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Real-Time Solar Energy Optimization Systems

P Mahesh Kannan[1], Raja TE[1]* and R Gowtham[2]

181 Vicente Rd Berkeley, 94705, USA

Abstract

In this era of searching the energy resources, the renewable energy resources are becoming popular. Among all the other renewable resources, solar energy is the powerful and the energy produced will be adequate when the production is mass and optimized. This paper presents the design of a solar tracking system to get the maximum power output from the solar panels. The efficiency of the system can be increased by maintaining the angle of the panels, perpendicular to the angle of incidence of the rays from the sun. This is possible by the micro-controller based double axis solar tracking system, by which the solar panels are aligned with the sun, in order to increase the generation of power. This system is designed using micro-controller, light detecting resistor, gyroscope, gear system and stepper motor. It works in both manual as well as automatic mode. It works on a closed loop which corrects the angle with the help of the gyroscope and with the help of the amount of the solar energy received according to the Light Dependent Resistor values. The limit switches are provided, which controls the movement of the panels. A model of solar tracking system is designed, constructed and tested. The design details and the test results are shown.

Keywords: Energy optimizer; Renewable power; Solar optimization

Introduction

For the past decades, researchers are concentrating on the development of clean, renewable and carbon free energy resources, and it is sure in the near future, to replace the carbon based resources such as oil, coal and gas. This is because of two important reasons. First is, most of carbon based energy will dry up within the next fifty years at most, and the second is, carbon based energy is responsible for the emission of greenhouse gasses and leads to Global warming. If nothing is done to eradicate this problem, it will result in the serious uncontrolled problems. It may lead even to the sinking of land forms and deployment of other resources. This made developed and the developing nations to focus on the carbon free easily renewable energy resources. The solar energy being the primary of all the energy resources, it is being focused by various sectors and the research groups, especially in region where sun shine is abundance like India, Africa, tropical and the equatorial regions. Lots of researches are carried out to improve the efficiency of the solar cells (Figure 1). The efficiency of the solar cells was merely 17% in the early 90's and it has increased to 35% in the later period. But still it has some drawbacks. One among them is the relatively high cost and the other one is their low efficiency even at the current rate of 35%. The important draw back among all of them is the positioning of the solar cells, especially during the summer season when the sun shines more than 16 hours a day and we do not extract maximum energy from the cells.

The solar tracker is the device used to track the movement of the sun and aligns the photovoltaic panels in the optimum position of the angle of incidence of the sun during the day hours and increases the amount of energy collected from 35% to 50% (Figures 2 and 3). Commercially single axis or double axis solar tracking systems are available. But it is necessary to keep the panels in a perfect angle of incidence to the sun. Hence the model has the capability of moving on both sides with the help of two stepper motors. One of those motor helps to turn the panel in the east to west direction where as the other motor helps in the movement of the component in the changing altitude angle [1]. Solar energy generation system is designed with the study of different applications to improve the efficiency by adding the tracking equipment to it. The aim of this paper is to design a micro controller operated 3-axis closed loop solar tracking system, which increases the efficiency of a conventional solar power generating systems with the utilization of lowest power.

Description of solar cells

The solar cell consists of the P-N junction semiconductors. It converts the light energy in to electric energy [1]. The photon from the solar energy passes through the glass and excites the electron.

The anti reflective coating is given so that to avoid the solar races to

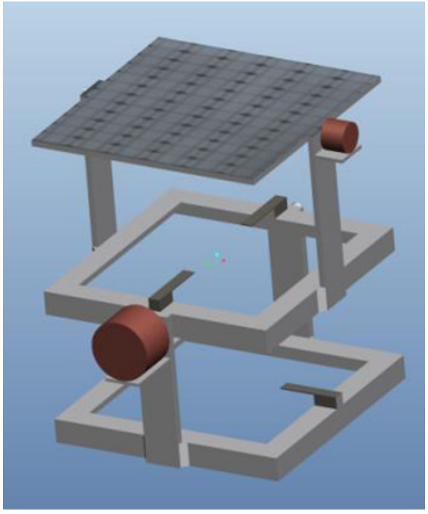

Figure 1: Model of a Dual Axis Solar Tracking System.

***Corresponding author:** Raja. TE, Department of Electronics and communication Engineering, SRM University, Chennai, Tamil Nadu, India, E-mail: rajate1992@gmail.com

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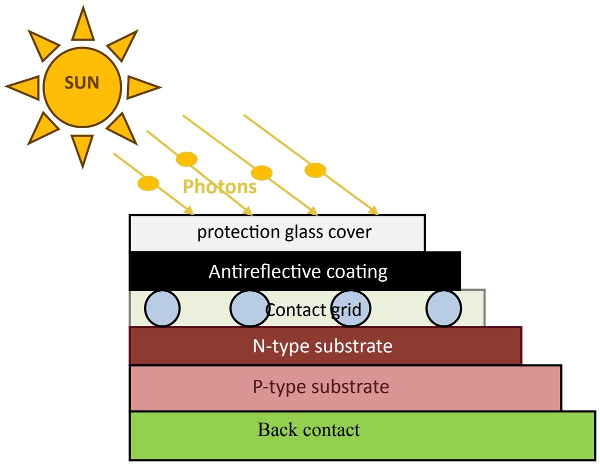

Figure 2: Showing the cross section of solar cell.

Figure 3: Orientation of Solar panel and the angle of incidence.

get reflected back out of the panels. Hence by shining the solar cells the photons excite the electrons [2]. The supply of current represents the electric current, the electrons after doing the work reaches the bottom layer and with the help of the catalyst it reaches back. Based on the characteristics of the P-N junction, the connection between the output current *I* and the output voltage *V* is represented as:

$$I = npI_{ph-np} I_{sat}\left[\exp\left(\frac{q}{KTA}\right)\left(\frac{v}{ns}\right)-1\right] \quad (1)$$

where *np* represents the parallel integer of the solar cell, *q* represents the contained electricity in an electron (1.6 x 10^{-19} C), K is the Boltzmann constant (1.38 x 10^{-23} J/K), T is the temperature of the solar cell, A is the ideal factor of the solar cell (A=1 to 5). The saturation current is denoted as *Isat*. Further the saturation current is denoted as:

$$Isat = Irr\left(\frac{T}{Tr}\right)^3 \exp\left[\left(\frac{qe}{Ka}\right)\left(\frac{1}{Tr}-\frac{1}{T}\right)\right] \quad (2)$$

Where *Tr* denotes the reference temperature of the solar cells, at the time when the solar cell reaches [3] its temperature *Tr*, *Irr* denotes the reversion saturation current and *Egap* is the energy needed for crossing the energy band gap in the semiconductor materials.

Methodology

Different methods were proposed, to track the position of the sun. But the better and the simplest of all is to use LDR (Light Dependent Resistor), by detecting the variation in the light intensity on the surface of the resistor. In the morning time the sun rays will fall towards the west from the east. Hence the intensity of the light is measured by the two LDRs placed at the edges of the plate and as the intensity is more towards the east side, the signal from the LDR reaches the micro controller the stepper motor helps in rotating the plate towards the east. The angle of the plate is monitored through gyroscope as closed loop.

As time goes on, the light intensity will be more in the middle sky as the sun reaches its maximum height in the noon. Hence the LDR sends the signal. Based on the triangular rule, the angle required is measured and the rpm of the motor is set by the controller as set before while programming it3. Similarly the motion of the plate is done to align it during the evenings. If the motor moves the plate further more a closed loop signal is sent to the controller to rotate the motor in the opposite side. So that to fix the position of the plate perpendicular to the angle of incidence of the solar rays4. This closed loop system led plate to change for every 30 seconds. The feedback from the gyroscope helps to optimize the angle of the plate by making it perpendicular to the angle of sunrays.

Limit switches are used at both the sides which will stop the rotation of the plate when maximum angle is reached. Importance of closed loop system comes to existence at points where the alignment of the plate [4] is to be more optimized towards the angle of incidence of sun. Hence it acquires more efficiency and gets more power with the same size of normal solar panel.

Design of dual axis tracker mount

The dual axis tracker mounting is introduced to align the panel towards both the east-west and the north-south axis. This is made possible by constructing the panel holder or the frame by two sections. The first section will rotate in the east-west axis, whereas, the second section will rotate in the north-south axis. The movement of the plates is possible with the help of the stepper motors connected to the gear system, which rotates the plate and aligns it according to the triangular rule in the particular angle. The frame has two stepper motor one is at the first section and the other is at the top of the second section at right angles to it. The values of North-South sensors are measured and compared. If the north and south values are same then no alignment is required if it is different, then the controller switches the stepper motor in the clock or the anti-clock wise direction. After it is aligned, the values of East-West sensors are measured and compared. If the East and West values are same then no alignment is required.

If it is different, then the controller switches the stepper motor in the clock or the anti-clock wise direction to align the panel. This alignment is done periodically in the given time gap and the values are monitored continuously. These alignments are done with closed loop to place the panels accurately towards the angle of incidence of the sun.

Results and Discussion

The Dual Axis Solar Tracking system is designed, constructed and tested (Figure 4). This could be a subject for further development. Solar tracking is the easiest method to increase the overall efficiency of the solar panels. The final design is successful. Power generation increased more than 35% for the same panel size. Hence the power to cost ratio is increased, in terms of real value. Which means the overall cost of the solar power generation system is reduced significantly, considering that more amount of power can be supplied by the same solar array coupled to a solar tracker assembly. The closed loop system of this assembly helps in optimizing the amount of power generated by the solar panels (Figures 5 and 6).

Hence, this system is the easiest method to increase the overall efficiency of solar power generation systems of domestic or commercial use.

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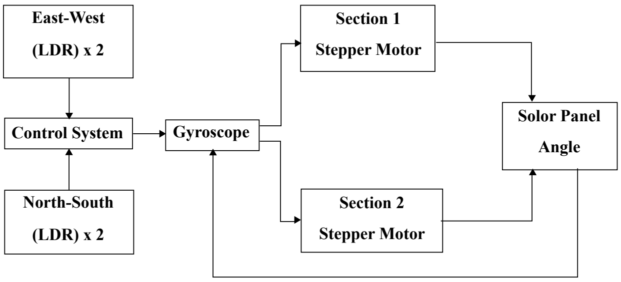

Figure 4: The Block Diagram of Dual Axis Solar Tracker.

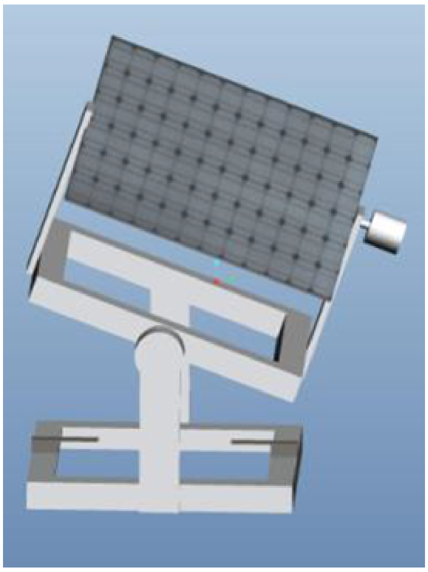

Figure 5: Showing the working of the Dual Axis Tracker.

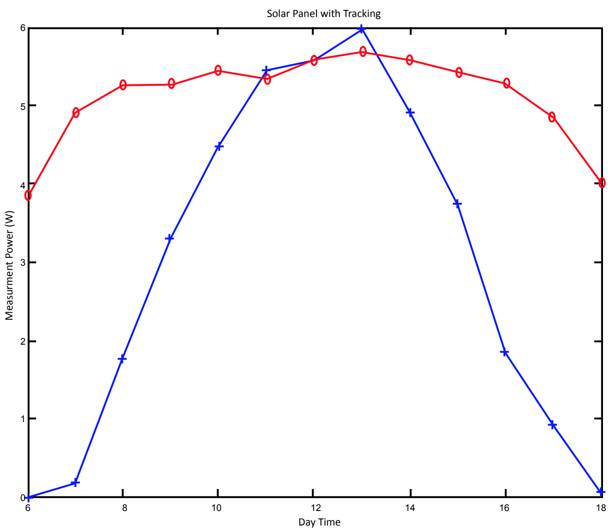

Figure 6: Graph showing Power from Fixed and Tracker panels.

Conclusion

A solar tracker is designed, constructed, tested and evaluated. The principle of micro controller based dual axis closed loop solar tracker system works relatively good and it is successful in maintaining the solar panels perpendicular the angle of incidence of the sun and thus the efficiency of the same array of solar panels can be increased by this system with less cost and less utilization of power. Hence the production power can be optimized with this low cost high efficient set up.

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