DESIGN AND DEVELOPMENT OF DUAL AXIS SOLAR TRACKER WITH WEATHER SENSOR

An Undergraduate CAPSTONE Project
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Under the Supervision of

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Associate Professor

Fall Semester 2021-2022
January, 2023

Faculty of Engineering
American International University - Bangladesh

DESIGN AND DEVELOPMENT OF DUAL AXIS SOLAR TRACKER WITH WEATHER SENSOR

A CAPSTONE Project submitted to the Faculty of Engineering, American International University - Bangladesh (AIUB) in partial fulfillment of the requirements for the degree of Bachelor of Science in their mentioned respective programs.

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DECLARATION

This is to certify that this project is our original work. No part of this work has been submitted elsewhere partially or fully for the award of any other degree or diploma. Any material reproduced in this project has been properly acknowledged.

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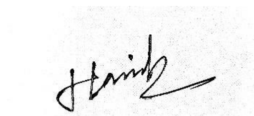

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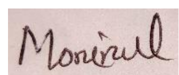

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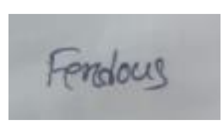

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APPROVAL

The CAPSTONE Project titled **DESIGN AND DEVELOPMENT OF DUAL AXIS SOLAR TRACKER WITH WEATHER SENSOR** has been submitted to the following respected members of the Board of Examiners of the Faculty of Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in the respective programs mentioned below on **January 2023** by the following students and has been accepted as satisfactory.

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ABSTRACT

Power crisis and pollution is two of the major problem currently facing by our country. The environment is getting polluted mostly due to power generation by the fossil fuel like, coal, gas etc. So, to save the environment and meet the power demand we must generate power by renewable sources which are eco-friendly. The paper proposes a dual axis solar tracker system that uses sunlight to generate power that is both eco-friendly and renewable. The proposed system will generate more power efficiently than a single axis solar tracker. It will track the sun and absorb the most irradiation possible. It will take the same amount of area as single axis takes but it will generate more power. So, the system will use the land efficiently also. To accomplish the project solar PV, LDR (Light Dependent Resistor), UV (Ultraviolet) sensor, buck converter and servo motor is used. The LDR and UV sensors detect sunlight and send a signal to the microcontroller, while the servo motor rotates the panel in response to the microcontroller's command. The suggested project uses a basic dual axis solar tracker system for design and implementation. Solar tracking systems must be integrated into solar power systems to maximize solar energy production. By following the sun's rays as they come from different directions coming to the solar panel, a dual-axis tracker can maximize energy. This solar panel has infinite rotational possibilities. The dual axis solar tracker system will sense the temperature of the environment and display it on the LCD. This Arduino UNO controller serves as the brain of the project which is incorporated with s solar panel, servo motors, current sensor, voltage sensor, Wi-Fi module (ESP32) and LCD to perform all the operations. The proposed project's main goal is to maximize energy efficiency by aligning the solar panel with the position of the sun. This is achieved by using LDR and UV sensor, which can gauge how much sunlight is coming into contact with the solar panel. When there is a large discrepancy in the values produced by the LDRs, a servo motor is used to actuate the panel so that it is approximately perpendicular to the sun's rays. The buck converter serves in balancing the power flow in the circuit, extending battery life, lowering heat and safe guarding against high voltage. The solar panel benefits greatly from the UV sensor which monitors ambient ultraviolet strength even in cloudy and extreme weather. The most challenging feature of this project is using a smartphone to regulate a solar panel. The ESP-32 is performing exceptionally well in this department and has excellent Wi-Fi capability. Since strong Wi-Fi connectivity is ensured in a static application, the ESP-32 was the best microcontroller option. The system's prototype has been built in a cost-effective way and validated in real-time circumstances and it has been found that the findings are consistent for each defining feature of this device and the errors found in each feature are very low, which makes it very reliable.

INTRODUCTION

1.1. Overture

Since the last 18 years people worldwide observing the earth is getting tremendous damage by the extremely high use of fossil fuel. While earth population is getting rapid exploitation day after day at a short period of time these non-renewable energy assets are rapidly decreasing and can no longer be accessible in the near future due to quick exploitation. Bangladesh is capable of producing 22,348 MW of electricity. According to BPDB data, approximately 52% comes from gas-powered plants, 27% from furnace oil-powered plants, 5.86% from diesel-powered plants, 8.03% from coal-powered plants, 1% from hydro, 0.5% from other renewable energies, and the remaining 5.27% is imported. The country generates 12,000 - 13,000 MW of electricity per day, compared to a demand of 14,000 - 14,500 MW [1]. Thinking all these sceneries the project aims at to increase power generation using renewable energy sources to meet up the demand. Solar Photo Voltaic (PV) cell will be used in this proposed project to collect photon energy and convert it to electric energy. The optimal angle for photovoltaic cells facing the sun is 45° in the spring and 20° in the summer, when the sun is high in the sky. Now the main point comes that is to track the sun continuously and all day long. A dual axis solar tracking system is proposed to solve this problem by tracking the sun from different angles and holding the PV panel towards the sun to create a better angle of collecting solar radiation. This smart device can run automatically by charging own power cell attached to the device. In other word it can be said that, with a view to obtain maximum output from the solar will be incorporated in the project.

1.2. Engineering Problem Statement

Day by day the non-renewable energy sources are decreasing at a high rate and therefore, it's becoming very difficult to produce enough electricity to meet our demand. Loadshedding is happening every day, and for that the industrial sector is facing a big loss and because of that the economy of Bangladesh is affected. To maintain our economic growth, we must produce electricity at our demandable rate. And for that along with the fossil fuel we must use renewable energy. But the problem is that the lack of access to every type of renewable sources therefore we can’t use it. Bangladesh has no geothermal potential, and its hydro potential, particularly that based on elevation, is limited. Tidal is a novel form of energy that is still in the development stage. As a result, the only current options are solar, wind, and biomass. So, we focused on the solar energy because of its availability of everywhere. So, some technology is needed that will harness the maximum irradiation of the sun and will transform it into electricity. With a view to achieve maximum power system will use dual axis tracker which is a new and efficient technology than the previous types of solar tracker. Thus, with the proposed engineering solution, that can be used to resolve this very important issue.

1.3. Related Research Works

This section of the report discusses some previously published related research. Those report and researches are based on the dual axis solar tracker development technologies. The primary goal of these is to maintain the highest possible level of solar power. Because of the execution and precision of the design to include temporal characteristics, this technique delivers accuracy. Due to its availability and environmental friendliness, solar energy is growing in popularity. Despite this, efficiency is still a significant issue in many applications. Tracking systems are typically used as a form of mitigation. Consequently, this paper explores dual axis solar tracking systems from a two-dimensional perspective. In order to determine where we are on the efficiency map, a review of the literature that has already been published was first carried out [1]. As a result, the efficiency of dual axis tracking configuration was discovered to be between 35 and 43 percent. Second, based on the review above, a general functional model of how a successful tracking system should operate is provided. The development of an effective solar tracker will be guided by the two coevolving components.

1.3.1. Earlier Research

In 1990, a paper was published by WILLIAM A. LYNCH and ZIYAD M. SALAMEH, which describes the creation of a sun tracker using two electro-optic sensors with a small, low-cost electronic control circuit. As one sensor, a four-ceU pyramid is positioned on the tracker plane [2]. The second sensor is a south-facing sunlight beam sensor. Because the control circuit tracking precision is within 0.1 degree, this technology reduces wandering on partially cloudy days. It will never turn multiple times or face the ground. Power MOSFETS (Metal Oxide Semiconductor Field Effect Transistors) power high-torque DC gearbox motors.

In the year 2006, A. Yazidi, F. Betin, G. Notton and G.A. Capolino published a paper related to a system to achieve high precision solar cell positioning [3]. Photovoltaic (PV) technology for converting sunlight into electricity is already a viable option for many applications around the world. Solar power is used in a variety of systems including grid-connected applications, corrosion prevention techniques including cathodic protection, water pumps, satellite communications and rural electrification.

In the year 2014, the Authors Yingxue Yao , Yeguang Hu b, Shengdong Gao, Gang Yang and Jinguang Du have proposed a concept based on a dual-axis multipurpose solar tracker that can be

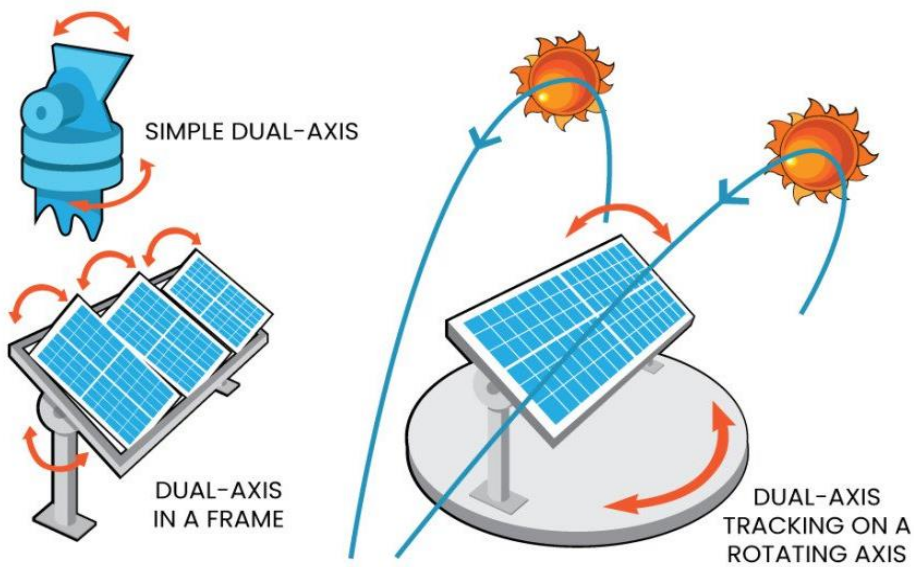

Figure 1.1: Dual axis solar tracker mechanism [4]

used in solar power systems [4]. A declination-clock mounting system is used in dual axis sun trackers to locate the primary axis in an east-west direction. Because of the scarcity and pollution of fossil fuels, solar energy is gaining popularity as a clean and sustainable energy source, particularly in the production of electricity. Flat PV systems or CSP (Concentrated Solar Power) systems are used to convert solar energy into electricity. The amount of energy that these systems can extract from solar radiation is only one of several factors that influence how much power they can produce. To boost power output, some researchers have investigated the ideal solar collector inclination. Because the sun's position changes throughout the day, a solar tracker is a more effective way to increase energy output. As a result, more and more academics are researching on the solar tracker.

In 2005, Karimov et al. installed four solar modules on a single axis on a rotor in a PV and the tilt angles of the other axes were manually adjustable to 23°, 34°, and 45°. The rotating unit installed two pairs of modules at a fixed angle (170°) on the system's upper side. A bridge circuit was connected between the four modules and the DC motor for solar tracking. The DC motor began to turn if a module's output voltage and the DC motor's input voltage were not equal. According to research, tracker's output voltage varies in the morning and at night in contrast to fixed modules, and their energy gain is 30% higher [5].

In 2014, Vijayalakshmi K. provides a control system for better photovoltaic (PV) array alignment with sunlight in order to harvest solar energy [6]. The proposed system alters its orientation along two axes by measuring the difference between the sun and solar panel to track the coordinates of sunlight. Hardware testing of the suggested system is done to ensure that it can monitor and follow the sun in an effective manner. This demonstrates the advantages of dual axis tracking systems over single axis tracking systems even more.

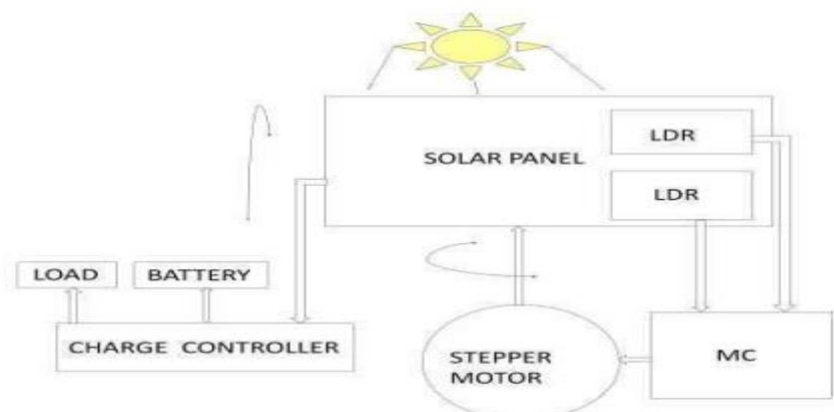

Figure 1.2: General Solar Tracking System [6]

In 2013, the solar tracking device created by Emmanuel Karabo Mpodi, Zeundjua Tjiparuro, and Oduetse Matsebe can follow the sun in two dimensions. They reviewed the body of knowledge already in existence to create a trajectory for gauging the effectiveness of the map. As a result, they discovered that the dual axis tracking yields current efficiency gains of 35 to 43%. To demonstrate how a general functional model should be used, along with its effectiveness and tracking system, is also shown. They design and develop an effective solar tracker using two components that are coevolving at the same time [7].

1.3.2. Recent Research

In 2021, Chaowanan Jamroen a,b, Chanon Fongkerd, Wipa Krongpha, Preecha Komkum, Alongkorn Pirayawaraporn , Nachaya Chindakham published a paper [8]. In their work, solar tracking devices have been presented as a means of improving PV generation. Solar tracking systems are classified into single-axis and dual-axis tracking systems based on the number of degrees of freedom.

Furthermore, each type of tracking system can be divided into two groups based on the control approach: open-loop controls and closed-loop controls. Offline geospatial estimates of the sun's course are required to accomplish this. A pseudo-azimuthal mounting structure is used in this solar tracking system. It takes advantage of the benefits of UV radiation enhancement and UV sensor capability to improve performance in terms of tracking movement and energy gain.

Figure 1.3: UV sensor Installation [8]

In 2018, a paper Masoumeh Abdollahpoura , Mahmood Reza Golzariana , Abbas Rohania , Hossein Abootorabi Zarchib published a paper [9]. His research suggests a dual-axial tracker that operates by analyzing pictures of a bar shadow. The system included a shadow-casting device, a webcam, electronic circuitry, computer controllers, and stepper motors. The webcam was used to capture the shadow. The results of the study showed that the tracker system kept the panel perpendicular to the direction of irradiation while tracking the sun with an accuracy of about 2°. This system operates regardless of its initial settings and can be applied anywhere in the world.

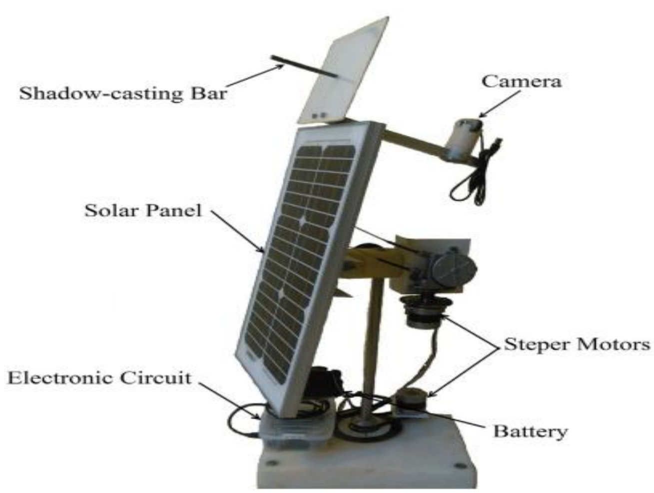

Figure 1.4: Electromechanical structure with two DoF [9]

1.4. Critical Engineering Specialist Knowledge

Design Engineering knowledge is essential for resolving any type of problem. The project of designing and developing a dual axis solar tracker system is based on critical engineering problems. This project requires in-depth knowledge of dual axis system, the Arduino IDE, C++ and Proteus. Comprehensive knowledge regarding different sensors is also required.

We learned Arduino IDE which allows us to edit, compile and upload code to the Arduino board. In the Arduino IDE, we can write and compile code for the Arduino module. It is an official Arduino program that compiles code. There are numerous Arduino models available, such as the Uno, Mega, Leonardo, and Micro. This system supports the C and C++ programming languages. In the proposed system the voltage data was continuously monitored using voltage sensors, looking for voltage readings that might point to a problem. When the voltage is too high, other assets could be in danger, while low voltage could indicate a possible problem. Utilizing a current sensor, the system detects voltage and transforms it into an output voltage that is simple to measure and proportional to the current flowing through the measured path. ESP 32 was preferred because it includes built-in Bluetooth and dual Wi-Fi capabilities. For a full stack internet connection, it has complete TCP/IP functionality. With the help of its Wi-Fi module, it can function as both a Wi-Fi station and an access point.

1.5. Stakeholders

The project is mainly focuses to improve the energy sector, using dual axis solar tracker. A person who is involve with the research regarding dual axis solar tracker are the stakeholders of that research literature.
Normally stakeholders are the organization, person or the team those who are building the project not only that but also those who will get the benefits form the research work, even the Government. Recent time most of the power plant are nonrenewable resources based or renewable resources based but not highly efficient. There are some solar power plants, but they are single axis or stable and they are not generating the amount of power which they are capable of. So, the stakeholder requirements for this dual axis solar project are to increase the efficiency of solar-based power plants or to upgrade the less efficient solar tracker to a dual axis solar tracker that is more efficient and environmentally friendly [9]. This can be beneficial to our environment and slow the rate of climate change. Engineers and researchers are attempting to increase the effectiveness of solar energy generation. They have provided various solutions to their research and publications. Hossein Mousazadeh studied and investigated the maximization of solar panel collected

energy on a solar assist plug-in hybrid electric tractor (SAPHT). He made use of four light-dependent resistance sensors as well as a sun tracking system [10].

In 2012, K.S. Madhu et al. in an International Journal of Scientific & Engineering Research, states that a single-axis solar tracker follows the sun from east to west, while a dual-axis solar tracker follows the sun at all times. As a result, it will absorb the greatest amount of sunlight by sensing the sun's direct beam. A photovoltaic panel (PV) transforms the light energy from the sun into electrical energy by using the photoelectric effect [11]. According to the test results he gathered, tracking solar plates have a 26 to 38% higher power efficiency than fixed plates on normal days. It varies at any level on cloudy or rainy days.

1.6. Objectives

Because of its environmental friendliness and accessibility, solar energy is becoming more popular. Regardless, efficiency is still a major issue in many applications. For mitigation, tracking systems are commonly used. The purpose of this project is to design and build a dual-axis solar tracker with a weather sensor. The main goal of this project is to maximize power harvesting from solar panels while also improving efficiency and accuracy over previous solar tracking systems such as single axis tracker.

1.6.1. Primary Objectives

- Develop a dual axis solar tracker that can provide 40% more electricity than a non-moving solar panel.
- Develop a solar system that can more adaptability, allowing for increased energy output on bright days.
- Develop a unique declination-clock mounting mechanism for a solar tracker.
- Create a system for tracking sunlight for solar panels.

1.6.2. Secondary Objectives

- To develop a solar tracker that could be the best choice in a limited space where many solar panels can't be installed.
- Using Wi-Fi module smart monitoring of the data.
- To develop a solar tracker system in a cost-effective way.

1.7.Organization of Book Chapters

Chapter-2: Project Management: This chapter mainly focuses on project management, which includes schedule management, management principles and economic models. The S.W.O.T Analysis, P.E.S.T. Analysis and professional responsibilities were also discussed.

Chapter-3: Methodology and Modeling: This chapter discusses the methodology and modeling of the project. The block diagram and working principle were also discussed here.

Chapter-4: Implementation of Project: This chapter describes the project's implementation process.

Chapter-5: Results Analysis & Critical Design Review: The project's outcomes were discussed in this chapter. This section displayed and analyzed the output data.

Chapter-6: Conclusion: The book's final chapter covered the novelty of the work, its limitations, the influences of cultural and social factors, the suggested professional engineering solution and lastly future scope.

Chapter 2

PROJECT MANAGEMENT

2.1. Introduction

Among renewable energy sources, the quickest growth rate is solar power. The suggested solution makes use of a straightforward dual-axis solar tracker system for design and implementation. Solar tracking systems must be integrated into solar power systems to maximize solar energy production. By following the sun's rays as they come from different directions coming from a solar panel, a dual-axis tracker can maximize energy. This solar panel has infinite rotational possibilities. The weather will be sensed by the dual-axis solar tracker project and shown on the LCD. This Arduino-powered system includes a servo motor, current sensor, voltage sensor, ESP32, solar panel, and LCD. The proposed project's main goal is to maximize energy efficiency by aligning with the position of the sun. This chapter will go over the project's S.W.O.T. Analysis, Schedule Management, and P.E.S.T. Analysis. This chapter will also contain the cost analysis of the project. Multidisciplinary components management and the project lifecycle will also be discussed at the end of this chapter.

2.2. S.W.O.T. Analysis

SWOT is an acronym that stands for Strengths, Weaknesses, Opportunities, and Threats. A project's acceptability can be determined by SWOT analysis. This analysis is done in this section.

2.2.1. Strength

When talk about the dual axis solar trackers features and operations, It is an excellent mechanism for producing energy. It is a more sophisticated mounting method for solar panels is solar panel tracking systems. When the sun shines at an unfavorable angle, stationary mounts, which hold panels in a fixed position, may not function as well. To compensate, solar trackers automatically "follow" the sun's path across the sky and increases the output.

- Due of increasing direct exposure to the sun's rays, trackers produce more electricity than their stationary counterparts. Depending on where the tracking system is located, this increase could range from 10 to 25%.
- Long-term maintenance problems for tracking systems have been significantly decreased due to improvements in technology and the dependability of electronics and mechanics.

- The sun's azimuth and altitude angles change all the time. To increase solar energy collection, the dual-axis tracking mechanism follows the sun. Based on the type of axis, dual-axis tracking systems are divided into two types: polar-axis tracking and altitude-azimuth tracking.
- Any results collected in cloudy or overcast conditions should be considered as possibly being inaccurate because it performs unreliably during those conditions.

2.2.2. Weakness

The following are some drawbacks of solar tracker systems:

- The lifespan of the solar tracking device may be shorter than that of conventional solar panels because it has moveable elements. In the event that the sky is clouded over or polluted, the solar tracker may not function accurately.
- There was not perfect and accurate financial planning.

2.2.3. Opportunities:

- Advanced solar panel can be used for more efficiency.
- Best use of unused land.
- Reduce dependency on fossil fuels.

2.2.4. Threats:

- If the solar panel is not placed accurately; it may not as efficient as it should be.
- If the servo motor fail, then the whole system will fail.
- Solar panel can be damaged by the thunder.

2.3. Schedule Management

The schedule management of this project is given below:

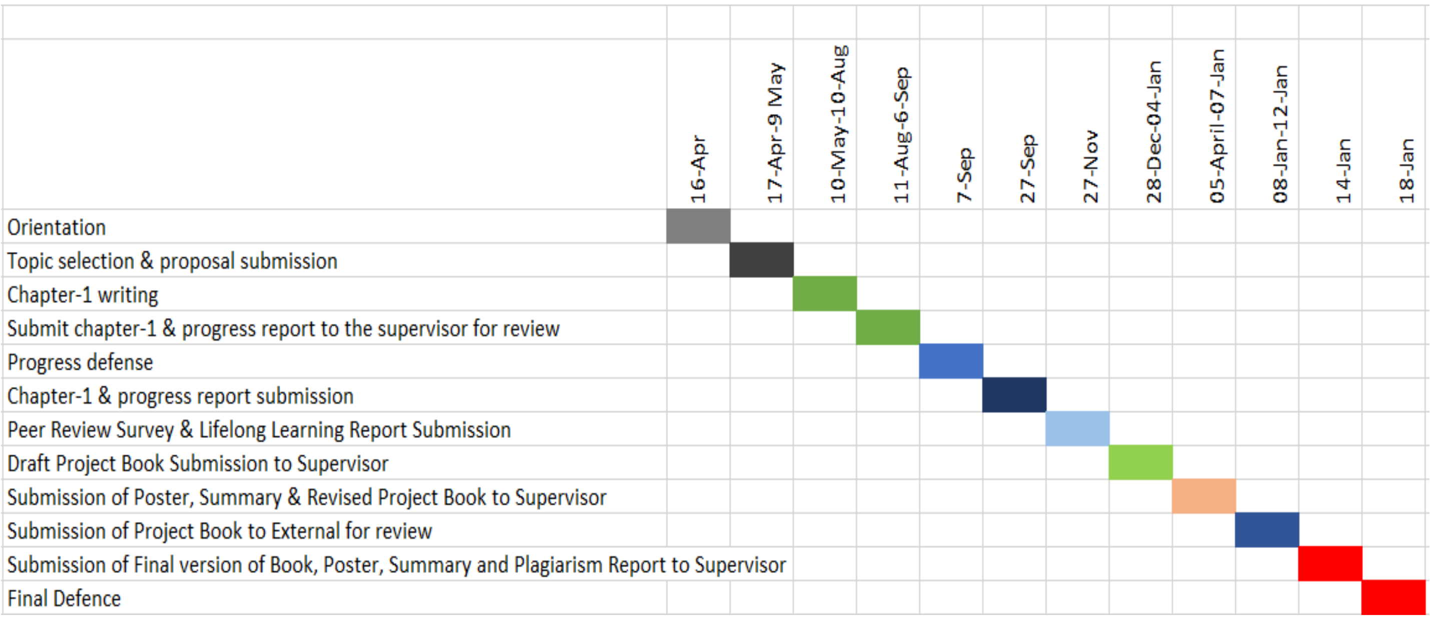

Figure 2.1: Gantt chart of this project

2.4. Cost Analysis

Cost analysis is a crucial component of any project. Cost reduction is the main objective of every project. Because the lower the cost of the project, the higher the demand. The actual cost and estimated cost are shown in Table. Table 3.1 shows final implemented cost and estimated cost. The standard deviation is calculated based on the formula shown below.

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2} \quad \text{---(3.1)}$$

Here,

N = the total number of quantities

μ = the mean cost

x_i = the individual cost.

Table 3.1: List of the components and their cost for dual-axis solar tracker prototype

Serial No	Component's name	Unit Price (BDT)	Quantity	Estimated cost (BDT)	Final cost (BDT)
1	Arduino UNO R3	1100	1	1250	11000
2	Current Sensor ACS712-5A	184	1	200	184
3	16x2 Serial LCD Display for Arduino Assembled	385	1	400	385
4	UV Sensor Module	410	1	500	410
5	BREADBOARD (Medium Size)	79	1	100	79
6	1/4w Resistors (Kiloohm)	5	4	40	20
7	GL-12 Breadboard	105	1	120	105
8	Buck Converter	120	1	150	120
9	ESP32	740	1	1000	740
10	LCD Display 16X2 with Header	255	1	300	255
11	Solar panel	950	1	1500	950
12	Voltage Sensor Module DC 0-25V	89	1	89	89
13	ON/OFF Switch	20	2	20	20
14	Jumper wire	3	50	200	150
15	LDR 10-12 mm Light Depending	35	4	150	140
16	LM35	90	1	100	90
17	Potentiometer	25	1	40	25
18	MG996R 10kg Servo	445	2	1000	890
	Total cost (BDT)			7159/-	5752/-

Calculation:

Count, N:	18
Sum, Σx:	5752
Mean, μ:	319.56
Variance, σ2:	15760.267

Here,

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

$$\sigma^2 = \frac{\Sigma (x_i - \mu)^2}{N}$$

$$= \frac{(1100-319.56)^2 + ... + (890-319.56)^2}{18}$$

$$= \frac{283684.8}{18}$$

$$= 15760.267$$

$$\sigma = \sqrt{15760.267}$$

= BDT 125/

Hence, the standard deviation is, σ = BDT 125/

2.5. P.E.S.T. Analysis

"PEST analysis" refers to a study of the political, economic, social, and technological sectors. It is a fundamental tool for studying macroeconomic indicators. This analysis can provide a clear picture of the impact that political, economic, social, and technical factors have on a project.

2.5.1. Political analysis

In this proposed project, many sensors and microcontrollers are used. There was no environmental leakage of any potentially harmful compounds from these sensors. There are no such limitations on the project, as far as our nation's regulations are concerned. As stated by the COP-26 aim, all governments today aspire to rely on renewable energy and reduce their reliance on fossil fuels by 2030 [12], and if this kind of initiative is carried out on a large scale, it can create a station that generates renewable energy. By doing this, we will have an endless supply of energy and an eco-friendly substation. So, considering all the situations there will be no problem implementing this project. It won't be wrong if we consider this a type of project our government is looking for.

2.5.2. Economic Analysis

In the proposed project, a dual-axis solar tracker was developed for eco-friendly electricity. The starting cost of this concept is only about BDT 10,000/. Since this is a prototype, after further research and development if properly designed with some modification mass, production will be more affordable and the dual-axis solar tracker will be sufficient to verify their efficacy. This means that the device will be reasonably priced.

2.5.2. Social Analysis

In this project, a prototype was built using a mixture of microcontrollers, sensors, tools, and electrical technology. This technology offers no threat to human health and is fully non-toxic to the environment. There are no environmentally hazardous elements in the proposed project. The proposed dual-axis solar tracker technology will generate power more effectively than previous methods, assisting in the reduction of reliance on fossil fuels. Carbon emissions will decrease as a result, partially achieving the goal of COP26 [13]. Additionally, this system needs less maintenance compared to fossil fuel, and solar energy is limitless. As a result, it will be highly beneficial for the rising need for energy. As a result, society will accept it in all respects.

2.5.3. Technical Analysis

Several components were utilized in this project, including the Arduino Uno and ESP-32S. In addition, the UV sensor and LDR sensor were utilized, along with a servo motor to allow for free panel rotation, a voltage sensor to gauge the amount of current flowing, to measure current a current sensor is used, a relay module to determine whether the current-to-voltage ratio is okay, and various other parts to generate electricity safely and effectively.

2.6. Professional Responsibilities

In any employment, professional obligations are a necessary component. There are various moral duties that engineers have to society and the environment. Recently, this field of study has been referred to as "macro ethics." However, there may be a clash between these professional social obligations and engineering's commercial component. To complete this project, we needed to provide several types of technical assistance in the design and development of the electrical system. To complete our dual-axis solar tracker project, we had to simultaneously manage every form of electrical system related to the hardware and software. Collaborating with the other members of the project team to carry out the suggested dual-axis solar tracker capstone project. Every issue has been investigated to promptly find solutions. Set priorities for and oversee project tasks to make sure they are finished on time. Review the dual-axis solar tracker project's system designs and suggest changes that would improve performance and dependability. We have regularly monitored the situation and have made every attempt to finish the proposed project initiatives within the allotted time constraints.

2.6.1. Norms of Engineering Practice

Engineering indicators are one of the most important requirements for resolving any engineering problem. It is much easier to solve any problems when following engineering standards. Proper standards are upheld in order to complete this project. Engineers are expected to uphold the highest ethical and moral standards. Our dual-axis solar tracker project adhered to proper standards and the system was tested several times under various conditions, yielding satisfactory results in each case. Engineering has a direct and significant impact on everyone's quality of life. To complete this dual-axis solar tracker project, ecological conditions and public health and welfare are perfectly maintained, providing a safer environment for all. First and foremost, the project's goal was chosen while adhering to engineering ethics principles. The discussion of the topic with the group members sparked the creation of a mind map. The prototype design was then built and tested in various ways. We took care to include appropriate security measures when developing our project. Furthermore, the device must be kept in a protective frame so that it can continue to function properly even after a natural disaster. Our devices are completely safe to use because they pose no risk to human health. The project's outcomes were satisfactory, and it was operational in every situation. These are all the necessary steps to complete the project in accordance with engineering standards.

2.6.2. Individual Responsibilities and Function as Effective Team Member

All of the group members worked together to implement the overall project. The following section discusses each group member's specific duties in successful completion of this project.

With the help of our respected supervisor, we chose the topic for our capstone project, and then we all began to read various published papers that were relevant to our project to get further knowledge. The tasks were then primarily divided among the group members based on three subsections, such as software skills, hardware selection, material procurement, implementation, and writing the capstone project book.

Sunny, Ferdous

- Learned C++ to operate the Arduino UNO and ESP-32S.
- Made a great contribution while writing the working principle, results section, and other important parts of the book.
- Conducted continuous testing of the equipment and the project.
- Implementation of the project

Hasib, Mahadi

- Purchased the various components including sensors, servo motor and a solar panel.
- Helped to implement the project.
- Testing the project.
- Write the few chapters of the book.
- Coding and simulation of the project

Islam, Md. Monirul

- Choosing the proper project components and tested them thoroughly to make sure that they functioned properly.
- Studying how to use the Arduino IDE and its operating system.
- Writing the project book within stipulated time.
- Helped during implementation and testing.

Ismail, Md. Naeem ben

- Give proper support,
- Purchased every component from the local market
- Project's block diagram, 3D model design
- Literature review and studying the project related papers to gather valuable information.
- Writing the poster and summary.

2.7. Management Principles and Economic Models

Engineering management is a specialist field that requires managerial as well as technical skills. A project's beginning is quite similar to the beginning of a new company because both require management tasks like planning, organizing and implementing etc. The suggested dual-axis solar tracker system is no exception; every project adheres to a set of models and concepts that serve as the foundation for the entire project's output. Throughout the life of a project, engineers from all over the world employ a range of project management methods. An "agile model" was picked out of the options in this situation to finish the project. Because it has more versatility than other models in a wide range of applications, that model was chosen. The project's outcome was not known with certainty before it began. As a result, whenever a challenging scenario developed, the project needed regular changes to satisfy the project goals. Fast progress was also necessary due to the project's timing constraints. These factors led to the deployment of the swift methodology, which enabled the project work to be finished on schedule.

The proposed project follows several principles. As this is always the first step in every project, the project's first goals were established before it began. To meet the objectives, careful preparation was necessary because the project's outcome could vary depending on the situation. As a result, flexible planning was used to accomplish the project's goals. Having a broad understanding of how the proposed prototype would operate, the project design step was then finished. The group assembled all the required tools, divided the project's burden equally among them, and gave each member's portion of it a deadline. Every project needs communication, and it was maintained between the team members the entire time. It was a challenging effort to select the best methodology, but the members' effective decision-making, which falls under the engineering management principle's leadership function, enabled success. High-performance requirements were created in order to meet the objectives while taking financial restraints into consideration. A few adjustments were made to manage the situation and achieve project objectives.

Any project should have an economic model, which paints a clear picture of the project's financial components before it is started. There are many economic models that can be applied to a project. The dual-axis solar tracker technology that was proposed employed the "Mathematical Model." In this kind of model, economic activities or variables are often defined using mathematical equations. The project's objective was to be finished within the allocated budget in an economical manner. As a result, the standard deviation was computed using the standard deviation method to establish whether or not the project was within an acceptable range. This standard deviation is an endogenous variable because it is produced by the model. The standard deviation was discovered to be within acceptable bounds even after changes to the project. This demonstrates that the job was completed efficiently and affordably without sacrificing the final product's quality.

2.8. Summary

This chapter focuses mostly on project management. The project's SWOT analysis, which stands for strengths, weaknesses, opportunities, and threats, has been covered in this article. The internal project factors are covered in this SWOT analysis. Here, the topic of timetable management has been discussed. A Gantt chart is used to show the management of the timetable. The cost analysis is also included in this chapter. The cost analysis contrasts the anticipated cost with the actual expenditure. The project's political, economic, social, and technological analysis is referred to as PEST analysis. This PEST study talks about the project's external factors. The analysis also demonstrates the impact on society.

Chapter 3

METHODOLOGY AND MODELING

3.1. Introduction

Introduce the basic engineering theories and methods that were used or implemented in the project. A country always wants to fulfill the ever-growing electricity demands in the most efficient way possible. But to generate electricity the system and sources they use are old and not environmentally friendly. For some years the world leaders have agreed to one point that the dependency on fossil fuel to generate electricity must be less by 2030 [12]. So, all the government in the world are trying to be as less dependent as possible on fossil fuel and trying to be more dependent on the renewable sources like air, water, solar, biomass, geothermal. But every government is facing difficulties because every renewable energy station takes a lot of large area and they can't generate as much as fossil fuel. So, this proposed project is to make electricity more efficiently. Many sensors and parts have been added to this project to make it more efficient. LDR sensor is used to detect sunlight, allowing the solar panel to face the sun directly. UV sensor to detect sun radiation, so that on cloudy days when the lights are not visible to the LDR, the UV sensor can detect sun radiation and direct the solar panel toward the sun to absorb more radiation. To freely rotate the panel servo motors were used. This chapter includes brief explanations of the equipment as well as its consequences and essential diagrams. This chapter also includes a block diagram of its internal process and a schematic representation of the whole design. As a result, this chapter will supply sufficient information on the general structure and operating mechanism of the project.

3.2.Block Diagram and Working Principle

The proposed tracking system more effectively tracks sunlight by allowing PV panels to rotate along two different axes. The tracker is made up of four LDR sensors, two stepper motors and a PIC microcontroller. A pair of sensors and one motor tilt the tracker in the east-west direction of the sun, and a second pair of sensors and a motor fixed to the tracker's bottom in the north-south direction of the sun. This system makes use of two stepper motors in total. Stepper motors in the upper panel holder and the base track the sun's linear and parabolic motion, respectively. These sensors and stepper motors are connected to a microprocessor. On the basis of LDR sensor input, the microcontroller instructs the motors to rotate in the proper direction along with the sun.

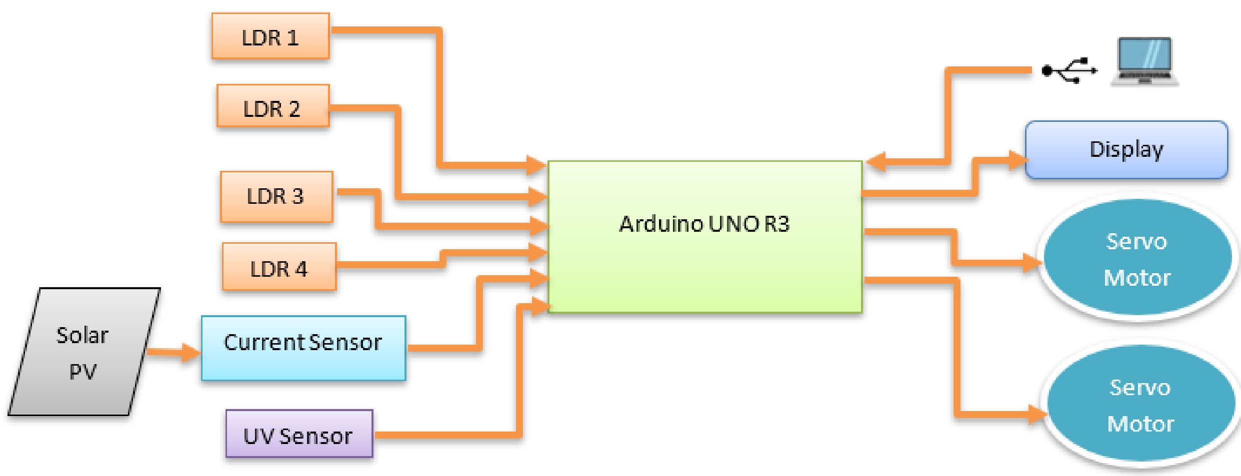

Figure 3.1: Block diagram of the project

In figure 3.1, it shows the LDR sensors send a signal to the microcontroller when they detect light. The microcontroller compares the signals from the LDR sensors and determines which signal is stronger when determining the rotation direction of the stepper motors. The microcontroller, an intelligent device, activates the motor driver circuit based on sensor input. The controller activates the driver circuits and moves the stepper motors to ensure that the light falling on the sensor pairs is identical. If there is a discrepancy, the motor moves the panel until the light falling on the sensor is identical.

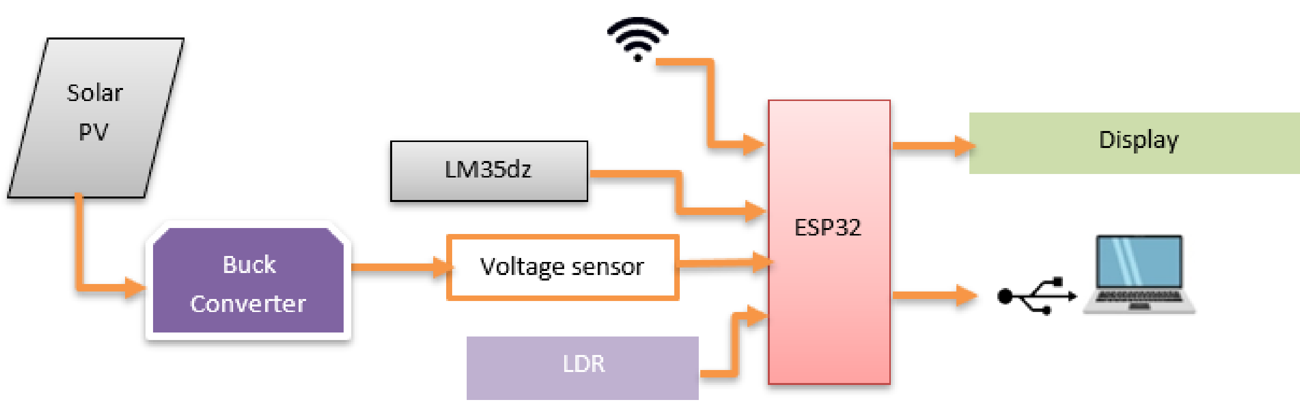

Figure 3.2: Block diagram of the smart monitoring system

In figure 3.2, The solar panel transmits the output to the voltage sensor via the buck converter. Along with the ESP 32 module, a buck converter, a voltage sensor, and an LCD display are connected. Solar panel output and the most recent weather temperature information or the sunlight intensity are displayed on LCD screens.

3.3. Modeling

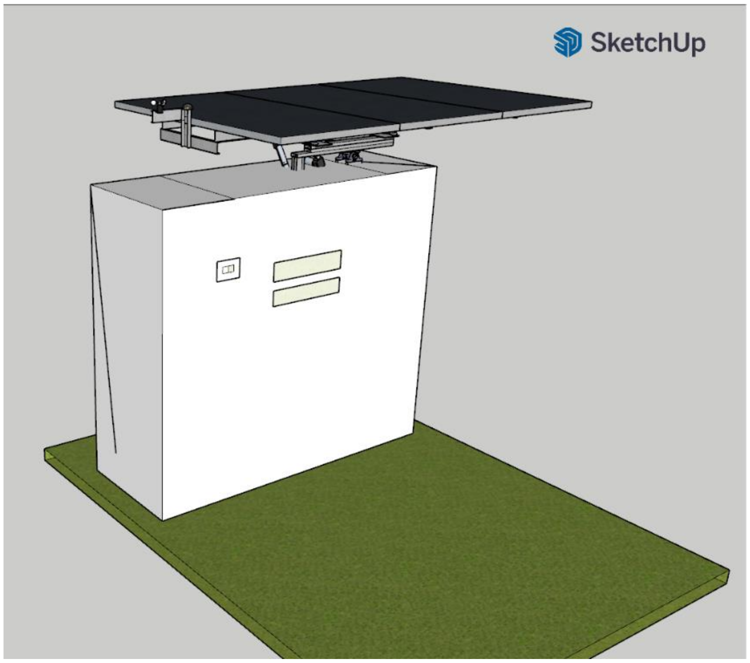

Figure 3.3: 3D diagram front view of dual axis solar tracker

In figure 3.3, this image displays the front view of the dual axis solar tracker project that we're considering. In addition to a switch that can turn on and off the entire system, there is a solar PV panel and two output displays.

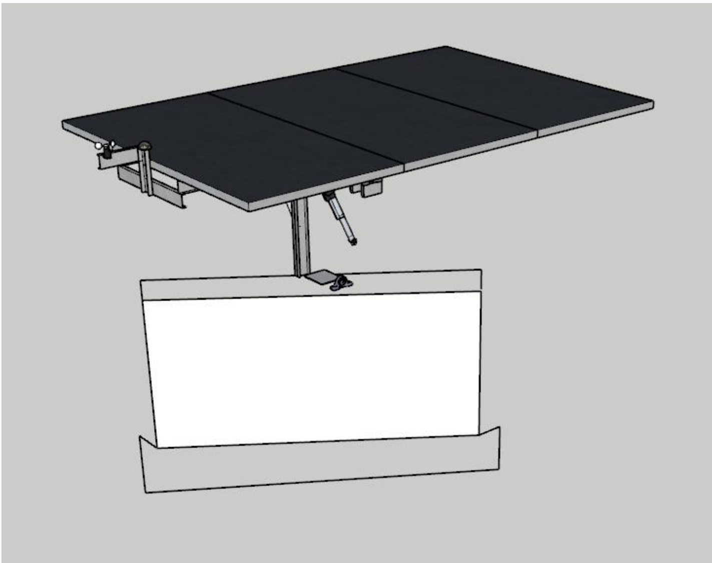

Figure 3.4: 3D diagram side view of dual axis solar tracker

In figure 3.3, it displays the side view of the dual axis solar tracker project. There are two servo motors attached to a solar PV panel. The PV panel's rotation was assisted by this servo motor.

3.4. Summary

This chapter briefly discusses the block diagram and working principle, as well as an introduction to all of the project's features and functions. The architecture of the project has been depicted in this chapter through a series of block diagrams. These block diagrams provide a structural view as well as operating principle of the project.

Chapter 4

PROJECT IMPLEMENTATION

4.1. Introduction

The proposed dual axis solar tracker system is designed for the development and implementation, where the sunlight will be absorbed most efficiently possible with current technology. Weather sensor has been used to get a report about the weather and on the other hand LDR sensor to sense the sun light. Arduino uno detects all the inputs coming through different sensors and gives output in which way it has been coded. A project's goal depends entirely on the proper implementation of the project. The more accurately the project is implemented, the better the output result. The hardware implementation of the whole project is discussed in this chapter.

4.2. Required Tools and Components

4.2.1. Software Components

Three software have been used to carry out the project.

1. Proteus
2. Arduino IDE
3. SketchUp

4.2.1.1. Proteus

Proteus is a tool for simulating, designing, and drawing electronic circuits. It was created by the LabCenter electronic. Two-dimensional circuit designs can also be created using proteus. Different electrical and electronic circuits can be built and simulated on computers or laptops using this engineering software. Circuit design on the proteus takes less time than practical circuit construction. The possibility of error is lower in software simulation, such as loose connections, which take a long time to find in a practical circuit.

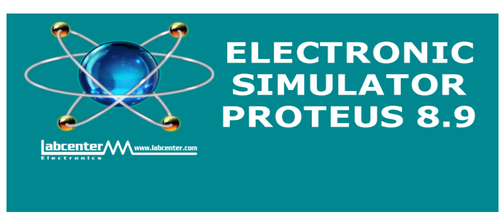

Figure 4.1: Simulation in Proteus 8.9 [13]

4.2.1.2. Arduino IDE

The Integrated Development Environment (IDE) of Arduino is the software that allows users to program the board. It is used for a variety of tasks including code creation, compilation to check for bugs, and uploading code to the Arduino. It is a cross-platform program written in C and C++ that can run on any operating system, including Windows, Linux, and macOS, with no additional software required [14].

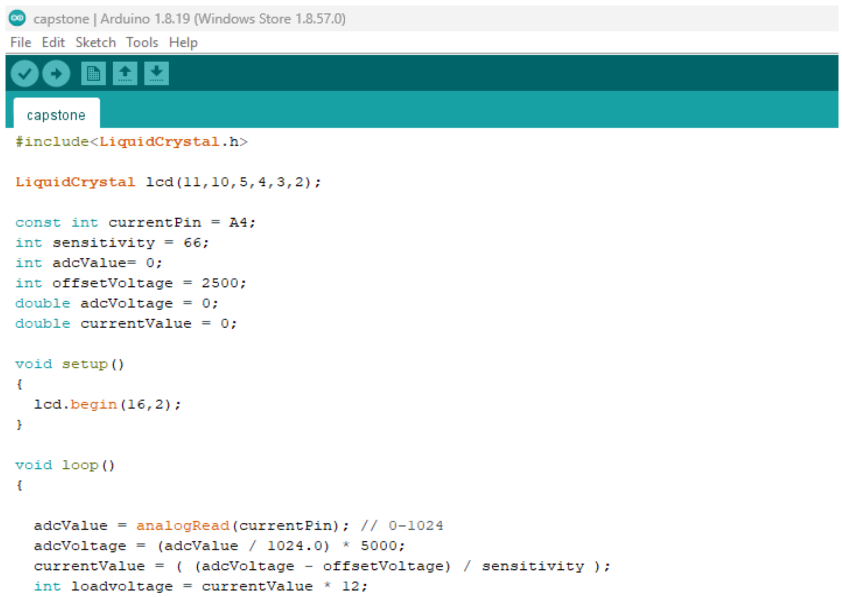

Figure 4.2: Coding in Arduino IDE

4.2.1.3. SketchUp

A very user-friendly CAD/3D design program is Sketchup. Anyone can construct anything, from skyscrapers to 3D-printable product prototypes, by starting with simple shapes and forms [15].

Figure 4.3: SketchUp [15]

4.2.2. Hardware Components

1. Arduino uno
2. Light Dependent Resistor (LDR)
3. Solar panel
4. LM35 Temperature Sensor
5. Solar Panel
6. MG996R 10 kg Servo
7. Potentiometer
8. Voltage Sensor Module DC 0 – 25 V
9. ESP32
10. Buck Converter
11. Current Sensor
12. Display
13. UV Sensor
14. Resistors
15. Breadboard

4.2.2.1 Arduino UNO

The Arduino UNO is a microcontroller that is controlled by the ATmega328. The Arduino UNO board is popular among beginners for use in electronics projects. The Arduino UNO board I is the only Arduino board that is supported. The most popular Arduino board is the Arduino board. The board includes 14 digital I/O pins, 6 analog input pins, a power jack, a USB connector, a reset button, an ICSP header, and other components. To function and be used in the project, all of these components are connected to the Arduino UNO board. The board can be charged via USB or directly through the DC power supply on the board [16].

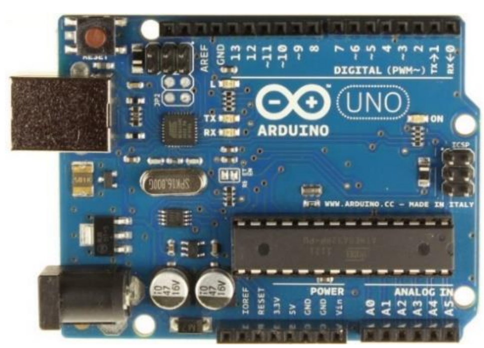

Figure 4.4: Arduino Uno R3 [16]

4.2.2.2. Light Dependent Resistor (LDR)

An LDR, often referred to as a photo resistor, photocell, or photoconductor, is a light-dependent resistor. It is a particular kind of resistor, and the resistance changes according to the amount of light that hits its surface. The resistance alters when light strikes the resistor. In many circuits where the need to detect the presence of light exists, these resistors are frequently used. The resistance and uses of these resistors are varied. For instance, the LDR can be used to turn ON a light when it is in the dark or to turn OFF a light when it is in the light.

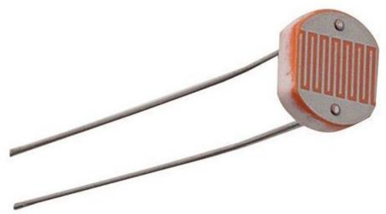

Figure 4.5: Light Dependent Resistor (LDR) [17]

4.2.2.3. LM35 Temperature Sensor

The LM35 temperature sensor has a proportional analog output voltage to temperature. It displays the output voltage in Celsius degrees (Celsius). No additional calibration circuitry is required. The sensitivity of the LM35 is 10 mV/degree Celsius. The output voltage rises proportionally to the temperature. It is a three-terminal sensor that measures temperatures between -55 and 150 degrees Celsius. The LM35 temperature output is more precise than thermistor output [18].

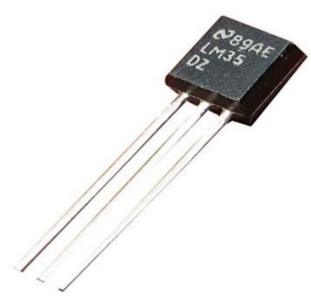

Figure 4.6: LM35 Temperature Sensor [18]

4.2.2.4. Solar panel

A solar panel is a grouping of solar cells that can generate electricity via the photovoltaic effect. These cells are arranged in a grid-like pattern on the surface of solar panels. As a result, it could also be described as a collection of photovoltaic modules mounted on a framework. A photovoltaic module is a packaged and linked 6 × 10 solar cell assembly. These panels are extremely resistant to abrasion and wear. The deterioration of solar panels is gradual. Their efficiency decreases by only one to two percent per year. The majority of solar panels are built with crystalline silicon solar cells.

Figure 4.7: Solar panel

4.2.2.5. MG996R 10 kg Servo

A servo motor is a self-contained electrical apparatus that rotates machine parts precisely and efficiently. This motor's output shaft has movement capabilities that a typical motor does not, including the ability to move at a specific angle, location, and speed. A conventional motor is used by the servo motor, and it is connected to a sensor to provide positional feedback. The controller is the most crucial component of the servo motor employed for this specific function [19].

Figure 4.8: MG996R 10 kg Servo [19]

4.2.2.6. Potentiometer

A potentiometer is a three-terminal variable resistor with manually adjustable resistance that controls the flow of electric current. A variable voltage divider is a potentiometer. A potentiometer's basic principle is that the potential drop across any section of a wire is directly proportional to its length, provided the wire has a uniform cross-sectional area and a uniform current flow through it [20].

Figure 4.9: Potentiometer [20]

4.2.2.7. Voltage Sensor Module DC 0 – 25

The voltage sensor module is a resistive voltage divider-based 0 - 25 DC voltage sensing device. It multiplies the input voltage signal by 5 and produces an analog output voltage in response [21]. Because of this, it can measure voltages up to 25 V using the 5 V analog pin on any microcontroller.

Figure 4.10: Voltage Sensor Module DC 0 - 25V [21]

4.2.2.8. ESP32 ESP-32S 30P Node MCU

The ESP32 is a SoC (System on Chip) microcontroller that has recently become very popular. It is debatable whether ESP32's popularity grew as a result of the growth of IoT or as a result of its introduction. The ESP32 can function as a self-contained system or as a slave device to a host MCU, reducing communication stack overhead on the main application processor. The ESP32 can communicate with other systems to provide Wi-Fi and Bluetooth functionality via its SPI / SDIO or I2C / UART interfaces [22].

Figure 4.11: ESP32 ESP-32S 30P Node MCU [22]

4.2.2.9. Buck Converter

A buck converter reduces the applied DC input voltage level directly. A buck converter is a non-isolated DC converter by definition. Non-isolated converters are suitable for all board-level circuits requiring local conversion. Board level circuits such as fax machines, scanners, cellphones, PDAs, computers, and copiers may require conversion at any point along the circuit. As a result, a buck converter converts the DC input voltage level into the other levels required [23].

Figure 4.12: Buck Converter [23]

4.2.2.10. Current Sensor

A current sensor is a device that detects and changes current in order to generate an observable output voltage. This output voltage is proportional to the measured current flow. The output voltage signal is then used to display the current measured by an ammeter, to control the system, or simply to store for later analysis within a data acquisition system. This is what a current sensor is for [24].

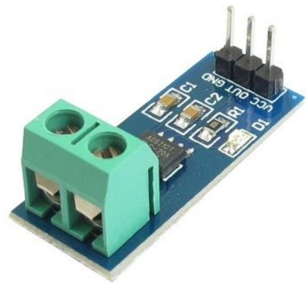

Figure 4.13: Current Sensor [24]

4.2.2.11. Display

The LCD1602 Parallel LCD Display is a simple and low-cost way to include a 162 White on RGB Liquid Crystal Display in your project. The display is 16 characters by 2 lines, with white text against a blue background/backlight that is very clear and high contrast [25].

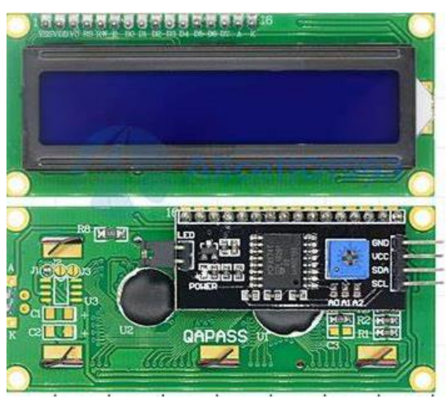

Figure: 4.14: Display [25]

4.2.2.12. UV Sensor

This UV Sensor Module is an excellent detector of ultraviolet light. It functions by generating an analog signal that corresponds to the intensity of UV light detected by the sensor. An onboard amplifier circuit with adjustable amplification factor is provided [26].

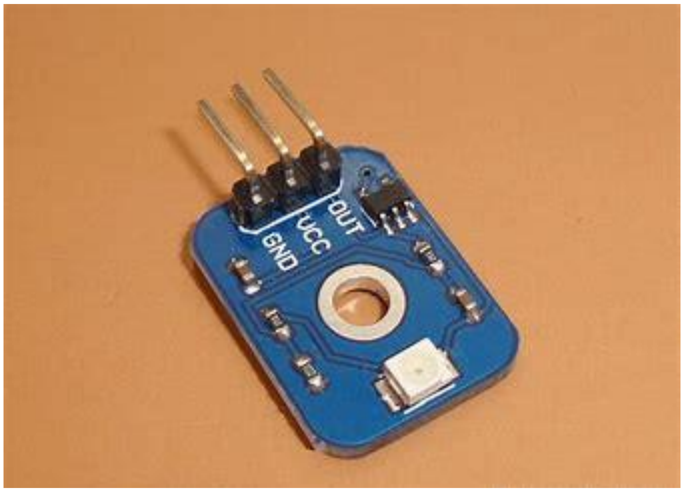

Figure 4.15: UV Sensor [26]

4.2.2.13. Resistors

A resistor is a two-terminal passive electrical component that acts as a circuit element by using electrical resistance. Resistors are used in electronic circuits to, among other things, reduce current flow, adjust signal levels, divide voltages, bias active elements, and terminate transmission lines. High-power resistors can dissipate hundreds of watts of electrical power as heat and can be used in motor controls, power distribution systems, or as generator test loads. Fixed resistor resistances vary only slightly with temperature, time, or operating voltage [27].

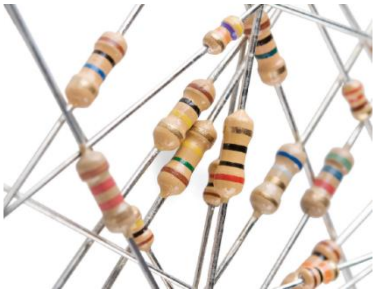

Figure 4.16: Resistors [27]

4.2.2.14. Breadboard

A breadboard is simply a board on which to prototype or build circuits. It enables you to place components and connections on the board to create circuits without the use of solder. The breadboard's holes take care of your connections by physically holding onto the parts or wires you place in them and electrically connecting them inside the board. The simplicity and speed are ideal for learning and rapid prototyping of simple circuits [28]. Breadboarding is less suitable for more complex and high frequency circuits. Breadboard circuits are not ideal for long-term use (protoboard) or PCB (printed circuit board) circuits, but they also lack the soldering (protoboard) and design and manufacturing costs (PCBs).

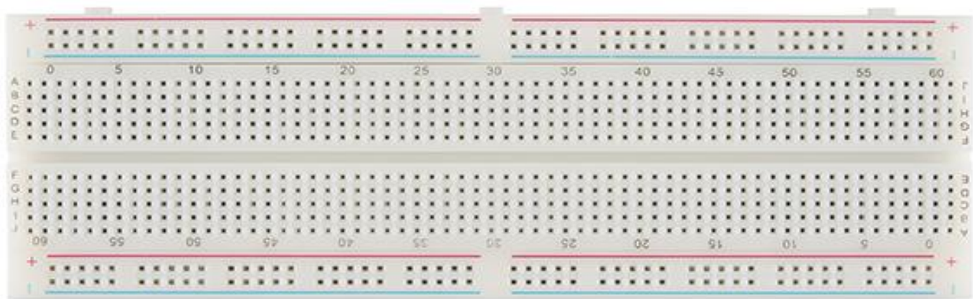

Figure 4.17: Breadboard

4.3. Implemented Models

In the proposed dual axis solar tracking system, a photovoltaic cell is used to capture solar energy. To demonstrate the effectiveness of this solar distributed generation system, a dual-axis solar tracker is designed, built, and tested. The tracker actively monitors the sun and adjusts its position as needed to maximize power output. In the built-in tracking system, sensors, comparators, and control circuits controlled by microcontrollers drive motors and gear-bearing assemblies with supports and mountings [29].

4.3.1. Simulation Model

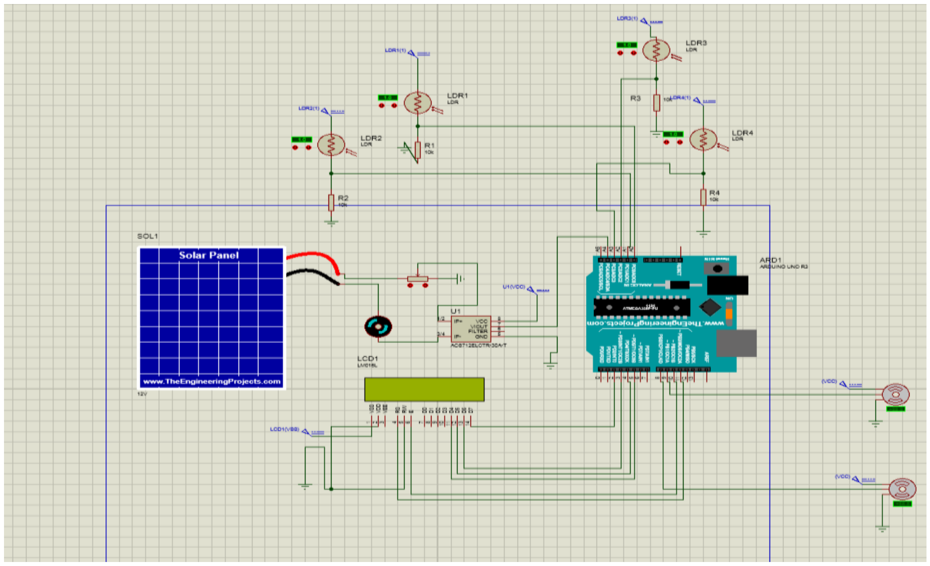

Figure 4.18: Simulation of dual axis solar tracker

Figure 4.18 depicts the project's simulation circuit diagram, as well as the connections of each component. Arduino UNO is connected with most of the components as can be seen in the simulation diagram. The Arduino Microcontroller, LDR and servo motor are the main components of our project.

4.3.2 Hardware Model

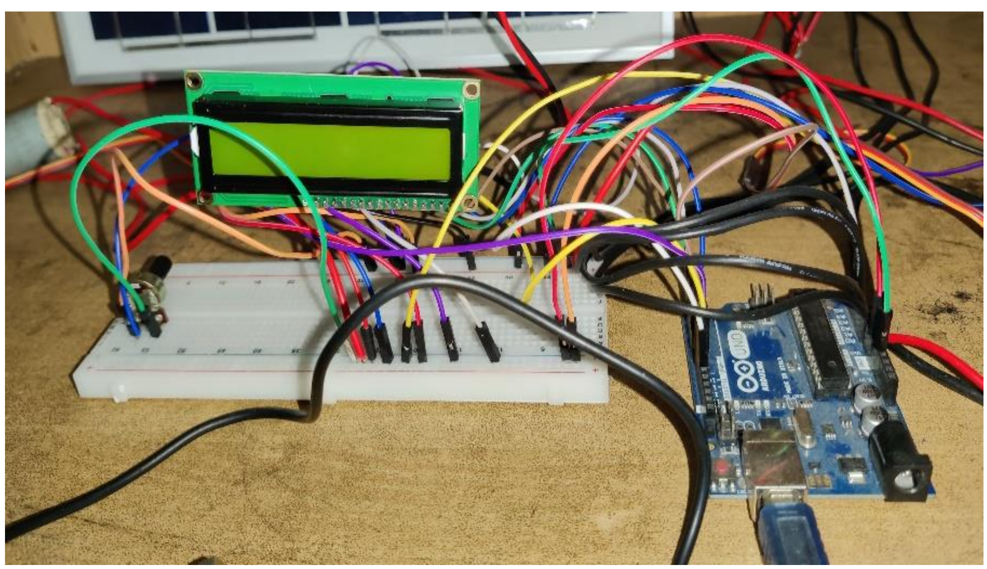

Figure 5.19: Circuit implementation of LDR and servo motor

Fig. 4.19 shows the connection of LDR and servo motor of the implemented project. There are four LDR’s used to complete this circuit connection.

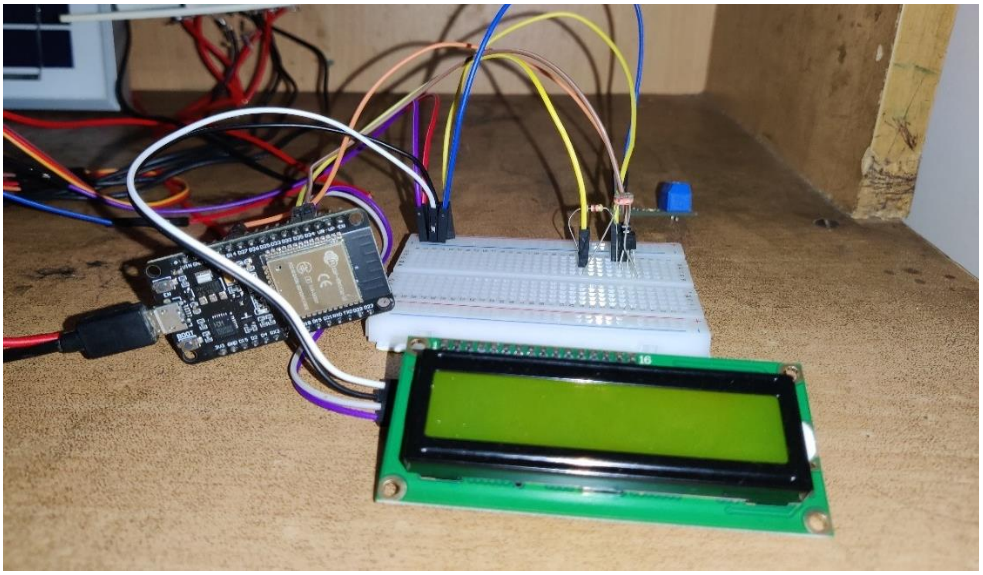

Figure 4.**20:** Circuit implementation of ESP32

Figure 4.20 shows the connection with ESP32 Node module. One LDR, resistor, voltage sensor and a display are connected in this circuit.

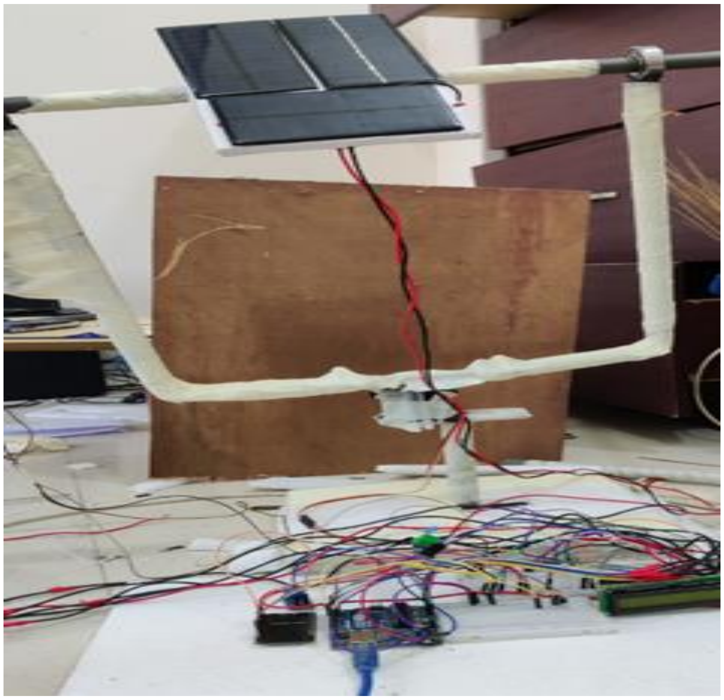

Figure 4.**21:** Circuit implementation of dual axis solar tracker

Figure 4.21 shows the full implementation of the protype dual axis solar tacker system. All components are successfully connected in this part.

4.4. Engineering Solution in Accordance with Professional Practices

The proposed Dual axis solar system is no exception to the rule that engineers must demonstrate the greatest dedication to the advancement of humanity through their efforts. While creating the prototype, social and cultural issues were taken into consideration. Every component of the project has the potential to significantly improve the precarious condition. To get the right technical information for the project, a lot of material was read. A solar tracker is a mechanical device that tilts or rotates a solar panel array to capture the maximum amount of solar energy while tracking the sun's position throughout the day. As a result, solar power systems utilizing solar trackers instead of fixed-tilt ground-mounted solar power systems have higher system output and the device which is implemented give the accurate output. The buck converter controls the DC voltage by bringing the output voltage to the same level as the input voltage or lower, and this is where the converter meets the maximum output of the system. The LDR's primary function is to detect higher intensity ranges of sunlight and send a signal to a relay circuit that directs the direction of the solar panel. The LDR does the job perfectly. Furthermore, extensive testing was done to guarantee that the suggested solution has no negative effects on the environment or human health. Additionally, engineers must make an economic contribution through their clever job. Electricity demand rises annually, necessitating the expensive importation of electricity from other countries. By improving electricity and reducing load shedding, the prototype will help the economy of the nation. As a result, the suggested solution satisfies the requirements for a qualified engineering response to society and culture.

4.5. Summary

This chapter focuses mostly on project management. The project's SWOT analysis, which stands for strength, weakness, opportunities, and threats, has been covered in this section. The internal project factors are covered in this SWOT analysis. Here, the topic of timetable management has been covered. A Gantt chart is used to show the management of the timetable. The cost analysis is also included in this chapter. The cost analysis contrasts the anticipated cost with the actual expenditure. The project's political, economic, social, and technological analysis is referred to as PEST analysis. This PEST analysis discusses the project's external factors. The analysis also demonstrates the impact on society.

Chapter 5

RESULTS ANALYSIS & CRITICAL DESIGN REVIEW

5.1. Introduction

This chapter summarizes the outcome and analysis of the prototype developed for the purpose of designing and developing a dual axis solar tracker system. This chapter describes the result analysis using the restorative characters and images associated with the implemented project. In the implemented project firstly the LDR detects the sunlight and gives signal to the Arduino. C++ language has been used for the Arduino UNO to detect the signal of the LDR. When the LDR detects the sun, it sends an input to the Arduino UNO board, which then instructs the servo motor to rotate in the direction of the sun. Buck converter was used to keep the output voltage to a desired limit so that the electronic components, that were used in the project will not get damaged. ESP32 was used to control the system via Bluetooth or Wi-Fi. The voltage and current sensor were used to measure the voltage and current of the generated power respectively. To provide a weather update, a temperature sensor was also used.

5.2. Results Analysis

The implemented dual axis solar tracking system incorporates several critical features. The prototype was created using the summation of these features. This section discusses the outcomes of these features.

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5.2.1. Simulated Results

The findings from the simulation are as expected. Several time it has been checked to find any error that may occur. But at the end no error was found. The LDR was working properly. It senses the sunlight and reacts instantly. The motors are working perfectly to track the sunlight. So, from the results it can be concluded that the result of the simulation is perfect.

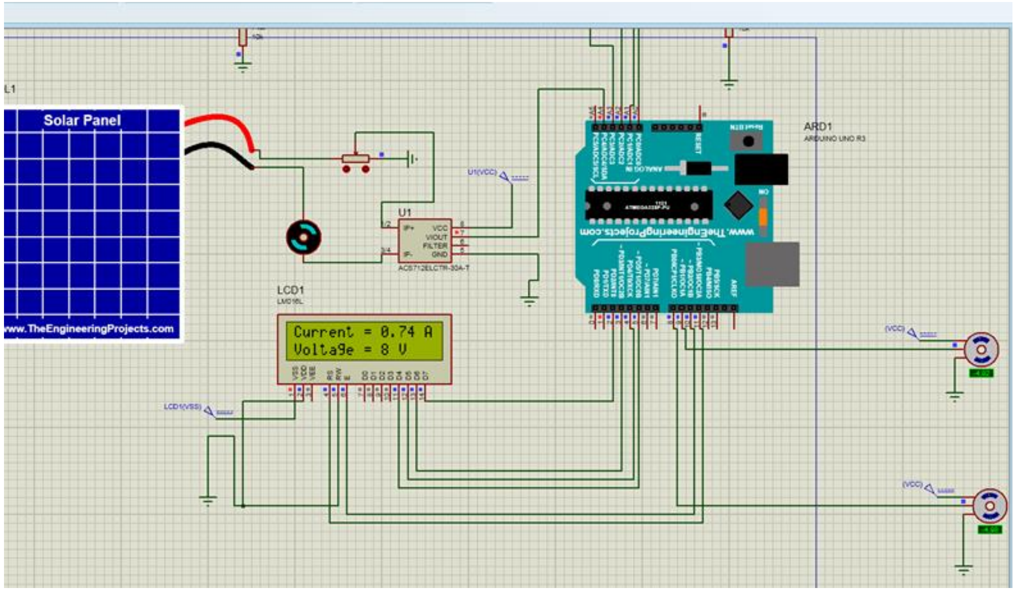

Figure 5.1: Simulation result of the project

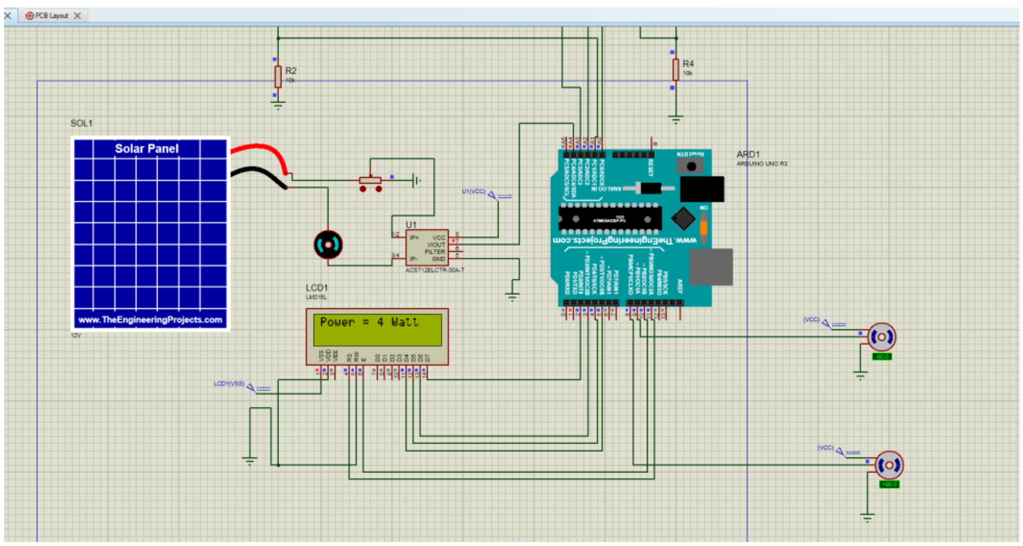

Figure 5.2: Simulation result of the power output

The main components the project is the Arduino UNO microcontroller, LDR, and metal gear servo motor. The microcontroller serves as the heart of the project and performs all the primary function of controlling/managing and prescribing the entire system. To move the MG90S motor in the proper direction, it receives a signal from the LDR and sends a corresponding signal level based on the program loaded on it.

Figure 5.1 shows the simulation result of the voltage and current output of in the project under certain condition.

The power output of the implemented project is shown in the figure 5.2.

5.2.2. Hardware Results

Hardware part was much harder than the simulation part. Every component had to taste many times and sometimes the components were not working for as usual reasons. But after tasting all the components, the hardware implementation was done and the result was satisfactory and was close to the simulation result. The LDR was not working as fast as in the case of simulation part. It took some delay of 3 - 4 seconds to respond. But the servo motor was working instantly. The entire system can be controlled by Wi-Fi and it was also working accurately.

Figure 5.3: Starting of the system

Figure 5.3 shows the welcome message which represents initial condition of starting.

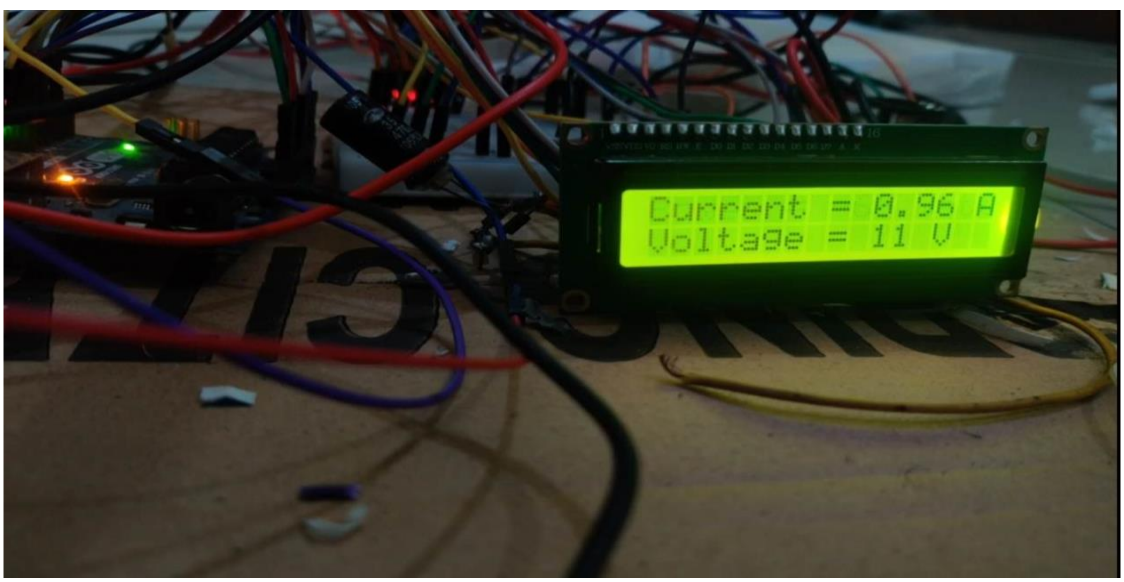

Figure 5.4: Output voltage and current under high light condition

Figure 5.4 shows the voltage and current output of which get from the solar panel under high illumination of sunlight.

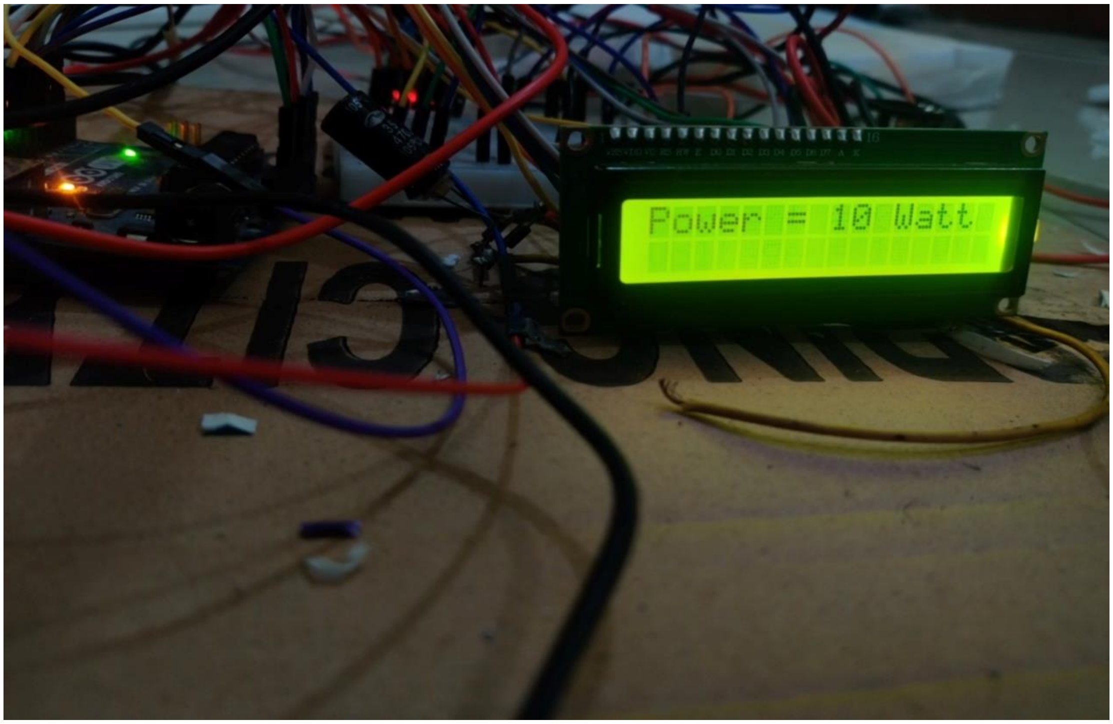

Figure 5.5: Power output under high light condition

Figure 5.5 shows the output of power from the solar tracker under high light condition.

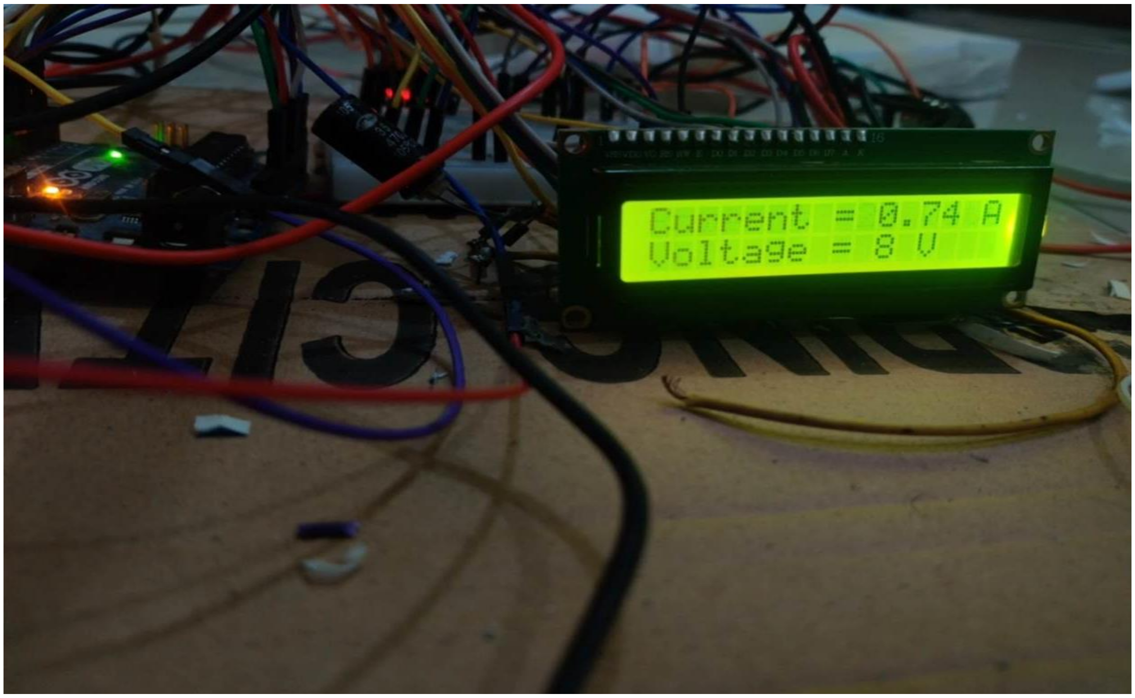

Figure 5.6: Output voltage and current under medium light condition

Figure 5.6 shows the voltage and current measured from the solar panel under medium illumination. of sunlight.

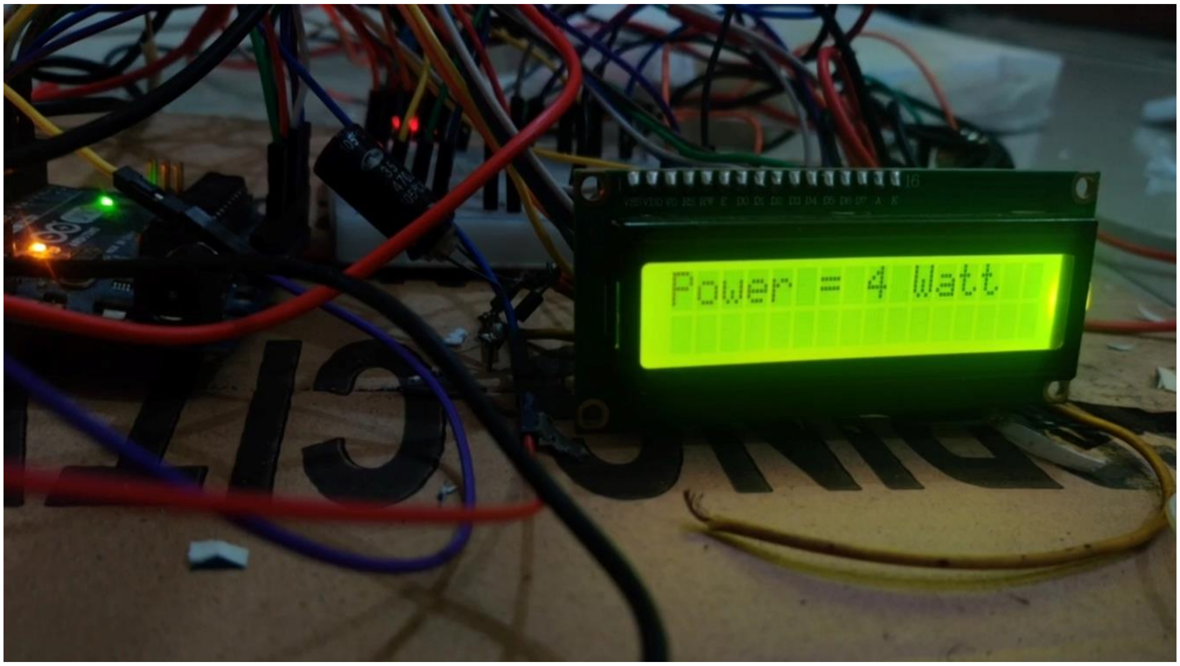

Figure 5.7: Power output under medium light condition

Figure 5.7 shows the output power measured by solar tracker under medium light condition.

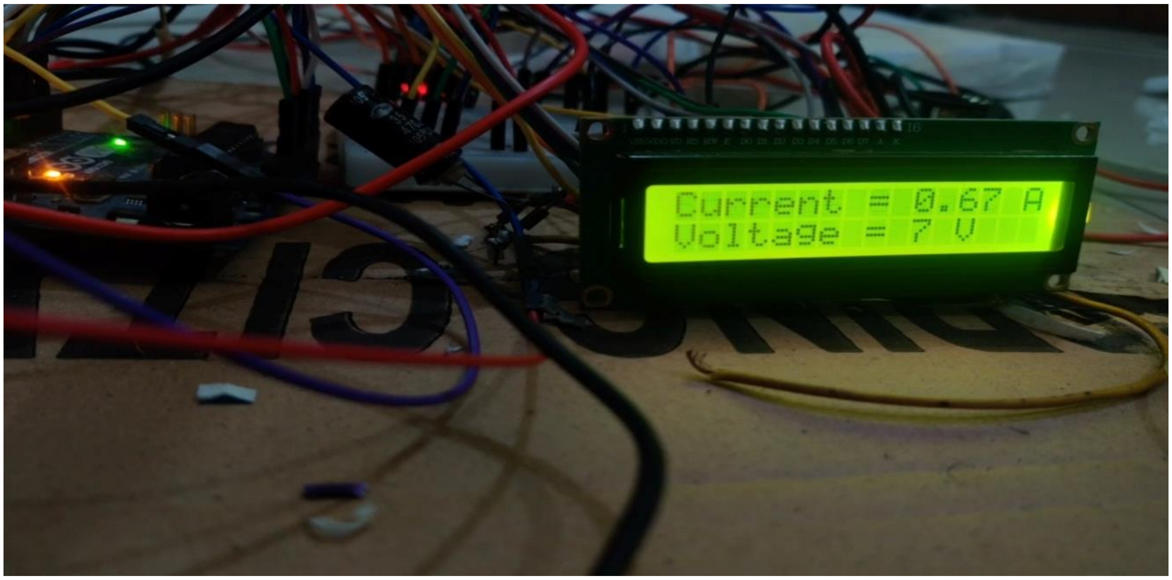

Figure 5.8: Output voltage and current under low light condition

Figure 5.8 shows the voltage and current output of which get from the solar panel under high illumination of sunlight.

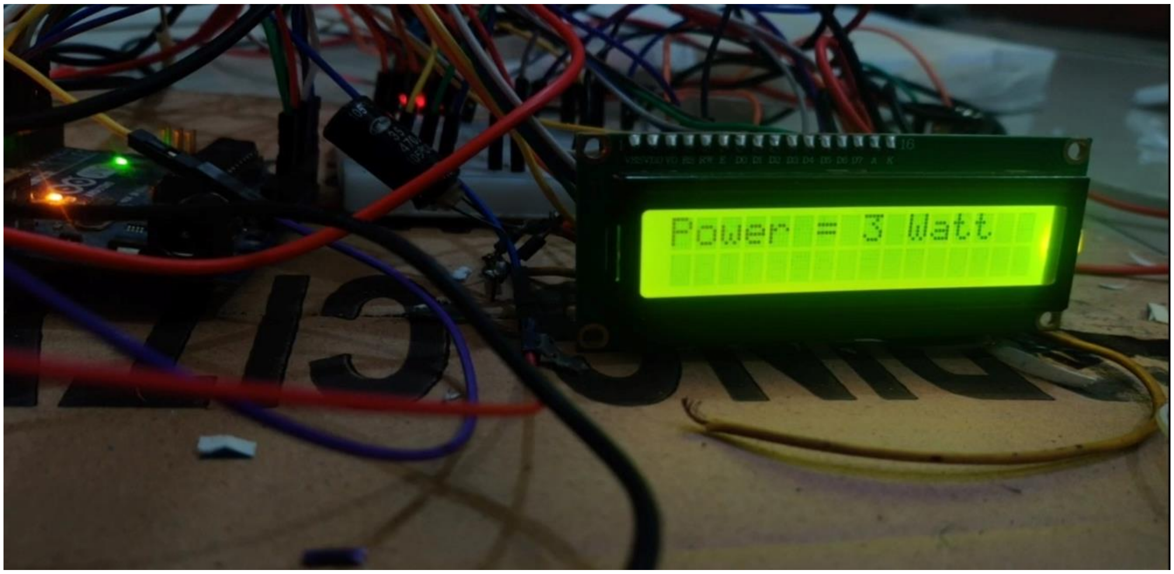

Figure 5.9: Output power under low light condition

Figure 5.9 shows the output power measured by solar tracker under low light condition.

5.3. Comparison of Results

The main objective of the project was to track the sunlight using dual axis tracker system for the improvement of power generation using solar energy. Its primary focus is to make an efficient and an ecofriendly power generation station. Generally, the results of the project have been well received. Dual axis solar tracker system is utilized in a variety of situations, and it's performed well in each and every case.

Figure 5.10: ESP real time monitoring

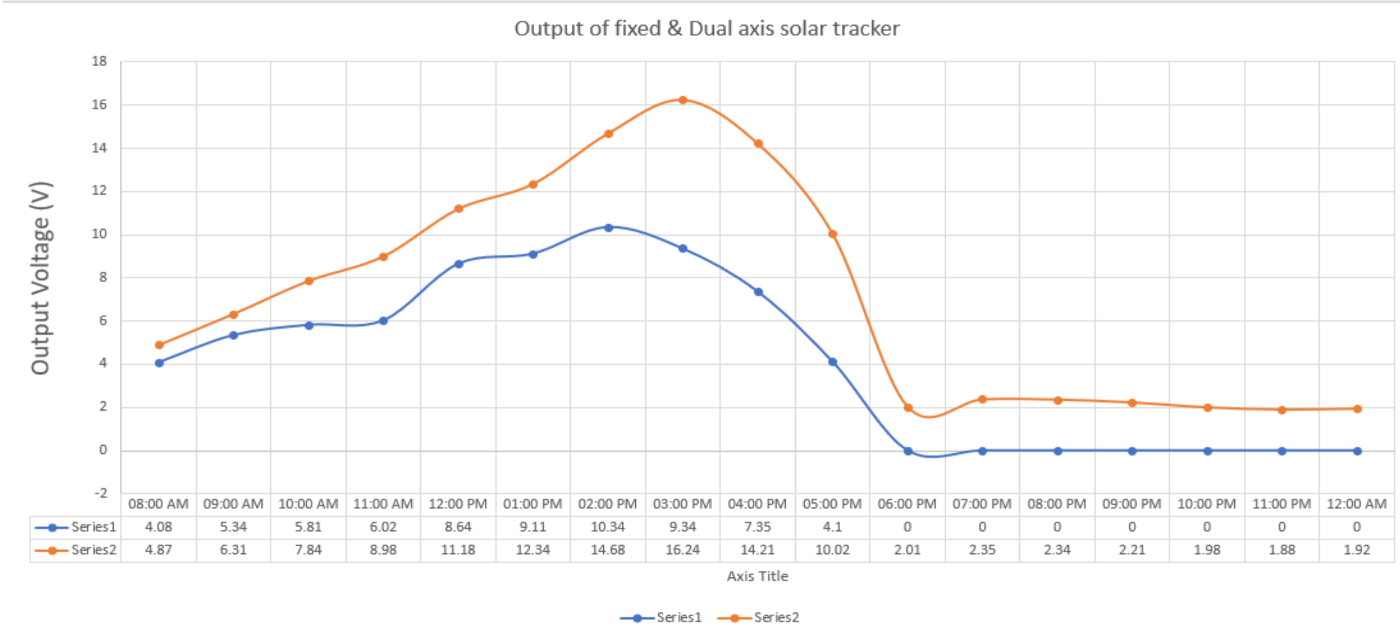

Figure 5.11: Output of Dual axis vs Single axis s solar tracker

All the results and the output of the project already discussed in the hardware result section. A detail comparison of result among different publish books and market available solution is discussed here.

The proposed projects key features have been stated above. This is the first project where LDR and UV features are integrated. Still now we have not found any project containing all these features together. Some of the publish book and research work is available related to the dual axis solar tracker project but they only covered only one feature at once. There are very few publications that have been able to implement these two features at a time in their project.

In the year 2020, Md. Abu Hasan Al Askary, Sumaiya maheen binte Hoque, and Bably Das published a paper titled Comparative Analysis of Dual and Single Axis Solar Tracker [30]. According to their findings, the average power obtained from a solar panel is 0.88589 W for a single axis solar tracker and 1.3832 W for a dual axis solar tracker. The efficiency of a dual axis tracker is 69.85%, while a single axis tracker is 44.74%. It is discovered that the dual axis tracking system produces more power and presents an efficient system for collecting solar energy, resulting in greater energy conversion than the single axis tracking system.

In our developed dual axis solar tracker project, LDR and UV sensor both are used to make it more efficient. The project can track the sun in every situation like if the sky is not clear or rainy or dusty then the UV sensor will absorb the radiation of the sun light on the other hand LDR will track the sunlight only in normal days. As the solar panel will be always towards the sun thus it will absorb more sunlight and will generate more electricity. The designed project has been tested a few times and shows satisfying results. In lower light, the panel was also facing the sun.

5.4. Summary

An in-depth discussion of the outcomes analysis has been covered in this chapter. In the capstone project book, this is one of the key chapters. By ensuring proper design after further research and development, the outcome analysis helps the system be even better, enabling us to create the most effective prototype. This project was successfully implemented and tested in every way. All of the parts were thoroughly tested in the field after the installation on various conditions. All of the parts produced an output that was faultless, meaning that the objectives were being achieved to some extent. The project's equipment was fully functional.

Chapter 6

CONCLUSION

6.1. Summary of Findings

In Bangladesh, there is a severe lack of energy. The rising consumer demand for electricity in our nation is greater than what can be produced. Bangladesh can rely on renewable energy, which can help the country become more energy efficient because conventional energy supplies are limited. Bangladesh's geographical location allows it to produce the most solar energy, which holds enormous promise as a renewable energy source. When the source light strikes the panel in the implemented project, the panel changes orientation to maximize the amount of light striking it perpendicularly. The project's goal has been attained instead of some limitations. This is achieved by using LDR and UV sensor, which can gauge how much sunlight is coming into contact with the solar panel. When the values produced by the LDRs differ significantly, servo motor is used to actuate the panel, so that it is approximately perpendicular to the sun's rays. The buck converter serves in balancing the power flow in the system, extending battery life, lowering heat, and safeguarding against high voltage. The solar panel benefits greatly from the UV sensor, which monitors ambient ultraviolet strength even in cloudy and extreme weather. The most challenging feature is using a smartphone to regulate a solar panel. The ESP-32 is performing exceptionally well in this department and has excellent Wi-Fi capability. Since strong Wi-Fi connectivity is ensured in a static application, the ESP-32 was the best microcontroller option.

6.2. Novelty of the Work

When we compare our suggested solution to the existing system, we can clearly see that this may a more efficient system with many possibilities. Traditional methods were previously initiated, but they were not as efficient as the dual axis solar tracker. The proposed project can generate more power in same amount of area compared to traditional method.

First, LDR sensors were used to sense the sunlight. So that the solar panel can absorb the highest radiation as much as possible. But sometimes there are cloud and dust in the sky so the LDR stops working in those weather, as a result the efficiency of the project may go down. UV sensor was used which will sense the radiation of the sun even if the sunlight is very low or under extreme weather condition. This system employs two servo motors. The upper panel holder servo motor tracks the sun linearly, while the lower servo motor tracks the sun parabolic displacement. A stepper motor and sensors are linked to an Arduino UNO. The Arduino UNO sends commands to the motors based on sensor input. LDR sensors detect light and transmit a signal to the Arduino UNO. In the proposed project, dual axis solar tracker was designed in such a way that both UV and LDR sensor features are included in a single system, which has never been done before.

6.3. Cultural and Societal Factors and Impacts

Engineering design and practices delves into the methods used by engineers to identify and solve problems. Cultural and societal factors heavily influence engineering design. Bangladesh is a South Asian country with a total land area of 148,460 square kilometers (57,320 sq. miles) [27]. The country ranks eighth on the list of the world's most densely populated nations, with a population of 162 million people. The country has a very limited supply of natural resources. Some of Bangladesh's population still lives in rural, isolated island and hilly areas without access to grid electricity. Because of its sustainability, low carbon footprint, and low production costs, renewable energy has recently gained popularity. Bangladesh is extremely fortunate to have a plentiful supply of renewable energy sources that can help meet the country's current and future energy needs. Because of its geographical location, Bangladesh has a significant potential for using solar radiation to generate electricity. The average daily solar radiation absorption in the country ranges from 4.0 to 6.5 kWh/m^2, with a 1018 - 1018 J energy production capacity [28]. Only 0.11% of this massive solar energy is used to meet the majority of the country's energy needs. Solar concentrating technologies have recently been developed to improve the efficiency of solar tracking systems in converting sunlight into energy. As a result, the proposed dual axis solar tracker system is intended to increase the efficiency of a dual axis solar power plant system in absorbing sun energy continuously throughout time with consistent performance in a variety of weather conditions.

6.3.1. Cultural and Societal Factors Considered in Design

Engineering design and practices delves into the methods that engineers generally use to identify and solve problems. Any kind of engineering design is heavily influenced by cultural and societal factors. In Bangladesh, there is a serious issue with electricity because there is not much unused land nor enough amount of gas, coal or oil. So, to generate electricity with the fossil fuel Bangladesh must buy those fossil fuel from other countries. On the other hand, as we know that, a large amount of area is needed to make renewable energy generation station, and because of not having a large amount of unused land Bangladesh and can't generate electricity from renewable sources efficiently with the traditional methods that are used [30]. Bangladesh is an overpopulated country where load shedding, blackout is still happening due to shortage of power generation. Hence the if proposed project is designed in such a way that it can generate more than traditional system after proper research and development. It will also work even when there is cloud and dust in the sky. The proposed system will generate more electricity in the same amount of area as traditional method. As overpopulated county Bangladesh has a less amount of unused land. So, we must use the land as efficiently as we can. Normally LDR will sense the sun light means it will detect which way the sun is moving. For worst case in a rainy day if the LDR sensor fails then the UV sensor will sense the radiation of the sun means which way the sun is. Then they will give this input to the Arduino UNO, and the Arduino will send command to the servo motor to rotate the solar panel towards sun. This way the proposed system always can be towards the sun means this proposed system can absorb more irradiation from the sun means it will generate more electricity. Then generated electricity will be connected to house or the national grid by going through the buck-boost converter. So that the generated power which is connected to grid or the household have the required voltage.

6.3.2. Cultural and Societal Impacts Considered in Design

Engineering solutions to any problem have always had a major impact on society and culture. In some cases, this impact is positive, and sometimes it is negative. Hence, societal, and cultural impact always play a vital role in the design of engineering solutions. Bangladesh is a small country with over population. The population growing at a very fast rate and the electricity demand is also growing. So, more electricity is needed but Bangladesh is not only an overpopulated country it is also a developing country. A huge amount of GDP is spending on importing the fossil fuel. Many people are jobless, many are going abroad to work. But if we can implement this project on a large scale then many jobs will be created so that many people will be benefited and most importantly, we can save a huge amount of money that were used to import fossil fuel. In 2020 mineral fuels including oil importing cost was: $6.8 billion (9.8%) [31]. So, if the proposed project is implemented successfully then the dependency on the fossil fuel is reduced. It will sense the sun by the help of LDR in normal condition and UV under extreme condition where the sunlight is low, or the sky is not clear. Overall, the system if properly designed and implemented after further research and development will help the power sector very much in Bangladesh, which will produce a significant positive impact on society and culture. The dual axis solar tracker can be helpful by fulfilling the energy demand, and the economy of the country will be healthy.

6.4. Limitations of the Work

There is no such thing as a faultless system. In order to realize the benefits of a system, certain drawbacks or limitations must be accepted. All challenges were attempted to be addressed when designing and building the project prototype. It is a prototype, so all constraints will be removed when it is mass produced after research and development. We chose Arduino since it is widely available. However, LDR interaction with the Arduino is little slow. We were trying to make the project as efficient as possible so the components we used are as usual. If the budget were a little high, the components would have been much better.

6.5. Future Scopes

Provide future scopes where the shortcomings of the project can be addressed. Future work can include the transformation of the experimental prototype into a mass production model, which requires improvement in its overall performance. In Bangladesh, electricity demand is very high. Due to not having enough number of powerplant and enough supply of fuels this demand is not fulfilled. This prototype idea may generate electricity very efficiently and its source is infinite and ecofriendly, so this problem can be resolved with this proposed project if properly implemented. As a result, the government must take the necessary efforts regarding the research on this sector. The following features can be added to this prototype to make it more advanced and accurate.

- The solar panel can be improved to absorb more irradiation to generate more electricity.
- The Arduino UNO microcontroller that is now utilized in this device may be replaced with a more recent version of the microcontroller or chip.
- More powerful LDR and UV sensor needs to be incorporated.
- The more precision servomotor is needed for exact tracking and position control.

6.6. Social, Economic, Cultural and Environmental Aspects

6.6.1. Sustainability

The focus of sustainability is the relationship between a specific project and the social, environmental, and economic components of the system that surrounds it. The majority of research has concentrated on the environmental aspects of sustainability rather than the economic aspects, with only a few studies addressing the social aspect. By keeping people healthy and safety I mind throughout the various stages of a project, social sustainability promotes the ideals of respect,

awareness, diversity, vitality and responsibility to the workforce and society. The proposed project generates electricity from the solar irradiation which is renewable energy. Thus, it has a sustainable, eco-friendly energy resource. The components that are used in the project is not harmful for anybody or anything.

6.6.2. Economic and Cultural Factors

Every country tries to improve their power sector. If the power sector improves, also the economic condition of the country will be improved. Engineers are held to a universal code of conduct because of their chosen profession. Engineers have to make sure that their project is not harmful for people and make sure that it does not harm the environment. It's an engineer's responsibility to use, only those products which is not harmful for neither people nor environment. These ethics were followed in the proposed project. Every component like Arduino UNO, LDR, servo motors are not harmful for people or any part of environment.

6.7. Conclusion

Technology is always evolving in the modern era. The advancement of technology has improved the comfort and ease of our lives. One of the most pressing issues in a developing country like Bangladesh is the energy crisis. The difference between electrical energy production and demand is very large. Large number of the population is entirely cut off from this blessing. Renewable energy is the only solution to this problem. Solar energy is one of the most powerful and promising renewable energy sources that could be used to resolve the energy demand to some extent. Since, the proposed system correctly aligns with the direction of the sun and records its movement, the performance of a dual axis tracker has greatly improved. Dual axis solar trackers have high power capture rates throughout the observation period, maximizing the conversion of solar irradiance into electrical energy output. The proposed system is also cost effective because a minor change to the single axis tracker resulted in a noticeable increase in system power. A dual axis solar tracker was successfully simulated and tested, resulting in increased overall power collection efficiency from the tracking devices with the same panel. In terms of real value, this means that the overall cost of a system can be significantly reduced because the solar array combined with a solar tracking device can supply significantly more power. By extracting more power from the same solar panel, the cost per watt is reduced, making solar power much more cost-effective than was previously achieved using fixed solar panels. Approaches to controller design are both cost effective and adaptable. Finally, all of these challenges provided opportunities to practice new problem-solving techniques. There are no negative environmental or societal consequences to this system. It may be a very comfortable and cost-effective system for the consumer if it is designed properly. Considering the present scenario, the future plan is to continue working on this project and to incorporate new features to make the project more effective, so that in can produce positive contribution towards our country.

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Appendix A

Datasheet of the ICs used

Arduino UNO R3:

Figure 1 Arduino Uno R3

Specifications:

- Microcontroller: ATmega328
- Operating Voltage: 5 V
- Input Voltage level :7-12 V (recommended)
- Input Voltage: 6-20V
- Digital input and output Pins: 14 (In total)
- PWM Digital input and output Pins: 6
- Analog Input Pin: 6
- DC Current per input and output Pin: 40mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory is: 32 KB
- Flash Memory for Bootloader is: 0.5 KB
- SRAM: 2 KB
- EEPROM: 1 KB
- Clock Speed: 16 MHz

ESP32:

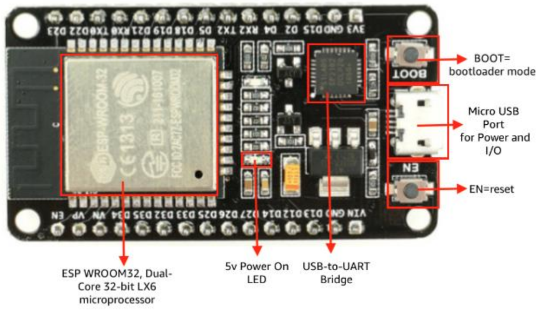

Figure 2 ESP 32

- Single or Dual-Core 32-bit LX6 Microprocessor with clock frequency up to 240 MHz.
- 520 KB of SRAM, 448 KB of ROM and 16 KB of RTC SRAM.
- Supports 802.11 b/g/n Wi-Fi connectivity with speeds up to 150 Mbps.
- Support for both Classic Bluetooth v4.2 and BLE specifications.
- 34 Programmable GPIOs.
- Up to 18 channels of 12-bit SAR ADC and 2 channels of 8-bit DAC
- Serial Connectivity include 4 x SPI, 2 x I^2C, 2 x I^2S, 3 x UART.
- Ethernet MAC for physical LAN Communication (requires external PHY).
- 1 Host controller for SD/SDIO/MMC and 1 Slave controller for SDIO/SPI.
- Motor PWM and up to 16-channels of LED PWM.
- Secure Boot and Flash Encryption.
- Cryptographic Hardware Acceleration for AES, Hash (SHA-2), RSA, ECC and RNG.

NodeMCU Code:

```
#include <LiquidCrystal.h>
#include <Servo.h>
/// ground motor
int pos = 90;
Servo servo_9;
/// solar motor
int pos2 = 90;
Servo servo_8;
/// sensors for ground motor
int sensorValue_1 = 0;
int sensorValue_2 = 0;
int sensorPin_1 = A0;
int sensorPin_2 = A1;
/// sensors for solar motor
int sensorValue_3 = 0;
int sensorValue_4 = 0;
int sensorPin_3 = A2;
int sensorPin_4 = A3;

int sensorPin_UV = A5;
int sensorValue_UV = 0;

// ldr arduino pin a0,a1,a2,a3
// a5 uv sensor
void setup1()
{
  servo_9.attach(9);
  servo_8.attach(8);
  Serial.begin(9600);
  Serial.println("STARTING!......");
```

```
    Serial.println("ldr_1 reading : ");
    Serial.println(sensorValue_1);
    Serial.println("ldr_2 reading : ");
    Serial.println(sensorValue_2);
    Serial.println("ldr_3 reading : ");
    Serial.println(sensorValue_3);
    Serial.println("ldr_4 reading : ");
    Serial.println(sensorValue_4);
    Serial.println("Both Motors at ");
    servo_9.write(pos);
    servo_8.write(pos);
    Serial.println(pos);
    // delay(3000);
}
void loop1()
{
    //////get l1 & l2
    sensorValue_1 = analogRead(sensorPin_1);
    sensorValue_2 = analogRead(sensorPin_2);
    /// get l3 & l4
    sensorValue_3 = analogRead(sensorPin_3);
    sensorValue_4 = analogRead(sensorPin_4);
    // ground servo motor
    sensorValue_UV = analogRead(sensorPin_UV);

    int avg_1_2 = (sensorValue_1 + sensorValue_2) / 2;
    int avg_3_4 = (sensorValue_3 + sensorValue_4) / 2;

    if (avg_1_2 < 510)
    {
        servo_9.write(0);
    }
    else if (avg_1_2 > 910)
```

```
    {
      servo_9.write(180);
    }

    if (avg_3_4 < 510)
    {
      servo_8.write(180);
    }
    else if (avg_3_4 > 910)
    {
      servo_8.write(0);
    }
    else
    {
      int pos = map(avg_3_4, 510, 910, 180, 0);
      servo_8.write(pos);
    }

    Serial.println("ldr_2 reading : ");
    Serial.println(sensorValue_1);
    Serial.println("ldr_2 reading : ");
    Serial.println(sensorValue_2);
    delay(100);
    // delay(1000);
  }

LiquidCrystal lcd(11, 10, 5, 4, 3, 2);

const int currentPin = A4;
int sensitivity = 66;
int adcValue = 0;
int offsetVoltage = 2500;
double adcVoltage = 0;
```

```
double currentValue = 0;

void setup()
{
  setup1();
  lcd.begin(16, 2);
}

void loop()
{
  loop1();
  adcValue = analogRead(currentPin); // 0-1024
  adcVoltage = (adcValue / 1024.0) * 5000;
  currentValue = ((adcVoltage - offsetVoltage) / sensitivity);
  int loadvoltage = currentValue * 12;
  int power = loadvoltage * currentValue * currentValue;

  lcd.print("Current = ");
  lcd.print(currentValue, 2);
  lcd.print(" A");
  lcd.setCursor(0, 1);
  lcd.print("Voltage = ");
  lcd.print(loadvoltage);
  lcd.print(" V");
  lcd.setCursor(0, 0);

  lcd.print("Power = ");
  lcd.print(power);
  lcd.print(" Watt      ");
  lcd.setCursor(0, 1);
  lcd.print("                ");
  lcd.setCursor(0, 0);
  delay(100);
```

```
}
```

Arduino UNO R3 Code:

```
#include <LiquidCrystal.h>
#include <Servo.h>
/// ground motor
int pos = 90;
Servo servo_9;
/// solar motor
int pos2 = 90;
Servo servo_8;
/// sensors for ground motor
int sensorValue_1 = 0;
int sensorValue_2 = 0;
int sensorPin_1 = A0;
int sensorPin_2 = A1;
/// sensors for solar motor
int sensorValue_3 = 0;
int sensorValue_4 = 0;
int sensorPin_3 = A2;
int sensorPin_4 = A3;

int sensorPin_UV = A5;
int sensorValue_UV = 0;

// ldr arduino pin a0,a1,a2,a3
// a5 uv sensor
void setup1()
{
  servo_9.attach(9);
  servo_8.attach(8);
  Serial.begin(9600);
  Serial.println("STARTING!......");
  Serial.println("ldr_1 reading : ");
```

```
    Serial.println(sensorValue_1);
    Serial.println("ldr_2 reading : ");
    Serial.println(sensorValue_2);
    Serial.println("ldr_3 reading : ");
    Serial.println(sensorValue_3);
    Serial.println("ldr_4 reading : ");
    Serial.println(sensorValue_4);
    Serial.println("Both Motors at ");
    servo_9.write(pos);
    servo_8.write(pos);
    Serial.println(pos);
    // delay(3000);
}
void loop1()
{
    //////get l1 & l2
    sensorValue_1 = analogRead(sensorPin_1);
    sensorValue_2 = analogRead(sensorPin_2);
    /// get l3 & l4
    sensorValue_3 = analogRead(sensorPin_3);
    sensorValue_4 = analogRead(sensorPin_4);
    // ground servo motor
    sensorValue_UV = analogRead(sensorPin_UV);

    int avg_1_2 = (sensorValue_1 + sensorValue_2) / 2;
    int avg_3_4 = (sensorValue_3 + sensorValue_4) / 2;

    if (avg_1_2 < 510)
    {
        servo_9.write(0);
    }
    else if (avg_1_2 > 910)
    {
```

```
    servo_9.write(180);
  }

  if (avg_3_4 < 510)
  {
    servo_8.write(180);
  }
  else if (avg_3_4 > 910)
  {
    servo_8.write(0);
  }
  else
  {
    int pos = map(avg_3_4, 510, 910, 180, 0);
    servo_8.write(pos);
  }
  Serial.println("ldr_2 reading : ");
  Serial.println(sensorValue_1);
  Serial.println("ldr_2 reading : ");
  Serial.println(sensorValue_2);
  delay(100);
  // delay(1000);
}
LiquidCrystal lcd(11, 10, 5, 4, 3, 2);
const int currentPin = A4;
int sensitivity = 66;
int adcValue = 0;
int offsetVoltage = 2500;
double adcVoltage = 0;
double currentValue = 0;
void setup()
{
  setup1();
```

```
  lcd.begin(16, 2);
}

void loop()
{
  loop1();
  adcValue = analogRead(currentPin); // 0-1024
  adcVoltage = (adcValue / 1024.0) * 5000;
  currentValue = ((adcVoltage - offsetVoltage) / sensitivity);
  int loadvoltage = currentValue * 12;
  int power = loadvoltage * currentValue * currentValue;

  lcd.print("Current = ");
  lcd.print(currentValue, 2);
  lcd.print(" A");
  lcd.setCursor(0, 1);
  lcd.print("Voltage = ");
  lcd.print(loadvoltage);
  lcd.print(" V");
  lcd.setCursor(0, 0);
  lcd.print("Power = ");
  lcd.print(power);
  lcd.print(" Watt       ");
  lcd.setCursor(0, 1);
  lcd.print("                ");
  lcd.setCursor(0, 0);

  delay(100);
}
```

APPENDIX B

ITHENTICATE PLAGIARISM REPORT

DESIGN AND DEVELOPMENT OF DUAL AXIS SOLAR TRACKER WITH WEATHER SENSOR

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