IJSR International Journal of Scientific Research

p-ISSN: 1234-5678e-ISSN: 1234-567x

Received date 30 July 2024; Revised 25 August 2024; Published 30 August 2024

DOI: 10.25299/IJSR.2023.11xxxx

Design of Solar Tracking System for Solar Panel Using Microcontroller Based on Internet of Things

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Abstract: Solar power plant (SPP) is an environmentally friendly technology because it produces less pollution than fossil fuel electricity. Indonesia has a tropical climate where the amount of sunlight is very high, so sunlight can be an alternative source of electrical energy using solar panels, but most SPP do not have a sunlight tracking system and are not integrated with the internet, causing the absorption of sunlight to be less than optimal. Therefore, in this research, a tool has been designed that can track or follow the direction of the sun's movement in order to produce alternative electrical energy and connect to the internet. The solar tracking system designed uses a servo motor to drive the solar panel so that its position is always perpendicular to the direction of sunlight, an ESP32 microcontroller is used as the main component in this research, and the battery used in this research uses a 12 Volt 7 Ampere battery, and a Solar Charger Controller as a controller for the power entering from the solar panel to the battery so that it remains in the same direction. The research methodology used for this final assignment consists of three stages. The first stage is to conduct a literature review by analyzing college books, libraries and internet media related to this research. The second step is to carry out laboratory studies where testing of the various components used in this design is carried out. The discussion approach is the final stage, where questions about this final project are asked to colleagues and discussions with the supervisor are carried out. Based on the results of tests carried out on the tool that has been designed, the tool can move following the movement of the sun and can absorb sunlight energy more optimally. compared to fixed solar panels with a percentage of 38.03542% which is more optimal.

Keywords: Solar Panel, Solar Tracking, Microcontroller, Internet of Things

1. INTRODUCTION

Sunlight is an alternative energy that exists in this universe, sunlight was chosen because renewable energy sources are the technology of choice for producing clean energy sources. Because Indonesia has a tropical climate, the amount of sunlight available for energy production is very high. SPP is an environmentally friendly technology because it produces less pollution than fossil fuel electricity. The use of solar panels in everyday life, such as streetlights, garden lights, traffic lights, etc., is an example of the use of sunlight which can be converted from sunlight into electricity. The disadvantages of using solar power as a renewable energy source rather than a fixed (conventional) system must also be considered. Where the objects attached to the solar panel are permanent. Therefore, the amount of sunlight obtained is not optimal. This is because the location of the solar panels is not parallel to the sun when the sun rises. To receive as much sunlight as possible, the solar panels must move according to the clock to track the path of the sunlight.

Innovative solar panel technology that tracks the movement of the sun using a microcontroller can be used to overcome this problem. This particular model has a real time clock (RTC) that obtains local date and time information from the internet using a microcontroller chip that functions as the main control component and reads the data programmatically. With this input, the microcontroller produces output data that can drive the servo motor, which automatically directs the solar panels towards the sun. Furthermore, the Blynk application can be used to display data from the angle of the solar panel on the smartphone. The aim of this research is to design and build a system that can track the position of sunlight with the highest intensity based on Real Time Clock (RTC). Apart from that, alternative sources of electrical energy other than fossil fuel-based electrical energy are limited in availability.

2. LITERATURE REVIEW

In conducting this research, the author was inspired by several previous studies including the following. In the journal entitled Design and Development of a Solar Tracker with an Arduino-Based Light Dependent Resistor Sensor conducted by [1,2], his research designed a tracker and monitoring system consisting of an Arduino Mega, ESP8266-12F, Light dependent resistor (LDR) sensor and servo motor. A simple web application is able to provide real-time information to users, so they can monitor solar panel productivity. When the solar panel produces electricity and passes the INA219 current sensor, the sensor will send an analog signal to the Arduino Mega which will be forwarded to the ESP8266 to send sensor data information which is sent to a simple web, then the data is accessed with the Google Chrome application as a user interface display. The LDR sensor can detect sunlight levels and send a signal to the Arduino Mega which will then be processed and send commands to the servo motor to move following the Arduino Mega's command, namely towards the light source.

Furthermore, in a journal conducted by Riza Alfita, Achmad Fiqhi Ibadillah, Diana Rahmawati, M.Kurniawan Hadi Kusuma, Adi Kuriawan, Rosida Vivin Nahari, In [3,4] entitled Designing a Four Axis Solar Tracker Based on the Internet of Things (IoT), in This research was designed to increase the efficiency of solar panels to the maximum point with various features, namely tracking systems, reflector mirrors and IoT monitoring. This system uses a LDR sensor which is used to detect light intensity and is also equipped with a driving motor to adjust the elevation angle, a reflector mirror as a light reflector, and IoT for remote monitoring. The research results show that the use of reflector mirrors is able to increase power during the day but decreases in the morning and evening, while the tracking system is able to produce better power at any time.

In the journal entitled web-based automatic solar tracker monitoring conducted by [5-7] created a web-based solar panel monitoring system that can make it easier for users to view parameter data obtained from the solar panel. The results obtained in the morning, afternoon and evening tests were successful in displaying parameter data sent every 15 minutes automatically on the web and providing notifications on the user's Telegram. The conclusion obtained is that the system for monitoring solar panels can display parameter data containing Lux 1, Lux 2, Panel 1, Panel 2, Yaw, Pitch, Battery Voltage and Capacity, Hours and Date on the website.

In the journal entitled Monitoring System for Determining the Movement of Solar Panel Positions Integrated with the Internet of Things by [8-12] designed a solar panel position monitoring system based on the IoT with the aim of being a monitoring system for optimizing light reception received by solar panels in real time. The method used is the dual-axis method, which is a method that allows the movement of flexible solar panels to follow the direction of maximum sunlight intensity. The parameters monitored in this research are the analog voltage value of each light intensity that hits the four LDR light sensors, the two dual axis movement angles and information on the position of the solar panels. From the tests that have been carried out, the system can work well as a monitoring system for determining the movement of solar panel positions integrated with the Internet of Things.

Finally in the journal entitled Solar Panel Power Output Monitoring System Based on IoT Solar Tracker with GoIoT by [13-16] created a monitoring system that works by connecting the NodeMCU ESP8266 Microcontroller to the internet network, if it is already connected to the internet network then it will be directly connected to the MQTT communication protocol. Once connected to the MQTT communication protocol, in real time GoIoT will display the values read by the INA 219 sensor and MAX 44009 sensor. Testing is carried out in three ways, namely testing the NodeMCU ESP8266 microcontroller connected to the MQTT broker, testing the use of GoIoT and testing the reading results on the platform GoIoT.

3. METHODOLOGY

The research methodology used consists of three stages. The first stage is to conduct a literature review. In this literature review process, various theories were studied by analyzing books obtained from lecture notes, library books, and studying internet media related to this research. The second step is to carry out laboratory studies. Based on these data specifications, laboratory studies involve research and testing various electronic components and other supporting components that will be included in the final project. The discussion approach is the final stage, where questions about this final project are asked to colleagues and discussions with the supervisor are held.

3.1 Analysis of the Proposed System

The concept of this monitoring and solar tracking system aims to optimize the absorption of sunlight and monitor the angle of the solar panel via smartphone, using RTC and the blynk application as a platform for monitoring the angle. An overview of the proposed system can be seen in the image below. Figure 1 shows the proposed analysis.

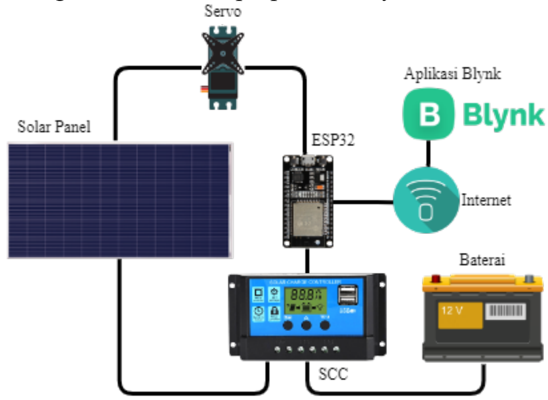

Figure 1. Analysis of the proposed system

3.2 Tools and Materials

There are several supporting elements needed in designing this solar tracking system in order to achieve the desired results, the components and materials needed include the following table 1.

Table 1. Tools and Materials

No.	Alat dan bahan	
	Hardware	Software
1	PC Lenovo AIO V130 Intel Celeron J4025	Sistem Operasi Windows 10
2	Smartphone	Bahasa Pemrograman C
3	Mikrokontroler ESP32	Aplikasi Blynk
4	Solar Panel	Arduino IDE
5	Motor Servo	
6	Solar Charger Controller	
7	Baterai 12v 7aH	

3.3 Tools Design

The stage after analysis is design. Before making a tool, design is carried out to minimize errors and ensure component characteristics. The hardware and software design stages are two parts of the design process that will be carried out. To provide an explanation of the system design that will be implemented in this solar tracking system design research. First, a block diagram will be created to illustrate it. Figure 2 shows the solar tracking block diagram.

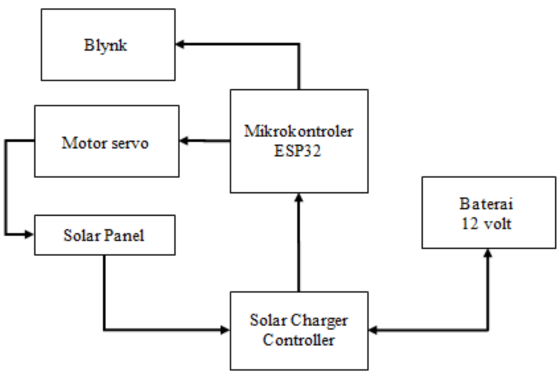

Figure 2. Solar Tracking System Block Diagram

3.4 Solar Tracking System Hardware Design

The aim of this design is to simplify the process of providing a general description of the location of the parts and the overall shape of the solar tracking system that will be created. There are several stages in designing solar tracking system hardware for solar panels. The following are the steps taken:

a. Create a simulation of a series of components that will be used in the design using draw io software. The following is a schematic of the tool design components used using draw io software. Figure 3 shows the schematic diagram.

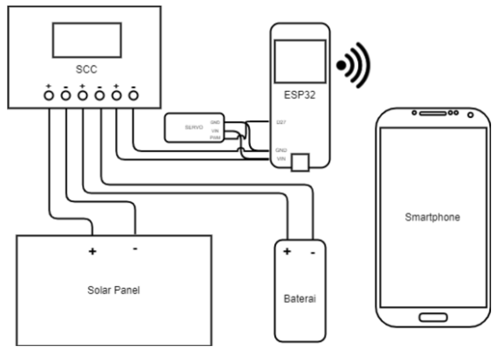

Figure 3. Schematic circuit design

b. After the components have been assembled, create a control program using the Arduino IDE software. After that, carry out trials until the program is declared suitable.

c. Next, design the layout of the components used in the design. This process continues with 3D design of the components used in the design using 3D blender software. Figure 4 shows the tracking system designed.

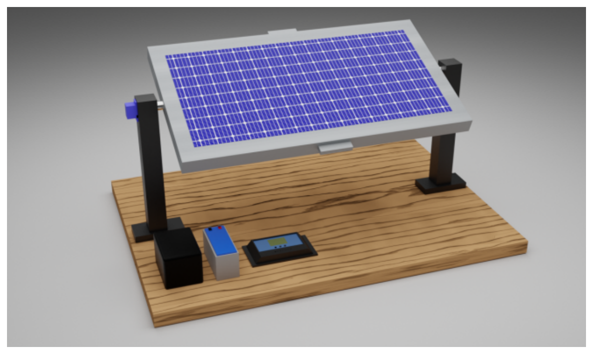

Figure 4. 3D Solar tracking system design

d. Assembling components of a Solar Tracking System for Solar Panels Using an Internet of Things Based Microcontroller.

3.5 Solar Tracking System Software Design

In making the design for solar panel tracking with a stepper motor as a Real Time Clock based driver, using C language via Arduino IDE software, this program was uploaded to the ESP32 microcontroller. There are two parts to designing the software for the Solar Tracking System for Solar Panels Using an Internet of Things Based Microcontroller. Preparing the layout for the Blynk application using a smartphone, this process completely depends on the user's creativity and needs, because Blynk already provides widgets on the device board that will be used, so this process only requires selecting the widget that suits your needs. The following are the widgets used in the design, table 2 shows layout the Blynk application.

Table 2. Design layout in the Blynk application

No.	Jenis Widget	Nama Widget	Keterangan
1	*Value Display*	*Current Time*	Menampilkan data jam lokal

2	*Value Display*	*Angle*	Menampilkan sudut dari solar panel
3	*Value Display*	*Date*	Menampilkan tanggal
4	*Button*	*Horizontal*	Tombol perintah untuk servo agar solar panel mengarah pada 90°
5	*Button*	*Back on Track*	Tombol perintah untuk servo agar solar panel kembali ke posisi *tracking*
6	*Superchart*	*Angle Chart*	Menampilkan data bagan dari sudut solar panel dalam kurun waktu 1 jam, 6 jam, 1 hari, 1 minggu, 1 bulan hingga 3 bulan

Next, create a program in the Arduino IDE software and connect it to the Blynk device using an auth token and also connect the layout that has been prepared using virtual pins. Virtual pins are a method provided by Blynk Cloud to connect the microcontroller with a smartphone. The following are the virtual pins used in the widgets that have been designed. Table 3 shows the virtual pin used in the system.

Table 3. Virtual Pin Used

No.	Virtual Pin	Jenis Widget	Nama Widget
1	V0	*Value Display*	*Current Time*
2	V3	*Value Display*	*Angle*
3	V5	*Value Display*	*Date*
4	V1	*Button*	*Horizontal*
5	V2	*Button*	*Back on Track*
6	V3	*Super chart*	*Angle Chart*

3.6 System Testing Techniques

The testing method used in this research is a direct testing method, namely using Black Box testing. System testing is carried out to determine whether the system can perform as desired and provide the desired results. The system testing process begins with sequential and independent testing of each component. The first test is a sensor test, where data from the sensor is sent to the servo to check whether each movement is carried out in accordance with the process. Next, recheck the input and output devices to ensure that all parts or modules work as expected. To find out whether the proposed device design can provide alternative electrical energy that can turn on or turn off electrical equipment, tests will be carried out using solar panels and batteries as electrical power sources.

4. RESULT AND DISCUSSION

The results of the design using components and tools from hardware for designing a solar tracking system for solar panels using an internet of things-based microcontroller can be seen in the image below. Figure 5 shows the technical design tools.

Figure 5. Tool design result

Refer the picture above you can see the physical form of the system design. The author uses 1 ESP32 module, 1 solar panel module, 1 servo motor, 1 solar charge controller and 1 battery in the component box. In this research, the hardware circuit consists of two parts, namely, the first part is the ESP32 circuit, battery, solar charge controller which will be connected via cable, for the second circuit it is a series of solar tracking devices consisting of 1 servo motor and 1 solar panel module as well as a buffer circuit. The following shows the design results for the Blynk application with the selected widgets used. Figure 6 shows the software designed results.

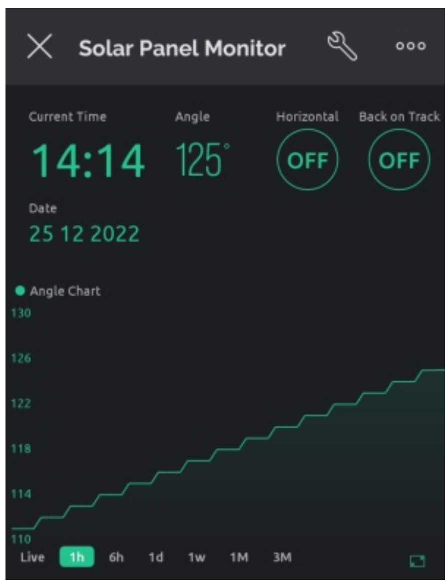

Figure 6. Software design results

p-ISSN: 1234-5678e-ISSN: 1234-567x

There is a data visualization widget that is used, the data displayed in the Blynk application in this design is, local time, angle of the solar panel, date, chart of the angle of the solar panel for from 1 hour to 3 months and two buttons that function to give commands to servo motor. At this testing stage, three different times were carried out, namely morning, afternoon and evening, by looking at the angular position of the solar panel using the Blynk application to see whether it was appropriate. The results can be seen in the image below. The test was carried out at 09:14 WIB on 25 December 2022, the following is the appearance of the device and the appearance of the Blynk application. Figure 7 shows the testing was conducted.

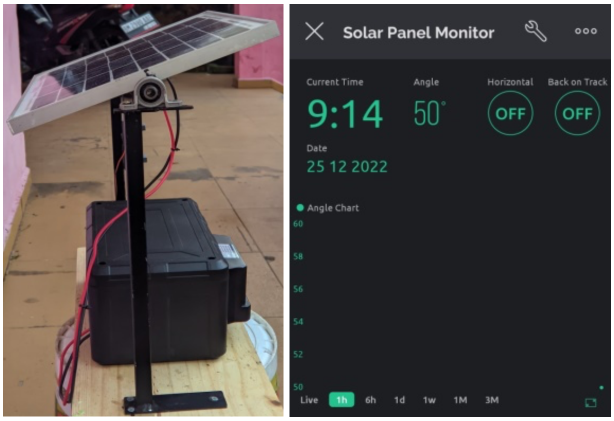

Figure 7. Testing in the morning

In the image above you can see the position of the solar panel pointing east at an angle of 50° in the Blynk application. The test was carried out at 12:23 WIB on 25 December 2022, the following is the appearance of the device and the appearance of the Blynk application. Figure 8 shows the testing was conducted.

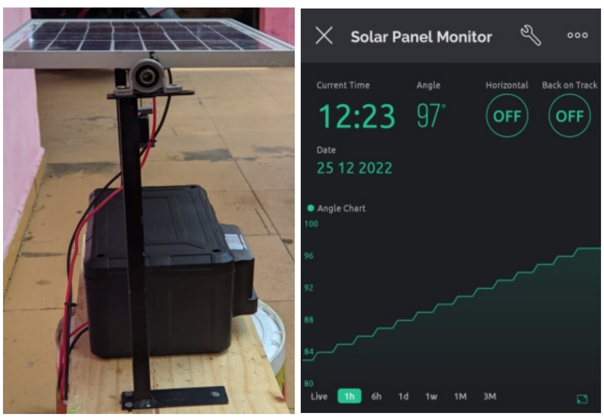

Figure 8. Testing during the daytime

In Figure above you can see the position of the solar panel at an angle of 97° in the Blynk application. The test was carried out at 16:27 WIB on 25 December 2022. The following is the appearance of the device and the appearance of the Blynk application. Figure 9 shows the testing was conducted during afternoon.

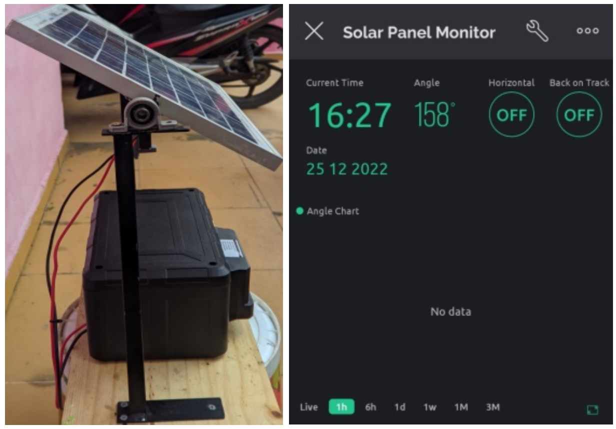

Figure 9. Testing in the afternoon

In the picture above you can see the position of the solar panel pointing at an angle of 158° in the Blynk application. The next test is testing electronic devices, namely lights. The aim of this test is whether the energy produced can be used in electronic devices as alternative electrical energy that does not need to use fossil fuels. In this test the author used a USB LED light on the USB port available on the solar charger controller module, where this USB port functions as an output port from the battery to the load. Based on the table above, the device is designed to produce and store electrical energy obtained from sunlight absorbed by the solar panel, so that it can light or provide power to a USB LED lamp.

(a)

(b)

Figure 10. Testing results (a)light on (b) light off

The next test is a comparative analysis of solar tracker and fixed solar. The test was carried out for three days, the results calculated were the number of watts sequentially for the solar tracker, namely (52.4816), (33.7424) (32.1535). Then the watt results for diesel remain sequentially, namely (38.3488), (18.7591) (28.6493). If an average calculation is carried out, then. Solar Tracker: (52.4816 + 33.7424 + 32.1535)/3 = 39.45903 Watts. Fixed Solar: (38.3488 + 18.7591 + 28.6493)/3 = 28.58573 Watts. The difference between the two is obtained = 39.45903 – 28.58573 = 10.8733 Watts, and if the above results are converted into percentages, it is 10.8733/28.58573 x 100% = 38.03542%. So, it can be concluded that the use of a solar tracking system can absorb sunlight more optimally compared to fixed solar panels with a percentage of 38.03542% which is more optimal.

5. CONCLUSION

Based on the results of the research, design and testing that have been explained previously, it can be concluded that, solar panels can move according to the clock calculation as expected, the angular position of the solar panels can be monitored on a smartphone using the Blynk application, and sunlight can be an energy source. alternative electricity other than using fossil fuel energy sources. This Solar Tracking System prototype is still far from perfect, to create a good device it is necessary to develop both in terms of benefits and in terms of system work, here are some suggestions for those who want to develop this device which might add value to the device or system later. For applications in the industrial world, it is best to use solar panel power and a larger battery capacity so that more is absorbed. Adding voltage and current sensors can further improve the system because the power absorbed can be calculated automatically by the microcontroller. The data displayed in the Blynk application will be more complete if you add the power data that has been absorbed from the solar panel to the battery.

ACKNOWLEDGMENT

This research was support by the Faculty of Informatics and Computing, Universiti Sultan Zainal Abidin, Malaysia.

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