Dual Axis Sun Tracker

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Abstract* — the objective of this project is to develop an algorithm that improves overall realization and fidelity of the Dual - Axis Sun Tracker. An embedded sun tracking system and actual-time algorithm have evolved because of improvement in photovoltaic panel. This device work independently without any external human interference. An experimental prototype is constructed which uses closed approach and results have observed between 30-40 percent of increase in power harvesting capacity of the solar panel. *Dual axis sun tracker is capable of moving solar panel completely 180 degrees in horizontal direction and 180 degrees in vertical direction.

Keywords — sun tracker, photovoltaic, servo, performance (key words**)**

I. Introduction

Extracting electricity from sun is one of the best possible options among renewable energy resources. Subsequent development of the solar cell, which is a semi-conductive material converts sun light into a DC current. Solar array, a series of solar cells interconnected, generates a dc voltage which can be supply to load. Solar panels are especially used in remote areas where reaching of electrical lines is not feasible. But solar panel had a limitation that they were not able to generate power efficiently throughout the day [1]. The energy extracted from the photovoltaic cell or solar panel depends on intensity of solar radiation falling on panel. To extract maximum energy from the sun, the solar panel should always be normal to the incident radiation [6]. Solar tracker is a device which tracks the sun using LDR(s) and keeps the orientation of the solar panel in the direction of the sun to maximize the efficiency of power generation [3].

There are two ways to improve the efficiency of the power harvested from the sun.

1) The first way is to improve the efficiency of the solar cell by changing the doping concentration levels or width of the layers.
2) Implementing techniques to maximize the energy that can be harvested by continuously changing the orientation of the solar panel [7].

The objective is to develop a way whereby maximum power can be obtained by generating maximum voltage and current together. Solar systems and equipment such as solar panels, day lighting systems, solar collectors and solar -powered heat engines work best when they collect maximum energy from the sun [3]. Adding a solar tracker to these systems increases their efficiencies at the expense of initial and maintenance costs and system complexity. It has been observed that the use of a one or two axis solar tracking system, over a fixed solar system, can increase the energy output by 20% - 40% with cost increase of 10%-30% [3].

Solar tracker system can be categorized into two types' single axis and dual axis. Single axis solar tracker can either have a vertical or a horizontal axis. Single axis solar trackers have one actuator and therefore are simpler to control than dual axis solar trackers [4]. As there are small amount of controlled variables, it is easier to write a control algorithm for following the sun's trajectory. Fewer components also mean lower initial investment on the system [2]. Whereas when we consider dual axis sun tracker, it can work in two axis i.e. both vertical and horizontal axis. Enabling to tracker the sun all over the space surrounding the solar panel. However, due to limitations of the servo motors controlling the frame, there may left the void in the space where the tracker cannot turn itself [2].

II. Methodology

The dual axis sun tracking was made possible by mounting two frames one over another. The below frame is to adjust the panels horizontally and the above frame is to adjust it vertically. Both the frame's position were controlled by servo motors.

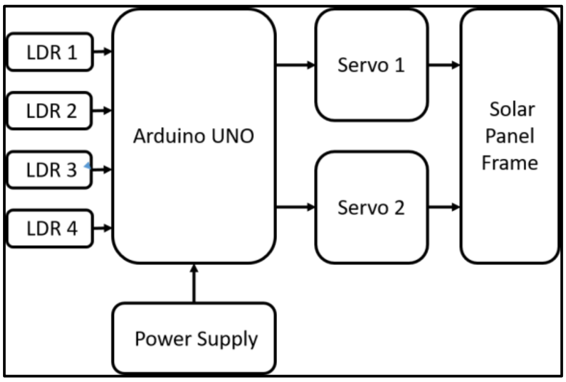


Figure 1. Block Diagram

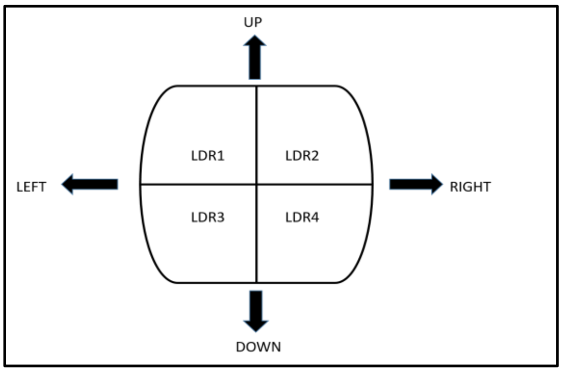


Figure 2. LDR Configuration

LDR (light dependent resistor) is selected for application of sun tracking because it is sensitive to the light. The resistance of LDR will decreases will decreases as the intensity of light following on them increases. By this we system decides where to move thee solar panel [5].

The block diagram of the dual axis sun tracker shows the Arduino microcontroller is functioning as the mind of the device, which takes input from the four LDR sensors which are acting as the eyes of the system. The four LDRs are arranged in two dimensional space such that each LDR is present in each quadrant near to the origin. Each of them are separated by walls. Walls are made such that to differentiate where the maximum intensity of light is falling and accordingly send the data to the microcontroller. Then the data is processed into the angles of servo motor and passed to them. Servo then adjust itself such that each LDR will experience the same intensity of sun light. Thus maximizing the output of the solar panel which are placed above the frame. As the solar panel will now be normal to the radiation of the sun. The microcontroller is supplied with an external power supply of 5v.

III. HARDWARE DESIGN

A. *Experimental Setup :*

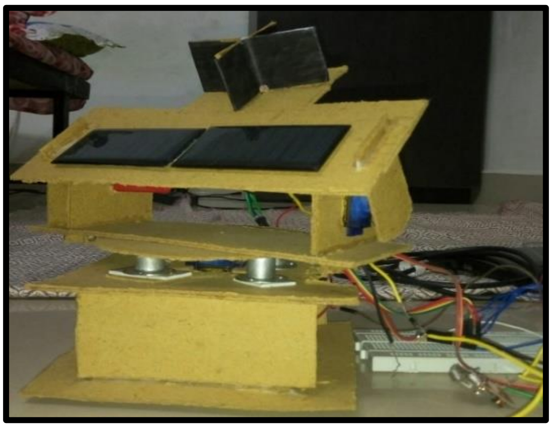


Figure 3. Experimental Setup

B. *Design Requirements :*

1) Tracking of thought the day.
2) The solar panel that will convert the radiation of the sun into electricity.
3) A base to support the solar panel.
4) A weather-resistant cover to protect the electronics components.
5) A motor to move the solar panel as the sun traverses through the sky.
6) Sensors to track the sun's position.
7) Microcontroller – To control and monitor operations. Arduino Uno is selected because it is cost efficient and easy to implement [2].

C. *Design Specifications :*

Components	Specifications
Solar Panel	2 x 6 V Model type: SBE15070
Arduino Uno	Microchip ATmega328P
Servo Motor	Torque = 2.5 kg - cm
Power Supply	5 V for Arduino
Light Dependent Resistor (LDRs)	4 x LDR 5mm (3190)
Other Material	Wires

Table 1. Components and Specifications

IV. SOFTWARE DESIGN

A. *Flow Chart :*

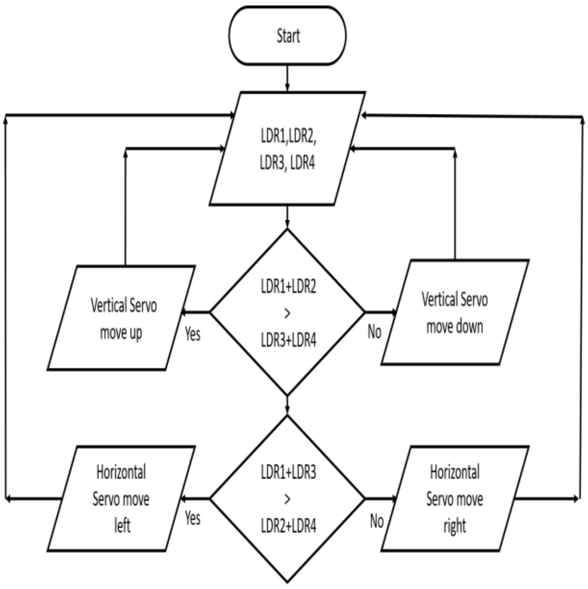


Figure 4. Flowchart

The flowchart shows that the data received by the microcontroller board from the LDRs is necessary and sufficient requirement for the working of dual axis sun tracker. Four LDRs are used namely one, two, three and four. Each of them are placed in one of the quadrant in the two dimensional plane, near to the origin. From the data of the LDRs the direction of maximum intensity of light is detected and accordingly servo motor's angle is adjusted. Two servo motor is used, one for up and down movement, that is in vertical axis and the second servo is used for right and left movement that is in the horizontal axis. When the sum of reading from LDR1 and LDR2 is greater than sum of LDR3 and LDR4 the servo sets itself in upward direction and vice versa in the other case. Similarly when sum of reading from LDR1 and LDR3 is greater than sum of LDR2 and LDR4 the servo sets itself in left direction and in right direction in the other case. This process continues and continuously the sun is being tracked [2].

V. RESULTS

The observations from results obtained in Table 2. Clearly shows that when the solar tracker was compared with static solar panel, an increase in output power of approximately 20 - 40 % was observed. However other factors also play a major role for deciding the output efficiency. Which are as follows:

A. Position of sun tracker should placed such that the minimum external obstruction occur ie no obstacle between the sun and the tracker. In that case the tracker wont we able to track the sun.

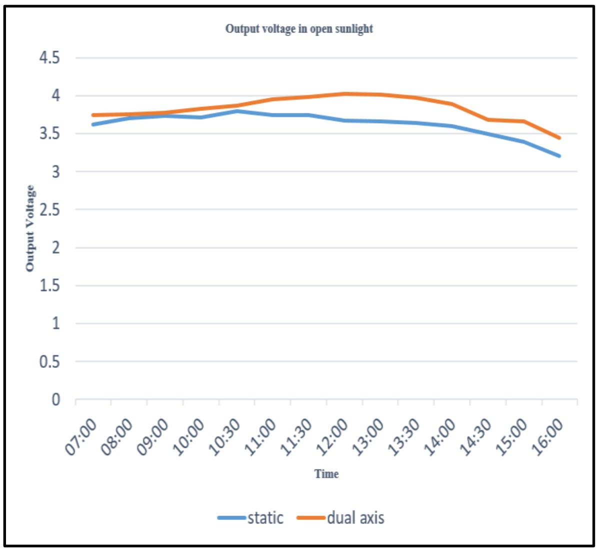
B. Trade off between implementation of Single axis and Dual axis system depends upon requirement.

C. Initial cost of implementation and maintainence cost are also considered.

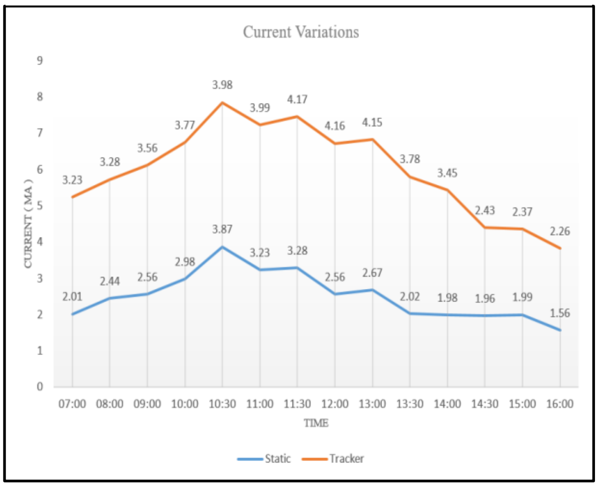
Hence, considering all parameters implementation of Sun Tracking should be done and analysis proves that efficiencies of generation of electric power has surely increased. Following data was measured on sunny day from 7:00 am to 16:00 pm evening.

Time	Static (voltage)	Current (mA)	Power (mW)	Tracker (voltage)	Current (mA)	Power (mW)	Power Gained by Tracker (%)
07:00	3.62	2.01	7.276	3.74	3.23	12.08	40%
08:00	3.7	2.44	9.028	3.76	3.28	12.333	27%
09:00	3.73	2.56	9.549	3.78	3.56	13.457	29%
10:00	3.71	2.98	11.06	3.83	3.77	14.439	23%
10:30	3.8	3.87	14.71	3.87	3.98	15.403	5%
11:00	3.74	3.23	12.08	3.95	3.99	15.761	23%
11:30	3.74	3.28	12.27	3.98	4.17	16.597	26%
12:00	3.67	2.56	9.395	4.02	4.16	16.723	44%
13:00	3.66	2.67	9.772	4.02	4.15	16.683	41%
13:30	3.64	2.02	7.353	3.97	3.78	15.007	51%
14:00	3.6	1.98	7.128	3.89	3.45	13.421	47%
14:30	3.5	1.96	6.86	3.68	2.43	8.9424	23%
15:00	3.39	1.99	6.746	3.66	2.37	8.6742	22%
16:00	3.2	1.56	4.992	3.44	2.26	7.7744	36%

Table 2. Current and Voltage Variations



Graph 1. Voltage Variations



Graph 2. Current Variations

VI. Conclusions

We have concluded that the dual axis sun tracker is efficient than the regular solar panel system, as it provides 20-40% of more power than the latter. However we need sufficiently enough power to run the motors and simultaneously supply power for load consumption.

However we now need to find new ways to control array of solar panels using very few motor and gears so that this dual axis sun tracker can be implemented for future solar power plants for a better and greener future.

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References

[1] S. Gupta et al., "Maximum Power Point Tracking for Solar PV System", Applied Mechanics and Materials, Vols. 110-116, pp. 2034-2037, 2012

[2] Instructables. (2017, October 10). Simple Dual Axis Solar Tracker. Retrieved from https://www.instructables.com/id/Simple-Dual-Axis-Solar-Tracker/.

[3] Engin, M., & Engin, D. (2013). Optimization mechatronic sun tracking system controllers for improving performance. *2013 IEEE International Conference on Mechatronics and Automation*. doi:10.1109/icma.2013.6618069.

[4] Ponniran, A., Hashim, A., & Munir, H. A. (2011). A design of single axis sun tracking system. *2011 5th International Power Engineering and Optimization Conference*. doi:10.1109/peoco.2011.5970440.

[5] Kumar, V. S. (2011). Automatic Dual Axis Sun Tracking System using LDR Sensor. *International Journal of Current Engineering and Technogy, 4*(5), 3214-3217. doi:10.14741/ijcet/4/5/2014/22.

[6] F. I. Mustafa, A. S. Al-Ammri and F. F. Ahmad, "Direct and indirect sensing two-axis solar tracking system," 2017 8th International Renewable Energy Congress (IREC), Amman, 2017, pp. 1-4.doi: 10.1109/IREC.2017.7926026.

[7] Yan, Z., & Jiaxing, Z. (2010). Application of Fuzzy Logic Control Approach in a Microcontroller-Based Sun Tracking System. *2010 WASE International Conference on Information Engineering*. doi:10.1109/icie.2010.134.