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Single Axis Solar Tracking with LDR

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Abstract: With the increasing focus to use sun as the source of energy, to not only substitute the use of fossil fuels as primary energy sources but also to reduce pollution in the environment, it is of utmost importance that solar energy be tapped at the highest efficiency possible. As we know the efficiency or output of the solar panel depends on the material from which they are made and the amount of exposure they experience from the sunlight. Currently, the materials used to make the solar panels are not highly efficient and the research is still going on in that area so it is essential that we make the solar panel face maximum radiation possible from the sun throughout the day, to receive maximum amount of energy and operate as close to its standard working condition as possible. The following research paper is an attempt to showcase the phenomena of LDR based tracking in order to do the same.
Keywords: Solar Tracking, LDR, Efficiency

I. INTRODUCTION

Solar Trackers are systems that are used to track or follow the sun as it moves its cycle of east to west through the day. The basic aim behind solar tracking is to orient the solar panels in such a manner that it is facing the sun in a normal direction. As such the sun rays falling directly on the solar panels are uniformly distributed on its surface and at any point of time all the solar cells with which the panel is composed off are completely exposed to sunlight and so all of them are giving the electrical output. On the contrary, when the solar panels are stationary the sun rays fall on it at different angles throughout the day and only once throughout the day is it normal to the solar panel surface, so it is able to work at its maximum efficiency for a limited period of time in a day. This leads to not only inefficient utilisation of the solar energy but also of the solar panel technology.

There are many ways to track the sun. Light Dependent Resistors or Photo Resistors commonly known as LDR's are one such method to do the solar tracking. LDR's are variable resistors whose resistivity changes on being exposed to sunlight. In LDR based tracking system a fin or thin sheet would be placed half way through the solar panel. During different time of the day sun ray's would fall on the solar panels at varying angle of incidence, hence due to the fin one particular side would have comparatively more sunlight as compared to the other. Therefore, the LDR's attached linearly across the solar panels (either the north-south axis or the east-west axis) experience different amount of exposure to sunlight so they give different resistivity and correspondingly different electrical output to the microcontroller to which they are attached, as such the micro-controller would work according to the manner in which in which it is programmed and orient the solar panels in such way that there is no differential output from the LDR circuit, therefore indirectly it orients the panels because only when the panels would be normally exposed to the sunlight would both the LDR's give equal electrical output. Hence change in resistivity is the basic principle behind which a LDR based solar tracking system works.

In order to exhibit the need to track the sun and percentage of direct power of sun lost due to misalignment of solar panel with the sun we have the following relation and corresponding table.

$$Lost\ Power\ = 1 - cos(angle\ of\ incidence)$$ [9]

Table 1: Loss of Power with respect to Angle of Incidence [9]

Angle of Incidence	Hours at misalignment	Percentage Power Lost
15°	1	3.4 %
30°	2	13.4 %
45°	3	30%

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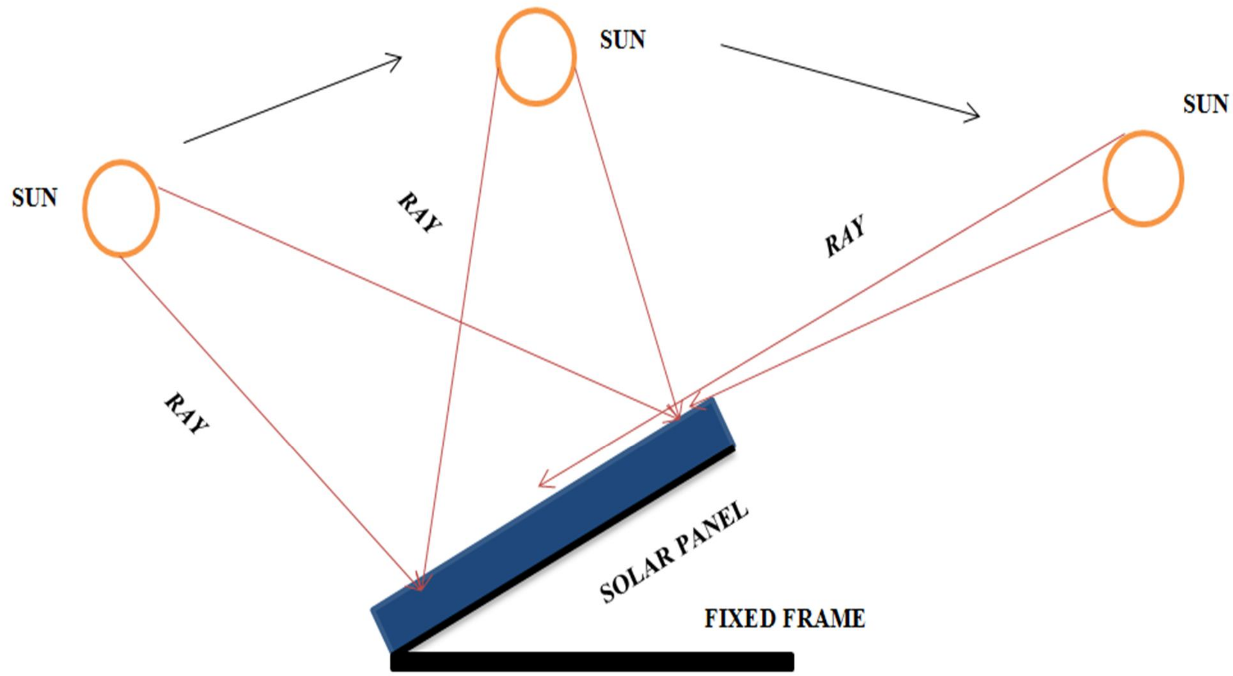

Fig 1: Sun Incident at various angles throughout the day for a stationary solar panel

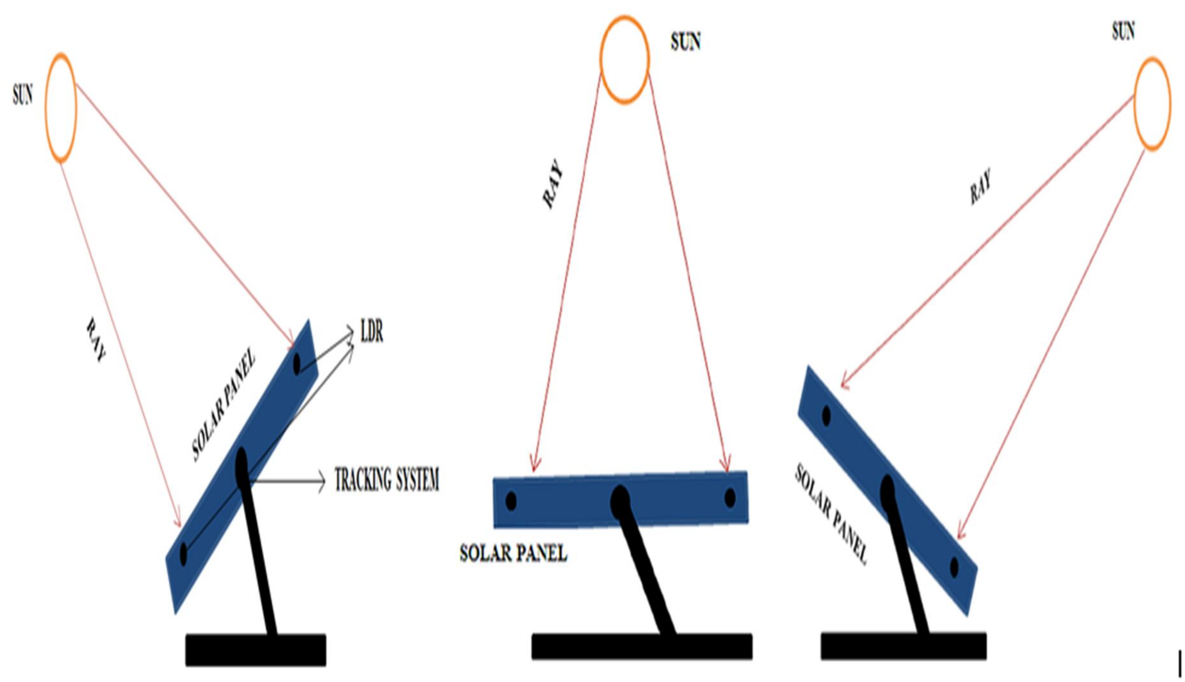

Fig 2: Sun is always normal to the Solar Panel with a Tracking System.

Fig 1 exhibits that when the solar panel is fixed then the rays of the sun, as it moves from the east to west through the day, would be incident at varying incidence angle and only once during the noon or depending upon the inclination of the solar panel would it give a normal angle of incidence to the solar panel surface, where we would receive maximum tapping of solar energy, hence throughout the day we would have to account for the loss of direct sunlight received from the sun.

Fig 2 shows that if a tracking system is in place with the sun then during different time of the day the panel would follow the sun and it will ensure that the angle of incidence of the sun is always normal to the solar panel surface.

II. CLASSIFICATION OF SOLAR TRACKING

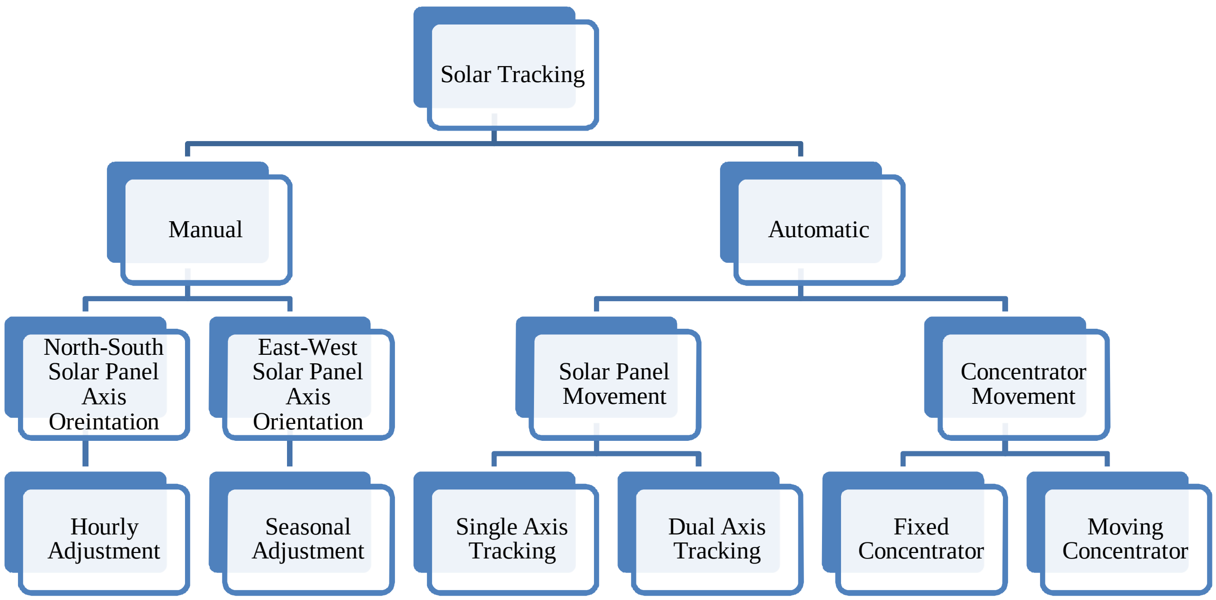

Fig 3: Classification of Solar Tracking.

III. LDR BASED SINGLE AXIS SOLAR TRACKING

This type of solar tracking is based upon the differential electrical output of the LDR's, given to the microcontroller in order to track the sun. In order to do the single axis LDR based solar tracking we would require the following components.

1) Light Dependent Resistor
2) Analog to Digital Convertor
3) Micro-controller with Program to drive it.
4) Motor Driver
5) Stepper Motor

A. Light Dependent Resistor

These are photo resistor who resistivity changes in accordance with the exposure to sunlight. They have inverse relation with respect to the exposure where if the sunlight would fall on it then the LDR's resistivity would decrease to a few ohms else there resistivity would increase to a few kilo ohms. A resistor is added in series with these LDR's which would convert the output signal of LDR's in terms of resistance to voltage which would form the bases of input of the microcontroller.

B. A/D Convertor.

Since the output of the LDR is in analog form whilst the microcontroller works on the digital input hence it is essential to do the conversion from analog to digital. The analog to digital convertor would compare the voltages of the 2 LDR's with the help of OPAMP comparator circuit and would give a differential output to the microcontroller.

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C. Microcontroller.

It is basically a programmable silicon chip which can perform the task of input output has its own separate memory and can assess and apply the logic itself. It is a computer on a single chip. The microcontroller in the following task would be fed with a certain logic that cause it to give the excitation electrical signal to the motor driver till it receives a differential input from the A/D convertor. The differential input would only stop when the motor orients the solar panel in such a manner that both the LDR's would receive same amount of sunlight.

D. Stepper Motor Driver

The maximum output current given by the microcontroller is of the order of milliampere; hence a Motor Driver is used between the microcontroller and the stepper motor which would provide the motor with the required amount of current for excitation of motor windings.

E. Stepper Motor

The stepper motor rotates in a series of steps, thereby at various instances the angle between the sun and the solar panel is different, until an instant where the amount of sunlight received by the two LDR's is same and hence no differential output is received by the microcontroller and hence it does not give an output to the stepper motor driver.

F. Power Supply

In order to give power to the microcontroller and the driver circuit it is necessary to give the external power supply. The power supply is known as regulated power supply and it contains a voltage regulator and bridge rectifier circuit in order to give the rectified voltage in the range of 5V-12V for a typical microcontroller as well as a capacitor which would filter out any unwanted signal in the input supply so that the functioning is without jerks.

Fig 4: Block Diagram for the Single Axis LDR Based Solar Tracking.

The above block diagram shown in figure 3 clearly shows the manner in which the system would work where the analog output of the LDR would be given to the Analog to Digital convertor which would in turn the give the digital input to the microcontroller. The digital output of the microcontroller would be given to the Stepper motor driver which would be used to drive the stepper motor in discreet steps as required by the solar panel for the time of the day and that is how it will remain at normal to the sun at all hour.

IV. MICROCONTROLLER PROGRAM FLOWCHART

The programming of the Microcontroller is based on the differential digital input that it would receive from the A/D convertor. If the differential input value is greater than the threshold value (in the following flowchart represented as 'thr') then the microcontroller will excite the stepper motor winding in such a manner that it would cause the motor to rotate towards the reference LDR (in our case we have LDR1) else if the value of differential input would be less than the threshold value then the microcontroller will cause the rotation of the stepper motor opposite to the reference LDR of the system. If either cases aren't satisfied then that means that the solar panel is normal to the sun and both the LDR's face equal amount of sun rays, and there is no need to give excitation signal.

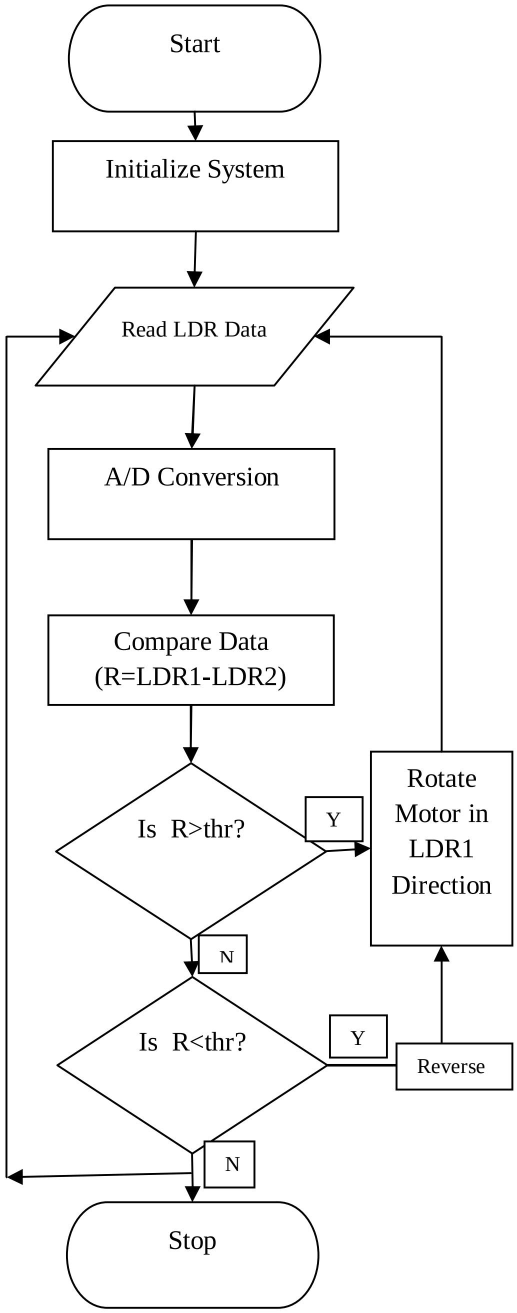

Fig 5: Flowchart for Microcontroller programming

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V. ADVANTAGES

1) Increases average voltage output of solar panel as compared to the fixed panel.
2) Helps in protecting the solar panel from dirt.
3) Greater amount of electrical output throughout the day.

VI. RESULT & DISCUSSION

The designed prototype was tested with the help of a mobile flash light in the laboratory. When the flash light was started from the east direction where LDR1 was placed the comparator differential output was found to be positive and greater than the threshold value. As we moved from east to west, than the comparator output value kept decreasing until a point where output of the comparator was zero, at this point the flashlight was normal to the solar panel. As we moved further west we saw that the comparator output started increasing in the negative direction. In the prototype PIC16F676 was used as microcontroller, OPAMP was used as comparator, ULN2003 was used as stepper motor driver and 28BY J-48 DC 5V Stepper Motor was used.

VII. EXPERIMENTAL RESULT

Table 2: Output Voltage and Current for a Fixed and a Tracking Solar Panel.

Time	Fixed Solar Panel		Tracking Solar Panel	
	Output Voltage (Volts)	Output Current (Ampere)	Output Voltage (Volts)	Output Current (Ampere)
8.00 hrs	18.8	0.21	19.1	0.37
9.00 hrs	18.9	0.45	19.5	0.47
10.00 hrs	19	0.48	19.9	0.51
11.00 hrs	19.4	0.50	20.1	0.53
12.00 hrs	19.8	0.52	20.8	0.56
13.00hrs	20.2	0.51	20.4	0.55
14.00hrs	20.1	0.50	20.5	0.53
15.00 hrs	17	0.43	18.5	0.49
16.00hrs	14.7	0.37	15.3	0.42

We know that Output Power of DC equipment is given as:

$$Pout = Voltage * Current \qquad ..... (1)$$

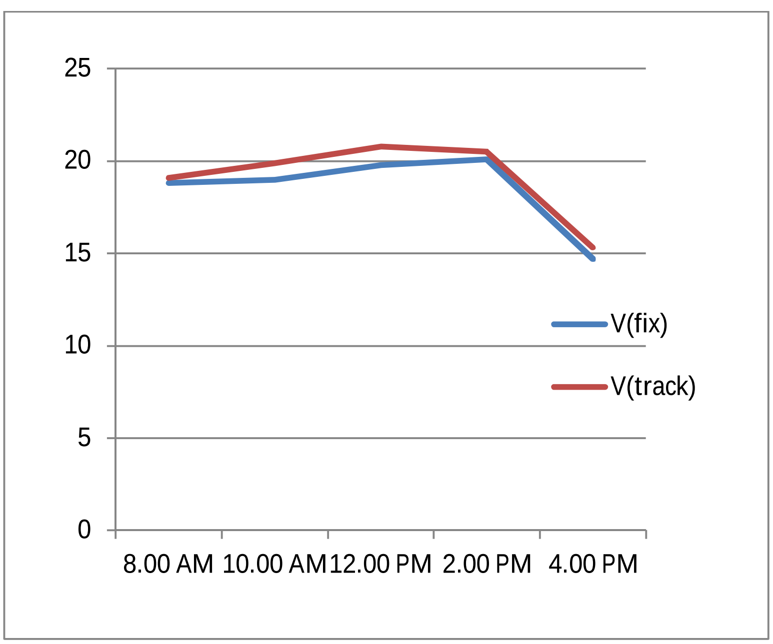

Fig 6: Comparison of Voltage O/P between fixed solar panel and tracking solar panel.

The above line graph representation in Fig 6 shows comparison between output voltage of a fixed solar panel (Vfix) and a tracking solar panel (Vtrack), at every 2 hrs interval shown on X-axis and Vout in volts on the Y-Axis.

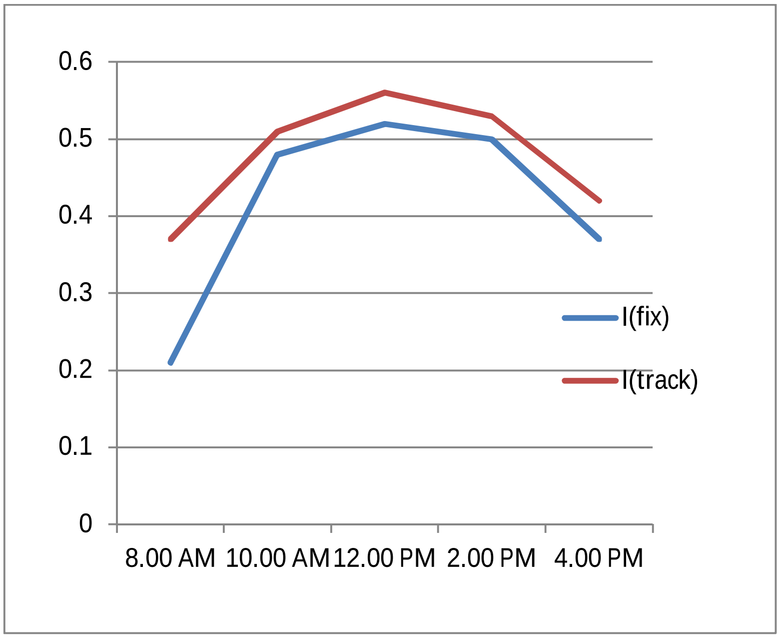

Fig 7: Comparison of Current O/P between fixed solar panel and tracking solar panel.

The above line graph representation in Fig 7 shows comparison between output current of a fixed solar panel, I(fix), and a tracking solar panel, I(track), at every 2 hrs interval shown on X-axis and Iout in Amperes on the Y-Axis.
To calculate percentage increase in the power output due to the tracking solar panels with respect to fixed solar panels we have the following formula:

$$\left(\left(\frac{Power\ Output\ of\ Tracking\ Solar\ Panel}{Power\ Output\ of\ Fixed\ Solar\ Panel}\right) - 1\right) * 100$$

.... (2)

We use the eqn (1) and eqn (2) to draw the table 3 as follows:

Table 3: Percentage increase in Pout due to tracking solar panels at different times of day

Time	Pout of Fixed Solar Panels	Pout of Tracking Solar Panels	% age Increase in Pout
8.00 hrs	3.948	5.1	29.1%
9.00 hrs	8.5	9.16	7.05%
10.00 hrs	9.1	10.14	11.4%
11.00 hrs	9.7	10.653	9.8%
12.00 hrs	10.296	11.648	13%
13.00 hrs	10.302	11.22	8.9%
14.00 hrs	10.05	10.865	8.1%
15.00 hrs	7.31	9.06	24%
16.00 hrs	5.439	6.426	18%

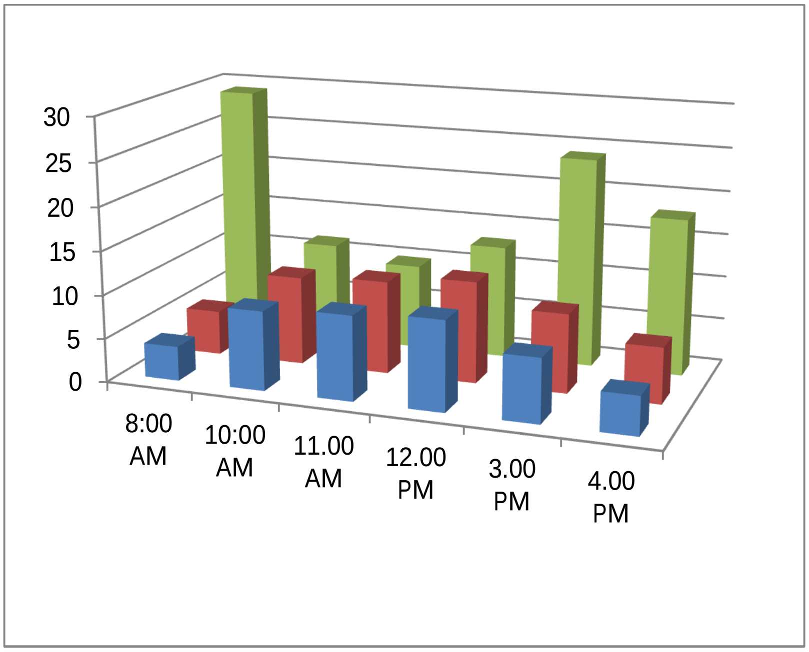

Fig 8: Bar Representation of % increase in Pout

*Blue bar represents Power Output due to fixed panels.
**Red Bar represents Power Output due to Tracking Solar Panels
***Green Bar represent percentage increase in Pout when using tracking solar panels.

From the above representation it is quite easy to infer that tracking solar panels can significantly increase the power output of a same solar panel that was previously fixed, quite significantly. It is important to note from Table 3 and Fig 6 that maximum increase in solar output is during those time of the day when the solar radiation would be typically less such as 8.00 AM, 3.00 PM and 4.00PM. Considering a solar panel technology which would generally give a nearly 30% efficiency a 10% or greater increase in the power output is quite a significant increase.

Table 4: Single vs Dual Axis Solar Tracking.

Parameter	Single Axis Tracking	Dual Axis Tracking
Tracking Axis	1 axis (Generally east-west)	2 Axis
Efficiency	Less	More
Hardware and Program Complexity	Less	More
Operational Wear & Tear	Less	More
Life Span	More	Less
Reliability	More	Less
Suitability	For equatorial climate with bright sunny days.	For bright sunny as well as cloudy days.
Cost	Less	More

As shown in the table 4 both the single and the dual axis has its share of advantages and disadvantages, in fact dual axis has greater efficiency, but owing to the lesser cost in designing the single axis tracker, not very major changes in the output of the solar panels due to two trackers in northern parts of the country experiencing bright sunny days and that depending upon the seasonal variation we can manually orient the solar panel due north during the summer and south during winter every 6 months with minimal fuss, we chose to design single axis tracking system.

VIII. CONCLUSION

The designed prototype was tested and was able to track the sun with the help of the circuit. On measuring the output voltage and current under fixed and tracking conditions significant changes were seen for the two cases. The solar tracking could work irrespective of the weather conditions. The threshold voltage value of the comparator can be adjusted according to our needs. A extra logic was added which made the solar panel reset to its original position, once it had reached its maximum west sided position so that it would start at its original east facing position during the morning. However this was a small prototype and only one dimensional tracking was taken into consideration which would vary the output with respect to practical conditions. We would aim to increase the dimensional movement of trackers in the future.

IX. ACKNOWLEDGEMENT

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REFERENCE

[1] "Microcontroller based Solar Tracker system using LDRs and Stepper Motor" by Shreyasi Chakrabory, Nilanjana Mukherjee, Rashmi Biswas, Tanushree Saha, Astika Mohinta, Neha Kumari Modi, Dip Prakash Samajdar ECE Department, Heritage Institute of Technology, Chowbaga Road, Anandapur, Kolkata-700107
[2] "Sun Tracking System with Microcontroller 8051" by Syed Arsalan International Journal of Scientific & Engineering Research, Volume 4, Issue 6, June-2013 2998 ISSN 2229-5518
[3] Anuraj, A.,and Gandhi R., 2014, Solar Tracking System Using Stepper Motor, Intl. J. Electronic & Electrical Eng., Vol.7 , 561
[4] Chhatwani, P. K., and Somani, J. S., 2013, Intelligent Solar Tracker System Implemented On 8051 Microcontroller, Intl. J. Eng. Trends Technol., Vol 4, 4267.
[5] Saxena, A. K., and Dutta, V., 1990, A versatile microprocessor based controller for solar tracking, Photovolt Specialists Conf., 21st IEEE Proc.
[6] Nirmal, H. B., and Naveed, S. A., 2013, Microcontroller Based Automatic Solar Power Tracking System, Intl. J. Electrical Eng. & Technol., Vol 4, 109.
[7] Tudorache, T., and Kreindler, L., 2010, Design of a Solar Tracker System for PV Power Plants, Acta Polytech. Hung., Vol 7, 23.
[8] Barsoum, N., and Vasant, P., 2010, Simplified Solar Tracking Prototype, Global J. Technol. Optim.,Vol. 1, 38.
[9] http://en.wikipedia.org/wiki/Solar_tracker#Non-concentrating_photovoltaic_(PV)_tracker