Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF WATER USAGE MONITORING SYSTEM USING ARDUINO PLATFORM

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Bachelor of Electronics Engineering Technology with Honours

2021

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A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electronics Engineering Technology with Honours

Faculty of Electrical and Electronic Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this project report entitled "Development of Water Usage Monitoring System Using Arduino Platform" 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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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 : 11/01/2022

DEDICATION

In the name of Allah, the most beneficent and merciful who gave me strength and knowledge to complete this final year project. I would like to express my gratitude to the supervisor, Ts. Eliyana Binti Ruslan and Ts. Mohd Faizal Bin Zulkifli who gave me this opportunity to fulfil this amazing report on my final year project. Not to forget both of my parents, family and all friends for every single little thing that had helped me in every kind of ways.

Thanks all. I really appreciate.

ABSTRACT

Water is one of the most priceless natural resources. Humans need water to carry out their daily lives because it is an essential resource in generating various fields such as domestic, agriculture, industry, fisheries, and electricity generation. The main factor of unnecessary water consumption is a lack of awareness daily water usage. To control this issue before it worst, a water monitoring system that enabled users to monitor their water usage and recorded on a web database has been developed. This system consists of two parts. The first part is a monitoring parts consisting of Arduino Nano, water flow sensor, OLED display, GSM module, and Bluetooth module. The water flow sensor will measure the water rate pass through and send the data to Arduino Nano. Users can monitor their water consumption in three different types of output. Firstly, users can monitor directly by observed the OLED display on the system. Next, user can also monitor wirelessly by using SMS and Bluetooth with a special mobile application. In the second part, all the data obtained can be uploaded to the web database for future references and observation. After several testing was done, it can be concluded that the system has successfully fulfilled its functionality as proposed in this project.

ABSTRAK

Air merupakan satu khazanah alam yang tidak ternilai harganya. Kita perlukan air untuk menjalani kehidupan seharian kerana ia sumber yang penting dalam menjana pelbagai bidang ekonomi seperti pertanian, perindustrian, perikanan dan penjanaan sumber tenaga elektrik. Faktor utama yang menyumbang kepada berlakunya penggunaan air secara berlebihan adalah disebabkan kurangnya kesedaraan mengenai penggunaan air dalam aktiviti seharian. Bagi membendung masalah ini daripada terus menjadi parah, sistem pemantauan penggunaan air yang membolehkan pengguna untuk memantau penggunaan air dan direkod didalam pengakalan data secara atas talian telah dibangunkan. Sistem ini mempunyai dua bahagian. Bahagian pertama adalah bahagian pemantauan yang mempuyai Arduio Nano, sensor aliran air, paparan OLED, modul GSM dan modul Bluetooth. Sensor aliran air akan mengukur kadar air yang melaluinya kemudian data tersebut dihantar ke Arduino Nano. Pengguna dapat memantau penggunaan air mereka melalui tiga pilihan keluaran yang berbeza. Pertama, pengguna dapat memantau secara terus dengan memerhati paparan OLED pada sistem. Kemudian, pengguna juga dapat memantau secara tanpa wayar dengan menggunakan SMS dan Bluetooth bersama aplikasi mudah alih khusus. Pada bahagian kedua, semua data yang diperolehi boleh dimuat naik ke dalam pangakalan data web bagi tujuan rujukan dan pemerhatian dimasa akan datang. Selepas beberapa ujian dijalankan, dapat disimpulkan bahawa sistem ini telah mencapai kebolehannya seperti yang dicadangkan didalam projek ini.

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A	-	Voltage angle
GHz	-	Gigahertz
KB	-	Kilobyte
Mbps	-	Megabits per second
MHz	-	Megahertz
mm	-	Millimeter
Q	-	Flow rate/total flow of water through the pipe
V	-	Average velocity of the flow

LIST OF ABBREVIATIONS

AT	-	Attention
EEPROM	-	Electrical Erasable Programmable Read-Only Memory
FAO	-	Food And Agriculture Organization
GFSK	-	Gaussian Frequency Shift Keying
GPRS	-	General Packet Radio Service
GSM	-	Global System For Mobile
GUI	-	Graphical User Interface
HMI	-	Human Machine Interface
I/O	-	Input / Output
IDE	-	Integrated Development Environment
IEEE	-	Institute of Electrical And Electronics Engineers
IoT	-	Internet of Things
LCD	-	Liquid Crystal Display
MCU	-	Microcontroller Unit
MIT	-	Massachusetts Institute of Technology
OLED	-	Organic Light-Emitting Diode
OS	-	Operating System
PC	-	Personal Computer
PIC	-	Peripheral Interface Controller
PLC	-	Photovoltaics
PWM	-	Pulse-Width Modulation
RF	-	Radio Frequency
SCADA	-	Supervisory Control And Data Acquisition
SRAM	-	Static Random Access Memory
USB	-	Universal Serial Bus
WI-FI	-	Wireless Fidelity

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CHAPTER 1

INTRODUCTION

1.1 Background

Water is very important and has been defined as one of the most precious natural resources. Water also played an important role in the growth of communities in a certain location. There are ten countries with a higher percent of lack basic water services in this world, and most of them are from Africa. In the first place, we have Eritrea with 80.7% lack of basic water services, followed by Papua New Guinea with 63.4% lack basic water services. Most of the population in that country lived in rural areas that make it more challenging for them to access for clean water services. In 2015, World Economic Forum announced that the water crisis ranks the eighth global risk with the highest likelihood of occurring within ten years.[1] So, any unnecessary water usage should be identified and eliminate if possible by these facts.

This project is about the development of Water Usage Monitoring System using the Arduino platform. Hence, this project is also based on the Internet of Things (IoT),GSM, Bluetooth, and can be powered by DC supply also solar energy. In this new era of technology, IoT is very common and widely used nowadays. IoT is more like physical things connected to the Internet to communicate and share data conveniently.

The water flow sensor paired with wireless communication is used to transfer the data from the device to the user. This connection is made through GSM and Bluetooth in the form of Electromagnetic (EM) Waves. Meanwhile, the data that were obtained can be upload to the database online. These features enable users to monitor the data of water usage and can be kept as future references.

All the components will be powered by DC supply or solar energy, which is the cleanest and renewable reliable energy produced to provide electricity. For this project, the user will have positive impact and can help them to monitor their water usage habits.

1.2 Problem Statement

Water is the necessity for daily life. Like electricity, clean water also plays a crucial part in carrying out daily activities such as domestic or agriculture used. Every day, the demand for clean water is increasing, especially in urban areas, coupled with the rapid development. Not only that, the source of treatable raw water is declining due to the polluted river conditions, complicating the water treatment process to be carried out. This situation becomes worst when there are still consumers who lack awareness of their water usage consumption.

The most common water usage problem in the domestic sector is that consumers were not alert with their water consumption in carrying out daily activities such as washing clothes, cooking, vehicle washing, watering plants, etc. All these activities will cause unnecessary water consumption without proper water monitoring. Meanwhile, in the tourism and agriculture industry, the main factor driving this issue is slightly different. For example, tenants usually forgot to turn off the water taps for the tourism industry when leaving the house. For the agriculture industry, plants are constantly watering without their notice. This unnecessary water consumption can be control if everyone alerts with their water used daily.

Thus, this project will overcome this problem by developing a device that can monitor water usage constantly. Moreover, this device also allows sending the data from the device to their mobile device wirelessly.

1.3 Project Objective

The objective of this thesis in completing this project will be the guidance for developing the project:

a) To study characteristics and functionality of water usage monitoring system
b) To design and develop of water usage monitoring system that can connect wirelessly to our device
c) To analyze in term of functionality
d) To monitor the flow of water through the mobile application

1.4 Scope of Project

IoT or the Internet of Things is the internet networking that connects any smart or physical devices to the cloud or was called as Internet. The smart devices can access the data from anywhere as long there is an Internet connection. Besides that, controller connected to water flow sensor to measure the flow, and the data were transmitted using GSM or Bluetooth.

For this project, Arduino Nano was used as a controller to manage the operation of the whole system. The sensor that used is the water flow sensor YF-S201. This sensor will measure the water that flows through it and will be paired to OLED SSD 1306 display to allow the user to read directly from the device. Then, this project also equips with GSM SIM800L and Bluetooth v2.0+EDR module to retrieve the data and upload it to the database. The solar energy also can be used to powered up the whole system.

1.5 Thesis Organizing

The project is about the water monitoring system against the IoT system and database. This thesis consists of five main chapters. For chapter 1, it will simply introduce the project. This chapter will cover the introductions, problem statement, objective, and scope of the project. Next, chapter 2 is about reviewing previous research papers or studies relevant to the project title. Then, any findings, similarities, or improvements were also stated in this chapter. For chapter 3, this part will include all the methods and procedures used for the development of this project based on the project objective. Next, in chapter 4, the results and analysis will be shown to prove the data recorded for this project. Lastly, this chapter 5 will explain the recommendations for future works against this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter examines and evaluates previous experiment work that is relevant to this project. The information and data gathered provide an additional source of data for researching and constructing more successful work. In addition, a few literature studies were conducted to have a better knowledge of the project's research. This literature review also consists a few improvement that can be made from the previous project.

2.2 Previous Project Research

Based on literature review that can be summarize by on research and finding information that related with my project through the existing resources such as Internet, books, journals etc. So, by this method, understanding of project can be achieved.

2.2.1 IoT and Cloud Computing Based Smart Water Metering System

According to [2], the water crisis is often attributed to a lack of planning on the government side, increased corporate privatization, human and industrial wastage. This problem usually occurs, especially in a populated area, due to a lack of metering and unidentified water leakage. By the year 2050, 1.6 billion people were expected to reach, which will worsen their problem. The main objective for this project to develop and implement the methodology of intelligent water meter based on the Internet of Things (IoT) and cloud computing equipped with machine learning algorithms.

Node MCU act as the central controller for this project that has equipped with a Wi-Fi system. This controller received data from the YF-S201 water flow sensor that sits on the main pipeline to measure water flow through it. The entire system was powered by solar energy to ensure this system can work independently without any external power source. Moreover, due to the internet connection put off for some time, this system is also equipped with a small memory unit that can store data temporarily until the internet connection is restored. The data obtained were transmitted to the ThingSpeak Cloud platform in real-time to be accessed through the mobile device.

The result on Figure 2.1 shows all the data recorded in detail from time to time. ThingSpeak will generate some graphical interface from the data obtained for the user to monitor and analyze the system's water consumption to make any future decision.

The main objective for this project was achieved, but some parts still can be improved to increase the effectiveness of the project, so it works more conveniently to use. YF-S201 water flow sensor was considered one of the best options to use in this project due to its performance meeting the price range. This sensor contains a pinwheel sensor to measure the volume of liquid passing through it by generating an electrical pulse with every revolution.

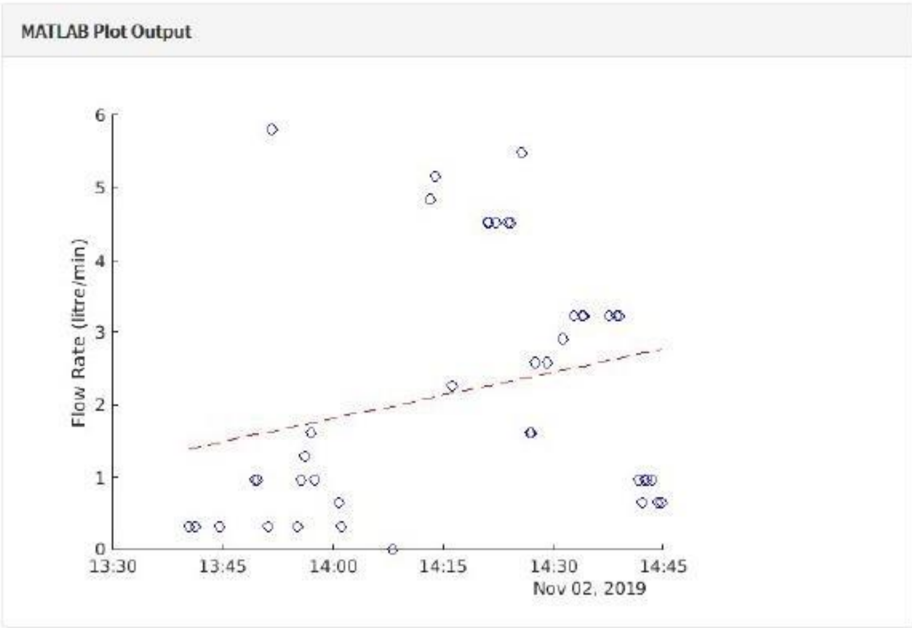


Figure 2.1: Result from ThingSpeak

2.2.2 Smart Water Meter System for Under-Centric Consumption Measurement

In South Africa and most other countries, analog and manual meter reading still used widely by the water services provider. This method is labor-intensive and sometimes can cause inaccurate reading because there is a lag in time and estimated based on historical data [3]. To improve their water services system, this paper has proposed implementing a smart water management system to obtain real-time data for real-time analysis.

This system is divided into three main components which are, the meter interface node, gateway device, and back-end system. The meter interface node connected directly to the digital meter through the Reed switch on the Dizic module (transmit module). This Dizic module is an IEEE 802.15.4 that used ZigBee supporting network. The obtained data from a digital meter that connected to Dizic module were transmitted to the gateway device. The gateway device is their main component in a communication system to ensure the transmitted and received data between sensor node and back-end system. The data were sent to the back-end system (web-based monitoring application) for further analysis and visualization. The data were visualized in various graphs to ensure users can analyze the system in real-time, daily, or monthly.

Since this water monitoring system is installed in a company, the generated graph on Figure 2.2 shows that the water consumption occurs mainly between working hours (8:00 16:30) Monday to Friday. Moreover, from 17:00 to 7:00, as expected, there is no consumption due to no one available in the office. This system was also able to compare the data between two different days.

The purpose of this project is to develop a smart monitoring system have been achieved. Since this project used wireless communication through ZigBee as their main component in communicating between meter interface mode and back end, it has many advantages. This is because the type of communication used is short-range, low-cost, and low-power, so it is very suitable for battery-powered devices. Unfortunately, due to this factor, the device only covered a small area that makes it a bit challenging if the location of the gateway and meter interface node far away. The best option that can be done is replacing the Dizic module with components with medium-range communication such as AX8052f143 RF-microcontroller with the same function but a different communication range.

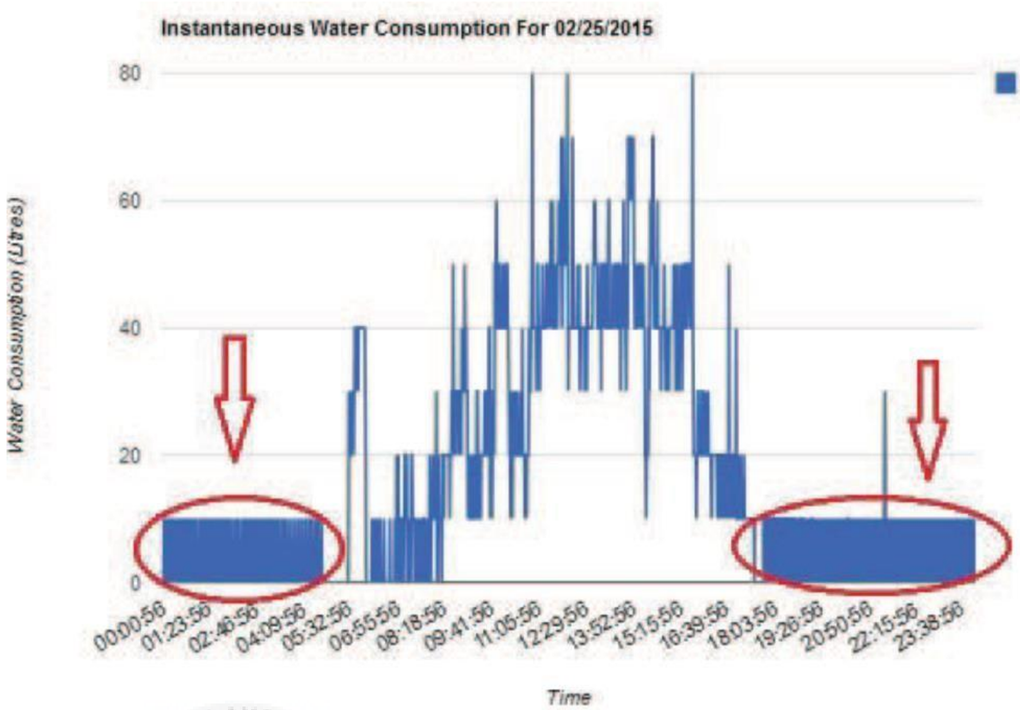


Figure 2.2: Result of water consumption by time

2.2.3 Smart Meter for Water Utilization Using IoT

According to the research paper by [4], water conversation is a big issue in many apartments, especially in an urban area. As an initiative to solve this issue, the apartment association should inform all residents about their water usage. So, this paper proposed developing a smart water meter for every house in the apartment to monitor the water consumption level using IoT technology. By using this method, excessive water usage in every home can be controlled. Not only that, but it also will help the resident to save their water for future use.

This project contains several components that were combined to make it complete system. The system was controlled by the main controller, which is the Node MCU. The benefit of using this microcontroller is that it has a built-in Wi-Fi to send data easily without any external module. This system is also equipped with a water flow sensor to measure the volume of water transferred from one point to another. The water flow rate is calculated by the average of velocity times the pipe's cross-sectional area (the size ofthe pipe). This data then transferred to a particular development web-based interface before it can show in a graphical interface to the user.

Usually, the actual result for the system obtained from the water flow sensor was shown in the list type of data as shown in Figure 2.3. This may confuse the user due to many data at one time. By using special development of cloud platform, this data will rearrange in the form of user friendly. By using this method, it helps the user to record and analyze the data more precisely.

In this project, the author chose Node MCU Microcontroller as their primary controller for the system. Node MCU is a microcontroller that is widely used due to its price range and features. This makes Node MCU Microcontroller the best option to use in a low-cost budget project that requires multiple features controller used minimum power. Moreover, this microcontroller is also compatible with the most popular controller software, Arduino IDE, which is already known as one of the most user-friendly software. This controller also has the same function as our project controller, which is Arduino Nano.

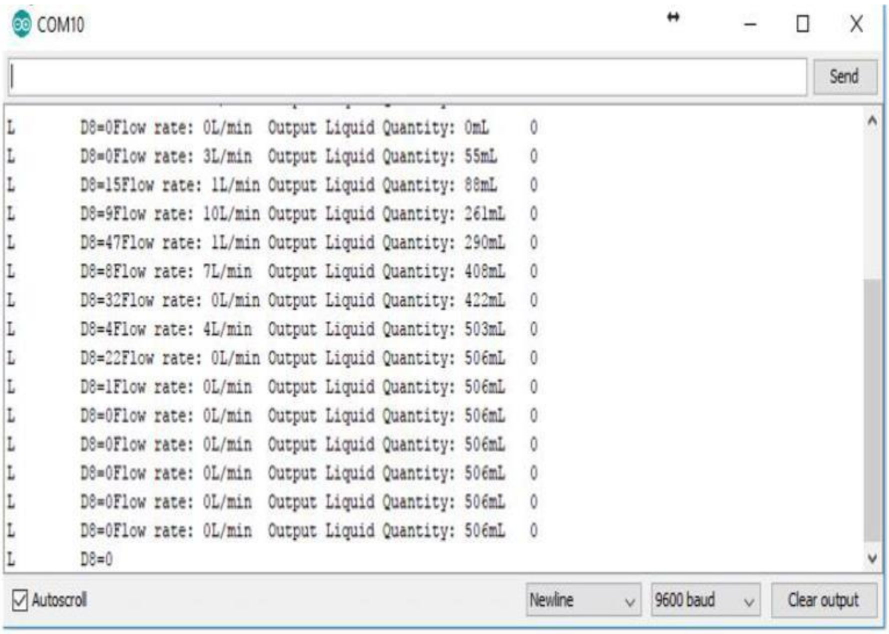


Figure 2.3: Output data from sensor

2.2.4 Water Management and Metering System For Smart Cities

According to the survey by FAO and water.org, 1.8 billion people worldwide will face water scarcity, and 2/3rd of the world will live under water-stressed conditions by 2025. Based on [5], water demand in metropolitan areas is increasing as the population growth. There is a lack of standardization among water distributors, affecting the quality and quantity of drinking and household water supplies. Water management company should play its role in improving the efficiency of the water distribution system to face this upcoming issue. There is a various wireless technology that has been proved that can overcome these challenges. This paper presents a water management system that will continuously monitor and analyze the quality of water supply to the user. Moreover, it also allows the user to customize their volume of water needs.

This intelligent system was separated into two modules; Module 1 consists of the flow sensor, a pH sensor, actuator, and controller while on Module 2 it consists of controller and display. The special of this project is using multiple types of microcontrollers that works independently and communicate via ZigBee as communication protocol. The flexible open-source platform Arduino will act as a controller that measures water pH reading and performs any activities such as moving the actuator. On the side, Raspberry Pi will be focused on display and transmitted received data from Arduino to the cloud server. The reason why using a separate microcontroller is to allow multiple transmitted data from multiple Arduino at one time. For example, two Arduino are considered two nodes, node A and note B, which are from Module 1, and Raspberry Pi from Module 2. Using this method, users can monitor water's condition and flow rate from multiple sources in real-time.

The data transmission from the Arduino (Module 1) to Raspberry Pi (Module 2) was stored in Raspberry Pi as .CSV file. The collected data were processed in the local server Raspberry Pi before it gets pushed to the cloud. In the special development of the web interface as shown in Figure 2.4, users can monitor their usage by login with their unique username and password.

The usage of two different microcontrollers for this project is good because every microcontroller has its advantage and operating limit. As an example, Arduino Uno only consists of 32KB flash memory and 2K SRAM to operate. Separating the process will reduce the microcontroller's load and allow it to perform in its optimal condition and decrease the error rate. On the other hand, Raspberry Pi is a microcomputer equipped with good enough hardware to perform multiple programs simultaneously. Finally, Raspberry Pi also have build in with Linux OS that can run almost any program.

Figure 2.4: Interface of web-based application

2.2.5 Cloud Based Smart Water Meter

An analog meter that measures water consumption, either private properties or premises, is still widely used in many parts worldwide. This meter required workers to read the meter monthly, and the bill will be computed based on certain rates depends on the water usage. Not every premise can be easily accessed by the meter reading workers. Sometimes the location of the water meter is quite challenging and can cause a human error; also, the accuracy cannot be guaranteed[6].This article aims to make the water supply more accountable and transparent so that manual assistance may be reduced and secure. It is also time-efficient solutions that allow the data to be delivered electronically.

This project is the combination of three sections, sensor, controller, and output data. This project uses ATmega 328, a high-performance Atmel Pico Power as their central controller for controlling all activities in the system. To measure the water flow, YF-S201 came into action by calculating the water flow and sending the data to the microcontroller in electrical pulse. In this project, multiple components generate the output result from the system, which is LCD display, buzzer, and GSM. All of these components have the same function to the notified user but in different conditions. The purpose of this project is to make the water supply more accountable and transparent is achievable. As the smart water meters are digitized and automated, the high accuracy can be guaranteed and reduce some meter reader effort to read the meter manually. Overall, The GSM module is functioning well, transmitting the bill amount and the amount of water consumed to the provided cellphone phone.

In this project, the usage of multiple outputs that can be seen on Figure 2.5 such as LCD display, buzzer and GSM is a good decision. The advantage of using GSM is that the coverage is wider than local wireless communication such as Wi-Fi, Bluetooth, and ZigBee communication. The GSM module influences this factor uses the same network as our mobile device that used high frequency to transmit and receive data in long-range. Moreover, for the rural area that does not have an internet connection, GSM is the best option for replacing the Wi-Fi. In addition, the user can access it anywhere as long it has a mobile network on their device. Because of this factor, GSM module is used on our project as one of our output options. Since the controller used is ATmega 328, which is almost same as Arduino Uno microprocessor, the configuration of this system should be same as normal Arduino Uno. What makes it different is, Arduino Uno have its own shield that will help developer to construct their circuit.

Figure 2.5: Circuit construction of Smart Water Meter

2.2.6 Arduino Based Smart Water Management

Rainwater harvesting stores the rainwater in containers before the rainwater goes beneath the ground and recharges the underground water table[7]. This paper proposes the design of a smart water management system based on Arduino as an IoT application to prevent this situation. Rainwater harvesting systems can supply households and businesses with water for use in dry seasons and reduce the demand for municipal systems. With water scarcity a pressing problem for many densely populated regions, non-potable water can be used to irrigate landscaping, flush toilets, wash cars, or launder clothes, and it can even be purified for human consumption.

The proposed design combines both hardware and software that work together to produce output for the user. Figure 2.6 show the whole circuit configuration for this Smart Water Management. The main controller used is Node MCU paired with an ultrasonic sensor to determine the water level on the storage tank. Then, the soil moisture sensor will provide information about the dryness of the soil. This system used two motors that act as a valve for the water storage tank. These motors will operate automatically depending on the water level in the storage tank and the dryness of the soil. All system activities were transmitted to the Blynk app installed on the user's mobile device in real-time. Because the placement of this system is outdoor, this system is 100% powered by solar energy that converts light from the sun, which is composed of particles of energy called "photons" into electricity.

This application will help improve water sustainability and management and smart city strategy that is appropriately tailored to different constraints. Furthermore, all implemented techniques must be linked to global societal knowledge of sustainable planning and management in order to make the most use of available resources. This will help cut expenses, improve service quality, and optimize system performance due to technological advancements.

The usage of solar energy is very efficient to use especially in outdoor. This is because by using solar energy, we get to reduce our monthly electricity consumption and reduce greenhouse gasses. Moreover, solar energy is the cleanest and pure energy from the sun that can be applied anywhere as long there is sunlight. In our project, solar energy will be the main power supply for the system because it is very suitable to use in Malaysia due to its climatic conditions.

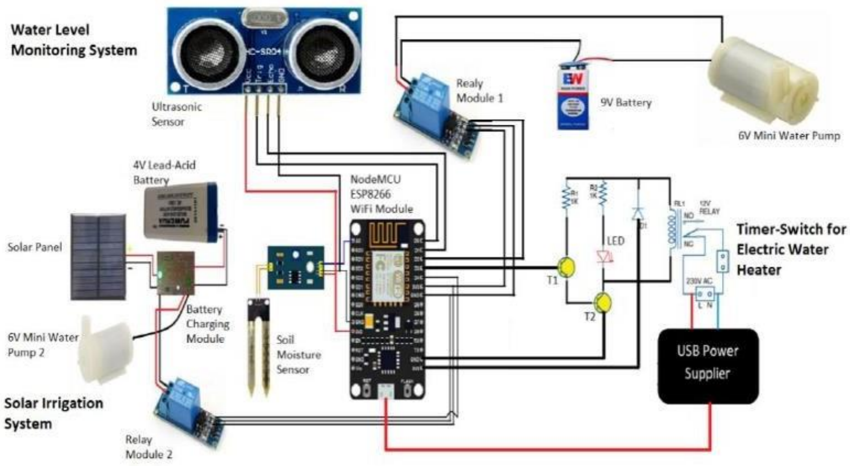


Figure 2.6: Circuit configuration Smart Water Management

2.2.7 Design And Implementation Of A Smart Monitoring System For Water Quality Of Fish Farms

Fish farms are one of the most important profitability for farmers. Meticulous and continuous care is needed to guaranteed the quality of the product. Smart system monitoring is the best option to solve this issue. According to [8], a system that has incorporated Bluetooth for remote monitoring has low latency, which is very good in wireless communication. The system is called ‘Smart Monitoring System for Water Quality of Fish Farms’ (SMWQ). It aims to monitor and control the temperature and water quality by using the mobile application in real-time.

This system is divided into two parts, the measuring and monitoring part. This first part is by measuring the temperature and pH of the water controlled by Arduino and sent the data to the second part through Bluetooth. Bluetooth technology is a low power consumption that makes it an ideal device to use as a transmitter and receiver in the water monitoring system. While, on the other side, special development of the mobile application will monitor the status of the whole system. This special mobile development designed using MIT App

Inventor, a Google software (opensource), will allow the user to monitor the water system with low cost and high reliability.

In this paper, a low-cost monitoring system was designed to monitor the behavior of the fish farm water (pH and temperature) through a mobile device. The special development application will convert the data from the sensor into a graphical user interface (GUI) to make it easier to analyze. This application will show the status of Bluetooth connectivity as well as water pH and temperature value.

This project transmitter circuit was designed by using Bluetooth module HC-05. Even this module have been ages, it is still reliable and cost efficient to be used nowadays. However, this wireless transmission medium was not limited to Bluetooth only, this can be replaced with Wi-Fi or RF with a better coverage area.

2.2.8 GSM Controlled Automatic Irrigation System

In terms of food production, agriculture plays a vital role in every country. As the population increases day by day, the demand for food will increase, and many factors should be considered to maintain demand and supply change. According to [9], one of the major problems faced by farmers is the lack of water to fulfill the demand for agriculture usage. This project aims to give updates to the farmer or user about the water requirement by sending a prior generated message.

In this paper, a design of GSM controlled automatic irrigation system is presented. This system is based on a microcontroller and embedded technology equipped with multiple sensors to determine the moisture and humidity of the crop field continuously and a GSM module for data transmission. The lack of humidity and moisture on the soil will generate the signal to the microcontroller, so the water can pump automatically until it reaches desired moisturization. Moreover, farmers can also monitor the system directly because it is equipped with an LCD that shows the status of the soil in real-time.

This system can run in two types of operating modes: fully auto or semi-auto. By using semi-auto, farmers will receive updates from the system and control the process with the help of the cellular phone by sending signals to the GSM module, which will further give commands to the microcontroller to carry out the assigned task. This prevents over-irrigation of the crops while also conserving water and energy resources.

The GSM module and LCD usage are convenient due to its low latency that can transmit data in real-time, even though some improvement can be made to improve its functionality. For example, incorporating this project into the pH meter will estimate the amount of potassium and sodium that help in fertilizing the crop. Next, to make the data organizable and easy to analyze, it can be transmitted to a special development app or web-based interface that will convert in the forms of a friendly graphical user interface (GUI).

2.2.9 Development Of Solar Powered Irrigation System

The irrigation system is defined as a system that distributes water to targeted areas that are focused on agriculture. The efficiency of irrigation is based on the system used[10]. There are numerous types of irrigation systems in use worldwide, but they all have their issues. So, the main objective of this project is the development and implementation of an automated SCADA-controlled system that uses PLC as a controller. This system would be powered by a solar system, a renewable energy source that converts sunlight into electricity using solar panel modules.

This project consists of electrical and mechanical parts. The electrical part consists of solar panels made from photovoltaic that convert sunlight into electricity and stored in the rechargeable battery. At the same time, the mechanical part consists of water pumps and solenoids to control the water flow. Programmable Logic Controller (PLC) as the main controller is interfaced with Supervisory Control Data Acquisition (SCADA) system that was developed in a personal computer (PC) using LabVIEW. SCADA system is used to controlling the automation system via computer. For users to interact or communicate with the system, a unique human-machine interface (HMI) needs to develop along with the SCADA system as Figure 2.7. This figure show the capacity tank status and the solenoid or valve that are open. In addition, to ensure the system's efficiency, soil humidity condition, water level condition, and the position of the Sun were considered as parameters that need to be continuously monitored.

The process of recording proceedings with an automated computer is known as data logging. Rather than saving data in the database for each given cycle, the system plots the behavior of the variables using previously recorded data in the database. By using this method, it helps to monitor the system continuously. Moreover, this system was able to display the output in the form of a graphical interface and show the previous data for days or hours as long as the data were still available in the database.

This project managed to show the fact that the largest advantage of using solar energy is, it is free and an unlimited resources. Even though the starting cost for solar energy development was a quit higher, it will provide a worthwhile return over long-term usage. In our project, solar energy is an alternative that being used to power up the system. We choose this type of power supply because if this system was placed outdoor, and will it receive sunlight every day. It is such a waste not using unlimited resources energy that is available.

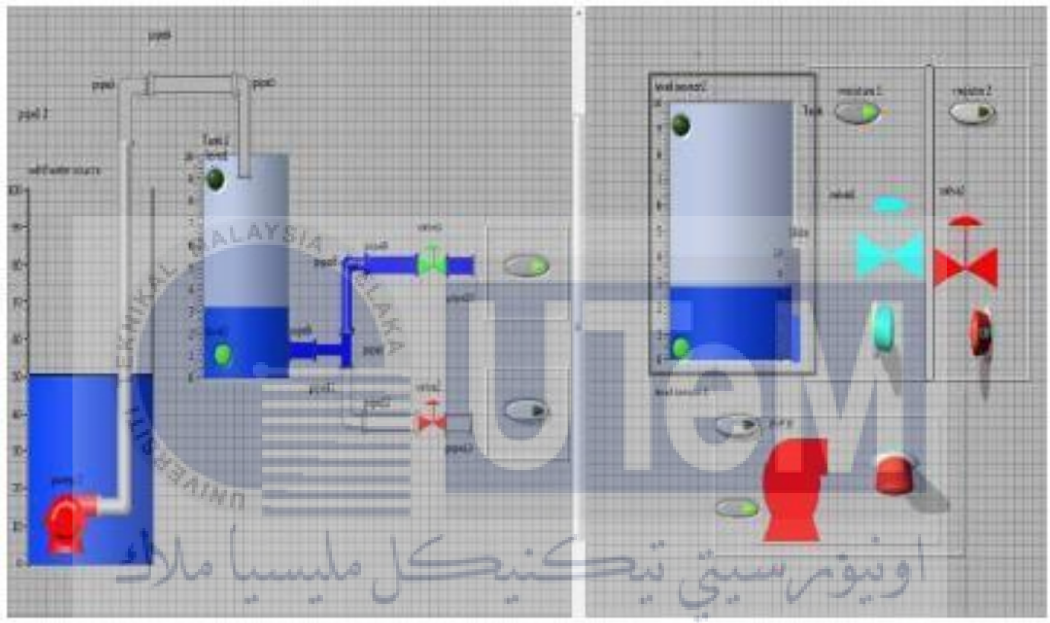


Figure 2.7: SCADA monitoring system on LabVIEW

2.2.10 IoT Based water usage Monitoring System Using LabVIEW: Interdisciplinary Series For Sustainable Development

A present conventional water meter used right now is to calculate the amount of water consumption for the monthly billing process. This method is not very efficient in monitoring water usage continuously, especially when it has been installed for several years. Sometimes, the water has been wastage with or without user knowingly will increase water consumption. Efficient management of the water used at homes could be essential as about 50% of water provided to the cities gets wasted through its incorrect utilization[11].

This water tracking system contains three modules: the wireless sensor module, central module, and server module connected. The wireless sensor module connects various sensor nodes to the central node. This wireless sensor has its own sensor circuit and power source that will let this module communicate with the central module through RF transceiver. The central module containing the Arduino board will act as the main controller that connected numerous modules with the RF module, solenoid valve, Wi-Fi shield, water flow meter, and indicators. Lastly, all the results will transfer to the server module. This module contains a few blocks such as computational block, monitoring/display block, and control block. From this module, the user will able to monitor the system hence control it at the same time using special development software in LabVIEW.

LabVIEW, which will function as a server, is a crucial part of the water control management system. This advance server device is capable of controlling and monitoring water consumption over unnecessary wastage. With these features, every water usage activity will be recorded on the server to ensure optimal water consumption. Moreover, if any unnecessary water usage occurs, this system will warn users to take action as soon as possible and cut off the main supply if there is no action taken at certain times. Users will receive weekly notifications about their water bill status and they also able to request notifications when they exceed their usage. So, the user will able to maintain their water bill monthly.

The integration of LabVIEW as the monitoring and controlling the water system management is a convenient usage. The features of LabVIEW that allow the developer to customize their Human Machine Interface (HMI) for controlling the existing system made it more practical to use as shown in Figure 2.8. In this figure its show the volume of water that have been used and the status of valve. Using this method, users can monitor their water usage and take action if some water leakage occurs. Moreover, all the modules in this system were powered by a separated power supply and connected wirelessly, make it possible to place anywhere around the premise without any communication cable that can cause interference and extra cost.

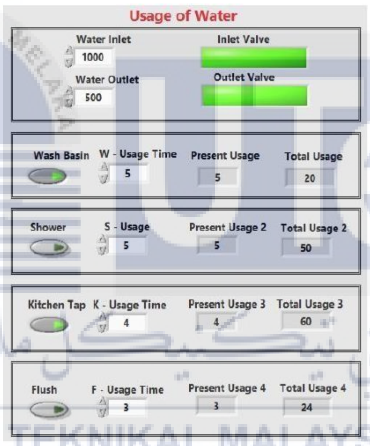


Figure 2.8: Control and monitoring interface on LabVIEW

2.3 Comparison Previous Project

By referring to Table 2.1 below, its shows the comparison between the past related works with the previous study. The table shows the year of the articles, author, component or hardware, software, controller, and type of transmission and monitoring system. Based on the table, a few types of the controller were used to operate the system. Most of them use Arduino and Node MCU as their microcontroller because it is much easier to configure and a more friendly user. Furthermore, this controller was compatible with Arduino IDE software which is there is plenty of guided that can be used on the Internet.

Furthermore, for the transmission type, most of them were using wireless communication as their medium to transmit and received data from system to user. This is because wireless communication has many advantages compared to wired communication. It is easier to place the transmitter and receiver without much hassle. The maintenance and installation of the network also much cheaper, and transmitted data is faster.

Regarding interfacing with the user, a web-based server seems the best option to use since the user can access it remotely. Moreover, the application is also very practical to be used as a monitoring system. The attractive GUI will help users to monitor the system efficiently. The reason behind choosing this project is because this project will have an advantage in daily life and help to monitor our water usage habits.

Table 2.1 Comparison between previous project

Author	Year	Sensor/Hardware	Software	Microcontroller	Transmission Type	Type of Monitoring System
Arita Ray Shreemoyee	2021	YF-S201 water sensor	Arduino IDE	Node MCU	Wi-Fi	Website GUI
Mduduzi J. M. Adnan M. A.	2017	Digital meter	-	Dizic IEEE 802.15.4	ZigBee	Website GUI
D. Anandhavalli K.S. Sangeetha V. Priya Dharshini B. Luksahana Fathima	20118	Water flow sensor	Arduino IDE	Node MCU	Wi-Fi	Website GUI
M. Kalimuthu Abraham Sundharson P. Chirsty Jackson J.	2020	YF-S201Water flow sensor pH sensor Solenoid valve	Arduino IDE Raspbian OS Phyton XAMPP	Arduino UNO Raspberry Pi	ZigBee	Cloud Storage
Regvedi Deshmukh Vrushali Bankar Vaishnavi Bangdagale Amruta Doiphode	2018	Water flow sensor Buzzer LCD Display GSM Module	Thingspeak	ATmega 328	GPRS	LCD Display Website GUI SMS
Vatsala Sharma Kamal Nayanam Himami	2020	Soil moisture sensor Ultrasonic sensor DC Motor Solar panel	Arduino IDE Blynk	Node MCU	Wi-Fi	Mobile application
Nahlal Abdul Jalil Salih Ihsan Jabbar Hassan Nadhir Ibrahim Abdulkhaleq	2019	pH sensors Temperature Sensors LCD Display Bluetooth module	Arduino IDE MIT App Inventor 2	Arduino UNO	Bluetooth	Mobile application LCD Display

Table 2.2: Comparison between previous project

Author	Year	Sensor/Hardware	Software	Microcontroller	Transmission Type	Type of Monitoring System
Shivam Mishra Anubah Srivastava Vijay Kumar Mall	2017	Soil moisture sensor LCD Display MAX232 GSM Module	-	PIC 8051	GPRS	SMS
AI Abdelkerim MMR Sami Eusuf MJE Salami A. Aibinu M A Eusuf	2019	DC Motor Soil moisture sensor Water level sensor	LabVIEW	Programmable Logic Controller (PLC)	Wired / Remote Terminal Unit (RTU)	Human Machine Interface (HMI)
P. arun Mozhi Devan K. Pooventhan C. Mukesh Kumar R. Midhun Kumar	2019	Water flow meter Solenoid valve Wi-Fi Shield	Arduino IDE LabVIEW	Arduino UNO	Radio Frequency (RF)	Human Machine Interface (HMI)

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will describe the mainstream structure that will be used to complete the proposed project. The proposed project is titled "Development of Water Usage Monitoring System With Arduino Platform". This study was conducted based on specific phases of an adequately performed venture and achieved by the objectives. This application device must be designed and built to fulfill and complete the project's goal. The prototype is a project involve the hardware and software that will be design according to the Figure 3.1.

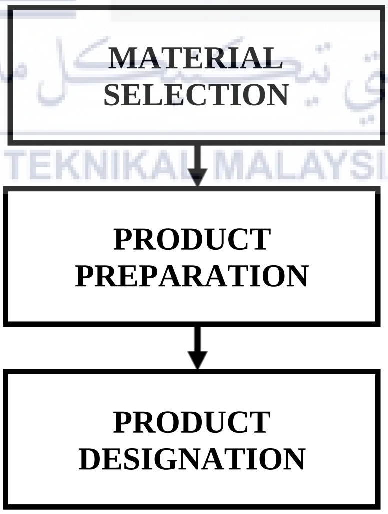


Figure 3.1: Flowchart of project

3.2 Design Of the System

To develop a water monitoring system, device design is required in several steps. First, a few literature reviews that are similar to this project have been completed, and methods to build the prototype have been identified. Aside from that, the system's functioning concept has been specified and defined by the project requirements. This project will consist of three main parts as shown in Figure 3.2 to make it a complete system of water monitoring.

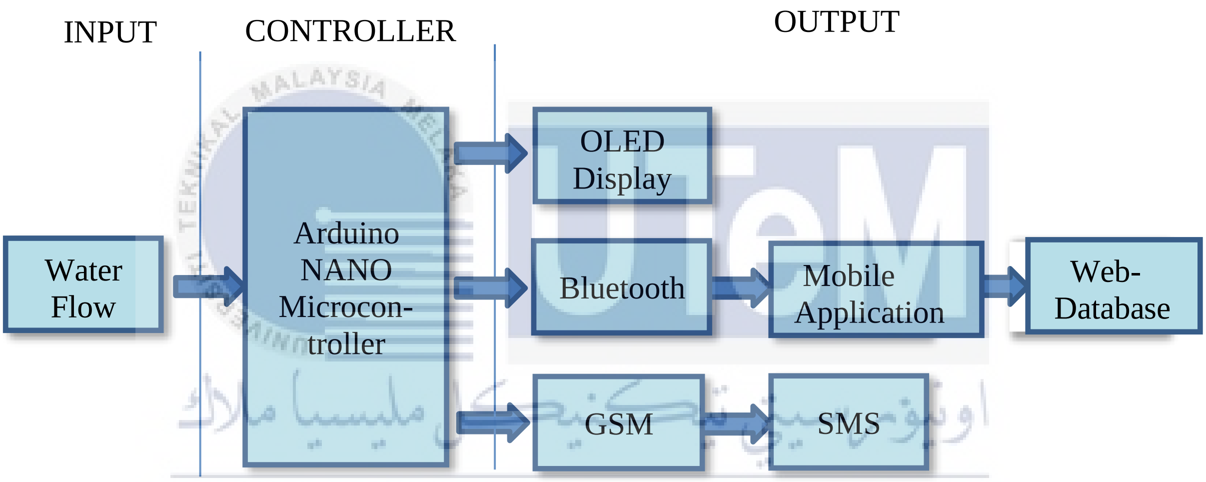


Figure 3.2: System design and block diagram

3.3 Hardware Implementation

Hardware construction is one of the most important aspects of a project's design since it determines what hardware components will be used. This is a crucial step to decide which components will be necessary for creating the project's prototype. Arduino, water flow sensor, OLED display, Bluetooth module, GSM module, and solar panel are among the hardware components that have been selected.

3.3.1 Solar Panel

Solar panels as per Figure 3.3 generate power by absorbing sunlight in photovoltaic cells and converting it into electricity. For example, solar collectors used to heat water or others used to heat air are referred to as solar panels. Photovoltaic modules (PV) or solar modules are other terms for solar collectors.

Figure 3.3: Solar panel

3.3.2 Charging Controller

This module is made for charging the rechargeable lithium battery using the constant-current/constant-voltage (cc/cv). Moreover, this module as Figure 3.4 also provides necessary protection to prevent any overcharging or over discharging the battery. This module also has Micro USB port with + and – connection that will act as input to charge the battery. This module can produce 4.2V with current protection up to 3A that make it the best option for charging Lithium Ion battery as this system using 3.7V Lithium Ion battery. The LED in this module will turn Red indicates charging while turn Blue to indicates charge complete. The size is very small which is 28mm x 17mm with 1.6g that make much more reliable to be used for this project.

Figure 3.4: TP4056 charging module

3.3.3 DC-DC Step-Up Converter

This module is used to boost any input voltage from 0.9V to 5V and step-up it into 5.0V stable voltage. This module will have to stable the input voltage for the microcontroller of the water monitoring system. It also able to provide output current 500-600mA at the max. With the present of USB port, it makes it the best option to powered up the Arduino that used USB as the input. Its ultra-small size: 34mm x 16.2mm also make it one of the best option to be used.

Figure 3.5: DC-DC step-up converter

3.3.4 Arduino Nano

Due to its ability to provide the desired results, Arduino Nano was chosen as a main controller in controlling all the activities in the system through input/output ports. This controller also can connect to a computer through a tiny USB cable or be powered by the board's Vin, a battery, or a power port with its 5V operating voltage. Furthermore, this controller on Figure 3.6 is equipped with an Atmega328P processor with limited memory and input/output pins due to its small form factor (18 X 45mm) with a weight below 10g. It's known very well due to its flexibility in regulating the voltage. However, the upside-down of Arduino Nano tends to be customized with C++ language. This microcontroller has 32KB flash memory and 1KB EEPROM integrated to ensure this device works properly. With this microcontroller's speed up to 16MHz, it will run any works better than the other processor. Then, it also contains eight analog and 22 digital (6 of which are PWM) pins as I/O ports for any sensor and output module. The mini-USB is one of the most important aspects of the Arduino Nano. The Arduino Nano can be powered through USB or by an additional power supply. Another essential feature is that it does not require a physical press to reset the catch because it is reset by ongoing programming on a linked PC. Finally, because of its fundamental yet practical features, Arduino Nano is the most sensible controller for the water monitoring system.

Figure 3.6: Arduino Nano

3.3.5 Water Flow Sensor

Water flow sensor is the sensor that used to measure the liquid or water that flow through it. This component as Figure 3.7 contains a pinwheel sensor that lies in line with the waterline and measures how much water has gone through it. With each revolution, an embedded magnetic Hall-Effect sensor generates an electrical pulse. Red/VCC (5-24V DC Input), Black/GND (0V), and Yellow/OUT are the three wires that come with the “YF-S201 Hall Effect Water Flow Sensor” (Pulse Output). By counting the pulses from the output of the sensor, we can easily calculate the water flow rate (in liter/hour) using a suitable conversion formula on Table 3.1. The basic formula for determining the flow rate can be found as below. However, the velocity, density, and the friction of liquid in the pipeline may interface with the flow rate water result. This sensor can support up to 1 ~ 30 l/min with it working voltage on 5 ~ 8 V with 15mA at max.

Table 3.1: Flow Rate Formula

Q=V x A,
Q = flow rate/total flow of water through the pipe
V = average velocity of the flow a
A = cross-sectional area of the pipe

Figure 3.7: YF-S201 water flow sensor

3.3.6 OLED Display

Figure 3.8 show a monochrome graphic display module with a 0.96-inch, 128X32-pixel high-resolution display built-in that known as OLED display. The OLED technology works without any backlight, making the contrast of an OLED display greater than that of a traditional LCD panel in a dark environment. Despite performing better than the LCD panel, this display module also lowers power consumption with a 3.3V operating voltage. In addition, this module was integrated with SSD1306 driver IC compatible with Inter-Integrated Circuit (I2C) and Serial Peripheral Interface (SPI) protocol that defines communication with a master and one or more slave devices.

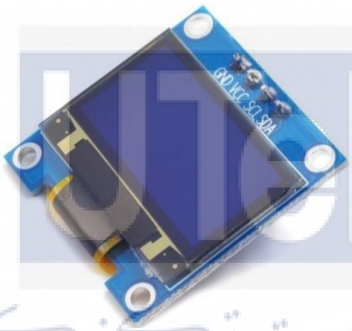


Figure 3.8: OLED display

3.3.7 Bluetooth Module

The HC-05 is a popular module which can provide two-way (full-duplex) wireless with v2.0+EDR and 2.4GHz frequency. This Bluetooth module as Figure 3.9 allows users to communicate over up to 80 meters. It supports ATcommands for configuration and allows you to alter the role and serial baud rate. This module is able to operate as master, slave or master/slave depending on our desired project. It is tiny with dimension 26.9 x 13mm and 5g weight, and its operating voltage between 3.3V to 6.0V. This module will allow the water monitoring to communicate with users mobile device through Bluetooth.

Figure 3.9: HC-05 Bluetooth module

3.3.8 GSM Module

The SIM800L GSM Module is the smallest and most affordable GPRS/GSM module that is the most used in embedded applications like Arduino and Node MCU. The module includes GPRS/GSM technology for communication with a mobile sim card. This module on Figure 3.10 operates on Quad-band 850/900/1800/1900MHz frequency that allow users to receive and send SMS along with phone calls. Despite its performance, it is low power consumption that operates only in 3.3V to 4.4V in size of 30mm x 30mm x 10mm. This module will be used to transmitting and receiving the data from water monitoring system to the users mobile device through SMS.

Figure 3.10: SIM800L GPRS GSM module

3.4 Software Implementation

The implementation needs software to proceed with a project. The reason behind using software in this project is to create instructions for the microcontroller to perform its operations. Then, the software also needs to design the whole system before implemented into the hardware,

3.4.1 Arduino IDE

The Arduino IDE software is mostly used in the electronic invention where it is used to develop code before compiling and running it on a controller. This system is Arduino software board compatible which got two parts with is editor and compiler. The sketch is developed on the IDE's main code platform will generate a Hex filebefore being uploaded to the designed board. In addition, the software used will help the developer or user to have a clear view of the input or output that will be created in the actualhardware or component. The interface for Arduino IDE is shown in Figure 3.11. All the coding for this water monitoring system will be write, compile and sent to microcontroller using port COM5 through USB.

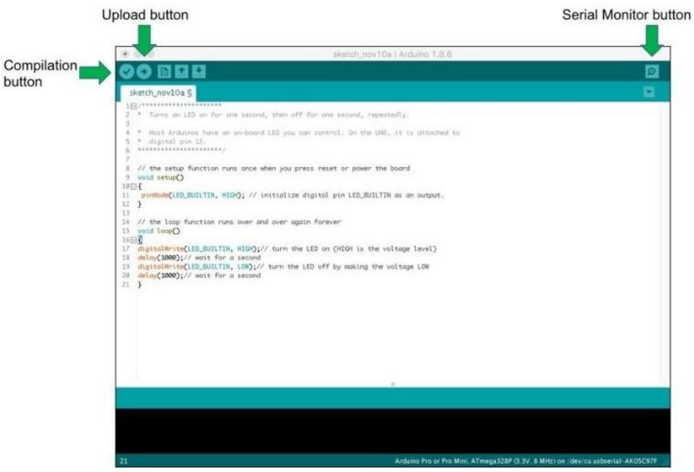


Figure 3.11: Arduino IDE Interface

3.4.2 Fritzing

Fritzing as on Figure 3.12 is an open-source hardware effort that allows anyone to use electronics as a creative medium. In the spirit of Processing and Arduino, this software provides a software tool, a community website, and services that build a creative ecosystem that allows users todocument their prototypes, share them with others, teach electronics in a classroom, and layout and build professional Printed Circuit Board (PCB). This software will be used to design the circuit configuration with their pin number for water monitoring system.

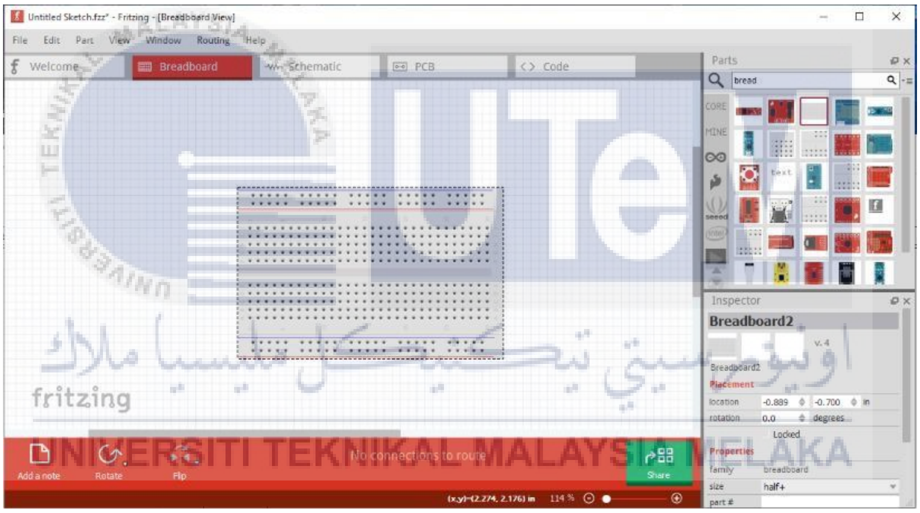


Figure 3.12: Fritzing Board Design

3.4.3 MIT App Inventor

MIT App Inventor is a web application integrated development provided by Google and maintained by the Massachusetts Institute of Technology (MIT). The MIT App Inventor as shown in Figure 3.13 allows unskilled users to develop apps without coding and a straightforward graphical user interface (GUI). Moreover, it is also effortless to use because it uses drag and drop features to control the visual block and link with each other. There are two main editors used in this software which are design editor and block editor. The design editor is an interface for user interface elements, while the block editor used a color-coded block-like puzzle to describe the program to help the inventor develop their desired apps. Not only that, MIT also provide an apps called App Inventor Companion that allows developers to test and change the behavior of their app in real time to improve development and testing without installing the actual application. This software will be use to design the specific Android application that can monitor can monitor and control the water monitoring system from user mobile device.

Figure 3.13: MIT App Inventor Interface

3.4.4 Google Spreadsheet

Google Sheets in Figure 3.14 is a web-based application that enable users to create, update and modify spreadsheets and then chare the obtain data online in real time. Basically, Google Sheets is parts of Google Doc Editors for free web applications. These also includes

Google Doc, Google Sheets, Google Drawing, Google Forms, Google Sites and Google Keep. Google Sheets is an online web application that allow users to create, edit and organize their works in real time around the globe. This Google Sheets also can integrate with other program to obtain the date and save it on the cloud. By using the help of Google Script Editor, developer can use Google Sheet as web database to store the obtain data freely and in real time with having additional cost. For this water monitoring system project, Google Spreadsheet have been used as the web database to store the data in the cloud or Internet.

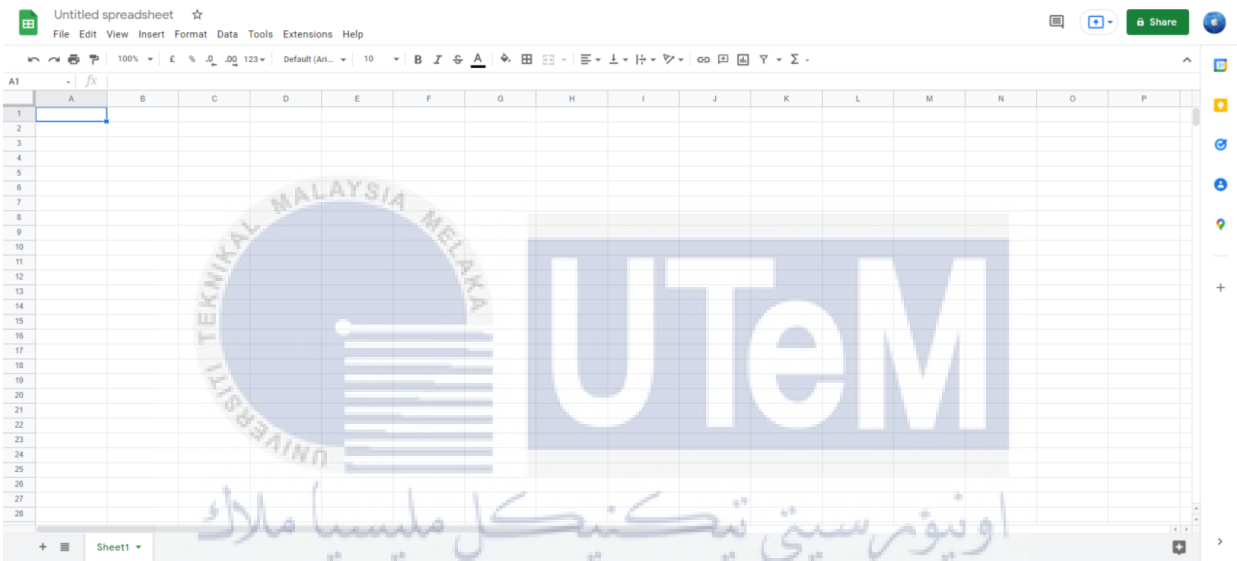


Figure 3.14: Google Spreadsheets

3.5 Flowchart

3.5.1 Project Working Flowchart

Figure 3.15 shows the flowchart of this project's working system. This system is started when there is a power supply to the circuit and initializing all the available ports. YF-S201 water flow meter will measure the flow and transmit the data to the microcontroller before producing the output. The output was separated in three different forms: through the GSM, OLED display, or Bluetooth that will connect to the specific development of a mobile Android application.

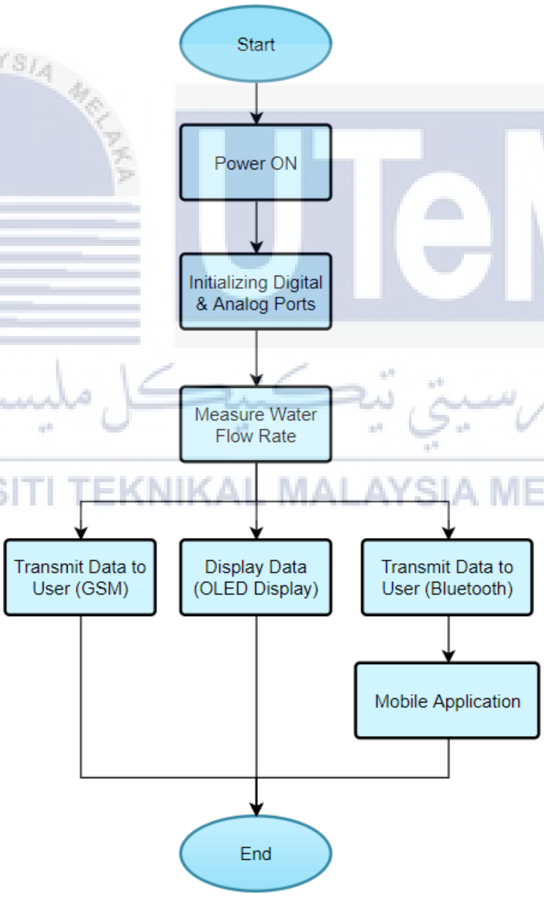


Figure 3.15: Flowchart of project working system

3.5.2 Communication Flowchart

Based on Figure 3.16, the flowchart shows two types of transmission communication with their specialties. For Bluetooth communication, users need to connect their mobile device with the system Bluetooth module to obtain water flow consumption data before uploading it to the web database. Meanwhile, for GSM, users will sent special code and receive reply from the water monitoring system on the mobile device via SMS.

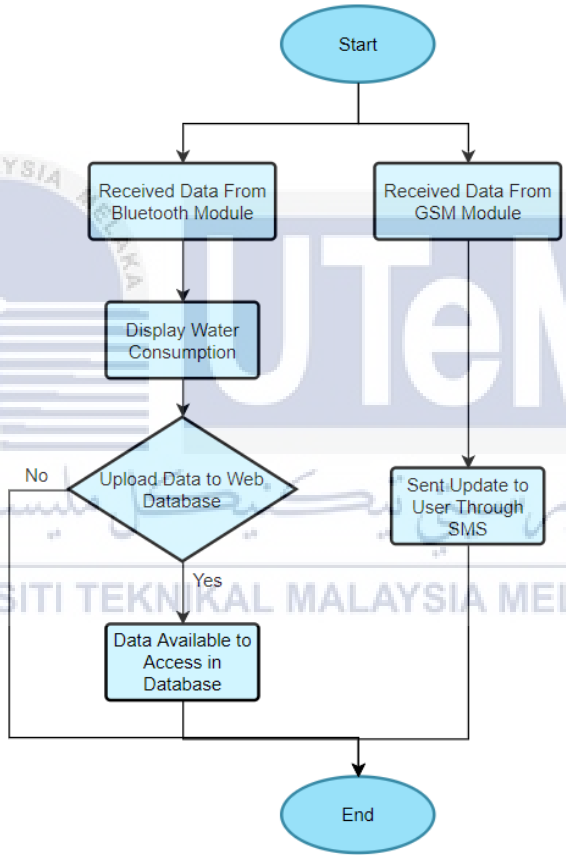


Figure 3.16: Communication Flowchart

3.6 Power Supply Circuit Construction

Figure 3.17 shows the power supply circuit construction to power up the entire project. This circuit consists of solar panel that connected directly to the charger module and have 1N4007 to ensure there is no reverse voltage or current. The output from the charger module will connected directly to the battery and DC-DC step up converter in parallel. By using this method, the water flow monitoring system will receive power from the battery if there is no supply from the solar panel or DC power supply.

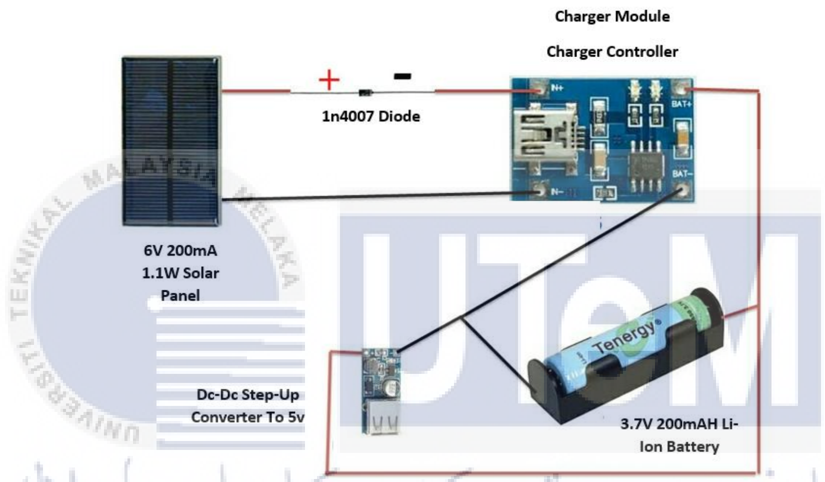


Figure 3.17: Power supply circuit construction of smart water monitor system

3.7 Circuit Construction

Figure 3.18 shows the circuit construction of the water monitoring system that was designed using Fritzing software. The circuit consists of an Arduino Nano as controller, YF-S201 water flow sensor, three output components; 0.96-inch OLED display, GSM SIM 800L module, and an HC-05 Bluetooth module. These components will work together to perform their function as water monitor systems to give information to users on their water consumption. Every component used has its ports on Arduino Nano where pins place in incorrect port will cause short circuits and damage the system. As on Table 3.3, the positive terminal for the sensor and OLED Display is connected to the Vin port, while for Bluetooth and GSM module are connected to the 5V port. All of the negative terminal will be connected to the GND on Arduino port. The input/output terminal from module will connect to digital port on microcontroller except for the OLED Display are connected to the analog port.

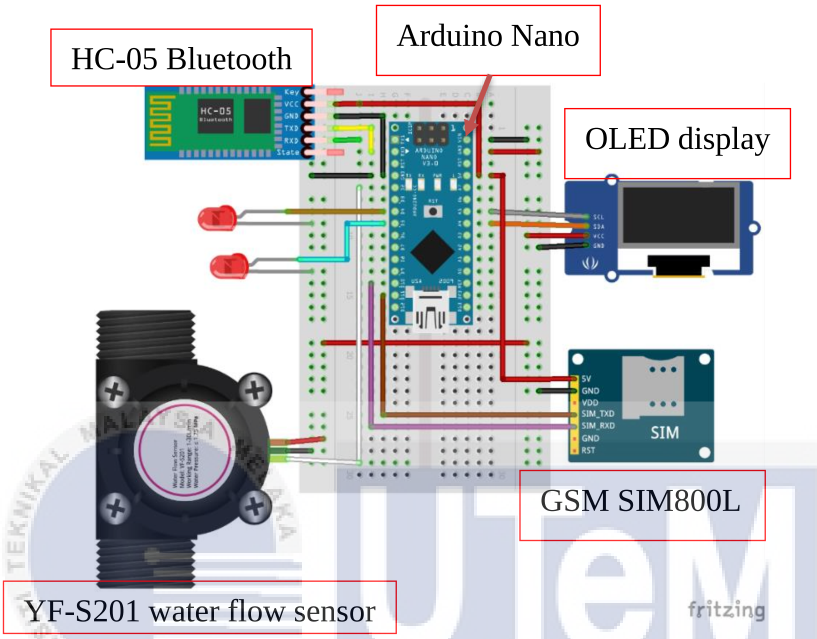


Figure 3.18: Circuit construction of water monitor system

Table 3.2: Pins Configuration

Arduino Nano Ports	Components Pins
VIN	VCC YF-S201 / OLED Display
5V	VCC Bluetooth / 5V SIM800L
GND	GND
D02	Water flow sensor
D04	Green LED
D05	Red LED
D10	RX of GSM module
D11	TX of GSM module
RX0	RX of Bluetooth
TX1	TX of Bluetooth
A4	SDA of OLED display
A5	SCL of OLED display

3.8 Summary

Water management systems will not be left out of this development process as smart technology advances. Based on the Arduino platform, this article offers a new and practical prototype of an innovative water monitoring system that allows users to monitor their water usage consumption.

CHAPTER 4

RESULTS

4.1 Introduction

This chapter explained the results obtained from developing a water monitoring system based on the Arduino platform. Data analysis was done to measure and record the results. Moreover, this chapter also highlighted the flow of the prototype for the water monitoring system from the hardware used to the software parts and discussed the obtained results. Finally, the functionality of the system was tested to ensure this project could meet its development objective. Hence, the summary described the whole findings for this chapter.

4.2 Data Analysis

The data analysis was managed to obtain from the results of the components on the water monitoring system project. The analysis was done to get accurate data from the sensor and component. Table 4.1 shows the relationship between the distance and the time taken to connect MIT develop apps with the water monitoring system through Bluetooth. The time taken will increase when the distance was increased every two meters. From Table 4.1, the maximum distance to connect the water monitoring system with the mobile device is around 20 meters. However, the application was unable to establish the connection to the water monitoring system on 22 meters. This is because, from 0 meters to 20 meters from the water monitoring system to the mobile device, there are obstructions that need to be considered that will affect the signal strength.

Table 4.1: Relationship between distance and time to connect through Bluetooth

Distance (m)	Time to Connect (s)
2	3.57
4	3.75
6	4.53
8	4.6
10	4.68
12	4.85
14	5.11
16	5.89
18	6.17
20	6.23

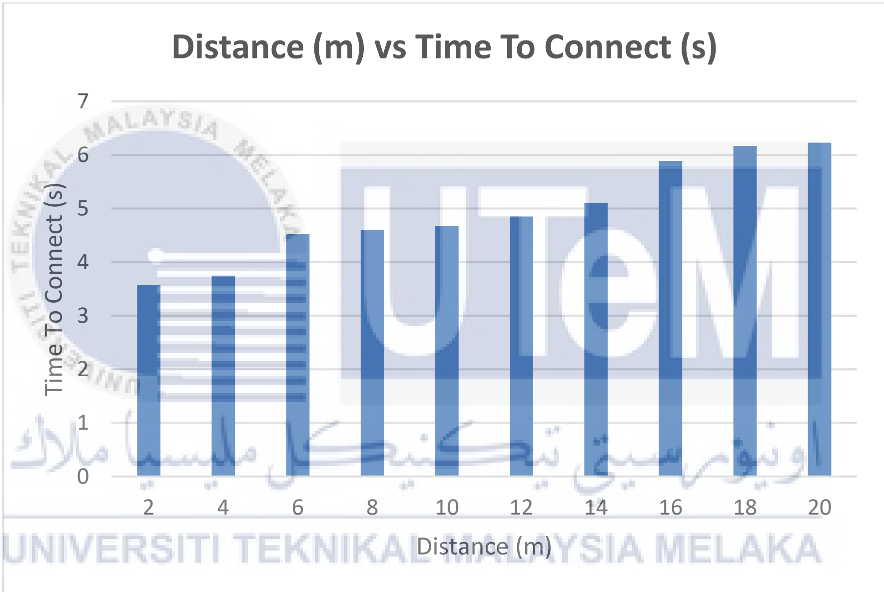


Figure 4.1: Chart that show the distance in meters vs the time to connect in second

Figure 4.1 shows a chart of the distance of the water monitoring system with mobile device in meters vs the time taken to connect through Bluetooth in seconds. The figure shows when the distance between the water monitoring system and mobile device increases, the time to communicate between two devices also increases. Hence, the time to connect will slightly increase with the distance. With a distance below 20 meters, users can monitor, control, and upload the data obtained to the database which developed specifically for this project.

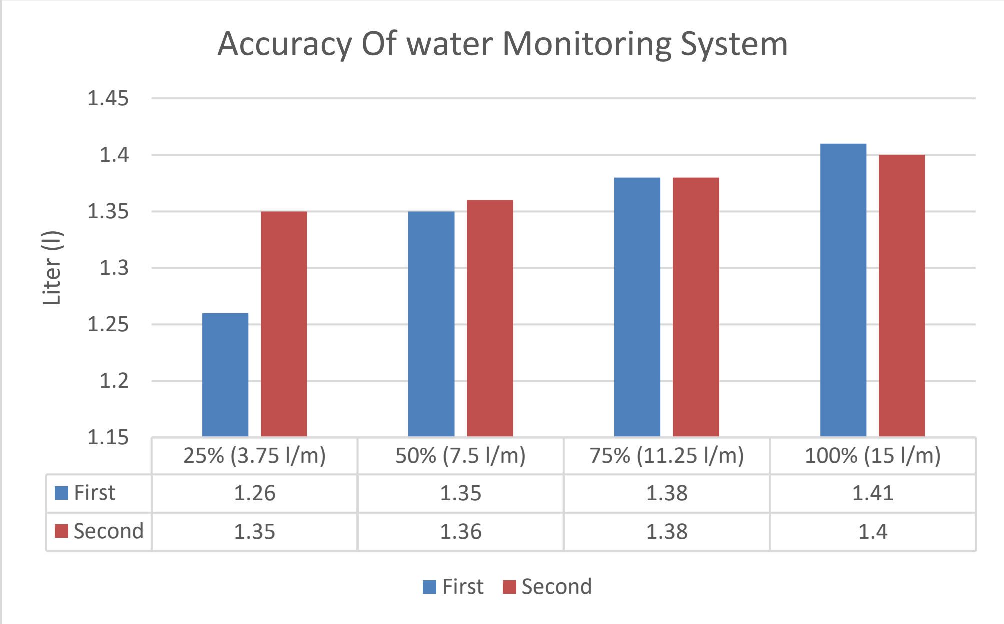


Figure 4.2: Accuracy of water monitoring system with 100ml

Figure 4.2 shows the water monitoring system's for recording 1000ml of water. The maximum flow rate for this testing is 15 l/m which is when the main outlet water tap is open 100%. Every testing was done using 1000ml (1 litre) of water and repeated in order to get better accuracy results. The first testing is by opening 25% of the water tap, which the flowrate was around 3.75 l/m. From Figure 4.2 , we can see that the water monitoring system measure the volume of water that has been flowed is approximately 1.26 litre to 1.35liter. Therefore, there is a slight difference between the recorded data and the expected result. This had also happened when the water tap was open 100%. The higher of the water flow rate, the accuracy of this water monitoring system is lesser. This might be happened because there is no pressure on the system as the water flow through it without any resistance. So, the accuracy for this water monitoring system is about 64% which is relatively low. This result may be different according to the maximum flow rate in the pipeline.

4.3 Result

The results of the water flow monitoring system were achieved as in the expected results. All the obtain results have been summarized in the table below.

Table 4.2: Result that consists hardware with its input and output

Result			
No.	Hardware	Input	Output
1.	YF-S201 water flow sensor	• Water flow through the sensor	• Sent the data to OLED display (`display.print("….")`) • Sent the data to serial monitor (`serial.print("….")`)
2.	OLED Display	• Receive data from sensor	• Current Flow: `(current flowrate)` • Volume : `(total volume of water)` • Valve : `(valve state OPEN/CLOSE)`
3.	GSM Module	• o= Open Valve • c = Close valve • v= show the value of total water flow	• Show the current flowrate, volume of water and valve status
4.	Light Emitting Diode (LED)	• Receive input from application or SMS	• Green LED ON, Red LED OFF indicates that valve status CLOSE • Red LED ON, Green LED OFF indicates that valve status OPEN

Table 4.2 shows the inputs and the output obtained from the hardware used in this project. The YF-S201 water flow sensor will detect the water flow by calculating based on Table 3.1. The data from this sensor will be declared as "*flowrate*" for the current flowrate in litre per minute (l/m), while the total volume of water was declared as "*totalLitres*" in litre (l). Next, this data will be sent to OLED display by using "*display.print*" command. Because the Bluetooth module uses the serial port to transmit and receive data, the data will be sent using the

"*serial.print*" command. This data can also be accessed or monitored using Serial Monitor on the Arduino IDE application.

Users can view or monitor this by using several methods. The easiest way is by directly monitoring the data that was displayed in the OLED display. The OLED display will show the current flowrate (l/m), the total volume of water (L) also with the valve status either Open or Close. The second option or method to monitor this system is the SMS command. Several commands can be used to monitor and control this system by typing o, c, or v. Each alphabet has its unique function. For example, by typing "o," it will open the valve and "c" for closing the valve of the water monitoring system. The "v" command can be used to retrieve the data from the system, such as the flow rate, total volume, and valve status. The advantage of using this method is that users can monitor and control their system even if they are far from the site and don't have an Internet connection.

Meanwhile, user can also monitor their system wirelessly through Bluetooth protocol. A special development Android application called Water Meter needs to be installed in the mobile device to monitor by Bluetooth. These apps will allow the user to check the total volume of water and control the valve either Open or Close according to the needs. Moreover, this application has been integrated with the web-based database, making it much more efficient. Users only need to hit a single button or icon on the application, and then, all the information or data will be uploaded to the cloud. This will indirectly reduce the loss of data and save time. Users also can retrieve this data anytime around the globe as long they have an Internet connection.

The valve's status can be seen through the OLED display, the received SMS and the LED. Usually, the OLED display and SMS will state in "Valve: *OPEN/ CLOSE*." Meanwhile, if the green LED turns ON and the red LED turns OFF, it will indicate that the valve status is CLOSE and vice versa. The reason for using the red and green LED is that red LED will attract or notify the user to be aware because the valve is opening and ready to close when needed. This can be controlled by using applications and SMS from user devices.

Figure 4.3: LED, OLED display and SMS status during valve Close and Open

4.3.1 Software Part

The interface of the Android application was designed using MIT App Inventor. The apps' interface was intended simply to ensure users do not have any problems while using it. An application consisting of monitoring, controlling, and uploading the data to the cloud is shown below.

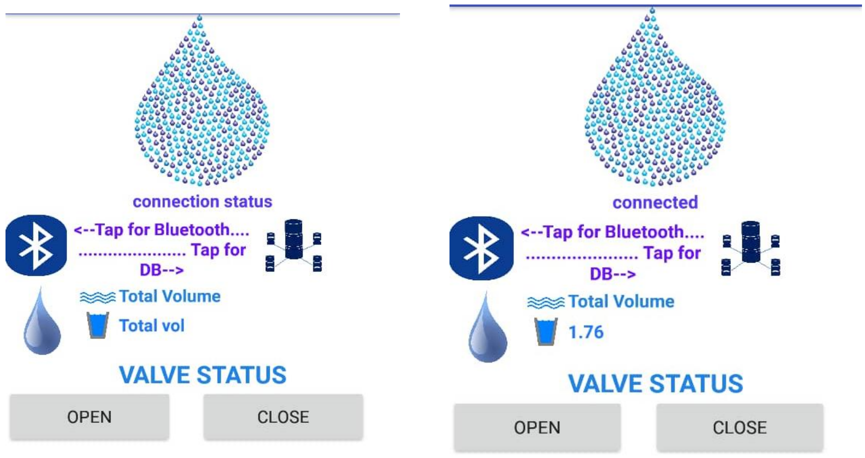


Figure 4.4: Interface of Android application

Figure 4.4 shows the interface of the application developed using MIT App Inventor. This app consists of a few icons or buttons that can operate the apps. The Bluetooth icon button on the left side connects the user mobile device to the water flow monitoring system within 20 meters. In the next section, user will be brought to the Bluetooth device selection as shown in Figure 4.5. To connect to the system, users must connect to the Bluetooth name HC-05 and wait for the connection to establish before proceeding to the next part. An error message will pop up as Figure 4.6 if there is some issue while connecting to the water monitoring system. This error will occur if the Bluetooth or the device is turned off, the monitoring system is already connected with another device, or the device is out of range. The Bluetooth status will change from “connection status” to “connected” when the Bluetooth connection is successfully paired.

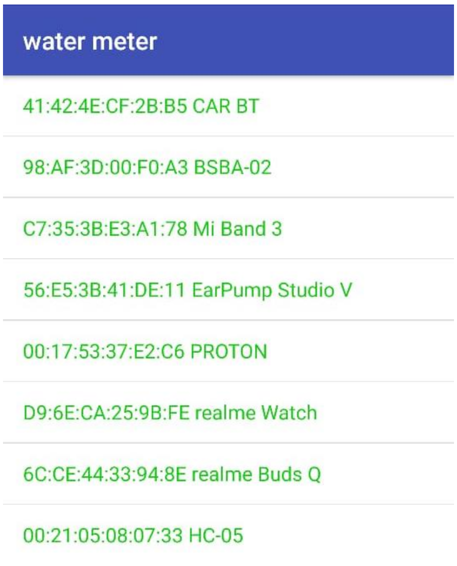


Figure 4.5: Bluetooth device selection

Figure 4.6: Error notification

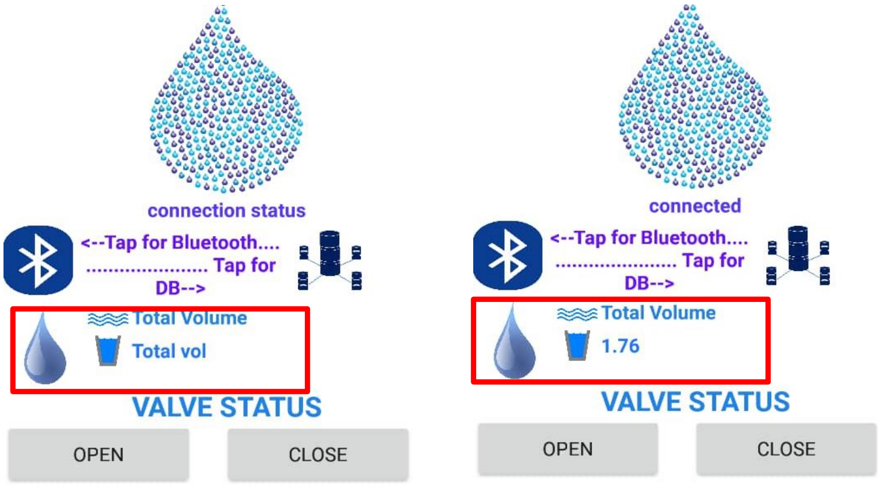


Figure 4.7: Total volume of water

The left of the app's interface's water drop icon on Figure 4.7 indicates the total volume of water measured in a litre (l). This value will synchronously automatically when connected to the water monitoring system Bluetooth module. The data was obtained from the controller's serial port for the water monitoring system, which is Arduino Nano. This data also can be seen on Serial Monitor on Arduino IDE if the system is connected to the computer.

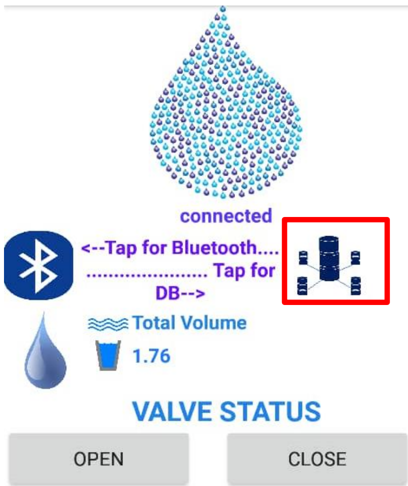
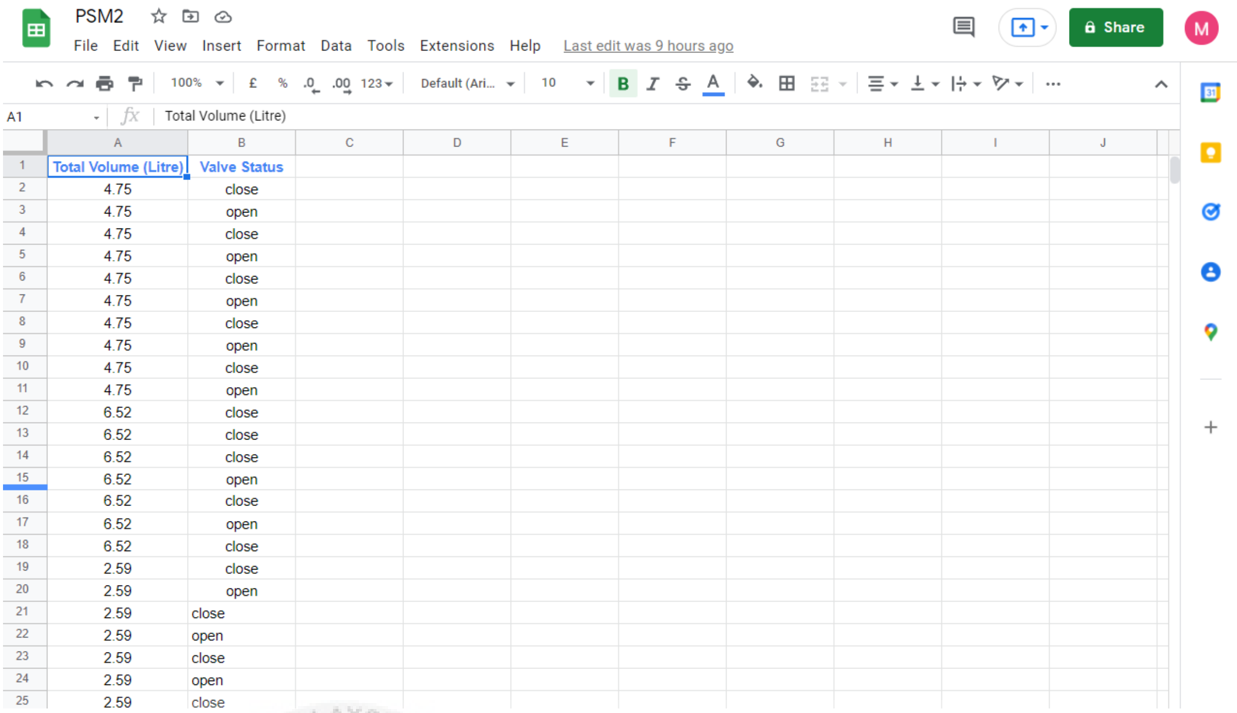


Figure 4.8: Database icon



	A	B
1	Total Volume (Litre)	Valve Status
2	4.75	close
3	4.75	open
4	4.75	close
5	4.75	open
6	4.75	close
7	4.75	open
8	4.75	close
9	4.75	open
10	4.75	close
11	4.75	open
12	6.52	close
13	6.52	close
14	6.52	close
15	6.52	open
16	6.52	close
17	6.52	open
18	6.52	close
19	2.59	close
20	2.59	open
21	2.59	close
22	2.59	open
23	2.59	close
24	2.59	open
25	2.59	close

Figure 4.9: Web-based database / Google Spreadsheets

Figure 4.9 shows the database icon on the specific Android application development interface used to upload or synchronous the volume of water to the cloud. By tapping or clicking the database icon as Figure 4.8, the data will be automatically uploaded or synchronous to the web database and can be accessed anywhere. In this process, users should ensure that the mobile device's network is enabled, else this process will never work. The uploaded data can be seen in Figure 4.8, where the volume of water was labelled as "Total Volume (Liter)," and the valve status also will be shown in "Valve Status."

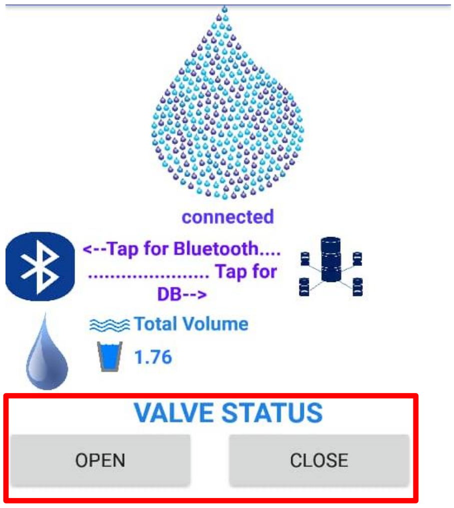


Figure 4.10: Valve status

Figure 4.10 shows the two buttons on the application interface that will control the status of the water monitoring system valve. This button will control the valve status either Open or Close based on users' needs. Every time the button was clicked or tab, if there is Internet access to the mobile device, it will become automatically synchronize the data to the cloud and remake the valve status. The valve can also be controlled by sending SMS with "o" for opening the valve and "c" for closing the valve.

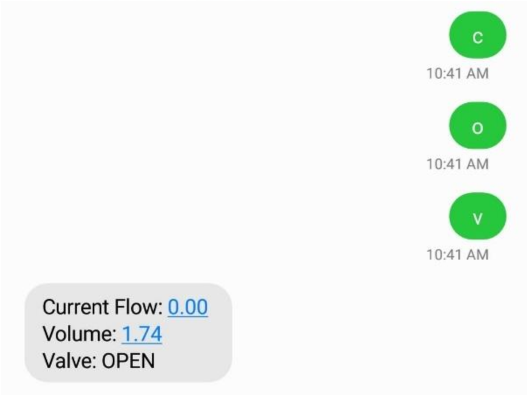


Figure 4.11: Interface from SMS

Figure 4.11 shows the interface for sending and receiving SMS from the water monitoring system. To open and close the valve, users need to send SMS with the alphabet "o" and "c." Meanwhile, users need to send SMS with the alphabet "v" and wait for the system reply to retrieve the data. If everything were configured correctly, users would be able to get the reply from the system with the current water flow status, the volume of water, and the valve status.

4.3.2 Hardware Part

Based on the hardware part, several techniques and configurations are used to ensure that the project is complete and working successfully. This part contains three main sections: the power supply, the water flow monitoring system, and the case or design of the prototype.

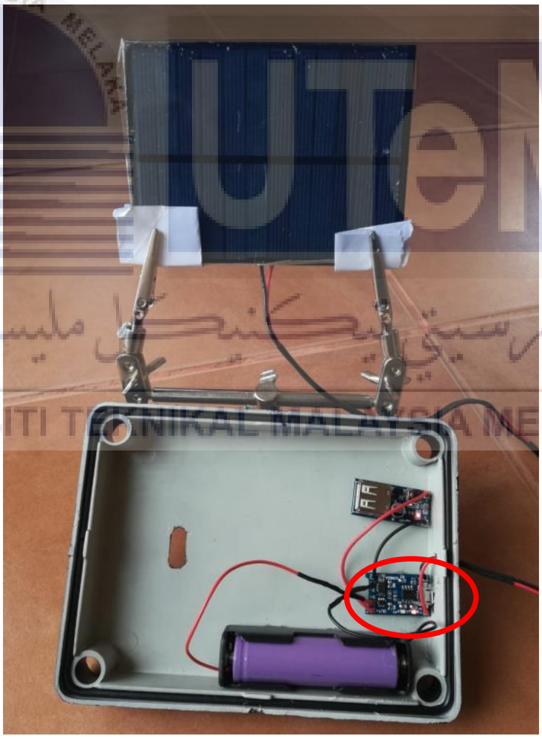


Figure 4.12: Power supply circuit

Figure 4.12 above shows the power supply's circuit construction to power up the water monitoring system. This power supply uses a 3.7V 200mAh battery to store the energy harvested from the solar panel. Rather than use a solar panel, user also can charge the battery using a standard phone charger because this power supply can receive 5V 1A at max, and it takes around 3-4 hours to charge from 0% to 100% fully. As in the figure above, the LED turn red indicates that the battery is in charging mode and will turn blue when fully charged. On fully charged, this power supply can provide enough power to run the water monitoring system for up to 6 hours. For best performance, user advises using a DC power supply rather than a solar panel to provide constant power to ensure the system runs without any problem.

Figure 4.13: Water flow monitoring system circuit configuration

Figure 4.13 shows the circuit configuration for the water monitoring system that has been combined into one breadboard and connected. This will allow the system to work properly. The pin configuration and the circuit diagram can be seen clearly in Table 3.2 and Figure 3.18. This circuit consists of a sensor, microcontroller, and a few data transmission modules that allow users to transmit and receive to and from the system. All the components have its position to be placed in the prototype. For example, the sensor or YF-S201 (numbering as 1 in Figure 4.13) water flow sensor was placed between two 3/4-inch (20mm) PVC pipes to measure the water that will be passed through it.

Meanwhile, Arduino Nano (numbering as 2 in Figure 4.13) was placed exactly beside the sensor to lower the latency while receiving data from the sensor. Furthermore, the Bluetooth module (numbering as 3 in Figure 4.13) was placed close to the prototype edge case to lower the obstruction when connecting to the mobile device. This will extend the connectivity range and reduce the time to connect the water monitoring system to the mobile device. On the other hand, the OLED Display (numbering as 4 in Figure 4.13) was placed on the top of the prototype while, GSM module (numbering as 5 in Figure 4.13) can be placed anywhere because it has a tiny antenna.

Figure 4.14: OLED Display interface

Figure 4.15: LED indicator

As in Figure 4.14, the OLED display is placed on the top of the prototype case. This is the best position for users to monitor their water monitoring system status. This display will show the current flow rate, water volume, and valve status. The LED will act as an indicator for the valve, and it is placed on the side of the prototype. The LED that used was bright enough and can be seen easily in the daytime. The green LED will light up, and the red LED will turn off when the valve status is CLOSE. The OLED display in Figure 4.14 also will state the "Valve: CLOSE." When the red LED lights up, and the green LED turns off, it indicates the valve is in OPEN condition, and the OLED display immediately changes from "Valve: CLOSE" to "Valve: OPEN."

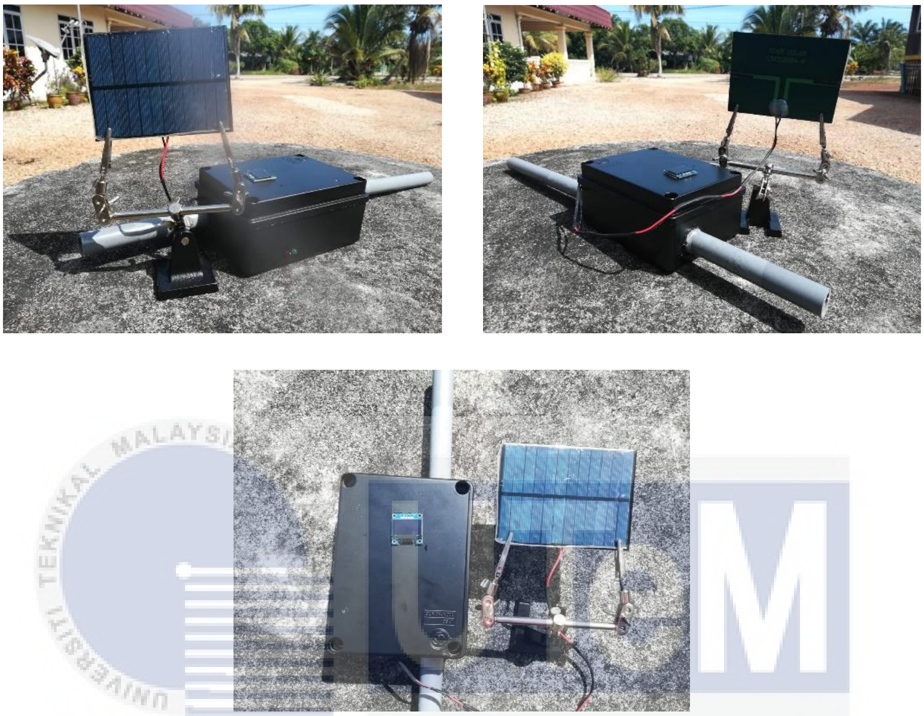


Figure 4.16: Water monitoring system prototype

Figure 4.16 shows the complete prototype. The case was made from a normal electrical box (110mm x 150mm x75mm) that has been modified to keep the components securely. Moreover, this box also uses high-quality plastic material and has an IP56 certificate which is good enough to be use as prototype case. The 1.1W (6V 200mA) solar panel is also connected directly to the box, and the position can be adjusted toward the solar source, as shown in Figure 4.17.

Figure 4.17: Solar panel stand

Figure 4.18: DC supply

As this water monitoring system can be powered with a DC supply or solar panel, micro-USB ports have been placed beside the input from the solar panel (inside red rectangle) as in Figure 4.18. This is because the DC supply and solar panel are using the same circuit to charge the Li-ion battery.

4.4 Summary

In summary, the prototype of the water monitoring system was successfully constructed according to the design in the previous chapter, together with the function of the sensors. This monitoring and controlling were managed to function even there were delayed interactions between the transmission module with the developed application. Based on the result that was obtained, the distance of the water monitoring system with the mobile device will affect the connectivity stability and may cause unable to connect when it reaches its limit.

CHAPTER 5

CONCLUSION AND FUTURE RECOMMENDATION

5.1 Introduction

This chapter inspects the conclusion for the whole project of the water monitoring system and the recommendation for future work and research. The data analysis, procedure, past research, and main component of the system culminate. Future recommendations are being analyzed for more efficient work and functions for the upcoming water monitoring system project.

5.2 Conclusion

As conclusion, the water monitoring system was constructed to give users information about their water usage. This project aims to design and develop a device or system that can allow users to monitor their water consumption. Thus, the project goal is to study the characteristics and functionality of the water monitoring system. The other objective is to design and develop a water monitoring system that can connect wirelessly to our device. The water monitoring system consists of two wireless communication that allow users to send a command and receive feedback.

The next objective is to analyze in terms of functionality and monitor the flow of water through the mobile application. The YF-S201 water flow sensor will calculate the water that passes through and send the data to the microcontroller. Then users can monitor by looking directly at the system because it has an integrated display or sending an SMS command to get feedback. Moreover, users also can connect the mobile device to the system via Bluetooth. By using the

Android application that has been developed, users control and updated the data to cloud.

Chapter 3 explained about the methodology for development of this prototype along with hardware and software that were used. While, Chapter 4 had discussed the data analysis and the functionality of every software and hardware in the water monitoring system. At the end of the project, the water monitoring system can achieve all the objectives and function as expected. Apart from that, this water monitoring system also has weaknesses and need some improvement, but it was easy to use.

5.3 Recommendation for Future Work

This project has a few improvements that can be made with a specific objective to improve the accuracy and reliability of the current process. Thus, accurate and suitable component selection can be used to improve the reliability of the water monitoring system for future work to match with the latest technology. Hence, the recommendations for the future water monitoring system are as follow:

- Change to high quality of water flow sensor to increase its accuracy.
- Use solar panel that have much higher power that match the battery capacity to lower the charging time when using solar energy as main power supply.
- Increase the battery capacity to ensure the water monitoring system can last longer without external source.
- Change the controller to ESP32 or other microcontroller that was small enough and have integrated Wi-Fi and Bluetooth connectivity.
- Use Wi-Fi technology so the data can be uploaded automatically to the database

REFERENCES

[1] X. Chen, S. H. Yang, L. Yang, and X. Chen, "A benchmarking model for household water consumption based on adaptive logic networks," *Procedia Eng.*, vol. 119, no. 1, pp. 1391–1398, 2015, doi: 10.1016/j.proeng.2015.08.998.

[2] A. Ray and S. Goswami, "IoT and Cloud Computing based Smart Water Metering System," *2020 Int. Conf. Power Electron. IoT Appl. Renew. Energy its Control. PARC 2020*, no. January, pp. 308–313, 2020, doi: 10.1109/PARC49193.2020.236616.

[3] M. J. Mudumbe and A. M. Abu-Mahfouz, "Smart water meter system for user-centric consumption measurement," *Proceeding - 2015 IEEE Int. Conf. Ind. Informatics, INDIN 2015*, no. July 2015, pp. 993–998, 2015, doi: 10.1109/INDIN.2015.7281870.

[4] D. Anandhavalli, K. S. Sangeetha, V. P. Dharshini, and B. L. Fathima, "Smart Meter for Water Utilization using IoT," *Int. Res. J. Eng. Technol.*, vol. 05, no. 04, pp. 4–7, 2018, [Online]. Available: https://www.irjet.net/archives/V5/i4/IRJET-V5I4221.pdf.

[5] M. Kalimuthu, A. S. Ponraj, and J. Christy Jackson, "Water management and metering system for smart cities," *Int. J. Sci. Technol. Res.*, vol. 9, no. 4, pp. 1367–1372, 2020.

[6] R. Deshmukh, V. Bankar, and V. Bandagale, "Cloud Based Smart Water Meter," vol. 9, no. 4, pp. 61–63, 2018.

[7] Vatsala Sharma, "Arduino based Smart Water Management," *Int. J. Eng. Res.*, vol. V9, no. 08, pp. 652–656, 2020, doi: 10.17577/ijertv9is080239.

[8] N. A. J. Salih, I. J. Hasan, and N. I. Abdulkhaleq, "Design and implementation of a smart monitoring system for water quality of fish farms," *Indones. J. Electr. Eng.*

Comput. Sci., vol. 14, no. 1, pp. 45–52, 2019, doi: 10.11591/ijeecs.v14.i1.pp45-52.

[9] S. Mishra, A. Srivastava, and V. K. Mall, "GSM Controlled Automatic Irrigation System," *Int. J. Eng. …*, vol. 0869, no. 8, pp. 22–24, 2017, [Online]. Available: https://media.neliti.com/media/publications/264951-gsm-controlled-automatic-irrigation-syst-a903b7f5.pdf.

[10] A. I. Abdelkerim, M. M. R. S. Eusuf, M. J. E. Salami, A. Aibinu, and M. A. Eusuf, "Development of solar powered irrigation system," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 53, no. 1, 2013, doi: 10.1088/1757-899X/53/1/012005.

[11] P. Arun Mozhi devan, K.Pooventhan, C.Mukesh Kumar, R.Midhun kumar, "IoT Based Water Usage Monitoring system Using LabVIEW,"., no. March, pp. 333–338, 2019, doi: 10.1007/978-3-030-01659-3_23

APPENDICES

Appendix A

```
#include <SoftwareSerial.h>
char inchar;
SoftwareSerial SIM800(11, 10); // gsm module connected here.
String TextForSMS;
String message;

char Incoming_value = 0;

String State = "CLOSE" ;

int greenled = 4;
int redled = 5;

#include <Wire.h>
#include <SoftwareSerial.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>

#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 64 // OLED display height, in pixels

#define SENSOR  2

Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire);

long currentMillis = 0;
long previousMillis = 0;
int interval = 1000;
float calibrationFactor = 4.5;
volatile byte pulseCount;
byte pulse1Sec = 0;
float flowRate;
unsigned long flowMilliLitres;
unsigned int totalMilliLitres;
float flowLitres;
float totalLitres;

void pulseCounter()
{
  pulseCount++;
}
```

```
void setup() {

  Serial.begin(9600);
  SIM800.begin(9600);

  pinMode(SENSOR, INPUT_PULLUP);

  pinMode(4,OUTPUT);
  digitalWrite(4,HIGH);
  pinMode(5,OUTPUT);
  digitalWrite(5,LOW);

  pulseCount = 0;
  flowRate = 0.0;
  flowMilliLitres = 0;
  totalMilliLitres = 0;
  previousMillis = 0;

  display.begin(SSD1306_SWITCHCAPVCC, 0x3C);
  attachInterrupt(digitalPinToInterrupt(SENSOR), pulseCounter, FALLING);

  randomSeed(analogRead(0));

  SIM800.print("AT+CMGF=1\r");  // set SMS mode to text
  delay(1000);
  SIM800.print("AT+CNMI=2,2,0,0,0\r");
  delay(1000);

  SIM800.println("AT+CMGD=1,4"); // delete all SMS
  delay(5000);
}


void sendSMS(String message)
{
  SIM800.println("AT+CMGF=1\r");                    // AT command to send
SMS message
  delay(1000);
  SIM800.println("AT+CMGS = \"+60173125661\"");    // recipient's mobile
number, in international format
  delay(1000);
  SIM800.println(message);                          // message to send
  delay(1000);
  SIM800.println((char)26);
  delay(1000);
  SIM800.println();
  delay(1000);                                      // give module time to
send SMS
                                                    // turn off module
}
```

```
void loop()
{

   currentMillis = millis();
   // Every second, calculate and print litres/hour
   if(currentMillis - previousMillis > interval)

   {
    pulse1Sec = pulseCount;
    pulseCount = 0;
    flowRate = ((1000.0 / (millis() - previousMillis)) * pulse1Sec) / 
calibrationFactor;
    previousMillis = millis();

    flowMilliLitres = (flowRate / 60) * 1000;
    flowLitres = (flowRate / 60);

    totalMilliLitres += flowMilliLitres;
    totalLitres += flowLitres;

      display.clearDisplay();
      display.setTextColor(WHITE);
      display.setTextSize(1.5);
      display.setCursor(35,0);
      display.print("AIDIL PSM");
      display.setCursor(5,30);
      display.print("Current:  ");
      display.print(float(flowRate));
      display.print(" l/m");
      display.setCursor(5,40);
      display.print("Volume:   ");
      display.print(totalLitres);
      display.print(" L");
      display.setCursor(5,50);
      display.print("Valve  :   ");
      display.print(State);

      Serial.print(totalLitres);

    }

else if(Serial.available() > 0)
  {
    Incoming_value = Serial.read();

    if(Incoming_value == 'a')
    {
      digitalWrite(5, HIGH);
      digitalWrite(4, LOW);
      State = "OPEN";
    }
    else if (Incoming_value == 'b')
    {
      digitalWrite(5, LOW);
      digitalWrite(4, HIGH);
      State = "CLOSE";
    }
  }
```

```
  else if(SIM800.available() == 0)
  {

  }

   else if (SIM800.available() > 0)

   {

    inchar=SIM800.read();
    Serial.println(inchar);
    delay(20);
        if (inchar=='v')
        {
        delay(10);

        Serial.println(inchar);

        SIM800.println("AT");

        SIM800.println("AT+CMGF=1");                    // Configuring TEXT mode

        SIM800.println("AT+CMGS=\"+60173125661\"");   //phone number

    float h = flowRate;
    float t = totalLitres;
        SIM800.print("Current Flow: ");                          // message to send
        SIM800.print(h);
        SIM800.print("\nVolume: ");
        SIM800.print(t);
        SIM800.print("\nValve: ");
        SIM800.print(State);
        delay(5000);
        SIM800.println((char)26);
        delay(1000);
        SIM800.write(26);
        delay(1000);                     // give module time to send SMS
        }

        else if(inchar=='o')
        {
        digitalWrite(5,HIGH);
        digitalWrite(4,LOW);
        State = "OPEN";
        }
        else if(inchar=='c')
        {
        digitalWrite(5,LOW);
        digitalWrite(4,HIGH);
        State = "CLOSE";
        }
    }

  display.display();

}
```

Appendix B

	Week																											
	BDP 1														BDP 2													
Task / Progress	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Briefing About BDP 1																												
Confirmation Research Project Title																												
Briefing Chapter 1																												
Background Of Study																												
Problem Statement																												
Objective, Project Scope																												
Briefing On Chapter 2 (Literature Review)																												
Research For Previous Related Project																												
Sorting Important From Previous Project																												
Literature Review Writing																												
Submission Draft Chapter 1, Logbook And Project Progress																												
Methodology																												
Expected Result																												
Submission Draft For Chapter 2,3 And 4																												
Correction And Submission Of BDP Report 1																												
Preparation And Presentation Of BDP 1																												

Appendix C

Task / Progress	Week																											
	BDP 1														BDP 2													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Briefing On BDP 2																												
Configuration For Hardware Implementation																												
Configuration For Software Implementation																												
Result And Analysis																												
Finalized Report For BDP 2																												
Preparation For Presentation Of BDP 2																												
Presentation Of BDP 2																												