Performance Improvement of Photovoltaic Panels Using Dual Axis Sun Tracker

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Abstract

Renewable energy is the most important type of energy sources nowadays. It's clean, abundantly available and can be obtained from nature without giving any negative impact to the environment. This is the opposite of what fossil fuel does by giving the carbon dioxide (CO2) emission and makes a huge damage to the atmosphere. Solar energy is one type of renewable energy and is considered a good effective alternative source of energy. The solar energy can be collected using solar panels from emitted radiation from the sun. The aim of this paper is building a dual-axis solar tracker to control the direction of the panels and get the highest output efficiency compared to the fixed panels. The sun tracker system consists of two main parts, hardware, and software. Hardware represented by using a microcontroller, Light Dependent Resistors (LDRs) to detect the light of the sun, servomotors use to adjust the direction of the solar panel (PV). The software represented by the application used and the codes. The results show that the dual axis tracking is more powerful than the fixed position solar cells and achieves better output power. The power measured were obtained by the data logger method.

Keywords: Renewable energy, Solar Energy, Sun Tracker, Dual Axis tracker. Microcontroller, data logger.

1. Introduction

Energy is the main nerve of the life which it used every day. The energy can be found in different forms and from different resources too. Nuclear energy, chemical energy, thermal energy, mechanical energy and electrical energy. The electrical energy specifically is one of the most important kind that our civilization stands on it [1]. Electronic devices, streetlights, air conditioning devices, vehicles, computers, phones and anything that we might imagine use electrical energy [2].

The electrical energy comes from renewable sources or fossil fuels. The fossil fuel occupies large space among energies, it's a dominant type of energy of countries. But its effects and emissions made the researchers and inventors think of alternative solution. The CO2 emissions killed green life and affected the atmosphere because of air pollution. Also, the cost of fossil fuel increases day by day and this made the living cost too high.

The renewable energy and its sources became at the forefront as an alternative. The renewable energy has many forms and they are getting attention because of the renewability. Hydroelectricity, Bioenergy, solar, wind, geothermal, tidal power and wave power are type of renewable energy [3].

Solar energy is one of the best sustainable energy that available in abundance in nature, it is coming from the sun which is unlimited source of energy.

Solar Energy has become common recently, it is clean, economical and environmentally friendly. It can be used in different applications, such as heating, lighting and electrical generating by converting solar radiation into other usable forms. The intensity of light out of the atmosphere is very high and it is near to 1353 W/m2 [2]. Atmosphere works attenuate this light intensity and this gives as significant energy production [4].

Seasonal variation of the planet affects on the amount of energy that can be produced. Summer season can provide us with more sunlight than winter also the difference between day and night effects on the photovoltaic cells' productivity. The solar panels are effected by the amount of the radiation reached the surface and the maximum power gain [5].

There are different types of sun trackers, fixed position toward the sunlight, no-side-shadow and one axis tracker [6]. This paper aims to construct a system that can track the sun during the day to get the highest energy possible, this system is a dual-axis sun tracker system that is constructed and tested in this paper. Then compare the data gotten with the fixed position solar panel.

The proposed tracking system consists of two servo motors used to redirect the direction of the solar panel and four LDRs that can sense the intensity of the light and they are distributed in four different places.

The system works on a rechargeable battery that can be charged from the solar cell itself. The output data will be gained and monitored in a real-time and displayed on OLED display. We used voltage divider rule to make the Arduino sense and measure the high voltage then record it using SD card module with Real-Time module DS3231 this method called data logger. It records the voltage immediately in Micro SD card and shows them using Microsoft Excel application.

1. Proposed System

Dual axis sun tracking system is presented in this work and it is shown in the figure 1. It is used to increase the light that reaches the panels based on Arduino Uno microcontroller. The system can be divided into two sections. These sections refer to the working principle of each part of the tracker. First section which is related to the mechanism of gathering solar energy which consists of LDR (light dependent resistor), solar panels and servo motors. Second section is the controller represented by the Arduino microcontroller (UNO).

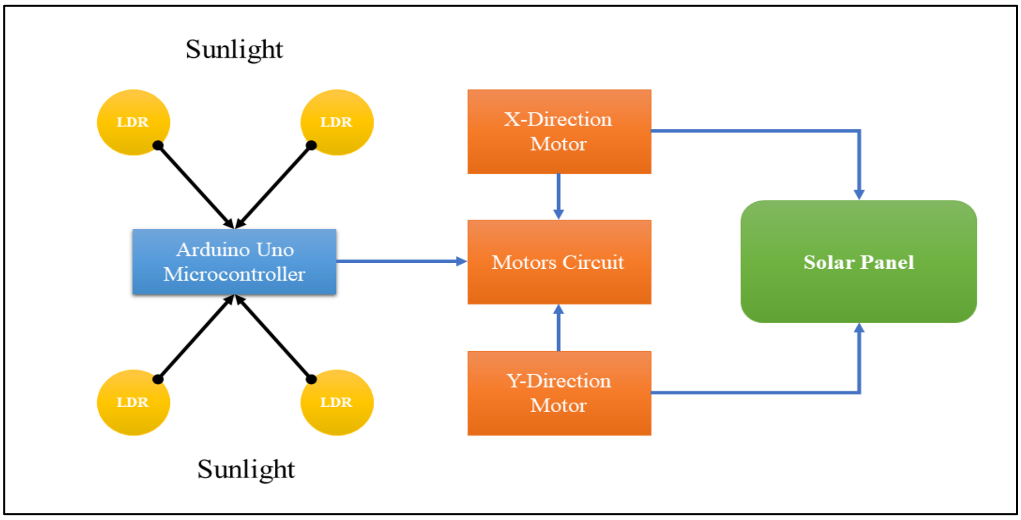


Figure 1: Block diagram of dual axis sun tracking system

2.1 Light Dependent Resistor (LDR):

LDR shown in figure 2 is a component has variable resistance affected by the light intensity and gives the value of intensity as electrical signal to the microcontroller to control the servo motors for repositioning the solar panels with respect to the sun. The LDRs is made of semiconductors and this material is a sensitive to light [7]. The type of the semiconductor material used in this paper is cadmium sulfide (CdS). The sensitivity of the LDR depends on the light falling on the it's surface and this will effect on the output signal of LDR sent to the microcontroller.

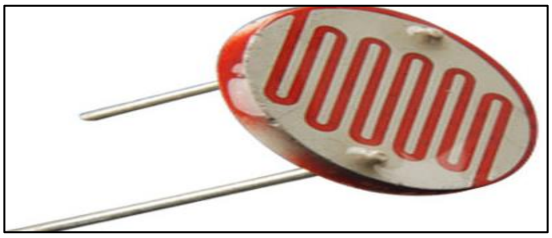


Figure 2: Light dependent resistor (LDR)

2.2 Servo Motors (MG996R):

The servo motors which are shown in figure 3 connected to the microcontroller. They are DC motors used in many applications. They are compact in size and its energy efficiency is good. Servo motors turn from 0 degrees to 180 degrees clockwise or counterclockwise direction depending on the order that comes from the microcontroller as electrical pulses. These motors have three terminals: power, ground, and control. The control terminal is a waveform (Pulse-width modulation) PWM. Its operation voltage is 3.3- 6V [8]. The servomotors attached to the solar panel that turns in the same direction of the sun.

Figure 3: mg996r servo motor

2.3 Solar Cell

The electrical current can be produced from the solar cells through a phenomenon called PV (Photovoltaic) effect using the radiant energy from the sun. the solar panel is made from semiconductor materials, these materials have an electrical conductivity value falling between a conductor and an insulator [2].There are different types and applications for the PV. In this paper, a 6V solar module shown in figure 4 will be used.

Figure 4: Solar Module

2.4 Microcontroller (Arduino UNO)

The second section of the system is represented by the microcontroller. It's the core of the system and all parts are connected using it. The microcontroller is a low cost modern small computer with an integrated circuit. It has input and output ports as well as a processor and memory. The microcontroller is used in many applications such as the internet of things (IoT), smart energy, household appliances and much more [9].The microcontroller that used is Arduino UNO which is shown in figure 4. It's an open-source single-board microcontroller used to build electronic project and control circuits. It can work without any external devices and can be programmed to use according to the mission needed [10].

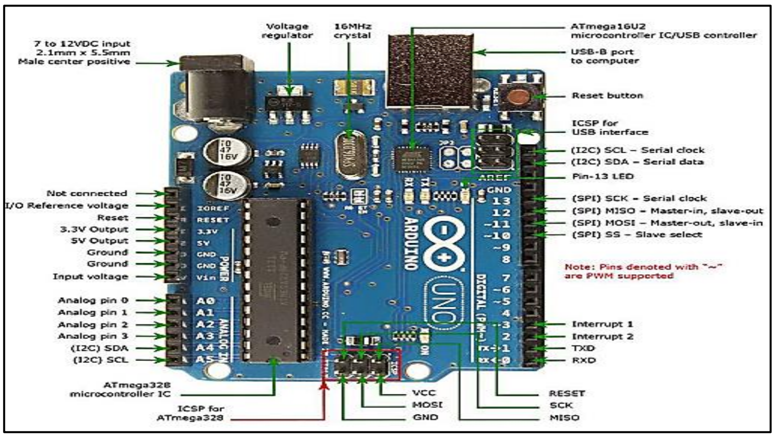


Figure 5: Arduino UNO

2. System Operation

The operation of the system begins when the LDR sensor start to sense the sun light then it gives an electrical signal to the microcontroller which it will give the order to the servo motor to reposition itself to get maximum power from the sunlight.

Output voltage can be monitored in different ways. In this paper we will take a method called data logger [10]. The reason of choosing the data logger is to check the output results anytime without the continues monitoring on the screen during the day.

This method allows us to save the data directly in SD card and show them in Microsoft Excel application anytime wanted using real time clock module DS3231, card reader module and screen if we want to check while the system is working, we added a component helps to check the electrical current gathered.

This section of the paper is focusing on the electrical circuit design and the connection of each part as well as the working flow diagram of the design as shown in figure 6.

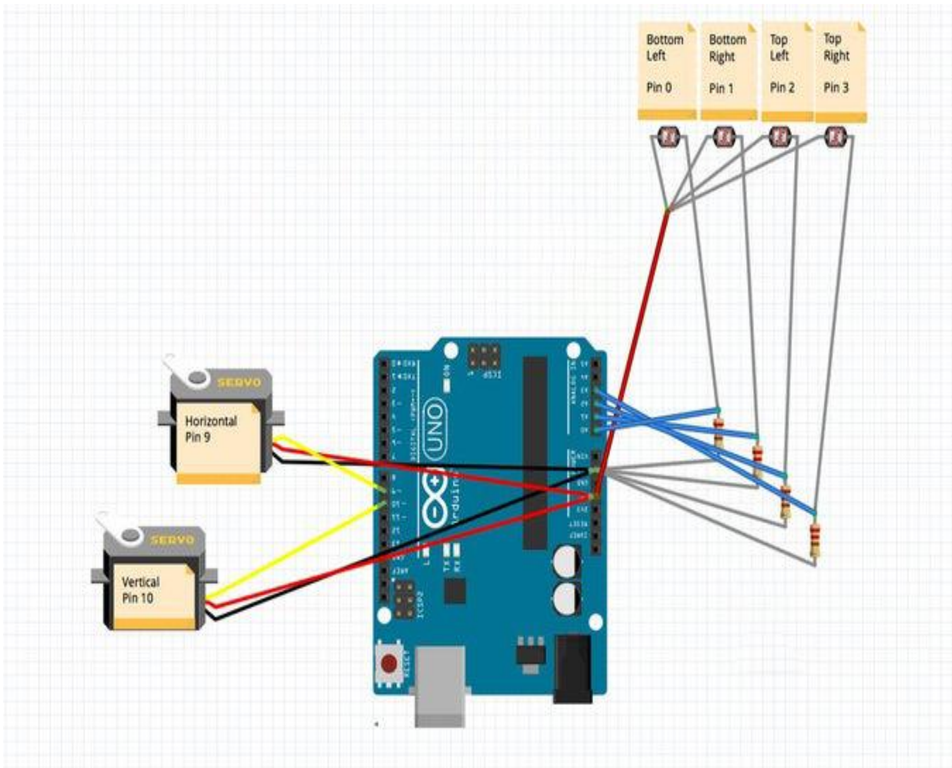


Figure 6: Electrical diagram of solar tracker

The data monitoring logger electrical circuit is shown in Figure 7 which is composed of real time module DS3231, SD card module, OLED display module and current sensor. System operation starts by uploading the program to Arduino that include all codes needed to operate the LDRs and servo motors along with the data logger. Then we feed the system with suitable source of power to work which is from the rechargeable battery. Switching on the Arduino lets the system work and attempts to detect the source of light depending on the highest intensity.

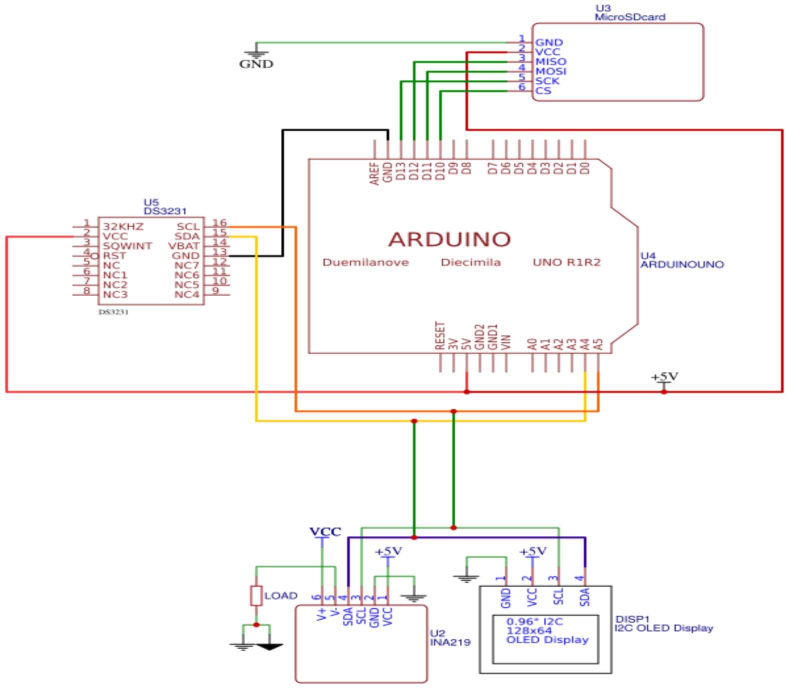
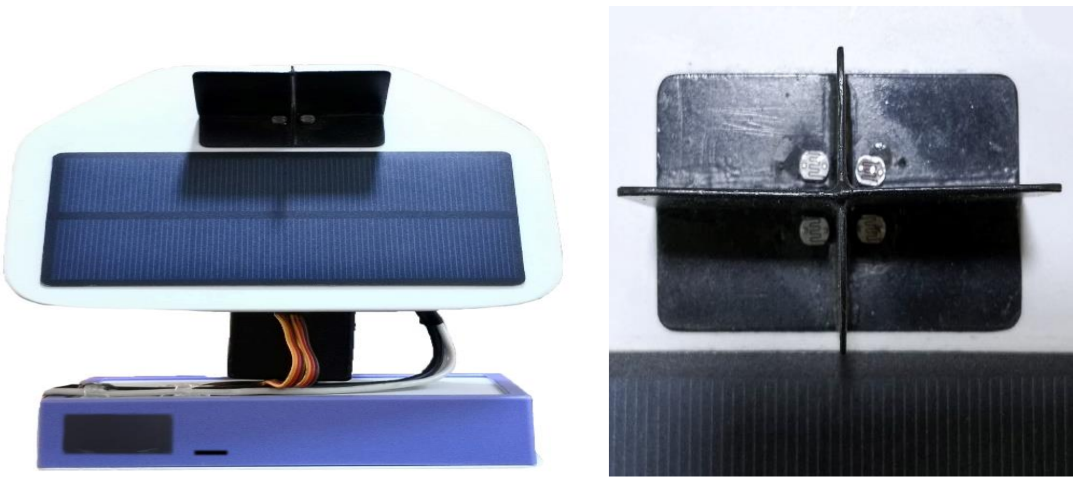


Figure 7: Proposed Data monitoring and logger circuit

After that it will show the data in real time on the screen in addition to recording it on micro SD card that's allow us to show them on Microsoft Excel. In figure 8 the full dual axis solar tracker build with LDRs is shown.



A B

Figure 8: A) Dual Axis solar tracker, B) The distribution of LDRs

3. Results and Discussion

The results of this work were obtained from the solar panel and recorded using the SD card. That data was gotten from the fixed solar panel and from the system built as showing in table 1. The data were recorded in June month every hour for 12 hours and saved directly to the memory. The data depends on the light intensity as mentioned before and the intensity which is changing during the day depending on the sun position.

Table 1: Output data of solar panel

Time	Fixed position solar panel			Dual-axis sun tracking system		
	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
6:00:00 AM	3.10	0.10	0.31	4.20	0.19	0.80
7:00:00 AM	3.60	0.19	0.68	5.74	0.29	1.66
8:00:00 AM	3.90	0.24	0.94	5.76	0.29	1.67
9:00:00 AM	4.20	0.20	0.84	5.80	0.30	1.74
10:00:00 AM	4.20	0.20	0.84	5.79	0.29	1.68
11:00:00 AM	5.10	0.25	1.28	5.80	0.30	1.74
12:00:00 PM	5.75	0.27	1.55	5.88	0.31	1.82
1:00:00 PM	5.60	0.27	1.51	5.90	0.32	1.89
2:00:00 PM	5.55	0.26	1.44	5.87	0.30	1.76
3:00:00 PM	4.50	0.21	0.95	5.74	0.29	1.66
4:00:00 PM	4.20	0.20	0.84	5.66	0.29	1.64
5:00:00 PM	4.16	0.20	0.83	5.65	0.29	1.64
6:00:00 PM	4.00	0.19	0.76	5.62	0.29	1.63

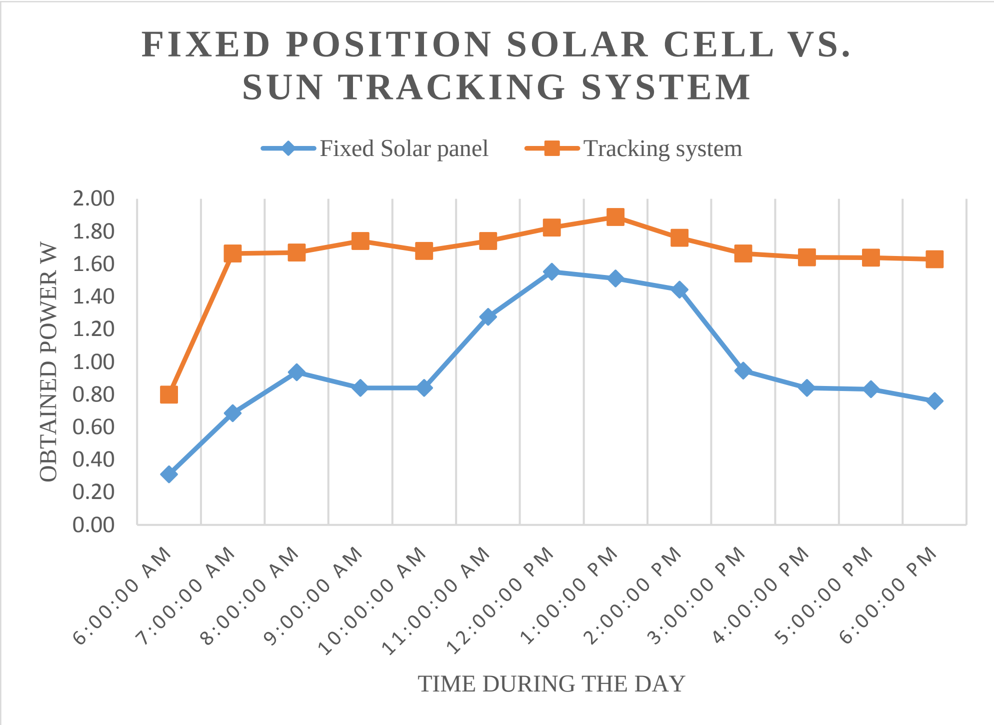


Figure 9: Power comparative of solar panels

As shown in the table 1 we can see a noticeable change. This change is an improvement of solar cell output voltage and current. This is a prove of the effectiveness of the system built. While the sun is changing its position in the sky our design is tracking and try to get the highest voltage and current. This achieves the objective of this paper. The solar tracking system collected the sunlight almost equally all day from the sunrise until the sunset. In the end, we got the best voltage all day. Power comparative between fixed position solar cells and dual axis sun tracker showing as curves in figure 9.

4. Conclusion

The aim of this paper is to design a dual axis tracker to get the highest intensity of the lights for getting maximum output power. The design is small in size with a low-cost component compared to other trackers. The reason of choosing the Arduino is because of its easy programming and accessibility. The output results we got proved that the design on this prototype improves the performance of the solar panel because we got almost the best output voltage and current in different times. The use of LDRs helped to get a good accuracy of sun position and the data logger saved lots of time for comparative and monitoring. This let us count on the renewable energy hopefully decrease of budget cost by using a type of energy available in nature and harmless like fossil fuel.

Conflicts of Interest

The author declares that they have no conflicts of interest.

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تحسين أداء اللألواح الكهروضوئية بأستخدام متتبع الشمس ثنائي المحور

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الخلاصة

الطاقة المتجددة هي أكثر الطاقات المهمة في هذه الأيام. حيث انها نظيفة ومتوفرة بكثرة ويحصل عليها من الطبيعة بدون إعطاء أي تأثيرات سلبيه للبيئة. وهذا هو معاكس لما يعمله الوقود الاحفوري بانبعاث غاز ثنائي أوكسيد الكاربون الذي يسبب ضرر كبير للغلاف الجوي. الطاقة الشمسية هي واحده من الطاقات المتجددة ويمكن ان تصبح مصدر طاقة جيد وبديل لما موجود. الطاقة الشمسية يمكن الحصول عليها باستخدام الواح الطاقة الشمسية عن طريق تحويل الطاقة الشمسية الى طاقة كهربائية. منهجية هذه الورقة البحثية هو بناء متتبع ثنائي المحور ليتحكم باتجاه الالواح الشمسية للحصول على اعلى كفاءة خارجة. نظام التتبع الشمسي هذا يتكون من جزئين رئيسيين وهما جزء برمجي وأدوات ومعدات. المعدات متمثلة بمتحكم دقيق ومقاومات ضوئية لتحسس الضوء القادم من الشمس ومحرك تيار مستمر يعمل باتجاهين لتعديل اتجاه الخلية الشمسية. الجزء البرمجي متمثل بالبرنامج والشفرة البرمجية المستخدمة. نتائج البحث بينت ان المتتبع الثنائي المحور يتفوق على الخلايا الشمسية الثابتة وتم الحصول على طاقة اعلى التي سجلت باستخدام مسجل البيانات.

الكلمات الدالة: متحكم دقيق، طاقة شمسية، نظام تتبع شمسي، متتبع ثنائي المحور، طاقة متجددة، مسجل البيانات.