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Microcontroller Based Dual Axis Sun Tracking System for Maximum Solar Energy Generation

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Abstract Solar energy is becoming a promising renewable energy technology. Conventional fixed solar panel with a certain angle limits there area of sun exposure due to rotation of Earth. The automatic solar tracking system solves this problem. In this paper a dual axis solar tracker is designed and implemented to track the sun in both azimuth and altitude axes by using an AVR microcontroller. The implemented system consists mainly of the ATmega 328 controller, DC motors, light sensors and relays. The results show that the designed low cost sun tracker increases the output power generation efficiency by 25-30 % as compared with the fixed panel systems. The effect of temperature and panel covering by colored cellophane, on the performance of the designed system is also studied. The temperature and the colored cellophanes decrease the output power of the solar panel.

Keywords: *Dual –Axis sun tracker, ATmega 328 Microcontroller, photo -voltaic, solar energy, maximum power point*

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1. Introduction

Energy is an essential factor for the development of nations. Most of the energy production depends on fossil fuel. The resources of the fossil fuel are limited; therefore, there is a growing demand on energy from renewable resources such as solar, geothermal and ocean tidal wave [1]. Solar energy is more popular than other renewable energy resources to take over the scarcity of hydrocarbon in future [2]. Photovoltaic (PV) panels convert the sun radiation to electricity. Maximizing output power from a solar system is desirable to increase efficiency. In order to maximize the output power from solar panels, they must be kept aligned with the sun. As such, a means of tracking the sun is required [3].

Solar tracker is a device that keeps photovoltaic or photo thermal panel in an optimum position perpendicularly to the solar radiation during daylight hours. This can increase the amount of collected energy from the sun by up to 40% [4]. Usually, fixed PV panels cannot follow the sun movement. The single axis tracker follows the sun East-West movement [5,6,7,8], whereas the two-axis tracker follows the sun a long a changing altitude angle too [9]. Many tracker system technologies have been developed by many scholars [10,11,12,13]. Figure 1 shows a dual axis solar tracker [14].

Dual axis solar trackers have more efficiency than both fixed angle panels and single axis solar tracker systems. But, this advantage is at the expense of more system complexity [15].

The implementations of the sun trackers systems have done by many workers [16,17,18,19]. The performance of PV module is influenced by several parameters such as ambient temperature, humidity, rain, cloud and dust. In a desert environment the operational performance is impeded via sand particles accumulation on surface and higher ambient temperature [20].

Therefore, in this paper a dual axis sun tracking system is designed and implemented. Its power generation performance is evaluated and compared with fixed panel systems under different temperature and cell covering situation at the geographical area of Kirkuk city-Iraq.

The proposed system model is explained in section 2, together with the hardware and software design and implementation details. In section 3, the results of the practical tests of the implemented system are given. Finally, concluding remarks are presented in section 4.

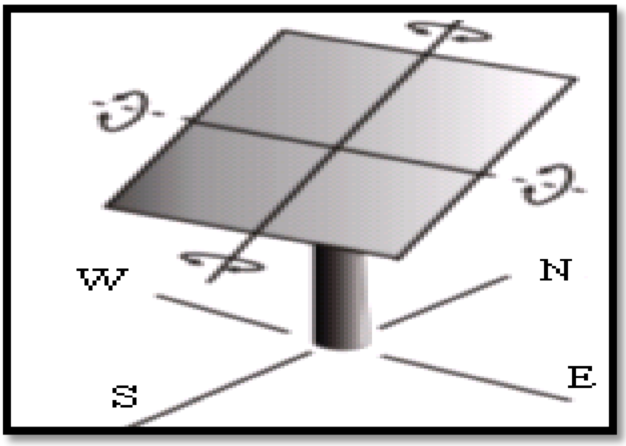

Figure 1. Dual axis solar tracker [6]

2. Experimental Setup

The proposed tracking system tracks the sunlight by rotating the PV panel in two different axes. The dual-axis solar tracker follows the angular height position of the sun in the sky in addition to following the sun's east-west movement. The proposed model for dual axis tracker is shown in Figure 2.

The tracker model is composed of: Solar panel of 87 watt and it is of poly crystalline type from Kyocera Company and its length is 100cm while the width of it is 65 cm, four Light Dependent Resistance (LDR) sensors, two DC motors, Arduino UNO microcontroller and four relays. Two LDR sensors and one motor with two relays are used to track the sun's east – west movement. The other two sensors and the other motor which is fixed at the bottom of the tracker with the other two relays are used to track the sun's up-down movement. The DC motors are basically performing function of sun tracking. Upper panel holder DC motor tracks the suns up-down movement and base DC motor tracks the east-west movement of the sun. These DC motors and sensors are interfaced with a microcontroller which is controlling DC motors on the basis of sensor's input. The LDR sensors sense the light intensity and send signal to the microcontroller. The microcontroller is compares the signals received from LDR sensors and decides the rotation direction of the DC motors according to the stored program. The designed system is described in detail in ref. [21].

Figure 3 shows the block diagram of the tracking system and the flow chart of the control program are given in Figure 4.

Figure 2. The proposed model for dual axis tracker

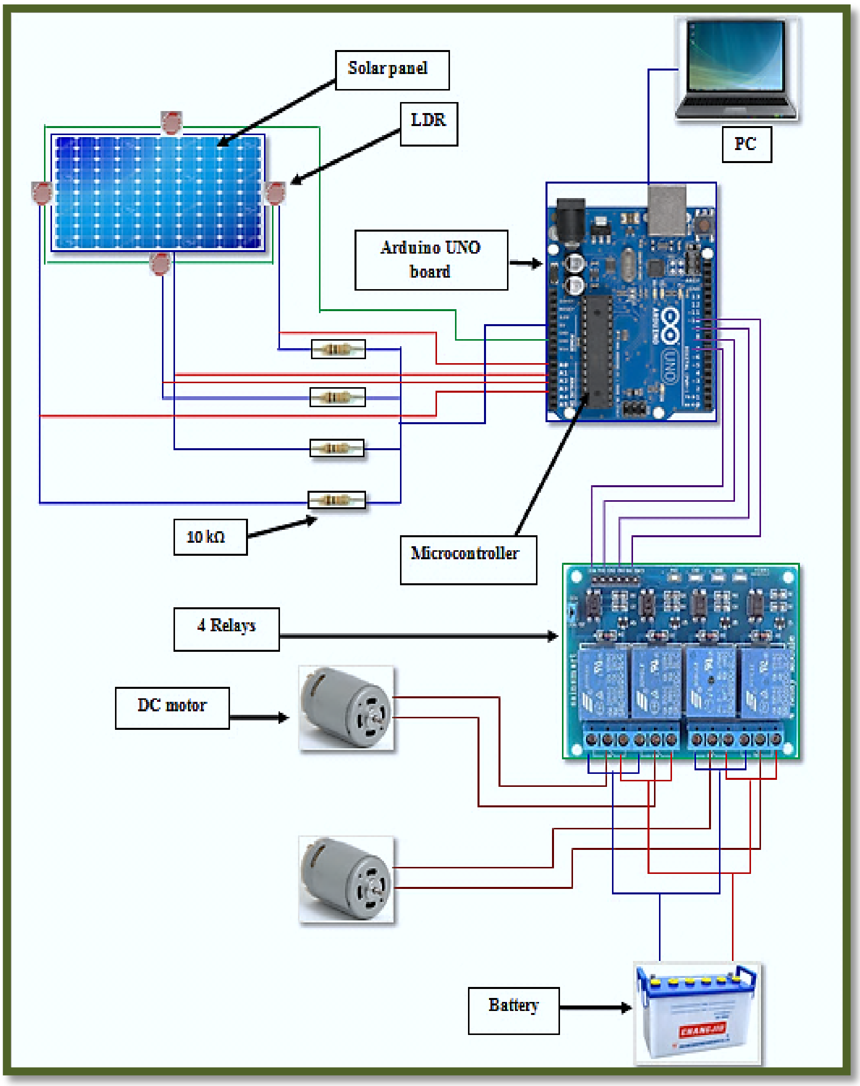

Figure 3. Tracking system

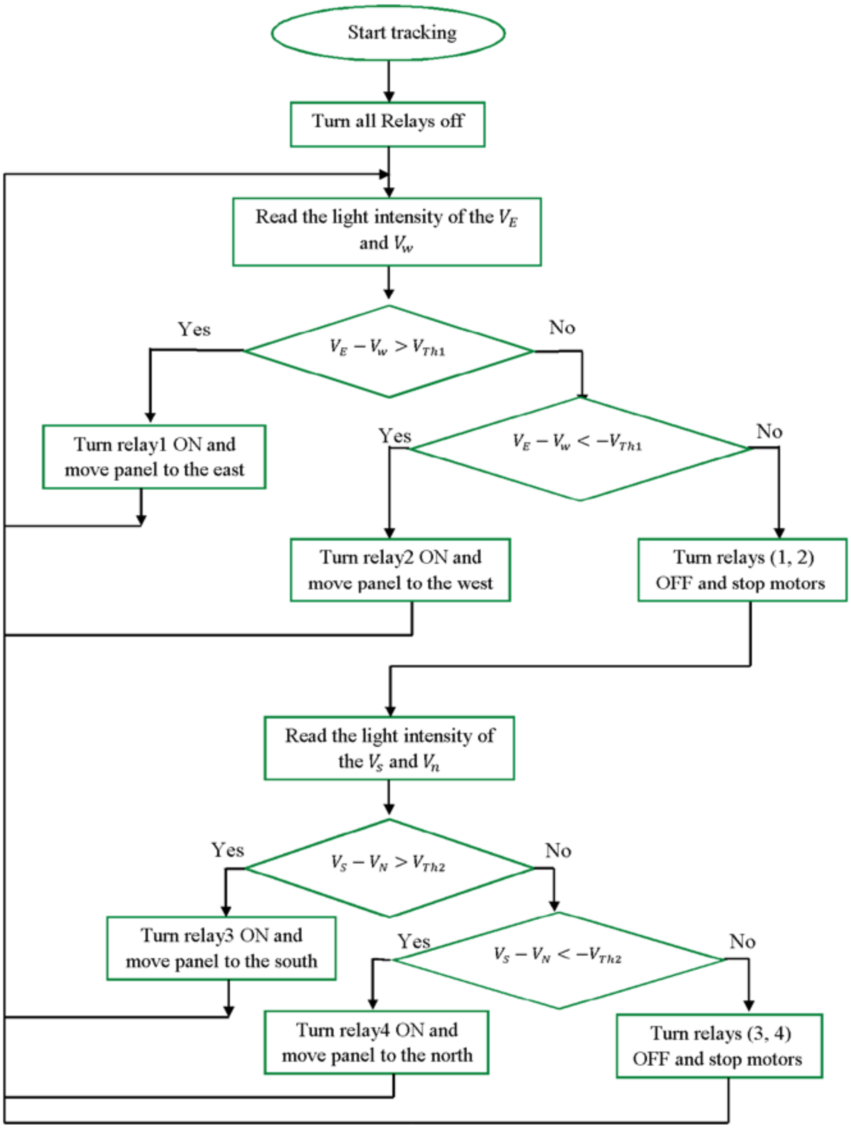

Figure 4. Tracker control algorithm

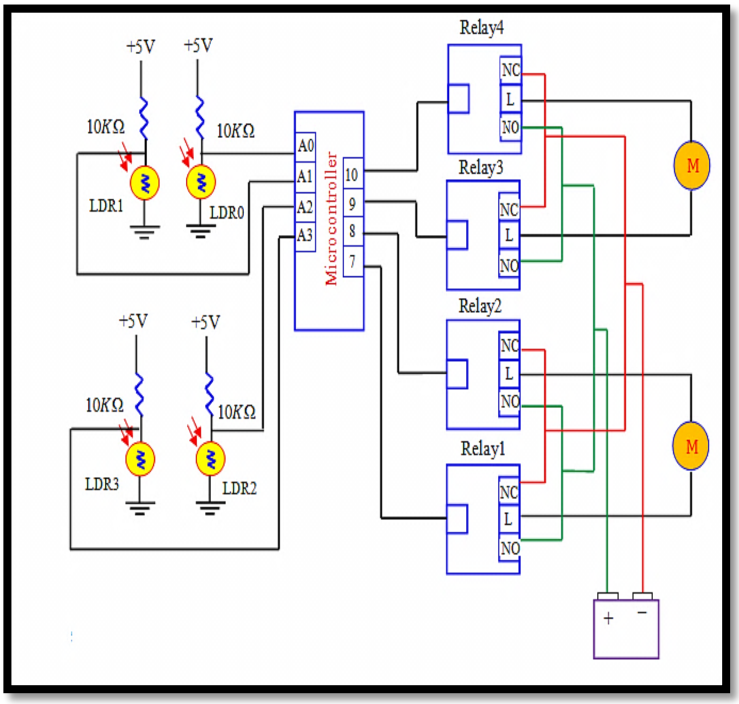

Figure 5. The electronic control circuit

Algorithm starts with taking data from LDR sensors. The microcontroller read this data and made a comparison between them and then decides about the movement direction of the DC motors. The electronic circuit is shown in Figure 5.

3. Experimental Results

Two panels were tested; one of them was fitted on the implemented tracking system where the position of the other was fixed at the local latitude 35^0 of Kirkuk/Iraq. The test was done at May (2016). The generated output current and voltage were measured during the local time of Kirkuk from (9 am) to (4 pm). Figure 6 illustrates the change of the output power of the solar panel, which is the product of the short circuit current I_{sc} and open circuit voltage V_{oc} with the local time for the measurement duration. Figure 6 shows a graphical comparison for the fixed panel, single and dual axis tracker output power.

Figure 6 shows that for the fixed panel the power increases gradually and be become maximum at 12 pm, then decrease with sunset. While for the single axis tracker the curve of the output power is higher above the fixed PV array system and the gain is (24.05%). The used single axis tracker is the same implemented dual axis tracker but operated in the east-west directions only and the up-down direction is fixed at 35^0 elevation angle. The dual axis achieves (26.22%) higher power as compared to the fixed panel, which is in agreement with the other works.

There are many parameters which have influence on the conversion efficiency of PV cell using tracker system such as temperature and illumination. So, the effect of temperature has been investigated in this paper. Figure 7 shows a plot of the output power versus time and monthly-average hourly panel temperature versus time for the tracker panel and the fixed panel in May, 2016.

Figure 7 show that when the temperature of the panel increases the output power of the panel is decreased.

Finally, the effect of the panel covering by colored cellophanes on the output power of the tracker system is studied. The color of the covers is yellow, green and blue. The output from this colored cellophane is compared with the output of the solar tracker panel without any color as shown in Figure 8. This colored cellophane is available in the market and cheap.

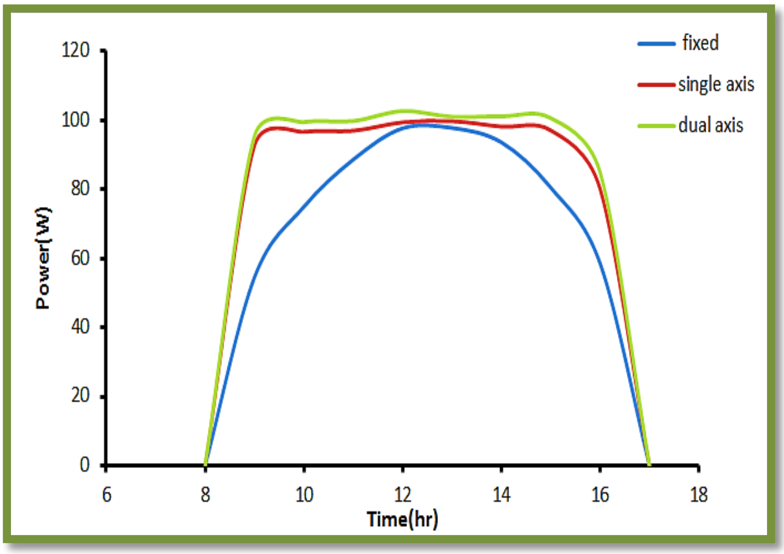

Figure 6. The hourly variation of the output power for the fixed, single and dual solar panel of May (2016)

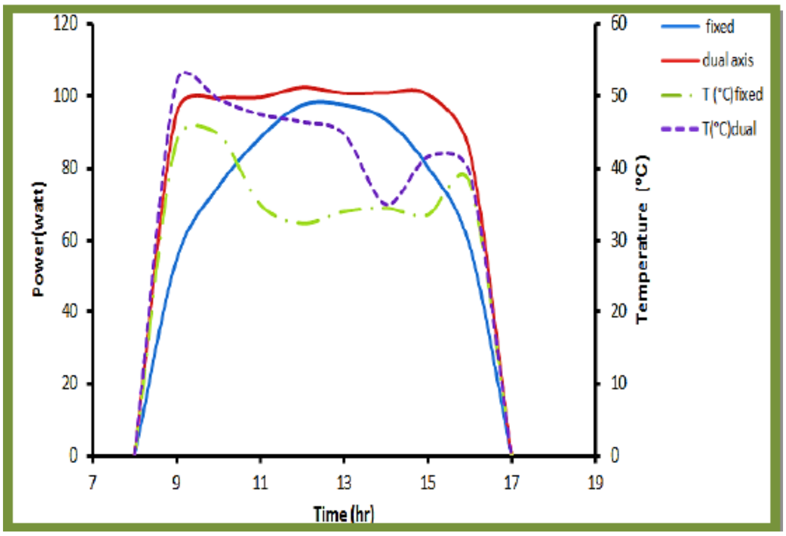

Figure 7. The hourly variation of the output power and temperature versus time at May (2016)

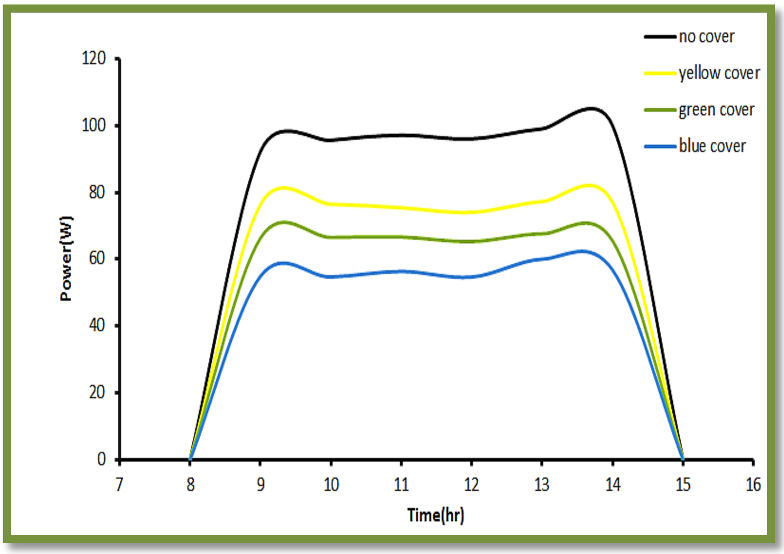

Figure 8. The hourly variation of the output power for the colored filters with respect to the output power of the tracker at May (2016)

From Figure 8 it can be concluded that the colored filters only allowed light of the same color to pass through. After analyzing the data, it was determined that the output of the panel under sun light was significantly higher than any of the other colored light. This is due to the loss of light intensity inherent to the tint of the color filters.

4. Conclusions

In this paper we have come to a conclusion that dual-axis solar tracker is more efficient in terms of the electrical energy output when compared to the single axis tracker and fixed solar panel. The gain of the dual-axis tracking system is about 25-30% compared with the fixed system. For the temperature and covers, they decrease the output power of the solar panel. Therefore, any covering such as dust protection covers will have a negative effect on the amount of power generated by the solar panel.

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