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Developments of Photovoltaic System with Multi Axis Tracker Ability

Haifaa Amira Hamizan[1], Md Nor Ramdon Baharom.[1]*, Zainab Zainal[1]

[1] *Department of Electrical Engineering Technology, Faculty of Engineering Technology, University Tun Hussein Onn Malaysia, 84600, Pagoh, Johor, MALAYSIA*

*Corresponding Author: ramdon@uthm.edu.my
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Abstract

The design, development, and installation of a solar panel system with dual axis tracking technology employing Light Dependent Resistors (LDR) are presented in this thesis project. The goal is to improve solar energy capture efficiency by dynamically transferring the position of the solar panel to face the sun ideally throughout the day. The suggested system includes an Arduino-based control mechanism that uses data from LDR sensors to detect the position of the sun in relation to the solar panel. Dual axis tracking allows for exact alignment with the sun's azimuth and elevation angles, guaranteeing optimum sunlight exposure. The LDR functions as light sensors, delivering real-time data to the control system, which then adjusts the solar panel orientation accordingly. The research thoroughly examines sun-tracking methods, sensor calibration methodologies, and hardware integration. The experimental findings show that the dual axis tracking system outperforms fixed solar panels in terms of efficacy. The results show a considerable improvement in energy harvesting efficiency, particularly in low-light settings and at different sun angles. This study advances renewable energy by proposing a cost-effective, dependable strategy for maximizing solar energy utilization. The dual axis tracking system with LDR is ecologically adaptable, making it a potential solution for applications requiring steady solar energy capture.

1. Introduction

Solar energy, obtained from sunshine, is a popular renewable energy source used in many Malaysian buildings to minimize power usage and promote sustainability. Solar panels, also known as solar cells or photovoltaic cells, use the photovoltaic effect to turn sunlight into electricity. Significant energy may be obtained by carefully arranging several solar cells inside solar collectors. The increased popularity of household solar photovoltaic systems is due to rising environmental awareness, lower solar panel costs, and government incentives. These systems let household members produce their own electricity, increasing energy independence and minimizing dependability on traditional power sources.

A significant advancement in solar technology is the creation of dual-axis solar tracking systems, which automatically modify the orientation of solar panels to maximize sunlight absorption. This research project desires to create a Photovoltaic (PV) tracker system hardware with features such as a photoresistor sensor used to detect sunlight intensity, which is controlled by Arduino, and solar cell panels that can provide real-time system feedback. The project's scope involves the building of a small-scale solar tracker system that uses Arduino Uno R3 for microcontroller operations, servo motors for movement, Light Dependent Resistors (LDRs) for light detection, and a voltage reader for user interface The Arduino adjusts the solar panel position based on light levels sensed by LDRs, and users receive real-time feedback via the voltage reader.

While this technology offers prospective consumers the chance to improve solar energy efficiency on a small scale, issues like scalability, weather sensitivity, calibration precision, and power consumption must be overcome. Expanding the system may be challenging, and poor weather conditions may influence performance. Optimizing the system's effectiveness requires precise calibration, frequent maintenance, and weather protection.

Single Axis and Dual Axis Trackers

Solar trackers are classified into two types: single-axis trackers in figure 1.1 and dual-axis trackers in figure 1.2, each with specific advantages. A single-axis tracker directs solar panels in one direction, from sunrise to sunset (east to west).

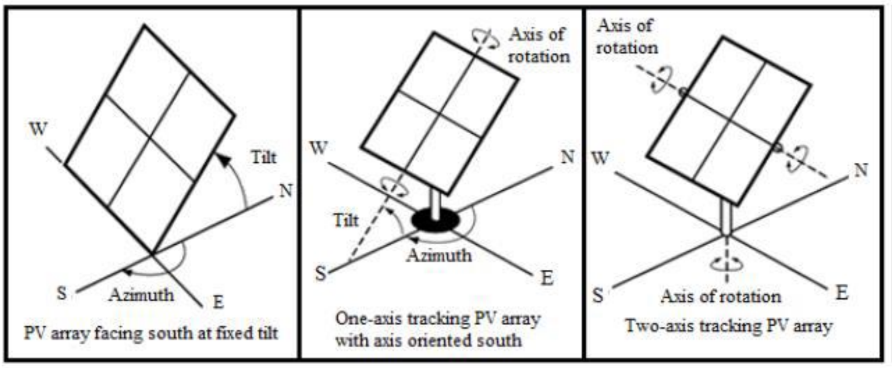


Figure 1.1: The Dual-Axis Solar Tracker

This significantly raises solar energy absorption during the day. A dual-axis tracker, on the other hand, moves panels in two directions—east to west and north to south— allowing for exact monitoring of the sun throughout the year. This seasonal flexibility optimizes solar energy generation, delivering constant and reliable performance in every environment.

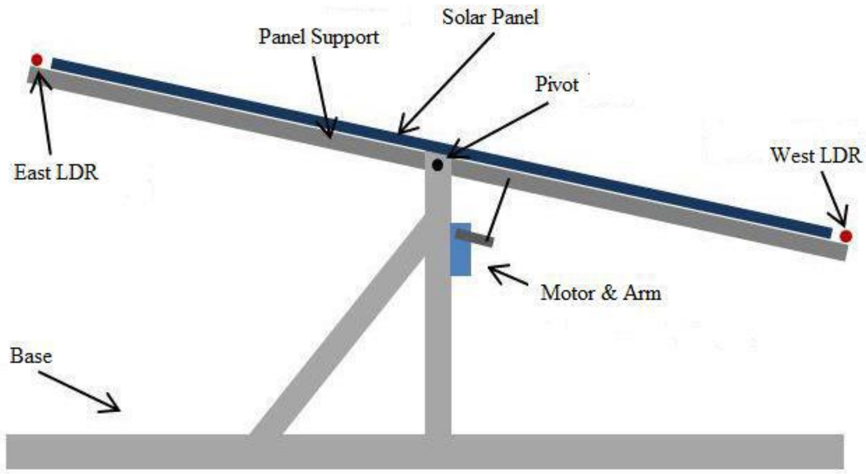


Figure 1.2 : The Single Axis Solar Tracker

Table 1 below is about the different types of solar tracker. There are many types of solar trackers in the industry. There is a single axis tracker, dual axis tracker, active solar tracker, passive solar tracker and chronological solar tracker.

Table 1: Types of Solar Tracker

Types	**Specification**

Single Axis Tracker	• Tracks in a single cardinal direction.
	• It has a single row tracking configuration.
	• More reliable.
	• It has a longer lifespan.
	• The common categories in which single axis trackers can be classified holds:
	  • Horizontal single axis trackers (HSAT).
	  • Horizontal single axis tracker with tilted modules (HTSAT).
	  • Vertical single axis tracker (VSAT).
	  • Tilted single axis tracker (TSAT).
	  • Polar aligned single axis tracker (PSAT).

Dual Axis Tracker	• It moves along two cardinal directions (Horizontal & Vertical). • The axes are traditionally orthogonal. • Its efficiency is much more than any single axis tracker. • It conventionally follows the movement of the sun and hence captivates maximum solar radiation.
Active Solar Tracker	• It uses motors and gear trains or direct drive actuators, to follow the movement of the sun. • Directed by a controller. • Deactivates during darkness based on the design of the system. • It uses a light sensor to locate the angle at which maximum sunlight can be absorbed. • The MCU directs the solar panel to change the angle.
Passive Solar Tracker	• It uses a liquid, easily compressible and boiled. • It is driven by solar heat. • The fluid moves when heated, like a teeter-totter and hence the solar panel moves.
Chronological Solar Tracker	• Works with the rotation of the earth. • Have no sensors. • Depends on the geographical location. • Uses a controller to calculate the moment and position of the earth with respect to the sun at a given time and location.

2. Methodology

A methodology provides a structure for gathering and analyzing data in order to accomplish a goal or objective. The exact design, the data collection process, and the data analysis process all be covered in the methodology outline. The methodology can be carried out with ease if the research conductor follows the right procedure.

System Block Diagram

The multi-axis solar tracker system is made up of numerous essential elements, as shown in Figure 2.1 , the Light Dependent Resistor (LDR), which serves as a sensor to monitor the intensity of sunlight and the servo motor to move the arm of the project, are the important components in this arrangement.

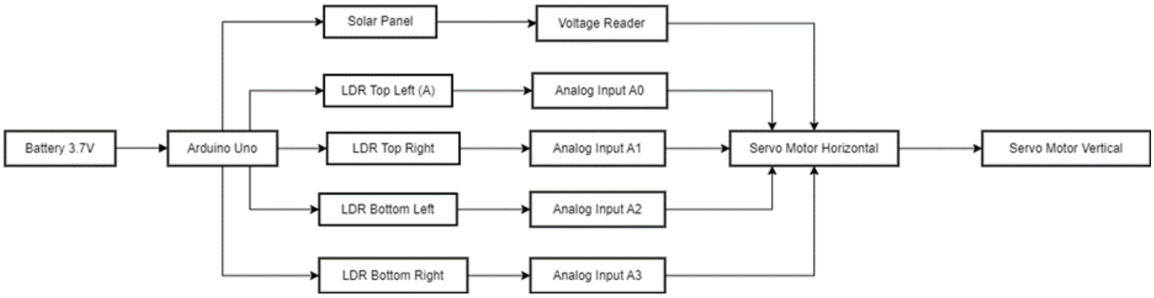


Figure 2.1: Block Diagram System

The LDR properly measures the amount of direct sunlight and delivers the details to the Arduino system. The information received from the LDR is processed by the Arduino system, which serves as the control center. It regulates the movement of the solar panels to maximize sun exposure. The servo motor, a vital driver in the prototype, is powering this movement.

This motor has been strategically set underneath and on top of the solar tracker system's upper arm. As a result, it is crucial to alter the direction of the solar panels. This dynamic movement keeps the panels aligned with the sunlight throughout the day, maximizing the accumulation of solar intensity. The combination of the LDR, Arduino system, and servo motor results in a complicated but efficient mechanism that optimizes solar panel orientation based on real-time direct sunlight intensity data.

System Flowchart

This project's specifications mainly by observing the movements of the servo motor both at the upper and the base in the model. As expected in the flowchart in figure 2.2. The LDR is in 4 different placements which are A, B, C and D. Then the system connected using Arduino Uno modules interfaces. The LDR transfer data to Arduino and sets the servo motor to move accordingly with the level of sunlight's intensity.

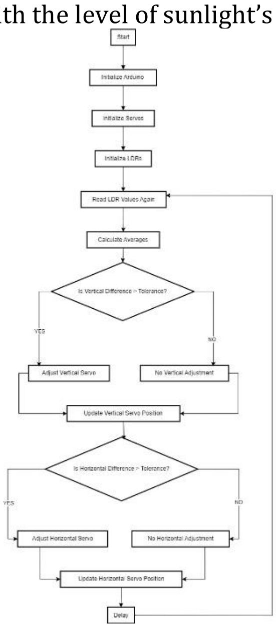


Figure 2.2: The Flowchart System

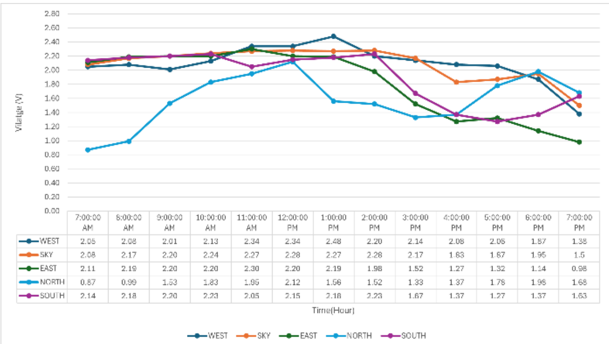
3. Results, Analysis and Discussion

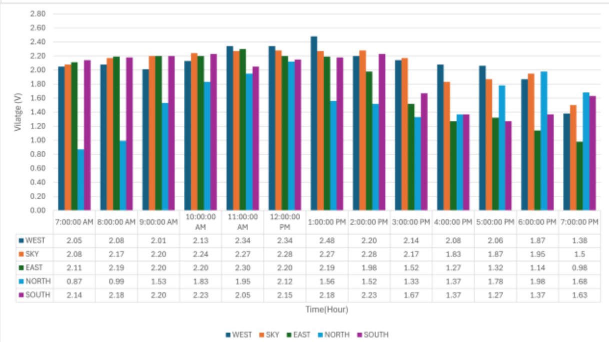
The significance of these findings for project objectives examined, as well as recommendations for future system development. The goal is to offer a thorough knowledge of the project's results and their importance in increasing renewable energy utilization.

An experiment was carried out to measure the voltage output of a solar panel at our location. The experiment used a solar cell with specifications of 2.5V and 3W. The voltage output of the solar panel was determined by facing the wind direction. The experiment's tabulated data and findings are shown here, and the results provide vital insights into the solar panel's performance at different facings of wind direction. The data was presented using both a bar graph and a line graph to illustrate how the voltage output of solar panels changes throughout the day based on their orientation.

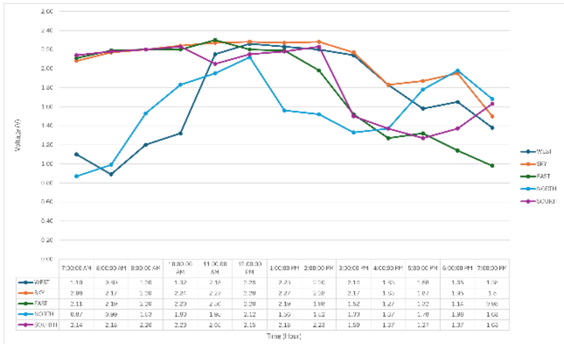
Table 2: The Data Collections

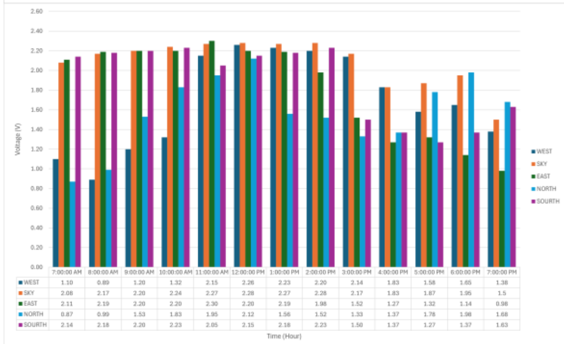
Data Collection for Day 1





Data Collection for Day 2





The table above shows a comparison of the voltage patterns for each source over two days, pointing out similarities, differences, and significant variations. On Day 1, WEST's voltage rises at 1.10 V at 7:00 AM, peaks at 2.26 V at 12:00 PM, then steadily declines to 1.38 V by 7:00 PM. On Day 2, it continues at a higher voltage of 2.05 V at 7:00 AM, rises slightly to 2.48 V at 1:00 PM, then falls to 1.38 V by 7:00 PM. This demonstrates that on Day 2, WEST begins and peaks at higher voltages before decreasing at the same value as Day 1.

On Day 1, SKY's voltage rises at 2.08 V at 7:00 AM, peaks at 2.28 V at 12:00 PM, and then drops to 1.50 V at 7:00 PM. Day 2 maintains a very identical trend, starting at 2.08 V at 7:00 AM, peaking at 2.28 V at 12:00 PM, and ending at 1.50 V at 7:00 PM. The voltage pattern for SKY is nearly identical on both days, with just a couple of changes in the afternoon readings, indicating constant behaviors.

The voltage readings for EAST on Day 1 rise at 2.11 V at 7:00 AM, peak at 2.30 V at 11:00 AM, and fall to 0.98 V at 7:00 PM. On Day 2, EAST begins at 2.11 V at 7:00 AM and peaks at 2.30 V at 11:00 AM before ending with a higher voltage of 1.38 V at 7:00 PM. NORTH had a similar voltage trend on both days, beginning at 0.87 V at 7:00 AM, rising at 2.12 V at noon, and declining to 1.68 V by 7:00 PM, indicating a consistent pattern.

Last but not least, SOUTH rise at 2.14 V at 7:00 AM on both days. On Day 1, it rises to a peak of 2.23 V at 2:00 PM and drops below to 1.63 V by 7:00 PM. However, on Day 2, SOUTH peaks at 2.23 V at 10:00 AM and returns to 1.63 V by 7:00 PM. This illustrates that, while the initial and final voltages are the same on both days, the peak occurs sooner on Day 2. These comparisons show that certain generators' voltage patterns remain consistent, whereas others vary, especially in the time and intensity of peak voltages.

4. Hardware Prototype

The hardware development consists of the development of an Arduino Board R3, a solar panel, four LDRs for sunlight detection, and two servo motors capable of moving the solar panel vertically and horizontally. Additional components include an expansion board, micro-USB and USB connections, a portable power shield, and two 3.7V batteries. The system adjusts the position of the solar panel using servo motors based on LDR feedback to capture the greatest amount of sunlight. The solar panel charges the batteries, allowing for continuous operation. Figure 4.1 shows the entire hardware arrangement.

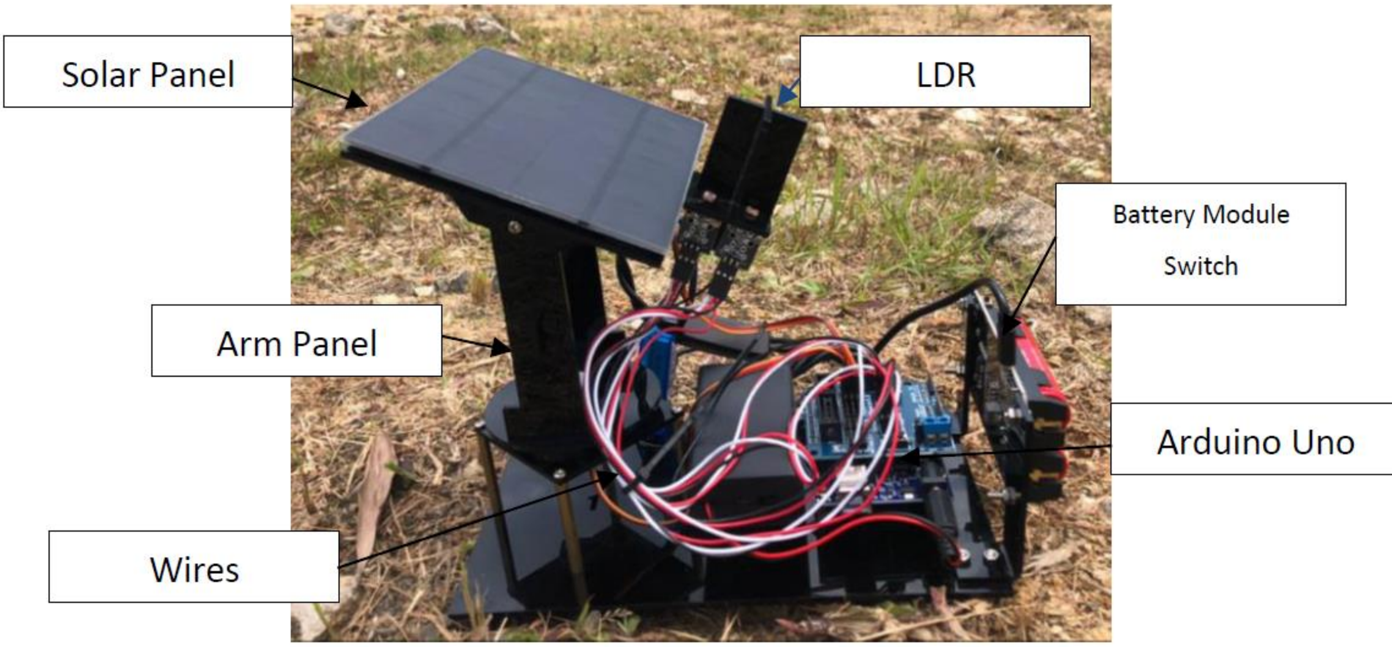


Figure 5.1: The Actual Prototype

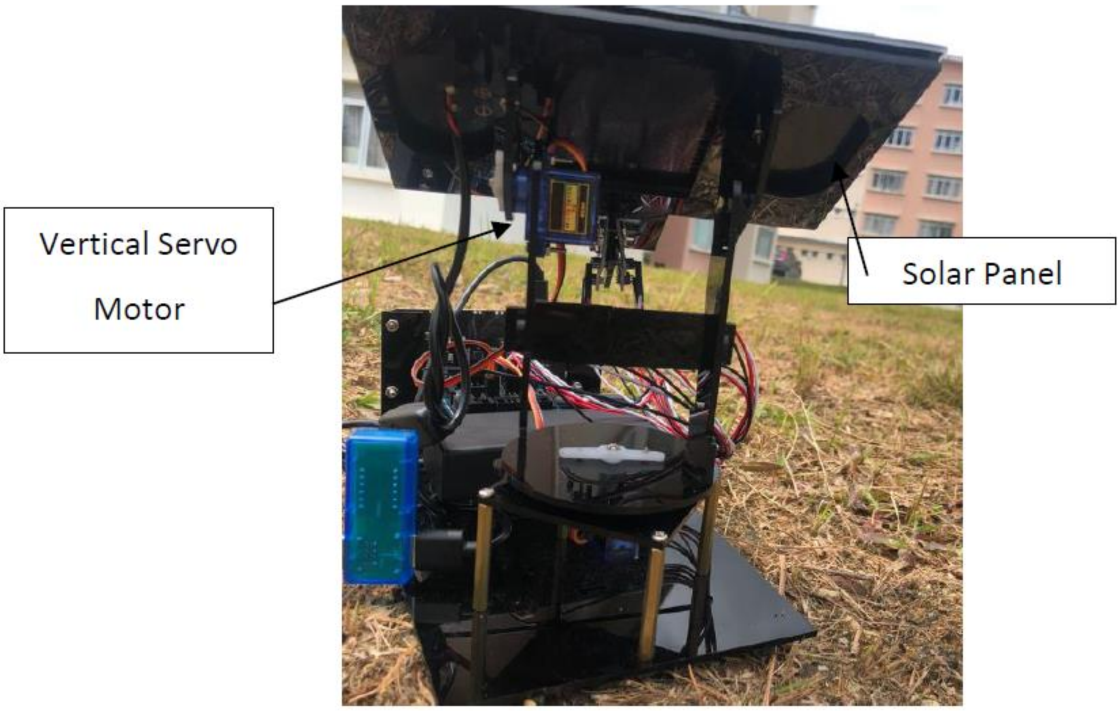


Figure 5.2 : The Vertical Servo Motor View

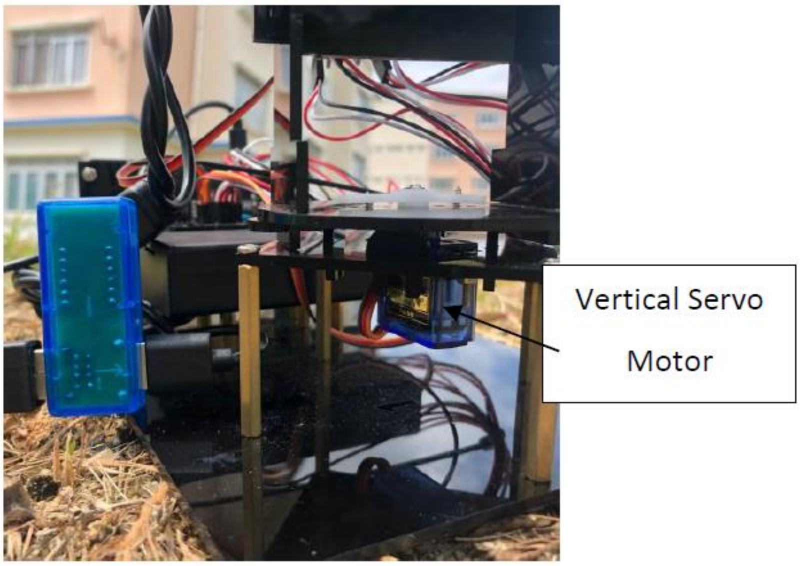


Figure 5.3: The Horizontal servo Motor

5. Conclusion

The solar tracker project significantly increased solar panel efficiency with an automated tracking system, demonstrating greater energy gathering over fixed panels. The project's flexibility to many circumstances and potential for wider use underlines its importance in improving renewable energy technologies. Future integration with IoT and AI promises to increase solar energy efficiency, deal with global energy concerns, and develop sustainable habits.

Integrating real-time meteorological data into the solar tracker system allows for optimal panel positioning depending on expected weather changes, improving energy efficiency and flexibility. Exploring innovative solar panel technologies for better sunlight collection and endurance presents exciting development potential. Continuous refining using intelligent algorithms such as Solar Pathfinder, along with IoT and AI integration, assures greater system performance, scalability, and long-term sustainability, supporting higher renewable energy adoption and global energy solutions.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Haifaa Amira Binti Hamizan[1], Md Nor Ramdon Baharom[1*],* Zainab Bin Zainal[1]*;* ***data collection****: Haifaa Amira Binti Hamizan[1]****; analysis and interpretation of results****: Haifaa Amira Binti Hamizan[1], Md Nor Ramdon Baharom[1],* Zainab Bin Zainal[1]***; draft manuscript preparation****: Haifaa Amira Binti Hamizan[1], Md Nor Ramdon Baharom[1*],* Zainab Bin Zainal[1]*. All authors reviewed the results and approved the final version of the manuscript.*

References

[1] Sciencedirect.com. (2018). Solar Tracking System - an overview | ScienceDirect Topics. [online] Available at: https://www.sciencedirect.com/topics/engineering/solar-tracking-system

[2] Aktaş, A. and Kirçiçek, Y. (2021). Chapter 2 - Eliminate the Disadvantages of Renewable Energy Sources. [online] ScienceDirect. Available at: https://www.sciencedirect.com/science/article/abs/pii/B9780323884990000021
Esakki Rajavel. Solar Panel Controller and Power Optimization. ResearchGate. Published May 7, 2018. Accessed October 28, 2023. https://www.researchgate.net/publication/324991215_Solar_Panel_Controller_and_Power_Optimization

[3] Sarla A, Charan S, Dandu R. Sun Tracking System. https://www.diva-portal.org/smash/get/diva2:1674078/FULLTEXT02

[4] Ghosh J. AUTOMATIC SOLAR TRACKING SYSTEM. https://rcciit.org/students_projects/projects/aeie/2019/GR2.pdf

[5] ScholarWorks@CWU Solar Tracker Haoyu Liu Recommended Citation. https://core.ac.uk/download/pdf/215342361.pdf

[6] Solar PV Tracker (Theory) : Solar energy Labs : Mechanical Engineering : Amrita Vishwa Vidyapeetham Virtual Lab. Amrita.edu. Published 2015. Accessed December 26, 2023. https://vlab.amrita.edu/?sub=77&brch=298&sim=1629&cnt=1

[7] Solar PV Tracker (Theory) : Solar energy Labs : Mechanical Engineering : Amrita Vishwa Vidyapeetham Virtual Lab. Amrita.edu. Published 2015. https://vlab.amrita.edu/?sub=77&brch=298&sim=1629&cnt=1

[8] Ghosh J. AUTOMATIC SOLAR TRACKING SYSTEM. https://rcciit.org/students_projects/projects/aeie/2019/GR2.pdf

[9] Sarla A, Charan S, Dandu R. Sun Tracking System. https://www.diva-portal.org/smash/get/diva2:1674078/FULLTEXT02

[10] Sundara. Automatic Dual Axis Sun Tracking System using LDR Sensor. ResearchGate. Published October 2014. Accessed December 26, 2023. https://www.researchgate.net/publication/266203938_Automatic_Dual_Axis_Sun_Tracking_System_using_LDR_Sensor?enrichId=rgreq-15f331877f0bc221ff8c2cb58cf9772e-XXX&enrichSource=Y292ZXJQYWdlOzI2NjIwMzkzODtBUzo4NjU2NDM0NjUyODU2MzNAMTU4MzM5Njg5MzE2NA%3D%3D&el=1_x_3&_esc=publicationCoverPdf

[11] Faisal M, Bin A, Halim A, Azwani L, Tiron B. Development of Sun Tracking Solar Panel Using Arduino. Journal of Engineering Technology. 2022;10(1):149-155. https://bmi.unikl.edu.my/wp-content/uploads/2022/11/149_155_Development-of-Sun-Tracking-Solar-Panel-Using-Arduino.pdf

[12] Scholarworks@cwu S, Liu H. Solar Tracker Solar Tracker.; 2018. https://digitalcommons.cwu.edu/cgi/viewcontent.cgi?article=1082&context=undergradproj