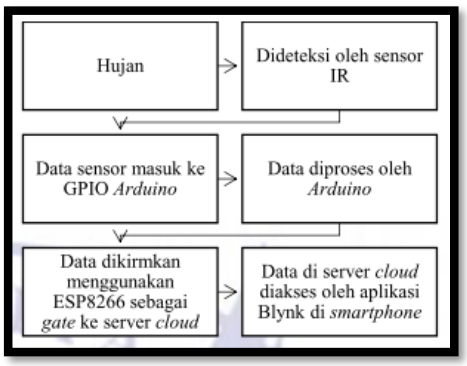


Figure 2.10 Block diagram of rain gauge system based on IoT(extracted from[8])

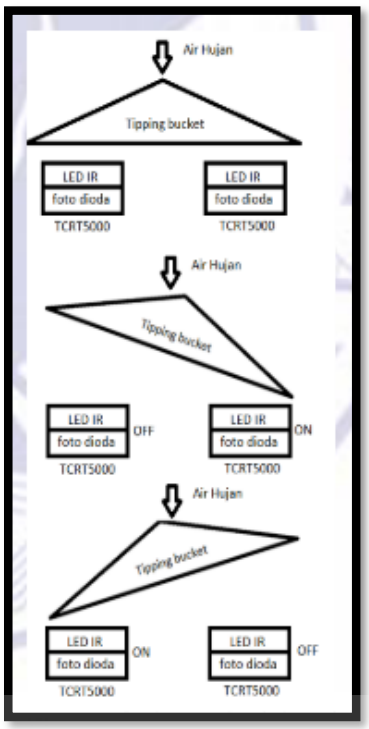


Figure 2.11 The process tipping bucket(extracted from[8])

Table 2.2 Result in 10 minutes(extracted from [8]).

Tabel 1. Hasil data percobaan yang dilakukan selama 10 menit

Waktu	Curah Hujan (mm)	Intensitas Curah Hujan (mm/min)
24-04-19 05:04	0.788	0.788
24-04-19 05:05	0.788	0
24-04-19 05:06	0.788	0
24-04-19 05:07	0.788	0
24-04-19 05:08	0.998133	1.576
24-04-19 05:09	38.5726	56.736
24-04-19 05:10	94.25793	57.524
24-04-19 05:11	117.7141	2.364
24-04-19 05:12	118.2	0
24-04-19 05:13	118.2	0

The process of tipping bucket is shown in figure 2.11 and table 2.2 shown result in 10 minutes.

2.3.5 Modification of Manual Raindrops Type Observatory Ombrometer with Ultrasonic Sensor HC-SR04

In this article [9], the author are modified manual rainfall gauge Ombrometer Observatory by using ultrasonic sensor HC-SR04. The data will measured automatically. The ultrasonic sensor is connected to Arduino to know the range of water level held in rain gauge. By used platform ceerduad.com to carried out the data with through ESP8266 wifi module. HC-SR04 has been set to detect water level in reservoir. The measurement of correlation of rainfall reached the 07.39%. Figure 2.12 is shown the block diagram of the system.

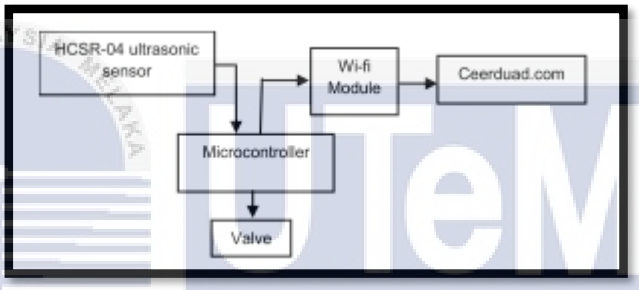


Figure 2.12 Block diagram of the system[9]

Table 2.3 Comparison rainfall specifications[9]

Days to -	Date month Year	Manual Measurement (mm)	Modification Measurement (mm)	Rainfall Intensity
1	26 April 2019	0	0	Low
2	27 April 2019	0	0	Low
3	28 April 2019	17.1	-	Low
4	29 April 2019	76.5	73.2	Low
5	30 April 2019	3.2	-	Low
6	1 May 2019	0	0	Low
7	2 May 2019	6.4	3	Low
8	3 May 2019	0	1	Low
9	4 May 2019	0	1	Low

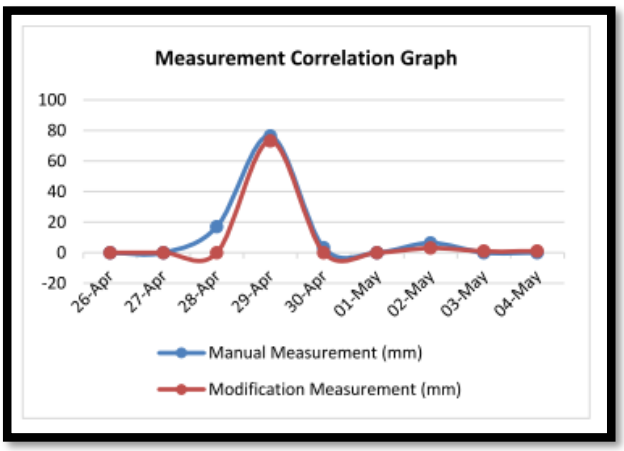


Figure 2.13 Measurement correlation graph[9]

Table 2.3 shown the comparison rainfall specifications and the graph of measurement correlation also shown in figure 2.13.

2.4 A Material of Rain Gauge

2.4.1 A Rain Gauge for The Measurement of Finescale Temporal Variations

In this paper [10], conventional rain gauge using different funnel materials were observed. The summary of the observed flow characteristics for different funnel material is shown on table 2.4. Based on observation, the effect of weathering showed the stability of the type of gauges was increased.

Table 2.4 Summary of the observed flow characteristics for different funnel material [10]

Material	Treatment	Initial wettability	Flow behavior
Aluminum	Polished	Adhesional wetting (irregular beads with volume ≅ 20 mm³)	Sudden beaded runoff (nonwetting)
	Uniformly roughened	Spreading wetting (irregularly shaped patches)	Irregular runoff with retention of considerable surface film
	Anodized and Electroless zinc	Adhesional or spreading wetting depending on grade of anodizing	Initial runoff will establish a laminar flow path. Good drainage except for heavy coats
Galvanized iron	Hot dip	Adhesional wetting (uniform beads with volume ≅ 30 mm³)	Sudden beaded runoff (nonwetting)
	Electroless zinc	Adhesional wetting (irregular beads with volume ≅ 20 mm³)	Irregular runoff, good drainage
	Uniformly roughened*	Spreading wetting (moderate regularly shaped patches)	Irregular runoff with retention of surface film
PVC plastic and acrylics	None	Adhesional wetting (irregular beads with volume ≅ 30 mm³)	Sudden beaded runoff (nonwetting)
	Uniformly roughened*	Spreading wetting (moderate regularly shaped patches)	Irregular runoff with retention of surface film

* Surfaces air blasted with 5–90-μm glass beads.

2.5 A Method Monitoring System

2.5.1 Design of IoT for Weather Monitoring using Raspberry

According to this paper [11], rain gauge with tipping bucket for the system monitoring weather were observed. Internet of Things (IoT) worked properly for weather monitoring. Block diagram of IoT weather monitoring is shown on figure 2.14. This paper used two sensors for sense relative humidity and temperature. Table 2.5,2.6 and 2.7 is shown the accurate measurement of rainfall, temperature, humidity and accessibilty are obtained based on IoT system.

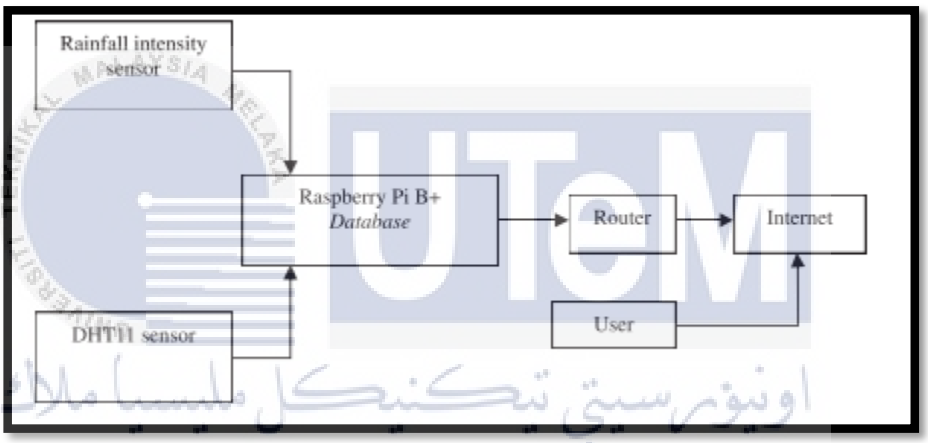


Figure 2.14 Block diagram of IoT weather monitoring[11]

Table 2.5 Rainfall intensity measurement[11]

No	Volume of water(ml)	Rainfall Intensity by Calculation (mm)	Number of counter	Rainfall Intensity by IoT instrument (mm)	Percentage of deviation
1	50 ml	2.27	4	2.26	0.44%
2	100 ml	4.97	8	4.53	1.90%
3	500 ml	24.86	43	24.38	1.93%
4	1000 ml	49.73	87	49.32	0.82%
5	1500 ml	74.6	131	74.27	0.44%
6	2000 ml	99.47	175	99.22	0.25%
7	2500 ml	124.34	219	124.17	0.13%
8	3000 ml	149.21	263	149.12	0.06%
9	3500 ml	174.07	307	174.06	0.44%
10	4000 ml	198.94	350	198.45	0.24%
Average of Percentage of deviation					0.66%

Table 2.6 Measurement of humidity[11]

No	Humidity measurement using hygrometer	Humidity measurement using IoT instrument	Percentage of deviation
1	85 %	87 %	2.29 %
2	82 %	83 %	1.20 %
3	73 %	75 %	2.66 %
4	70 %	72 %	2.77 %
5	60 %	62 %	3.23 %
6	58 %	60 %	3.33 %
7	55 %	56 %	1.78 %
8	37 %	39 %	2.56 %
9	35 %	36 %	2.77 %
10	34 %	35 %	2.85 %
11	33 %	34 %	2.94 %
12	33 %	33 %	0 %
13	34 %	35 %	2.85 %
14	35 %	35 %	0 %
15	35 %	36 %	2.77 %
16	37 %	38 %	2.63 %
17	40 %	41 %	2.43 %
18	41 %	42 %	2.38%
19	62 %	63 %	1.58%
20	67 %	69 %	1.44%
Average of Percentage of deviation			2.23 %

Table 2.7 Measurement of temperature[11]

No	Humidity measurement using hygrometer	Humidity measurement using IoT instrument	Percentage of deviation
1	26 °C	25 °C	3.84 %
2	27 °C	27 °C	0 %
3	28.6 °C	28 °C	2.09 %
4	30.9 °C	30 °C	2.91 %
5	31 °C	31 °C	0 %
6	32 °C	32 °C	0 %
7	33.4 °C	33 °C	1.9 %
8	35.6 °C	35 °C	1.68 %
9	37.4 °C	37 °C	1.06 %
10	39.6 °C	39 °C	1.51 %
11	39.4 °C	39 °C	1.01 %
12	38.8 °C	38 °C	2.06 %
13	37.6 °C	37 °C	1.59 %
14	36.4 °C	36 °C	1.09 %
15	35 °C	35 °C	0 %
16	31.7 °C	31 °C	2.20 %
17	31 °C	31 °C	0 %
18	30.9 °C	30 °C	2.91 %
19	28.6 °C	28 °C	2.09 %
20	27.4 °C	27 °C	1.45 %
Average of % of deviation			1.47 %

2.5.2 Iot Based Rainfall Monitoring System using WSN enabled Architecture

In this paper [12], a WSN (wireless sensor network) which design for a rainfall monitory system to transmit and collect real time data via a cellular network using GPRS (general pocket radio services) were observed. The rain gauge station and the data collection are the two main stages of the WSN rainfall monitoring network. For measured the precipitation volume and transfer the collected data to a remote server is the function of RG station. To classify the data set of rainfall, vector machine (SVM) is used.

2.5.3 ESP8266 Nodemcu based Weather Monitoring System

This article [13], ESP8266 nodemcu microcontroller in weather station is used to manage and monitor the condition of the location whenever and wherever remotely controlled NET PI network system is used. Figure 2.15 below is shown the overall of system connection diagram. The real results on Net PI platform is also shown in figure 2.16.

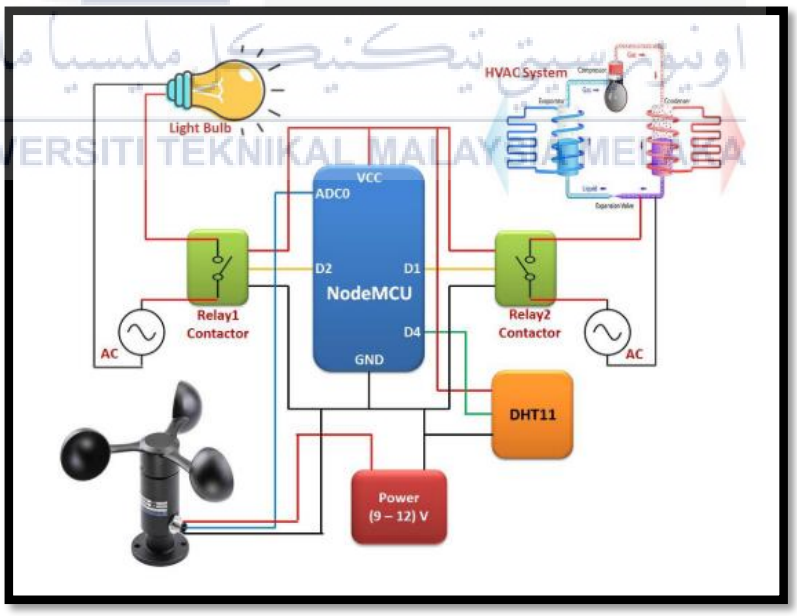


Figure 2.15 Overall system connection diagram[13]

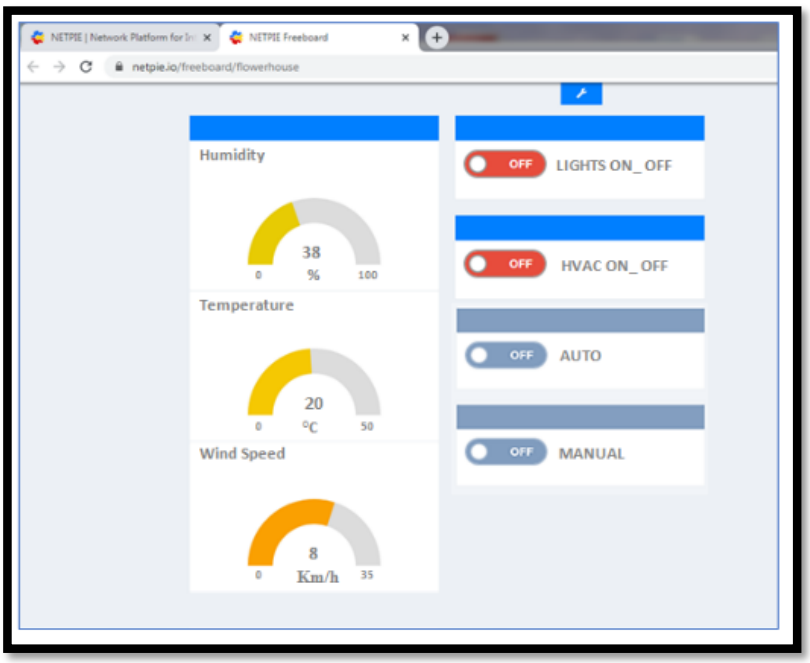


Figure 2.16 Real results on Net PI platform[13]

2.6 Comparison

Table 2.8 Comparison of research paper

	Title	Method	Results
1.	Determination of Corrections for Measuring Amount of Rainfall using The Standard Rain Gauge	Use measuring stick to tube and the volume of measuring stick depends on height of rainfall in tube.	There are different results because using different rain gauge. The error occurs since it was manual rain gauge.
2.	Weighing Type Rain Gauge with Weather Monitoring System	Use load cell to measure the rainfall magnitude. Arduino as microcontroller. ThingSpeak server as store the data.	This system shows weather changes in every 15 seconds and the graph wil display in ThingSpeak server.
3.	The Performance Measurement Test on Rain Gauge of Tipping Bucket Due to Controlling of The Water Flow Rate	Use tipping bucket system to test measurement repeabilities of varying the water.	Tipping bucket rain gauge is not suitable for high rain intensity. To measured rain in high intensity, use double layer tipping bucket.
4.	Rain Gauge Development Employing Bluetooth and RF Modem	Use bluetooth and RF – FSK modem for easy and prompt reading of rain gauge.	Differerence between device measurement and manual calculation from 0,24 mm to 0,03mm.
5.	Development of Rain Gauge using Weight Measurement for Microwave Network	Use DC motor to empty the water collected. Rain gauge use weight measurement by using load cell sensor.	Data is collected in mm/h accurately. The mechanism discard water fast and smooth.
6.	A Rain Gauge for the Measurement of Finescale Temporal Variations	Different material funnel for conventional rain gauge.	All types are improved because effect on surface diffusion polar water drops of dry deposition and oxidation of the funnel.
7.	Design of IoT for Weather Monitoring using Raspberry	IoT for weather data monitoring use Raspberry. Use rain gauge and tipping bucket for the system.	Accuracy of rainfall intensity and temperature measurement are 99.34% and 98.53% respectively. Humidity measurement is 97.77%.
8.	IoT based Rainfall Monitoring System using WSN enabled Architecture	Rainfall monitoring system by WSN-enabled architure. GPRS for transmitt and collect real time data.	It has suitable data rate for data transmited to the web server

	Title	Method	Results
9.	Development of Electronic Rain Gauge System	Electronic rain gauge system is developed for tipping bucket with potentiometer and capacitive sensor	Potentiometer is stable and highly sensitive.
10.	A Comparison of Automatic Rain Gauge	Difference rain gauges have limitation in techiques.	The acoustical inversion method used to measure drop size distribution, allow rainfall classification and rain parameter is estimated for other.
11.	IoT based Rain Gauge using Arduino	Use tipping bucket to get data through IR sensor then transmitt to arduino uno follow by ESP8266 module.	The result display in Blynk server.
12.	Modification of Manual Raindrops Type Observatory Ombrometer with Ultrasonic Sensor HC-SR04	Modified manual type Ombrometer Observatory and add with ultrasonic sensor HC-SR04. Use ESP8266 module as carried out data to platform ceerduad.com.	To sending the rainfall data can be automatically used ESP8266 WIFI module.
13.	ESP8266 Nodemcu based Weather Monitoring System	ESP8266 use to manage and monitoring for weather station	The results of the measurement used are intended to be shown as adjustable gauges on the NET PI web server

2.7 Summary

In this chapter are discussed about past research paper for rain gauge. Every method and techniques are discussed and summarize that some method very good but lacked in terms accurate and else. Some are using IoT but the technique not suitable to use. Mostly the mechanism to discarded water are not taken seriously in past of research paper. Every type of rain gauge and method have advantages and disadvantages. In this chapter also discuss a rain gauge for monitoring and different material funnel.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The purpose of this project is to develop an Internet of Things IoT-based automatic rain gauge. All progress, techniques and methodology are carried out during the development of this project will be explained in this chapter. This chapter also will overview the operation of work, followed by explanation for hardware and software. Besides, in this chapter also will list the part of component used in this project.

3.2 Methodology

The overall flowchart of this project is shown in figure 3.1. This project started with literature review of articles or past journal which are related with types of rain gauge and methods used. Based on the discussed research, the main function of rain gauges is to measure rainfall but there are errors in the accuracy of measurement and the components used are complicated to design. According to past survey article, this project used IoT to make sure the design provides ease for the users. Therefore, the system of this project are using Nodemcu ESP8266 microcontroller because it is built in Wi-Fi capability. So this component is suitable with every project that is related with IoT.

The design of this system consists of two parts which are the software and hardware development. Software development refers to the ESP8266 that are connected to Blynk application. In order to complete the project, hardware development should be done by installing all components and designing of the project. Both hardware and software should

be run simultaneously. If any error occurs in project, the testing and troubleshooting process will be conducted to ensure all the system is working. After all is completed successfully, the collected data will be analyzed.

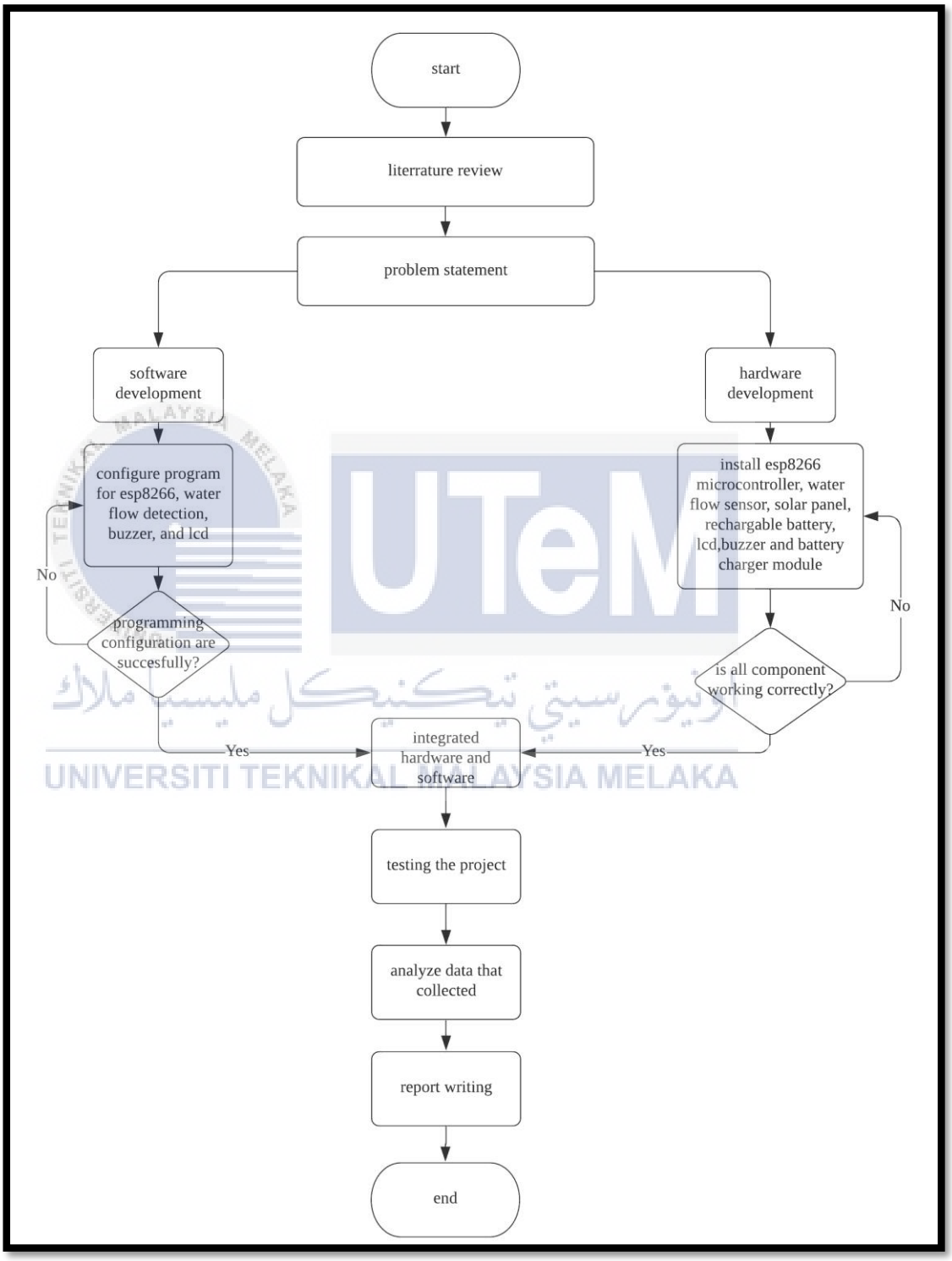


Figure 3.1 General process flow of project

3.3 Experimental Setup

3.3.1 Hardware Development

Figure 3.2 shows the design circuit of the system IoT-based Automatic Rain Gauge using nodemcu. This system works when the weather is rainy. It is because when it is raining, the system will work through the flow based on the circuit diagram. This circuit will attach with rain gauge.

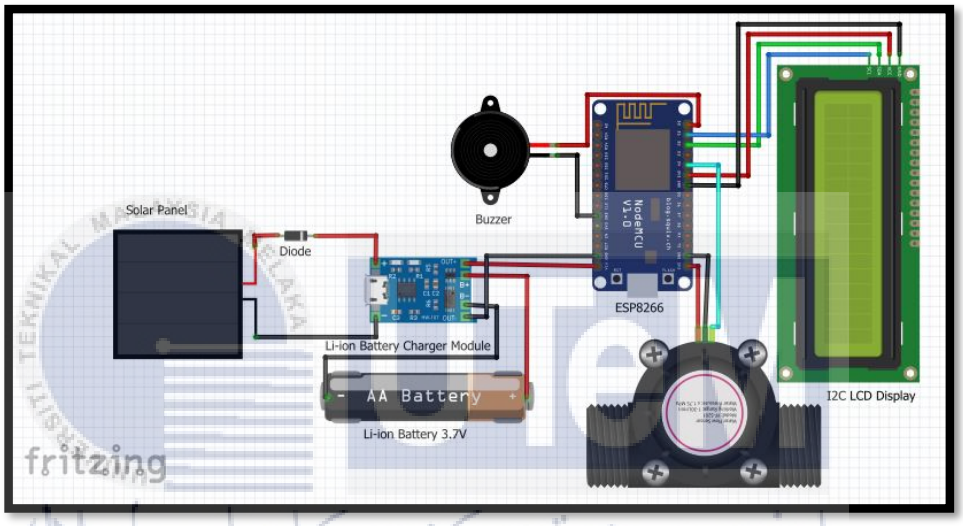


Figure 3.2 Design circuit of project

Based on the figure 3.2 above, there are three parts which are input, output and controller. Input part consists of water flow sensor. Water flow sensor is connected to ESP88266. The rainfall water will flow through water flow sensor and a hall effect sensor outputs corresponding pulse signal. The signal will be transferred to microcontroller. It is also built in Wi-Fi capability, so the result of accumulated water will displayed on Blynk application. The accumulated water will be show in milimetre.

For output part, the connection are buzzer, LCD display and Blynk application. The buzzer will produce sound when the timing was reset into 0. At the rain gauge system, the accumulated water in milimeter and rain rate in mm/hr will be displayed on LCD. Blynk application is free server to let all users to use and from this application will design based on

this project. The design in Blynk app will consist of rain rate, the accumulated water in mililiter and milimetre. Futhermore, the data will be shown and stored on the Blynk app. Solar panel and batteries are used as power source for the rain gauge system.

3.4 Parameters

For parameter part, the surface area of circle in centimeter per square. The formula will show in below to calculate the surface area of funnel. Figure 3.3 shows the design of funnel rain gauge.

Figure 3.3 The design of funnel rain gauge

The formula of surface area of circle is:

$$A = \pi * r^2$$

$$= \pi * (7.7)^2$$

$$= 186.27 cm^2$$

The radius of this funnel is 7.7cm. Based on calculation the area of circle funnel is 186.27 cm^2.

Table 3.1 Calibration of rain gauge

Amount of water (ml)	Measured testing (ml)				
500	524	523	518	496	517
350	381	345	338	338	324
250	261	258	258	246	239

Every amount are set using 4.67 calibration factor value. Table 3.1 shows the amount of water by using calibration in mililiter. After accuration is done, rainfall need to calculate in milimetre which is liter per meter square. The surface area of funnel rain gauge is 186.27 cm^2.

$$Rainfall(mm) = \frac{l}{m^2}$$

$$1l = 1000ml$$

$$ml = 0.5l * 1000$$

$$= 500ml$$

$$Rainfall(mm) = \frac{500ml}{0.018627m^2}$$

$$= 26.84mm$$

By using this formula, the amount water in 500ml will obtain in 26.88mm. Table 3.2 show the amount of water in various ml and mm.

Table 3.2 The amount of water in calculation

The amount of water (ml)	The amount of water (mm)
400	21.47
500	26.84
600	32.21

3.5 Equipment

3.5.1 Nodemcu ESP8266

In this project, nodemcu ESP8266 is chosen to be used because it was open source microcontroller and specially it was targeted for IoT based application shown in figure 3.4. To store the data and programs, nodemcu has 128kb RAM and 4Mb of flash memory. It is also built in Wi-Fi capabilities. Table 3.3 is shown the specification of nodemcu ESP8266.

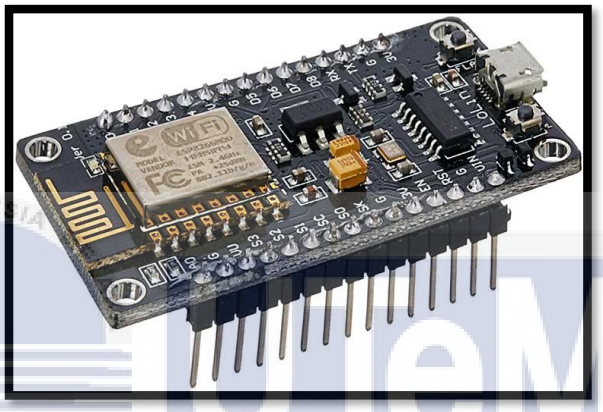


Figure 3.4 Nodemcu ESP8266

Table 3.3 Nodemcu ESP8266 specification

Parameter	Specification
Microcontroller	Tensilica 32-bit RISC CPU Xtensa LX106
Operating voltage	3.3v
Input voltage	7-12v
Digital I/O pins	16
Analog input pins	1
UARTs	1
SPls	1
12Cs	1
Flash memory	4 MB

SRAM	64 KB
Clock speed	80 MHz

3.5.2 Water Flow Sensor

Figure 3.5 Water flow sensor

Figure 3.5 shown the water flow sensor is used to measure the water flow rate in per unit time. This sensor works when water flows through the rotor rolls and rate of flow will be different based on the speed of water flow. So the output will be in pulse signal. Table 3.4 shown the specifictaion of water flow sensor.

Table 3.4 Specification of water flow sensor

Parameters	Value
Dimensions	0mmx0mmx0mm
Weight	G.W 79g
Battery	Exclude
Mini. Working Voltage	DC 4.5V
Max. Working Voltage	15mA (DC 5V)
Working voltage	DC 5V-15V

Interface dimensions	G1/2 Inch
Flow rate range	1-25L/min
Frequency	F=(11*Q)Q=L/min±3%
Error range	(1-30L/min) ±3%
Load capacity	≤10mA(DC 5V)
Operating temperature	0-80°C
Liquid temperature	≤120°C
Operating humidity	35%-90%RH
Water pressure	≤1.75Mpa
Material description	H57Copper+POM
Storage temperature	-25-+80°C
Storage humidity	25%-95%RH
Output pulse high level	<DC 4.7v (input volatge DC5v)
Ouput pulse low level	<DC 0.5v (input volatge DC5v)
Ouput pulse duty cycle	50%±10%

3.5.3 LCD Display

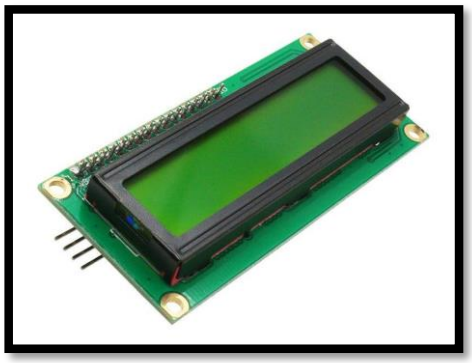


Figure 3.6 LCD Display

Figure 3.6 above shown the LCD or liquid –crystal display is a flat panel display which uses liquid crystals in primary form of operation. Commonly, it is found in smartphone, television, computer monitors and device panels. LCD is allowed displays to be much thinner than CRT (cathode ray tube) technology.

3.5.4 Blynk Application

Figure 3.7 Blynk application

Figure 3.7 shown the Blynk is a platform which design for IoT and also enable hardware to be controlled remotely. In this application, a digital dashboard may create a graphic interface based on the project. It also can display sensor data, store data,vizualize it and others. Three major components in this platform which are very important are Blynk App, Blynk Server and Blynk Libraries. Since this project is about IoT, blynk server is responsible to communicate between hardware and mobile phone.

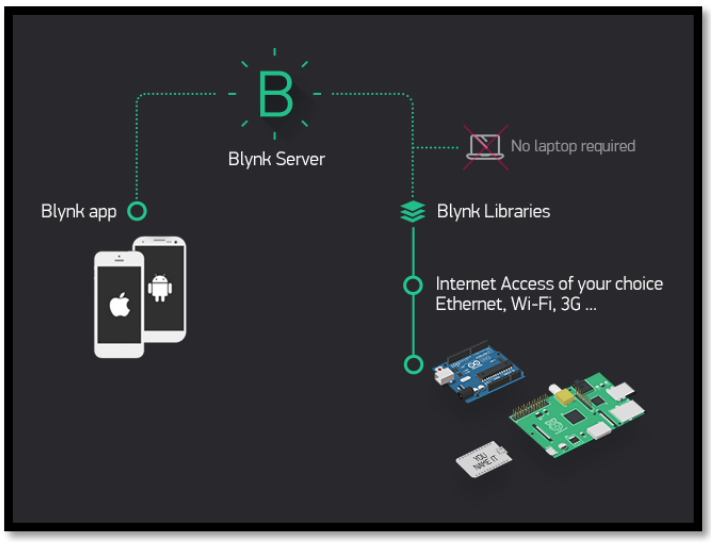


Figure 3.8 The connection from hardware to mobile phone

Figure 3.8 shown the connection from hardware to mobile phone. The connection to the cloud is enabled though the use of WiFi, Bluetooth and (BLE) Bluetooth Low Energy, Ethernet, USB (serial), GSM and others. This blynk can create amazing interfaces for all projects.

3.5.5 Solar Panel

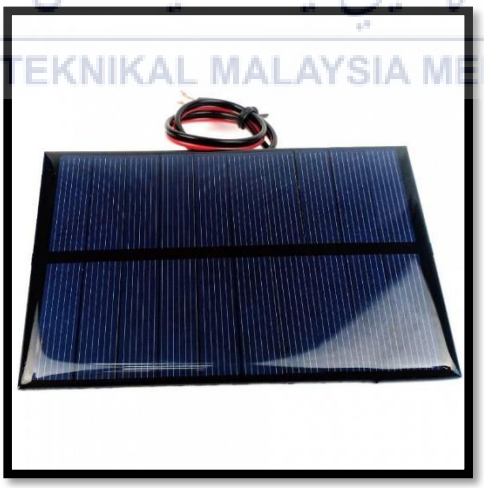


Figure 3.9 Solar panel

Figure 3.9 shown the solar panel is used to convert sunlight into electricity, solar panel is applied. Solar panel is used in wide type of application including remote power system for cabins, telecommuncation equipment, remote sensing and production of

electricity. Solar panel is a very practical way to produce electricity for many application. The lifespan of this equipment can be long lasting depending on the quality of the system.

3.5.6 Li-ion Battery 3.7V

Figure 3.10 Li-ion battery 3.7V

A lithium-ion battery or li-ion battery is a rechargable battery. Lithium-ion batteries are frequently used in portable electronics, electric cars and also used in military and aerospace application. Li-ion battery 3.7v is shown on figure 3.10.

3.5.7 Li-ion Battery Charger Module

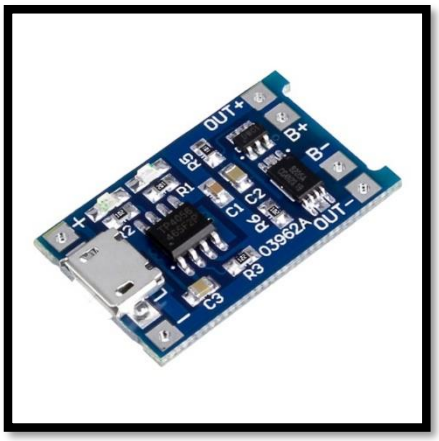


Figure 3.11 Li-ion battery charger module

Since a lithium battery should not be overcharge and drained, this module will keep track of the battery's voltage during charging and discharging. Li-ion battery charger module is shown on figure 3.11. Mostly all project will involve this module if lithium-ion battery is used.

3.5.8 Buzzer

Figure 3.12 Buzzer

Figure 3.12 shown the buzzer or beeper is an audio signalling device, which are electromechanical, piezoelectric and mechanical. Alarm devices, timers, and confirmation of users input such as mouse click or keyboard are all common uses for buzzers and beppers.

3.5.9 Diode

Figure 3.13 Diode

Figure 3.13 is shown the component diode. Diode is a semiconductor device that acts as one way switch for current. It only allows cuurent in one direction while restricts current flow in other side. Diode also has polarity which is anode and cathode.

3.5.10 Measuring Jug

Figure 3.14 Measuring jug

Figure 3.14 shown the measuring jug. The measuring jug or beaker is used to measure and pour amount of liquids. The unit of beaker is in mililiter(ml).

3.6 Software Development

In this project, a nodemcu ESP8266 microcontroller will use Arduino IDE software which is easy to write code and upload to board. This software can be used with any board. For this project, it runs the program for water flow sensor where it responds to the Blynk application to display the flow rate of rainfall. Arduino IDE software acts as a medium of communication between the ESP8266 module and serial monitor. Figure 3.15 and 3.16 shown the platform Arduino IDE and the example platform of serial monitor.

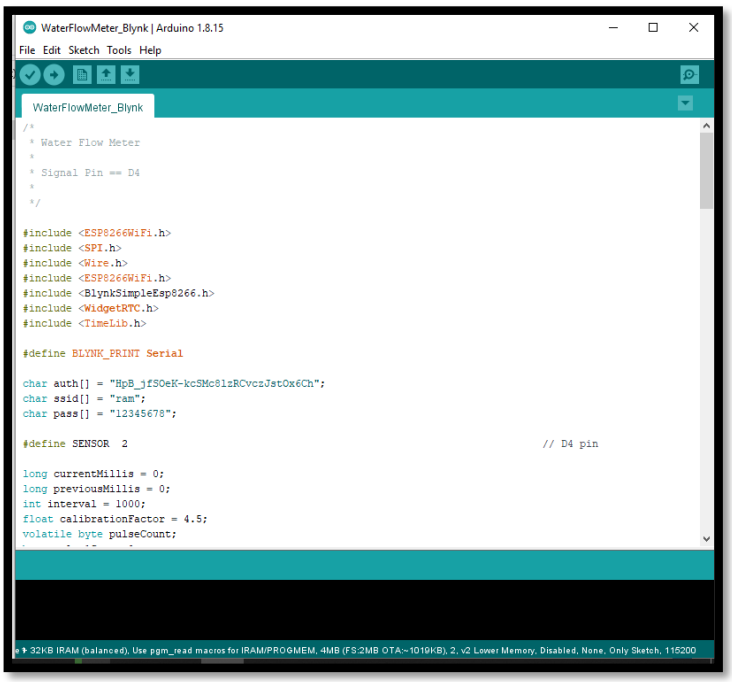


Figure 3.15 Platform Arduino IDE

Figure 3.16 Example platform of serial monitor

Figure 3.17 Blynk application

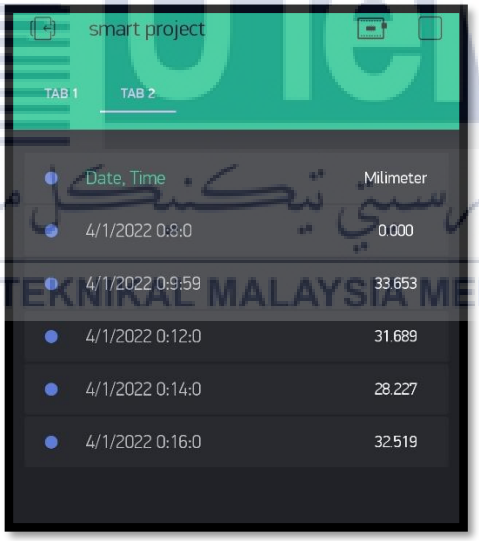
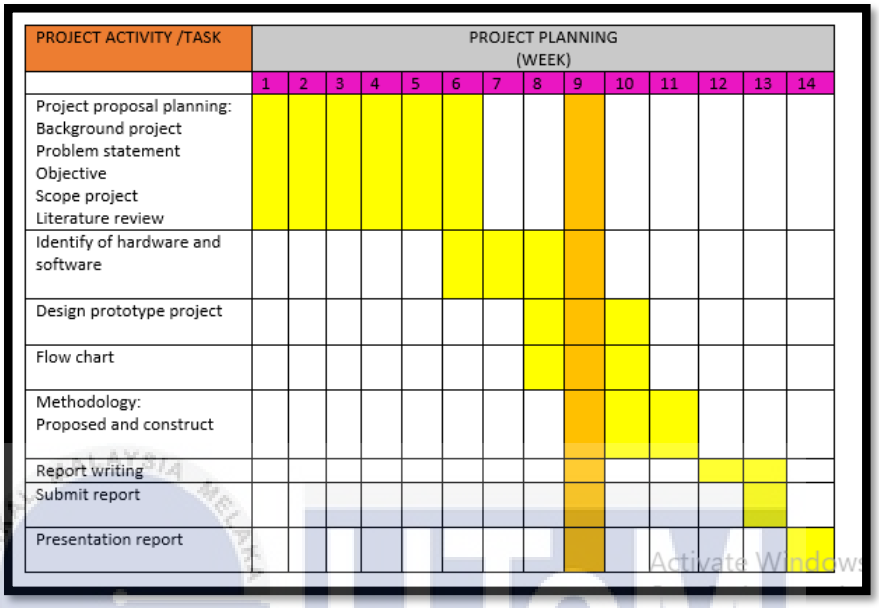


Figure 3.18 Blynk application

Figure 3.17 and 3.18 above shown the data that accumulated will display at blynk application. The data will accumulated in milimeter.

3.7 Gantt Chart

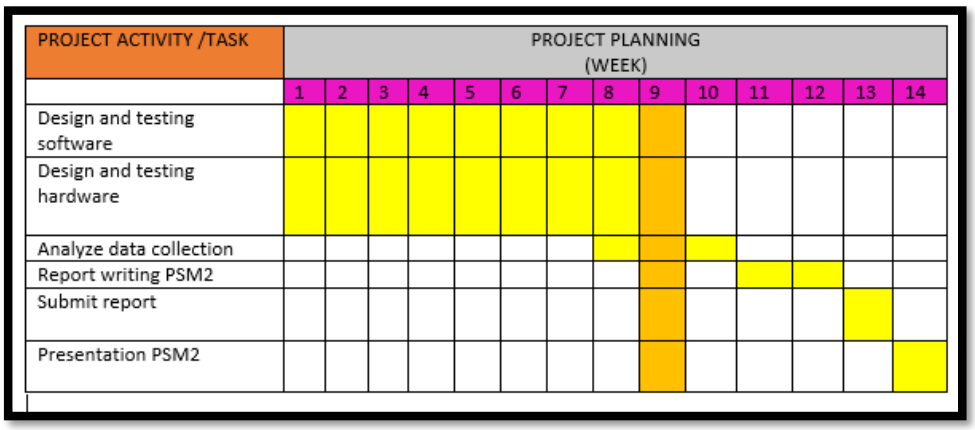
Gantt chart is very important for project management because it shows overview process of project. It is useful to keep task on track based on timeline and deadlines.



PROJECT ACTIVITY /TASK	PROJECT PLANNING (WEEK)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Project proposal planning: Background project Problem statement Objective Scope project Literature review														
Identify of hardware and software														
Design prototype project														
Flow chart														
Methodology: Proposed and construct														
Report writing														
Submit report														
Presentation report														

Figure 3.19 Gantt chart PSM1

Figure 3.19 showed the flow progress of project. In week 1-6, the project will start with proposal planning and writing report for chapter 1 and chapter 2 which consist of introduction, objective, problem statement, scope project and literature review. After that, in week 6-9, the equipment has to be identified. A prototype project is sketched in sketchbook to understand the function of the project. Then, a flow chart is designed to show the flow function of project.



PROJECT ACTIVITY /TASK	PROJECT PLANNING (WEEK)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Design and testing software														
Design and testing hardware														
Analyze data collection														
Report writing PSM2														
Submit report														
Presentation PSM2														

Figure 3.20 Gantt chart PSM2

Based on figure 3.20 above, it is a gantt chart for next semester. Basically, for next semester it is to design if any additional information and test and troubleshoot if any error occurred. After the project is run successfully, the data will be collected and analyze in better performance.

3.8 Limitation of Proposed Methodology

In this project there are some limitations which is the material of rain gauge is used plastic pvc that has very poor heat stability and it is also can leaked when installation is not proper. When installation is leaked, there will be error in measurement. Besides, it also can be cracking when dropped or stepped on. Next, for another limitation is it needs to test at field area but this project only testing by pouring water in rain gauge. This limitation need to overcome to improve in future. For material of rain gauge will used another material which is aluminium because it is can protect corrosion from bad weather. In future, it needs to testing in real of rainfall and testing at field area.

3.9 Summary

In this chapter, the system of this project are already being discussed. The part of hardware is very important to ensure that it is working. A software is also important because the platform used is correct. The flow chart shows all the process of IoT-based on Automatic Rain Gauge using nodemcu is clear and easy to understand. Besides, this chapter should be clear of component that used and paramater has to be correctly to ensure there were error in calculation and measurement.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results and analysis on the development of Internet of Things (IoT)-based Automatic Rain Gauge using Nodemcu for Rainfall Measurement. This project will measured the amount of water that accumulate by pouring water in mililiter and results will show in milimetre. The result will be performed in this chapter. For rain rate, the result will show also but in this project will more focus only accumulated water of rain gauge. The results will shown in various mililiter that used to compare the measurement with calculation. By done of parameter and calibration that show in chapter 3, the output can be obtained as the result.

4.2 Results and Analysis

Figure 4.1 Automatic rain gauge

Figure 4.1 above shows the design of automatic rain gauge which is used to collect accumulated water through the funnel of rain gauge. Usually in raining day, the rainfall will go through the funnel to obtained the accumulated water that flow through water flow sensor. But for this project will replaced by pouring water using various milliliter. For example, using measuring jug pouring 500 milliliters, the water will flow through the funnel and water flow sensor. The water flow sensor will detect and send the signal to the microcontroller for processing.

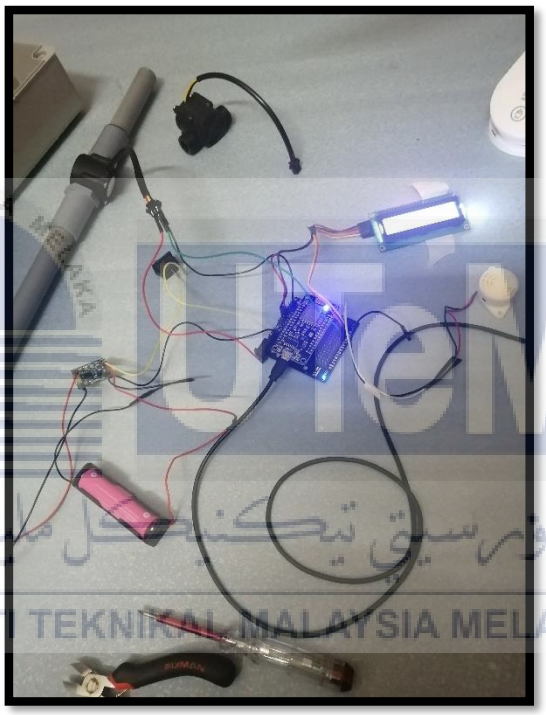


Figure 4.2 Circuit of system

Figure 4.2 shows the setup circuit of whole system. The water flow sensor will transmit the signal to microcontroller, then the data will be received to mobile phone and LCD by connected with Wi-Fi module. The result will display at LCD and mobile phone which is Blynk application. Blynk app will show the data and also stored.

Table 4.1 The accumulated water (mm)

The amount of water (ml)	The accumulated water in measurement(mm)				The accumulated water in calculation(mm)
400	21.9	22.16	22.49	21.49	21.47
500	26.32	27.54	25.68	26.43	26.84
600	33.65	31.69	28.23	32.52	32.21

Table 4.1 shows the accumulate water in calculation and measurement. By using various milliliter, the accumulate of water will different and for measurement the testing was take in 4 sample to see the accuration of each accumulated water. The calculation and measurement almost same and accurate. So the result is obtained will done.

Figure 4.3 The accumulated water for 400ml

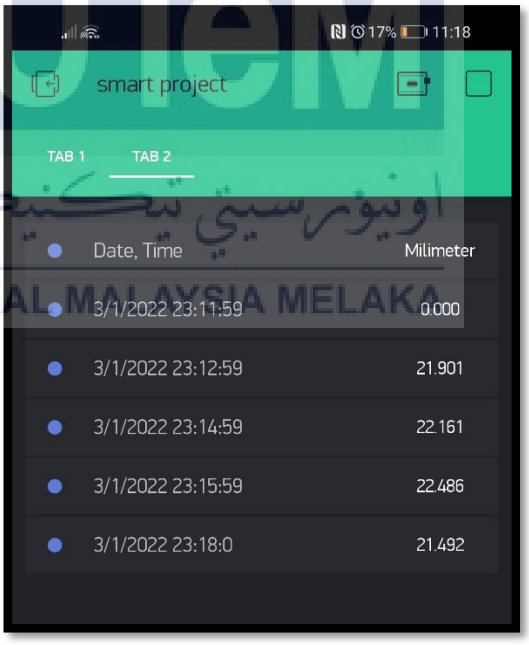


Figure 4.4 The data will stored in Blynk application

Figure 4.5 The accumulated water for 500ml

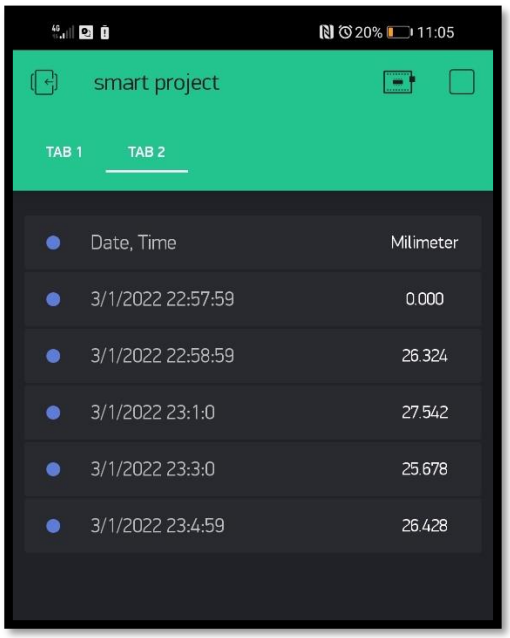


Figure 4.6 The data will stored in Blynk application

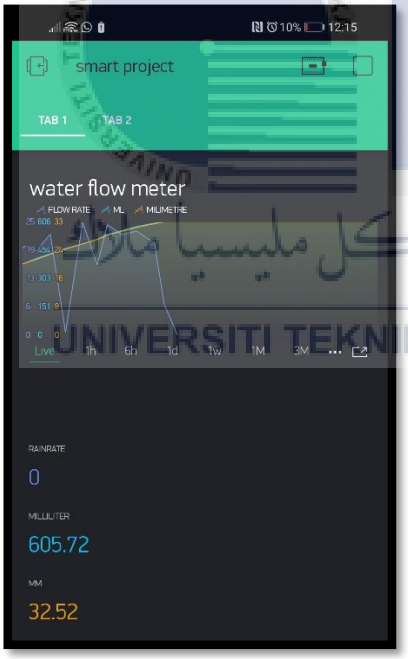


Figure 4.7 The accumulated water for 600ml

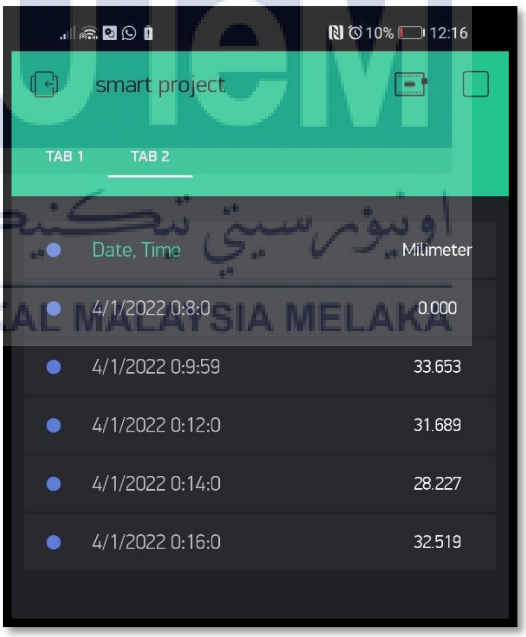


Figure 4.8 The data will stored in Blynk application

Figure 4.3, figure 4.4, figure 4.5, figure 4.6, figure 4.7, and figure 4.8 shows the display result on Blynk application. The graph will show when water was flow through the funnel. The result show the rain rate is will be 0 mm/hr when water flow was stop. When

water starting flow the rain rate will show the value in mm/hr. The result also display accumulated water in mililiter and milimetre. Every the amount of water that collected will be store in Blynk application.

Figure 4.9 LCD display result

Figure 4.9 shows the result in LCD display. The result shows exactly same with the Blynk application.

4.3 Summary

This chapter presented to demonstrate applicability of the proposed system automatic rain gauge by Internet of Things using nodemcu for rainfall measurement. Basically the result will display at LCD display and Blynk application. The result will show accumulated of water in milimetre. The data also can be exported from Blynk application to the excel file.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The purpose of this project is to develop an automatic rain gauge based on Internet of Things (IoT) that is able to read accumulated rainfall data automatically using nodemcu microcontroller. In order to achieved an objectives, the data will be read automatically using nodemcu microcontroller through the water flow sensor. In addition, it can also measure and record data of the rainfall in milimeter into cloud. Blynk application is the platform that is used in this project to display the data of accumulated water in mililiter and milimetre. Calibration are been carried out to get the accuracy in read the accumulated water. This project have some limitation for carried out of accumulated water. Besides, this project mostly focus on the functionality of automatically rain gauge system based on IoT.

This project can help meterodologist to collect the measurement of accumulated water with ease and conveniently. In conclusion, the project presented in this report has successfully implemented and can be useful to replace the conventional rain gauge through its advanced functionalities for rainfall measurement and data recording.

5.2 Future Works

For future improvements, accuracy of the automatic rain gauge could be enhanced as follows:

i) Replace the materials of automatic rain gauge to a better heat tolerant material.

ii) Improve mechanism of measuring using water flow sensor to produce more accurate measurement.

iii) Carry out real field test and calibration to come out with a better system.

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