ISSN: 2249 – 8958, Volume-3, Issue-4, April 2014

Dual Axes Maximum Light Intensity Tracker

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***Abstract*— Efficiency of any solar powered system reduces due to mismatch between the direction of the sun's rays and axis of the solar panel. Aim of the proposed and implemented scheme is to increase the efficiency of such a system, by reorienting the plane of the solar panel orthogonal to the sun's radiation by using a simple low powered system. To achieve this, the panel is moved about two axes after a certain interval of time depending upon the ambient light conditions.**

***Index Terms*— LDR, Gimbal Structure, ADC, LSB**

I. INTRODUCTION

The world population is increasing day by day and the demand for energy is increasing accordingly. Oil and coal as the main source of energy nowadays, is expected to end up from the world during the recent century which explores a serious problem in providing the humanity with an affordable and reliable source of energy. The need of the hour is renewable energy resources with cheap running costs. Solar energy is considered as one of the main energy resources in warm countries.

Solar Tracker is a Device which follows the movement of the sun as it rotates from the east to the west every day. The main function of all tracking systems is to provide one or two degrees of freedom in movement. Trackers are used to keep solar collectors/solar panels oriented directly towards the sun as it moves through the sky every day. Using solar trackers increases the amount of solar energy which is received by the solar energy collector and improves the energy output of the heat/electricity which is generated [1]. Solar trackers can increase the output of solar panels by 20-30% which improves the economics of the solar panel project.

In section II objective of this project is explained. Section III and IV give idea about the proposed scheme and hardware components used in the project respectively. Observations taken using the implemented scheme is included in section V. Section VI and VII present advantages and applications of the implemented scheme.

II. OBJECTIVE

The aim of the proposed and implemented scheme is to keep the solar photovoltaic panel perpendicular to the sun throughout the year in order to make it more efficient. The dual axis solar photovoltaic panel takes ambient light data as reference and the tracking system has the capability to always point the solar array toward the point of maximum light intensity and can be installed in various regions with minor modifications.

Manuscript received on April, 2014.
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The vertical and horizontal motion of the panel is obtained by taking altitude angle and azimuth angle as reference. The microcontroller has been used to control the position of DC motors. The mathematical simulation control of dual axis solar tracking system ensures the point to point motion of the DC motors while tracking the point of maximum light intensity.

III. PROPOSED SCHEME

The purpose of a solar tracker is to accurately determine the position of the sun. This enables solar panels to interface to the tracker to obtain the maximum solar radiation. With this particular solar tracker a closed loop system was made.

The electrical system consists of four LDR [2] sensors which provide feedback to a micro controller. This micro controller processes the sensor input and provides two PWM signals for the movement of motors.

This motor moves the solar panel towards the higher density of solar light. The entire electrical system is powered by a 12volt source power supply. Initially four different analog values are obtained from LDR's, and then they are feed to micro controller. Micro controller gives two different PWM signal for the movement of solar panel through DC motor [3].

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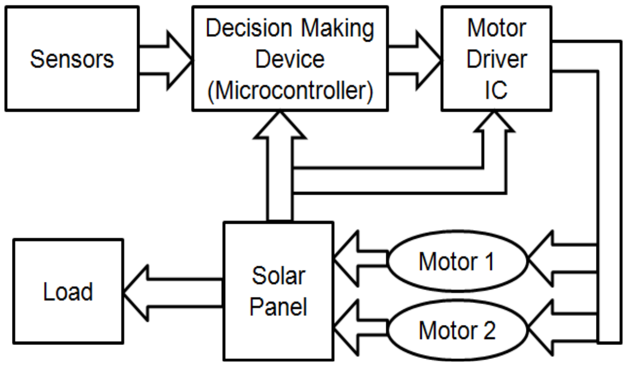

Figure 1: Block diagram of the system

As shown in the Figure 1, solar tracker is a feedback system. Light Sensors are employed to get the information about light intensity. There are four light sensors placed in a special fashion, two are for altitude movement and remaining are for azimuthal movement of the panel.

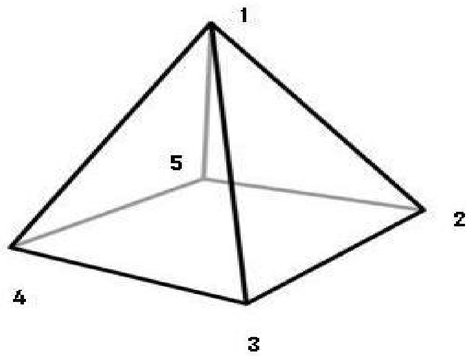

Figure 2 Sensor pyramid schematic

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The system uses a square pyramid as shown in Figure 2, with light sensors placed on the following sides - [123(a), 134(b), 145(c), 125(d)].
The pyramid will be placed adjacent to the solar panel making axis of pyramid passing through vertex 1 parallel to that of solar panel. The sensors placed on the opposite faces of the pyramid belong to one pair. Constructed sensor pyramid is shown in Figure 4. Output coming out from such oppositely placed sensors is sampled by microcontroller (ATmega8). Analog signals from light sensors are converted to 8 bit digital data using in-built 8 bit ADC of microcontroller. The digital data from two opposite sensors is stored in two variables. The panel is moved accordingly so as to make the output both these variables equal.

IV. HARDWARE DESCRIPTION AND DISCUSSION

A. Sensors

We are using Four Light Dependent Resistors as a sensor. They are placed on the structure as shown in the Figure 5.4. They sense the higher density area of sun light. The solar panel moves to the high light density area through DC motors.
Each LDR is connected to power supply forming a potential divider. Thus any change in light density is proportional to the change in voltage across the LDR's.

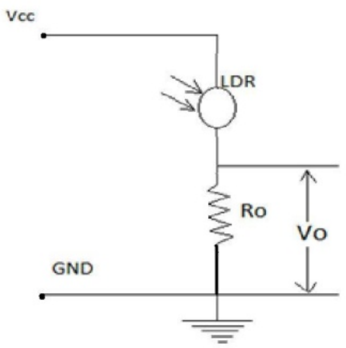

Figure 3 Sensor Circuit

LDR is a passive transducer hence we will use potential divider circuit as shown in Figure 3 to obtain corresponding voltage value from the resistance of LDR.
LDRs resistance is inversely proportional to the intensity of light falling on it i.e. higher the intensity or brightness of the light the Lower the resistance and vice versa.

B. Gimbal Structure

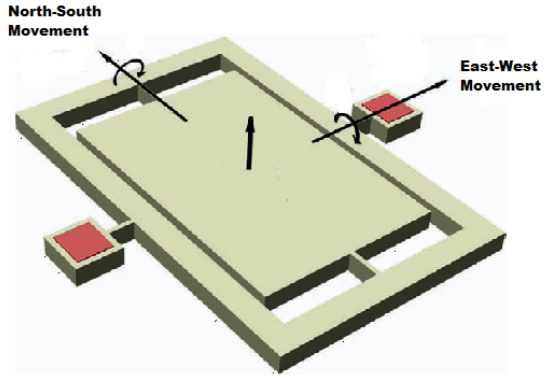

Figure 4 Gimbal Structure

Gimbal is a pivoted support that allows the rotation of an object about a single axis. A set of three gimbals, one mounted on the other with orthogonal pivot axes, may be used to allow an object mounted on the innermost gimbal to remain independent of the rotation of its support. For example, on a ship, the gyroscopes shipboard compasses, stoves, and even drink holders typically use gimbals to keep them upright with respect to the horizon despite the ship's pitching and rolling.
Such a gimbal structure is used in our prototype to hold and move the solar panel. In order to cover the entire hemisphere of sky it is essential to move the solar panel along two axes, i.e. azimuthal axis (North-South) and elevation axis (East-West) as shown in the Figure 4. Employing such a pivoted structure allows swift and power efficient movement of panel. The structure is mode so as the outer frame moves in the east-west direction and the inner frame, which is the panel itself, moves in north south direction. Adding these two motions to the structure makes it a two axis tracking system.
For minimizing the power consumed by motors, it is necessary to apply force directly to the edge of the frame which is to be moved. In order to achieve this, we have made use of a belt wrapped around the pulley which is connected to the motor. Free ends of the each belt have been tied to the frame edges so a couple gets generated providing maximum torque and thus it serves the purpose.

V. OBSERVATIONS

The observations of the output of the solar panel were taken indoors and the graph is shown in Figure 5. Following parameters are taken into consideration while noting the observations -

1. A 100 Watt incandescent bulb was used as the light source, and no spurious radiation other than from this bulb was allowed to be incident on the solar panel.
2. The distance between the solar panel and light source was kept constant at all points of time, even while changing the angle of incident radiation in steps of 10˚ or 15˚. This was achieved by tying one of the light source to the axis of the solar panel with a string.
3. The output of the solar panel was connected to a voltage divider circuit of 1KΩ and 42KΩ and the output of voltage readings were taken across the 42KΩ resistor.

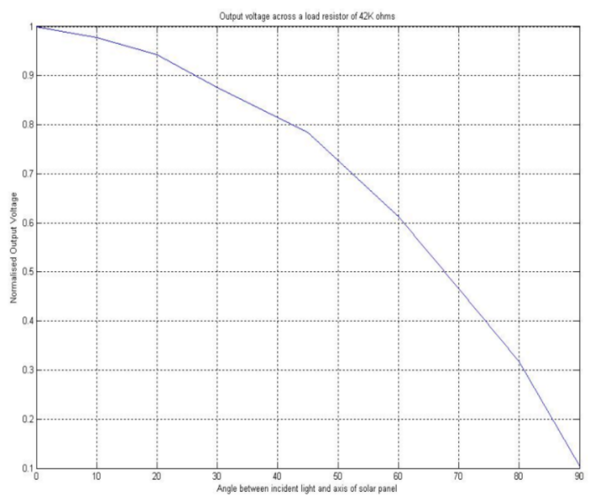

Figure 5 Plot of Normalized Output Voltage at different angles

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Figure 6 represents the data transferred from the microcontroller controlling the solar tracker apparatus to the computer, via serial port.

'a', 'b', 'x', 'y' represent the output of the 4 sensors. 'a' and 'b' represent two opposite faces of the sensor pyramid, and 'x' and 'y' represent the other two opposite faces. When the light source is more inclined towards one side of the pyramid (like in the first case where output of 'b' and 'y' are high), there is an imbalance; thus the motor is rotated to correct this imbalance.

Eventually this imbalance is corrected in a few iterations and the difference between the values on opposite faces is brought within the digital range of 20 (cases 5 to 7). Here the motor stops rotating, and the panel is correctly oriented to the light source.

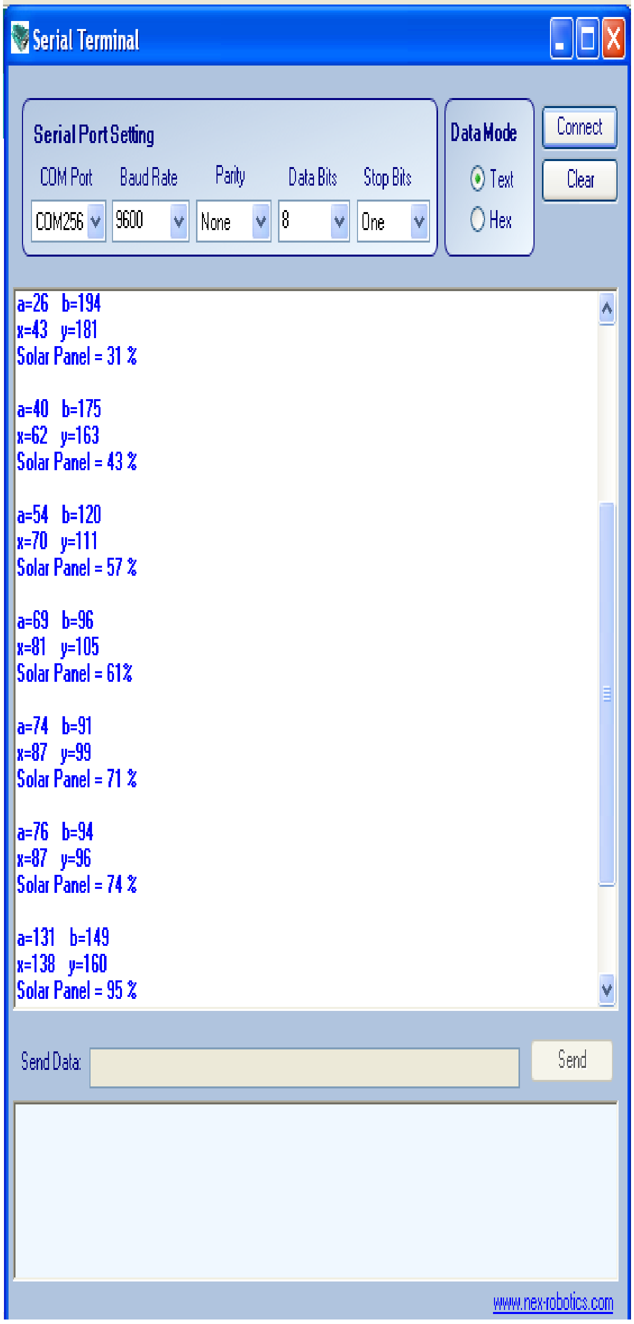

Figure 6 Digital outputs of sensors and normalized solar panel output

As seen in the observations, the output of the solar panel increases as its orientation to the light source is corrected in each iteration.

VI. ADVANTAGES OF THE PROPOSED SCHEME

The proposed scheme which works on samples of surrounding light taken after regular interval of time has an upper hand over the conventional pre-programmed trackers wherein the solar panels are moved according to the originally fed path computed by astronomical calculations. Therefore in the conditions where sun is eclipsed by clouds or hidden behind any structure such as buildings or trees, instead of pointing the panel towards sun which might not be the point of maximum light intensity in this case, the implemented tracker would position the solar panel in the direction of maximum radiation.

Moreover, the gimbal structure used for holding the panel helps in providing maximum torque to the structure, thereby making it power efficient.

In addition to that, the program is written so as to avoid unnecessary movement of solar panel because of spurious changes in surrounding light intensity. It is written so that if the microcontroller senses change in the intensity for more than a specific period of time then only the panel will be moved.

VII. APPLICATIONS

Dual axes maximum light intensity tracker finds its applications wherever single axis or fixed solar panels are used.

VIII. CONCLUSION

We successfully implemented a working prototype of two axes solar tracking system. We made use of light dependent resistors to sense the ambient light and accordingly reorient the solar panel after a regular interval of time to the point of maximum light intensity. Observations recorded using the implemented prototype gave evidence to the fact that tracking increases efficiency of the system.

Using the gimbal structure gave us freedom to use a pulley system and apply force to the end of the frame, thus minimise power consumption. In the actual product of this tracker system, the equipment can switched on only for 10 seconds every 10 minutes and on sleep mode for the remaining time. This again reduces power consumption of the tracking equipment.

Since this tracking scheme points solar panel to the maximum light intensity and makes use of non pre-programmed algorithm, the implemented system can be placed anywhere.

IX. ACKNOWLEDGMENT

The authors are thankful to the members of Akashmitra: Mr. Prabhakar Gokhale, Mr. Manoj Binhani, and Mr. Govindraj for their guidance and support.

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