International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-12, October 2019

Performance of Multi Axis Sun Tracking System of Battery Charging Optimizing for Amphibian Research Crawler

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Abstract: ***In today's modernization era, there are various technologies being invented to adapt to daily routines. In the growing years, technology has become more complex. Development in the renewable energy is no exception indeed to sustain the demand for energy. This paper discusses a source of renewable energy that focuses solely on solar. This model was presented by developing a tracking system consisting of single and dual axis tracking systems. The purpose of this model is to analyze the performance of the whole system. The tracking system is designed based on the position of the sun in the morning, noon and night. The system will move toward the maximum light energy received as detected by the Light Dependent Resistor sensor (LDR).The results obtained show that the dual axis sun tracking system is more efficient than single axis due to the rotation in four directions while single axis only rotates along two directions which are east and west. The Voltage Boost Converter DC-DC Step up Module is used to maximize the power output. This idea will increase the power of battery charging optimization for Amphibian Research Crawler***.

Keywords: Light Dependent Resistor Sensor, Renewable energy, Voltage Boost Converter.

I. INTRODUCTION

Solar energy is largely known as an unlimited source of energy but there are some problems when using this source of renewable energy. The problem concerns the availability which varies universally with time. The differences in availability occur daily because of the day and night cycle following the earth orbital movement around the sun. To solve the problems, the solar panel should regularly gain the maximum intensity of light. It has been seen in the past, that the efficiency of the solar panel is around 10-15% which did not meet the desired load requirements.

Revised Manuscript Received on October 30, 2019.
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So, there is a need of improving the panel efficiency through an economical way such as using renewable energy (Khanna.A. 2016). The sun tracking system was created to overcome this problem. Active trackers use motors and gear trains to direct the tracker as appointed by a controller responding to the solar direction. The solar tracker can be used for certain applications such as solar cells, solar day-lighting system and solar thermal arrays. The solar intensity earned by the solar panel is proportional to the output voltage of the solar panel. Single axis tracking system has one degree of freedom that acts as an axis of rotation. There are several types to implement single axis sun tracking system which are horizontal single axis trackers, horizontal single axis tracker with bend modules, vertical single axis tracker, bend single axis tracker and polar aligned trackers. The orientation of each of the module will affect their performances. The vertical axis in figure 1 which is used in high latitudes where the sun is not very high, but the summer days can be very long .For horizontal types in Figure 2 are usually used in tropical regions where the sun gets very high at noon, but the days are short (Kamrul Islam, 2017).

Fig. 1 Vertical single axis

Fig. 2 Horizontal single axis

Dual Axis Sun tracking system has two-degree rotation of freedom that acts as an axis rotation. In Figure 3 shows the axis that is located at the ground is the primary axis while the axis that is referenced towards the primary axis will be considered as the secondary axis.

There are two common examples of dual axis tracking which is tip-tilt dual axis and azimuth altitude dual axis trackers. The dual axis tracking axis can angle themselves where ever the location of the sunlight is. (Kamrul Islam, 2017)

Fig. 3 Dual Axis Sun Tracking System

II. METHODOLOGY

A. Block Diagram

The Figure 4 shows the block diagram of this project. The module of this block diagram has 3 stages consisting of input, process and final process. The input consists of power supply, sun energy and the LDR sensors. The data will be collected and integrated by Arduino. Then the output will be stepper motor which can follow the direction of the sun, the load and the data logging that will be used to collect the data.

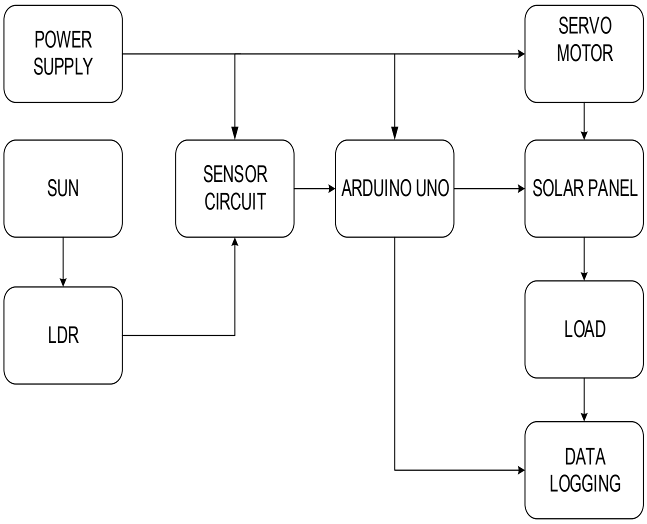

Fig. 4 Block Diagram

B. Single Axis Sun Tracking System Flowchart

Figure 5 below shows the system flowchart for single axis sun tracking system. First, the energy was collected from the sun. Light Dependent Resistant (LDRs) were utilized to recognize the higher intensity of light from the sun. After that, the data was integrated into Arduino. For example, if LDR sensor 1 (S1) has a higher intensity than LDR sensor 2 (S2) than the motor will turn right otherwise the motor will turn left. Next, the voltage data that were collected from the voltage sensor were recorded in data logging. Then, the results were analyzed.

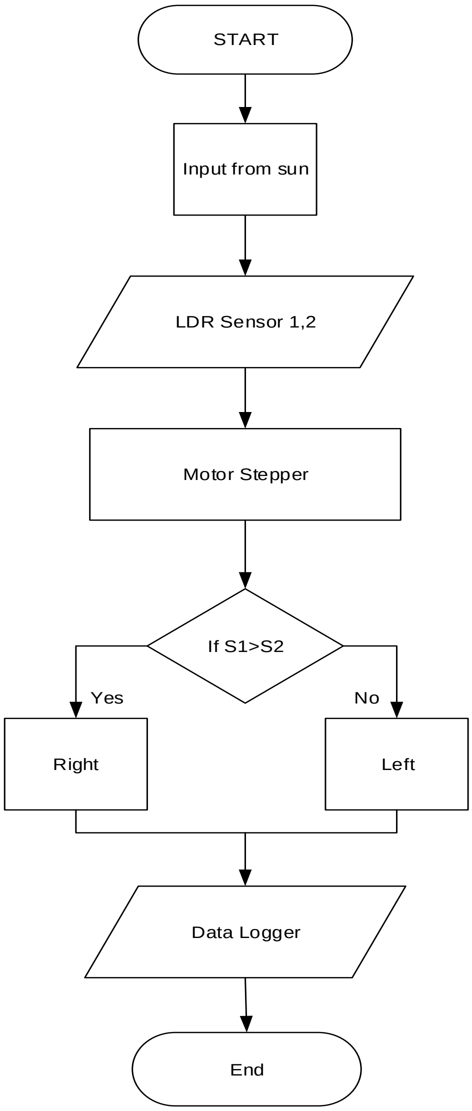

Fig. 5 Single Axis Sun Tracking System Flowchart

C. Dual Axis Sun Tracking System Flowchart

First, the energy was collected from the sun. Light Dependent Resistant (LDRs) were to recognize the higher intensity of light from the sun, the data were then integrated into Arduino. The tracking system used 4 LDR sensors and two motors. The LDR sensor 1 and 2 (S1 and S2) was to move the motor one which functioned vertically. For example, if LDR sensor 1 (S1) had a higher intensity than LDR sensor 2 (S2), the motor would turn right otherwise it would turn left. Motor 2 that received data from LDR sensor 3 and 4 (S3 and S4) functioned horizontally For example, if LDR sensor 3 (S3) had a higher intensity than LDR sensor 4 (S4), then the motor would turn right otherwise it would turn left. Next, the voltage data that were collected from the voltage sensor were recorded in data logging. Then, the results were analyzed.

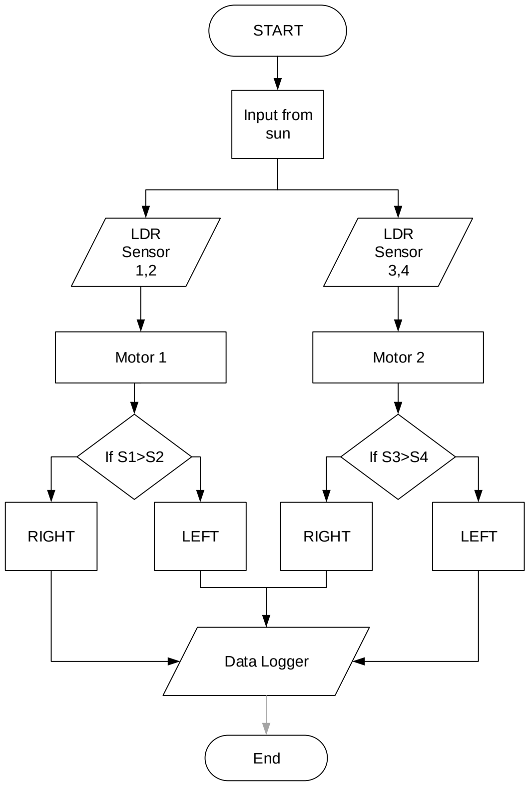

Fig. 6 Dual Axis Sun Tracking system Flowchart

D. Single Axis Sun Tracking System Circuit Diagram

Figure 7 below shows the simulation for the single axis system. It was designed by using Proteus. The coding from Arduino was extracted for this software to run the simulation.

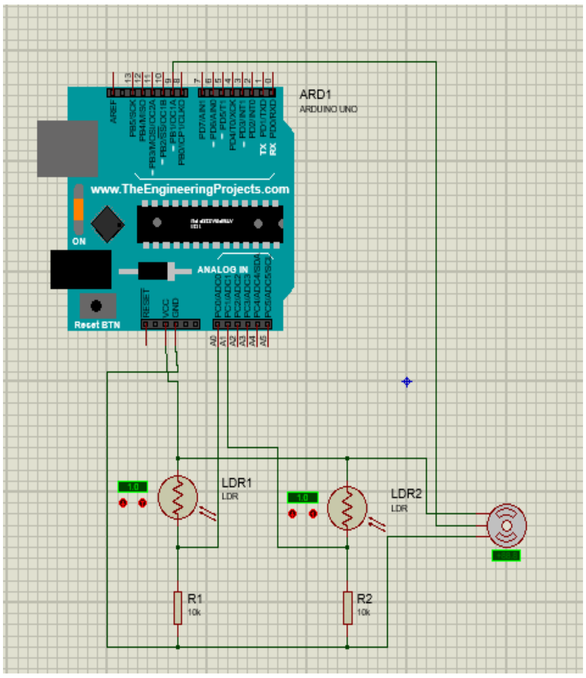

Fig. 7 Single Axis Sun Tracking System Circuit Diagram

E. Dual Axis Sun Tracking System Circuit Diagram

The dual axis sun tracking system circuit diagram used the same concept as the single axis designed by Proteus where the simulation was performed by extracting the coding from Arduino. It used two motor which were primary and secondary. LDR use was indicated by one motor for double functions. as shown by Figure 8 below.

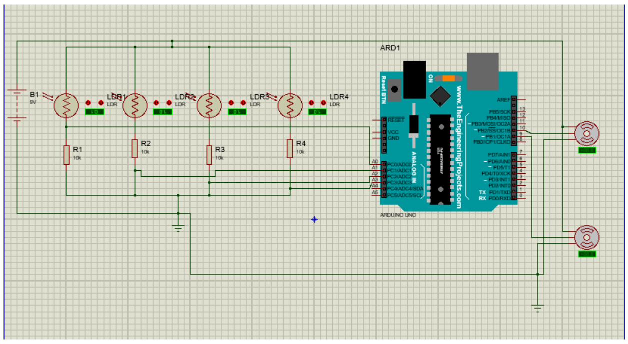

Fig. 8 Dual Axis Sun Tacking System Circuit Diagram

III. RESULTS AND ANALYSIS

This paper shows the results of a project which consists of two different designing processes such as the design of the circuit and the design of the model for the project. The circuit was designed by using Proteus using Solid work. After construction of the model was completed, the system was programmed by using Arduino IDE because it was an open source. It was easy to understand than any other programming languages. The research and the results were run and collected at Universiti Kuala Lumpur Malaysia Institute of Marine Engineering Technology (UNIKL MIMET). The data was monitored by using Arduino IDE screen monitored beginning 8.00 am until 4.00 pm. The data were collected based on the current and voltage before the power was determined.

A. Comparison performance between single axis and dual axis sun tracking system

Table. 1 Single Axis Sun Tracking System

	Single Axis Sun Tracking System		
	V	mA	Total Power(mW)
8.00 a.m	10.6199	0.537	5.7029
10.00 a.m	11.70	0.61	6.8802
12.00 p.m	7.007	9.131	63.9809
2.00 p.m	3.070	8.667	26.6597
4.00 p.m	4.077	4.077	16.6219

Table. 2 Dual Axis Sun Tracking System

	Dual Axis Sun Tracking System		
	V	mA	Total Power(mW)
8.00 a.m	5.151	5.151	26.156
10.00 a.m	9.302	9.302	64.0443
12.00 p.m	8.594	8.594	92.1105
2.00 p.m	9.131	9.131	83.1469
4.00 p.m	8.374	8.374	69.9229

Table 3 shows the results for single axis sun tracking system. It shows the maximum results at 12.00 pm. It was due to the location where the data were collected received the maximum energy at this time. Table 4 states the results for dual axis sun tracking system. It follows the same results as a single axis which received the maximum energy at 12.00 pm. Figure 8 shows the differences in results between the single axis sun tracking system and the dual axis sun tracking system. From this result, the dual axis sun tracking system shows the higher power output than a single axis sun tracking system with an 18%. The maximum power that can be obtained from these two systems was at 12.00 pm while the minimum was at 8.00 a.m. This is due to a position of the sun and the efficiency of the light that can be tracked by the system.

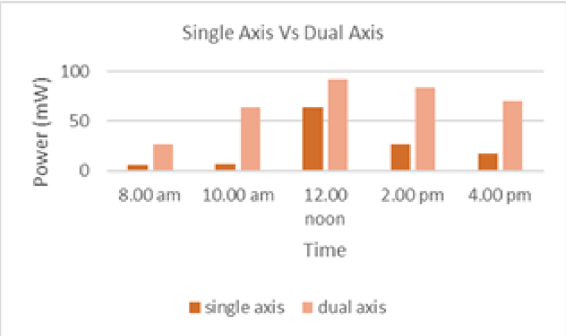

Fig. 8 Comparison between Single Axis and Dual Axis Sun Tracking System

B. Comparison between single axis and dual axis sun tracking system by adding DC-DC Step up Converter

The function of DC-DC Step up Converter is to boost the voltage. The results below show there is an increase between voltage and power.

Table. 3 Single Axis Sun Tracking System with Buck Boost

	Single Axis Sun Tracking System with Buck Boost		
	V	mA	Total Power(mW)
8.00 a.m	5.908	8.1	47.8548
10.00 a.m	8.25	9.841	78.5607
12.00 p.m	14.136	14.624	128.5303
2.00 p.m	14.52	8.427	122.4022
4.00 p.m	8.2	8.179	67.0923

Table. 4 Dual Axis Sun Tracking System with Buck Boost

	Dual Axis Sun Tracking System with Buck Boost		
	V	mA	Total Power mW
8.00 a.m	16.923	5.054	85.5228
10.00 a.m	12.915	12.915	167.1072
12.00 p.m	17.163	17.09	293.3157
2.00 p.m	14.941	14.941	223.2335
4.00 p.m	12.231	12.183	149.0103

Table 3 shows the results for the single axis sun tracking system while Table 4 shows the results for the dual axis sun tracking system. Figure 9 shows the differences results between the Single Axis and the Dual Axis. The lowest power was obtained at 8.00 am while the maximum at 12.00p.m.The differences between the single axis sun tracking system and the dual axis sun tracking system was 30%. This was because the dual axis could be rotated west, east, south and north but the single axis sun tracking system could only turn west and east. The position of the sun was also an important element because it was in different positions at different times. It shares the concept as the previous system, but the voltage could be stepped up by using the DC-DC step-up converter. The output voltage could be boosted until 28V.

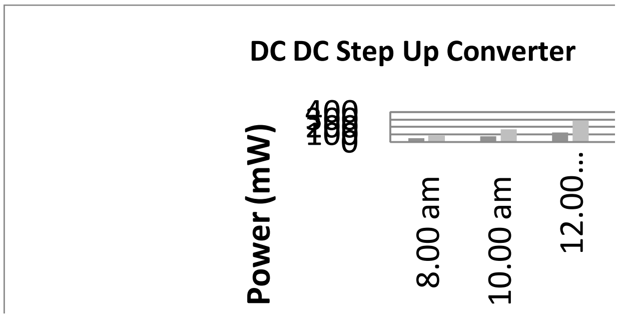

Fig. 9 Comparison between single axis and dual axis sun tracking system by adding DC-DC Step-up Converter

IV. CONCLUSION

It can be summarized that this experiment will benefit the society. This research is user- friendly and suitable for users. Generally, this model is designed to analyze the efficiency in tracking the sunlight and collect the maximum output from the solar panel. Then, the differences in results from these two models were produced. The result shows that the dual axis received more power output than the single axis sun tracking system. The battery charging optimization can be related to the output power that was received from the system. The higher power charging would yield higher power output. Additionally, the power can be increased by adding the DC-DC Step up converter. Lastly, the result obtained indicates that the dual axis sun tracking system has higher efficiency than the single axis sun tracking system.

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AUTHORS PROFILE

Wardiah Mohd Dahalan received her B.Eng. (Hons) in Electrical & Electronics Engineering in 1996 from University of Dundee, UK and Master in Decision Science from Universiti Utara Malaysia. She received PhD degree from the University of Malaya, Kuala Lumpur, Malaysia in 2014. She has working experience in educational field for at least 19 years. She is currently Senior Lecturer at Department of Marine Electrical and Electronics Engineering, University of Kuala Lumpur (UniKL) and also Head of Research and Innovation. Her research interests are renewable energy, reconfiguration area and optimization techniques. She is a member of IEEE, Rina-ImaRest and Malaysia Board of Technologist (MBOT). She also had a great contribution in publishing articles, journals, symposium papers in the field of Electrical Engineering.

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Aminatul Hawa Yahaya served in Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology (UniKL MIMET) for over 13 years. Immediately after graduation, she joined Universiti Teknologi MARA (UiTM) as a lecturer for 3 years before joining UniKL MIMET in 2006. She is currently a Lecturer in Maritime Management Section, UniKL MIMET. She also appointed as Final Year Project Coordinator under Research and Innovation Section. She previously holds posts in the institute where she was a Head of Section Applied Science and Technology. She graduated with Bachelor of Science (Honour) majoring in Statistics in 2002 from Universiti Putra Malaysia (UPM) and with Master of Applied Statistics from Universiti Malaya (UM). Her research interest are in applied statistics focusing on regression model development, model building procedure and logistic regression.
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