Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF SOLAR TRACKING SYSTEM FOR STREET LIGHT APPLICATION USING ARDUINO

NIURUL NABILA BINTI ISMAIL

Bachelor of Electrical Engineering Technology with Honours

2022

DEVELOPMENT OF SOLAR TRACKING SYSTEM FOR STREET LIGHT APPLICATION USING ARDUINO

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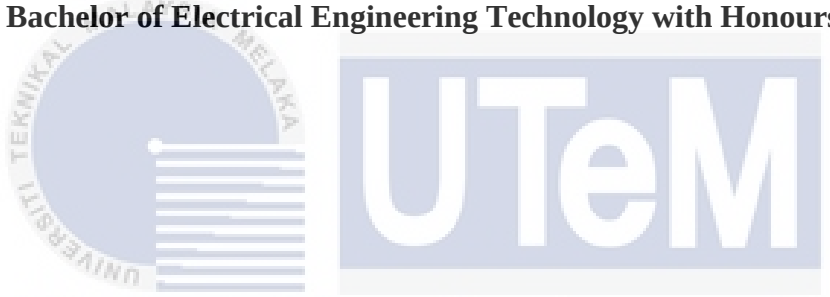
A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electrical Engineering Technology with Honours



Faculty of Electrical and Electronic Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I declare that this project report entitled “Development Of Solar Tracking System For Street Light Using Arduino” 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.

Signature :

Student Name : Nurul Nabila Binti Ismail

Date : 27 January 2023

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.

Signature : 

Supervisor Name : Rohaina Binti Jaafar

Date : 27 January 2023

DEDICATION

I acknowledge my sincere dedication, honours and gratitude to my beloved father, Ismail bin Mohamed, and mother, Wahidah binti Yusof, for all their love, encouragement, support, understanding, and sacrifices throughout whole of my life especially in education journey. Without their sacrifices and encouragement, impossible for me to reach at this stage. Special gratitude also dedicated to my grandmother, Siti binti Damiri which always support me in whatever I do in my life, sacrifices her time to comfort me whenever I at my lowest and for my siblings, thank you for always support me.

To my dearest Muhamad Nazmi bin Mohd Nazri, thank you for always been there for me since first year of degree, thank you for all your support and sacrifices throughout my degree life. Without you, I may not be finished by Bachelor Degree Project successfully. Last but not least, I wanna thank me, I wanna thank me for believing in me. I wanna thank me for doing all of this hardwork, I wanna thank me for no days off. I wanna thank me for never give up and the passionate.

ABSTRACT

Examples of renewable energy resources include solar energy, hydropower, wind energy, biomass energy, and geothermal energy. Renewable energy, often known as clean energy, is produced from natural sources or processes that are continually refreshed. Despite the fact that their availability is based on time and weather, sunlight and wind, for example, continue to shine and blow. Humans today use solar energy for a variety of purposes, including powering electronics, generating electricity, heating water, and so on. Because of the high energy consumption in industrialised countries, solar energy is widely employed, particularly in countries with the biggest population. Using an Arduino Uno microcontroller as the project's main brain to control all of the components is one of the project's goals. Additionally, during the day, an LDR sensor detects light and adjusts the position of the solar panel toward the sun for consistent efficiency output. It will give the microcontroller digital information about the presence and absence of light intensity. For the solar panel, a servo motor is employed to create a free rotation X-Y axis. Then, at night in the highway, LEDs that act as street lights will collect electrical energy from the sun to power them. As a result, a solar tracking system was developed, which can modify the position of an item in reference to the sun. To deliver the greatest electrical energy to the highway street lights, the efficiency of the solar panels will be determined. A solar tracking system is one of the applications for boosting the efficiency of solar panels. It will adjust the solar panel's movement and direction so that it remains pointed toward the sun. The goal of this project was to provide benefits to people who drive in the dark or at night in order to save lives and avoid fatal accidents. The street light will have a higher electrical energy efficiency as a result of this solar tracking system, allowing it to run for longer periods of time at night.

ABSTRAK

Contoh sumber tenaga boleh diperbaharui termasuk tenaga suria, tenaga hidro, tenaga angin, tenaga biojisim, dan tenaga panas bumi. Tenaga boleh diperbaharui, yang sering dikenali sebagai tenaga bersih, dihasilkan daripada sumber semula jadi atau proses yang sentiasa disegarkan. Walaupun ketersediaan mereka berdasarkan masa dan cuaca, cahaya matahari dan angin, sebagai contoh, terus bersinar dan meniup. Manusia dewasa ini menggunakan tenaga suria untuk berbagai tujuan, termasuk menggerakkan elektronik, menghasilkan elektrik, memanaskan air, dan sebagainya. Kerana penggunaan tenaga yang tinggi di negara-negara perindustrian, tenaga suria digunakan secara meluas, terutamanya di negara-negara yang mempunyai populasi terbesar. Menggunakan mikropengawal Arduino Uno sebagai otak utama projek untuk mengawal semua komponen adalah salah satu matlamat projek. Selain itu, pada siang hari, sensor LDR mengesan cahaya dan menyesuaikan kedudukan panel solar ke arah matahari untuk output kecekapan yang konsisten. Ia akan memberikan maklumat digital mikropengawal mengenai kehadiran dan ketiadaan keamatan cahaya. Untuk panel solar, motor stepper digunakan untuk membuat paksi X-Y putaran bebas Kemudian, pada waktu malam di lebuh raya, LED yang bertindak sebagai lampu jalan akan mengumpul tenaga elektrik dari matahari untuk menghidupkannya. Akibatnya, sistem pengesanan solar telah dibangunkan, yang boleh mengubah suai kedudukan item merujuk kepada matahari. Untuk menyampaikan tenaga elektrik terbesar ke lampu jalan lebuh raya, kecekapan panel solar akan ditentukan. Sistem penjejakan solar adalah salah satu aplikasi untuk meningkatkan kecekapan panel solar. Ia akan menyesuaikan pergerakan dan arah panel solar supaya ia tetap menunjuk ke arah matahari. Matlamat projek ini adalah untuk memberi manfaat kepada orang yang memandu dalam gelap atau pada waktu malam untuk menyelamatkan nyawa dan mengelakkan kemalangan maut. Lampu jalan akan mempunyai kecekapan tenaga elektrik yang lebih tinggi hasil daripada sistem penjejakan solar ini, yang membolehkan ia berjalan untuk jangka masa yang lebih lama pada waktu malam.

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My highest appreciation goes to my parents and family members for their love and prayer during the period of my study. An honourable mention also goes to my roommates for all the motivation and understanding and we gone through this journey together. Finally, I would like to thank all my classmates, the Faculty members, as well as other individuals who are not listed here for being co-operative and helpful.

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LIST OF SYMBOLS

δ	-	Voltage angle
%	-	Percentage
Ω	-	Ohms

LIST OF ABBREVIATIONS

V	-	Voltage
MW	-	Megawatt
cm	-	Centimeter
kg	-	Kilogram
mAh	-	Miliampere/hour
mA	-	Miliampere
MHz	-	Megahertz
KB	-	Kilobyte
A	-	Ampere
C	-	C-rate

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This chapter consist of the research background of the project, problem statement, the objectives, and the scope of research. This should set out the key reason for doing this project and the concept of how it will be making this project.

1.1 Background

Solar energy , hydropower, wind energy, biomass energy and geothermal energy are some of the example renewable energy resources as shown in Figure 1.1. Renewable energy, often known as clean energy, is derived from natural sources or processes that are renewed on a regular basis. Sunlight and wind, for example, continue to shine and blow despite the fact that their availability is dependent on time and weather. Today, humans used solar energy in many ways such as power devices, electricity, to warm the water and etc. For developed countries, solar energy is being used widely mostly in countries that has the highest population in the world because of the energy consumption. Based on the data from Solar Power by Country 2022, China was the top countries that produce the most solar power which is 175,018 megawatts (MW), then goes to United States with 62,200 megawatts (MW). However, according to the National Renewable Energy Laboratory, “in one hour, the sun provides more energy to the earth than the entire globe consumes in a year.” It shows that still have countries that not used solar energy as their main energy consumption. As a result, a solar tracking system was created since it can adjust an object's position in relation to the sun. The solar panel's efficiency will be determined in order to provide the most

electrical energy to the highway street lights. One of the applications for increasing the efficiency of solar panels is a solar tracking system. It will change the solar panel's movement and direction to ensure that the solar panel remains towards the sun.

Figure 1.1 Renewable Energy

Other than that, almost half of all fatal car accidents, according to the National Highway Traffic Safety Administration (NHTSA), road accident occur at night due to compromised night vision as shown in Figure 1.2. Street light is important in every inch of road to ensure the safety of drivers. Transport Minister Datuk Seri Dr Wee Ka Siong said, there were 225,532 road accidents reported from January to September 2021. Based on police statistics, 3,302 were fatal from road accidents.

Figure 1.2 Road accident at night

1.2 Problem Statement

Renewable energy is sources that much less environmental impact to the climate changes because it derived from natural resources. Solar energy is used widely around the world even in rural areas. However, the efficiency of solar panels not exceed the maximum output because the position of solar panels is stationary and it do not move towards the sun. The solar panels can only work well if there is a significant presence of the sun, and it inform that the incidence of sunlight varies with the time of day. In order to verify these problems, solar tracker was introduced with dual axis to increasing the efficiency of solar panels. Solar tracker will make a free rotation in X-Y axis. However, solar energy is primarily used for residential appliances. It is rarely utilized for street lights that are on dark highways or in rural areas, as it increases the risk of a traffic accident. Therefore, in this work, solar tracker system for street light was built because it is more convenient for humans to drive at night in dark places and severe weather, as well as on highways, to avoid road accidents. This is due to the fact that many accidents occur on the road at night as a result of insufficient street lighting. Aside from that, when a dual-axis solar tracker is developed, the cost will be lower because more negative repercussions will be avoided.

1.3 Project Objective

The main objective to run this project is to increase the efficiency of solar panel to help provide electricity for street light to avoid the road accident. The objectives of this project are:

1.To develop dual axis solar tracking system based on microcontroller.

2.To integrated the system for street light monitoring.

3.To analyze the efficiency of the solar tracking system for street light.

1.4 Scope of Project

The scope of this project is made to inform the feature and components used in this project. Among the scope of the project is using Arduino Uno microcontroller as main brain to control all the components used in this project. Additionally, LDR sensor is used to detect the light during day and change the position of solar panel towards sun for consistent efficiency output. It will send the digital in formation about presence and absence of light intensity to the microcontroller. Stepper motor is used to make a free rotation X-Y axis for solar panel. Then, LEDs that serve as street lights will receive electrical energy from the sun to power them at night in the highway.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review is the review on the past journal, project and discussion of research paper regarding Development of Solar Tracking System for Street Light Application using Arduino. To ensure that this project is successful, this chapter will be used in the future as a guide to assist with the experience of problems during project implementation.

2.2 Overview of Solar Tracking System

In today's modern society, energy efficiency is identified by renewable energy. Solar energy is most of renewable energy that used widely around the world because it is supply that inexhaustible resources and it is nonpolluting. Solar energy can generate the radiation that produces by the sun that able to produce heat and generate electricity. Other than that, sunlight is the largest source of energy that earth received by and energy source from the sun is extremely powerful. Solar panels, also known as photovoltaic cells, are the most common way to harness solar energy. Photovoltaic solar panel has a different efficiency and different type such as monocrystalline, polycrystalline, HIT and thin film. The efficiency of a panel is often determined by its design and how it is constructed to catch various frequencies of light energy. Furthermore, the factors that can impact the efficiency of solar panels is the positioning and angle of the panel installation. It is because the appropriate installation will capturing the maximum amount of sunlight and also will maximize the efficiency.

A solar tracking system was designed to boost the efficiency and maximise the energy produced by the solar panel. In fact, solar tracking system has a two types which is single axis solar tracking and dual axis solar tracking. Single axis solar tracking just has one degree of movement and to tracks the daily motion of the sun and capture the direct sunlight. While for dual axis solar tracking has two degrees of movement tp tracks and daily and seasonal motion of dirent sunlight. So basically the solar panel is positioned at an angle to the sun using a solar tracking system. The most typical application of a solar tracker is to place a photovoltaic (PV) panel perpendicular to the sun's rays. More sunlight strikes the solar panel if it is kept perpendicular to the sun, less light is reflected, and more energy is absorbed.

2.3 Research, Ideology and Concept Previous Project

2.3.1 Arduino based Dual Axis Smart Solar Tracker

his project is made by Jyoti Mishra, Ritula Thakur and Alok Deep on May 5, 2017[1]. The function of dual axis smart solar tracker is changing the orientation at the day just to follow the sun’s path to maximize the energy. The effectiveness of solar panels can be greatly boosted if they rotate continually, according to this article. When comparing solar trackers to fixed solar, the electricity generation from solar trackers can rise by up to 40%. As a result, this solar tracker is necessary to increase energy generation and improve conversion efficiency of energy into electrical energy.

Furthermore, this solar tracker should be integrated with the solar panel in order to provide a more precise reaction in a variety of scenarios. However, the author claimed that this technique was inefficient because to the LDR's low sensitivity and disruption. Apart from that, a pre-programmed 2K microcontroller device PIC 18F4560 was utilized to

intelligently manage the rotation in this project, which gives a straightforward programming approach through C language. Next, this project proposes a more efficient, low-cost, and simple-to-use approach for developing an effective solar tracker that detects voltage and displays the result in an Android app utilizing a Bluetooth module. Figure 2.1 shows the block diagram and component that used such as Arduino UNO, Bluetooth module, Solar panel, servo motor, and light dependent resistor (LDR) were utilized in this project.

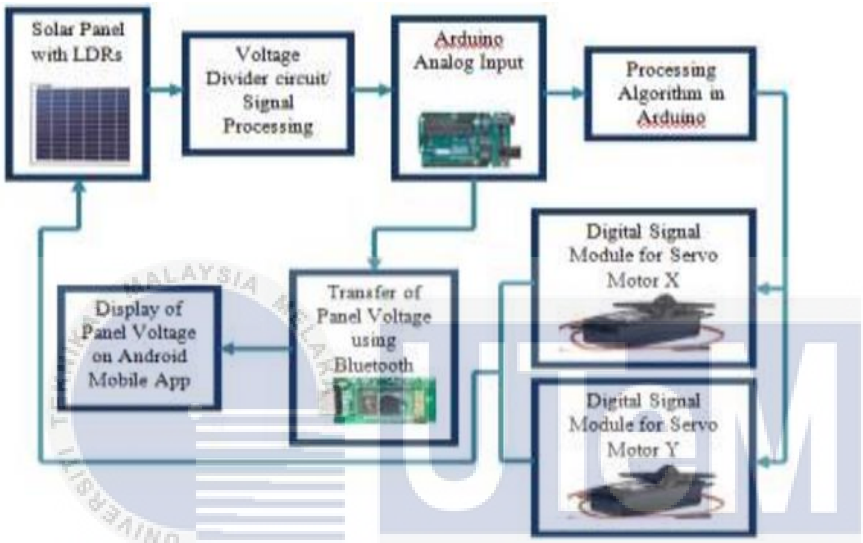

Figure 2.1 Block diagram of system

2.3.2 Dual axis solar tracker with IOT monitoring system using Arduino

This journal was published by Mohamad Nur Aiman Mohd Said, Siti Amely Jumaat and Clarence Rimong Anak Jawa on August 7, 2019[2]. Because Malaysia has the most solar radiation that may be utilised to generate electricity, the goal of this project is to construct a dual axis solar tracker with an IOT monitoring system using Arduino. According to this source, solar tracking systems are the most effective technique for increasing solar panel efficiency, and when compared to single axial solar trackers, this system creates more power, voltage, and current due to its two-axis solar tracking. To assure the performance of the solar tracker, the internet of things (IOT) will be used to monitor the project.

This project's process is depicted in Figure 2.2. It all begins with the sensor, which will detect sunlight and provide data to the Arduino. The Arduino will then be processed, and a motor will be rotated to guarantee that the solar panel moves towards the sun. The photovoltaic system will then collect the energy generated and charge the battery, which will then send the value to Arduino. Finally, Arduino will transmit the data received from the WIFI module to the IOT.

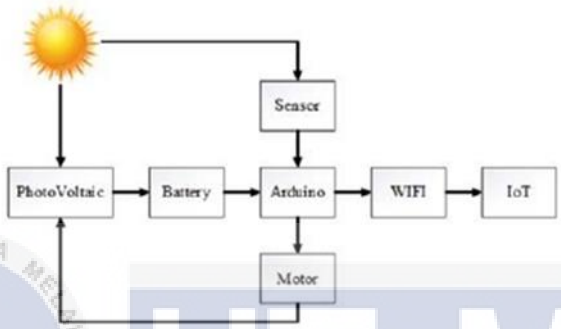

Figure 2.2 Process of solar tracker system

2.3.3 Design and implemention of a sensorless axis solar tracking system based on solar sun algorithm using arduino

In this journal that published by Fazlur Rahman and Md. Mamunor Rashed[3]. The goal of this project is to improve the efficiency of dual axis solar tracking by making it sensor-less and based on a solar sun chart programmed that runs on Arduino. This project was created because the solar sun chart algorithm will assist in precisely tracking the sun even when the weather is cloudy. According to the study, increasing costs will be the most difficult obstacle to simplify the system and improve efficiency. The open loop tracking system was chosen for this project since it is less expensive than alternative options. Even in diverse weather conditions, open loop tracking is more accurate than closed loop tracking.

This sensor-free axis solar tracking system uses a solar sun chart algorithm to follow the sun from 8 a.m. to 4 p.m.

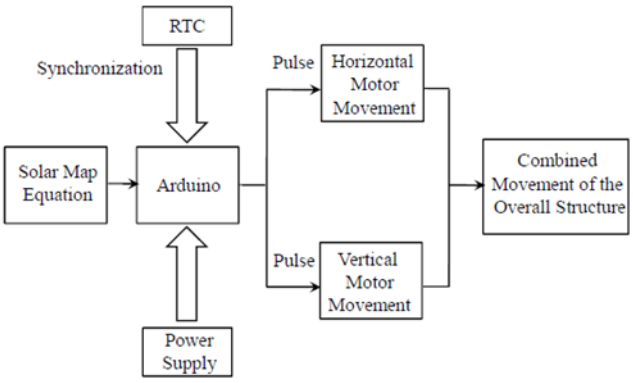

Figure 2.3 Block diagram of the system

Real Time Clock (RTC) is started for this system based on the block diagram in Figure 2.3, which is utilized to give time and date data to Arduino for computation purposes. According to the instructions, an Arduino command will cause the servo motor to rotate. The Arduino's pulses will activate the servo motor, which will subsequently spin the solar module according to the solar sun algorithm. Finally, the author stated that the system should be properly calibrated to assure accuracy.

2.3.4 Solar Tracking System Using Arduino

On 2018, Pratik Pawar proposed this research to recommend and put in place a system that collects energy from direct sunlight, stores it in a battery, and then converts it to electricity[4]. According to the creator, this system was created to withstand extremes in temperature and weather. The light detecting modules are the starting point for this project in the block diagram as shown in Figure 2.4. The light sensor modules will face east and west, respectively. The information regarding the presence and absence of light intensity

will then be sent to Arduino. The Arduino will then choose an output signal for the motor driver to follow. As a result, the motor driver gets the signal from the Arduino and drives the solar panel in a given direction at a specific speed.

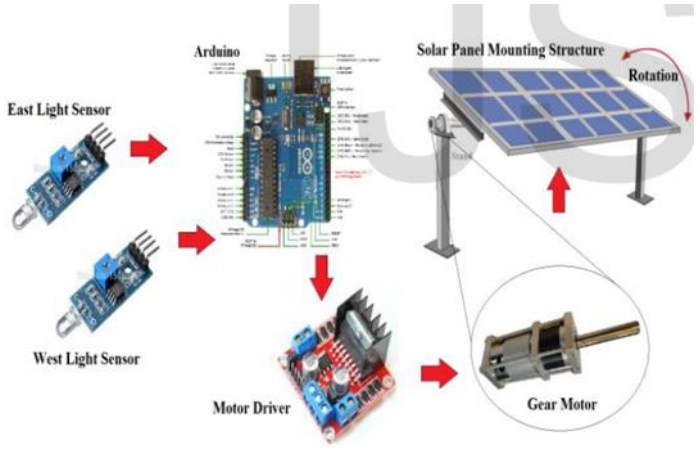

Figure 2.4 Block diagram

2.3.5 An Improved Dual Axis Controller for Photovoltaic Cells

On 2019, Ukoima Kelvin Nkalo proposes this study to recommend and implement a dual axis controller for photovoltaic (PV) cells in order to reduce the electrical circuitry used in prior and existing systems[5]. This project is designed as a closed loop system with two compartments: upper and lower parts of the model. The upper portion will run on a horizontal axis, while the lower portion will run on a vertical axis. Furthermore, this project made use of an Arduino UNO board-based analogue-to-digital converter (ADC). A microcontroller chip, the Atmega328p, a small PV module, and a DC battery will also be employed as it shows in Figure 2.5. It used a 9V DC battery and the LM7805 voltage regulator integrated circuit for the battery.

Figure 2.5 Constructed dual axis solar tracker

The experiment is carried out with a polycrystalline PV panel and a sun tracker with a fixed angle. PV panel dimensions were 19.6 x 10.5cm, and two servo motors were utilized to make a rotation for PV panel to move in azimuth and altitude angles at the same time. According to the results of the investigation, the output from dual axis solar tracking is more accurate than a fixed panel.

2.3.6 Optimization of Solar Energy Tapping by an Automatic Solar Radiation Tracker

This journal was published by Bikash Monger and Jigme Namgyel in June,2017[6]. According to the author, one of the solutions to optimum solar energy is to create a solar panel that can be moved in all directions towards the sun. This is a twin axis automated solar tracker project. Furthermore, this project was created with Arduino-controlled operations in mind. The LDR will then be installed on the solar panel, and the LDR will send the data to the Arduino. The Arduino will tell the motor driver whether it should rotate clockwise or counterclockwise.

Because Arduino is the central component of the system, it will take an analogue voltage from the LDR and convert it to a digital value. The motor driver is also a key component because it will be needed in the project to ensure that the panel moves accurately

for this system. Aside from that, the resistor will be connected in parallel because it will be used as an Arduino input voltage. The simplest components are employed in this project to keep costs down without sacrificing efficiency. The inventor claims that after testing the project, this sun tracking device can collect roughly 8% more than a fixed panel. As a result, this initiative was a success.

2.3.7 Arduino Based Solar Street Light

This paper by Aron D'souza and Omkar Bhosale on 2019 [7]. The researcher proposed this research about developed the smart street lighting to ensure the system can reduce the consumption of energy and can increase its efficiency. The reseacher want to produce the energy by solar to reduce the costing. Other than that, researcher said that most of street light will always ON even the ambient of lighting is higher. So, the reseacher want to having a smart street light which it can OFF the street light when the ambient lighting falls below the specific intensity. It is because the street lighting application are mostly in manual control and it will used more costing in order to monitor it.

The possible solutions to do this project is, renewable energy source should be used because it is more efficient, more friendly environment and low costing or LED technology will offers to be used in this project. The reseacher used solar energy as the main source in this project because the solar energy will charge the battery in the day time to its capacity and during the night time, the battery will supply the voltage to the components connected. Then, they also used LED technology system to reduce the energy consumption. Reseacher said energy consumption and maintenance cost can be reduced about 20-25%.

2.3.8 Solar Street Light

This journal was published by S. Nakanishi and K. Matsumura in 2019 [8]. The author proposed using renewable energy to replace fossil fuel losses in energy efficiency. The researchers stated in this project that the solar panel can generate energy indirectly from photovoltaic and concentrated solar power. Because solar energy can reduce power consumption, solar street lights were distributed. Aside from that, it can be used over a long period of time to conserve the environment. Solar street light components include a solar panel, rechargeable battery, lighting fixture, and pole. In particular, this project employs a controlling method to ensure that the system facilitates people and reduces costs.

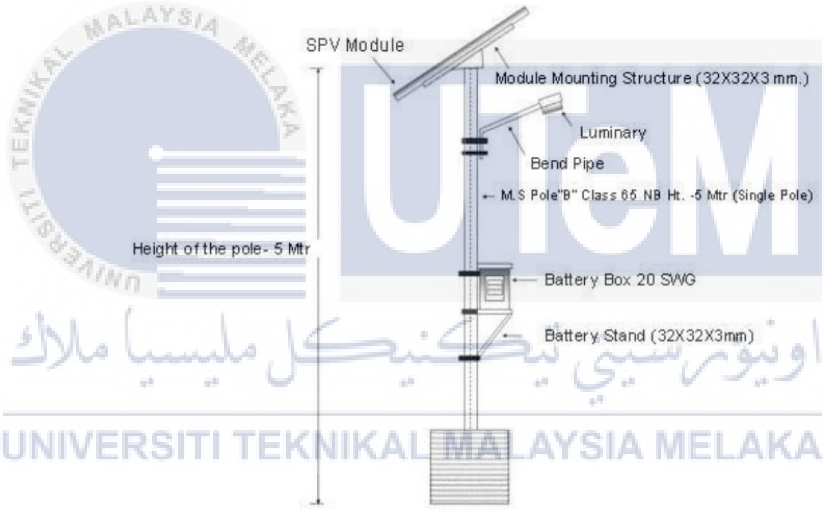

Figure 2.6 Solar Panel

Figure 2.6 depicts the author's solar panel design. The solar streetlight's operating principle is to capture solar energy during the day. A battery is used to store solar energy and convert it into electrical energy. During the night, the solar streetlight will automatically light up and draw power from the battery.

2.4 Summary

Table 2.1 Summarize the concept from the previous project.

No.	Author	Title	Functional	Remark
1	Jyoti Mishra, Ritula Thakur, Alok Deep (2017)	Arduino based Dual Axis Smart Solar Tracker	Change their orientation throughout the day to follow the sun's path to maximize energy capture.	• The efficiency of solar panel can be increased to a great extend if solar panels continuously rotate. • Maximize the power consumption by just rotating the solar panel according to sun's position. • The system was less efficient because of the low sensitivity and disturbance of LDR.

				• Used Bluetooth in Android app to show the voltage in Android device. **Components:** Arduino UNO, Bluetooth module, Solar panel, servo motor, Light dependent resistor (LDR)
2	Mohamad Nur Aiman Mohd Said, Siti Amely Jumaat, Clarence Rimong Anak Jawa (2019)	Dual axis solar tracker with IoT monitoring system using Arduino	Develop dual axis solar tracker with IOT monitoring system using Arduino because Malaysia has the higher solar radiation that can be used to generate electricity.	• Most effective technology to improve efficiency of solar panels is solar tracking system. • If compared with single axial solar tracker, this system generates more power, voltage and

				current because its two-axis solar tracking. • The platform that has been use in this project is Raspberry Pi 3 (RPi3). • build dual-axis solar tracking system using programmable logical controller (PLC) based on automatic tracking system. **Components:** Arduino UNO, Light dependent resistor (LDR), servo motor, WIFI ESP8266 device, solar panel.

3	Fazlur Rahman Bin Karim, Md. Mamunor Rashed, Muhammad Quamruzzaman	Design and implementation of a sensor-less dual axis solar tracking system based on solar sun chart algorithm using Arduino	Improve the efficiency of the dual axis solar tracking.	• implement it sensor-less and it based on solar sun chart program using Arduino. • solar sun chart algorithm will help to track the sunlight accurately. • Open loop tracking system is used in this project since it is less costly. • Open loop tracking system also more accurate than closed loop tracking system **Components:** Arduino UNO, real time clock

				(RTC), solar module, DC servo motor.
4	Pratik Pawar, Ashish Yadav, Pritam Makwana, Shubham patil	Solar Tracking System Using Arduino	Collects energy from direct sunlight, stores it in a battery, and then converts it to electricity.	• This system was created to withstand extremes in temperature and weather. • Light detecting modules are the starting point for this project. **Component:** Arduino, LDR, motor driver, solar panel, power supply.
5	Ukoima Kelvin Nkalo, Ekwe Ogbonnaya Agwu, Nwokeafor Joseph Chibuike	An Improved Dual Axis Controller for Photovoltaic Cells	Implement a dual axis controller for photovoltaic (PV) cells in order to reduce the electrical circuitry used in prior and existing systems.	• Designed as a closed loop system with two compartments: upper and lower parts of the model. • Upper portion will run on a

				horizontal axis, lower portion will run on a vertical axis. • Used a polycrystalline PV panel. **Component:** Arduino UNO, PV module, DC battery, LM7805 voltage regulator.
6	Bikash Monger, Jigme Namgyel, Kelzang Tenzin, Namgay Dorji, Dechen Lhamo	Optimization of Solar Energy Tapping by an Automatic Solar Radiation Tracker	Create a solar panel that can be moved in all directions towards the sun.	• Dual axis automated solar tracker project. • Arduino is the central component of the system; it will take an analogue voltage from the LDR and convert it to a digital value.

				• Resistor will be connected in parallel because it will be used as an Arduino input voltage. • This sun tracking device can collect roughly 8% more than a fixed panel. **Component:** Arduino, LDR, motor driver, resistor, solar panel.
7	Aron D'souza, Omkar Bhosale, Miheer Bhilare, Shubham Sawant	Arduino Based Solar Street Light	Developed smart system of streetlight	• To reduce the energy consumption. • To helps dimming the lighting with specific intensity. • Solar energy charges the battery during the daytime to supply

				streetlight during nighttime. **Component:** Solar panel, Arduino ATMega, PIR sensor, rechargeable battery.
8	S. Nakanishi, K. Matsumura, H. Mori, K. Ishii, K. Ogawa	Solar streetlight	Reduce fossil fuel using renewable energy	• Solar panel can generate energy indirectly from photovoltaic and concentrated solar power. • Used over a long period of time to conserve the environment. • A battery is used to store solar energy and convert it into electrical energy. **Components**: solar panel, rechargeable

				battery, lighting fixture, and pole.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter explains the entire development process for the project "Development of Solar Tracking System for Street Light Application Using Arduino." The block diagram and flow chart are explained first in every technical part. The role of each part in this chapter clearly defines the project. This chapter also covers the hardware design and software development functions of the project. From beginning to end, all processes and flows of each phase in the manufacturing are documented. Aside from that, each step is described in detail one by one.

Figure 3.1 Project Concept

This is the project's concept, as illustrated in Figure 3.1. The LDR sensor, which tracks daylight exposure, is the first step. The data from the LDR will be programmed and a rotation for the servo motor will be made by the Arduino as the main microcontroller. A two-axis rotation is achieved with a servo motor. The electrical energy from the solar panel

is stored using a lithium-ion battery. After then, the LED will be light up by electrical energy from the battery.

3.2 Project Design

This project design depicts the entire procedure from start to finish. One approach for displaying the sequence of project flow is to use a flowchart. The flowchart is shown in Figure 3.2 as a method for completing the project. The project's flowchart explains each aspect of the method for achieving the end objectives. Software and hardware research and software research are the two aspects of the project.

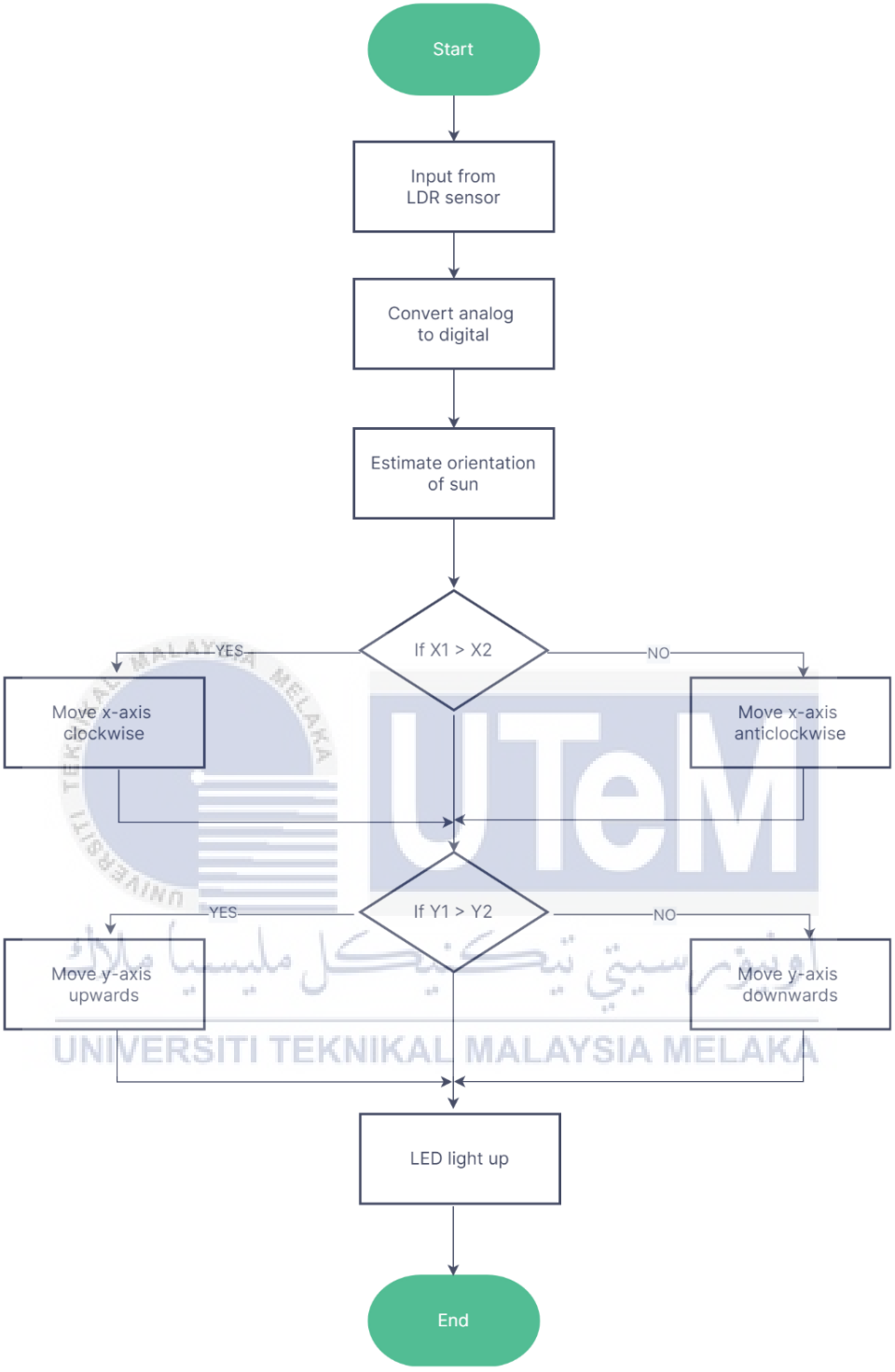

Figure 3.2 Flowchart Project

3.3 Project Architecture

The block diagram for this project depicts in Figure 3.3 the operations that are involved. This makes it easy for researchers to identify the issue when it arises.

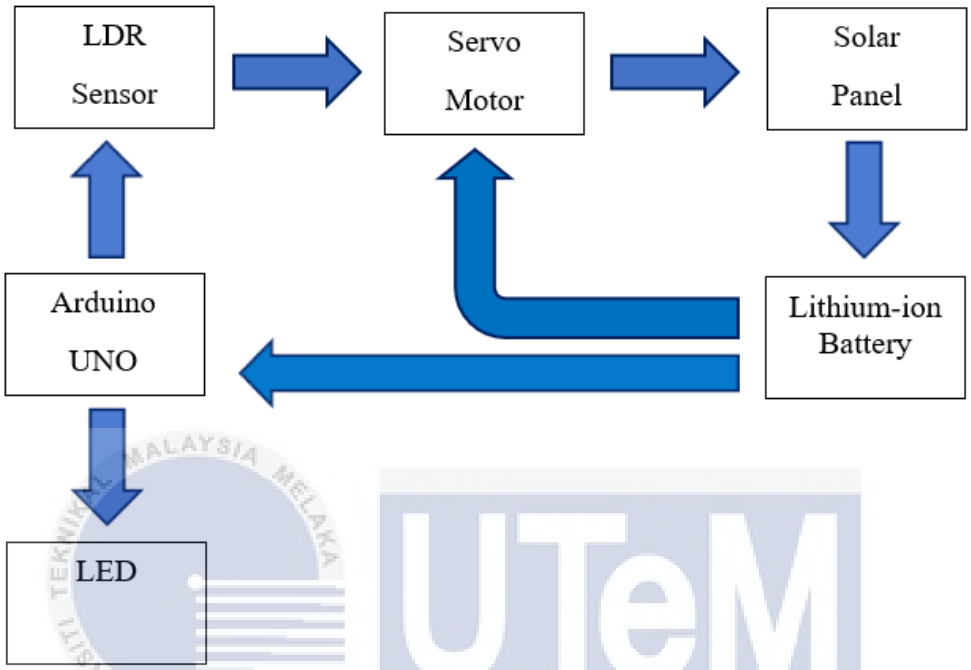

Figure 3.3 Block Diagram

The system starts with the LDR sensor detecting the presence of sunlight and sending data to the Arduino in this project. The Arduino will then use the data from the LDR sensor to command the rotation of a servo motor rated at 3kg/cm with an operating voltage of 4.8 to 6V for X-axis or Y-axis rotation in order to keep the solar panel moving towards the sun in order to get the most electrical energy. The solar panel then collects the energy from the sun and charges the 3.7V 850mAh battery used in this project, which then sends the electrical energy to the LED to light it up.

3.4 Hardware Requirement

3.4.1 LDR Sensor (Light Dependent Resistor)

The presence of light is detected by a light-dependent resistor sensor shown in Figure 3.4. It works with both digital and analogue output pins on the board, which are designated as DO and AO. Due to the intensity of light, the resistance of LDR drops considerably, even to a few ohms, when light is present, whereas in the dark, the resistance is large. Furthermore, during daylight, the normal resistance of an LDR sensor is 5000 Ohms, and in the dark, it is 20000000 Ohms.

Figure 3.4 LDR Sensor

3.4.2 Arduino UNO

Because it uses embedded technology, this Arduino UNO microcontroller as shown in Figure 3.5 makes programming easy. Aside from that, it comes with everything you'll need to get started with the microcontroller, including a battery, an AC-to-DC adapter, and a USB cable. Because it contains a battery connector, this microcontroller can work with 9V batteries. It also includes 13 LED pins, 14 digital input/output pins, 6 analogue input pins, and PWM pins built in [9]. The input/output voltage is also 5V.

In addition, because it can regulate all functions, the Arduino controller is the circuit's core. The characteristics of the Arduino UNO are shown in Table 3.1. The Arduino UNO has a low operating voltage of 5V and a supply voltage ranging from 7V to 12V. Other good characteristics of the Arduino UNO that have been demonstrated.

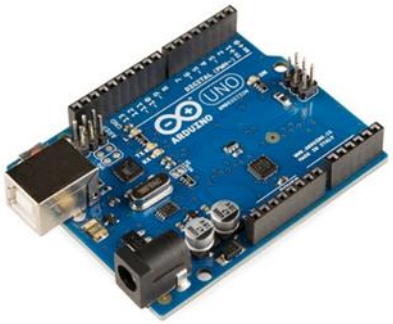

Figure 3.5 Arduino UNO

Table 3.1 Characteristics of Arduino UNO

Operating Voltage	5V
Supply Voltage	7-12V
DC Current per I/O Pin	40mA
DC Current for 3.3V Pin	50mA
Flash Memory	32KB of which 0.5KB
SRAM	2KB
EEPROM	1KB
Clock Speed	16MHz

3.4.3 Servo Motor

The purpose of a servo motor that shown in Figure 3.6 is to ensure that its rotation is precise. This servo motor is used to accomplish this project because it can spin an object at a certain angle or distance. It is also a part of a machine with great efficiency. In addition, servo motors are part of a closed-loop system that includes a servo motor, control circuit, potentiometer, shaft, amplifier, driving gears, and either an encoder or resolver. Aside from that, this tiny and lightweight servo motor boasts a high-power output and an aluminium gear wheel. The operating voltage of this servo motor ranges from 4.8V to 7.2V [10]. Most servo motors are rated in kg/cm, such as 6kg/cm or 12kg/cm, which indicates how much weight the servo motor can raise.

Figure 3.6 Servo Motor

3.4.4 6V Solar Panel

The type of solar cell used is 6V polycrystalline cells that mounted with the fiberglass PCB and covered with epoxy resin to protects the cells without dropping its efficiency as depicts in Figure 3.7. Polycrystalline has been chosen because it is quite efficient and affordable. Other than that, this solar cell can simplify the digital making because it comes with wire or lead pre-soldered.

Figure 3.7 6V Solar Panel

3.4.5 Rechargeable Li-Ion 3.7V/3800mah Battery

The battery's that shown in the Figure 3.8 job is to store the electrical energy generated by the solar panel. Because lithium-ion is more stable and can be recharged hundreds of times, it was chosen. It also has a larger voltage capacity as well as a higher energy density. This battery's nominal capacity is 3800mAh. The maximum charge voltage is 4.20V ± 0.05V and the discharge cutoff voltage is 3.0V. Aside from that, the battery's operational temperature ranges from 0 to 45 degrees Celsius for charging and -20 to 60 degree Celsius for discharging.

Figure 3.8 Li-Ion 3.7V/3800mah Battery

3.4.6 Light Emitting Diode (LED)

The function of the LED in Figure 3.9 as a streetlight. The LED will light up when there are electric current flows through it. LED is a semiconductor that has a combination of two junction which is P-type semiconductor and N-type semiconductor. Then it will release the energy in the form of light when the sufficient forward voltage is applying that cause the electrons combine at the P-N junction. Other than that, LED just allows the current flows in the forward direction and block in reverse direction. Furthermore, the material that used in the semiconducting element will determine the color of the LED.

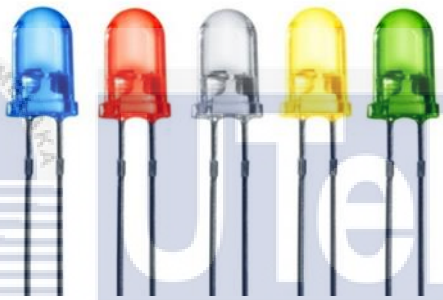

Figure 3.9 Light Emitting Diode

3.5 Software Requirement

3.5.1 Arduino IDE

The Arduino IDE that shows in Figure 3.10 is a simple programmed with nearly all settings. To begin using the Arduino IDE software, go to the top menu bar and select "File" from the drop-down menu (new, save on load, etc.). Then select "Edit" (font, copy, paste, etc.). Aside from that, "Sketch" can be used to compile the command and change other settings. Click "The Tools" to select relevant options for testing projects, and "Help" to

access the IDE's centre part, which includes a rudimentary text editor for entering software code. Last but not least, the IDE's bottom part is dedicated to displaying the compilation status, which includes faults in the software, memory use, and other relevant messages.

Figure 3.10 Arduino IDE

Sketches are projects created with the Arduino, and they are often written in a C++ cut down.

3.5.2 Proteus Software

Proteus software that shown in the Figure 3.11 is one of the important software to finish this project. Proteus circuit simulation of this project will be done in this software to ensure the simulation is functionally well before construct the hardware. Proteus software not only can design the embedded system of schematic, but it also can design Proteus PCB. Other than that, it is user friendly for beginner. To construct the simulation of solar tracking system for street light application, the components used is Arduino Uno, servo motor, LDR sensor and LED.

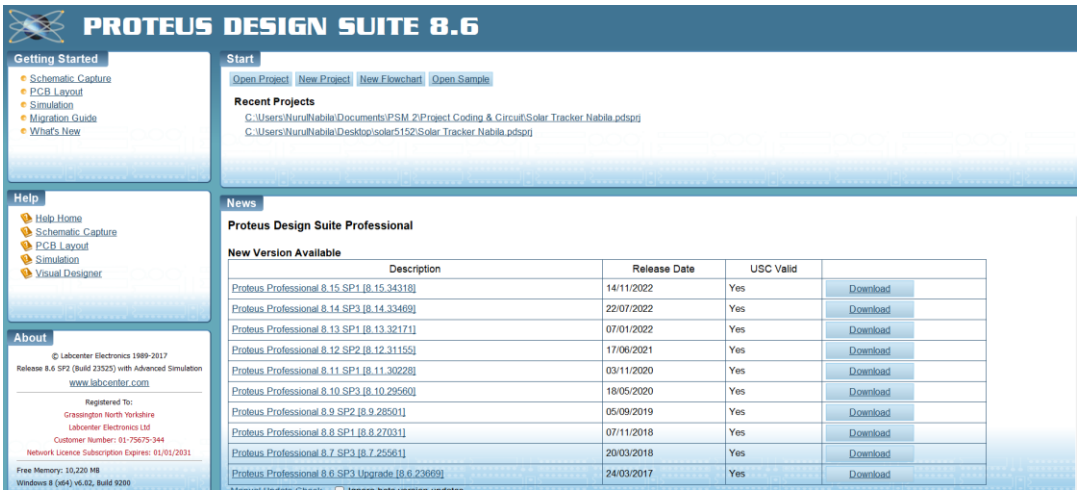

Figure 3.11 Proteus Software

3.6 Product Design

The design of the dual axis solar tracker is shown in Figure 3.12. The solar panel has been placed at the top of the design to ensure that it can absorb the maximum amount of sunlight and is not blocked by other components. Aside from that, the dual axis solar tracker requires space to rotate in the X- and Y-axes, which is why the solar panel should not be placed at the bottom of the design because the servo motor must be able to make a precise rotation. The design for locating the controller, which is Arduino, LED, and battery, is then placed on the board or inside the box. This is due to the fact that it is simple to troubleshoot any difficulties or errors that may occur with the controller or other components. Furthermore, this style can save space on the board while also looking elegant.

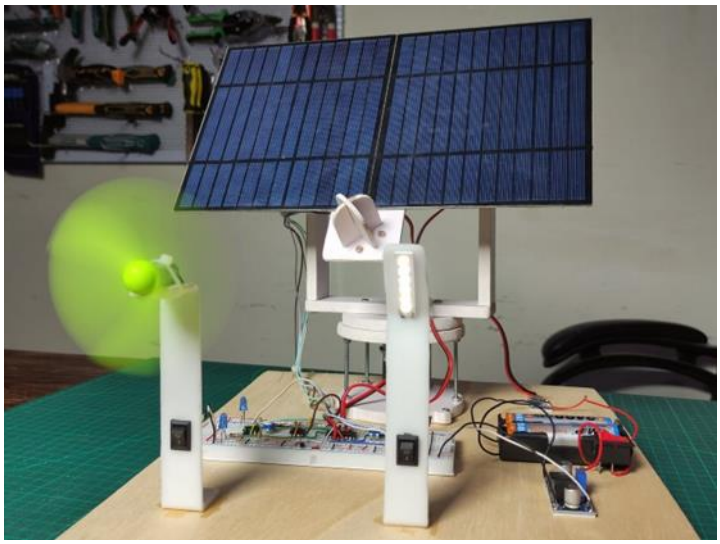

Figure 3.12 Dual axis solar tracker

3.7 Gantt Chart

Figure 3.13 depicts the Gantt Chart timeline for this project, which was used to organise and monitor multiple tasks. The progression of Bachelor's Degree Project 1 is depicted in the Gantt Chart below. For the progression Bachelor's Degree Project 2, it shown in Figure 3.14.

No.	Project Activity	Expected / Actual	WEEK													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Topic confirmation and discussion with the supervisor	Plan														
		Actual														
2	Final year project (PSM1) briefing by panel	Plan														
		Actual														
3	Research on academic papers	Plan														
		Actual														
4	Study background project	Plan														
		Actual														
5	Prepare for Chapter 1: Introduction	Plan														
		Actual														
6	Initial project: Simulation	Plan														
		Actual														
7	Update to supervisor: Progress Work 1	Plan														
		Actual														
8	Prepare for Chapter 2: Literature Review	Plan														
		Actual														
9	Prepare for Chapter 3: Methodology	Plan														
		Actual														
10	Report Draft Submission	Plan														
		Actual														
11	Update to supervisor: Progress Work 2	Plan														
		Actual														
12	Report Submission to Panel	Plan														
		Actual														
13	PSM Presentation Evaluation	Plan														
		Actual														

Figure 3.13 Gantt Chart Progress Bachelor's Degree Project 1

No.	Project Activity	Expected / Actual	WEEK													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	PSM2 briefing	Plan														
		Actual														
2	Meeting supervisor and buy component	Plan														
		Actual														
3	Send claim form	Plan														
		Actual														
4	Start program the project	Plan														
		Actual														
5	Construct hardware part by part	Plan														
		Actual														
6	Update to supervisor: Progress Work 1	Plan														
		Actual														
7	Start making overall Project	Plan														
		Actual														
8	Prepare for Chapter 4	Plan														
		Actual														
9	Prepare for Chapter 5	Plan														
		Actual														
10	Report Draft Submission	Plan														
		Actual														
11	Update to supervisor: Progress Work 2	Plan														
		Actual														
12	Submit Report to panel	Plan														
		Actual														
13	PSM2 presentation and evaluation	Plan														
		Actual														

Figure 3.14 Gantt Chart Progress Bachelor's Degree Project 2

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter will cover the observation and analysis of data collected from testing, as well as observations that will be followed by a discussion of the results gained. There have been various advancements in order to obtain the desired outcome.

4.2 Hardware Setup

4.2.1 Servo Motor Wiring Diagram

In this project, the microcontroller that been use is the Arduino setup to configure for servo motor function as shown in Figure 4.1. Servo motor is used to make a dual axis rotation for the solar panel that produce the signal from the LDR sensor. For constructing the rotation for solar panel, 2 unit of 6V servo motor is used as shown in Figure 4.2. Servo motor is used for the rotation in vertical and horizontal axis. The minimum and maximum limit for the motor to rotate is set by 90 degree for minimum limit, and 140 degree for maximum limit for both axis.

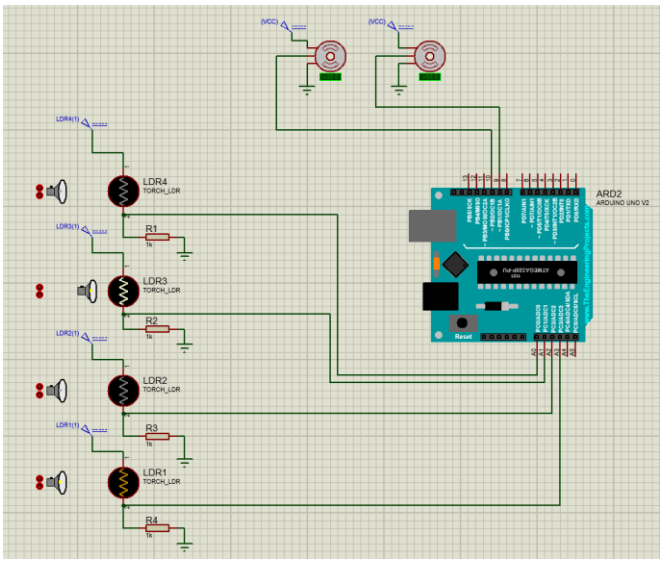

Figure 4.1 Servo Motor using Arduino

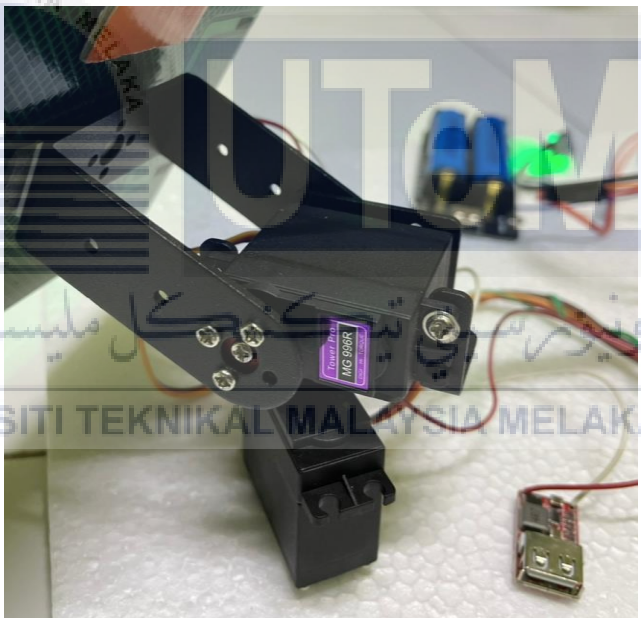

Figure 4.2 Actual Hardware Servo Motor

4.2.2 Solar Wiring Diagram

Based on Figure 4.3, it shows the wiring diagram for the solar that created by Proteus software. Solar will rotate to captured the sunlight and transfer the energy to the battery in order to charge the battery until it is fully charged. Battery need to power up the street light

during night time. Other than that, battery also need to power up the servo motor during day time to make sure the solar panel can make a dual axis rotation. Dual axis rotation for the solar panel is identify by the 4 unit of LDR sensor. Figure 4.4 shows the actual hardware solar that construct after the simulation from the Proteus software.

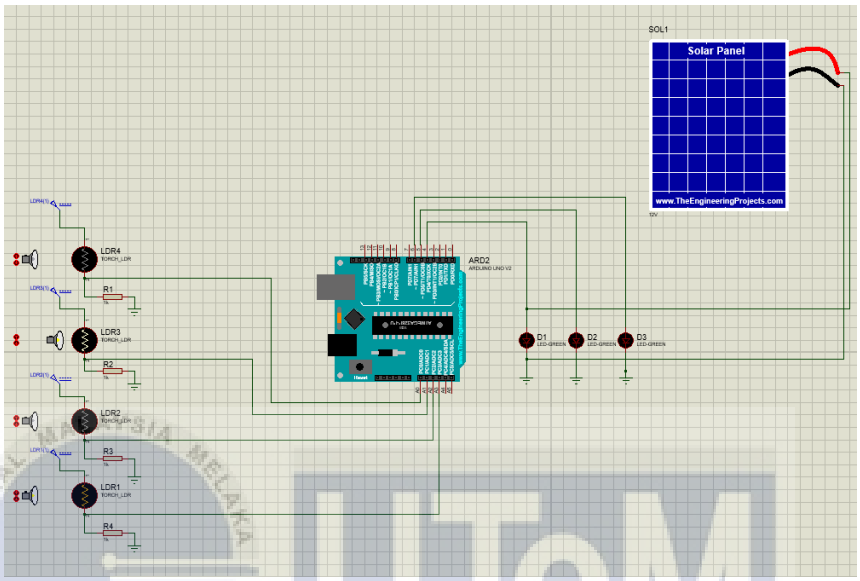

Figure 4.3 Solar Wiring Diagram

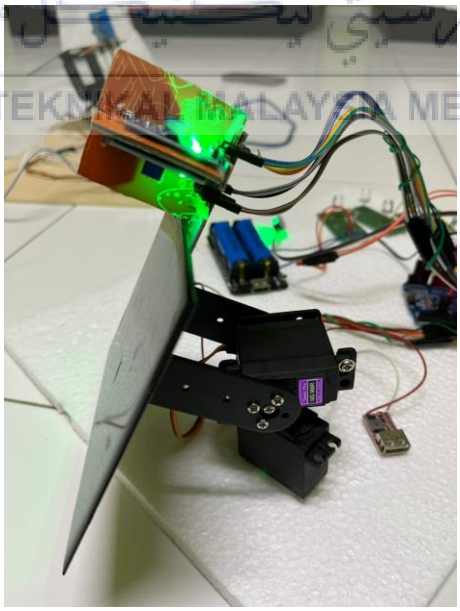

Figure 4.4 Actual Hardware Solar

4.2.3 Street Light Wiring Diagram

Figure 4.5 shows the street light connection that created by the Proteus. LED is an indicator as a street light which it will light up during night time and darken during day time. LED is connected to the Arduino at pin 4, 5, and 6. One LDR sensor is used in order to light up or darken the LED. In Figure 4.6, the actual hardware of LED that act as street light can light up during the night time.

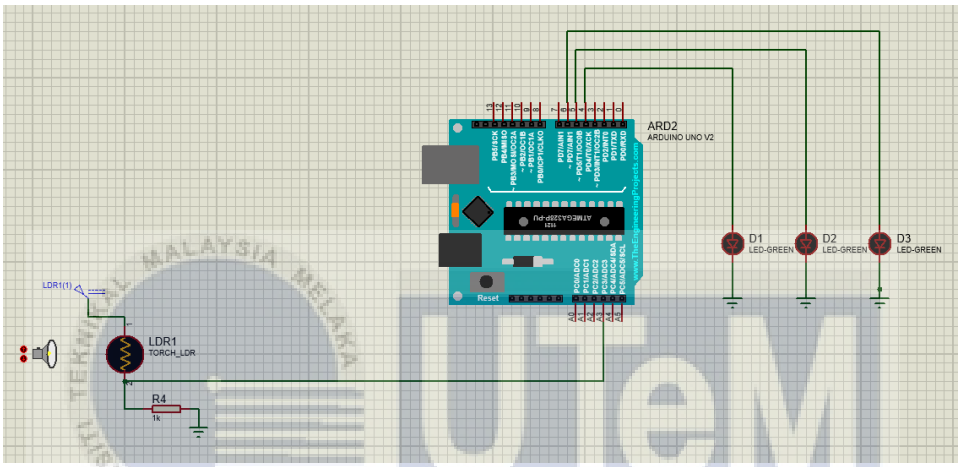

Figure 4.5 Street Light Wiring Diagram

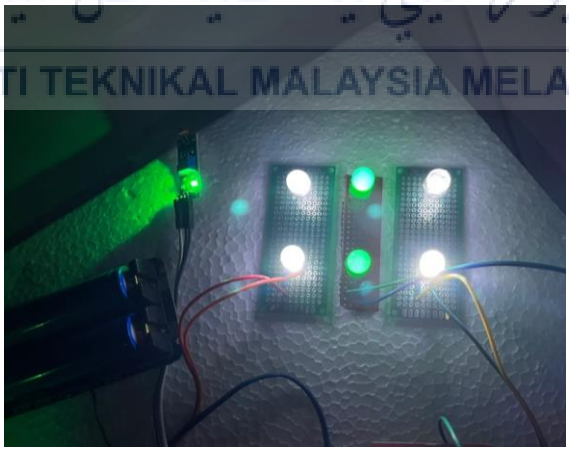

Figure 4.6 Actual Hardware Street Light

4.2.4 Arduino Setup

In this project, the microcontroller that been use is the Arduino to configure for functioning the dual axis solar tracking system. Figure 4.7 shows the whole circuit for simulation in Proteus software.

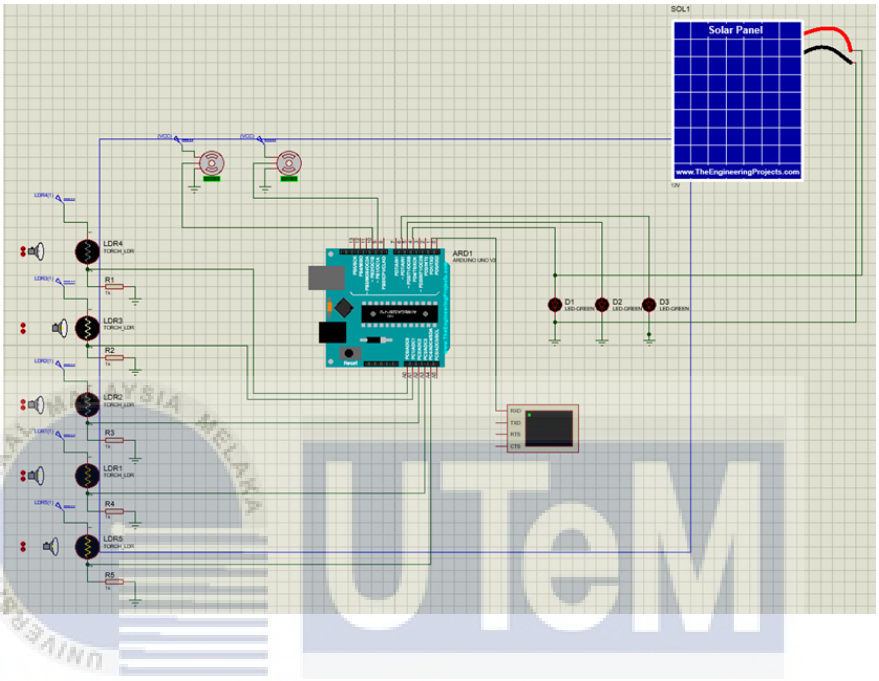

Figure 4.7 Arduino Setup

The details about Arduino Uno connection with this component is shown in the Table 4.1 below.

Table 4.1 Arduino Setup

Arduino Pin	Function
4, 5, 6	Light up the LED
9	Rotate the servo motor horizontal axis
10	Rotate the servo motor vertical axis
A0	Connect to LDR1
A1	Connect to LDR2

A2	Connect to LDR3
A3	Connect to LDR4
A4	Connect to LDR5 and make a LED light up and darken the LED.

4.3 Hardware Design

For this section, we can see that the actual design that been constructed are as a prototype for the street light monitoring by the dual axis solar tracking in Figure 4.8. In Figure 4.9, solar panel in size 11cm x 13cm are suitable for this project because to ensure the solar can make smooth rotation in dual axis without any problem. It is because the pan and tilt servo does not have big surface to support the weight of big size of solar when it stick together and it easy to ripped off.

For this experiment, the hardware wiring is been put in the box that shown in the Figure 4.10 in order just to show the solar tracker and LED only. Not to forget also the LDR5 as a indicator to ensure the LED will be light up during night time and darken during day time. Plus, it also make a prototype more neat and tidy. The position of solar tracker will be put higher than the base prototype because to ensure the rotation does not ruin the connection wire at 4 units of LDR sensor.

Figure 4.8 Hardware Design

Figure 4.9 Solar Panel Size

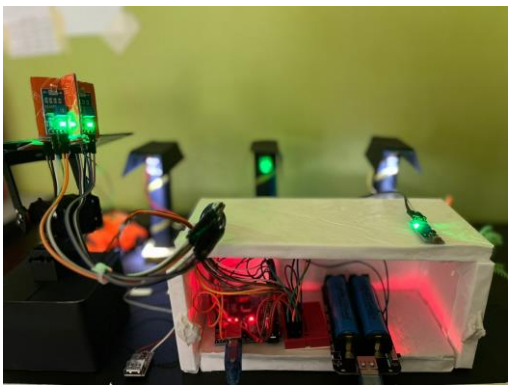

Figure 4.10 Hardware Wiring

4.4 Testing and Analysis Method

This part is the main for this project, it is because the system need to be analysed the operation of dual axis solar tracking for street light using Arduino. This part will discuss after completing the dual axis solar tracking system. There will be several experiment and analysis that will be done to get the best result and archieved the objectives.

4.4.1 Measurement for Output Voltage of Solar Tracker

In this analysis, the output voltage and the angle of solar tracker are measure as shown in Figure 4.11. The measurement are took in three days. The measurement are took from morning 9.30 am until evening 5.30 pm. This measurement is to obtain the efficiency of solar tracking system. The graph for the measurement are shown in Figure 4.12, Figure 4.13, and Figure 4.14.

Figure 4.11 Measure Output Voltage of Solar

4.4.1.1 Output Voltage for Solar Tracker in Day 1

Table 4.2 Measurement Table 1

Time	Voltage (V)	Angle	
		Vertical	Horizontal
9.30 am	1.961	90	140
10.30 am	2.264	100	140
11.30 am	2.4	95	140
12.30 pm	2.432	107	140
1.30 pm	2.563	140	140
2.30 pm	3.2	90	140
3.30 pm	1.356	69	140
4.30 pm	1.749	60	140
5.30 pm	2.98	60	140

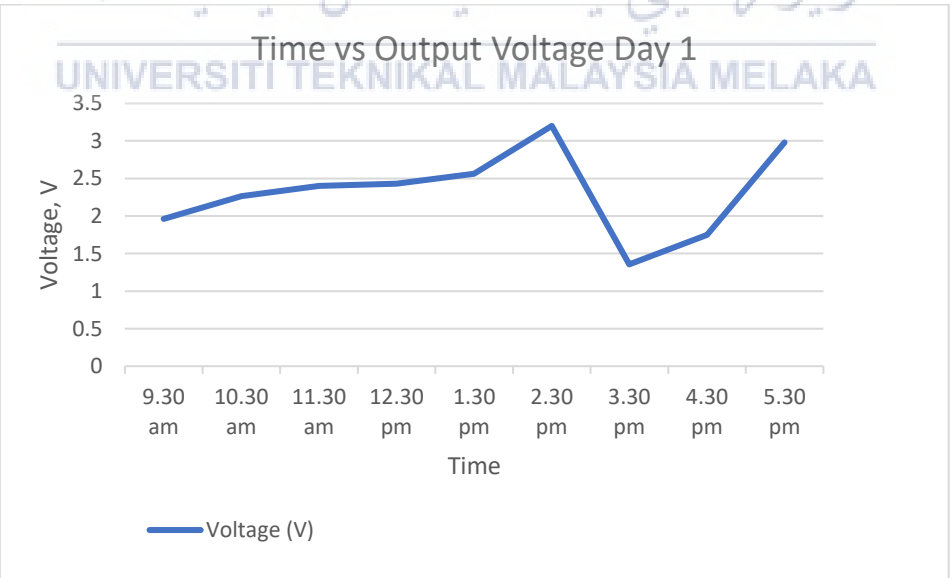

Figure 4.12 Measurement Graph 1

Figure 4.12 depicts the graph for the measurement of output voltage in Day 1. Based on the graph, the output voltage is increase proportionally from 9.30am until 2.30pm. But the graph dropped sharply at 3.30pm according to the cloudy weather that can lead to rain. Then, the sunlight comes out and the output voltage increasing again. The highest output voltage captured by the solar is 3.2V at 2.30pm.

4.4.1.2 Output Voltage for Solar Tracker in Day 2

Table 4.3 Measurement Table 2

Time	Voltage (V)	Angle	
		Vertical	Horizontal
9.30 am	2.35	97	140
10.30 am	3.49	106	140
11.30 am	4.132	140	140
12.30 pm	4.78	90	140
1.30 pm	1.90	128	140
2.30 pm	2.04	90	140
3.30 pm	2.63	140	140
4.30 pm	2.13	140	140
5.30 pm	2.08	140	140

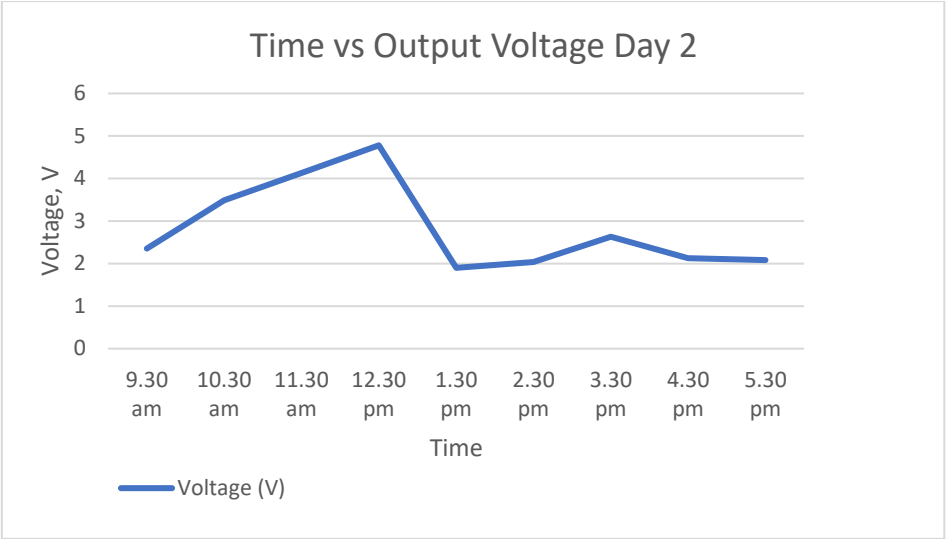

Figure 4.13 Measurement Graph 2

Figure 4.13 depicts the graph for the measurement of output voltage in Day 2. The graph shows that the output voltage rises from 9.30am until 12.30pm. However, due to the cloudy weather and brief rain, the graph dropped sharply at 1.30pm. Then the sun comes out, and the output voltage increases again after 1.30pm, but it decreases depending on the weather. At 12.30pm, the solar panel captured the highest output voltage of 4.78V.

4.4.1.3 Output Voltage for Solar Tracker in Day 3

Table 4.4 Measurement Table 3

Time	Voltage (V)	Angle	
		Vertical	Horizontal
9.30 am	2.23	140	140
10.30 am	2.94	128	140
11.30 am	2.99	140	140
12.30 pm	3.38	90	140
1.30 pm	3.49	128	140

2.30 pm	3.161	90	140
3.30 pm	2.95	140	140
4.30 pm	2.843	140	140
5.30 pm	2.671	120	140

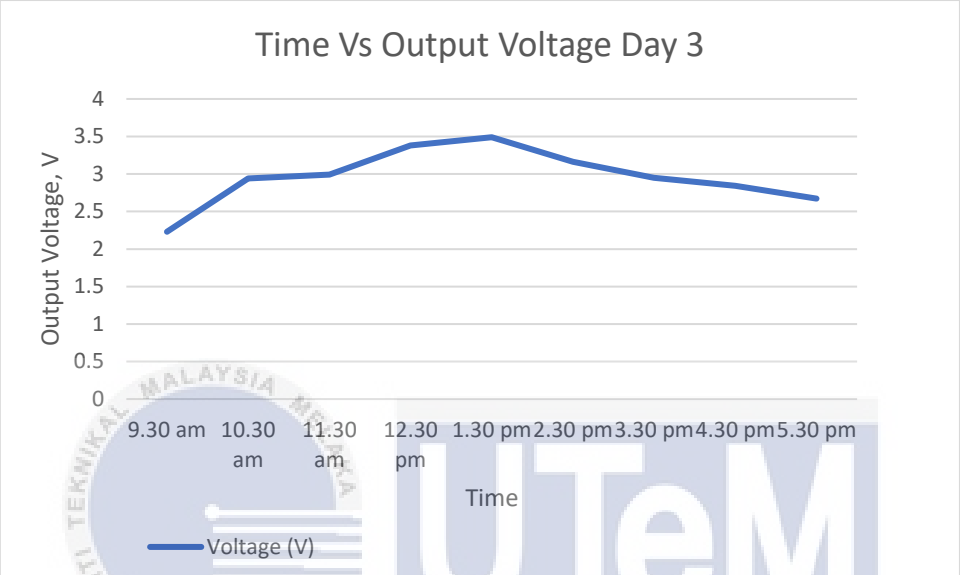

Figure 4.14 Measurement Graph 3

Figure 4.14 depicts the measurement graph for output voltage on Day 3. After the result has been plotted, the output voltage measurement result appears in the bell curve graph. The output voltage rises proportionally from 9.30am to 1.30pm and then falls proportionally from 1.30pm to 5.30pm. At 1.30pm, the highest output voltage captured by the solar is 3.49V. The weather is pleasant when the measurement is taken.

4.4.2 Measurement for Distance Light Luminance

In this analysis, the distance of light from the LDR sensor are measured and also the luminance of the light captured by the LDR sensor. The luminance is measured to ensure the value of luminance of light that can light up and darken the LED. Figure 4.15 shows the

graph distance of light vs luminance. In the graph, the LED are OFF when the distance of the light with LDR sensor are 15cm and 30cm. When the light far away from the LDR sensor, the luminance are decrease and the LED will light up.

Table 4.5 Measurement for Distance Light Luminance

Distance of Light (cm)	Luminance	ON/OFF
15	52	OFF
30	43	OFF
45	32	ON
60	22	ON
75	16	ON
90	11	ON

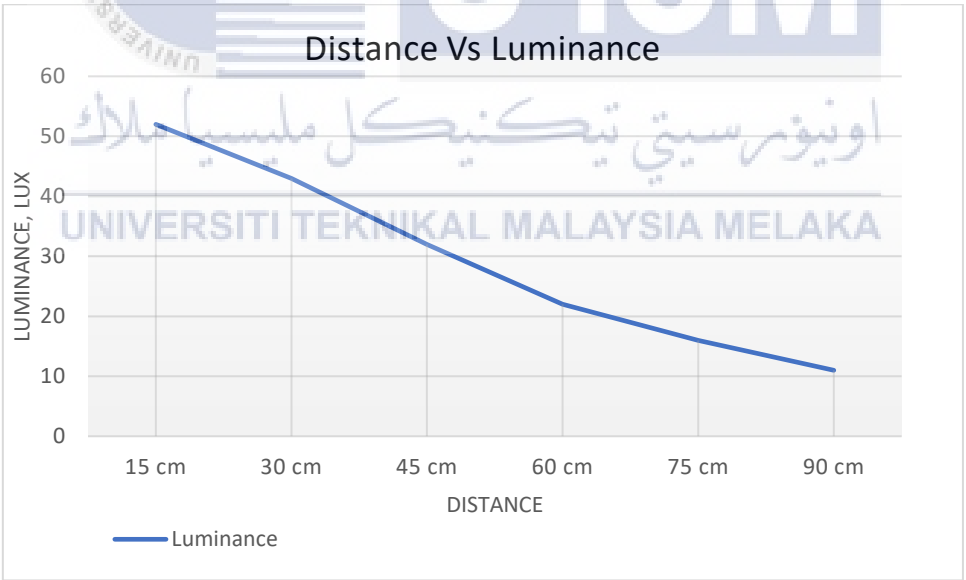

Figure 4.15 Distance of Light vs Luminance Graph

CHAPTER 5

CONCLUSION

In this last chapter, it will conclude overall function and result that obtain for this project, dual axis solar tracking system, problem encountered and also recommendation for this project. Beside that, the important things in this chapter is problem faced according to finish this project. From the problem encountered, we can find other way to make an improvement and overcome the problems. This chapter also cover the way how to improve this project in the future.

5.1 Achievement

For the final result of this dual axis solar tracking, all objectives had succesfully achieved. This project is capable to use for the real life situation but need to replace the efficient solar that can capture the maximum energy from the sunlight to ensure the efficiency of the system and make sure the solar can make a dual axis rotation without any difficulty. The system for street light can light up during the night time according to its setting system. Other than that, solar successfully rotate in dual axis according to the light get by LDR sensor.

5.2 Final Product

For this final product, there a two section. The first section is the main part of this project which is solar tracking system and the second section is street light application. Solar tracking will rotate in vertical and horizontal axis due to captured maximum of sunlight to charge the battery. Battery is used to power up the servo motor and to ensure the solar can

rotate on dual axis. Other than that, LDR sensor is the main role in this solar tracking since it will give the signal to servo motor where direction and what angle solar need to rotate. Then, in the second section, LED is used to illustrate as a street light. LED will light up when the LDR sensor get the signal about there is no brightness in the surrounding, while when there is brightness in the surrounding, LED will darken. LED is light up according to the one LDR sensor.

5.3 Problem Encountered and The Limitation of Project

The most problem encountered is when need to used small size of solar panel due to its problem during rotation. This is because there is only two servo motor used to make a dual axis rotation for the solar, especially in vertical axis the solar cannot stick properly with the pan and tilt of servo motor. Beside that, the output voltage produced from the solar is really low and only charge the a small of battery with capacity 3800mAh. But, if large capacity of battery is used, need a long time taken to charge and supply. Other than that, rotation of solar will not too accurate when the system on for the first time, it will take time to make sure it can make a smooth rotation.

5.4 Recommendation for Future Project

From the problem that encountered and the limitation of the project, it can be improvise by using a suitable size and capacity equipment and component so that the project can be more reliable and suitable to be used in real life. About the lower voltage, big size and big capacity of solar can be used to produce a larger power to the battery thus the large capacity of battery also can be used to store the energy that get from the solar panel. Besides that, the accuracy of the rotation of solar panel towards the sunlight can be achieved.

According to analysis that need to measure the voltage and to see the angle of the solar, LCD display can be added to facilitate the user to monitor the solar tracking system. Then, the problem with the solar panel rotation can be improvised by increasing the total of servo motor and need to ensure stick the servo motor in every corner of the solar due to solar panel stability.

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APPENDICES

Appendix A Arduino Coding

```
#include <Servo.h>
#include <Wire.h>

Servo horizontal;
int servoh = 90;
int servohLimitHigh = 140;//max
int servohLimitLow = 40;//min
Servo vertical;
int servov = 90;
int servovLimitHigh = 140;
int servovLimitLow = 40;

int ldrlt = A0; //LDR top left
int ldrrt = A1; //LDR top rigt
int ldrld = A2; //LDR down left
int ldrrd = A3; //ldr down rigt

#define sensorPin A4
int val = 0;
int led1 = 4;
```

```
int led2 = 5;

int led3 = 6;


void setup()

{

  Serial.begin(9600);

  pinMode(led1, OUTPUT);

  pinMode(led2, OUTPUT);

  pinMode(led3, OUTPUT);

  digitalWrite(led1, LOW);

  digitalWrite(led2, LOW);

  digitalWrite(led3, LOW);

  horizontal.attach(10);

  vertical.attach(9);

  horizontal.write(90);

  vertical.write(90);

  delay(3000);

}
```