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Bachelor of Electronics Engineering Technology with Honours

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DEVELOPMENT OF DUAL AXIS SOLAR TRACKER WITH IOT MONITORING SYSTEM

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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



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DECLARATION

I declare that this project report entitled "Development Of Dual Axis Solar Tracker With IOT Monitoring System" 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.



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 Electrical Engineering Technology with Honours.

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DEDICATION

To my beloved mother, Norzaini Binti Othman, and father, Ku Mudzir Bin Ku Desa and

To my friends, Puteri Iffah Irdina Binti Izrul Syahril and Idham Zabidi



ABSTRACT

Solar energy is a technology used to obtain energy based on sunlight. Solar energy has been much of a traditional technology for centuries and is widely devoid of other energy supplies. Its use will be widespread if awareness is related to environmental costs and its supply is limited by other energy sources, such as fuel. Solar energy storage system is an effective technology to increase the efficiency of solar panels by detecting and following the sun's movements. With this system in place, solar panels can improve the way sunlight is managed, allowing for the production of more electricity since the solar panels can maintain a stable position. As a result, this project combines the development of a two axis solar tracker developer with the use of an Arduino Uno as the primary system's controller. To help in the development of this project, four of light-dependent resistor (LDRs) has been utilized for daily light execution and maximum light intensity. Two servo motors were utilised to turn the solar panel in response to the LDR's detection of the sun's light source. Next a WIFI ESP8266 device is utilised as an intermediate between device and Blynk application. Blynk is an online application that serves to store data, and this system is known as the Internet of Things (IOT). The system's capabilities have been evaluated and compared to those of single axis solar. As a result, a dual-axis solar system generates significantly more power, voltage, and current.

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ABSTRAK

Tenaga suria adalah teknologi yang digunakan untuk mendapatkan tenaga berdasarkan cahaya matahari.Tenaga suria adalah banyak tradisional teknologi selama berabad-abad dan adalah secara meluas tanpa adanya bekalan tenaga lain. Kegunaannyaakan meluas jika kesedaran berkaitandengan kos persekitaran danbekalannya dibatasi oleh sumber tenaga lain, seperti bahan bakar. Sistem simpanan tenaga suria adalah teknologi yang berkesan untuk meningkatkan kecekapan panel solar dengan mengesan dan mengikuti pergerakan matahari. Dengan adanya sistem ini, panel suria dapat meningkatkan cara pengelolaan sinar matahari, memungkinkan untuk menghasilkan lebih banyak tenaga listrik kerana panel surya dapat mempertahankan posisi stabil. Hasilnya, projek ini menggabungkan pengembangan pemaju pelacak solar dua-pakis dengan penggunaan Arduino Uno sebagai pengawal sistem utama. Untuk membantu pengembangan projek ini, empat perintangbergantungcahaya (LDR) telah digunakanuntukpelaksanaancahaya harian dan intensiti cahaya maksimum. Dua motor servo digunakan untuk memutar panel suria sebagai tindak balas terhadap pengesanan LDR mengenai sumber cahaya matahari. Seterusnya peranti WIFI ESP8266 digunakan sebagai perantaraanantara peranti dan aplikasi Blynk. Blynk adalah online aplikasi yang berfungsi untuk menyimpan data, dan sistem ini dikenal sebagai Internet of Things (IOT). Keupayaan sistem ini telah dinilai dan dibandingkan dengan tenaga solar paksi tunggal. Hasilnya, sistem solar paksi dua menghasilkan lebih banyak tenaga, voltan, dan arus.

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LIST OF SYMBOLS

PV Photovoltaic _ LCD Liquid Crystal Device -Light Dependent Resistor LDR -Internet of Things IOT _ Liquid Crystal Device LCD -Light Dependent Resistor LDR -Internet of Things IOT -



LIST OF ABBREVIATIONS

- Voltage Power V -
- Р -
- Current С _
- Percentage % _
- °C - Temperature in Degree Celcius



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CHAPTER 1

INTRODUCTION

1.1 Background

Due to the lack of electricity, mankind has always looked for the most available and environmentally friendly type of electrical energy in the course of growth [1]. Renewable energy is energy obtained from natural renewable natural resources, such as sunlight, wind, tides, hydropower, biomass energy and geothermal energy . Today, Malaysia regards solar energy as a viable renewable energy source. The country's power generation is 30,875.23 MW, of which solar panels account for 0.55 percent [3]. This shows that Malaysia has the highest solar radiation that can be used to generate electricity. Renewable energy sources, such as electricity, have surpassed fossil fuels as the primary source of electric energy. From now on, the extinction of fossil fuel resources is predicted to end over the next hundred years. Solar energy is the most effective energy for producing electricity generation when it comes to renewable energy. It is mostly used as a primary energy resource in countries with warm climates around the world. Solar technology is always accessible, inexpensive, pollution - free, and environmentally friendly. Diffused, direct and reflected solar radiation shown in Figure 1.1.



Figure 1.1 Types of solar radiation [1]

Furthermore, the issue with solar photovoltaics is their low performance. This is a challenge when it comes to generating the full amount of output power from sunlight. The only solution, according to researchers, is to increase the production of output power by implementing a solar tracking system. It is now commonly used in today's world of technology. It functions by aligning the solar PV panel so that it is perpendicular to the sun's radiation. The elements of electrics, electronics, and mechanics came together to build and design this solar tracking device.

The solar energy efficiency can thus be increased and enhanced by using a tracking system for solar PV. This system will assist in increasing the production power efficiency to achieve the best results.

1.2 Problem Statement

Solar panels were widely used in the globalized world to absorb the sun's rays as a source of energy that converts solar radiation to electrical energy. Most of the solar panels are in a static position which does not face straight forward to the sun. In Malaysia, fixed solar systems and single solar systems are the two most common types of solar systems. But fixed solar panel are lack of energy collection by sun throughout the day. However, the problem with both solar trackers is that they have a poor anti-interference function, particularly in terms of shading. Besides, the limitation of the solar system can be monitored via LCD only and not via an online system. Lastly, fixed solar panel is very expensive due to install more solar panels to produce enough power.

اونيونر سيتي تيڪنيڪل مليسيا ملاك 1.3 Project Objective UNIVERSITI TEKNIKAL MALAYSIA MELAKA

In order to maximize the efficiency of a great solar power system, a solar tracker is essential. This led to the three main goals of the project:

- a) To design a dual-axis solar tracker that moves independently in both the X and Y axes.
- b) To develope a monitoring system controlled by WI-FI module.

c) To analyze the output power parameters of solar panel.

1.4 Scope of Project

The development and design of an intelligent method using a solar tracking device is one of the project's goals. To get the best sun radiation, this system will use four LDR sensors on the top of the solar PV panel to determine the strength of light intensity. The solar PV panel's surface will be moved by the tracking device to orient and align with the incoming sunlight beam. Since the motors will rotate in a specific direction, two DC servo motors will be used in this design. The motors can switch into their desired positions, angles, and movements based on the signal emitted by the Arduino microcontroller.

There are two requirements that have been considered for this project, which are the software and hardware part that must be created. The hardware development part of this project is more focused on the Arduino, servo motors, LDR sensors and solar tracker mechanism. The Arduino is the suitable microcontroller for this project because it meets all of the project's requirements in terms of performance. The Arduino Uno's function is to control the entire system and transfer data to the Blynk application. A wifi module will be in charge of transferring data to the Blynk application.

If the LDR sensor detects and records the intensity of sunlight, the input device is working. Its sensitivity, location, and accuracy are the key factors. The motor drivers, also known as servo motors, were used in the project because of their ability to guide the location and control the solar tracker so that it moves in accordance with the sun. The first servo motor controls the vertical rotation of the solar panel, while the second controls the horizontal rotation of the solar panel. The solar tracker mechanism was developed and built to achieve the goal of creating a system that can monitor solar energy. Then use the ESP8266 WIFI device as an intermediary between the user and the IoT monitoring system. DHT 11 which is temperature and humidity sensor will be used to sense the temperature and humidity of the surrounding solar panel. Then, the data will be sent to the Blynk application within a second. In this project, a polycrystalline PV module 9 volt, 3 W will be used.

1.5 Chapter Outline

This report is divided into five chapters. All of these chapters are covered in the implementation of this project operation, which is about "Development of Dual Axis Solar Tracker With IOT Monitoring System."

Chapter 2 consists of a literature review. This section discusses previous research and studies that are relevant to this project. Previous studies used a different microprocessor as the main part of the movement mechanism and completed the entire process for the prototype. The microprocessors used in the previous research papers were Raspberry Pi 3 , ATMega 328, and Arduino Uno. All microprocessors are used in different proposals based on their advantages.

Chapter 3 discussed the methods employed in the development of this project. This project is divided into two major components: hardware and software. In general, this chapter will explain and explore the project development process briefly utilize flow charts and block diagrams to ensure a better knowledge of the process. It explains the techniques used in the project and the concept for developing the solar tracking prototype.

Chapter 4 summarizes the project's findings and analyses. The first section discusses software and hardware development, while the second section discusses monitoring a dual- axis sun tracker via the Blynk application. Following that, this chapter discusses the an analysis of the dual-axis solar tracker's output performance parameters.

Chapter 5 summarizes the project's findings. Additionally, recommendations are offered for future work to improve the dual axis sun tracker system and to broaden the scope of the evaluation.



CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Green energy, also known as regeneration energy, has recently received a lot of publicity. Green energy, including sun, water, wind, biomass, terrestrial heat, sea temperature differences, sea waves, morning and evening tides, and so on, can be recycled. Solar energy is the most efficient of these resources for generating electricity. For industrial continuous processes, a great energy source prospect is:

- Low cost to operate and build;
- There is almost no effect on the environment;
- Pleasant to the environment.
- Modular, and therefore flexible in terms of size and use;
- Exceptionally dependable and low-maintenance; SIA MELAKA

2.2 Solar Radiation Concept

In theory, when the sun emits solar radiation, it will emit solar radiation. Diffuse radiation and direct radiation are the two types of solar radiation. If the sunlight passes directly on the solar PV plate, this is known as direct radiation. Around 90 % of the solar radiation is carried by means of diffused energy radiation. In other words, diffuse radiation occurs when the sun is filtered due to temperature, wet environments, cloudy conditions, and other factors. It is primarily caused when solar energy is beamed into a cloud after being beamed into a solar PV panel. The biggest incident radiation that our planet has replicated is

energy radiation. This kind of radiation is called global radiation in photovoltaic solar panels[2].

2.3 Introduction of A Solar Tracking System

Generally, a solar panel tracking system is a device used to locate photovoltaic panels so that the angle between the sun and the surface of the solar panel is minimal during the day. When it is aimed directly at the light, it performs better because the output power's efficiency is at its highest. As a result, it will increase the project's complexity and budget, which is a disadvantage.

When the system rotates toward the sun and receives the maximum solar radiation intensity, the solar radiation intensity decreases. One of the benefits is that it can help maximize solar energy efficiency. The limitation is that the system's operation energy consumption will be high, making it difficult for the system to produce more energy than expected. Fundamentally, a well-organized solar tracking system must perform at its best in order to produce maximum output power while consuming minimal energy.

2.4 Electrical Application of Solar Energy

Today, the primary concern with solar energy is the generation of electricity from it via photovoltaic (PV) or solar cells. Solar cells of various varieties are being developed to boost their efficiency. Different parameters regarding photovoltaic module are described below:

a) PV Cells

Solar cells are a type of electronic device that successfully converts sunlight directly into electricity. Solar cells generate electricity when light strikes them. They create both current and voltage. This process consists of two components: a substance that absorbs light and raises an electron's energy state, and the transfer of this higher energy electron from the solar cell to an external circuit.



Figure 2.1Photo electric effect in PV cell

The figure 2.1 illustrates the fundamental operation. The basics involved in solar cell operation are:

• the production of carriers generated by light;

- the power dissipated in the load and parasitic resistances; LAKA
 - b) I-V Curve

The IV curve of a solar cell is the superposition of the IV curve of a diode in the dark and the current produced by light. This light successfully moves the IV curve of the diode to the fourth quadrant, where power can be extracted. If a cell is introduced, the typical "dark" current in the diode increases, and the diode law

$$I = I_0 \left[\exp\left(\frac{qV}{nkT}\right) - \mathbf{1} \right] - I_L$$

becomes:

where *IL* = light generated current.

Without illumination, a solar cell behaves similarly to a big diode electrically. When sunlight passes on the cell, the I-V curve rises upward as the cell generates energy. The solar cell's IV-curve is depicted in Figure 2.2.



2.4.1 Single Axis Tracker

There is only one degree in this tracker. It functions as an axis since the rotation of a single axis may be in either horizontal or vertical directions. The movement of this device is dependent on the tracker's technology. Every state in the tropical area, including Malaysia, is organized as a horizontal type tracker since the sun is at its lowest position in terms of receiving high solar intensity.

Normally, a one axis tracker travels in one direction. It can rotate and move in one of two directions: horizontal or vertical as shown in figure 2.3 and figure 2.4 below which are horizontal and vertical single axis solar tracker. This tracker is easier to monitor, and the cost of construction is inexpensive. The issue is that the solar tracker system's efficiency in capturing large amounts of solar irradiance is insufficient and poor [3].



Figure 2.3 Horizontal Single Axis Solar Tracker[2]



2.4.2

The horizontal and vertical axes of a dual axis tracker will freely rotate. It can rotate in the direction of a vertical axis, either east. Following that, the horizontal axis will reverse direction, either north to south. When compared to a single axis tracker, dual axis trackers can have significantly better performance and accuracy. The sensors mounted on the top of the photovoltaic panel would aid in catching as much current and voltage from the sun as feasible. In comparison to a single axis tracker, which has a significantly lower output power, a dual axis tracker often increases output power by 40percent to 50 percent.



2.5

Numerous efforts have been made to determine the accuracy of various sun tracking systems and to improve it. [4] conducted an experiment in Malaysia in 2013 to investigate the efficiency of a dual-axis solar tracker and a static solar tracker. The dual axis tracker will rotate from 70 degrees east to 70 degrees west, as well as from 30 degrees north to 30 degrees south. Since power from solar panels during cloudy days was also studied, they conducted their experiment using an open loop tracking system. As a result, the performance of a dual- axis solar tracker is 82.12 percent on sunny days and 24.91 percent higher on cloudy days than a static solar tracking system [5]. Figure 2.5 depicts the dual axis solar tracker. Figures 2.6 and 2.7 show how much electricity is generated on a sunny day and how much electricity is generated on



gloomy day. As shown in figure 2.8 shows that On a Cloudy Day, Electrical Power Generation.

Figure 2.6 Transmission lines and a beautiful sunset



Figure 2.7 On a Sunny Day, Electrical Power Generation[4]



Figure 2.8 On a Cloudy Day, Electrical Power Generation[4]

As shown in figure 2.9 below it compared that the performance of dual-axis and single- axis with fixed mount in a study published in 2013. Most solar tracking systems employ an open loop system with light dependent resistors on one axis and photo transistor sensors on two-axis system. He found that a one-axis tracker was 13 percent more effective thana fixed mount, and a dual-axis tracker was 25 percent more efficient. [7] findings also suggest that a dual- axis tracker is more effective than a single-axis tracker, even on cloudy days.



Figure 2.9 Comparative Analysis of Fixed-Mount and Single-Axis

Tracking Systems [6]

2.6 **Overview of Existing Project**

This section will examine prior project implementations in relation to this project's system. Numerous scholars have conducted study to determine the most effective strategies for optimizing the utilization of the solar tracker system.

2.6.1 IOT Based Solar Tracking System For Efficient Power Generation

This project was created with the goal of designing a precise dual axis solar tracker and sharing the data with users through the Internet of Things including hardware and software development [10]. This system is implemented through Arduino Uno controller. For the hardware part composed of two-DC motors, solar panel, temperature sensor, sensor module, WI-FI module, humidity sensor and electronic circuit. The use of LDR sensors as well as high-precision voltage and current sensors ensures that the tracking system is more precise and efficient. It also uses an application to show sensor parameters to a user over the internet and warns the user when the sensor parameters exceed specific limits.

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2.6.2 Solar Tracker with Dual Axis and IoT Monitoring System using Arduino

The purpose of this project is to develop a dual-axis solar tracking system with an IoT monitoring device using Arduino [4]. Solar panels can improve their detection of sunlight with the assistance of this method by allowing them to collect energy in a sunny location. Thus, the research is focused on the development of dual-axis solar tracking developers that make use of the Arduino Uno as the primary controller for the system. This project utilized four light-dependent resistors (LDRs) to detect sunlight and determine the maximum light intensity. The solar panel is rotated by two servo motors

in response to the LDR's detection of the sun's light source. Then, as an interface between the client and the IoT monitoring system, a WIFI ESP8266 device is utilized. Finally, the Ubidots platform is used to compare the voltage, current, and power output of the solar panel.

2.6.3 Increase the Efficiency of an Automated Photovoltaic Solar Tracker with a Cooling System

This project [8] improves the solar tracker's performance by using a cooling system. Since solar panels have a temperature coefficient, their output power decreases, and the cooling system lowers the temperature of the panels. The LDR sensor's input signals will be viewed and analyzed in this project using C++ programming to detect the direction of the sun's beams. Due to the fact that the servo gets PWM signals from the microcontroller programmer, it is utilized to monitor the solar panel's movement and rotation. Battery storage has been used to store the energy collected from the solar panel. Furthermore, water pump has been used. When heat sensor triggered water pump will on and water will flow to solar panel. Finally, data was gathered on the voltage, current, and power generated by the solar tracker with and without a cooling system.

2.6.4 Implementation of a Dual Axis Solar Tracker using The Internet of Things for Polycrystalline Photovoltaic with Energy Storage.

This project, titled Implementation of a Dual Axis Solar Tracker Using the Internet of Things for Polycrystalline Photovoltaic with energy storage, features two degrees of freedom that serve as the horizontal and vertical rotational axes, respectively [9].Servo motor has been used to control the solar rotation angle. Arduino Uno is the key mechanism that controls the motor's movement and senses the LDR. This project uses Polycrystalline solar panel that has high efficiency type other than monocrystalline. The differences between a static solar panel and a solar panel with a tracking device are also investigated in this project. As a light sensor, light dependent resistors (LDRs) have been used, with the resistance varying depending on the amount of light falling on it. Furthermore, the energy collected from the sun that needs to be used later by the load is stored in a rechargeable battery, which is usually of the lead acid form. The Internet of Things (IoT) is used in this project to monitor the output of photovoltaic voltage using the Blynk software on a smartphone.

2.6.5 A Dual-Axis Smart Solar Tracker Powered by Arduino

This project describes that the design of a solar tracking device based on an Arduino Uno that allows the solar panel to shift in the direction of the most sunlight. The study discovered that using a stepper motor allows for precise sun monitoring and LDR sensors have been used to determine the solar light intensity. According to the research, solar panels' performance can be greatly improved if they rotate continuously in the direction of the sun. In an innovative mechanical configuration for solar trackers, two stepper motors with free rotation on the X and Y - axis were used. The rotation was smartly monitored by a pre- programmed 2K microcontroller chip PIC 18F4560, which supports C programming. This project also aims to create a low-cost instrument based on an Arduino Microcontroller that uses a Bluetooth module to detect voltage and display the results in an Android app [7].

2.6.6 Low-cost Active Dual Axis Solar Tracker based in Arduino

In this work, the researcher decided to develop and build a cost-effective dual-axis solar tracker controlled by an Arduino UNO [11]. The design of a dual axis solar tracker is determined by the type of engine, the number of LDRs and compression using LabVIEW software. The researcher also compares two main types of motor, stepper motors and servo motors, for this project. A stepper motor's downside is its lack of f eedback and missing step under load, whereas a servo motor consumes less energy to do the same purpose. This helps the researchers in selecting the appropriate motor for this study. Researchers also condense data by comparing the actual prototype to a graphic prototype (LabVIEW).

2.6.7 Solar Array Tracker using the Internet of Things

The article discussed how to design and construct an internet of things for a solar tracker [1]. The Raspberry Pi 3 platform was used in this project. The RPi3 is a single board that runs Linux and requires programming C language. Its purpose is to transmit data f rom the solar tracker's output to the IOT system. Apart from data transfer to an IoT system, the RPi3 can also drive servo motors; in this case, the solar tracker used two servo motors, the one controlling the vertical axis and the second controlling the horizontal axis. The researcher shows the results obtained from the solar tracker at the end of this project and concludes that the Internet of Things system is capable of processing raw current and voltage data in order to calculate power and other metrics.

2.6.8 Solar Tracking System

This article discussed the design of a Solar Tracking System. It compares solar trackers with single and dual axes. While single axis solar trackers capture the sun only at noon, two axis solar trackers collect the sun from north to south and east to west, increasing power output by 40%. This article examines three distinct types of solar trackers, including passive trackers that use the sun's heat to move the solar panel. The second type is an Active Tracker, which uses hydraulics to move the solar panel, and the third type is an Open Loop Tracker, which does not involve sensing but instead records data to identify the sun's location. The system is controlled by a decade counter, a 555 timer, a capacitor Darlington pair for current amplification, a ULN2003 driver IC, and a stepper motor . Figure 2.10 below shows a block diagram for solar tracking system process.



Figure 2.10 The solar tracking system's process is depicted in block diagram form[13]

2.6.9 Solar Tracking System using LabView and Servo Motor

The objective of this study is to demonstrate how a solar tracking system with servo motor may be designed and implemented using Lab view software. The project as shown in figure 2.11 below use a servo motor in conjunction with a gear to spin the solar panel 360 degrees in order to follow the sun. Lab view DAQ controls a servo motor with a gear. The hardware component consists of an LDR sensor, a servo motor with gears, a solar pane 1, and a DAQ card acting as the system's microcontroller as shown in figure 2.12 below for solar tracker block diagram.



2.6.10 Design and Implementation of a Solar Tracking Algorithm

The article describes the development and implementation of a Solar Tracking Algorithm. The methodology is demonstrated on a solar tracking system that utilizes a tri-positional control mechanism in conjunction with a dual-axis solar tracking algorithm. The structure of the command algorithm consists of four unconnected inputs
and two unconnected outputs. This command was developed mathematically using Matlab software. To communicate between the computer and the solar tracker, a DC motor with two axes of rotation, a worm gear, and a National Instrument acquisition board (NI BUS 6008) are utilized [14]. Figure 2,13 below shows the mechanical structure that enables the solar panels to be positioned.



2.6.11 Comparison of Existing Projects

Table 2.1 Comparison	between	the com	ponents	used
----------------------	---------	---------	---------	------

Component and irrigation Project Title	Arduino UNO	LDR Sensor	Servo motor	WIFI Module	Bluetooth module	Temperature sensor	Humidity sensor	LCD display	Battery
1.0IOTBasedSolartrackingsystem for efficientpower Generation[15]									

2.0 A dual Axis Smart Solar Tracker powered by Arduino [16]					
3.0 Increase the efficiency of an automated photovoltaic solar tracker with a cooling system [5]					

Table 2.1 shows a comparison between the components and the methods used in different previous projects. Project 1.0 refers to IOT Based solar tracking system for efficient power generation. Project 2.0 refers to dual axis smart solar tracker powered by Arduino and the last project 3.0 illustrates the Increase efficiency of an automated photovoltaic solar tracker with a cooling system.

By analyzing three previous projects' systems, it is revealed that the majority of projects utilize the Arduino UNO as the primary microcontroller for the system. It is because the coding language that used in the Arduino is easy which is C or C++ programming language.

Furthermore, based on the two project which is "IOT Based solar tracking system" and "Efficiency of an automated photovoltaic solar tracker" both project used servo motor to control the rotation of a solar panel. The servomotor is used because it is capable of providing accurate angle control e.g. 45 degrees, 90 degrees and 180 degrees.

Lastly, for project 1.0 which is "IOT based solar tracking system" is using WIFI module. It will display the sensor parameters to the user via the internet, based on the effectiveness of the application, and also alert the user if the sensor

parameters are problematic to the limit. While for project 2.0 which is "A dual axis smart solar tracker" is using Bluetooth module to receive notification. So, it will transmit the data to user via Bluetooth. However, Bluetooth is limited to a short range. As a result, all of the projects above achieved their objective to complete the project.

2.7 Proposed Work

After reading and reviewing every research article published on solar tracking systems, this project related for building and designing a new effective solar tracker which is dual axis solar tracker with IOT monitoring system. This system will determine the strength of light intensity utilizing four LDR sensors mounted on the top of a solar photovoltaic panel to capture the maximum amount of sun energy. The tracking mechanism will orient and align the solar photovoltaic panel's surface with the incoming sunlight beam. The Arduino UNO is used as the system's brain because it is easier to program, simpler circuit, and less expensive. Next, to obtain the most energy, this project employs a 360- degree rotation of a solar panel for rooftop installation. This system will utilize two servo motors that will spin in the horizontal and vertical axes. Then, polycrystalline solar panel will be used as known as it has high efficiency and low cost. Additionally, a WIFI ESP8266 device serves as an intermediary between the user and the IoT monitoring system, monitoring the output via the Blynk application. So, user can monitor output performance of the solar panel which are current, voltage, power and temperature from Blynk.

2.8 The Tracking System's characteristic

Tracking system	Advantage	Disadvantage
Single axis	Cost savings, an easy-to-use control	Performance is less than the
	system, and constructive simplicity.	dual axis tracking system.
		Placement is limited [27]
Dual axis	In comparison to single axis tracking, this	Costly and difficult in terms
	system is particularly efficient.	of construction.
	Increased precision in placement [28]	
Passive	Simple construction; no control system or power source required [29].	Inefficient. Limited to devices with a single axis.
Active	In comparison to passive tracking, this system is more efficient. Operate in any climate and are applicable to systems with one or two axes[30].	Needs an external control system electricallypowered. Greater complexity compared to passive tracking.

Table 2.2 Comparison between the components used

Table 2.2 shows that comparison between the solar tracking system which are single axis, dual axis, passive and active tracking system.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter focuses the methods used to construct this project. The hardware and software components of this project will be separated. To ensure the success of a project, several components must be examined and organized properly to ensure the project's completion. In general, this chapter will explain and describe the project's development process briefly through flowcharts and block diagrams to ensure a better knowledge of the process.

3.2 **Project Review**

The project used the internet of things to monitor the solar system's operation. This project is also divided into two sections. The first is software development, which includes Sketch Up, Proteus, and Arduino programming. Second, hardware development entails the installation of a solar array module comprised of sensors and an Arduino board that enables data from the sensors to be sent and presented to the connected PC.

In the simulation, the sensors are coupled to an ADC on the Arduino Uno microcontroller, which converts the analogue signal to a digital signal. The Arduino then transfers the data to the Blynk platform via the WIFI module, where the I-V and P-V curves are displayed.



Figure 3.1 Solar Tracker Process Project

3.3 **Project Development**

This project technique will be separated into numerous sections to improve the project's flow and troubleshooting. The first stage in developing the project is to create it according to the flowchart in Figure 3.1.

The flowchart in Figure 3.2 depicts the total project's flow from hardware to software in order to accomplish the project's purpose. Additionally, to avoid any complications during development, a flowchart will be created to handle the working segment. The flowchart illustrates the overall scope of the project, how it will be developed and troubleshooted until the desired outcomes are obtained. The procedure begins with research f rom past articles or theses, as well as several other sources. A new simulation circuit is developed after understanding the requirement, concept and operating principal. To obtain results, a simulation of a photovoltaic array will be created. Following that, if there are no issues

during troubleshooting, the project will go on to hardware design.

A prototype will be developed for the hardware design in order to conduct testing. The prototype uses four Light Dependent Resistors (LDRs) to detect the movement of the sun. Following that, two servo motors will be used to move and align the solar panel with the sun. A photovoltaic array is designed to capture solar panel data using sensors.

The Sketch Up application is used to design the prototype before the actual prototype is made for the software design, which will support in determining the best design f or this project. Complex coding will therefore be created to ease the mobility and transmission of data from the solar panel to Blynk application.





Figure 3.2Flowchart of project planning

3.3.1 Block Diagram



Figure 3.3 Block diagram

As illustrated in the figure 3.3 block diagram, four Light Dependent Resistors (LDRs) are mounted on a common plate alongside the solar panel. They receive varying amounts of light from a source.

Each LDR sends an appropriate signal, which is set by the appropriate programming logic, to the Microcontroller. The values are compared by reference to each other with a particular LDR value.

The servo motor is used to run a solar panel. The two servo motors are positioned to allow the solar panel to move on both the X and Y axes. The microcontroller controls the servo motors by sending suitable signals based on the input signals from the LDRs. One servo motor tracks the x-axis, and the other tracks the y-axis.



Figure 3.4 NodeMCU ESP 8266 block diagram

Figure 3.4 illustrates how the Blynk application interacts with the wireless NodeMCU ESP 8266. This ESP 8266 Wi-Fi module features a single input that is wired to a humidity and temperature sensor. As a result, the humidity and temperature of the solar panel is continuously monitored via the Blynk application on a smartphone or a computer.

3.4 Software Requirement

This section illustrates and describes the software that has been and will be utilized to make this project a success.

3.4.1 Proteus 8 Professional

Proteus 8 Professional as shown in figure 3.5 is used to simulate circuits prior to applying them to real- time circuits. The software is accessible in the English, French, Spanish, and Chinese languages and operates on the Windows operating system. Proteus is a software program that is used to simulate microprocessors, capture schematics, and design printed circuit boards (PCB). The ISIS, the circuit design environment, and the ARES, the circuit board

designer are two important components.

ISIS (Smart Schematic Input System) is used to design schemes and run real-time simulations of circuits. Human interaction is allowed during the simulation's run duration, resulting in real-time simulation. ISIS's component library has a diverse set of components. It features signals generators, measuring and analyzing equipment such as voltmeters, oscilloscopes, and samples to monitor parameters in real time.

ARES (Advanced Routing and Editing Software) is used to design printed circuit boards. It includes the capability of examining the output 3D view of the planned PCB and associate components. ARES can design PCBs with up to 14 inner layers, including surface mount [22]. It contains the footprints of several types of components, including integrated circuits, transistors, headers, connectors, and other discrete components.



Figure 3.5 Proteus 8 professional

3.4.2 Arduino (IDE)

Arduino as shown in figure 3.6 is a cross-platform application in the Java language It is designed to provide a programming introduction for persons new to software development. Arduino (IDE) is a software platform that is frequently used in conjunction with the Arduino board. The code editor includes a syntax markup, automated indentation and the ability to compile and upload the software.

Sketches are programs created with the Arduino Software Development Kit (IDE). Sketches are stored as text files with the extension on the download page. Ino. The Arduino IDE enables C and C++ programming by the application of specific code organization principles.



3.4.3 Blynk Application

The development of the internet of things is a lengthy process. If one has to construct it from start, it will be a lengthy and time-consuming process. IoT middleware systems provide as a jumping-off point by consolidating the tools required to manage the development of a program, from network monitoring to data consumption, into a single service as shown in figure 3.7 below.

Blynk is an internet-of-things (IoT) and machine-to-machine middleware platform. It is

capable of remotely controlling hardware, displaying sensor data, storing data, and visualizing data. The technology is being created in order to facilitate the integration of data from a range of sensors and actuators via the internet. Receiving and collecting data from Internet of Things devices has gotten a lot easier in recent years. Additionally, the platform helps developers in developing vertical applications.



3.5 Hardware Component

This section will discuss the electronic components that were used to complete the project. UNIVERSITI TEKNIKAL MALAYSIA MELAKA This project utilizes a variety of electronic components, including an Arduino UNO, a voltage sensor, humidity and temperature sensor, a light-dependent resistor (LDR), a servo motor, and a solar panel.

3.5.1 Arduino UNO

Arduino UNO is a microcontroller platform based on the ATmega328P. It features a 14 - pin digital input / output (six of which can be used as PWM outputs), six analogue inputs,

a 16- MHz crystal, a USB port, a power supply, an ICSP header, and a reset button. It's all about supporting microcontrollers; simply connect it to a computer with a USB cable or turn it off with an AC-to-DC adapter or battery to start it. You can play with your UNO without being too balanced doing something wrong, if the worst -case scenario could be replacing the chip for a few dollars and restarting it. Arduino UNO as shown in figure 3.8 below.



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3.5.2

In this project, two servo motors of the 180 degree angle type are used. 4.8V - 6V power supply (usually using 5V). The servo motor as shown in figure 3.9 is used in this project because it is capable of providing accurate angle control e.g. 45 degrees, 90 degrees, and it is also capable of continuously generating angles. Servo motors operate at a frequency of 40Hz. It is 0 degrees to 180 degrees when the pulse task ration changes. The angle is the pulse duration applied to the control wire. This is referred to as Pulse Width Modulation. The servo is expected to produce a pulse within 20ms.



Figure 3.9 Servo motor

When the engine is running, the potentiometer's resistance increases. Movement and direction of movement occur by this control circuit. The power supplied to the motor will reach the specified position. This is accomplished by electrifying the pulse and illuminating the signal wire. Motor speed is related in relation to the current and inspired position.

3.5.3 Light Dependent Resistor (LDR)

Light -sensitive resistors (LDRs) as shown in figure 3.10 below are made of universitive properties. Numerous semiconductor materials to allow them to have light - sensitive properties. Numerous substances may be used, however the most frequently used substance is cadmium sulfida, CdS. Light resistors are light -sensitive components. If light falls on it, the resistance will change. The LDR resistance value can change at the sight of numerous magnitudes of the resistance value falling as the light level increases.

LDR is a high resistance because there are some free and moving electrons. An electron is locked to the crystal lattice and cannot move. As a result, this condition is a great LDR resistance. Due to the fact that the light is attached to the semiconductor, the light's photograph is taken by the semiconductor.



Figure 3.10 Light Dependent Resistor (LDR)

3.5.4 Solar Panel

Polysilicon is a metallurgical grade silicon with a chemical purification process, called the Siemens process. It is a waterproof cell surface that is for many applications. Figure 3.11 shows the Polycrystalline solar panel that used in this project and Table 3.1 is the specifications for this type of solar panel.



Figure 3.11 Polycrystalline Solar Panel

Photovoltaic Cell	Poly-crystalline Solar Cell
Maximum Power	3W
Maximum Power Voltage	9V
Maximum Current at Maximum Power	320mA
Size	190x120mm

3.5.5 WIFI Module

The ESP8266 Wi-Fi module as shown in figure 3.12 is a complete chip system based on an integrated transmission control protocol / internet protocol (TCP/ IP) stack that can provide microcontroller access to your Wi-Fi network. ESP8266 is an application that can host or load various Wi-Fi network functions from other application processors. Each ESP826 6 module has been programmed with AT-compatible firmware, which enables it to communicate with the Arduino and utilize a variety of Wi-Fi capabilities provided by the Wi-Fi Shield. The ESP8266 module is a cost- effective way to connect a large and continuously growing community.



Figure 3.12 ESP8266 WIFI Module

Features of WIFI module ESP8266 (Beetrona, 2020).

- Power Supply: +3.3V
- Current Consumption: 100mA
- o I/O Voltage: 3.6V (max)

- I/O source current: 12mA (max)
- A small, low-cost, and highly capable Wi-Fimodule
- Can be utilised as a station, an access point, or a combination of the two.

3.5.6 Voltage Sensor

The voltage sensor as shown in figure 3.13 is a low cost voltage sensor which is a resistive voltage divider design based on design principle. It can make the input voltage of the red terminal connector small. The voltage detection sensor module is a facility that uses a potential divider to reduce the input voltage by a factor of five. This enables us to use an Analog microcontroller's pin input to measure voltages that are higher than those that the microcontroller can generate. For example, the analogue input range of 0V -5V enables you to adjust the voltage up to 25V. Additionally, table 3.2 below shows pin description for voltage sensor.

Name of the PinERSITI TEKNIKAL N	Description A MELAKA
VCC	External voltage source's positive terminal
	(0-25V)
GND	External voltage source's negative terminal.
S	Analog pin attached to Arduino's analogue
	pin.
+	Not connected
-	The ground pin is wired to the Arduino's
	GND.

Table 3.2 Pin description for voltage sensor



Figure 3.13 Voltage Sensor

3.6 Component List

BIL	COMPONENT	QUANTITY	PRICE
1	Arduino Uno	1	RM 44.90
2	Solar panel 9V 2W(Polycrystalline)	1	RM 19.90
3	Breadboard 830 point	1	RM 5.90
4	WIFI Module ESP 8266	1	RM 19.90
5	LDR	4	RM 4.00
6	Servo motor	2	RM 40.00
7	Female to Male	40	RM 4.60
8	Voltage Sensor	ىتى تىك	RM 3.90
9	Current sensor	1	RM 9.00
10	LCDNIVERSITI TEKNIKAL	MALAYSIA	RM11.31
11	DHT 11 Humidity Moisture	1	RM 5.61
12	Stripboard 10cm x 25cm	1	RM 5.61
	Total	• •	RM 174.63

Table 3.3 Component and cost implementation.

Table 3.3 above shows that component and cost implementation to built this project hardware.

3.7 **Project Development Flowchart**

Developing this project requires planning specifically for the hardware fabrication

process, as all circuit simulations must be verified not just with simulation software, but

also with protoboard testing to ensure the circuit actually works. The flowchart in Figure 4.8 illustrates the project development process, which involves simulation of all the circuits necessary to achieve effective solar tracking. This flowchart illustrates the process of developing the project's hardware as shown in figure 3.14.



Figure 3.14 Project Development flowchart

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter will present the project's outcome and analysis. The first section discusses software and hardware development, while the second section discusses monitoring a dual-axis solar tracker using the Blynk application. Following that, this chapter analyses the output performance parameter of a dual-axis solar tracker and discusses the performance of the developed monitoring detection system through an outdoor experiment.

4.2 Flowchart of the System

The purpose of a system flow chart is to provide an overview of the movement or rotation system for a dual-axis solar tracker.

Figure 4.1 depicts the solar tracker's movement operating system. Starting with four sensors that detect the sun's position. The data received from the sensor will be converted to digital data and read in Arduino UNO to make a comparison for positioning the solar panel directly toward the sun ray. The system will analyze data to decide the direction of the sun and start moving the horizontal and vertical servo motors in accordance with the command set in the Arduino IDE. Table 4.1 displays the definitions of the words used in the flow chart.



UNIVERTable 4.1 Component and cost implementation. KA

Code	Function
Name	
LT	Left Top
LD	Left
	Down
RT	Right
	Тор

RD	Right
	Down

When power is applied to the circuit, the Arduino UNO and servo motor will be activated. As shown in figure 4.2 below, the simulation circuit is using Proteus 8. To rotate the solar tracker, the Arduino is used as the main processor unit, and a servo motor is used as the hardware component. This project employs two 180-degree-angle servo motors for horizontal and vertical rotation. The servo motor will be controlled by an LDR sensor that detects the sun's rays. First, when sensors LT and RT detect more sun radiation than LD and RD, the vertical servo motor will rotate from 0 to 120 degrees. Second, if LT and RT are less than LD and RD, the vertical servo motor will rotate from 0 to 30 degrees. Third, if the sensors LT and LD are greater than the sensors LT and RD, the horizontal servo motor will turn 180 degrees, and when all of the sensors are equal, which means all of the sensors detected sun rays, the motor will stop. All of these conditions are dependent on the position of the sun and whether or not the sensor detects the sun. The system will be looped to determine the best sun position.



Figure 4.2 Simulation Circuit using Proteus 8

4.3 Hardware Design

Sketch Up software was used to create the prototype design. The design essentially chose to hold and move a solar panel. The concept of this design is made easier for moving **UNVERSITI TEKNIKAL MALAYSIA MELAKA** in small area. When it comes to the actual prototype design, there will be some changes. The change should take into account how the environment or application functions in real time. Figures 4.3 and 4.4 depict the Sketch UP software design that was created. As shown in figure 4.5 below is for real hardware to built the dual axis solar tracker system.



Figure 4.3 Isometric view



Figure 4.4 Top view



4.4

The solar panel in this project's purpose is to display the output value of voltage, current, and power that absorb from the sun's rays and the serial monitor of the Arduino IDE shows the value of all the output. After running the coding shown in Figures 4.6 and 4 .7, which show the output on the serial monitor in Arduino, the output coding will be combined with IOT coding. ESP 8266 WI-FI module has been used as an intermediary between the user and the IoT monitoring system. It will send the data through Blynk application.



The LCD is used as a temporary part in this project to achieve the best output result.

This aids in determining whether the output from the serial monitor and the LCD show the same value, ensuring that there will be no problems when the coding is combined with IOT coding. After this project is completed, the monitoring coding will be combined with IOT coding to connect to the Blynk application, as shown in Figure 4.8. When using the Blynk application to monitor a dual axis solar tracker, it will send data from the temperature and humidity sensors to the application.

```
#include "DHT.h"
#define DHTTYPE DHT11
#include <ESP8266WiFi.h>
#define BLYNK_PRINT Serial
#include <BlynkSimpleEsp8266.h>
#define dht dpin V3
DHT dht(dht_dpin, DHTTYPE);
char auth[] = " MTwHmi5RKNHWm_3z6UilmdzC92uquhsc";
char ssid[] = "Gaming House 5G";
char pass[] = "Ilovegame 101";
void setup (void)
£
 dht.begin();
 Serial.begin(9600);
 Blynk.begin(auth, ssid, pass);
 Serial.println("Humidity and temperature \n\n");
 delay(700);
}
WidgetLCD lcd(V0);
void loop() {
   Blynk.run(); AYS/A
   float h = dht.readHumidity();
   float t = dht.readTemperature();
                                  ");
   Serial.print("Current humidity =
   Serial.print(h);
   Serial.print("% ");
   Serial.print("temperature = ");
   Serial.print(t);
   Serial.println("C ");
   Blynk.virtualWrite(V0, t);
   lcd.print(0,0,t);
   Blynk.virtualWrite(V2,t);
   if(t>=39){
      UNIVERSITI TEKNIKAL MALAYSIA MELAKA
```

Figure 4.7 WIFI Module Coding for Monitoring System using Blynk

4.5 Hardware Development

To begin, an LDR sensor is used to detect the position of the sun. Second, the Arduino UNO board serves as the device's main controller. All of the settings are written in source code and uploaded to the Arduino board. Furthermore, the communication component, the WIFI module ESP8266, is constantly updating the data to the Blynk application. Moreover, DHT 11 which is humidity and temperature will be used to monitor the temperature and weather conditions outside.

4.6 Dual Axis Solar Tracker Monitoring System Via Blynk Application.

This experiment is conducted at outside of my house to determine the temperature and humidity of the surrounding solar panel. At this point, the coding has been focused on testing to ensure that it works properly with the prototype that has been created. This project's components must be connected in the correct order. The accuracy of the output solar panel, movement toward the sun ray, and connection of the WIFI module ESP8266 with the Blynk application should all be considered during testing. Aside from that, the prototype will be up and running to see if the output value is similar between the serial monitor and the output on the Blynk application as shown in figure 4.8.



Figure 4.8 The Data Transfer to Blynk Application

The solar panel was used in the experiment to produce the results, which are current, voltage and power. However, the temperature and humidity around the solar panel are not available so internet of things (IOT) was used to detect the temperature and humidity of surrounding by using WI-FI ESP 8266 and Blynk application.

The data stream was created and saved in the Blynk application after a few seconds. The figure above depicts an example of a data stream from the Blynk Application. Data sent to the Blynk application is saved in the data stream.

4.7 **Result from Outdoor Experiment**

The outdoor analysis is carried out in the actual environment based on the data collected. The outdoor testing will take place in Batu Berendam, Melaka, on the 28th, 29th, and 30th of December 2021. An hour was spent analyzing the decision from 9.00 a.m. to 6.00 p.m. The goal is to put the system through its paces in relation to the position of the sun. Two servo motor was tested to determine the angle and direction of the solar panel. So, the system tracker can moves independently in both the X and Y axes to capture the sunlight. Throughout the period, the angle of the solar panel changed in relation to the intensity of solar radiation from the sun. The results are shown in Tables 4.2, 4.3, and 4.4. From 9.00 a.m. to 6.00 p.m., the solar panel received the most sunlight, yielding the highest value of 9.62V.

TIME	VOLTAGE (V)	CURRENT (A)	POWER (W)
9.00 am	8.01	0.17	1.36
10.00 am	8.11	0.17	1.38
11.00 am	8.15	0.20	1.63
12.00 pm	8.25	0.22	1.82
1.00 pm	8.29	0.23	1.91

 Table 4.2 Result for output of solar panel on 31 December 2021

2.00 pm	8.30	0.23	1.91
3.00 pm	8.30	0.23	1.91
4.00 pm	8.25	0.20	1.65
5.00 pm	8.20	0.19	1.56
6.00 pm	8.15	0.17	1.39

Table 4.3 Result for output of solar panel on 1 January 2022

TIME	VOLTAGE (V)	CURRENT (A)	POWER (W)
9.00 am	7.01	0.11	0.77
10.00 am	7.05	0.12	0.85
11.00 am	7.10	0.15	1.07
12.00 pm	7.50	0.20	1.50
1.00 pm	7.55	0.21	1.59
2.00 pm	7.72	0.23	1.78
3.00 pm	7.93	0.24	1.90
4.00 pm	7.51	0.20	1.50
5.00 pm	7.42	0.19	1.41
6.00 pm	7.35	0.15	1.10
	100		

Table 4.4 Result for output of solar panel on 3 January 2022

sh	TIME	VOLTAGE (V)	CURRENT (A)	POWER (W)
-	9.00 am	8.05	0.17	1.37
	10.00 am	8.11	0.17	1.38
UN	11.00 am	8.15 KNK	0.20 ALAY	1.63 MELAK
	12.00 pm	8.25	0.22	1.82
	1.00 pm	8.31	0.23	1.91
	2.00 pm	8.33	0.23	1.92
	3.00 pm	8.33	0.23	1.92
	4.00 pm	8.27	0.21	1.74
	5.00 pm	8.20	0.19	1.56
	6.00 pm	8.15	0.17	1.39

From the table above, the data have been recorded in 3 days which are 31 December 2021. 1 January 2022 and 2 January 2022. The output of solar panel was measured using multimer to determine the voltage and current. Figure 4.9 represents a voltage vs. time graph where the parameter output was recorded from 9 a.m. to 6 p.m. When the solar panel first interacts with the sun's rays at 9 a.m, the voltage value is 8.01 V. Because of the weather factor, the voltage increases to 8.30 V from 9 a.m. to 3 p.m. and decreases slightly at 6 p.m. While the Figure 4.10 represents the graph of current vs time. At 9 a.m the value of current increase to

0.23 A and a bit low at 6 p.m which is 0.18 A. Finally, Figure 4.11 depicts a power vs. time graph, with the result indicating when the solar panel gains current and voltage from the sun's rays. The P=IV formula will be used by the system to calculate the value of power.

The highest power produced on 31 December 2021 was 1.91 W. While, on 1st January 2022 the highest power was 1.90 W because it was a cloudy day. Finally, the last test was on 2 nd January 2022. The weather quite good so the highest power produced was 1.92 W.



Figure 4.9 Graph of Voltage Vs Time for 31 December 2021, 1 January 2022 and 2 January 2022



Figure 4.10 Graph of Current Vs Time for 31 December 2021, 1 January 2022 and



Figure 4.11 Graph of Power Vs Time for 31 December 2021, 1 January 2022 and 2 January 2022.

4.8 Comparison of F and Dual Axis Solar Tracker System Output

This section will go over how to compress data from a single axis solar tracker system and a dual axis solar tracker system. The goal of this comparison is to determine which tracker system is more reliable in terms of voltage, current, and power. For both solar tracker systems, data and graphs of voltage vs. time, current vs. time, and power vs. time will be used to build the comparison as shown in table 4.5 below.

	System					
Time (Hours)	Single Axis Solar Tracker System			Dual Axis Solar Tracker System		
TEVA	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
9.00 AM	7.1	0.01	0.07	7.3	0.02	0.15
10.00 AM	7.91 _{Mn}	0.04	0.32	8.0	0.05	0.40
11.00 AM	مليسيبا م9.9	0.04	ى بە=0.32	8.0	0.05	0.40
12.00 PM	NIVERSITI T	0.10 EKNIKAI	0.80 MALAYS	8.2	0.15	1.23
1.00 PM	8.15	0.13	1.10	8.4	0.20	1.68
2.00 PM	8.3	0.20	1.66	8.6	0.22	1.89
3.00 PM	8.4	0.20	1.68	8.8	0.25	2.20
4.00 PM	8.4	0.18	1.51	8.7	0.22	1.91
5.00 PM	8.01	0.11	0.88	8.5	0.19	1.62
6.00 PM	7.8	0.09	0.70	8.2	0.15	1.23

Table 4.5 Comparison of Single Axis and Dual Axis Solar Tracker



Figure 4.13 Current comparison for a single axis and dual axis solar tracker system.



Figure 4.14 Power comparison for a single axis and dual axis solar tracker system.

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The curves produced by single axis and dual axis solar tracker systems differ slightly, as shown in Figure 4.12. The difference in this figure is that the single axis solar tracker system outperforms the dual axis solar tracker system when the solar panels absorb solar energy from the sun between 9.00 am and 1.00 pm, but after 1.00 pm until 6.00 pm, the single axis solar tracker system outperforms the dual axis solar tracker system. Figure 4.13 shows current comparison for a single axis and dual axis solar tracker system.

Figure 4.14 illustrates a power vs. time graph. The power calculated from the voltage and current produced by the solar panel. This means that the power generated by the dual axis solar tracker system has a constant voltage and current value. The following formula is used to calculate power output.

In general, a dual axis solar tracker system receives more sun rays and produces more voltage, current, and power than a single axis solar tracker system. The overall system
efficiency with the tracker can be calculated using the formula below.

$$Efficiencv = \frac{AveragePower_{dualaxistracking} - AveragePower_{sin gleaxistracking}}{AveragePower_{sin gleaxistracking}} \times 100\%$$

Summary

As conclusion, this chapter discussed the result and analysis of the dual axis solar tracker project. For software development, the simulation result has been tested using Proteus 8 and IOT monitoring system using Blynk application. The coding for both software have been uploaded and successfully meet the requirements to complete this project. Furthermore, this chapter also discussed about the performance of the developed monitoring detection system by conducting outdoor experiment. Finally, this project was able to analyses the output performance parameter of dual axis solar tracker such as current, voltage and power. It is also shows that dual axis solar tracker has better efficiency than single axis solar tracker.

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CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Finally, the dual axis solar tracker has been successfully developed. The monitoring system includes an ESP8266 WIFI module to transfer data from the solar panel to the Blynk application. The system can only function in one condition: the dual axis solar tracker must be within WIFI coverage so that the user can connect the system to the ESP8266 WIFI module and access the solar panel temperature and humidity via the Blynk application. Another aspect of success is the development of a solar tracker with two angles. This solar tracker has two movements that can be classified as horizontal and vertical. Both movements make use of two servo motors at a 180-degree angle.

As conclusion, all three objectives of this project are achieved. The solar panel is able to rotate for 2 axes which are horizontal and vertical axis. Four LDR sensors act as light sensor attach at the solar panel to read the difference value of LDRs effectively. Moreover, WIFI module act as IOT was able to monitor the solar panel and sends data to the smartphone. Lastly, this project able to analyze output parameters of the solar panel which are current, voltage and power as shown in Chapter 3.

To verify the system's functionality, an experiment will be conducted to establish whether the sensor would perform effectively when the tracker was tested outdoors. The output parameter stored in the IOT system can be enhanced in the future by enhancing or changing the platform such as Ubidots platform. Finally, the solar tracker has the potential to revolution our society and more environmentally friendly to utilize due to its lack of pollution.

5.2 **Recommendation**

This project is successful in meeting all stated objectives and satisfies all target requirements. Although, there are some limitations that can be overcome, improved, or upgraded in the future, including the following:

- Improvements to the IoT platform to receive multiple outputs at one time to receive the purpose of the monitoring system.
- Enhance the development of a system capable of being utilized in extreme weather conditions
- Add battery for system storage to use at night.



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APPENDICES

Appendix A Coding for Arduino

// include Servo library #include <Servo.h>

Servo myservo; // horizontal servo Servo horizontal; int servoh = 180;

int servohLimitHigh = 180; int servohLimitLow = 0; int pos =0; Servo vertical; int servov = 180;

int servovLimitHigh = 180; int servovLimitLow = 0;

// LDR pin connections
int ldrTR = 0; // LDR top right
int ldrTL = 1; // LDR top left
int ldrBR = 2; // LDR bottom right
int ldrBL = 3; // LDR bottom left

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void setup() {
 Serial.begin(9600);
 // servo connections
 horizontal.attach(9);
 vertical.attach(10);
 // move servos
 horizontal.write(180);
 vertical.write(180);
 delay(0.5);
}

```
}
```

```
void loop() {
```

```
for (pos = 0; pos <= 180; pos += 50) { // goes from 0 degrees to 180 degrees
    // in steps of 1 degree
    myservo.write(pos);    // tell servo to go to position in variable 'pos'
    delay(0.5);    //</pre>
```

}
int tr = analogRead(ldrTR); // top right
int tl = analogRead(ldrTL); // top left
int br = analogRead(ldrBR); // bottom right
int bl = analogRead(ldrBL); // bottom left

int dtime = 0; // change for debugging only int tol = 50;

int avt = (tl + tr) / 2; // average value top int avd = (bl + br) / 2; // average value bottom int avl = (tl + bl) / 2; // average value left int avr = (tr + br) / 2; // average value right

int dvert = avt - avd; // check the difference of up and down int dhoriz = avl - avr; // check the difference of left and right



```
// check if the difference is in the tolerance else change vertical angle
if (-1 * tol > dvert || dvert > tol) {
    if (avt > avd) {
        servov = ++servov;
        if (servov > servovLimitHigh) {
```

```
servov = servovLimitHigh;
  }
 }
 else if (avt < avd) {
  servov = --servov;
  if (servov < servovLimitLow) {
   servov = servovLimitLow;
  }
 }
 vertical.write(servov);
}
// check if the difference is in the tolerance else change horizontal angle
if (-1 * tol > dhoriz || dhoriz > tol) {
 if (avl > avr) {
  servoh = --servoh;
  if (servoh < servohLimitLow) {</pre>
   servoh = servohLimitLow;
  }
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 }
 else if (avl < avr) {
  servoh = ++servoh;
  if (servoh > servohLimitHigh) {
   servoh = servohLimitHigh;
  }
 }
 else if (avl = avr) {
  // nothing
 }
 horizontal.write(servoh);
}
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delay(dtime);
}
```

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Appendix B Coding for IOT

```
#include "DHT.h"
#define DHTTYPE DHT11
#include <ESP8266WiFi.h>
#define BLYNK_PRINT Serial
#include <BlynkSimpleEsp8266.h>
#define dht_dpin V3
DHT dht(dht dpin, DHTTYPE);
char auth[] = " MTwHmi5RKNHWm_3z6UilmdzC92uquhsc";
char ssid[] = "Gaming House_5G";
char pass[] = "Ilovegame_101";
void setup(void)
ł
dht.begin();
Serial.begin(9600);
 Blynk.begin(auth, ssid, pass);
 Serial.println("Humidity and temperature \n\n");
delay(700);
}
WidgetLCD lcd(V0);
void loop() {
  Blynk.run();
  float h = dht.readHumidity();
  float t = dht.readTemperature();
  Serial.print("Current humidity = ");
  Serial.print(h);
  Serial.print(t);
  Serial.println("C ");
  Blynk.virtualWrite(V0, t);
  lcd.print(0,0,t);
  Blynk.virtualWrite(V2,t);
  if(t > = 39){
   Blynk.notify("Kebakaran Kantor Anda");
  }
  delay(800);
```

```
}
```

Appendix C



Figure 5.1 Gantt Chart

