DEVELOPMENT OF DUAL SOLAR TRACKER FOR INCREASED ELECTRICITY GENERATION

Abhijit Kumar Bhagat[1] M C Chattopadhyay[2]
Research Scholar[1] Research Coordinator[2]
Chandradeep Solar Research Institute, Kolkata, India

Abstract: A conventional energy resource is limited and causes environmental pollution, so the world is focusing on renewable energy resources, particularly solar energy. Conversion of solar radiation into electricity by a solar module has limited efficiency and also costly. A Solar tracker tracks the Sun more efficiently and maintains a solar module perpendicular to the sun's rays throughout the day, hence it increases the electricity generation and reduces the cost in terms of number of modules needed. In this research paper, by using light sensors and comparators, a solar tracker is designed. Here the solar tracking systems tracks the Sun using Light Dependent Resistors (LDR) and then actuate the DC motor to position the solar module where it can receive the maximum sunlight. Instead of using complex controlling system and programming like other trackers, a simple tracker is designed which is cost effective and increases electricity generation.

***Index Terms**:* Solar tracker, Light Dependent Resistors (LDR), DC motor, Comparator, Power Amplifier.

I. INTRODUCTION

Energy is an important factor for the development of any country. Huge amount of energy are consumed daily in the world, and almost 80% to 85% of energy produced by fossil fuels. Since the fossil fuels are limited and it causes environmental pollution, the world wants to shift towards the renewable source of energy to provide a sustainable power production and clean energy generation. At now there is a growing demand for energy from renewable sources like solar, wind, geothermal and ocean tidal wave.

Solar cell directly converts solar radiation into electrical energy. The angle between a solar panel and the sun affects the efficiency of the panel, that's why the solar trackers are used.

In this undertaken project, by using comparator and light sensors, we track the sun position and motor is actuating which control the solar panel to obtain the desired output position. By using the comparator, compare the output of two light sensors, and the output of the comparator can amplify by using the power transistor or power amplifier to drive the DC motor, which moves the solar panel.

Here Light Dependent Resistor (LDRs) are used as sensor which sense sun's position and according to the output of sensor the stepper motor rotates clockwise and anticlockwise.

II. LIGHT DEPENDENT RESISTOR

Light Dependent Resistor (LDR) is the most commonly used optical sensor. Here the solar tracker system uses two LDR for sensing the sun position. LDR is a passive sensor whose resistance is inversely proportional to the light intensity fall on it. Here the LDR is placed in series with another resistor. A voltage divider circuit is formed and at the junction between photo resistor and resistor the output is taken as the input to comparator.

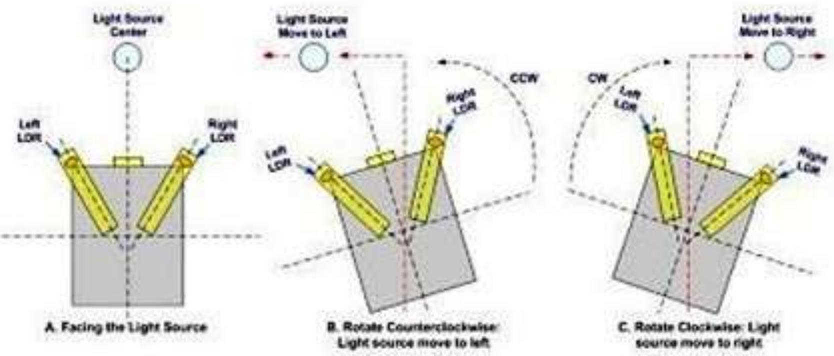
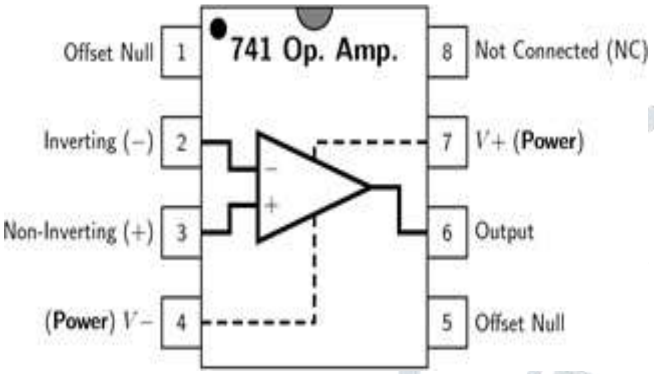


Fig.1: Tracker sensing the position of sun by using two LDR [2].

Here two LDRs are used for sensing the position of sun. The stable position for the system is that when the light intensity falls on two LDRs are same. When the source i.e. sun moves from east to west, the light intensity falling on both LDRs changes and this change is calibrated into voltage. The changes in voltage are compared by comparator and output of comparator control the motor rotation clockwise or anticlockwise.

a. Comparator

Comparator is an electronic device which compares the two voltages that which one is high and which one is low voltage according to that the output voltage or waveform will be generated. The simple comparator circuit is design by using OPAMP. An operational amplifier or OPAMP is DC-coupled high-gain electronic voltage amplifiers with a differential input and a single output. OPAMP have two input terminals one is Inverting and other Non-Inverting.



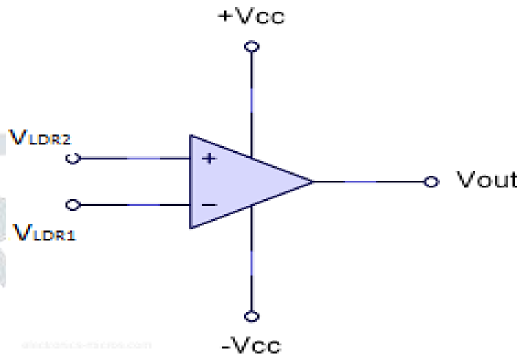


Fig.2: Pin configuration of IC 741 Fig.3: OPAMP used as comparator

IC 741 is used as OPAMP. It has 8 pin, two power supply pin 7 and 4. Pin 7 is $+V_{cc}$ and $-V_{cc}$, two input pin 2 and 3 used named as Inverting and non-inverting respectively. Whatever voltage given to input signal pin the difference is amplified and output voltage generates at pin 6. Pin 1 and 5 are offset null which use to minimize ht error of the opamp IC.

In this project the OPAMP used for designing the comparator. In the comparator circuit the input voltage applied to the Inverting (-ve) and Non-inverting (+ve) are compared. If the both terminal voltage are equal the output will be 0V. If the +ve terminal voltage large compare to –ve terminal voltage the output will be $+V_{sat}$, i.e. positive saturation voltage. And if the -ve terminal voltage large compares to +ve terminal voltage the output will be $-V_{sat}$, i.e. negative saturation voltage.

b. DC Motor

Since DC motor easy to use, in this project 12V, high torque, low speed (3rpm) DC motor use to position the solar panel at the desired location to get the maximum intensity light on the panel. Here DC motor is used with gear system, gear is used for the reduction of speed, since the used motor is low speed motor but it again speed required to reduce. Gear also used for the load distribution so the load on the motor is reduced.

III. OPERATION OF THE SOLAR TRACKER

This project designs the dual axis tracker. It is easy to design and cost effective. Sun rise from east and set in the west in the day time. For achieving the maximum efficiency of solar tracking system, the solar plate rotates from east (left) to west (right) as shown in fig.1, since the sun moving from east to west in the day time. The position of the sensor placed in the system is shown in fig.4. Sun has also small movement in south and north which is the seasonal movement. This movement is recognized by sensor 3 and sensor 4 as shown in fig.4. Here by circular rotating of the panel, it is placed at the desired position for the seasonal movement to get maximum electricity across the output.

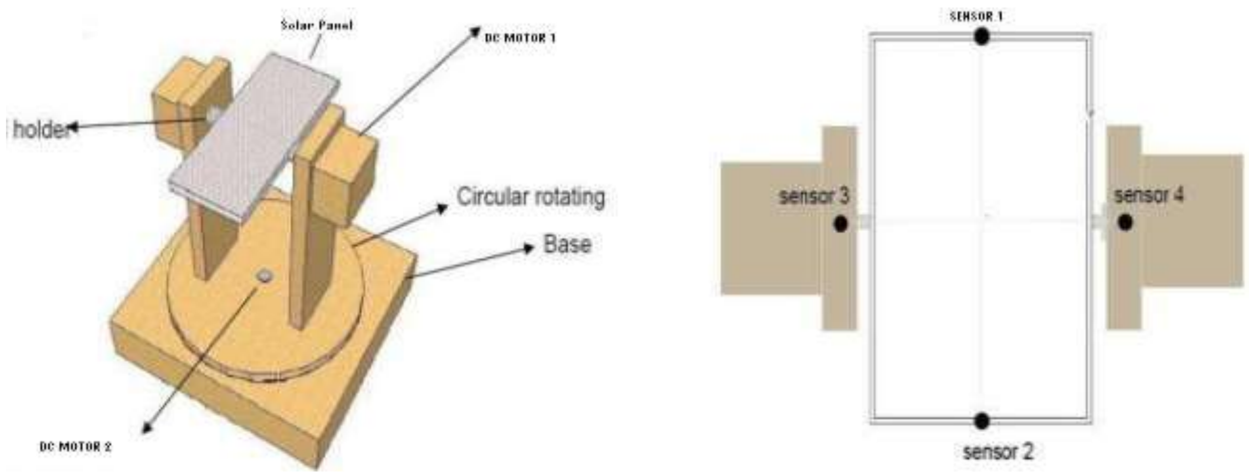


Figure 4: Model for Dual Axis Tracker [4]

When the sun light fall on Light Dependent Resistors (LDR) the resistance of the LDRs will be change and corresponding to that its voltage will be change. These change voltage due to LDRs are the input to comparator. Here two comparator circuit is use one for tracking the daily movement of sun and other for the tracking of seasonal movement of sun. LDR1 is placed at the East position of plate and LDR2 placed at West position of plate. When sun light fall on the sensor its resistance will be change. The LDR who get high intensity light, the resistance of that LDR increases more and the output is high. Now output of both LDRs are the input to comparator. LDR1 output is connected to '–ve' terminal of OPAMP and LDR2 output is connected to '+ve' terminal of OPAMP.

Here OPAMP IC power supply pin is connected to either ±15V or ±12V power supply. And we can generate the across the output pin in the range of +14V to -14V.

If, $V_{LDR1} > V_{LDR2}$ then dc motor & tracking system rotates clockwise direction.
If, $V_{LDR1} = V_{LDR2}$ then motor stop, the system is in stable condition and the solar plate is at static.
If, $V_{LDR1} < V_{LDR2}$ then motor & tracking system rotates anticlockwise direction.

In this project dc motor is used with gear system which is connecting with the output of comparator which shows the control of the tracking system. Here in this design there should be a power amplifier or power transistor to be used for generate large power for driving the DC motor. The output of the comparator is input to the power amplifier and output of it is connected to DC motor. DC motor rotates the solar panel to make it at right position for high electricity generation.

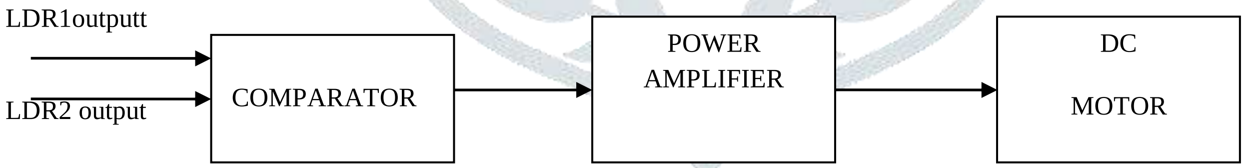


Fig.5: Block diagram of solar Tracking system

Similarly LDR3 and LDR4 generate the output for the south and north movement of sun which is the seasonal movement.

At the night we can shut down the system. And at the morning the system is on and it work automatically.

Fig.6:- Field experiment

FLOWCHART

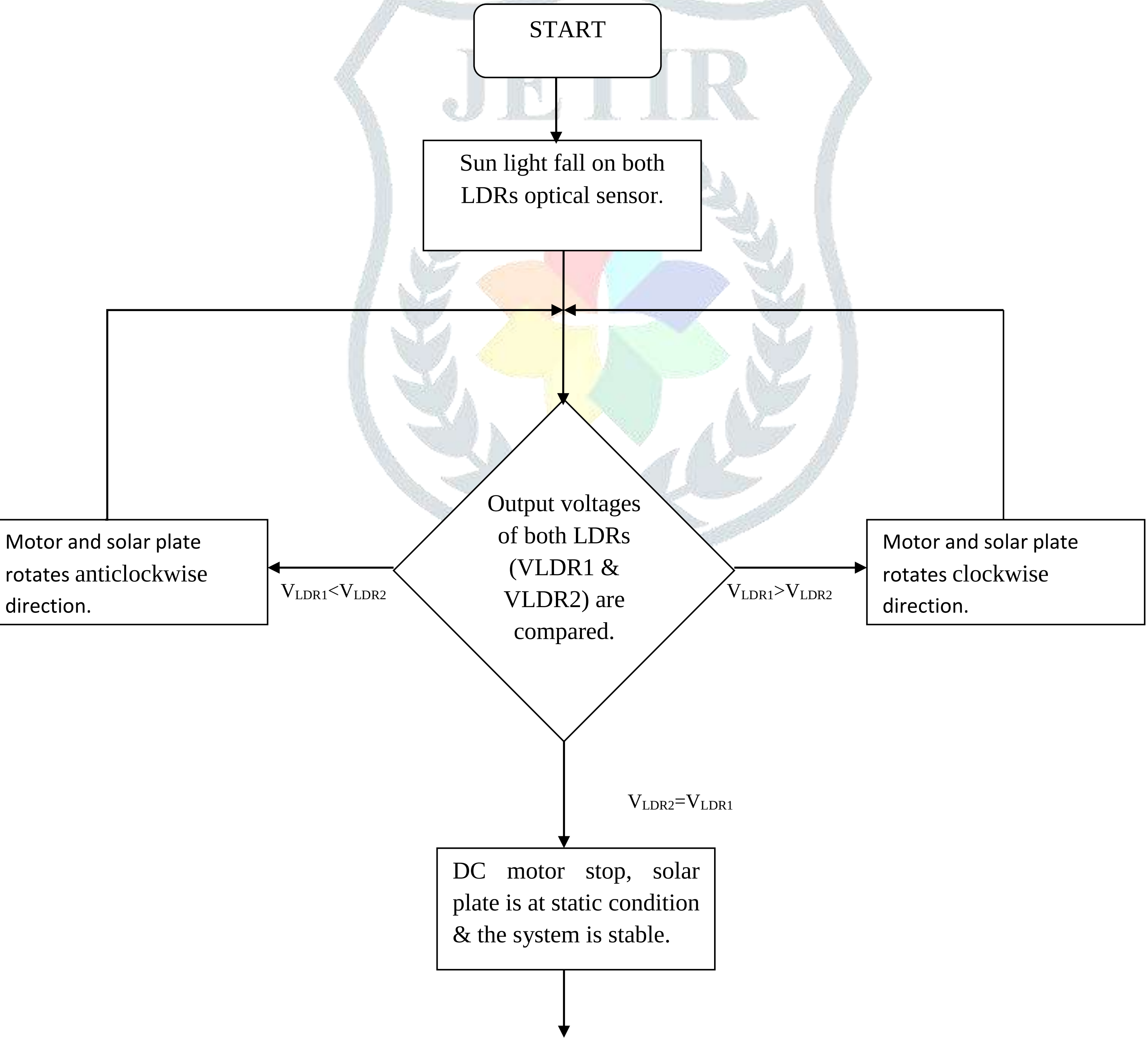


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Fig.7: Flow chart of operation

IV. COMPONENT REQUIRED

Sl. No.	Component Name	Specification	Quantity
1	Solar Panel	Vikram solar, Eldora 40P	2
2	LDR	GM 9516	4
3	Multimeter	Excel, A830L	1
4	Solar Meter	Solar Power Meter, TM-206	1
5	Resistor	¼ w, 1KΩ	2
6	Potentiometer	20k pot	2
7	Opamp	IC741	2
8	DC Motor	12V, Low speed (3rpm), high torque.	2
9	Mechanical Base		2
10	Connecting Wire	1mm	As required
11	Power transistor	TIP 31	2
12	Power transistor	TIP 32	2
13	Diode	IN4007	4

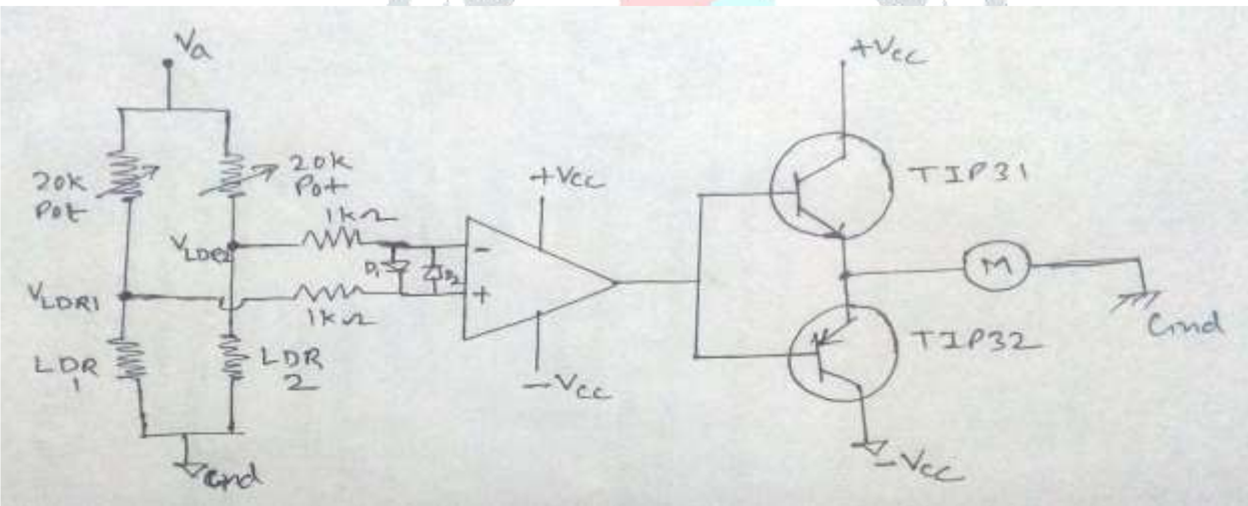


Fig.8: Circuit diagram of tracking operation

V. CIRCUIT OPERATION

When the sun light is fall on LDR, the LDR resistance changes.

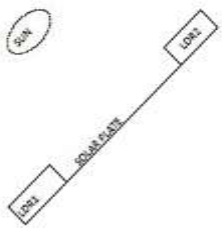
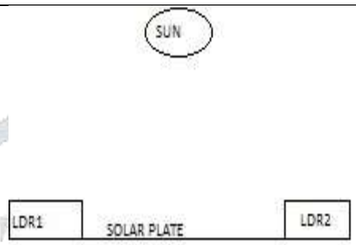
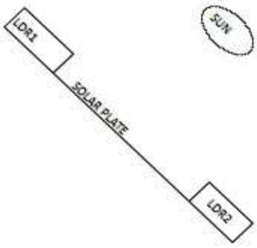
From fig.7 when LDR1> LDR2 then $V_{LDR1}>V_{LDR2}$, and the output of the opamp is $+V_{sat}$, then the transistor TIP31 is on and TIP32 is off and motor rotate clockwise.

When LDR1= LDR2 then $V_{LDR1}=V_{LDR2}$, and the output of the opamp is zero, then the transistor TIP31 and TIP32 both are off and motor stop and the solar plate is at static condition.

When LDR1< LDR2 then $V_{LDR1}<V_{LDR2}$, and the output of the opamp is $-V_{sat}$, then the transistor TIP31 is off and TIP32 is on and motor rotate anticlockwise.

Similar process is happen for south and north movement by the LDR3 and LDR4.

Hence as per the movement of sun from east to west the solar plate moves for facing the maximum intensity light throughout the day.

Time	**Stepper motor movement**	**Solar Plate Position**
Morning	Rotates anticlockwise	
Noon	Rotates clockwise	
Evening	Rotates clockwise	

VI. RESULT

In this experiment the solar tracker is designed and its output is compared with the fixed solar panel. This experiment performed for seven days from 25th April, 2017 to 1st May, 2017 at Nabagram colony, near Kolkata, West Bengal. Here the observation were taken form 8.00 am to 3.00 pm and the comparison of solar panel output with and without tracking is below.

DATE:- 25/4/2017						
TIME	TEMPERATURE in degree	SOLAR RADIATION in W/m^2	OPEN CIRCUIT VOLTAGE in volt		SHORT CIRCUIT CURRENT in Amp.	
			With tracking	Without tracking	With tracking	Without tracking
8.00 am	31	517	22	19.6	1.64	0.96
9.00 am	32	622	19.6	19.4	1.81	1.33
10.00 am	34	816	19.6	19.1	1.79	1.73
11.00 am	35	818	19.1	19.0	1.85	1.81
12.00 am	36	815	20.4	19	1.85	1.8
1.00 pm	37	819	19.1	19.1	1.94	1.94

2.00 pm	37	781	19	19	1.95	1.72
3.00 pm	37	474	19.2	19	1.64	1.22
DATE:-26/4/2017						
8.00 am	30	401	19.3	19.3	0.61	0.5
9.00 am	32	540	19.4	19	1.78	1.1
10.00 am	33	768	19.1	19.0	2.05	1.84
11.00 am	35	833	19	18.8	2.11	2.08
12.00 am	36	854	18.6	18	1.91	1.8
1.00 pm	38	770	18.6	18.6	1.93	1.91
2.00 pm	38	641	18.7	18	1.83	1.61
3.00 pm	38	625	19.0	18	1.9	1.09
DATE:-27/4/2017						
8.00 am	31	545	20.0	19.6	1.6	0.97
9.00 am	32	754	19.3	19.0	1.67	1.49
10.00 am	33	783	20.8	20	1.71	1.7
11.00 am	35	847	18.3	18.0	2.09	1.75
12.00 am	36	820	19.9	18.8	1.93	1.9
1.00 pm	36	830	19.2	19.0	1.88	1.8
2.00 pm	36	657	19.5	19.3	1.85	1.6
3.00 pm	36	563	19.3	19.0	1.72	1.26
DATE:- 28/4/2017						
8.00 am	30	716	20.8	19.5	1.71	1.02
9.00 am	32	768	19.4	19	2.03	1.64
10.00 am	33	844	21.3	20.1	2.03	1.82
11.00 am	35	860	19.1	19.0	2.05	2.08
12.00 am	36	883	19.3	18.7	2.01	2.0
1.00 pm	36	775	18.7	18.6	1.95	1.89
2.00 pm	37	646	19.0	18.8	1.85	1.64
3.00 pm	36	508	20.8	18.7	1.58	1.15
DATE:-29/4/2017						
8.00 am	29	240	20.0	18.8	1.35	0.54
9.00 am	32	574	21.2	21.0	1.84	1.41
10.00 am	33	823	21.1	20.2	1.96	1.72

11.00 am	34	852	18.7	18.0	1.92	1.85
12.00 am	36	790	19	18.8	2.03	2.0
1.00 pm	37	767	19.0	18.8	2.0	1.96
2.00 pm	37	700	19.1	18.8	1.86	1.67
3.00 pm	37	474	19.3	19.0	1.58	1.17
DATE:-30/4/2017						
8.00 am	30	576	20.0	19.5	1.71	0.91
9.00 am	32	682	19.7	19.5	1.88	1.43
10.00 am	33	808	19.6	19.0	2.0	1.84
11.00 am	34	849	19.4	19.0	2.02	2.00
12.00 am	34	845	19.3	19.0	1.97	2.01
1.00 pm	36	763	19.2	19	1.89	1.92
2.00 pm	37	678	20.1	19.1	1.87	1.65
3.00 pm	36	746	19.5	19.2	1.66	1.22
DATE:- 1/5/2017						
8.00 am	28	494	20.6	19.6	1.57	0.95
9.00 am	30	715	19.2	19.3	1.92	1.41
10.00 am	32	762	19.4	19.0	1.92	1.73
11.00 am	33	828	19.6	19.3	2.06	2.0
12.00 am	33	374	19.5	19.8	1.16	1.2
1.00 pm	34	620	19.9	19.0	0.97	0.94
2.00 pm	34	619	19.4	19.2	1.7	1.47
3.00 pm	33	514	19.7	19.45	1.46	1.22

VII. CONCLUSION

Here this Dual axis tracker perfectly aligns with the sun location and tracks the sun movement in very efficient way and has a good result. The experimental results clearly show that dual axis tracking is more superior to fixed solar module systems. The design and implementation of this project is not complex and it is cost effective. By the help of this project, the overall electricity generated by the solar module will be increased and hence the cost can also be reduced.

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