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Design and Implementation of Dual Axis Solar Tracking system

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Abstract -
Solar energy is a promising technology that can have huge long term benefits. Solar cells convert the solar energy into electrical energy. Solar tracking system is the most suited technology to improve the efficiency and enhance the performance by utilizing maximum solar energy through the solar cell. In hardware development we utilize LDR's as sensors and two servomotors to direct the position of the solar panel. The software part is implemented on a code written using an Arduino Uno controller.
***Index Terms*–**LDR, Servomotor, Arduino Uno, Charge controller**.**

I. INTRODUCTION

A Solar tracker[4] is a device used for orienting a solar photovoltaic panel or lens towards the sun by using the light sensors connected with the machine using a motor, since the position of the sun varies throughout the day, hence to get maximum solar radiation at the solar panel. The main objective of a solar tracker is to tilt the solar panel in the direction of movement of the sun. This is done to ensure that the solar cell receives maximum solar energy at all times.

All tracking systems have one or two degrees of freedom depending upon the number of axes of rotation. On this basis solar trackers are classified into two categories: Single axis solar tracker and Dual axis solar tracker.

II. BACKGROUND

From solar ovens to solar panels, solar energy has been harnessed by humans since the beginning of human history. As far back as the 5th century, humans were constructing homes and buildings to maximize the energy of the sun.

As it stands, when a person wants electricity they are forced to purchase it from someone else. The average person does not have access to coal mining equipment or coal-fired power plants to make their own electricity. However, the average person does have access to the sun. Solar energy is produced by sun. It can be harnessed like any other type of energy and used to create electricity to run homes and businesses. When individuals are able to own the equipment that generates their electricity, which means, hence, they don't have to rely on fluctuating prices and, or power shortages from outside energy producers. Hence, in our project we plan to exploit the solar energy to the next degree, as it proves to be cheaper, more efficient and cleaner compared to the conventional form of energy source, Fossil fuel.

Hence, in this paper we have presented an idea which we have implemented, Active Sensor based Dual-axis solar tracker.

III. SOLAR TRACKER

A. Types of Solar Trackers

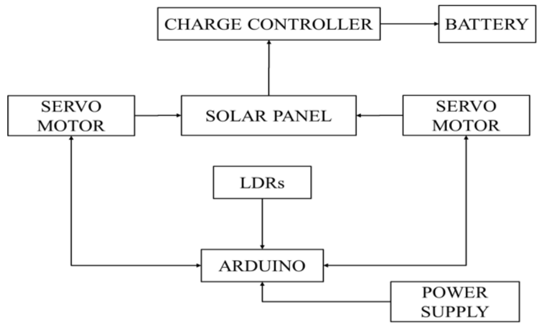
Single Axis Solar Tracker - It can pivot in only one plane – horizontal or vertical. Although the construction is less complicated it is also less effective in harnessing the total solar energy. Single axis trackers are less efficient than Dual axis trackers; the latter produces more 15% of Single axis trackers.

Dual axis solar tracker - It has two degrees of freedom that act as axes of rotation. These axes are typically normal to one another. The axis that is fixed with respect to the ground can be considered a primary axis.

The axis that is referenced to the primary axis can be considered a secondary axis. It can rotate simultaneously in horizontal and vertical directions and are able to point at the sun at all times. Due to this they are highly effective in terms of their performance. Dual axis trackers track the sun both East to West and North to South for added power output (approx. 40% gain) and convenience.

IV. DUAL AXIS SOLAR TRACKER

A. Block Diagram



Firgure1. Block diagram of the whole idea to implement an Active Dual Axis Solar Tracker.

The solar panel is initially placed flat on the mechanical structure. The panel captures the entire light incident on it and converts it into electrical energy with the help of semiconductor layers. The charge controller, connected directly to the panel, stabilizes the electrical output in order to minimize any fluctuations in the voltage and current values. The charge controller feeds the battery which is charged to its maximum potential. The Arduino [1] is responsible for all the logical calculations that are required for the system to perform as expected. A 7 or 9 Volt battery is used to power the Arduino, which takes analog input from LDRs and provides power to the servomotors [2]. Depending upon the position of the sun, the Arduino analyses the signals received from the LDRs. Depending on which of the two LDRs has more light incident on it, its resistance and hence the magnitude of current flowing into the Arduino will vary. This variation is then translated into the input signals for the motors. The servomotors, which are connected to the shaft that has the panel mounted on it, are responsible for dual-axis movement of the panel [6].

This causes the panel to tilt in the direction of the LDR offering the least resistance and thus, ensures that there is maximum light incident on the panel. This significantly increases the quantity of light energy captured and converted into electricity.

B. Software Programming of the Arduino Uno

Algorithm –

Step1: Start

Step2: Initialise all necessary inputs and outputs to zero.

Step3: Assign analog LDR outputs and PWM servomotor inputs to Arduino Uno.

Step4: If centre LDR = 0, then delay (longer).

Step5: Check alignment (Simultaneously for north-south and east-west)

Step6: If up (LDR) greater than centre and down (LDR) lesser than centre, then increase position of servomotor1 by 1 unit. Give delay.

Step7: Else if up (LDR) lesser than centre and down (LDR) greater than centre, then decrease position of servomotor1 by 1 unit. Give delay.

Step8: (Simultaneously along with step6) If right (LDR) greater than centre and left (LDR) lesser than centre then increase the position of servomotor2 by 1 unit. Give delay.

Step9: Else if right (LDR) is lesser than centre and left (LDR) greater than centre then decrease position of servomotor2 by 1 unit. Give delay.

Step10: Goto Step 5.

Step11: End.

C. Hardware Implementation of Dual axis Solar Tracker

The miniature prototype tracker was constructed using materials like Particle board, Double-sided Tape and a few cutting tools [5]. To enable dual-axis rotation, the panels were stuck onto a particle board base slightly larger in dimensions than the panels using double-sided tape. The LDRs were placed on the centres of all four sides of the board and also at the centre of the whole board. At the bottom of the base an aluminium rod was attached from the centre extending to any one of the sides of the base.

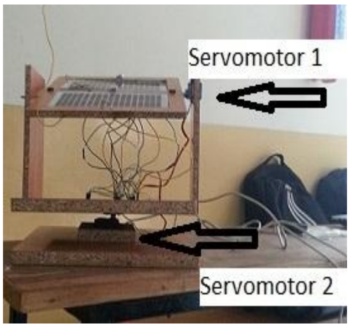


Figure2. Represents the positions of the two servomotors to enable North-South and East-West motion.

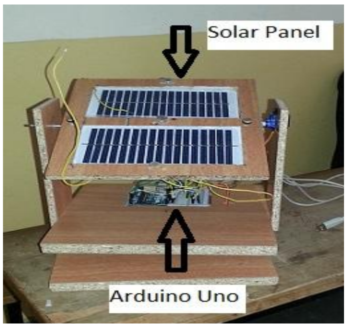


Figure3. Represents the placing of the Solar Panel and the Arduino Uno.

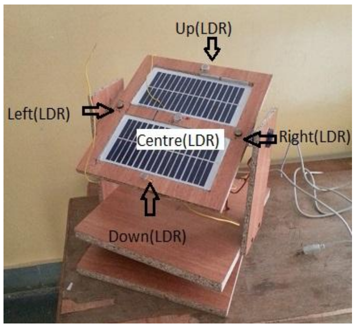


Figure4. Represents the positions of the five LDRs which give input For the servomotors to angle the Solar Panels.

On the side opposite to the makeshift shaft, a hole was made near the edge to attach the servomotor horn which would enable East-West movement of the panels. Terminals of the panel and LDRs were taken out from the bottom of the base by making holes at appropriate places. This assembly was then mounted upon another particle board base with the help of two vertical supports, one on each side. On one side, the support had a hole where the shaft would be inserted and allowed to protrude a little to ensure attachment. While the other support had the TowerPro servomotor fit onto it, the servo horn was then passed through the hole on the base to complete single axis rotation assembly. The electronic components i.e. Arduino [7] and the breadboard consisting of resistors and other pin connections were placed on the particle board base. To incorporate the second axis of rotation another servomotor (Vega V3006) was used, which rotated the whole single axis assembly. To achieve this, the servomotor was first mounted on a wide particle board base to ensure that there was enough support to keep the servomotor upright. Next, the centre of the bottom side of the particle board base was marked and double-sided tape was stuck forming a Plus sign. Then the Plus-horn was fixed to the servomotor and the motor was stuck to the base. This completed the prototype structure for our Dual-axis tracker.

D. Charge Controller

A charge controller [3], charge regulator or battery regulator is a device which limits the rate at which electric current is added to or drawn from electric batteries.

It prevents overcharging and may protect against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. It may also prevent completely draining ("deep discharging") a battery [9], or perform controlled discharges, depending on the battery technology, to protect battery life.

The charge controller is placed between the output of the solar panel and the input of the battery. When the intensity of sunlight is high the solar panel produces more electrical output, and when sunlight is less intense the output of the panel is less. Charge controller is used to stabilize the variation in electrical input to the battery [8]. It also prevents over charging of the battery thereby increasing its life span. An additional function of the charge controller is to prevent reverse current flow, especially during night times.

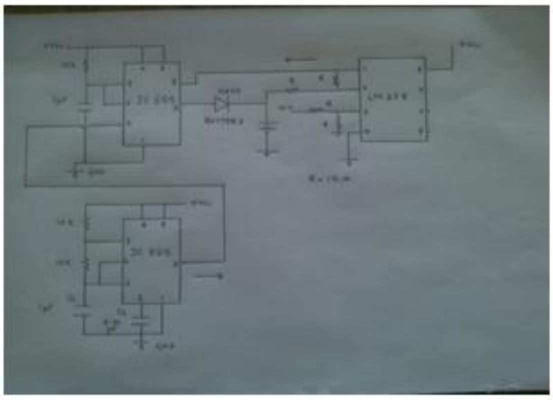


Figure5. Represents the circuit diagram of the Charge controller.

V. CONCLUSION

As dual-axis tracking generates 40% more power from each panel, you can achieve the same power output with fewer panels, frames and so on, which reduces a project's upfront costs and offsets to a great extent the additional cost for tracking hardware. On the other hand, you can use the same number of panels as originally planned and generate 40% more power and higher revenues. This reduces the project's payback time and also increases the overall return on investment (ROI), depending on the financial specifics of the project.

VI. FUTURE SCOPE

- *Fabrication of Microcontroller using ASIC concepts:* The number of wires can be greatly reduced by directly if a customized PCB is made upon which all the resistors can be directly soldered. This also eliminates the use of a Breadboard which was used to make all the external connections.
- *Mounting of the Panels:* In our design, the panels are mounted on a horizontal shaft supported strongly at both ends. We can mount the panels directly onto a motor placed at the centre of the Panel-Base in order to provide East-West movement. This reduces the weight and effective cost of the project.

VII. ACKNOWLEDGMENT

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