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Development of Dual Axis Solar Tracker with IoT Monitoring System

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Abstract:

Despite the fact that solar energy is infinite, harvesting it is challenging owing to panel inefficiency. In many years, the old solar tracking method was normally set where the solar panel does not shift orientation towards the sun. Since the sun change its position with time, hence dynamic tracking system is needed. The aim of this project, to develop a dual solar tracker that can absorb more lights and real-time monitor its performances. By use of four light dependent resistor sensors, the sun position is tracked, and the microcontroller controls the servo motors to align the solar panel perpendicular to the sun. As a result, the dual solar axis tracker can capture 27.4% more solar power compared to fixed tilted axis. With an internet of things integrated to the proposed system, hence enable the real-time monitoring for the solar panel output performance through Blynk application and Thing speak website accessible from anywhere with stable internet connection.

Keywords: ***(Dual solar tracker, close loop tracking, Arduino Uno, , Internet of Things, cloud, Bylnk, Thingspeak)***

1.0 INTRODUCTION

Environmental concern such as climate change and global warming are currently considered to be the most pressing issues. The biggest contributors to human-caused climate change are greenhouse gases. The process of producing energy adds to the release of greenhouse gases such as Carbon dioxide (CO2) and Carbon Monoxide (CO), which contributes to the global warming and pollution [1]. To reduce carbon and other pollution emissions, there is an urgent need for the development of renewable energy, with solar energy being the most important and necessary resource for sustainable energy [2]. Malaysia have look at solar energy as one of renewable energy that useful because Malaysia's electricity gain ration totaled at 30,875.23 MW including solar system which contribute 0.55% [3-4]. This is proving that Malaysia has the higher solar radiation that can be used to generate electricity. Besides that, solar energy is one of the best power sources since it is available in nature and not generates any pollution in this world. It is the conversion of energy from sunlight into electricity and this process is known as the photoelectric effect. This renewable energy had been widely used and keep on improving continuously. Despite of solar energy being a good source of energy, it is needed to improve the methods to harness this energy. This can be achieving by using dual solar tracking system that has two degrees of freedom that act as axes of rotation. The primary axis is the axis is fixed with respect to the ground while the secondary axis is the other axis is referenced to the primary axis [4]. Solar tracker is a device with the orientation of the following the sun's path to maximize energy capture. It helps to minimize the angle of incidence which will make a greater performance of photovoltaic panel. In paper [5] discuss a development of dual solar tracker that has high efficiency on trace the maximum sunlight source to power the solar panel. The researcher has been using light dependent resistor (LDR), two servo motor that control by Arduino UNO to move the solar panel directly to the sunlight. This research is comparing a dual solar tracker with static solar panel. This paper [6-7], decided to design and construct dual solar tracker that control by Arduino UNO. The construction on dual solar tracker will be considered on types of motor, numbers of light dependent resistors will be use and compression using LabVIEW software. This paper [8-9] discussed of a design and build internet of things on solar tracker. The platform that has been use in this project is Raspberry Pi 3 (RPi3). In this paper [10-11], the researcher is focusing on build dual-axis solar tracking system using programmable logical controller (PLC) based on automatic tracking system. The function of PLC in this research is to control the movement of solar tracker. In paper [12-13], the researcher had compared the dual-axis solar tracking system with fix-angle solar tracking system and the result shows the electricity generated by dual-axis solar tracker has an overall increase of 8% until 25% more than the fix-angle solar tracker. This paper [14-15] uses an ATMega328 as a controller to move the dual-axis solar tracker. The ATMega328 is a single-chip microcontroller that created by Atmel. The ATMega328 is capable with 8-bit Alf Vegard's Risc (AVR) and it combines with 32 kB In-System Programming (IPS) flash memory. The comparison on dual-axis solar tracker shows average output voltage that was 37% higher than fix solar tracker. These prove the dual-axis solar tracker is more affection to use than fix solar tracker base on output voltage. The objective of this project is to design dual solar tracking system that able receive maximum power of solar radiation. Secondly, to monitor the performance of solar tracker system using Internet of Things (IoT). Finally, to evaluate its performance compared to the conventional fixed tilted axis system. The NodeMcU Esp8266 controller is used to transmit the data to the Blynk application and IoT Thing speak website via cloud for the real-time monitoring.

2.0 METHODOLOGY

The development of this project is divided into two parts. The first part is software development, and the second part is hardware development. Figure 1 shows the block diagram of the proposed system. The system starts with the four LDR sensors mounted on PV module detect the sun position and then send analog signal to the microcontroller. The microcontroller processes the information and command the servo motors to position the PV module perpendicularly to the sun. The data information such as voltage, current, temperature and humidity are sensed by sensors and then send to microcontroller and IoT monitoring system [16-20].

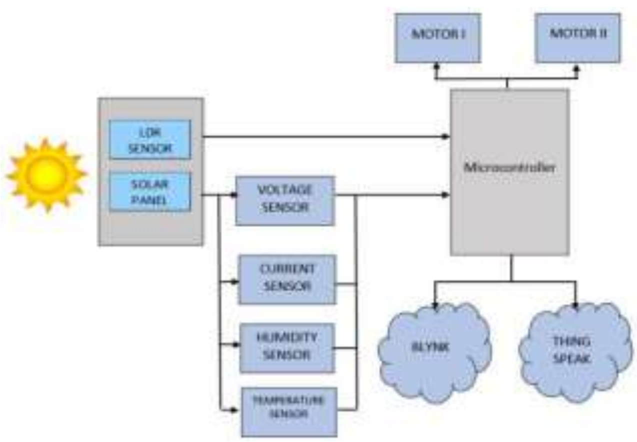


Figure 1: The proposed dual axis solar tracker with IoT monitoring system

2.1 Software Development

The proposed system was initially designed and tested its functionality using Proteus simulation software. The software used to design simulation circuit to test solar tracker movement mechanism of this project. Figure 2 and 3 shows the flowchart of dual axis solar tracker and working process of IoT monitoring system.

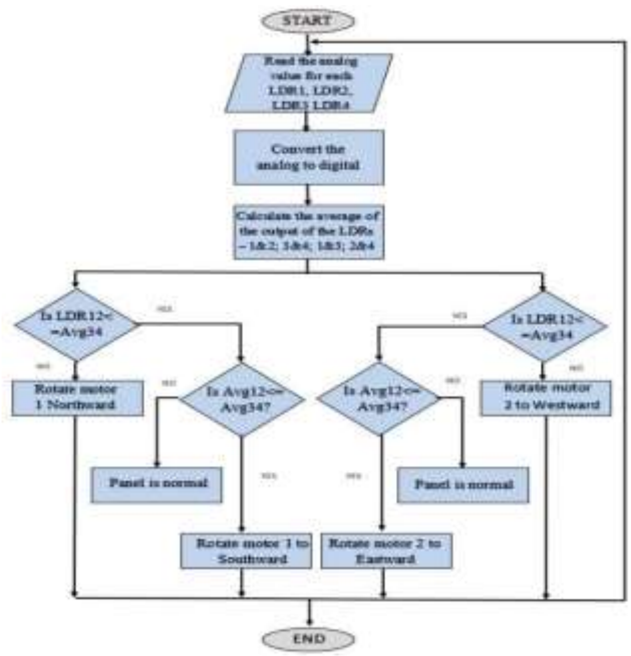


Figure 2: Process of dual axis solar tracking

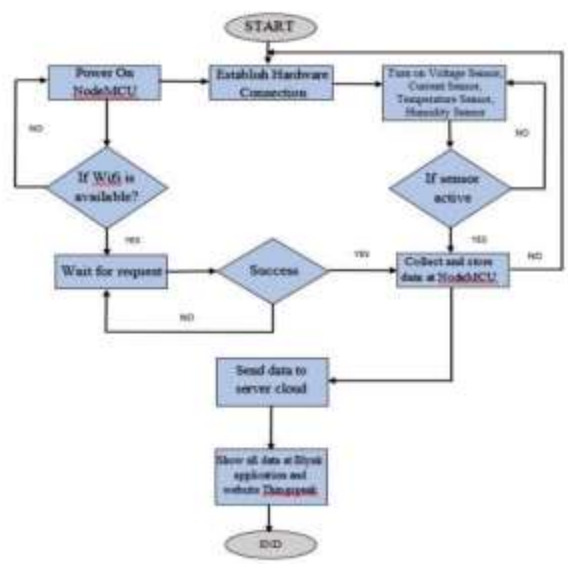


Figure 3. Process of IoT monitoring

Figure 4 shows the circuit used to control the proposed solar tracker. When circuit is powered up, the LDR sensors detect the intensity of light. Based on this input, the

Arduino Uno Microcontroller control the servo motors to either rotate in clockwise or counterclockwise rotation. The controller calculates the average value of each of four LDR sensors (top, bottom, left and right) to determine the position of solar panel module to perpendicular to the sun ray. If the analog value top is less than bottom, the controller send signal to servo motor 1 (vertical) to move northwest and if analog value (top) is more than bottom, the controller send signal to servo motor 1 to move southwest. Next, for left and right use same operation as before but servo motor 2 (horizontal) will move east west and southwest depends on analog value from left and right. If all voltages are equal, then servo motor will be in stop position.

The IoT process using Microcontroller NodeMCU Esp8266 is shown in Figure 3. Another four sensors were used to measure the temperature, humidity, voltage and current produced by the solar panel. The reading data from these sensors were collected by NodeMCU Esp8266 and forwarded to the smartphone through Wi-Fi. The power generated by the solar panel is obtained by multiplying measured voltage and current which was pre-programmed in microcontroller. The data is then monitored using Blynk application on handphone and displayed online at Thing speak web browser.

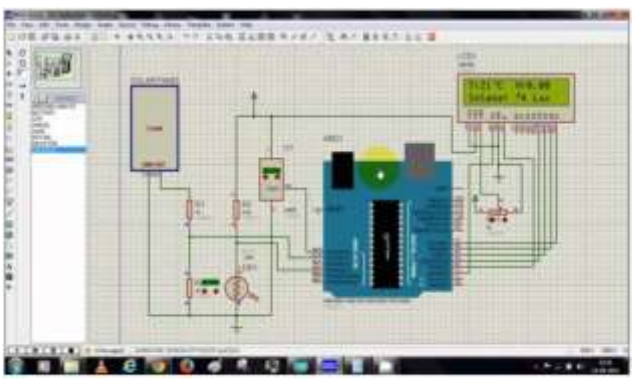


Figure 4: Simulation of Circuit

2.2 Hardware Development

The hardware development can be divided into mechanical movement mechanism and electrical part. The idea of the movement mechanism is to hold and move the solar panel module towards the sun position. The control box is used as storage for controllers and other components. Figure 5 illustrates the 3D mechanical movement mechanism of the proposed solar axis tracker: the front view, isometric view, and top view which was drawn using SolidWorks 2019 Software. Figure 6 shows the actual mechanical prototype of the proposed dual solar axis tracker has been developed. The dimension of dual solar tracker which is 400mm (Length) x 360mm (Width) x 480mm (Height). The solar panel module is mounted to a holder that made from polyurethane materials using a high durable mild steel rod. Figure 7 and 8 shows the electrical wiring of the controller and sensors.

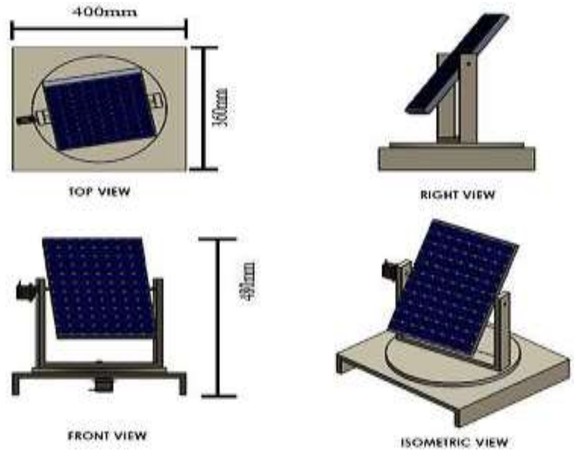


Figure 5: 3D design of the proposed solar axis tracker; the front view, isometric view, and top view

Figure 6: proposed dual axis solar tracker prototype

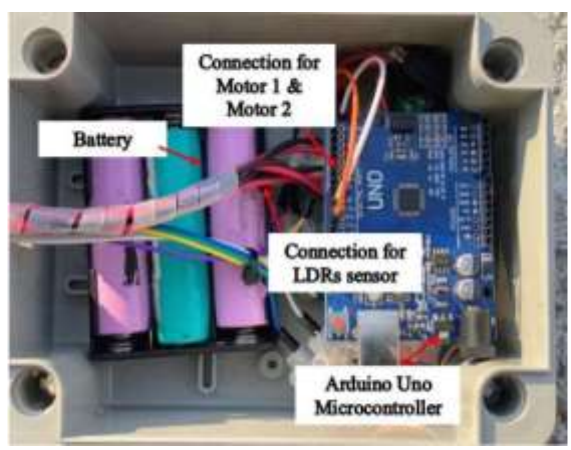


Figure 7: electrical wiring of controller

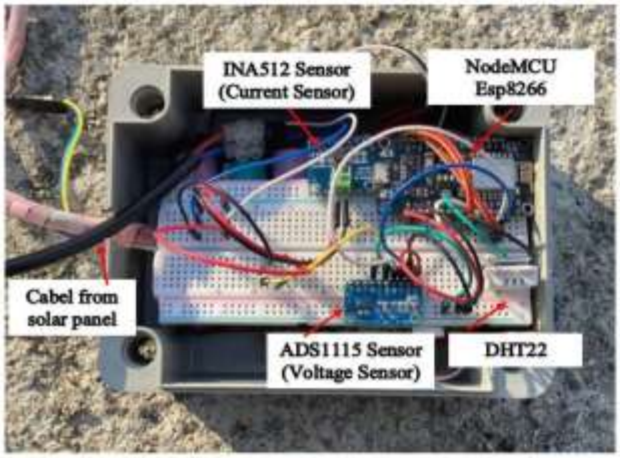


Figure 8: Electrical wiring of sensors

3.0 RESULTS

This section presents the results yield from hardware experiment set out in this project. This includes the result obtained from outdoor experiment, performance comparison of solar output between single axis and dual axis solar tracker system and IoT online monitoring platform such Blynk and Thing speak. These experiments have been conducted in Seremban, Negeri Sembilan, Malaysia (place and time: 2°42'36 North, 101°57'00"). The parameter data such as output voltage, output current, temperature and humidity were measured and recorded from 7.00am to 7.00pm. These experiments were carried out from 4th to 6th November 2021 to collect measurement data from fixed tilted solar tracker and proposed dual axis solar tracker system. The recorded data was collected without any obstruction and free from shading (tree, building or etc).

3.1 Result from Blynk and Thing speak

The parameters data measured from sensors were collected by NodeMCU Esp8266 then send to the internet through Wi-Fi. The parameter data can be monitored through Blynk application installed on handphone and Thingspeak IoT web browser platform. Figure 9 to 11 shows the Blynk application which displays (1) temperature, (2) humidity, (3) solar output voltage, (4) solar output current and (5) graph showing hourly measured solar output voltage and current. Besides, the Thing speak will display same data collected output from solar panel as shown in Figure 12. Energy output data is sent to a router and made available through an online interface with internet-based monitoring.

Figure 9: Widget in Blynk Application

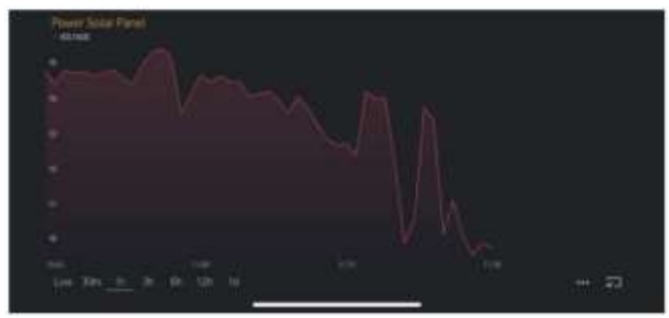


Figure 10: Hourly voltage output from of solar panel.

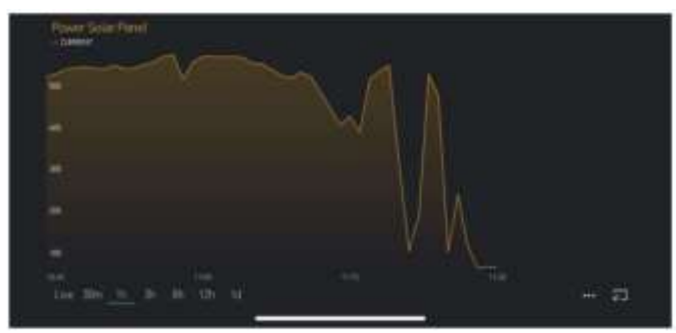


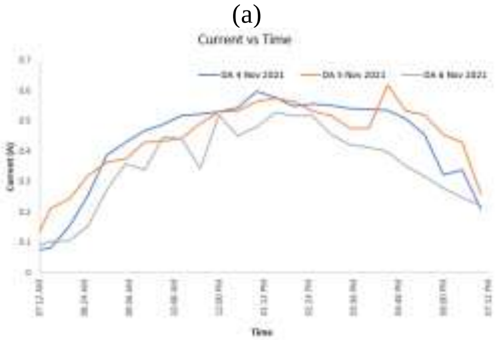
Figure 11: Hourly current output from of solar panel.

Figure 12: Thing speak website interface

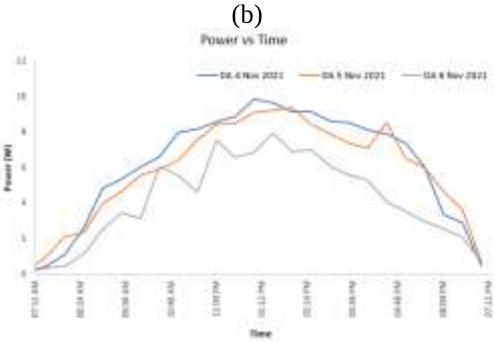
3.2 Result from Outdoor Experiment

Figure 13(a), (b) and (c) shows the graph results of voltage, current and power against time of dual axis solar tracker.

(a)



(b)

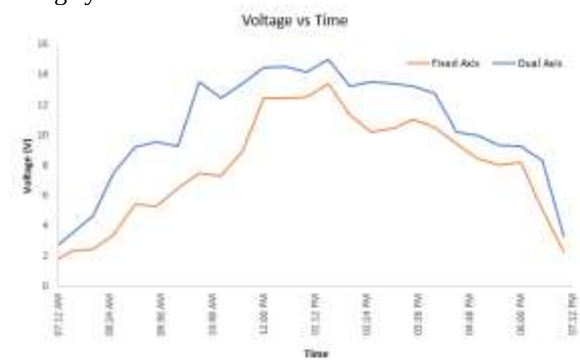


(c)

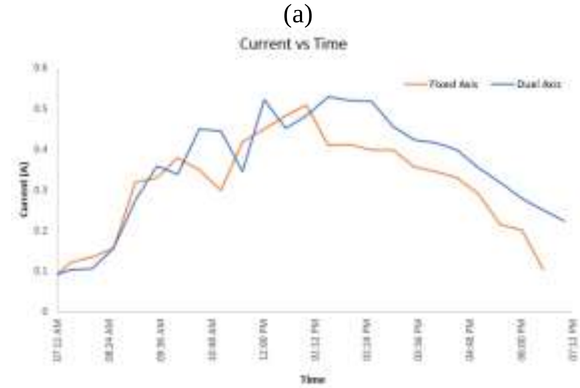
Figure 13: measured parameter results (a) voltage, (b) current and (c) power of dual axis solar tracker

3.3 Comparison of solar panel output between single axis and dual axis solar tracker system

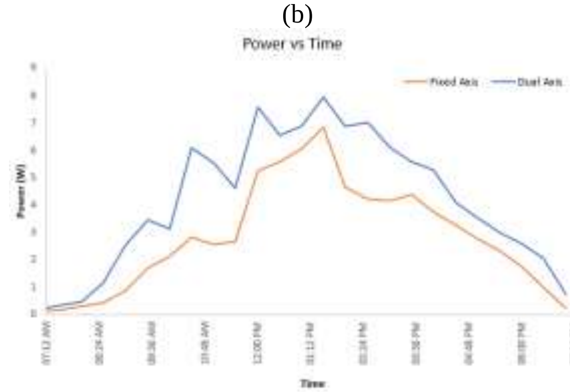
The comparison of performances between the existing fixed axis solar tracker and the proposed dual axis solar tracker system. Figure 14 shows the power against time where the power is calculated from measured voltage and current produced by solar tracking system. There is significant increment in magnitude in dual axis solar tracking system in terms of voltage, current and power as recorded in Table 1. Overall, dual axis solar tracker system can produce more power compared to fixed axis solar tracking system.



(a)



(b)



(c)

Figure 14: shows the measured parameter results (a) voltage, (b) current and (c) power of dual axis solar tracker recorded at 7.00am to 7.00pm.

Table 1: Average for Voltage, Current, and Power.

Day	Fixed Tilted Solar Panel			Dual Axis Solar Tracker		
	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
1	11.1560	0.4015	5.2724	12.6836	0.4298	6.0987
2	10.8664	0.3856	4.7862	12.1912	0.4279	5.6910
3	7.8688	0.3024	2.8070	10.4204	0.3524	4.1450

Table 2: The percentage difference for Voltage, Current and Power.

Day	Voltage (%)	Current (%)	Power (%)
1	12.0439	6.5932	13.5491
2	10.8669	9.8855	15.8988
3	24.4866	14.1884	32.2799

Table 2 shows the percentage differences for output voltage, output current and output power which was increased by 24.5%, 14.2% and 32.3%. Based on this data, the proposed dual axis solar tracker was able to produce more power. It generates more power over time than a fixed axis panel because of its dynamic features in absorbing sunlight. Throughout the day, the solar panel need be kept in a perpendicular to the sun's direction.

4.0 CONCLUSION

The dual solar tracker was developed and able to increase the solar still capability to capture more solar radiation with the use of a microcontroller and LDR sensors, this dual solar tracking system project has demonstrated a method of tracking the sun's location which allow the solar panel always to be positioned perpendicular to the sun. Therefore, the system tracking become more robust and accurate with applied calibration of LDR sensor. Next, this project prototype able to monitor solar panel output performances by implement IoT technology system. The second objective had achieved by transmit all data have been collected and display through Blynk application and Thingspeak website for monitoring the output of solar panel such as voltage, current, temperature and humidity. The benefit of having this system is that the measured solar panel parameter data can be monitored real-time where it is accessible from anyplace with an internet connection. Finally, the performance of a fixed tilted solar panel and a dual-axis solar panel was compared, and it was determined that the dual solar panel tracker can capture more solar radiation and thus produce higher solar power than the fixed solar panel.

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