Faculty of Electrical Technology and Engineering

DEVELOPMENT OF SOLAR-POWERED FLOOD MONITORING WARNING DEVICE USING IOT FOR HOME ALERT

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DEDICATION

To my beloved mother, Hashimah binti Isa, and father, Mohd Zahir bin Mohd Khairudin, and To future wife, Siti binti Fatimah and my beloved , Datin Dr. Fadzilah binti Salim.

ABSTRACT

Every year, Malaysia experiences the devastating impact of the East Coast monsoon phenomena, particularly in coastal regions like Kelantan, Terengganu, Johor, KL, Selangor, and Pahang. Consequently, it becomes imperative to develop a cutting-edge flood monitoring device capable of issuing timely warnings to individuals in their homes. This innovative gadget utilizes advanced technology to provide accurate flood information and alerts to residents living in low-lying areas that are prone to frequent flooding. Floods are among the most destructive natural disasters, causing not only substantial material damage but also leaving a lasting psychological impact on the affected individuals. Therefore, the primary objective of this project is to design and assemble a circuit incorporating a microcontroller, warning device, and water level sensor. In the design of the circuit, an ultrasonic sensor has been employed to detect the water level. The output of this device consists of a buzzer and three LEDs: red, yellow, and green. When the sensor detects a rise in water level, the microcontroller transmits the data to the Blynk application, where the water level is displayed digitally and graphically. When the water reaches a certain level, the sensor is triggered, causing the LED and buzzer to activate. Additionally, the Blynk application sends a notification to the user in real-time. The key idea behind this project is to utilize the Blynk application to inform users if water levels are rising, while also incorporating solar panels to generate sustainable power for the device. By successfully implementing this project, the anticipated outcome is to empower people to proactively prepare for imminent floods.

ABSTRAK

Setiap tahun, Malaysia mengalami impak yang menghancurkan fenomena monsun pantai timur, terutamanya di kawasan pesisir seperti Kelantan, Terengganu, Johor, KL, Selangor, dan Pahang. Oleh itu, menjadi penting untuk membangunkan peranti pemantauan banjir berteknologi terkini yang mampu memberi amaran tepat pada masanya kepada individu di rumah mereka. Gajet inovatif ini menggunakan teknologi canggih untuk menyediakan maklumat banjir yang tepat dan amaran kepada penduduk yang tinggal di kawasan rendah yang cenderung mengalami banjir kerap. Banjir merupakan salah satu bencana alam yang paling merosakkan, tidak hanya menyebabkan kerosakan bahan yang besar tetapi juga meninggalkan impak psikologi yang berkekalan terhadap individu yang terjejas. Oleh itu, objektif utama projek ini adalah untuk merancang dan menyusun litar yang memasukkan mikropemproses, peranti amaran, dan pengesan paras air. Dalam reka bentuk litar ini, pengesan ultrabunyi digunakan untuk mengesan paras air. Output peranti ini terdiri daripada buzzer dan tiga LED: merah, kuning, dan hijau. Apabila pengesan mengesan peningkatan paras air, mikropemproses menghantar data ke aplikasi Blynk, di mana paras air dipaparkan secara digital dan grafik. Apabila air mencapai paras tertentu, pengesan diaktifkan, menyebabkan LED dan buzzer berfungsi. Selain itu, aplikasi Blynk menghantar pemberitahuan kepada pengguna secara masa nyata. Idea utama di sebalik projek ini adalah untuk menggunakan aplikasi Blynk untuk memberi tahu pengguna jika paras air meningkat, sambil juga memasukkan panel solar untuk menghasilkan tenaga lestari bagi peranti ini. Dengan berjaya melaksanakan projek ini, hasil yang dijangka adalah memberi keupayaan kepada orang untuk bersedia secara proaktif menghadapi banjir yang akan datang.

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LIST OF ABBREVIATIONS

SLA	-	Sealed Lead-Acid
LCD	-	Liquid crystal display
IoT	-	Internet of Thing
$NodeMCU$	-	Node Microcontorller Unit
LED	-	Light Emitting Diode

CHAPTER 1

INTRODUCTION

1.1 Background

Every year, Malaysia is affected by the east coast monsoon phenomena, which is particularly severe in locations along the shore such as Kelantan, Terengganu, Johor, KL, Selangor, and Pahang. This is a result of the recent unexpected weather. The individuals who lost their properties as a result of this natural occurrence are psychologically affected long-term by the flood phenomena.

In general, these monsoon phenomena that cause flood has an impact on social, economic, and environmental elements. Extreme flooding can also result in fatalities and the spread of deadly illnesses. Every year the number of fatalities rises during the flood season in Malaysia, a series of annual monsoon floods hit several states in Peninsular Malaysia, especially the country's east coast. During the phenomenon, some people drown in the swift river, while others perish from malnutrition as a result of the disruption of the food supply.

Therefore, it is necessary to develop a flood monitoring device utilizing to warn people at home. This gadget uses technology to provide flood information and alerts to people who are situated in low-lying locations that are frequently prone to floods. A warning sound and a notification will be delivered to the user's smartphone via a Blynk application if the gadget detects a particular amount of rising water.

1.2 Addressing Global Issue for Smoke Detector

One global issue related to flood monitoring devices is the lack of knowledge about the existence of these devices and use in developing countries. A flood monitoring device is a tool that functions to notify residents that the water is rising, which can be the first warning if there is a flood in the surrounding area. This device may be underutilized or too expensive to be purchased by families who are less able at the same time will increase the damage to public property because they are not prepared for floods. Additionally, because floods can happen at any time, some areas' limited use of flood monitoring equipment may be a result of a lack of awareness of the necessity of such tools and precautions during the monsoon season.

1.3 Problem Statement

Flood is the most destructive type of natural catastrophe. Floods may have a long-lasting impact on both victims psychologically and their property. The abrupt release of water from lakes, reservoirs, or other sources can result in floods. Malaysia is among the nations on the list that experienced severe flooding, such as during the monsoon seasons of 2014 and 2021. With roughly 64,000 casualties, the storm in 2021 had the greatest flood victims. Additionally, this resulted in extensive damage to both public property and flood victims' property, including automobiles and homes. Therefore, one of the solutions to overcome the above-mentioned issue is to utilize a flood monitoring device to warn the users and those around them.

1.4 Project Objective

The following are the primary goals of this project:

1) To analyze the existing flood warning device.
2) To design and assemble a circuit that contains the microcontroller, warning device, and water level sensor.
3) To evaluate the performance of the developed flood warning device.

1.5 Scope of Project

The scope of the project is defined as follows:

a) This project is targeted for outdoor use, especially on the car porch
b) The ultrasonic sensor is used to detect the water level if rising.
c) The type of solar panel used in this project is polycrystalline.
d) The battery used to store the excess energy generated by the solar panel is therechargeable Seal Lead Acid(SLA).
e) The system in this project uses ESP8266 Nodemcu as the main microcontroller.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The theories and system design for a flood monitoring device are compiled in this chapter. The overview of the traditional flood monitoring system and the statistical damage brought on by floods are also explained in this chapter. To improve the project's results, related projects from publications, journals, and other works have also been discussed and compared.

2.2 Overview of Existing Project

This section will examine a few earlier project designs and executions that have been accomplished in connection to this project system. Many outstanding researchers have worked for years to discover how to optimize flood monitoring equipment.

2.2.1 Design of River Height and Speed Monitoring System using Arduino

The development of this system is to monitor floods using Arduino UNO ATMega328. This system detects water level by using an HC-SR04 ultrasonic sensor where the sensor detects the water sensor by transmitting a short ultrasonic pulse, and can measure the travel time of that pulse (the echo) to the liquid and back. Then subtract that distance from the total depth of the tank to determine the water depth. The ultrasonic sensor is placed on top of the tub. The ultrasonic sensors are connected to the Arduino UNO, which reads data from them. However, while implemented in the river flow there are several water level errors due to the floating objects flowing in the river through the ultrasonic sensor [1].

2.2.2 Development of portable solar storage device

This flood monitoring system was created to alert users in the event that the river's water level rises. In this project, the water level was measured using an ultrasonic sensor by timing the transmission of the signal and reception of the echoes to establish the object's distance. The microcontroller received the data from the ultrasonic sensor after it had determined the water level. This project's microcontroller was an Arduino UNO ATMega328. The system also has a liquid crystal display (LCD) and SIM900 GSM/GPRS, which can both transmit SMS messages to the user and display the water level on the LCD. The technology used in this research was also created with a 1000-millisecond delay. Based on the data from the sensors, the microprocessor kept an eye on the river's water level [2].

2.2.3 Flood Early Warning Detection System Prototype Based on IoT Network

This project was created to keep track of river levels and floods that occur throughout Malaysia. There are three significant hardware components that might be used in this project. The system's microcontroller, Arduino UNOR3, is used to collect input signals from the ultrasonic sensor [HC-SR04], process those data, and then communicate theresults to the GSM & GPRS module [SIM 900]. The third device, a GSM & GPRS module,will then receive the data from Arduino as an Internet of Things (IoT) device, upload the data to a ready-made website, and send a message about a certain water level to a pre- programmed number. The four water levels that have been established are "SAFE," "ALERT," "STANDBY," and "BEWARE." However, based on the outcomes of the experiment, this method will be helpful as one of the fixes for reducing the number of floodvictims that might occur in the future [3].

2.2.4 IoT-based Flood Monitoring and Alerting System using Raspberry Pi

To predict nearby flooding caused by rain, this project was developed. In order to predict flood symptoms and notify the appropriate authorities, this project uses a Raspberry Pi equipped with water and rain sensors. In addition, it advises adjacent villages to leave since there is a danger of flooding, by sounding an alarm. Water sensors are used in this project to measure the water level. To determine the amount of rain in a certain location, rain sensors are also used. These sensors later communicate readings of water and rain to the Raspberry Pi via IoT. Now, at the controlling end, once it surpasses the threshold limit value, the system calculates the time it would take for flooding to occur in a region and informs the villagers. There is no need for in-person training because this technology is low-cost and self-guided. Additionally, this system achieved high performance, affordability, and adaptability [4].

2.2.5 Flood Monitoring and Alerting System

Through phone calls, this initiative will warn users who are close to the river area. The system as a whole is managed by an Arduino Uno microcontroller. A GSM modem

SIM900A, an ultrasonic sensor (HC-SR04), and an Ethernet shield are all connected to it. The distance between the water and the ultrasonic sensor is measured, and the water's height level is determined. On the website, the computed height value is updated. The computed water level would then be compared to the predetermined threshold, and if the current level is higher than the predetermined threshold value, the microcontroller would enable voice calls to be issued to inhabitants through the GSM module to notify them. The ARP33A3 device is being used in this project to record voice, and it is connected to the GSM modem so that the recorded voice may be heard when the call is answered [5].

2.2.6 Design of Information Monitoring System Flood-Based Internet ofThings (IoT)

Throughout the system, an Arduino Uno Atmega238 is utilized as the controller. The Wireless NRouter TL-MR3020, a Wireless Broadband Router with the fundamental function of an access point and a GSM modem interfaced with a GSM modem, has been utilized in this project. Additionally, the HC-SR04 Ultrasonic Sensor, which emits ultrasonic waves at a frequency of 40 kHz, can measure the distance to an item, as well as the rain sensor, which can measure rainfall, is utilized as an ultrasonic sensor in this project.

Water and rainfall data can be transmitted to users of Internet browser-based software using ultrasonic-based flood sensors, rain sensors, Arduino Uno, ethernet shields, and wireless routers. Information such as water depth, rainfall, and flood status, including safe, alert, and danger status (based on a 32 cm water level), are presented [6].

2.2.7 GSM & Web-Based Flood Monitoring System

For the chosen towns around the Mandulog River, the project's objective is to create a local real-time river flood monitoring and warning system. The detection and early warning alert system (through website and/or cell phone text messaging) that warns local subscribers of probable flooding events is the only topic of this study. Additionally, this system is interactive, allowing non-registered subscribers to request information about the real water level in the area they want to monitor. The evaluations also offer an expected time when a particular river stream may flood. The water level monitor, GSM module, and microcontroller development board are the three main components of the hardware employed in the design [7].

2.2.8 SMS-Based Flood Monitoring and Early Warning System

In this study, a Flood Monitoring and Early Warning system based on SMS technology is presented, along with its development, implementation, and experimental validation. This system utilizes SMS to store contact information and maintain sufficient credit. Users have the option to request text updates on water level measurements. When the water level surpasses a user-defined threshold, the system promptly provides information and sends SMS alerts to individuals at risk as well as the relevant authorities.

The Arduino Uno microprocessor plays a key role in this system, as it reads input from the pressure sensor, calculates water height, and sends text messages to mobile devices using the Global System for Mobile Communications (GSM) module. This straightforward and cost-effective warning system enables swift communication with the appropriate authorities and vulnerable residents. However, it's worth noting that a potential issue may arise if the network provider changes the network, as the GSM module might not be capable of updating itself [8].

2.2.9 IoT System: Water Level Monitoring for Flood Management

The purpose of the flood monitoring system was to offer a useful flood notification system that gave the local community in the affected region an early warning. Due to the vast coverage and general availability of the GSM network across Malaysia, the notification system will use this network. Users in that region, including those near the police station, the nearest emergency services, and the head of the village will receive the notification messages.

The GSM Modem SIM900A, the Arduino UNO R3, and the DHT22 are the four primary components that have been utilized. Utilizing an Arduino UNO as the micro-controller, a system architecture was created that would carry out a number of tasks, including monitoring humidity, temperature, and water level as well as sending SMS messages via a GSM shield. This device will measure the water's height accurately in real- time and deliver SMS notifications [9].

2.2.10 Flood Monitoring and Early Warning System Using Ultrasonic Sensor

The primary components in this project include an ultrasonic sensor to gauge the depth of the water, an Arduino microcontroller to process the sensor's signal, a GSM module to transmit data or information to a computer server, and a power source made up of a solar panel, regulator, and battery. When a sensor is activated, an output signal is transmitted to the microcontroller, which acts as a switch to cause the associated GSM module to send an alarm message or the status of the water level to a different GSM modem linked to a server. There are four different alert levels: "Normal" (inches 5 and above), "Moderate" (inches 6 to 10), "Critical" (inches 11 to 15), and "Emergency" (inches 16 and beyond) [10].

2.2.11 Early Flood Monitoring System Using IoT Applications

The development of a flood monitoring system utilizing the Thingspeak application platform for storing and retrieving data from systems using the HTTP protocol via Local Area Network is represented in this article. One NodeMCU board that has been combined with the Thingspeak program serves as the system's foundation. Initially, a NodeMCU is installed in flood-prone locations where it serves as the transmitting unit and has an ultrasonic sensor for detecting the water level during floods. The data is then shown on the LCD. Now, the Thingspeak web application will receive the data gathered by the ultrasonic sensors. A water flow monitor is used to determine the flow rate, and it records the flow rate to the Thingspeak application. Thingspeak keeps data in private channels by default, however, public channels may be used to share data with the whole public. As a result, the outcome demonstrates that the system can monitor flood-prone locations [11].

2.2.12 IoT-Based Early Flood Monitoring, Detection and Alarming System

With the aid of Arduino, a prototype platform, and portable sensors for level, temperature, humidity, and flow, a flood monitoring system using the Internet of Things is developed and clearly demonstrated in this article. The hardware unit is first installed in flood-prone locations, the Wi-Fi module (ESP8266) functions as the transmitting unit, and the system's connected sensors measure the necessary data. Then, the IOT web application receives the correctly measured parameters and displays them on the LCD display. Here, data is stored in a private channel using the Thingspeak web application, which then notifies those in charge and the public when a flood happens [12].

2.2.13 Flood Disaster Indicator of Water Level Monitoring

This study showcases the utilization of an Arduino board and GSM shields to create a comprehensive early warning system. Both hardware and software components were incorporated in the design and implementation of this system. The model employs float switch sensors to monitor the water level and subsequently analyzes the collected data to assess the associated risk. Upon detecting a specific level, the system generates an alarm message which is then transmitted to the user. The GSM network serves as the medium for connecting the various system components, enabling communication through SMS. [13].

2.2.14 Early Warning System of Flood Disaster Based on Ultrasonic Sensors and Wireless Technology

This study outlines the creation of a flood disaster early detection system. Two ultrasonic sensors serve as a water level detector in this device, and a water flow sensor serves as a water flow velocity sensor. GSM and wireless technologies are both employed as informational channels. The Katulampa Dam in Bogor's water level conditions is used to develop the system. The water level detector's characteristics revealed that it operates efficiently in the range of 14 to 250 cm, with a maximum relative error of 4.3%. In the meanwhile, wireless connectivity is reliable out to 75 meters, and SMS transmission takes 8.20 seconds [14].

2.2.15 Smart IoT Flood Monitoring System

A smart IoT flood monitoring system is created to warn residents of impending flooding. The procedure begins when an ultrasonic sensor gauges the river's water level. The sensor's acquired data are aggregated, sent to the microcontroller, and then displayed on the web server. Data will then be examined and contrasted. He or she has wireless control over the buzzer and stepper motor. Based on the information gathered, the flood's risk status will be decided. As a result, the web server and LCD will show the current water level. An LED will light on to show the current water level. Additionally, when the flood level reaches the highest threshold value, the stepper motor will switch on to prevent the passage of excessive flooding, and the alarm will sound instantly to inform the public. Therefore, before the flood ever happened, the residents would have been well-prepared for evacuation [15].

2.2.16 Investigation of Ultrasonic Sensor Type JSN-SR04T Performance as Flood Elevation Detection

With a 0.5 cm measurement resolution, the JSN-SR04T ultrasonic sensor will be used in this study to construct a water surface elevation measuring system. As a system for processing measurement data, an Arduino-Uno microcontroller with an Atmega238 CPU was employed. The system was tested in a river, where the device was positioned beneath a bridge and a sensor was used to record the elevation of the water's surface levels. After that, the LCD panel showed the results. 37 different conditions of the river's water surface were tested throughout the test's execution. The system's measurement findings were then contrasted with those from the manual measurement. According to the findings, the measurement error was calculated to be 0.75%. The datasheet states that the JSN-SR04T sensor can have a maximum resolution of 0.5 cm, which is consistent with our observation [16].

2.2.17 Prototype of Google Maps-Based Flood Monitoring System Using Arduinoand GSM Module

In this article, a prototype for a flood monitoring system based on Google Maps has been developed. It uses ultrasonic sensors as a height detector, an Arduino Uno as a processor, a U-Blox Neo 6m GPS module, and a GSM module to send information about the water level and its location to a station that monitors floods. The prototype's layout generates flood altitude data together with its location based on the Google Maps user experience [17].

2.2.18 Water Level Monitoring and Flood Early Warning Using Microcontrollerwith IoT-Based Ultrasonic Sensor

In this study, researchers created a flood detection system that automatically checks water levels and broadcasts early flood alerts. The NodMCU ESP8266 with ultrasonic sensors and IOT is used in this water level monitoring system to deliver real-time data for determining the water level generated at specific levels. This system is online-connected and functions as a flood early warning by integrating the Telegram application with the Thingspeak platform to provide real-time water level data. According to the test findings of this system design, ultrasonic sensors are accurate, producing an average error rate of 0.78% and an average inaccuracy of 1 cm [18].

2.2.19 Flood Warning and Monitoring System Utilizing Internet of Things Technology

This study creates a wireless sensor node-based real-time flood monitoring and early warning system for a flood-prone area. This system is built utilizing integrated NodeMCU technology. Application for Blynk. When a flood or heavy rain happens, the wireless sensor node can assist the victims by monitoring the water levels and rain intensity and issuing an early warning. The sensor node, which is located in the designated flood region, is made up of rain and ultrasonic sensors and is controlled by the system's NodeMCU microcontroller. When the flood reached a particular threshold of danger, the buzzer and LED started to activate and inform the sufferer. Through a wireless connection, the Blynk application receives data collected by the sensors. The victim may browse the interface and receive a push notification through the Blynk application on an iOS or Android smartphone to learn about the current flood and rain conditions. The information on the flood level delivered by email may be useful to numerous organizations for flood forecasts and system development. As a consequence of testing, it was discovered that this prototype could watch for floods, be alerted to them, and warn the victim before they happened [19].

2.2.20 Real-Time Wireless Flood Monitoring System Using Ultrasonic Waves

This project's goal is to use the idea of ultrasonic waves to create a real-time wireless flood monitoring system. Everything in contemporary human existence has advanced quickly. Since electronics and information technology have advanced, we have created a system that can detect the water level automatically and send that value to the control room via wireless technology to be displayed on an LCD. Additionally, based on measurements from earlier years for the same river, we have a set of LEDs to indicate where the current water level value is located. This study was created using an ATMEGA32 microcontroller [20].

2.3 Comparison of Literature Review

Table 2.1 compares the elements used in the earlier relevant study stated above. The majority of relevant initiatives employed ultrasonic sensors to measure the water level, according to an evaluation of the literature studies. Additionally, the GSM SIM900 has been utilized to enable users to transmit and receive data through GPRS, send and receive SMS, and make and receive phone calls.

The project "Development of portable water level sensor for flood management system" utilizes an Arduino UNO as the microcontroller. Additionally, as they are IoT-based systems and image processing techniques, the IoT-based Flood Monitoring and Alerting System utilizing Raspberry Pi employed Raspberry Pi as its microcontroller.

Table 2. 1 Comparison between the components used in the related existing project system

Component / Existing Project	Arduino UNO	Raspberry PI	NodeMCU ESP8266	Mbed NXP LPC17668	GSM SIM900	HC-SR04	APR33A3	GPS U-Blox Neo GM Module	Rain Sensor	Water Level Sensor	Pressure Sensor	Ultrasonic Module	DHT22	DHT11	JSN-SR04T	Stepper Motor	Water Velocity Sensor	Float Switch Sensor	Water Flow Sensor
Design of River Height and Speed Monitoring System by using Arduino	■					■											■		

Development of portable water level sensor for																			
flood management system																			
Flood Early Warning Detection System Prototype based on IoT Network																			
IoT-based Flood Monitoring and Alerting																			

System using Raspberry Pi																			
Flood Monitoring and Alerting System																			
Design of Information Monitoring System Flood-Based Internet of Things (IoT)																			

GSM & Web-Based Flood Monitoring System																			
SMS-Based Flood Monitoring and Early Warning System																			
IoT System: Water Level Monitoring for Flood																			
Management																			

Flood Monitoring and Early Warning System Using Ultrasonic Sensor																			
Early Flood Monitoring System Using IoT Applications																			
IoT-Based Early Flood Monitoring, Detection, and Alarming System																			

Flood Disaster Indicator of Water Level Monitoring System																			
Early Warning System of Flood Disaster Based on Ultrasonic Sensors and Wireless Technology																			
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Prototype of Google Maps-Based Flood Monitoring System Using Arduino and GSM Module																			

Water Level Monitoring and Flood Early Warning Using Microcontr																			
oller with IoT-Based Ultrasonic Sensor																			
Flood Warning and Monitoring System Utilizing Internet of Things Technology																			

Real-Time Wireless Flood Monitoring System Using Ultrasonic Waves																			

2.4 Background of Solar Power System

The use of solar energy as a clean, alternative renewable energy source has increased dramatically in recent years. Utilizing natural resources has been a priority, especially in industrialized cities, because it is effective and simple to maintain. The energy crisis brought on by climatic changes, rising fuel costs, and the depletion of fossil fuel reserves are addressed by this program. People will need to rely on other energy sources once all fossil fuels have been used. In the future, power will be produced via renewable energy methods.

2.4.1 Types of Photovoltaic (PV) Solar System

One of the renewable energy sources used in several applications, including water pumps, lighting systems, remote home power, and rural electrification, is solar energy. There are two types of solar photovoltaic (PV) systems: grid-connected systems and freestanding PV systems, as shown in Figure 2.1.

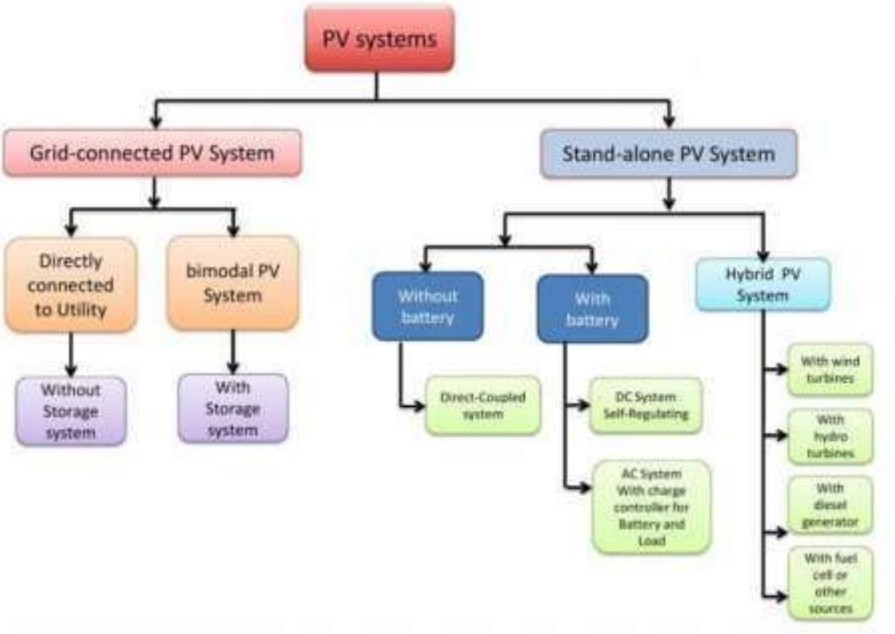

Figure 2.1 PV System Types

When consumers want to reduce their utility costs, the grid-connected PV system arrangement is the most prevalent. At the same time, even when the PV array is not providing any electricity, the utility grid is still usable. Utility- Interactive or Grid-Tied PV System refers to the PV array that is directly linked to the grid without utilizing a storage system, as depicted in Figure 2.2. As illustrated in Figure 2.3, a bimodal PV system, also known as a battery backup PV system, is what is used when surplus energy is stored in battery banks for later use.

Figure 2. 2 The connection of the Utility Interactive PV System

Figure 2. 3 The connection of the Bimodal PV System

As seen in Figure 2.4, all freestanding (off-grid) technologies function independently of the utility grid. To determine the size of the solar system and the necessary load, the ideal supply and demand match must be expected. The PV system is known as a Direct-Coupled PV System since it has relatively few components and doesn't need storage if the calculation is appropriate for a single load.

Figure 2. 4 The connection of the Standalone AC PV System

Another standalone, which may be used later during cloudy days or at night, needs a storage system to keep extra energy on hand when it is not needed for the load. This system can be connected directly to DC loads or indirectly to AC loads via an extra power conditioner or inverter. The hybrid photovoltaic system, which serves loads in parallel with the photovoltaic array and is another popular freestanding technology, is seen in Figure 2.5. Batteries have been utilized to store the energy in this system, which may also employ fuel cells, diesel generators, hydroelectric turbines, and diesel generators as energy sources.

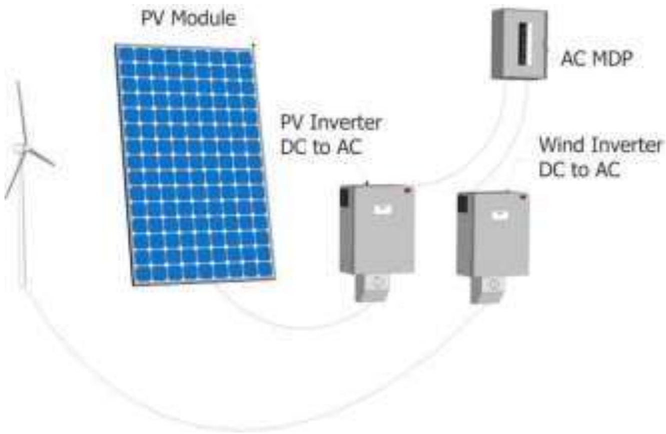

Figure 2. 5 The connection of the Hybrid PV System

Enough energy can be produced by a stand-alone (off-grid) solar energy system to satisfy customer demands. A solitary system has no utilities attached to it. In the absence of grid electricity, solar energy systems are used to electrify remote residences and rural locations. When only a modest quantity of energy is needed to power rural homes or towns, solar standalone systems are more cost-effective than main electricity.

2.5 Major Elements of Standalone Solar Power System

To produce electricity from sunshine, solar energy systems are composed of several parts. Solar panels, a solar charge controller, a battery bank, and a DC-DC converter are the main components of a freestanding solar power system. The components of a solar energy system are selected based on the system type, application, and climatic and geographic conditions.

2.5.1 Solar Panel

A solar energy system must have solar panels or solar modules. Solar energy is captured by solar panels, which then transform it into direct current power. Additionally, the solar module strings can be linked in parallel or series, as shown in Figure 2.6. In a series connection, the solar panel provides increased voltage while maintaining the same current level. In contrast, a parallel connection allows the solar panel to provide greater current while maintaining a steady voltage.

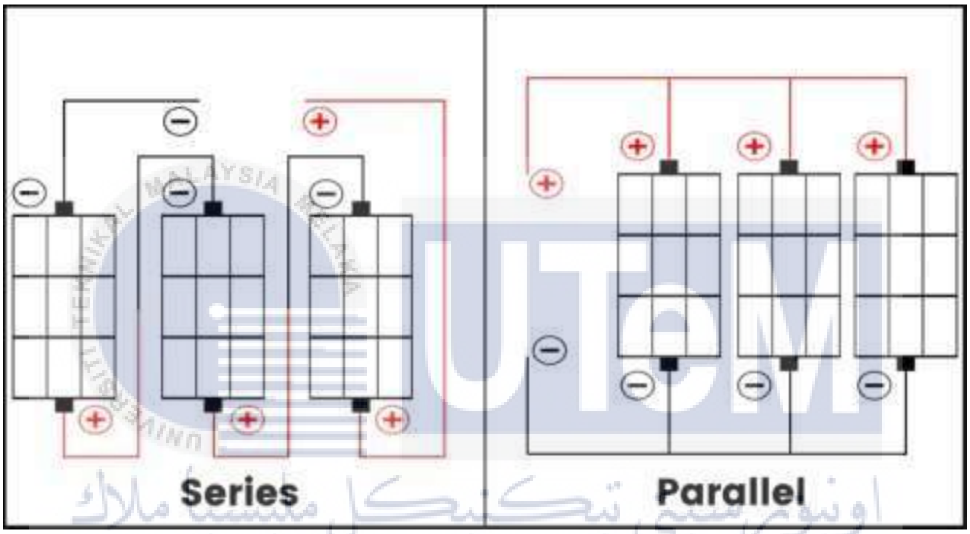

Figure 2. 6 Types of Solar Panel Connection

2.5.2 Solar Panel

The solar charge controller is the most important component of a freestanding solar power system. Performance, robustness, and reliability are all handled by the system's core. The main element of any freestanding system is a solar charge controller, often known as a solar regulator.

A battery bank is necessary for an off-grid solar power system for residential usage when the sun is not shining. The loads are powered by the battery when the sun is not shining.

A battery-powered system has to employ a charge controller. The voltage and current that go from the solar module to the battery are primarily regulated by the charge controller. Battery life is increased with solar charge controllers that accurately match the battery specifications and prevent overcharging

2.5.3 Battery Bank

A battery bank is a group of batteries that are connected to provide a larger amount of electrical energy. Battery banks are used in a variety of applications, including backup power systems, off-grid renewable energy systems, and in vehicles and boats.

The selection of batteries for a battery bank depends on the particular application and its specific requirements. Several commonly used battery types in battery banks include lead-acid batteries, lithium-ion batteries, nickel-cadmium batteries, and flow batteries. Each type of battery offers its own set of advantages and disadvantages concerning factors such as cost, energy density, efficiency, and environmental impact. Lead-acid batteries are often chosen for their affordability, while lithium-ion batteries are recognized for their high energy density and extended lifespan. Ultimately, the choice of battery type will be determined by the specific needs of the application. Table 2.2 compares the lead-acid and lithium-ion.

Table 2. 2 Comparison Between Lead-Acid and Lithium-Ion Batteries

Specification	Lead-Acid	Lithium-Ion
Specific energy (Wh/kg)	30-50	90-12
Internal resistance	Very low	Very low
Life cycle (80% Depth of Discharge)	200-300	1000-2000

Charge time	8-16 hours	1-2 hours
Overcharge tolerance	High	Low
Self-discharge/month (room temperature)	5%	<5%
Cell voltage (nominal)	2V	3.2-3.3V
Maintenance requirement	36- months	Free
Cost	Low	High
Safety requirement	Thermal stable	Protection circuit mandatory
Environmental	Not eco-friendly	Eco-friendly

According to the table, lead-acid batteries are the heaviest of the other batteries since they have the lowest range of specific energy. Additionally, it has the longest charging time and the shortest life cycle. In addition, lead-acid batteries require less maintenance, have the lowest monthly self-discharge percentage, and are thermally stable. Despite being inexpensive, lead-acid batteries are not environmentally friendly due to the toxicity of their electrolyte.

Additionally, Li-ion batteries are lighter than lead-acid batteries since they have the largest range of specific energy. Like lead-acid batteries, it has very low internal resistance as well. Additionally, Li-ion batteries have the longest lifespan due to their lowest monthly self-discharge rate. Comparatively speaking to a lead acid battery, it also has the highest nominal voltage. Although Li-ion batteries are inexpensive and need no maintenance, they are pricey and require a protective circuit. Since Li-ion batteries can explode if overheated or handled carelessly, they are no safer than conventional batteries.

2.5.4 DC to DC Converter

The DC-to-DC converter, sometimes referred to as a power optimizer, is created to maximize the ability of solar and wind turbines to capture energy. It is important to raise or lower the input panel voltage until the desired battery level is reached. The three main components of the DC-to-DC converter circuit are the inductor, the capacitor, and the MOSFET.

2.6 Microcontroller

A microcontroller is a type of integrated circuit (IC) device that governs various elements of an electronic system. It accomplishes this by utilizing memory, peripherals, and a microprocessor unit (MPU). These devices are specifically engineered for embedded applications that require both computational capabilities and efficient, precise interaction with electronic, digital, or analog components.

2.6.1 NodeMCU ESP8266

The open-source NodeMCU (Node MicroController Unit) is built upon a cost-effective System-on-a-Chip (SoC) known as the ESP8266. Designed and manufactured by Espressif Systems, the ESP8266 combines all the necessary components of a computer, such as a CPU, RAM, networking capabilities (WiFi), and even a modern operating system and software development kit (SDK). This comprehensive integration makes the ESP8266 an excellent choice for a wide range of Internet of Things (IoT) projects. Figure 2.7 shows the structure of ESP8266.

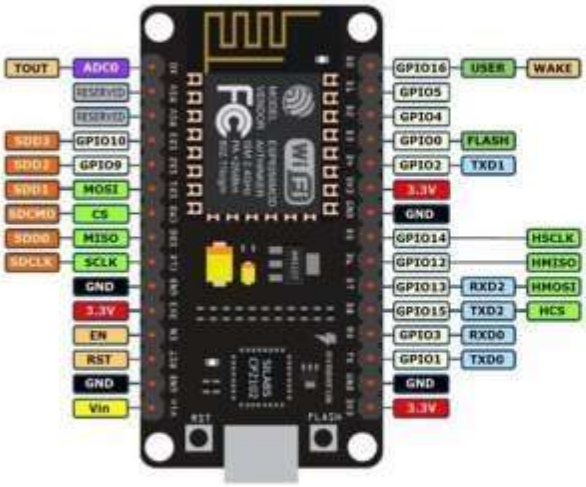

Figure 2. 7 The Structure of ESP8266

2.6.2 Raspberry Pi

The Raspberry Pi is a tiny, inexpensive computer about the size of a credit card that connects to a display or television using a regular keyboard and mouse. With the help of this capable little gadget, people of all ages may learn about computing and how to program in Python and Scratch. It is capable of all tasks that are often done on a desktop computer, including browsing the internet, watching high-definition videos, creating spreadsheets, word processing, and even playing games.

The Raspberry Pi board is made up of a CPU, a graphics chip, and random access memory (RAM). An Ethernet port, GPIO pins, an Xbee socket, a UART, and a power connection are also included. Additionally, there are several interfaces available for various external devices. We achieve mass storage by utilizing an SD flash memory card, which is what it needs. As a result, when a computer boots into Windows from its hard drive, the Rasberry Pi board will begin booting from the SD card similarly. Figure 2.8 shows the structure of Raspberry Pi.

Figure 2. 8 The Structure of Raspberry Pi

2.6.3 Arduino UNO

Modern microcontrollers come in a vast variety, and one of the most well-known and straightforward development boards is Arduino. There are many various kinds and varieties of Arduinos, and each one has a unique set of computer capabilities and interface features. The Arduino UNO's construction is seen in Figure 2.9.

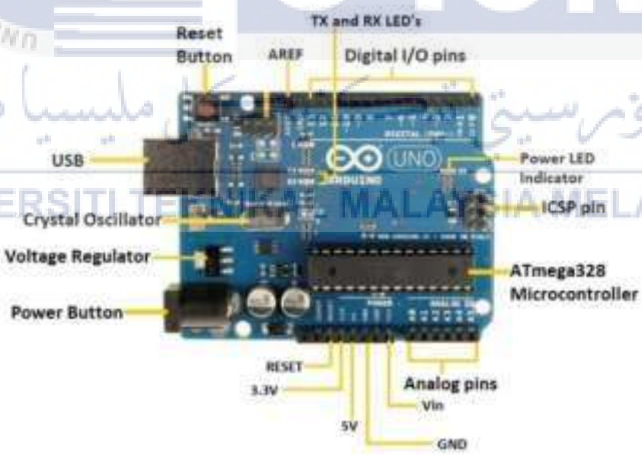

Figure 2. 9 The Structure of Arduino UNO

A microcontroller board called Arduino UNO is based on the ATmega328P. It includes 6 analog inputs, and 14 digital input/output pins, 6 of which may be utilized PWM outputs. A 16 MHz quartz crystal, a USB port, a power connector, an ICSP header, and a reset button are other features of this microcontroller. Everything required to support the microcontroller is included; all that is needed to run it is a USB connection to a computer, an AC-to-DC adapter, or a battery

2.7 Summary

This chapter discussed the previous related studies. This study is about flood monitoring warning devices. All of the suitable components have been researched to make sure the components that will be used are suitable for use in Malaysia. Types of solar panels also have been searched to identify which solar panels are most efficient to generate power. The type of charge controller also has been researched to make sure which type of solar charge controller is suitable for this project. From the previous research, the modern sealed lead acid battery would be the most commonly used battery to store electricity.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter highlights the methodology of the project. The development of the hardware and software for this project is split into two separate phases. For the project to succeed and to produce the required results, the technique is crucial. For a better understanding of the process, flowcharts and block diagrams are used in this chapter to define and illustrate the project's development process.

3.2 Methodology

This project will use a variety of techniques to accomplish the goals, including reading materials, the creation of a standalone solar PV, and a flood monitoring device. The system is created in stages, starting with the search for the project title, the identification of the problem statement, project goals, and scope, followed by a literature search, the creation of the hardware and software, and finally the gathering of data. In this part, all of the applied techniques, tools, and software utilized for this project are described. The whole project development flowchart is shown in Figure 3.1.

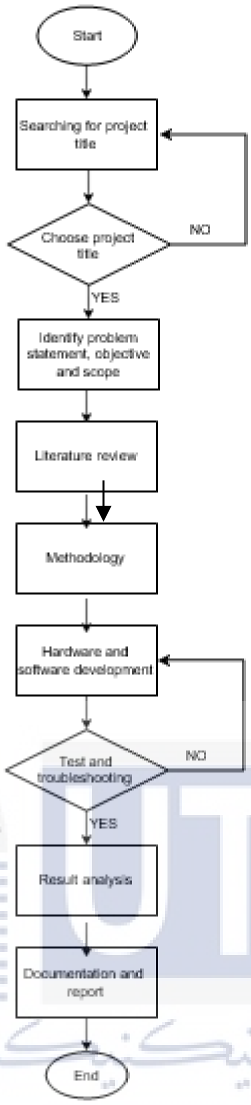

Figure 3. 13 The Flowchart of the Overall Project

3.3 Project System Flowchart

The aim of this project system flowchart as shown in Figure 3.2 is to visualize how the system operates. The first step of the operation is when the ultrasonic sensor detects the water level and the line graph will display on the website of Blynk. The use of buzzers and LEDs is to inform the people around that water is rising. While ESP8266 will send a notification to the user by sending a message to the Blynk application.

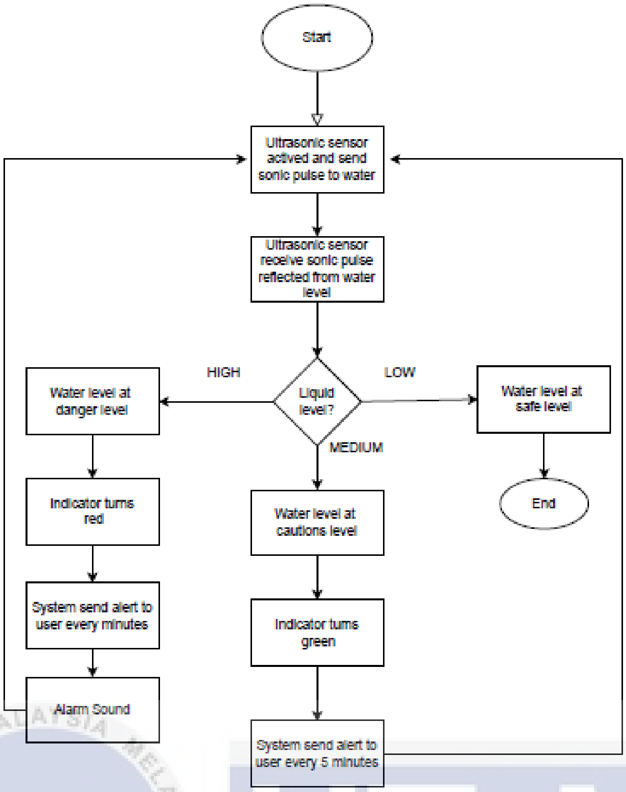

Figure 3. 14 Project System Flowchart

3.4 Block Diagram of a Standalone PV Solar

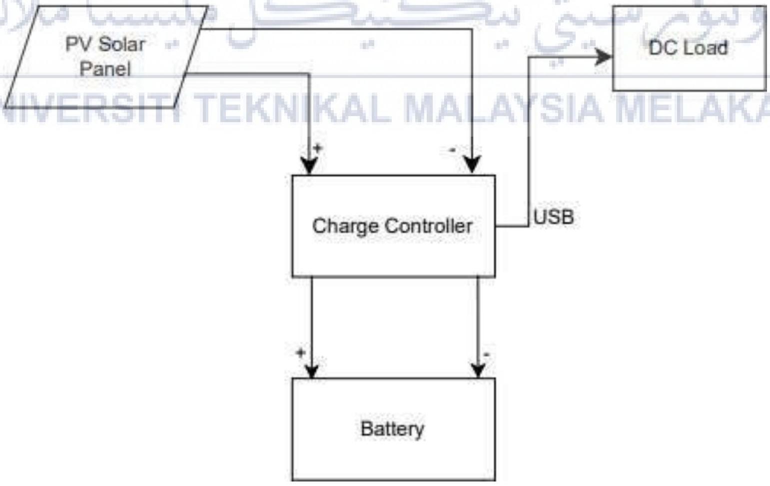

Figure 3. 15 Block Diagram of A Standalone PV Solar

Photovoltaic (PV) solar panels receive sunlight from the sun and convert it into direct current (DC) electricity, as seen in Figure 3.3. The charge controller will charge the batteries to supply electricity to the load at night or during the day.

3.5 Block Diagram of Overall System

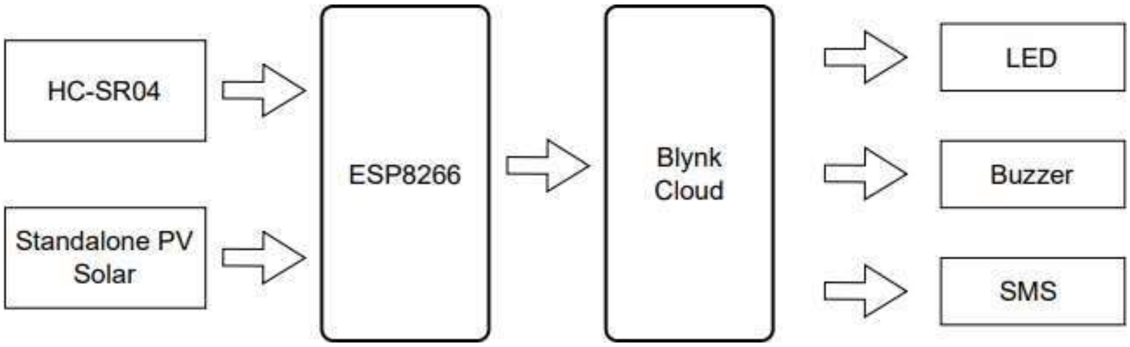

Figure 3. 16 Block Diagram of Flood Monitoring Device

As illustrated in Figure 3.4, the standalone PV solar supplies the power to the ESP8266 to operate it. When the ultrasonic sensor (HC-SR04) detects a water level, it will transmit the data to the Blynk Cloud. The Blynk will process the data and transmit the output to ESP8266 which will be on the LED, buzzer and send an SMS to the user.

3.6 Software Development

In this section, the software utilized to construct this project, such as Arduino IDE, Blynk Cloud, and Proteus 8 Professional, will be described. These applications are used for coding, circuit design, and simulation.

3.6.1 Proteus 8 Professional

Proteus 8 Professional, sometimes known as Proteus, is a program primarily used to design PCB layouts and schematic simulations. Due to its numerous microcontroller libraries, this software is also useful for developing and testing programming programs. Before attaching the circuit to the hardware in this project, Proteus is used to design and simulate it. Figure 3.5 displays the Proteus 8 Professional programme.

Figure 3. 17 Proteus 8 Professional Software

3.6.2 Arduino IDE

The open-source Arduino IDE program is used to write, compile, and upload code to the majority of Arduino modules. Software for the Arduino UNO, Arduino Mega, Arduino Leonardo, Arduino Micro, and other Arduino boards is available. A Hex File may be uploaded to the board's controller using the main code, commonly known as a sketch, produced on the IDE platform.

Additionally, the Editor and Compiler are the two key elements of the IDE environment. The relevant code is written in the Editor, and the Compiler compiles and uploads it to the Arduino Module. Both the C and C++ programming languages are supported by this software. The Arduino IDE software is seen in Figure 3.6.

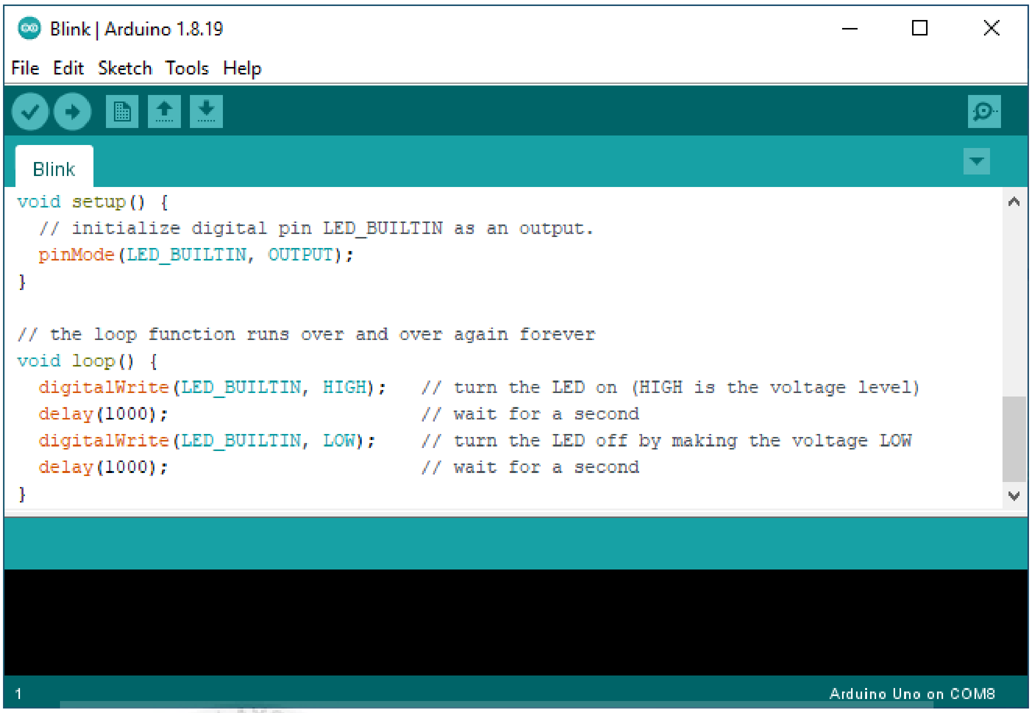

Figure 3. 18 Arduino IDE Software

3.6.3 Blynk Application

Blynk is a well-liked platform for creating mobile applications to manage Internet of Things (IoT) gadgets. It offers a user-friendly interface along with a collection of tools and frameworks that make it simpler to develop mobile apps for controlling hardware devices like the Arduino, Raspberry Pi, ESP8266, and many more. You may create unique mobile applications with Blynk that connect with your hardware devices over the internet. With the platform's drag-and-drop interface, you can build the user experience of the app and add sliders, buttons, graphs, and other UI elements to control and show data from your connected devices.

To handle the connection between your mobile app and the hardware, Blynk offers a cloud-based architecture. It makes use of an easy-to-use protocol that enables instant communication with the gadgets. The hardware may be instructed and updated with data from sensors or other sources. The Blynk software is shown in Figure 3.7.

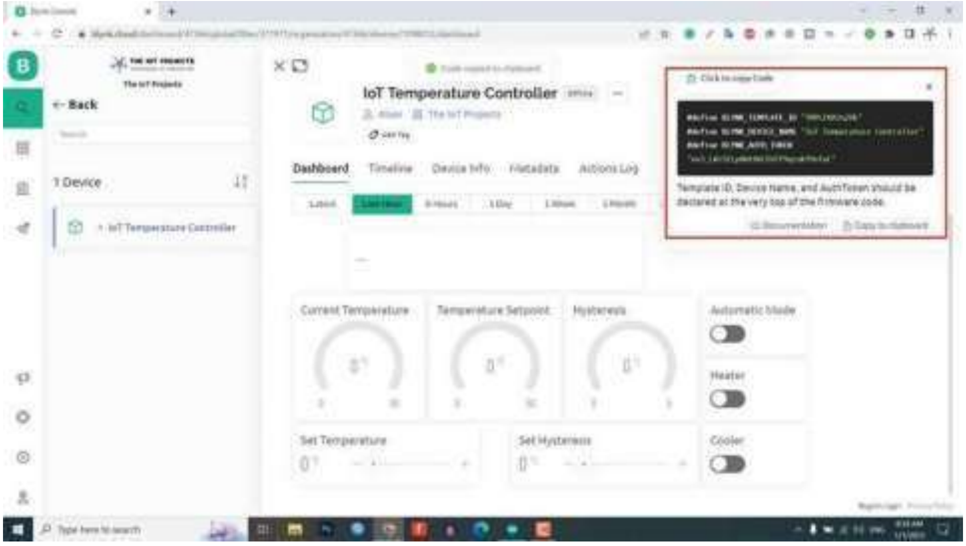

Figure 3. 19 Blynk Application

3.7 Component of Standalone PV Solar System

The solar PV system is the most crucial part of the project, as it will generate the electricity that will power the flood monitoring device. Several elements are important in developing PV solar: solar panel, charge controller, and battery bank.

3.7.1 Polycrystalline Silicon Solar Panel

Solar panels that are polycrystalline or multi-crystalline have many silicon crystals inside of each PV cell. The wafers of polycrystalline solar panels are created by fusing many silicon shards. The polycrystalline solar cells are created by cooling the molten silicon directly on the panel. These solar panels feature a surface that resembles a mosaic. They have a square shape and a vivid blue color as a result of their polycrystalline silicon composition. Polycrystalline panels limit the mobility of electrons inside the cells since eachcell contains a large number of silicon crystals. These solar panels convert sun energy into electricity by absorbing it. Figure 3.8 shows a polycrystalline silicon solar panel.

Figure 3. 20 Polycrystalline Silicon Solar Panel

3.7.2 Sealed Lead Acid Battery

Solar A sealed lead-acid (SLA) battery is a rechargeable battery that stores and discharges electrical energy using lead plates and an electrolyte solution. SLA batteries are maintenance-free and do not require the addition of water or electrolytes like conventional lead-acid batteries do. They are frequently employed in different applications, including emergency lighting and backup power systems. SLA batteries are dependable for applications that call for repeated deep discharges because they can withstand them without suffering major harm. Small batteries for portable devices are one size, while bigger batteries for backup systems are another. SLA batteries should be handled carefully since they contain dangerous substances like lead and sulfuric acid.

It's essential to adhere to safety precautions while utilizing SLA batteries. While they may normally be used safely if handled correctly, care should be taken to avoid damage or injury. Furthermore, due to the presence of hazardous materials in SLA batteries, safe disposal is crucial. To ensure their ecologically friendly disposal and to recover valuable materials, recycling programs should be undertaken. SLA batteries can offer dependable power storage options for a range of applications while abiding by safety regulations and ethical disposal techniques. Figure 3.9 shows the Sealed Lead-Acid (SLA) battery.

Figure 3. 21 Sealed Lead-Acid (SLA) Battery

3.7.3 Intelligent Charge Controller

Through the battery, the charge controller links the solar panel to the storage batteries. To prevent the battery from being overcharged, it controls the electricity coming from the solar panel. Overcharging the battery might harm it in the absence of a charge controller. The solar charge controller for the solar PV system is shown in Figure 3.10.

Figure 3. 22 Solar Charge Controller

3.8 Component of Standalone PV Solar System

This section will explain the hardware used in developing the flood monitoring device. The main components used are ESP8266, Ultrasonic Sensor (HC-SR04), buzzer, and LEDs.

3.8.1 ESP8266

The ESP8266, as illustrated in Figure 3.11, is a popular and reasonably priced system-on-a-chip (SoC) that combines an embedded Wi-Fi module with a microcontroller unit (MCU). It permits the installation of Wi-Fi connectivity to electrical equipment and was created by Espressif Systems. The ESP8266 provides enough computing capability for Internet of Things applications with its 32-bit Tensilica Xtensa LX106 MCU. It has variable quantities of flash memory for firmware and data storage and is 802.11 b/g/n Wi-Fi compatible. The chip's GPIO pins enable communication with other devices, and it can be programmed in C/C++ and MicroPython utilizing these and other programming languages and environments. It is appropriate for a variety of applications in home automation, sensor networks, and Wi-Fi-enabled devices because of its low power consumption, abundant documentation, and vibrant community. It is a flexible and dependable way to add a Wi-Fi connection at a reasonable price.

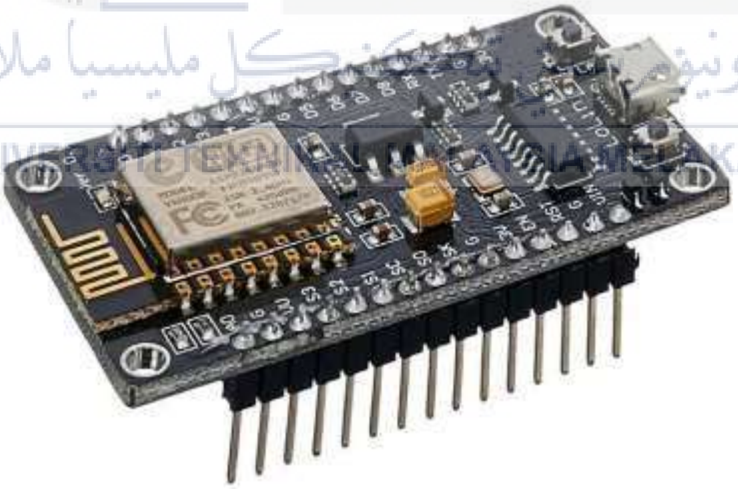

Figure 3. 23 ESP8266

3.8.2 HC-SR04

The HC-SR04 is an ultrasonic sensor module that is frequently used in robotics and automation applications to measure distance. It is made up of a pair of ultrasonic transmitter and receiver devices that cooperate to calculate the distance to an item. When an item is present, the sensor's transmitter sends out an ultrasonic wave with a high frequency that passes through the air and reflects to the receiver. The sensor determines the distance to the item by timing how long it takes for the sound wave to travel and bounce back. The working operation of the ultrasonic sensor is shown in Figure 3.11. The HC-SR04 sensor normally runs at a frequency of roughly 40 kHz and has a maximum range of around 4-5 meters. It uses the Trigger and Echo pins to regulate time and measure distance, and it needs a supply voltage of 5V. Obstacle avoidance, distance sensing, and localization in robots, as well as different automation and security systems where non-contact distance measurements are required, are common uses of the HC-SR04 sensor. Figure 3.13 shows the ultrasonic sensor (HC-SR04).

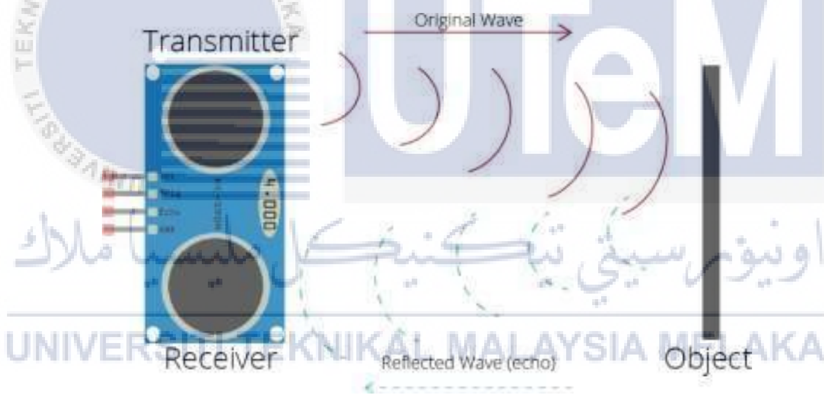

Figure 3. 24 Working Operation of Ultrasonic (HC-SR04) Sensor

Figure 3. 25 Ultrasonic (HC-SR04) Sensor Module

3.8.3 Resistor

A resistor is a two-terminal passive electrical component that resists current flow. The resistance of a resistor is its opposition to the flow of current. In this project, the resistor limits the current flow to prevent the LEDs from burning. Figure 3.14 shows a two-terminal passive resistor.

Figure 3. 26 Resistor

3.8.4 Buzzer

A buzzer is a small audio signaling device commonly used in electronics, game shows, sports, and other applications. Figure 3.15 shows a buzzer. It converts electrical signals into sound, producing a continuous or intermittent buzzing sound. In electronics, buzzers are used for alarms, timers, and notifications. In game shows, contestants press a buzzer to indicate their readiness to answer a question. In sports, buzzers mark the end of a period or time limit. In this project, buzzers are used to alert the user about floods that can happen at any time. Additionally, "buzzer" can refer to a buzzing sound associated with malfunctioning electronic equipment or faulty connections.

Figure 3. 27 Buzzer

3.8.5 Light-Emitting Diode

LED stands for Light-Emitting Diode. It is a semiconductor device that emits light when an electric current passes through it. LEDs are widely used in various applications due to their energy efficiency, durability, and versatility. Figure 3.16 shows the different colors of LEDs. LEDs are commonly found in lighting fixtures, electronic displays, indicators, automotive lighting, and many other devices. In this project, LEDs are used to represent the water level. The red, yellow, and green LEDs will indicate the respective low, medium, and high.

Figure 3. 28 Different Colours of Light-Emitting Diodes

3.9 Size of Solar Panel

Load details:

1 no's of 0.5W ultrasonic sensor use for 24 hour/day 2 no's of 0.044W LED use for 0.08 hour/day

1 no's of 1W buzzer use for 0.08 hour/day

1 no's of 70mW ESP8266 use for 24 hour/day 3 no's of 0.25W resistor for 0.08 hour/day

Total load = (1 x 0.5W x 24) + (2 x 0.044W x 0.08) + (1 x 1W x 0.08) + (1 x 70Mw x 24) + (3 x 0.25W x 0.08) = 13.827W

System specific requirement:

Energy usage (per day) = 13.827Wh

Depth of Discharge (DoD) = 50%

Days of Autonomy (DoA) = 2 day

Battery Bank Temperature Multiplier (BBTM) = 1

Peak Sun Hour (PSH) = 4 hours

Solar panel size:

The output power of solar panel

= Energy usage (per day) ÷ PSH ÷ system efficiency

= 13.827Wh ÷ 4 hours ÷ 0.85

= 4.07W

Polycrystalline silicon panel size = 12V, 5W

Therefore, 4.07W ÷ 5W = 1 solar panel

Hence, I polycrystalline silicon solar panel is needed for the system to operate.

3.10 Size of Battery Bank

Average daily:

Energy usage (per day) = 13.827W

Battery bank capacity (Wh):

= (Daily average usage x DoA x BBTM) ÷ DoD

= (13.827Wh x 2 days x 1) ÷ 0.5

= 55.308Wh

Battery bank capacity (Ah):

= Battery bank capacity (Wh) ÷ system voltage

= 55.308Wh ÷ 12V

= 4.61Ah, 12V

Sealed Lead Acid battery size = 5.0Ah, 12V

Therefore, 4.61Ah ÷ 5.0Ah = 1 battery

Hence, this project needs only 1 battery of Sealed Lead Acid.

Summary of system sizing:

i) Energy usage: 13.827W, 1 day

ii) Solar panel size: 12V, 5W x 1 solar panel

iii) Battery size: 5.0Ah, 12V

iv) Depth of Discharge: 50%

v) Days of Autonomy: 2 days

3.11 Cost and Bill of Materials

The total expected to purchase all the hardware components for this project is about RM153.12. Table 3.1 shows the cost and bill of materials used in this project.

Table 3. 1 Cost and Bill of Materials for Overall Project

No.	Material	Description	Quantity	Price (RM)
1.	12V, 5W Polycrystalline Solar Panel	1 unit = RM20.00	1	20.00
2.	12V, 5000mAh Sealed Lead Acid (SLA) battery	1 unit = RM40.00	1	40.00
3.	ESP8266	1 unit = RM28.00	1	28.00
4.	Ultrasonic Sensor (HC-SR04)	1 unit = RM3.30	1	3.30
5.	Resistor	1 unit = RM0.10	3	0.30
6.	Buzzer	1 unit = RM1.38	1	1.38
7.	Light-emitting diode (LED)	1 unit = RM0.12	2	0.24
8.	Jumper Wire Female-to-Male	1 unit = RM3.70	1	3.70
9.	Jumper Wire Male-to-Female	1 unit = RM3.70	1	3.70
10.	Breadboard	1 unit = RM2.50	1	2.50
11.	Other	1 unit = RM50.00	1	50.00
Total (RM)				**153.12**

3.12 Development Sustainable

A sustainable approach to flood monitoring and warning devices using the Internet of Things (IoT) involves various tools and procedures that contribute to long-term development. One crucial aspect is the deployment of sensor networks in flood-prone areas. These IoT sensors enable real-time monitoring of water levels, rainfall intensity, and other relevant parameters. The collected data is then processed using advanced analytics techniques, including historical pattern analysis and anomaly detection, to predict and identify flood events accurately. By integrating this information into an early warning system, alerts can be sent to authorities and at-risk communities in a timely manner. To ensure effective communication, a robust infrastructure incorporating various channels such as SMS, mobile apps, email, and sirens is established. Community engagement plays a vital role, as raising awareness about flood risks, educating residents on evacuation procedures, and promoting proactive measures enhance resilience. Collaborating with emergency services further strengthens response efforts during flood events. The scalability and flexibility of the system allow for its expansion and incorporation of new technologies and sensors. Energy efficiency is prioritized through the use of low-power sensors, renewable energy sources, and energy-efficient communication protocols, aligning with sustainability goals. Encouraging data sharing and collaboration among stakeholders fosters comprehensive flood risk models and effective mitigation strategies. By implementing these tools and procedures, a sustainable flood monitoring and warning system utilizing IoT can significantly reduce flood impacts, protect lives and infrastructure, and promote resilient communities.

3.13 Gantt Chart

Table 3.1 Shows the tasks or activities and duration to complete BDP 1 and BDP 2

No.	Task	PSM1														PSM2													
	Weeks	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1	Work on the Software/Hardware	■																											
2	Project Title Conformation and Registration		■																										
3	Briefing with Supervisor			■																									
4	Study the Project Background			■																									
5	Drafting Chapter 1: Introduction			■	■																								
6	Task progress evaluation 1						■																						
7	Drafting Chapter 2: Literature Review							■	■																				
8	Table of Summary Literature Review								■																				
9	Drafting Chapter 3: Methodology										■	■																	
10	Work on the Software/Hardware									■	■																		
11	First Draft submission to Supervisor										■																		
12	Task progress evaluation 2											■	■	■															
13	Submission Report to the Panel													■															
14	Presentation of BDP1														■														
15	Drafting Chapter 4: Analyze Data and Result												■																
16	Data Analyze and Result												■	■			■	■											
17	Record the Result																		■	■									
18	Drafting Chapter 5: Conclusion and Recommendation															■					■	■	■			■			
19	Compiling Chapter 4 and Chapter 5																							■	■	■			
20	Submit Latest Report to Supervisor																										■		
21	Finalize the Report																										■	■	
22	Presentation of BDP2																												■

3.14 Summary

The suggested process for starting a new system development project is described in this chapter. Each of the suggested improvements from the chapter must be put into practice successfully if the project's overall goal is to be met. All of the system's hardware and software components are described in detail in this chapter. A flowchart and a block diagram that detail the producers are also used to show how the processing system works. This chapter went into greater detail regarding the hardware and software used for this project as well as the reasoning behind its execution.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter highlights the troubleshooting process and results obtained based on the data of the output of this project. The analysis is focused on two parts which are the electric power produced by the standalone PV solar system and the effectiveness of the flood monitoring device. The tabulated project results will be analyzed and explained in this chapter.

The project prototype has been developed with all the chosen components and tools based on the study conducted in Chapter 2. The selection of the components used has been made based on the calculations done in Chapter 3. Besides, the chosen hardware for the standalone PV solar system and flood monitoring device has been partly assembled according to the circuit design simulated in Chapter 3. All the software and tools stated in Chapter 3 are used during the project's design, simulation, assembly, and troubleshooting process. The system coding is tested and adjusted several times to meet the desired output.

4.2 Prototype Development

There are two systems connected in this project: a standalone PV solar system and a flood monitoring device.

Firstly, the components used for the standalone PV solar systems are polycrystalline PV solar panels, 10A charge controllers, and a 12V 7000mAH Sealed Lead Acid (SLA) battery. The system has been developed by connecting the solar panel to the charge controller input port. The 10A charge controller is used to charge the Sealed Lead Acid (SLA) battery and protect the battery from overcharging or undercharging. Next, the charging port of the charger controller is attached to the battery terminal. The output port USB of the charge controllers is connected to the Esp8266 microcontroller. Figure 4.1 shows the standalone PV solar system proposed in this project.

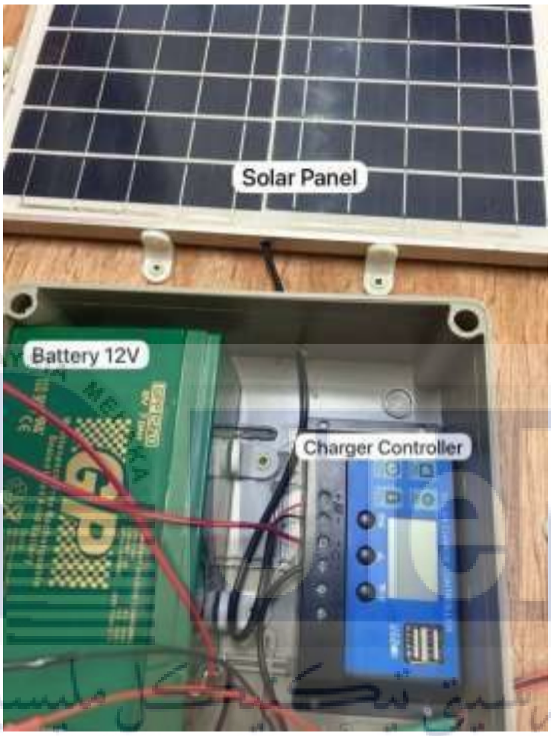

Figure 4. 1 Standalone PV Solar System

Moreover, several components are employed in the development of the flood monitoring device, featuring NodeMCU ESP8266, an ultrasonic sensor (HC-SR04), an LED, and a buzzer. Following the circuit design, the ultrasonic sensor, LED, and buzzer are connected to the pins of the ESP8266. The program, crafted using Arduino software, is uploaded into the ESP8266 microcontroller. Subsequently, the standalone PV solar panel system is integrated with the flood monitoring device by utilizing a micro-USB connection

linked to the charge controller port.

Precaution steps are taken to ensure that the connections, especially the components' terminal, are correctly connected to prevent the circuit from blowing up and harming the hardware. Figure 4.2 shows the completed project prototype.

Figure 4. 2 The completed project prototype

4.3 Project Testing Result

To evaluate the system's functionality and gather more precise data, tests were run for five days in a row, starting on November 25, 2023, and ending on November 30, 2023. Furthermore, the procedure of gathering data is also conducted every two hours for a total of twelve hours a day, from 8 a.m. to 6 p.m. This process has been carried out to guarantee that the solar panel can get the most sunlight possible and operate as intended. To confirm the battery bank's efficiency based on the calculation, a load has also been connected to the output side.

The electrical power formula is used to calculate the power generated by the solar panel during data gathering. Equation 4.1 illustrates the relationship between the power, voltage, and current of a solar panel. Meanwhile, Equation 4.2 has been used to get data regarding battery charging times.

$$P = VI \quad \text{(Eq 1)}$$

Where P = Solar panel power(W)

V = Solar panel voltage (V)

I = Solar panel current (mA)

$$T = CR \quad \text{(Eq 2)}$$

Where T = Battery bank charging time (Hours)

C = Battery bank capacity (mAH)

R = Charging current (mA)

4.3.1 PV Solar System Data Day 1

Table 4.1 shows the data obtained from the standalone PV solar system on 25/11/2023. The weather recorded on that day was hot in the morning and rainy in the afternoon.

Table 4. 1 The result of data collection for day 1

Time	Solar Panel Voltage (V)	Solar Panel Current (A)	Solar Panel Power (W)	Battery Bank Voltage (V)	Charging Time (Hours)
8 am	6.23	0.134	0.835	12	52.24
10 am	7.02	0.145	1.018	12	48.26
12 pm	7.16	0.150	1.074	12	46.67
2 pm	6.78	0.140	0.950	12	50.00
4 pm	6.14	0.120	0.737	12	58.33
6 pm	5.30	0.090	0.477	12	77.78

Based on Table 4.1, the solar panel generated the lowest power at 6 pm with a valueof 0.477W as the sun was getting set. In comparison, the power generated by the solar panelat 12 pm is the highest recorded, with a value of 1.074W. The power dropped a noon as theweather started to rain and cloudy in the evening.

4.3.2 PV Solar System Data Day 2

Table 4.2 shows the data obtained from the standalone PV solar system on 26/11/2023. The weather recorded on that day was hot in the morning and cloudy in the afternoon.

Table 4. 2 The result of data collection for day 2

Time	Solar Panel Voltage (V)	Solar Panel Current (A)	Solar Panel Power (W)	Battery Bank Voltage (V)	Charging Time (Hours)
8 am	6.00	0.110	0.660	12	63.63
10 am	6.91	0.150	1.037	12	46.67
12 pm	7.00	0.160	1.120	12	43.75
2 pm	7.27	0.165	1.200	12	42.42
4 pm	6.13	0.02	0.123	12	350
6 pm	6.80	0.05	0.340	12	140

Based on Table 4.2, the solar panel generated the lowest power at 6 pm with a valueof 0.123W as the sun was getting set. In comparison, the power generated by the solar panelat 2 pm is the highest recorded, with a value of 1.2W. The power dropped a noon as the weather started to rain and cloudy in the evening.

4.3.3 PV Solar System Data Day 3

Table 4.3 shows the data obtained from the standalone PV solar system on 27/11/2023. The weather recorded on that day was hot in the morning and rainy in the afternoon.

Table 4. 3 The result of data collection for day 3

Time	Solar Panel Voltage (V)	Solar Panel Current (A)	Solar Panel Power (W)	Battery Bank Voltage (V)	Charging Time (Hours)
8 am	6.23	0.134	0.835	12	52.24
10 am	6.3	0.101	0.636	12	69.31
12 pm	7.30	0.125	0.913	12	56.00
2 pm	6.6	0.113	0.746	12	61.95
4 pm	6.45	0.103	0.664	12	67.96
6 pm	5.30	0.080	0.424	12	87.5

Based on Table 4.3, the solar panel generated the lowest power at 6 pm with a value of 0.424W as the sun was getting set. In comparison, the power generated by the solar panel at 12 pm is the highest recorded, with a value of 0.913W. The power dropped a noon as the weather started to rain and cloudy in the evening.

4.3.4 PV Solar System Data Day 4

Table 4.4 shows the data obtained from the standalone PV solar system on 28/11/2023. The weather recorded on that day was hot in the morning and rainy in the afternoon.

Table 4. 4 The result of data collection for day 4

Time	Solar Panel Voltage (V)	Solar Panel Current (A)	Solar Panel Power (W)	Battery Bank Voltage (V)	Charging Time (Hours)
8 am	5.31	0.019	0.101	12	368.42
10 am	6.42	0.106	0.681	12	66.03
12 pm	6.77	0.116	0.785	12	60.34
2 pm	7.16	0.130	0.931	12	53.85
4 pm	5.91	0.073	0.431	12	95.89
6 pm	5.20	0.047	0.244	12	148.94

Based on Table 4.4, the solar panel generated the lowest power at 6 pm with a valueof 0.244W as the sun was getting set. In comparison, the power generated by the solar panelat 2 pm is the highest recorded, with a value of 0.931W. The power dropped a noon as the weather started to cloudy in the evening.

4.3.5 PV Solar System Data on Day 5

Table 4.5 shows the data obtained from the standalone PV solar system on 29/11/2023. The weather recorded on that day was hot in the morning and cloudy in the afternoon.

Table 4. 5 The result of data collection for day 5

Time	Solar Panel Voltage (V)	Solar Panel Current (A)	Solar Panel Power (W)	Battery Bank Voltage (V)	Charging Time (Hours)
8 am	5.20	0.045	0.234	12	155.56
10 am	7.01	0.142	0.995	12	49.23
12 pm	7.3	0.163	1.190	12	42.94
2 pm	6.64	0.124	0.823	12	56.45
4 pm	6.13	0.125	0.770	12	56.00
6 pm	5.31	0.094	0.450	12	74.470

Based on Table 4.5, the solar panel generated the lowest power at 8 am with a valueof 0.234W as the sun was getting set. In comparison, the power generated by the solar panelat 12 pm is the highest recorded, with a value of 1.190W. The power dropped a noon as theweather started to cloudy in the evening.

4.4 Standalone PV Solar System Average Data Analysis

The result obtained from day 1 to day 5 has been analyzed and calculated to get the average data value. The average output of solar panel voltage, current, power, battery voltage, and charging time data for the 5 days are shown in Table 4.6 below.

Table 4. 6 The average output of data collection for 5 days

Day	Average				
	Solar Panel Voltage (V)	Solar Panel Current (A)	Solar Panel Power (W)	Battery Bank Voltage (V)	Charging Time (Hours)
1	6.44	0.130	0.849	12	53.85
2	6.69	0.109	0.747	12	64.22
3	6.36	0.109	0.703	12	64.22
4	6.13	0.082	0.529	12	85.37
5	6.27	0.116	0.743	12	60.34

Based on Table 4.6, the average solar panel generated the lowest power on the fourth day with a value of 0.529W. In comparison, the average power generated by the solar panel on the first day is the highest recorded, with a value of 0.849W.

Figure 4.3 illustrates the graph of the relationship between the average solar panel power and average solar panel current. According to the graph in Figure 4.5, average solar panel power decreases as the average solar panel current decreases, as well as the average solar panel power increases as the average solar panel current increases.

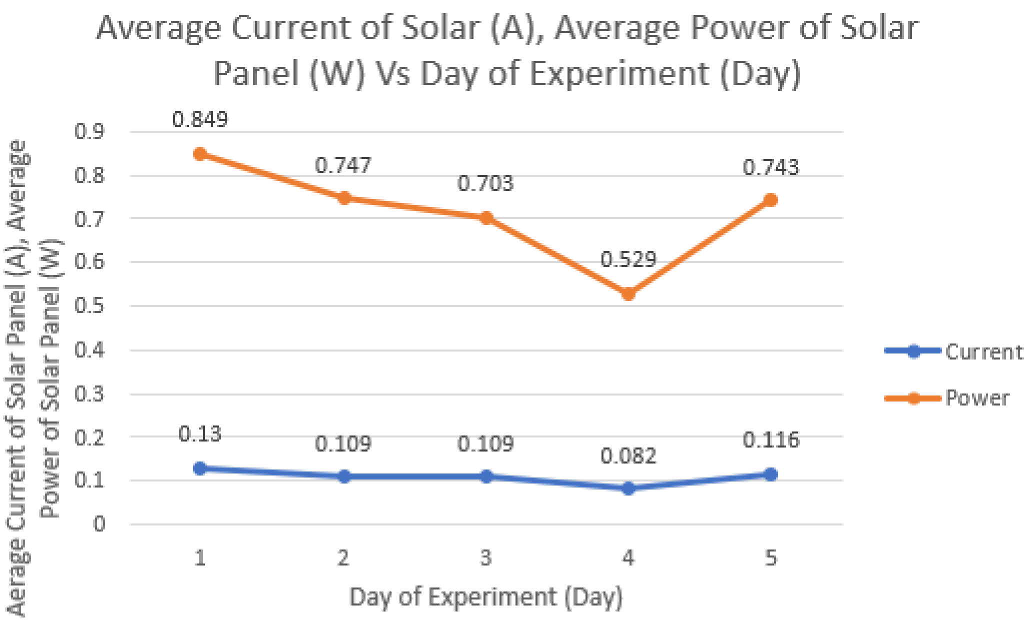

Figure 4. 3 Graph of the relationship between average solar panel currentand average solar panel power

During the prototype testing at the end of the year, which is during the rainy season in Malaysia, the amount of sunlight for the solar panel was not ideal. The 5-day average intensity of solar radiation was low because the weather was mostly gloomy and rainy. This caused a significant difference in the daily data collected.

Additionally, the recommended size of the solar panel for this project was another factor contributing to its low output current. The calculations for the solar panel size assumed a peak sun hour of 4 hours on a bright sunny day. However, during the actual testing week, the weather was consistently cloudy, affecting the solar panel's output. On a sunny day, the proposed 10W, 12V PV solar panel could produce a maximum current output of 550mA. Unfortunately, due to the overcast weather during testing, the panel could not reach its maximum output, resulting in a small current. This mismatch with the panel specifications led to a diminished ability to convert sunlight into electricity. The highest average output power observed during the experiments was only 1190mW, with an average output current of 109.2mA.

Moving on to the charge controller, a crucial component for charging Sealed Lead Acid (SLA) batteries, it regulates the charging current to protect the battery from overcharging and over-discharging. However, based on the experimental data in Table 4.6, the battery bank took more than 24 hours to fully charge. The low output current from the solar panel caused the charge controller module to function incorrectly.

In Figure 4.4, which illustrates the relationship between the average solar panel current and battery bank charging time, it is evident that the average charging time decreases as the average solar panel output current increases. This suggests that a higher output current from the solar panel results in a quicker full charge for the battery bank.

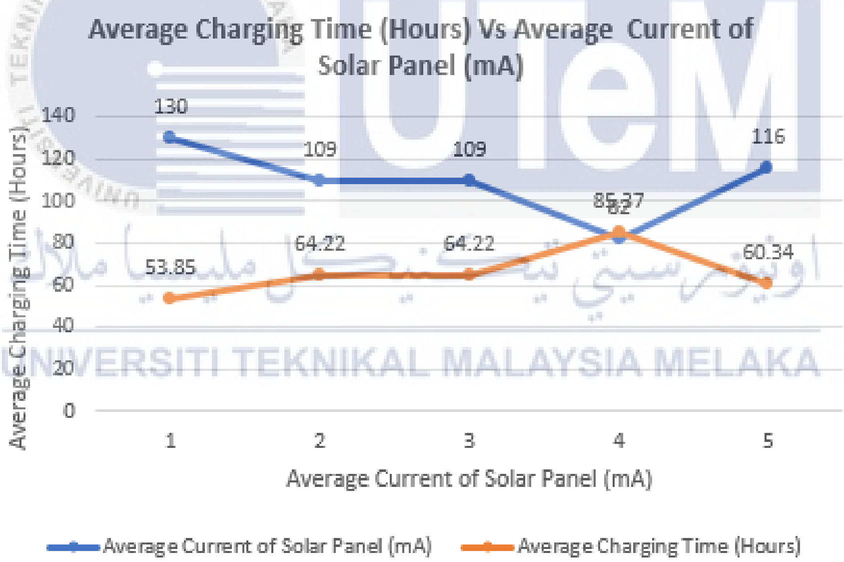

Figure 4. 4 Graph of the relationship between the average battery bank chargingtime and average solar panel current

4.5 Battery Bank Performance

According to the data collected from the 5 continuous days with 6 hours each day, the data for power generated by solar panels and the charging time for the battery is recorded. With the solar panel receiving sunlight for the 6 hours of daytime for 5 continuous days, the average power generated is 0.7142W while the average charging time for the battery bank is 65.6 hours. The system will be activated for about 24 hours every day, the battery bank will be charged with load during the daytime. With the battery bank is fully charged during the daytime, the system will be running fully depending on the battery bank at night.

The battery endurance of the battery bank is the maximum time for the load to be supplied by the battery bank only. The battery endurance can be estimated with the formula below.

$$Battery\ Endurance = Vdc \times Ah / Load\ AC \qquad (4.1)$$

Therefore, by entering the parameters of the battery bank used for this project, we can determine the battery endurance.

$$Battery\ Endurance = 12Vdc \times 7Ah / 1W \qquad (4.2)$$

$$Battery\ Endurance = 84\ Hours$$

The calculation shows that the system can run fully depending on the battery bank without any charging for a maximum of 84 hours. However, the performance of any battery bank is only approximately 90% of its stated parameter, hence the real operating hours should be

$$\text{Battery}\ Endurance = 12Vdc \times 7Ah / 1W \times 90\% \qquad (4.3)$$

$$Battery\ Endurance = 75.6\ Hours$$

4.6 Flood Monitoring Device Performance Analysis

The Flood Monitoring Device is an advanced flood management system harnessing solar power as its primary energy source. Comprising four essential components the Node MCU ESP8266 microcontroller, ultrasonic sensors, buzzer, and LED. The system is designed for efficient and intelligent flood detection.

The Node MCU ESP8266 and ultrasonic sensor collectively consume 1W of power per hour. The ultrasonic sensor, strategically positioned at an elevated location, interfaces with the ESP8266 to detect rising water levels. The system operates under two distinct conditions to signify different water level states, promoting accurate monitoring without unnecessary alarms.

Upon initialization, the system ensures that all LEDs remain off, indicating a normal or safe water level. This precautionary measure prevents false alarms and unnecessary warnings. As the water level reaches 20cm, the yellow LED activates, accompanied by a notification sent to the user via the Blynk application, as depicted in Figures 4.5 and 4.6. This provides a clear visual representation of the increasing water level.

Figure 4. 5 Shows that yellow LED light on

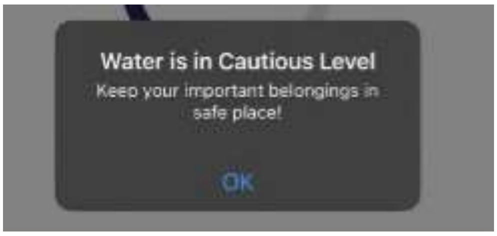

Figure 4. 6 The notification from the Blynk Application is sent

If the water level rises to a critical 10cm, the red LED illuminates, the buzzer sounds, and an alert is sent to the user through the Blynk application, as illustrated in Figures 4.7 and 4.8. This immediate and multi-sensory feedback ensures timely awareness and enables users to take prompt action to mitigate potential risks.

Figure 4. 7 The red LED light is automatically switched on

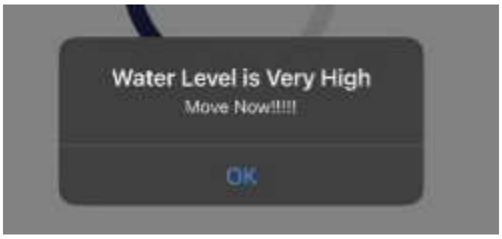

Figure 4. 8 The notification from the Blynk Application is sent

The code implementation of these thresholds guarantees an intuitive and responsive system, allowing users to quickly discern the current water level conditions. With a safe water level set at 30cm and a danger level at 10cm, this configuration prioritizes the safety and optimal functionality of the monitored environment. Users benefit from clear visual indicators, facilitating informed decision-making based on real-time water level information.

4.7 Summary

This chapter provides a summary of the experimental data collection and analysis conducted in this project to assess the performance of the proposed standalone PV solar system. The system is designed to be tested on a sunny day for optimal power output and faster battery charging. However, the results indicate that the system sizing is not suitable for testing on overcast days, and during the rainy season, insufficient sunlight is available to fully charge the battery bank, leading to concerns about its ability to support the load in the absence of sunlight. The primary goal of the project is to evaluate the suitability of the solar panel, charge controller, battery, and sensor for a flood monitoring device. In conclusion, the proposed PV solar system appears to be under-designed, lacking the necessary specifications to power the flood monitoring device as intended. Despite these challenges, the project has achieved success by effectively utilizing ultrasonic sensors as water detectors.

CHAPTER 5

CONCLUSION

5.1 Conclusion

This chapter summarizes the development of an advanced flood monitoring warning device, utilizing a self-sufficient solar-powered Photovoltaic (PV) system. The project aims to assess the viability of standalone PV solar elements in independently powering the flood monitoring warning device. The system comprises two integral components: the PV solar system, which converts solar energy into electricity to power the flood monitoring device and charge the battery bank during sunlight, and the flood monitoring device, equipped with water level sensors for early flood detection. This intelligent system ensures continuous functionality by seamlessly transitioning to stored battery power when sunlight is unavailable. Ultimately, this project represents a significant stride in enhancing user safety through sustainable and autonomous flood monitoring, providing timely warnings in hazardous conditions, and contributing to community resilience.

5.2 Project Objectives

Three main objectives of this project are briefly revisited and discussed as follows:

5.2.1 To analyze the existing flood warning device

In the second chapter, an examination of several pre-existing systems was conducted through a comprehensive analysis of relevant articles, journals, and works by other researchers. This study focused on reviewing the methodologies and functionalities employed in various project systems, with a specific emphasis on understanding their designs and operations. The literature review facilitated a comparison of different elements, aiming to identify the most fitting components for the development of the flood monitoring device powered by the standalone PV solar system.

5.2.2 To design and assemble a circuit that contains the microcontroller, warningdevice, and water level sensor

The successful accomplishment of the second objective involved the development of a standalone PV solar generator and a flood monitoring device. Both systems were meticulously constructed to guarantee their optimal performance. The selection of components for the PV solar generator and flood monitoring device was based on a comprehensive comparison of specifications outlined in Chapter 2. In Chapter 3, the determination of the solar panel, charge controller, and battery sizes was conducted, considering the system's power usage. The strategic design of the project played a pivotal role in ensuring the prototype's smooth development. The standalone PV solar system and intelligent flood monitoring system were effectively created following the proposed design.

5.2.3 To evaluate the performance of the developed flood warning device

To create a standalone system for this project, the hardware selections made for the system must work together. To determine which equipment is best suited for the project, a comparative analysis of many components was carried out in Chapter 2. Through research and computation, the ideal dimensions for solar panels, batteries, and charge controllers have been established. For the system to function when the sun is not shining, the solar panel needs to provide enough energy to match the requirements of the flood monitoring device, and the battery bank needs to have enough energy storage capacity. To charge a battery bank without overcharging or over-discharging, a suitable solar charge controller is required.

Moreover, a suitable sensor for detecting the water level has also been selected for this system. Chapter 4 elaborates on the analysis of the experimental data collected to evaluate the suitability of the components chosen to develop the standalone PV solar system and smart flood monitoring system. The sizing of the standalone PV solar system has been concluded to be under-designed as the sizing of the solar panel, charge controller, and battery bank proposed is insufficient to produce the desired output.

5.3 Project Limitation

While developing the prototype of the project and gathering testing data, various limitations and challenges were encountered, impacting the experimental output data. Given that the project testing coincided with the conclusion of the year during the rainy season in Malaysia, the solar radiation's average intensity was relatively low, and the peak sun hours were shorter. The proposed sizing of the PV solar system was initially intended for implementation on a sunny day, as per the sizing calculation specifying a peak sun hour of 4 hours. Consequently, deploying the proposed PV solar system on an overcast day is not viable, as the solar panel's efficiency in converting solar energy to electricity diminishes. Additionally, opting for sealed lead-acid batteries as battery banks has added complexity to the charging system, necessitating multiple charge controller modules to expedite the battery bank charging process.

5.4 Recommendations

The purpose of this project is to investigate the compatibility of the parts utilized in the construction of the flood monitoring gadget and standalone PV solar system. To guarantee that the flood monitoring device can be adequately powered by the standalone PV solar system on both sunny and cloudy days, the most crucial factor is the size of the solar panel, charge controller, and battery bank.

A few components have been examined, such as the battery bank durability, charge controller, and solar panel performance. Thus, this project can be improved in a few ways. The following are the suggestions made:

1. Use an intelligent charge controller to make the charging circuit simpler and charge the battery faster.
2. Increase the PV solar panel's size to convert more solar energy into electricity even on cloudy days.
3. Implementing a solar panel tracker enhances energy output by dynamically aligning the panels with the sun's movement for optimized sunlight exposure and improved electrical conversion.

5.5 Project Potential

Every invention must have its commercialization potential, a transformative process turning it into a viable product or service, elevating the project to a stage where companies or factories would find interest in the resulting product or system. In this project, two systems show substantial commercial potential: standalone PV solar systems and flood monitoring devices.

An effective flood monitoring device can provide early warning signs to allow people to evacuate and take preventive measures. This can significantly reduce the impact of floods on both human lives and property.

Using a standalone PV solar system will give some value added by making the device more sustainable and resilient. It will reduce the dependency to use conventional power sources and can operate in areas with limited access to electricity. A solar-powered flood monitoring device will attract people and organizations who are environmentally conscious.

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APPENDICES

APPENDIX A

Coding for this Project

```
#define BLYNK_TEMPLATE_ID "TMPLXcsS84l1"
#define BLYNK_DEVICE_NAME ""
#define BLYNK_AUTH_TOKEN "vXyuKuzC8ReUDyy6DiIcq6yXhQwzqH_8"
#define TRIG D1
#define ECHO D2
#define buzzer D3
#define ledred D4
#define ledyellow D5
#define ledgreen D6

// Comment this out to disable prints and save space
#define BLYNK_PRINT Serial

#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
WidgetLCD lcd(V1);
char auth[] = BLYNK_AUTH_TOKEN;

// Your WiFi credentials.
// Set password to "" for open networks.
char ssid[] = "Redmi Note 11";
char pass[] = "naksekarangke";
BlynkTimer timer;
// This function sends Arduino's up time every second to Virtual Pin (5).
// In the app, Widget's reading frequency should be set to PUSH. This means
// that you define how often to send data to Blynk App.
```

```
void myTimerEvent()
{
// You can send any value at any time.
// Please don't send more that 10 values per second.
Blynk.virtualWrite(V5, millis() / 1000);
}

void setup()
{
pinMode(TRIG,OUTPUT);
pinMode(ECHO,INPUT);
pinMode(buzzer,OUTPUT);
 pinMode(ledred, OUTPUT);
pinMode(ledyellow, OUTPUT);
pinMode(ledgreen, OUTPUT);
// Debug console
Serial.begin(115200);
lcd.clear(); //Use it to clear the LCD Widget
lcd.print(0,0,"Distance in cm");
Blynk.begin(auth, ssid, pass);
// You can also specify server:
//Blynk.begin(auth, ssid, pass, "blynk.cloud", 80);
//Blynk.begin(auth, ssid, pass, IPAddress(192,168,1,100), 8080);

// Setup a function to be called every second
timer.setInterval(1000L, myTimerEvent);
}

void loop()
{
lcd.clear();
lcd.print(0, 0, "Distance in cm"); // use: (position X: 0-15, position Y: 0-1, "Message you want to print")
```

```
long duration, distance;

digitalWrite(TRIG,LOW);
delayMicroseconds(3);
digitalWrite(TRIG,HIGH);
delayMicroseconds(12);
digitalWrite(TRIG,LOW);
duration = pulseIn(ECHO,HIGH);
distance = (duration/2) / 29.1;
Serial.print(distance);
Serial.println("Cm");
lcd.print(7,1,distance);
Blynk.virtualWrite(V10,distance);
Blynk.virtualWrite(V11,distance);
delay(100);

if (distance <= 10){
digitalWrite(buzzer, HIGH);
digitalWrite(ledred, HIGH);
digitalWrite(ledyellow, LOW);
digitalWrite(ledgreen, LOW);
delay(100);


}
else if(distance <= 20){
  digitalWrite(buzzer, LOW);
  digitalWrite(ledred, LOW);
  digitalWrite(ledyellow, HIGH);
  digitalWrite(ledgreen, LOW);
  delay(100);
```

```
}
else if(distance <= 30){
digitalWrite(buzzer, LOW);
digitalWrite(ledred, LOW);
digitalWrite(ledyellow, LOW);
digitalWrite(ledgreen, HIGH);
delay(100);

}
else {
digitalWrite(buzzer, LOW);
digitalWrite(ledred, LOW);
digitalWrite(ledyellow, LOW);
digitalWrite(ledgreen, LOW);
delay(100);
}
Blynk.run();
timer.run(); // Initiates BlynkTimer


}
```