PHOTOVOLTAIC WATERING PLANT SYSTEM WITH IoT

LEONG LEK CHUNG

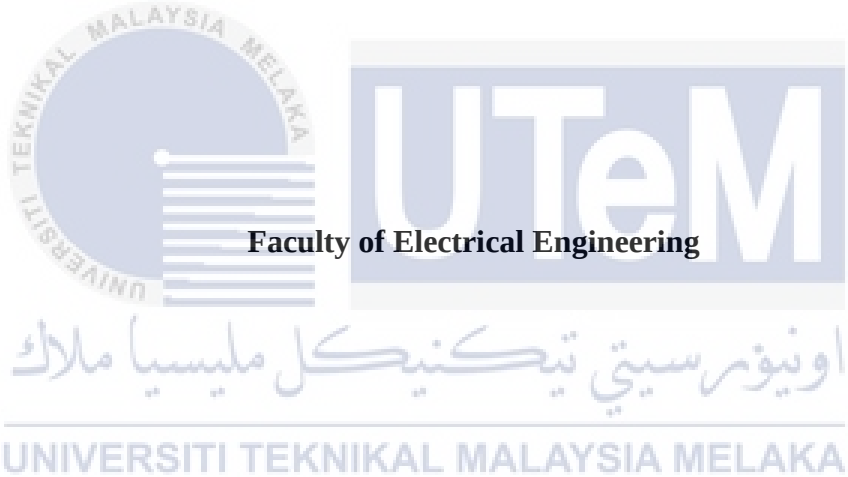
Bachelor in Electrical Engineering (Industrial Power)
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

July 2021

PHOTOVOLTAIC WATERING PLANT SYSTEM WITH IoT

LEONG LEK CHUNG

A report submitted
in partial fulfillment of the requirements for the degree of
Bachelor in Electrical Engineering (Industrial Power)



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

July 2021

DECLARATION

I declare that this thesis entitled Photovoltaic Watering System with IoT is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Name : Leong Lek Chung

Date : 05/07/2021

APPROVAL

I hereby declare that I have checked this report entitled “Photovoltaic Watering System with IoT” and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours.

Signature : .....

Supervisor Name : DR. ELIA ERWANI HASSAN

Date : 5 JULY 2021

DEDICATION

This dissertation is dedicated to my beloved family members who support me to pursue and complete my paper.

ACKNOWLEDGMENT

First and foremost, I would like to appreciate and deepest thank our University Teknikal Malaysia Melaka that had provided a project degree subject for the student. This is a good opportunity for a student to gain experience in project and knowledge. Therefore, students have a subject for them to research on their project.

Next, a big appreciation is given to all those who are involved in preparing this report directly and indirectly. Those people had done a lot in helping me to prepare this report to ensure that this report is a success. A special thanks is given to my Degree project coordinator, Dr. Nurdiana Binti Nordin who has given her effort to support the students in preparing the project.

Then, I am quite appreciating to my faculty of Electrical Engineering which has lent me the electronic components and instruments to assist me in building a presentable prototype. The quality of the component is so good and robust which gives a high precision and consistent result. Without the helping hand from the faculty, I believe it would be another troublesome that could not be easily solved.

I also would like to express my appreciation to my project supervisor, Dr. Elia Erwani Binti Hassan who willing to guide and encourage me to finish the project on time. The knowledge and technique in reporting where my supervisor has been shared before are valuable and meaningful. I appreciate her effort in giving me full guidance to complete the project within the period given.

Moreover, I also would like to thanks my friends who gave me full support in my project. We shared information and exchange our thought together on the discussion topic. They provided mental support to me and helped me in releasing my pressure so I could finish my project.

My biggest thank goes to my family for their unlimited support in making me successful in this project. Family support is not only about mental but physical as well. The family would contribute to clean and maintain a pleasant environment for study which help me to be able in staying focus for a longer time of period.

ABSTRACT

In this era, agriculture is important to fulfill the food demand from people. Although the crops harvested are increasing from year to year but the price of crops selling in the market doesn't seem to be able to maintain. Therefore, the maximization of crops yielding is still a big issue faced by the population in a country. There is still farmer out there who are using the conventional method to do their irrigation to the crops. Conventional irrigation needs a lot of human intervention to operate a water pump. The time taken for irrigation is being controlled in a personal way as the farmer cannot count exactly the water volume that has been given without using any instrument. The solution to improve this scenario is to apply the IoT idea to agriculture. Numerous type sensors which comprised of the temperature sensor, humidity sensor, soil moisture sensor, flux sensor and water flow sensor are being used to measure the living condition of crops. The sensors' data will then be processed and stored in the personal cloud. Solar power generation will be the further trend to reduce carbon emissions. Solar energy is easy to be captured by using solar modules and has a zero cost price during the energy generation process. Therefore, Solar equipment setup can be set as near as possible to their load or battery storage side. Meanwhile, solar energy sustainability is being to be considered as well due to the fluctuation of energy production amount. Furthermore, water resource is vital in agriculture field. Excessive water being driven into the soil can cause root stress. The root of plants being submerge in the high soil moisture for a long period can cause immediate degradation. Hence, a Fuzzy Logic controller is being implemented to control the water volume being given. The objective of the Fuzzy Logic controller is to replenish the water content losses during the evapotranspiration process. Throughout the experiment, the Fuzzy Logic controller helped in controlling the best suitable water volume and shown the result which approximate to actual evapotranspiration real data.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST OF SYMBOL AND ABBREVIATION

V	-	Voltage
A	-	Ampere
℃	-	Degree Celsius
Wh	-	Watt-hour
g	-	Gram
Ω	-	Ohm

LIST OF APPENDICES

CHAPTER 1

Introduction

1.1 Project Background

This project is about to introduce an irrigation system combined with technology sensors to get a better amount of plantation yields. Since the irrigation system is connected with technology devices, it would require a certain amount of electrical energy to power up. Therefore, it is suggested to the used photovoltaic system supply the necessary electricity which could keep the water pump and sensors to be able to work in normal condition [1]. The photovoltaic system mainly converts solar energy into electrical energy. Solar energy is one of the renewable energies and it can be capture from daylight. This energy is well-known for its eco-friendly characteristic since there will have no toxic gas or polluted matter would be produced during the process of energy conversion.

Normally, a farmer will spend plenty of time irrigating their crops at a particular time like early in the morning or evening. But it might miss out on some details like soil moisture or humidity in the air [2], [3]. With the rapid growth of technology, it can be assigned to the right reaction to take care of the crops. There are a few parameters that need to be controlled to maximize the yield growth. The quality of soil, air, nutrient, and weather condition are quite crucial in determining the condition of yields. But all of these factors cannot be simply observed through the laid eyes or bare hand. Therefore, the sensor will work for the human to measure the physical input and convert it to a digital form of data. In this project, there will have a soil moisture sensor, temperature sensor, humidity sensor, and water flow sensor. With all these sensors, the irrigation system can be fully automated without requiring human intervention.

There will be a huge amount of raw data to be collected from the sensor. Raw data would not be meaningful and usable without visualization of the graph, diagram, table, or any other presentation method. Therefore, a friendly user interface is crucial to let people

be able to read and interpret the data to determine their next moves. The user interface is developed by using Google Sheet. Google sheet is a good platform to store data online. All the data being recorded will be attached in real time and date. Therefore, the data if the sensors or pumps were facing any failure. It can be detected through the dashboard that has been created on Google sheet. For the prevention of farmers from missing out on any details, the dashboard will send a daily data report to keep farmers updated.

The power source is crucial for every electronic device to keep working in normal condition. In this market, there are many available ways to give power supply to the technology sensor, electric pump, and microprocessors like motor-generator, direct power supply from residential area, wind energy generation, etc. Thus, in this project, it is proposed to use a photovoltaic panel to generated electricity. Since the crops are always been planted in an open area and this area will always be exposed to the sunlight. Therefore, it will be the right choice to choose a photovoltaic panel as the main power source. The photovoltaic panel alone will generate a fluctuate and versatile electrical power. A poor power quality that is being delivered to sensitive sensors and microprocessors will lead to semiconductor damage or even explosion. To prevent such a scenario to have occurred. A device called a solar charge controller is needed to be integrated with a photovoltaic panel to maximize and stabilize the power output.

1.2 Problem Statement

The electrical fee is getting expensive as compare with young age. In our country, there is a huge percentage of electrical energy is being produced by conventional fuels like fossil fuel, coal, natural gas, etc [4]. Conventional fuel is classified as non-renewable energy. This fuel cannot be manufacture by any manufacture instead it is extracted from the deep below surface of Earth. Besides that, fossil fuel does emit a lot of carbon monoxide, nitrogen dioxide, hydrocarbons, and other toxic gases. These gases bring an impact on the environment and the human body as well. It is a thinning surface of the ozone layer and gives way for a strong Ultraviolet (UV) ray to be passed through. Human skin cells can be died off easily for a long period of exposition with UV rays and chances

to get skin cancer is a high possibility [5]. Therefore, fossil fuel is hazardous and is not eco-friendly.

Traditional irrigation will waste a lot of water resources to irrigate the crops. The farmer will make a habit to water its crops at a particular time regardless of weather conditions. When it is during raining season, farmers will carry out it same routine to walk down the field to do irrigation, pesticide action, and weeding action. But with modern technology, it can show that it is not necessary to do such a routine every day. There are a few parameters that were not counted by farmers like weather forecast, air humidity, ambient temperature and soil moisture [6]. Besides that, the irrigation system is not built to be perfect. The material defect on water piping, blockage on sprinkle head and leakage of water piping are quite common to happen periodically. There will have no notification to the farmer unless there is someone is reporting the issue. When issues come up, remedial work needs to be done as quickly as possible since it will affect the yield of crops. Therefore, a monitoring system needs to be established to present the farmer with a better inside view of the quality of its crops.

The health condition of crops can always be unknown if there is no sign of yellowish color on leaf or fruit. Whenever the crops have shown signs of sickness, they might not be consumable or usable. The health condition of crops can be affected by surrounding temperature, air humidity and soil humidity. In high-temperature condition, the crops will lose their water content in a rapid process. Water content losses will result to have small size of crops. Besides that, air humidity will affect the respiratory system of crops. When the environment is too humid, it will attract the fungus or spores to reproduce on the surface of the leaf which will cause the crops to fall sick. Next, appropriate soil humidity will provide a good condition for the root part to absorb nutrients for the growth of crops. Hence, the ambient temperature, air humidity and soil humidity should be able to monitor to evaluate the health condition from time to time.

1.3 Objectives

- To supply electrical energy for a prototype watering system for soil area of $0.03m^2$ using a photovoltaic (PV) system.

- To observe the parameters for a better quality of crops by using the sensor like soil moisture sensor, temperature sensor, humidity sensor, flux sensor and water flow sensor to link with IoT system.

- To design Fuzzy Logic controller for smart watering system with IoT.

1.4 Scope of project

This project is focused to design a watering system with IoT. Although the established traditional irrigation is simple to operate and cheap to maintain. But there are so many limitations to the existing system. The efficiency will always be unknown without using a scientific method or being calculated through a computer. The issues that existed a long time ago can be solved by modern solutions.

A well-organized project scope gives a tangible objective for the reader to be easier to understand the message that wishes to convey. The scope of this project is limited to the following statements.

- Designing an automated watering system by using electrical board NodeMCU which is powered by PV.

- Implementing DHT 22 sensor to detect, measure and transmit data of ambient temperature and air humidity to the microprocessor.

- Utilizing light sensor BH1750 to record lux value and soil moisture sensor to read the water content percentage of the soil.

- Storing the collected data on personal cloud and presented on a graphical dashboard through platform Google Sheet.

- Controlling the operation time of the water pump precisely and fulfilled the demand of water resources needed by using Fuzzy Logic control.

- The prototype of the soil area is 0.3m x 0.3m x 0.3m.

1.5 Project overview

The project overview is proposed as shown in figure 1.1. The microprocessor that has been selected as the processing unit is NodeMCU 32. NodeMCU 32 will take part in processing the input data from all the sensors. The reaction will then be taken to determine the amount of water need for irrigation.

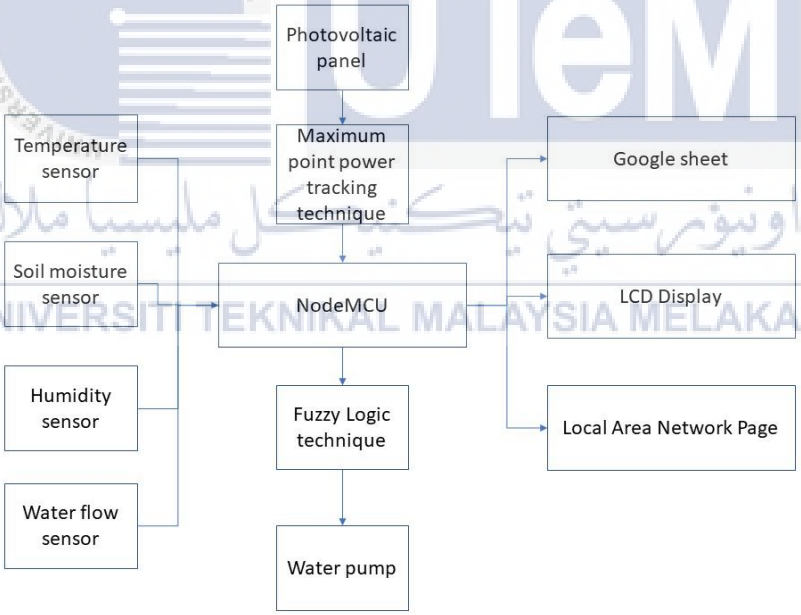


Figure 1.1 Flow chart of the watering system prototype

The Fuzzy Logic method is one of the control systems that used to precise the output value based on multiple inputs. Mandani Fuzzy interference system will be implemented.

The project is power by a photovoltaic system. Although solar energy is small as compared with direct supply for the building but it is more than enough to power all the electronic gadgets. The photovoltaic system will be controlled by the maximum power point tracking technique. When a photovoltaic module is placed in an open area, the surrounding temperature will affect the output rating of the photovoltaic module. This technique would maximize the performance of the photovoltaic module to produce the maximum energy as much as it could.

Next, the collected data from all sensors will be shown online. This real-time data will be recorded in a Google Sheet that is linked with a personal Gmail account. The data will be presented in a graphical chart instead of showing a bunch of data. The LCD is the main for display the condition photovoltaic system. A photovoltaic system can be used to charge the backup battery to ensure the irrigation system can function properly even though it is at night time.

NodeMCU 32 is good to have small size and there are Wi-Fi and Bluetooth module has been embedded in a small piece of electronic board. It is quite convenient to add on extra system, sensor or controlling device in the further.

1.6 Summary

In this chapter, it has been proposed the idea of photovoltaic system-based irrigation with IoT. The whole project will be powered by a photovoltaic system as solar energy is free of charge and no carbon emission occurred. Photovoltaic will be controlled by the maximum power point tracking technique. The health condition of crops will be monitor by using various kinds of sensors like soil moisture sensor, temperature sensor, humidity sensor, flux sensor and water flow sensor. The collected sensor data will be displayed on a Google Sheet. Next, the irrigation process is controlled by using the Fuzzy Logic method to maintain the best environmental condition for crops to grow.

CHAPTER 2

Literature Review

2.1 Introduction

This chapter will review more detail about the idea of a photovoltaic-based irrigation system with IoT. Many similar projects were taken as a reference from the previous research works. The following section will review on the related work for the photovoltaic system and smart watering system.

2.2 Photovoltaic system

The photovoltaic system is used to convert solar energy into electric energy. The magnitude of electric energy that could be produced is directly propositional to the amount of sunlight present. The photovoltaic system consists of a solar panel, voltage stabilizer and power inverter [7].

The photovoltaic panel is made of silicon which is one of the common materials on Earth. The photovoltaic panel needs to be doped with P-type and N-type silicon before it can fully function. By nature, the photovoltaic panel will capture the sunlight. When sunlight hits P-type, the potential difference between P-type and N-type material will drive the electron to move [8]. Hence electricity will be produced. The electricity generation process didn't emit any form of gas like fossil fuel or petroleum. Therefore, solar energy has been classifying as one of the cleanest sources of energy [9].

The performance of the photovoltaic panel is sensitive to solar radiation, ambient temperature and humidity as well [10]. The generation of voltage and current can be varied from time to time. The fluctuation of electrical energy can trigger several electrical failures like overcurrent, undervoltage, electrical harmonics, etc [11]. Therefore, a voltage stabilizer is needed to be connected with a photovoltaic panel instead of directly

plug into the load. The voltage stabilizer will feed constant voltage and limited current to protect the electronic gadget from getting damage [12].

The photovoltaic panel would produce direct current and direct voltage. However, the power rating of the load circuit will not be the same as the photovoltaic panel. Therefore, a power converter is responsible to adjust the voltage amplitude to suit for needs of electronic circuit load [13]. There are two types of converter which are buck converter and boost converter. Buck converter is used to step down the voltage and step up the current from the power source. While the boost converter is operated in an opposite manner of the buck converter.

2.2.1 Photovoltaic system power controller

As the solar panel voltage will fluctuate due to changes in surrounding temperature and other atmospheric conditions. Therefore, a charge controller is recommended to couple between the solar panel and electrical load.

The charge controller can be built by two methods which are Pulse Width Modulation (PWM) technique and Maximum Power Point Tracking (MPPT) technique. The most significant difference between these two techniques is the efficiency of delivering electrical power. Under similar environmental conditions with the same radiation and surrounding temperature, the MPPT charge controller has 15% higher efficiency as compared to the PWM charge controller [14].

The PWM charge controller uses two MOSFETs to control the charging current to an energy storage tank. To produce a different level of charging rate, MOSFET is being used as a switch by manipulating the signal transmission to its Gate terminal. The Gate terminal signal frequency can be easily controlled by a microcontroller or discrete electronic components. Next, a comparator is needed to compare the voltage of both solar panels and energy storage tanks [15]. A comparator will determine the amount of PWM signal need to be injected into MOSFET. The ideology of the PWM charge controller only

depends on one parameter which is voltage value but the MPPT charge controller will count the surrounding temperature.

The MPPT charge controller is come up with an algorithm to predict the maximum output power point. Therefore, the charging power will vary with time. The classic algorithms that will be used are Perturbation and Observation (P&O). Perturbation and Observation measure the power output of the solar panel. The voltage value will be kept on changing either decrease or increase until the maximum power is obtained. The increment or decrement of voltage will be changing at a linear rate [16]. The problem that has been raised by the P&O algorithm is the value of maximum power will not come to a fixed point.

2.3 Irrigation system

Irrigation is a regular work for farmers to execute on the plantation estate. Raining water just doesn't provide enough water for the crops. Although raining water is a kind of free resource. But the quantity of rain water varies from time to time. The formation of rain water is affected by seasons. With sufficient water resources for the crops, it can have a better quality of growth. Therefore, an irrigation system is needed to help farmers to distribute the water resources evenly for every crop [17].

The irrigation system is an artificial application used to cover the water supplement to an area portion of crops [18]. In the irrigation system, water is being transmitted through various kinds of systems like conveyance system, distribution system, drainage system, etc.

Nowadays, there are some irrigation methods available in the market. The irrigation methods will bring effect to the growth of crops. A bad irrigation method could lead to soil erosion, environmental pollution or even as a ground for mosquitoes to breed. According to the report that is published by Institute for European Environmental Policy, it has listed several impacts brought by irrigation toward the environment for the long and short term [19]. The negative impact is significant as it increases over time. In general,

water is good for a plant to moisture its surrounding soil. In fact, it would decrease the soil strength when excessive amounts of water are poured into the soil [20]. Wet soil will expose the root to a high chance of getting a disease. Hence, the impact that brings to the environment needs to be minimized by using appropriate irrigation methods.

Overview, the irrigation method has been improved over time. There are various methods of irrigation and they can be classified into three main ways: furrow irrigation, drip irrigation and sprinkler irrigation. Difference methods will result to have different efficiency of irrigation, degree of soil erosion, and complexity.

2.3.1 Types of irrigation system

Irrigation is an artificial application to deliver water to the crops through different types of distribution lines like hose, pump, sprays and tube. The large scale of irrigation would bring up the environmental pollution. Soil erosion is the most common scenario that happens on the field. Soil erosion will endanger the structure crops and cause the total amount of yield to decrease. Therefore, different type of irrigation system is being improved to reduce the impact of irrigation toward environment [21].

Furrow irrigation is channeling the water by gravity [22] Water dispersed through the field is not evenly spread. A large stream of furrow irrigation will erode the soil and a small stream will flow only a short distance. Therefore, achieving uniform irrigation would require the limit the distance of water flow. Otherwise, the soil would be eroded quickly. The distance of water flow can be control by adjusting the slope of the burrow.

Drip irrigation is designed in a way of one dripper serve for only one plant. It can precisely moisture a particular area of the soil thereby it results in high revenue per unit of water resource. But the emitter can be easily blocked by residual in the water [23]. Therefore, water filtration is essential to segregate impurities.

The sprinkler irrigation system will carry water through a network of pipes under medium and high pressure and is forced through a nozzle [24]. In sprinkle irrigation

system, there are perforated pipe system and rotating sprinkler impact sprinklers. The sprinkler irrigation will apply water uniformly in all places within the sprinkle area. Water penetrates only to the root zone and the soil will not face with the issue of high-level water stress.

2.4 Internet of Thing in agriculture

Internet of Things (IoT) is an ideology to form a network that connects anything through the internet. The implementation of IoT requires plenty of devices that can communicate with IoT platforms. IoT platform is can be accessed through the Wi-Fi, Local Area Network (LAN), General Packet Radio Service and other method network connectivity methods [25].

The implementation of IoT in agriculture can solve the issue of resource usage efficiency, environmental pollution, and the effect that bring by climate changes or others. IoT in agriculture can be classified into three sectors as shown in figure 2.1 which are applications, services, and sensors. There will have a drastic improvement when a farmer has transformed their traditional farming method. The productivity of crops yield has been increased due to the implementation of IoT [26].

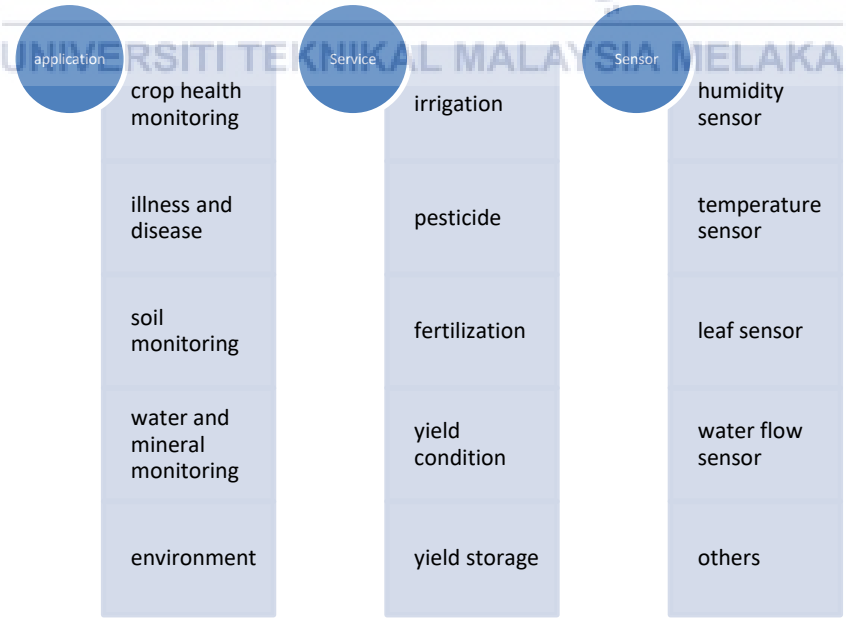


Figure 2.1 Figure IoT classification in agriculture