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Development of an IoT Based on Solar Tracking System

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Abstract

Solar energy, a renewable resource with significant potential, encounters challenges in attaining optimal utilization, particularly in static solar systems where energy production can be limited by less-than-optimal alignment with the sun's position during the day. To obtain the desired outcomes, a system employing detectors is necessary. This system utilizes an ESP32 microcontroller to regulate the movement of the panels and display the solar input production of the panels. The selection of this tracking system was based on its superior accuracy in capturing the highest possible amount of solar energy. The objective of this technology is to enhance the efficiency of energy acquisition by aligning the solar panels with the path of the sun. The objective of the research is to assess the system's performance in relation to a stationary system, with the goal of quantifying the enhancement in energy generation achieved by implementing continuous sun monitoring. The results indicate a substantial rise of up to 25% in energy generation compared to a fixed system. This enhancement pertains to the tracking system's consistent capability to align with the sun's position, guaranteeing optimal performance. This study highlights the ability of solar tracking technology to enhance the utilization of renewable energy and promote the progress of sustainable energy solutions.

1. Introduction

Solar energy is commonly recognized as a highly desirable renewable energy source that is far cleaner and less harmful to the environment than conventional options [1, 2]. In addition, solar energy offers the benefits of consistent accessibility, an inexhaustible resource and environmentally beneficial characteristics. Photovoltaic (PV) panels could convert solar energy into electricity [3].

Furthermore, Malaysian government actively encourages the advancement of renewable energy, particularly solar energy, by establishing the Sustainable Energy Development Authority (SEDA Malaysia). SEDA is a legally created organization that functions under the supervision of the Ministry of Energy, Green Technology and Water [4]. Furthermore, the government provides a benefit to homeowners who have surplus electricity generated from solar panels, which can be sold back to TNB through a two-way system. The Clean Energy Metering (NEM) system allows for the conversion of surplus electricity into credits that can be used to offset your electricity bill. Homeowners can benefit from a 10% to 15% decrease in monthly bills [5].

Next, to maximize energy generation efficiency from solar panels, it is important to orient directly towards the sun. Solar tracking is a robust and effective method of increasing the efficiency of solar panels by keeping them aligned with the location of the sun. In recent years, solar trackers have become increasingly popular worldwide as a highly efficient method of harnessing solar energy [6, 7]. Rubio states in [8] that the first factor to consider when building a solar tracking system is energy efficiency. A time and date based solar system was developed to eliminate the need to determine the location of the sun regularly during prolonged periods of cloudy weather. This can save a large amount of energy that would otherwise be used to operate the actuator. In a previous investigation [9], Huang created a solar tracking mechanism including a single axis and three locations, aiming to minimize energy consumption during operation. By reducing energy consumption, greater quantities of energy can be conserved for use in alternative applications. Furthermore, Bakos faces significant constraints in dual-axis solar tracking systems as outlined in [10]. In particular, the sensor mode cannot accurately monitor and follow the path of the sun when the solar radiation is low. This situation can cause a significant decrease in the overall efficiency of the system. Various studies have used time-based techniques in the development of solar tracking systems, which have led to a reduction in expenditure and energy consumption, ultimately resulting in energy savings [11, 12].

The main objective of this project is to develop and construct a solar panel that can effectively capture sunlight at a specific angle, with the ability to autonomously change itself. Furthermore, the incorporation of LCD and IoT monitoring facilitates the gathering of data pertaining to the durability of voltage and current. Recognizing power losses and comprehending their underlying causes is crucial for maintaining the reliability of the solar system. This may involve the collection and processing of data in real-time. The initiative will utilize renewable energy, primarily solar energy, to establish a more sustainable and ecologically conscious energy composition. The solar tracking system employs two light dependent resistors (LDR) to perceive and monitor the motion of daylight, while a servo motor is utilized for the rotational mechanism. As a result, it can generate energy efficiently.

2. Materials and Method

A methodology provides a structure for gathering and analyzing data to accomplish a goal or objective. The design, the data collection process, and the data analysis process will all be covered in the methodology outline. The methodology can be conducted with ease if the research conductor follows the right procedure. The movement of the sun as well as the Single-axis Solar Tracking System and will implement the monitoring of voltage and current using IoT.

2.1 Block Diagram

Figure 1 illustrates the block diagram of the overall Single-Axis solar tracker system. The project will utilize 12V solar panels as a resource to provide power for the load. The input system will consist of two Light Dependent Resistors (LDRs) that serve as sun trackers. These sensors were utilized to track the movement of the sun as part of the project's functionality. Another input is a voltage and current sensor, which is used to measure the output voltage.

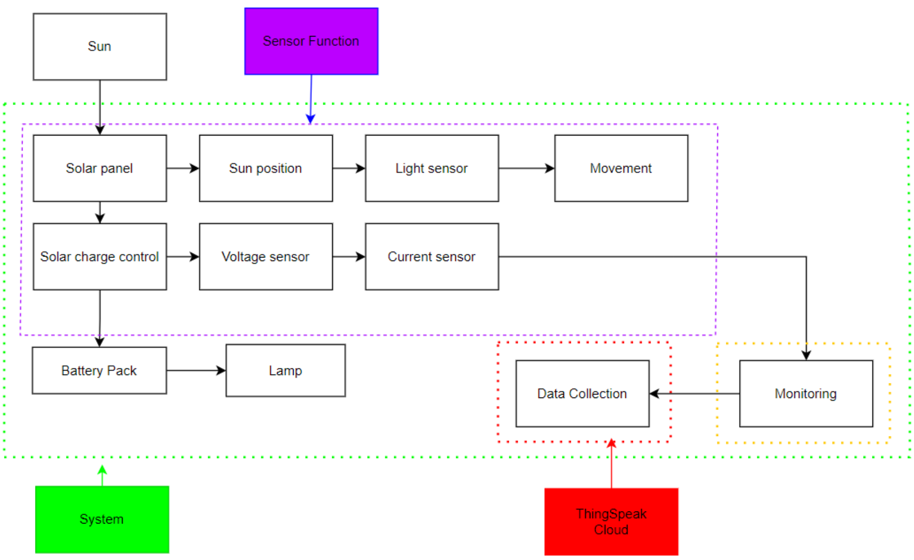

Fig. 1 *System Block Diagram*

The output system consists of two servos that are configured to track the LDR input and move the solar panel accordingly. Furthermore, the project employs an LCD display to visually present the current and voltage values. The Internet of Things (IoT) for this project utilizes the Thing Speak Cloud platform. Its primary goal is to visually represent the voltage and current data over time by graphs.

2.2 Flowchart System

This project consists of two parts: a monitoring system and a single-axis solar system. The monitoring system's flowchart, shown in Figure 2. (a), begins with the ESP32 checking for an internet connection. If connected, the ESP32 links with the Thing Speak Cloud. The sensor at the solar panel transmits signals to the microcontroller's analog pin, displaying data on the Thing Speak Cloud and an LCD. The sensor reads data, uploads it to the Thing Speak Cloud, which then generates a graph. Figure 2. (b) illustrates the flowchart for the servomotor's operation in the single-axis solar tracker system. The process starts by turning on the ESP32 microcontroller, setting the servo's initial position to 180 degrees. The position adjusts based on input from a Light Dependent Resistor (LDR) to track and capture sunlight, controlling the servo motor's movement of the solar panel. The servo shifts according to the LDR's input, aligning the servos towards the light source. If the Light Dependent Resistor (LDR) detects a higher intensity of sunlight coming from the east, the servo motor will be activated and move in the direction of the east. If the Light Dependent Resistor (LDR) detects a greater amount of sunlight coming from the west, the servo motor will be activated and move in the direction of the west. The movement ceases when two Light Dependent Resistors (LDRs) detect an identical light intensity.

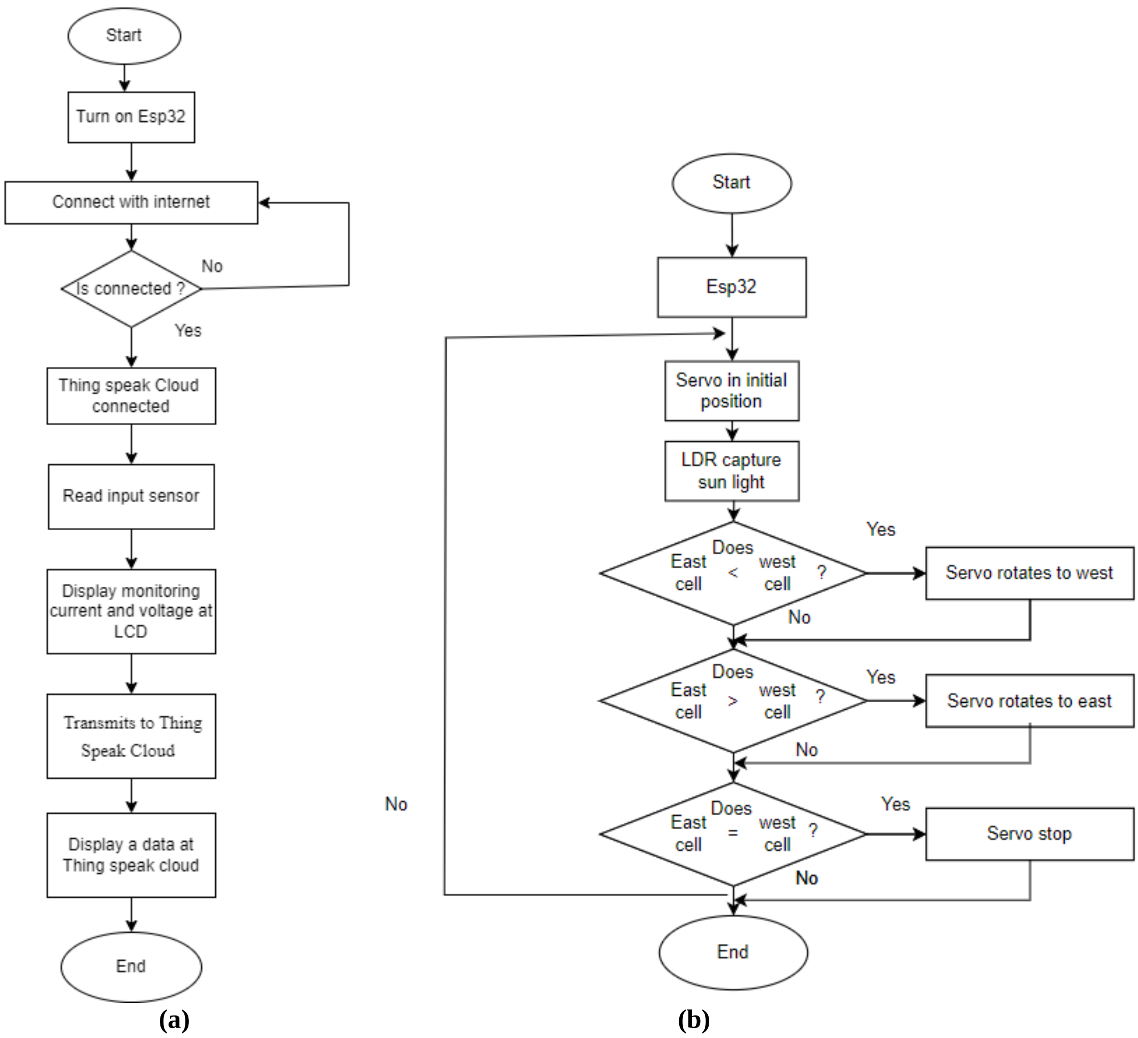

Fig. 2 *(a) Flowchart Monitoring System; (b) Flowchart Single-Axis Solar Tracker System.*

2.3 Materials and Design

Design and development of single axis solar trackers and IoT sensors as shown in Figure 3. Using a 12V, 25W polycrystalline silicon solar panel to absorb solar energy to produce electricity and using a solar charge controller for an electrical device that controls the electricity produced by the solar cell and directs it to the battery. The purpose is to prevent the battery from overcharging during the day and to prevent any excess power from flowing back into the solar cell. Additionally, using 2 servo motors allows for precise angular motion manipulation, making it easy to rotate items at the correct angle or distance. A light dependent resistor (LDR) sensor, sometimes referred to as a photoelectronic device or photo sensor, detects the magnitude of light and converts it into an electrical signal. As the light intensity increases, the resistance of the LDR sensor decreases and is used to capture sunlight. ESP32 Devkit V1-Doit is an electrical platform that facilitates the creation of interactive electronic items. Its main purpose is to supervise the operation of the entire solar tracking system. The monitoring system will use an LCD display and send data to the Thing Speak Cloud, displaying the measurements obtained from the voltage and current sensors read by the DC voltage, DC current sensor.

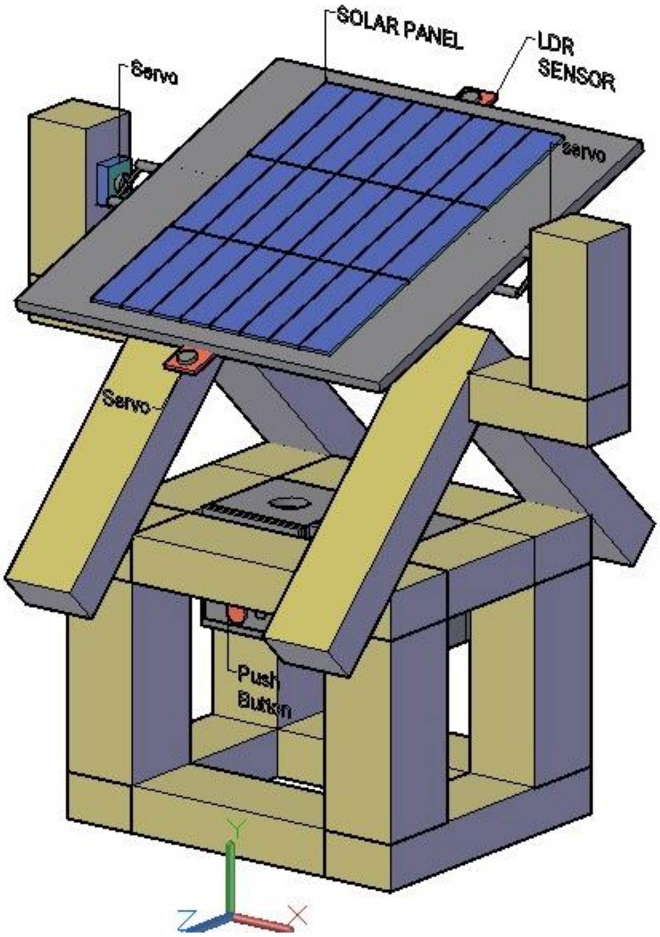

Fig. 3 *3D Design*

3. Result and Discussion

This section offers a comprehensive overview of the operation and accomplishments of the project. In addition, this chapter also investigates the discrepancy in solar energy generation between a single-axis system and a stationary panel. This section provides a thorough assessment of the effectiveness of an integrated approach, delivering valuable insights for developments in solar energy technology. The data is provided in table and graphical formats to enable a comprehensive comparison of the performance of each condition.

3.1 Hardware Prototype

The hardware development of this project is in Figure 4. Prior to implementation on physical hardware, this circuit is initially designed and tested using software to prevent any potential faults or erroneous connections. The system circuit comprises an ESP32 microcontroller, two servos, two LDR sensors, an LCD display, an I2C module for the LCD, a current sensor, and a voltage sensor. Also, the prototype is used for the experiment to get the monitoring power.

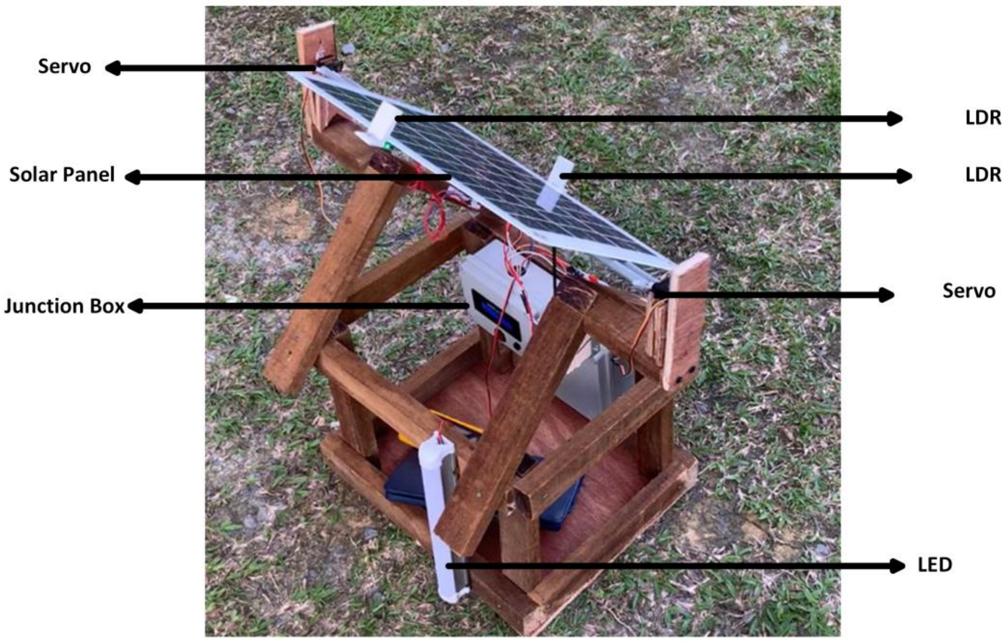

Fig. 4 *Hardware development*

3.2 Single-Axis System

Figure 5 shows data is collected and analyzed results are displayed on a Liquid Crystal Display (LCD). This is a visual representation illustrating Single-Axis Solar Panel the outcomes of the evaluation. Also, Figure 6 displays the outcomes of an IoT study that generates data in the form of a graph at 30-minute intervals. The graph displayed illustrates the monitoring of voltage and current.

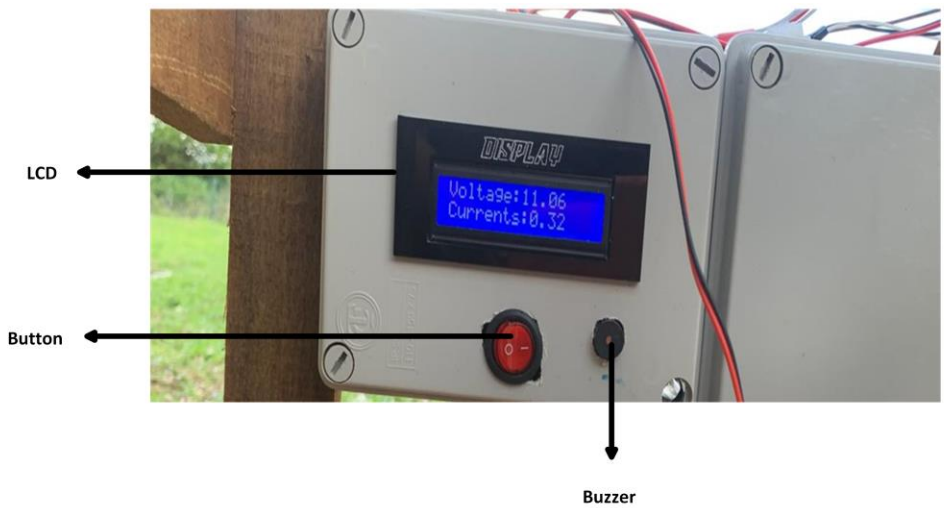

Fig. 5 *LCD Single-Axis System*

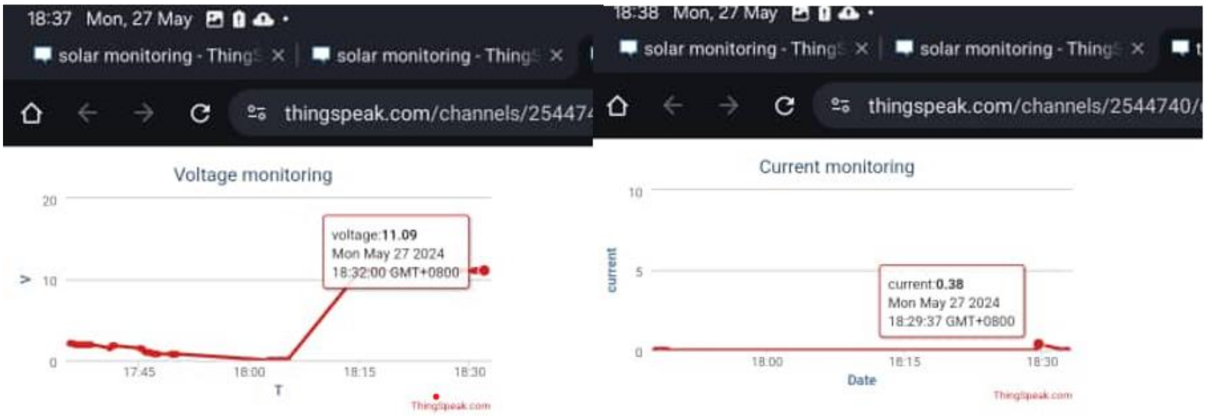

Fig. 6 *IoT Single-Axis System*

3.3 Static System

In this study, the area and position are equivalent to that of a single axis. Furthermore, solar electricity exhibits the same characteristics in terms of both output voltage and power. Figure 7 presented below illustrates the scenario during the process of data collection. Also, Figure 8 illustrates the placement of the solar panel at a 45-degree tilt, taking into consideration the pitch of the roof. Degree conditions are assessed via an Irradiance measuring apparatus.

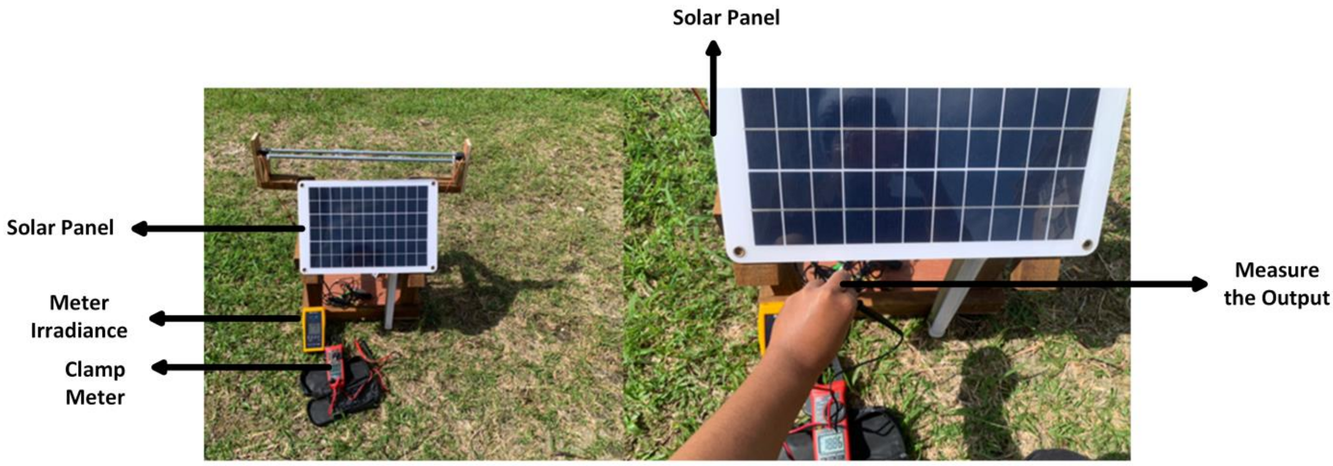

Fig. 7 *Static Solar Panel*

Fig. 8 *Tilted Angle for Static Solar Panel*

Progress in Engineering Application and Technology Vol. 5 No. 2 (2024) p. 95-103

3.4 Analysis Single-Axis System Vs Static Solar Panel

The study's findings will be derived from the data recorded in table 1 Data Single-Axis and table 2 Data Static, which includes measurements of irradiance, time, voltage, tilted angle and current.

Table 1 *Data Single-Axis Solar Panel*

Times	Irradiance (*W/m²*)	Tilted Angle	Vmp (*V*)	Imp (*A*)
0930	197	12	10.47V	0.24A
1030	920	15	11.04V	0.36A
1200	951	3	11.08V	0.36A
1300	945	3	11.34V	0.33A
1400	983	22	11.36V	0.38A
1500	432	17	11.23V	0.27A
1700	282	24	10.56V	0.24A
1800	524	24	11.09V	0.38A

Table 2 *Data Single-Axis Solar Panel*

Times	Irradiance (*W/m²*)	Tilted Angle	Vmp (*V*)	Imp (*A*)
0930	197	45	11.01V	0..27A
1030	920	45	11.05V	0.32A
1200	951	45	11.08V	0.32A
1300	945	45	11.03V	0.33A
1400	983	45	11.36V	0.38A
1500	432	45	10.03V	0.27A
1700	282	45	10.09V	0.24A
1800	524	45	11.09V	0.24A

The findings derived from the study will be presented in the form of a graph to facilitate a comparative examination. Figure 9 shows the graph voltage static and single-axis solar panel. Also, Figure 10 shows the graph current static and single-axis solar. According to the obtained data, it is evident that the voltage and current are reducing due to the constantly shifting sun path. As a result, the efficiency of sunlight is falling for static systems, but not for single-axis systems. The technology is designed to track the movement of the sun to optimize light exposure.

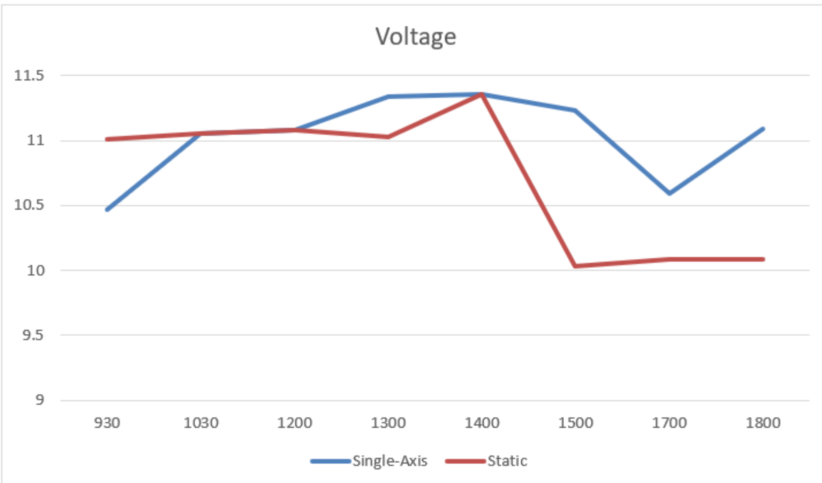

Fig. 9 *Graph Voltage*

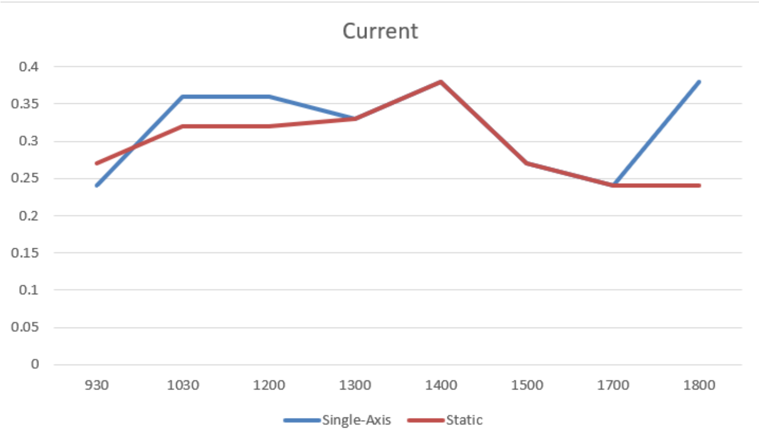

Fig. 10 *Current Graph*

4. Conclusion

Static solar panels possess various drawbacks, primarily attributable to their immovable orientation. Photovoltaic systems have less efficiency compared to detection systems due to their inability to dynamically optimize solar capture throughout the day. Consequently, their energy generation is less stable, relying heavily on the positioning of the panels and the angle of the sun.

On the other hand, single-axis solar panels provide notable benefits. Dynamic solar panels have the capacity to enhance energy generation by 10-25% in comparison to stationary panels. This increase is contingent upon the geographical location and the design of the system. The panels' ability to track the sun's movement across the sky enables this improved performance. This leads to increased efficiency and a more uniform energy generation throughout the day, as it constantly adapts to capture the optimal quantity of sunlight.

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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:** Irfan Nur Hafiy Bin Hairil[1], Faridah Hanim Binti Mohd Nor; **data collection:** Irfan Nur Hafiy Bin Hairil[1]; **analysis and interpretation of results:** Irfan Nur Hafiy Bin Hairil[1], Faridah Hanim Binti Mohd Nor[2]; **draft manuscript preparation:** Irfan Nur Hafiy Bin Hairil[1], Faridah Hanim Binti Mohd Nor[2]. All authors reviewed the results and approved the final version of the manuscript.*

References

[1] Aryuanto Soetedjo. Modeling of Maximum Power Point Tracking Controller for Solar Power System.

[2] TELKOMNIKA Indonesian Journal of Electrical Engineering. 2012; 10(3): 419-430.

[3] R. Dhanabal, V. Bharathi, R. Ranjitha, A. Ponni, S. Deepthi, and P. Mageshkannan, "Comparison of Efficiencies of Solar Tracker systems with static panel Single- Axis Tracking System and Dual-Axis Tracking System with Fixed Mount", International Journal of Engineering and Technology, vol. 5, no. 2, pp. 1925–1933, 2013.

[4] "FiT-SEDA-Malaysia - Home solar|Photovoltaic|Solar voltaic|Sun solar|Solar sun|Solar panel|Power solar|Panel solar|Solar cells|Renewable energy|Solar energy|Solar|Solar pv|Solar power|solar electricity|green energy|Renewable Energy||Go green|passive income", [Online]. Available: http://www.fit-seda-malaysia.com/. [Accessed: 21-Oct-2014].

[5] Chee, J. (2024, February 15). Cost guide to installing a solar panel in Malaysia. DollarsAndSense.my. https://dollarsandsense.my/cost-guide-to-installing-a-solar-panel-in-malaysia/

[6] Improved Particle Swarm Optimization Algorithm TELKOMNIKA Indonesian Journal of Electrical Engineering, January 2014; 12(1): 261~ 268

[7] Syed Arsalan. Sun Tracking System with Microcontroller 8051. International Journal of Scientific & Engineering Research, June-2013; 4.

[8] F.R. Rubio, M.G. Ortega, F. Gordillo, and M. López-Martínez, “Application of new control strategy for sun tracking”, Energy Conversion and Management, vol. 48, no. 7, pp. 2174–2184, Jul. 2007.

[9] B.J. Huang, Y.C. Huang, G.Y. Chen, P.C. Hsu, and K. Li, “Improving Solar PV System Efficiency Using One-Axis 3-Position Sun Tracking”, Energy Procedia, vol. 33, pp. 280–287, 2013.

[10] G.C. Bakos, “Design and construction of a two-axis Sun tracking system for parabolic trough collector (PTC) efficiency improvement”, Renewable Energy, vol. 31, no. 15, pp. 2411–2421, Dec. 2006.

[11] K. Sambasiva, Harish, V.N.V Ramana, and M.V.S. Krishna, “Time operated solar tracking for optimum power generation”, International Journal of Scientific and Engineering Research, vol. 4, no. 5, pp. 1909–1912, 2013.

[12] R. Fauzan, A.S. Amir, and H. Miyauchi, “Microcontroller ATmega8535 Based Solar Tracker Design for PV System Applications in Equator Region”, International Journalof Control and Automation, vol. 7, no. 4, pp. 217– 234, Apr. 2014.