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SURAT PENUGASAN TENAGA PENDIDIK

Nomor : 70-VII/03.1-F/III/2024

SEMESTER GENAP, TAHUN AKADEMIK 2023 / 2024

Nama	:	**Agus Sofwan,H.,Dr.,-Ing. M.Eng.Sc.**	Status Pegawai	:	Dosen Tetap
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Jabatan Akademik	:	**Lektor**			

Bidang	Perincian Kegiatan	Tempat	Jam / Minggu	Kredit (sks)	Keterangan
I PENDIDIKAN dan PENGAJARAN	**1. Pengajaran dikelas termasuk laboratorium**				
	• Manajeman Proyek Teknik	S2	09:00-12:00	1	Sabtu
	• Instrumentasi Sistem Kendali	S2	13:00-18:00	1.5	Sabtu
	• Etika Profesi	S1	15.30-17.00	1	Senin
	• Disain Sistem Kelistrikan (A&K)	S1	08.00-09.40	1	Kamis
	• **Kewirausahaan**	S1	15.30-17.00	1	Jumat
	• **Kapita Selekta (A&K)**	S1	15.00-16.00	2	Rabu
	2. PEMBIMBING				
	• Seminar				
	• Kerja Praktek				
	• Tugas Akhir/Tesis				
	• Pembimbing Akademik			1	
	3. PENGUJI				
	• Tugas Akhir/ Tesis			1	
	• Kerja Praktek				
	4. Tugas Tambahan				
	• Menduduki Jabatan di Perguruan Tinggi			3	
II PENELITIAN	1. Penelitian Ilmiah				
	2. Penulisan Karya Ilmiah			1	
	3. Penulisan Diktat Kuliah				
	4. Menerjemahkan Buku Kuliah				
	5. Pengembangan Program Kuliah Kurikulum				
	6. Pengembangan Bahan Ajar				
III PENGABDIAN DAN MASYARAKAT	1. Menduduki Jabatan di Pemerintahan				
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	3. Memberikan Penyuluhan/Pelatihan/Penataran/Ceramah			1	
	4. Memberikan Pelayanan Kepada Masyarakat				
	5. Menulis Karya Pengabdian Pada Masyarakat yang tidak dipublikasikan				
	6. Pengolahan Jurnal Ilmiah				
IV PENUNJANG	1. Menjadi anggota panitia / Badan pada suatu Perguruan Tinggi				
	2. Menjadi anggota Badan Lembaga Pemerintah				
	3. Menjadi Anggota Organisasi Profesi			1	
	4. Mewakili PT / Lembaga Pemerintah duduk dalam Panitia antar Lembaga				
	5. Menjadi Anggota Delegasi Nasional ke Parlemen – Parlemen Internasional				
	6. Berperan serta aktif dalam pertemuan ilmiah/Seminar				
	7. Anggota dalam Tim Penilai Jabatan Dosen				
	Jumlah Total			**15.5**	

Kepada yang bersangkutan akan diberikan gaji / honorarium sesuai dengan peraturan penggajian yang berlaku di Institut Sains Dan Teknologi Nasional. Penugasan ini berlaku dari tanggal 01 Maret 2024 sampai dengan 31 Agustus 2024

Jakarta, 01 Maret 2024
DEKAN

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1. Wakil Rektor 1 – ISTN
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TWO-AXIS SOLAR PANEL TRACKING DEVICE PROTOTYPE WITH IOT-BASED MONITORING

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Abstract: The aim of this project is to develop a dual-axis solar tracker equipped with an IoT monitoring system with the BLYNK platform using Arduino. Overall, solar energy refers to technologies that generate power from sunlight. The utilization of solar energy has been around for centuries and has been widely used without relying on other energy supplies. However, its importance is increasing as environmental awareness grows and the availability of other energy sources, such as fuel, becomes limited. Sun tracking systems are an effective technology that can improve the efficiency of solar panels by following the movement of the sun. With the help of this system, solar panels can automatically orient themselves to sunlight, improve sunlight detection, and increase electricity collection because solar panels can always be in a bright position. This project focuses on developing a two-axis sun tracker using Arduino Uno as the main controller. For its implementation, four light-sensitive resistors (LDRs) are used to detect sunlight and maximum light intensity. Two servo motors are used to move the solar panel according to the direction of sunlight detected by the LDRs. Furthermore, an ESP8266 WIFI device is used as an intermediary between the device and the IoT monitoring system. The IoT monitoring system is a website that serves to store data. The efficiency of this system is tested and compared with single axial sun tracking. The results show that the two-axis solar tracking system generates more power, voltage, and current compared to the single axial solar tracker.

Keywords: Internet of things (IoT), Prototype Solar Tracker, Dual axis, Photovoltaic, Solar energy.

INTRODUCTION

Indonesia's potential natural resources, both renewable and non-renewable, make the country a very promising place to live [1]. In many inhabited areas around the world, solar energy is one of the most environmentally friendly forms of energy resources [2]. Technological developments encourage the need for community intelligence in utilizing natural resources wisely [3]–[5]. Along with technological advances, there is an increase in electricity consumption by society [6], [7]. In Indonesia, reliance on fossil fuel energy sources as the main source of electricity is still ongoing [8]. Fossil fuels, which are non-renewable and will eventually run out, are the main choice even though it is not clear when the supply will be met [9]. Therefore, Indonesia needs to follow in the footsteps of countries in Europe that have prepared alternatives to replace fossil fuels [10]. As a tropical country with an astronomical location between 6°N - 11°N and 95°E - 141°W, Indonesia has great potential in utilizing renewable energy sources, especially through the use of sunlight throughout the year [11]–[13]. In this context, sunlight is a potential source of renewable energy to be used as a substitute for fossil fuels [14], [15] . The utilization of solar energy can be done through various types of natural or nature-based power plants that can be an alternative to replace fossil fuels. For example, solar power plants (PLTS) are one of the solutions that can be counted on [16], [17]. Therefore, in this final project, the author aims to design a power plant design that uses solar thermal energy. This design will focus on the optimization and efficiency of the energy produced by solar panels.

Solar panels are generally permanently installed at a fixed angle, causing them to be unoptimized in absorbing solar radiation due to the sun's movement from east to west [18], [19]. In order for the absorption of solar radiation to be optimized, the surface of the solar panel needs to move so that it is perpendicular to the direction of sunlight [20]. Therefore, efforts need to be made to move the surface of the solar panel so that it can always be in the right position with respect to solar radiation [21], [22]. A solar panel tracking device is a device used to follow the movement of the sun. Changes in the direction of light emitted by the sun and sensor detection can be utilized to monitor the movement of the sun. Sensors commonly used in this research context include photodiodes or LDRs (Light Dependent Resistors) [23], [24].

Previous research has implemented solar panel tracking such as in the study of [25]. The components involved in the circuit include the power supply, ATmega 8535 microcontroller, Liquid Crystal Display (LCD), stepper motor driver, and Light Dependent Resistor (LDR) circuit. As a result, solar trackers or solar panels that are dynamic and can follow the direction of sunlight can produce an increase in output voltage of about 11.53%, compared to fixed or stationary solar modules. The initial output voltage is 11.57 V, an increase of about 1.18 V compared to the static state [26]. Solar trackers refer to electromechanical systems that have the ability to follow the path of sunlight, aiming to point solar panels or collectors directly towards the sun. The goal is to maximize energy collection. Therefore, this research focuses on the manufacturing process and automation of microcontrolled solar trackers. Two mobile structures were constructed: one equipped with a high-precision step motor and four luminosity sensors placed separately in quadrants by a cross structure, while the other was equipped with a DC motor and a 275 Wp solar panel. This allowed the design and evaluation of their behavior separately. The control and automation system is governed by an Arduino MEGA2560 microcontroller, which runs the tracking and positioning algorithms. The successfully created prototype made it possible to carry out an in-depth study of solar tracking strategies based on sensors and controls applied to the DC motor [27].

Photovoltaic (PV) energy is one of the most significant renewable energy sources globally. PV efficiency can be increased up to 60% by using dual-axis solar trackers, which aim to maximize PV exposure to the sun. The main component in this dual-axis solar tracker is the sun location sensor, which uses four Light Dependent Resistors (LDRs) connected to a potentiometer to improve accuracy. The system is controlled by an Arduino UNO which controls two stepper motors. Two experiments were conducted, resulting in an LDR tolerance of 0.05V and an LDR calibration error of 0.03V. Both experiments show that the LDR has good capabilities for dual-axis sun trackers, and the use of a potentiometer successfully improves the accuracy. In the context of increasing global energy demand and depletion of fossil resources, the development of new electricity production systems is becoming increasingly important. Photovoltaic solar energy, due to its simplicity and applicability, is becoming one of the most desired solutions in various homes. This research involves the development of a new photovoltaic solar tracker prototype with an Arduino platform. A feedback control system was designed to enable solar tracking with two axes using stepper motors and linear actuators controlled by photodiode-based electronic circuits. In addition, the physical construction of the prototype allowed the observation of the effectiveness of the design and its ability to make maximum use of solar radiation. The prototype positions the panel perpendicularly to sunlight, enhancing its performance for future deployment in homes. Comparison results between the developed prototype and static panels oriented at latitude show an increase in energy gain of about 18% [28]. Then there is also research [29], [30] exploring the significance of implementing a sun tracking system in solar energy extraction using LabVIEW software. monitoring using LabVIEW is very simple, low-cost, and reliable [31], but with the advancement of technology internet-based monitoring would logically be better because it is certainly easier and more integrated and can be anywhere to monitor [32].

Based on the explanation and previous research in monitoring it is still not good and effective, while in the current era the internet is very helpful and facilitates work, therefore the authors conduct research on monitoring and monitoring based on the Internet of Things (IoT), because by utilizing the Internet everything will become easier and more effective [33], [34]. However, there have also been studies that use the Internet of Things as a tool for monitoring or monitoring tracked solar panels, in research [35], Using the Internet of Things (IoT) as a monitoring of solar panels with Ubidots platform, the IOT monitoring system is a website that serves to store data. The efficiency of this system has been tested and compared with a single axial solar tracker. As a result, the two-axis solar tracking system produces more power, voltage and current. In this research used in monitoring and monitoring is with the Blynk platform. Then compare the power data results from the tracked solar panel prototype with the untracked one and the performance improvement on the solar panel. The results of this study will add to the research data on monitoring or monitoring solar panel tracking properly and effectively.

RESEARCH METHOD

The system setup in the methodology details the steps of designing a two-axis solar panel device with IoT-based monitoring. This process includes system design sequences, block diagrams, and flowcharts that describe the design of the device.

Design Flow

In designing this two-axis solar panel tracking device, there are several work steps that I take to obtain the desired results, as can be seen in Figure 1

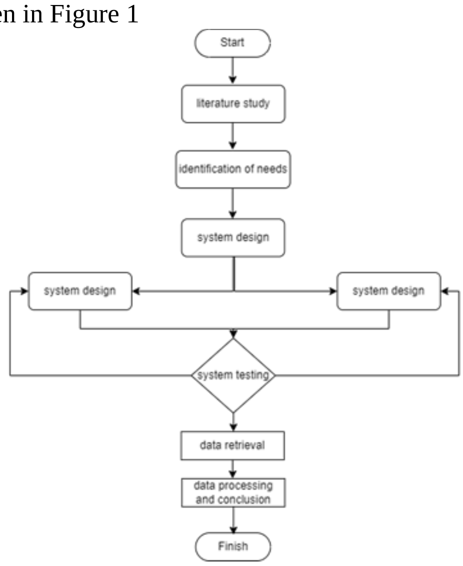


Figure 1. Flowchart of the design of a two-axis solar panel tracking device

Block diagram of System design

This block diagram provides a basic overview of the system to be created. Each part in the system block has a specific function. The block diagram to be created will be similar to the one shown in Figure 2

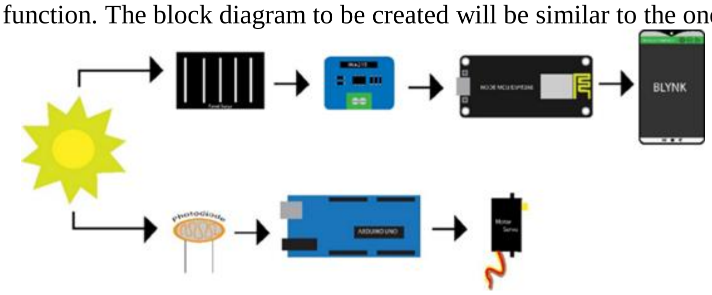


Figure 2. Block diagram of System design

With reference to the scheme above, this solar panel tracking device equipped with an IoT-based monitoring system uses two microcontrollers, namely Arduino and NodeMCU ESP8266. Each microcontroller has its specific role. The Arduino microcontroller is responsible for processing input from the LDR (Light Dependent Resistor) sensor, which will drive the servo motor according to the degree that has been set in the Arduino program. Meanwhile, the NodeMCU ESP8266 microcontroller acts as a data sender obtained from measuring voltage, current, and power using the INA219 sensor. The data will be sent to the BLYNK application via a WiFi connection that has been prepared.

Hardware Design

The manufacture of this LDR (Light Dependent Resistor) sensor involves a connection with an Arduino Uno Microcontroller, along with an additional component in the form of a 1K ohm resistor, as shown in Figure 3 below.

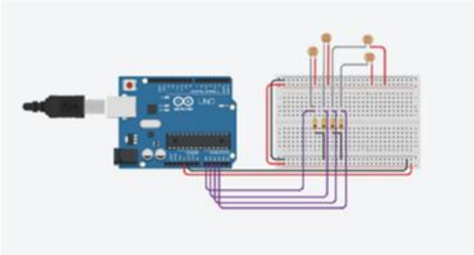


Figure 3. LDR sensor hardware design

Table 1. LDR Sensor Connection Pins

LDR Sensor	**Arduino Uno**
LDR 1	Input A0
LDR 2	Input A1
LDR 3	Input A2
LDR 4	Input A3

The servo motor design involves using two servo motors to adjust the position of the solar panel according to a preset degree, following the direction of the incident sunlight.

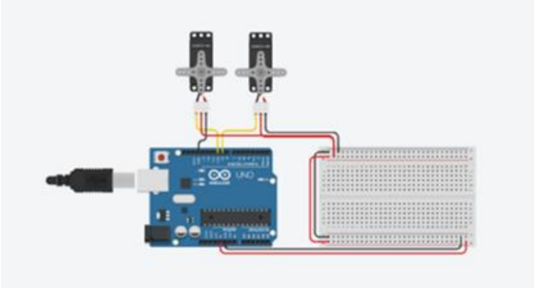


Figure 4. Servo Motor Hardware Design

Table 2. Servo Motor Connection Pins

Motor Sevo MG966R	**Arduino Uno**
GND	GND
VDC	In +5
Data	Digital Pin 9 and 10

With reference to the block diagram in Figure 1, the functioning of this hardware involves the use of an Arduino UNO as the control center and an LDR sensor as the sunlight detector. The LDR sensor detects the sunlight falling on it, allowing the servo motor to move and adjust its position according to the direction of the sunlight. The hardware schematic of the two-axis solar panel tracking system is shown in Figure 5.

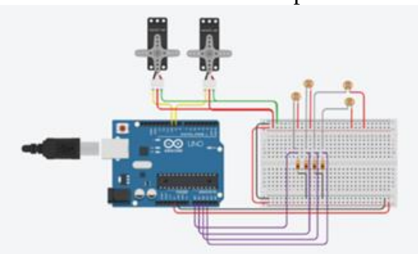


Figure 5. Hardware Design of Sensors and Servo Motors

Software Design

The software is designed through the use of the Arduino IDE application, which needs to be installed on a computer or laptop beforehand. In the Arduino IDE, the C programming language is used. In addition to the Arduino IDE, another tool used is the flowchart diagrammer. More information can be found in the explanation below.

The Arduino IDE is an application used to code the device being planned, using the C programming language as its primary language.

Figure 6. Arduino IDE Application View

In Figure 7 there is a flow chart of the solar panel tracking device, starting with the initialization of the pins connected to each component such as four LDR sensors and two servo motors. After pin initialization, the next step is to find the average value generated by each LDR sensor and divide it into four sections, namely top left, top right, bottom left, and bottom right. After obtaining the average of each section, calculations are performed to find the difference in value between the upper and lower sensors. Next, a comparison is made to determine the movement of the two servo motors used. If the value of the upper sensor is smaller than the lower sensor, the vertical servo motor will move downward, reducing the degree value of the vertical servo motor, and vice versa. Furthermore, if the value of the right sensor is smaller than the left sensor, the servo motor will move towards the left until the values of all sensors become equal.

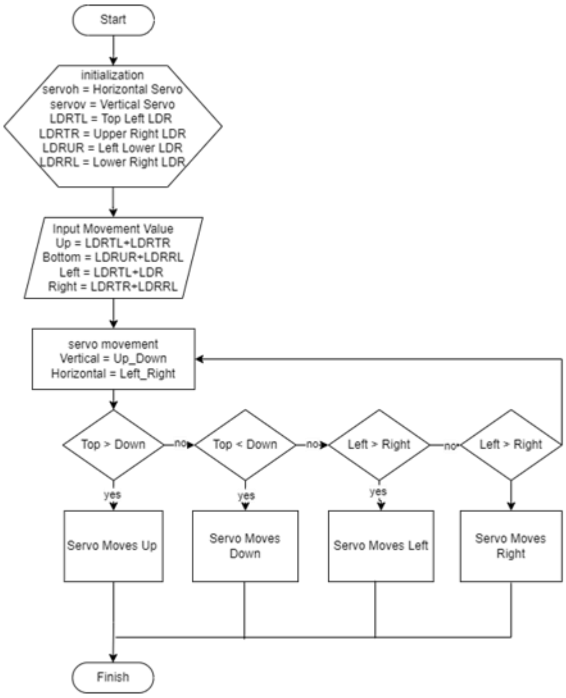


Figure 7. Software System Flowchart

The flowchart shown in Figure 8 details the ESP8266 MCU Node program to read the current, voltage, and power generated by the IoT-based two-axis solar panel tracking device. In initialization, there is a wifi and address configuration to send data to the BLYNK application. The next process involves setting the wifi and BLYNK address, where the ESP8266 will connect to the wifi network that has been set in the program. After that, the INA219 sensor will read the voltage, current, and power generated by the solar panel tracking device. Once the INA219 sensor successfully reads these values, the information will be immediately sent to the BLYNK application that has been prepared by the researcher.

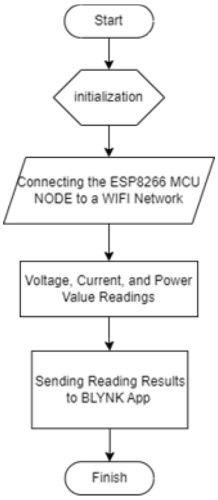


Figure 8. NodeMCU ESP8266 program flowchart

In this study, researchers utilized BLYNK as a means to monitor the voltage, current, and power generated by the solar panel with the help of calculations from the INA219 sensor. The BLYNK display design that has been prepared can be found in Figure 9 below.

Figure 9. Display of the designed BLYNK application

RESULT AND DISCUSSION

Hardware Design Results

The resulting hardware design can be seen in Figure 10, where the hardware is assembled in a 145×95 mm box containing an Arduino Uno, ESP8266 MCU Node, and INA219 sensor.

Figure 10. Components contained in the box

In the illustration above, it can be explained that in the box there is an Arduino microcontroller, ESP8266 MCU Node, INA219 sensor, and a series of resistors to inhibit the current from the LDR sensor connected to the ground on the Arduino. The LDR sensor is mounted on the top of the solar panel to optimally detect sunlight. Meanwhile, servo motors are mounted on the left and bottom of the panel to allow movement with two axes, namely horizontal and vertical, as seen in Figure 11.

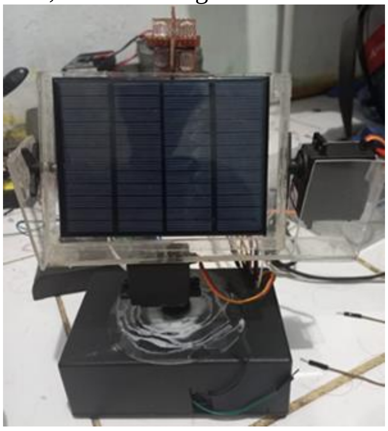


Figure 11. Solar Panel Tracker

The power or energy generated by the solar panel will pass through the INA219 sensor to measure voltage, current and power. After that the solar panel is also connected to the solar charge control, to regulate the power so that it can charge the battery or directly flow to the load.

Solar Panel Monitoring Results

When monitoring the second solar panel, the Blynk app was used interchangeably to monitor the voltage, current, and power generated by the panel. In addition, there are rotating axes used in the solar panel tracker, namely the vertical and horizontal axes. These two axes operate according to the position of the direction of incoming sunlight. In Figure 12, we can see how the placement is done during data collection on the solar panel tracker.

Figure 12. Testing the tracking solar panel

In this test, researchers compared two solar panels, one with a tracking system and one without. Both solar panels have identical specifications, namely 12 volts with 1.5 watts of power. Data collection was carried out every hour for three days, starting from 07:00 to 18:00. The results of monitoring the solar panels using the BLYNK application are documented in Table 3.

Table 3. Tracking Solar Panel Measurements

Date	Time	Solar Panel tracker			Tracerless Solar Panels			Lux meter	Conditions
		Volt	Ampere	Watt	Volt	Ampere	Watt		
10/07/2023	08.00	12,31	0,117	1,444	12,04	0,057	0,690	4261	Clear cloudy sky
	09.00	12,18	0,119	1,449	12,02	0,093	1,115	4890	Clear sky slightly cloudy
	10.00	12,09	0,122	1,469	12,12	0,102	1,233	5451	Clear sky slightly cloudy
	11.00	12,28	0,129	1,585	12,14	0,110	1,332	40360	Clear cloudless sky
	12.00	12,49	0,128	1,596	12,34	0,127	1,567	64500	Clear cloudless

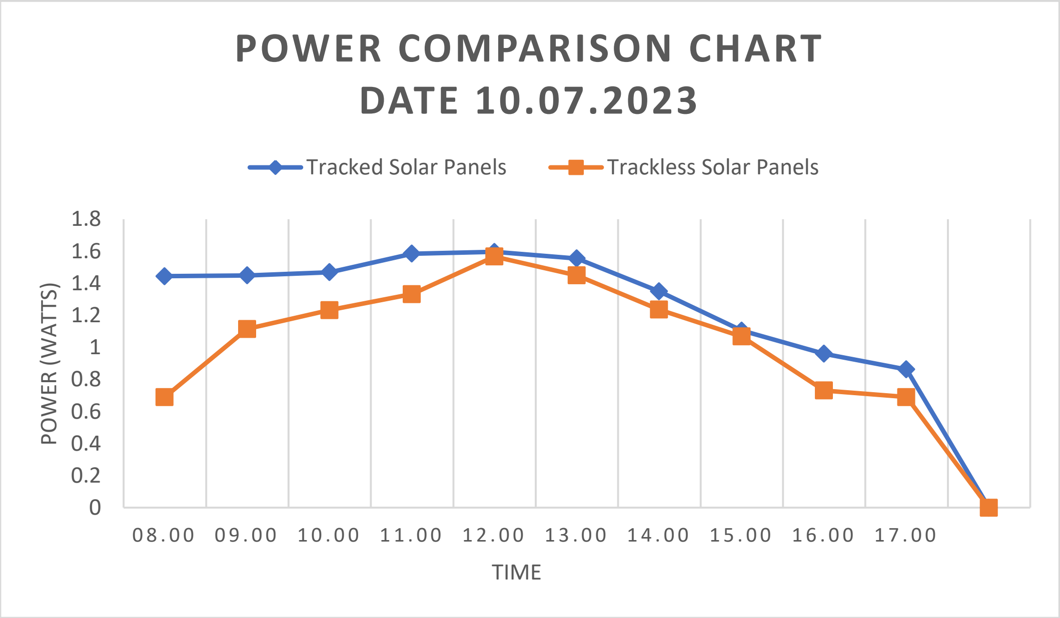
									sky
	13.00	12,36	0,126	1,555	12,28	0,118	1,449	50750	Clear sky slightly cloudy
	14.00	12,56	0,107	1,349	12,34	0,100	1,236	38760	Clear cloudless sky
	15.00	12,20	0,091	1,105	12,28	0,087	1,068	8965	Clear cloudless sky
	16.00	12,06	0,080	0,960	11,98	0,061	0,731	6895	Clear cloudy sky
	17.00	10,90	0,079	0,863	12,04	0,057	0,690	5226	Clear sky slightly cloudy
11/07/2023	08.00	12,13	0,097	1,179	11,75	0,053	0,625	5613	Clear cloudless sky
	09.00	12,08	0,106	1,283	12,05	0,098	1,182	9180	Clear cloudless sky
	10.00	12,01	0,105	1,263	12,01	0,105	1,263	26420	Clear cloudless sky
	11.00	12,22	0,109	1,334	12,12	0,106	1,281	31980	Clear cloudless sky
	12.00	12,12	0,115	1,389	12,06	0,109	1,309	31100	Clear sky slightly cloudy
	13.00	12,21	0,113	1,382	12,14	0,099	1,198	35830	Clear sky slightly cloudy
	14.00	12,11	0,115	1,387	12,04	0,090	1,085	20390	Clear cloudy sky
	15.00	12,18	0,105	1,282	11,94	0,098	1,171	14880	Clear sky slightly cloudy
	16.00	12,11	0,105	1,274	10,67	0,057	0,606	8902	Clear cloudy sky
	17.00	11,13	0,057	0,633	10,08	0,031	0,310	5528	Clear cloudy sky
12/07/2023	08.00	12,00	0,083	1,001	10,85	0,053	0,575	26130	Cloudy sky
	09.00	12,01	0,084	1,011	11,02	0,057	0,628	35030	Clear cloudy sky
	10.00	12,23	0,089	1,091	11,45	0,079	0,905	42070	Cloudy sky
	11.00	12,46	0,089	1,110	12,45	0,081	1,008	43890	Clear sky slightly cloudy
	12.00	12,30	0,109	1,343	12,25	0,103	1,262	38460	Clear sky slightly cloudy
	13.00	12,31	0,097	1,190	12,01	0,090	1,083	34960	Clear cloudy sky
	14.00	12,28	0,094	1,154	11,96	0,082	0,981	33780	Clear cloudy sky
	15.00	12,27	0,090	1,099	11,75	0,060	0,705	25110	Cloudy sky
	16.00	12,10	0,080	0,970	11,31	0,060	0,679	25830	Cloudy sky
	17.00	12,01	0,082	0,985	10,98	0,059	0,648	2796	Clear sky slightly cloudy

From the two sets of data, it can be seen that both produce almost the same power at 12:00. This is because at that time, the sun is directly above both solar panels, so the solar panels without a tracker can also receive sunlight directly without any obstruction. However, at 08:00 and 17:00, there is a significant difference because the sun is not directly above the solar panels. As a result, the trackerless solar panel experiences a greater power drop.

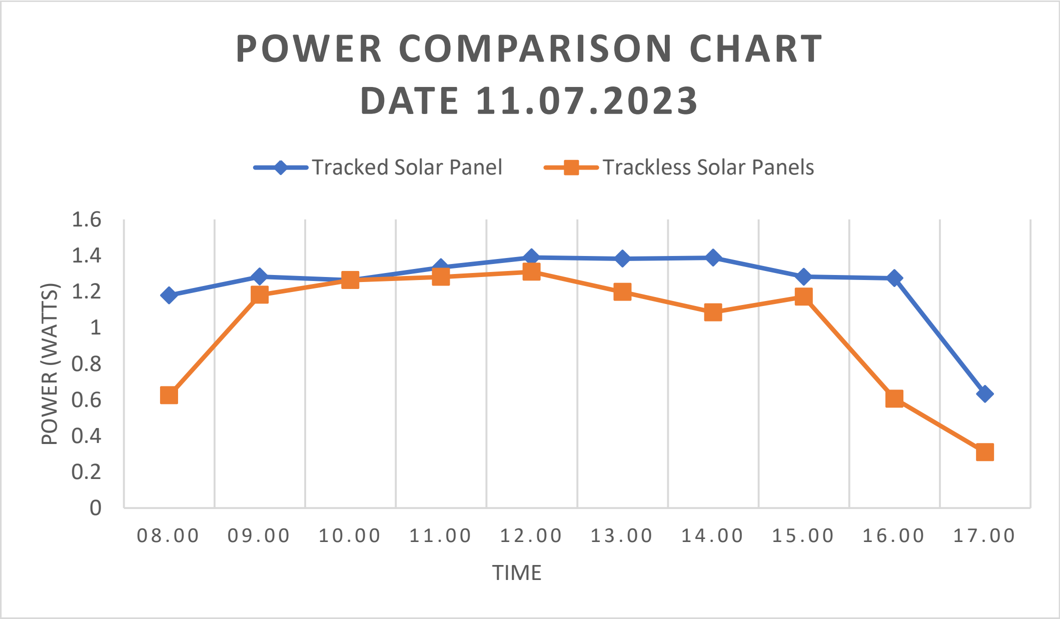
Comparison Results of Two-Axis Tracked Solar Panels with Trackless Solar Panels.
To ascertain the difference in values produced by the tracking solar panel and the non-tracking solar panel, the two solar panels were compared. The following power comparison of the two solar panels can be seen in Table 4

Table 4. Tracking Solar Panel Measurements

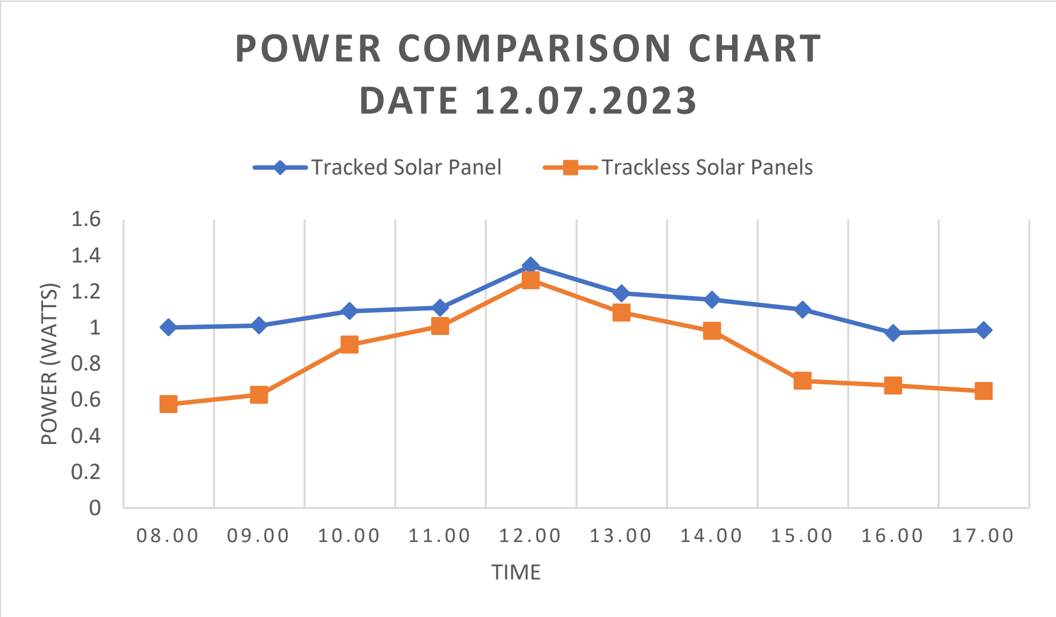
Date	Time	Solar Panel tracker	Tracerless Solar Panels	Difference (Tracer - No Tracer)
10/07/2023	08.00	1,444	0,690	0,75
	09.00	1,449	1,115	0,33
	10.00	1,469	1,233	0,24
	11.00	1,585	1,332	0,25
	12.00	1,596	1,567	0,03
	13.00	1,555	1,449	0,11
	14.00	1,349	1,236	0,11
	15.00	1,105	1,068	0,04
	16.00	0,960	0,731	0,23
	17.00	0,863	0,690	0,17
11/07/2023	08.00	1,179	0,625	0,55
	09.00	1,283	1,182	0,10
	10.00	1,263	1,263	0,00
	11.00	1,334	1,281	0,05
	12.00	1,389	1,309	0,08
	13.00	1,382	1,198	0,18
	14.00	1,387	1,085	0,30
	15.00	1,282	1,171	0,11
	16.00	1,274	0,606	0,67
	17.00	0,633	0,310	0,32
12/07/2023	08.00	1,001	0,575	0,43
	09.00	1,011	0,628	0,38
	10.00	1,091	0,905	0,19
	11.00	1,110	1,008	0,10
	12.00	1,343	1,262	0,08
	13.00	1,190	1,083	0,11
	14.00	1,154	0,981	0,17
	15.00	1,099	0,705	0,39
	16.00	0,970	0,679	0,29
	17.00	0,985	0,648	0,34


POWER COMPARISON CHART
DATE 10.07.2023
Tracked Solar Panels
Trackless Solar Panels
POWER (WATTS)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
08.00
09.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
TIME

(a)


POWER COMPARISON CHART
DATE 11.07.2023
Tracked Solar Panel
Trackless Solar Panels
POWER (WATTS)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
08.00
09.00
10.00
11.00
12.00
13.00
14.00
15.00
16.00
17.00
TIME

(b)



(c)

Figure 13. Solar Panel Power Measurement Chart (a) Solar Panel Power Measurement Chart (b) Solar Panel Power Measurement Chart (c)

From Figure 13, it can be concluded that solar panels with a tracker produce more stable power than solar panels without a tracker. This is because the position of the solar panel with a tracker follows the direction of movement of sunlight, so that the solar panel slab is always exposed to direct sunlight. The improvement in solar panel power performance can be calculated by taking the average difference and multiplying it by 100%. Therefore, the value of the increase in solar panel power performance can be calculated as follows: 0.226 × 100% = 0.226% on 10.07.2020, 0.237 × 100% = 0.237% on 11.07.2020, and 0.248 × 100% = 0.248% on 12.07.2020. Thus, it can be concluded that the increase in power on the solar panel with the tracker is about 0.27%.

CONCLUSION

Based on the research that has been conducted, the following conclusions can be drawn:

a. Solar panel systems, both with and without tracking, have been successfully designed and tested in the sun. Sensor readings correspond to the direction of incoming sunlight, and energy calculations are performed accurately, enabling the sending of calculation values to the prepared Blynk application.
b. The solar panel tracking design successfully produced up to 1.5 watts of power. The largest power difference between the tracked and untracked solar panels is 0.75 watts. The increase in power obtained from solar panel tracking is about 0.27%. This is due to the specifications of the solar panel used, which is 12 volts with a power of 1.5 watts, so the difference is relatively small, being below 1%.
c. The voltage produced by solar panels tends to be stable when exposed to sunlight. However, the current and power generated are strongly influenced by weather conditions. In sunny and unobstructed weather, the current and power produced tend to be large. Conversely, in cloudy or cloudy weather conditions, the current and power generated by solar panels become relatively small.

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