IJAREEIE
e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

Volume 10, Issue 7, July 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.282

9940 572 462 | 6381 907 438 | ijareeie@gmail.com | www.ijareeie.com

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 7, July 2021 ||

| DOI:10.15662/IJAREEIE.2021.1007063 |

An Automatic Multi-Axis Solar Tracking System

Laxmi Kant[1], Arjun Singh[1], Dhananjay Singh[1], Hemalata Singh[1], Sachin Kumar[1], Jitendra Kumar Vashishtha[2]

UG Student, Dept. of EE, Rajkiya Engineering College, Bijnor, Uttar Pradesh, India[1]

Assistant Professor, Dept. of EE, Rajkiya Engineering College, Bijnor, Uttar Pradesh, India[2]

ABSTRACT: As the energy demand and the environmental problems increase, the natural energy sources have become very important as an alternative to the conventional energy sources. The renewable energy sector is fast gaining ground as a new growth area for numerous countries with the vast potential it presents environmentally and economically. Solar energy plays an important role as a primary source of energy, especially for rural area. It can be easily harnessed with the help of solar photovoltaic (PV) panels. But we mainly observe that most of the solar panels are positioned at fixed angles. In order to maximize the amount of solar radiation collected by a solar panel, we use solar tracking device whose function is to follow the sun orthogonally throughout the day which enhances the energy capacity of the system. This paper comprises of development and design of dual axis solar panel tracking system experimental study of dual axis solar tracker compared to fix position solar panel in terms of performance enhancement. The tracking mechanism of the sun requires light dependent resistor (LDR) as sensor to sense the maximum light availability two servomotor for two axis movement (i.e., vertical and horizontal) to direct the position of solar panel. The software part is done by the help of written code using an Arduino Uno controller.

KEYWORDS: PV panel, Servomotor, LDR, Arduino Uno Controller.

I.INTRODUCTION

In present scenario dependency on energy is increasing day by day, which leads to the increase in demand of energy resources mainly fossil fuels (coal, oil and gas). The crisis of energy and environmental degradation are main causes of increasing concern. Utilization of sustainable and renewable energy sources are key solutions of these problems (Sharma, D. K., & Purohit, G., 2014). Solar energy is an everlasting, clean and renewable source of energy without any potential damage to environment. The power received by the earth through the sun is about 1.8*10 11 MW, which is thousand times larger than the current power consumption from all sources. Conversion of solar energy into electrical energy takes place by photovoltaic (PV) cells using photovoltaic effects. A PV module is a combination of interconnected assembly of PV cells. In order to gain maximum power output from PV panels, one needs to keep the panel in the most appropriate position. So that sun radiations are orthogonal to the panel during the day. So, it is essential to have a sun tracker attached to the PV panel (Quesada, G., Guillon, L., Rousse, D.R., Mehrtash, M., Dutil, Y. Paradis, P.L., 2015). As compared to the fixed position PV panels, a mobile PV panel is better result oriented as it gains maximum solar energy (Khanduri, Naman, Arvind Kukreti, and Neeraj Shah, 2017). So many different approaches have been implemented so far in the designing of dual axis solar tracker.

Generally, they are categorized as either open-loop tracking types or closed loop tracking. An open loop tracking approach is achieved by a tracking formula or control algorithm. The control algorithms are executed with the help of microprocessor controller. In closed-loop tracking approach, active sensor such as light dependent resistors (LDRs) are used as in (Çinar, S.M., Hocaoğlu, F.O. and Orhun, M., 2014). This paper proposed a model of dual axis solar tracker with possible minimum complexities & more feasible in terms of cost and operation. It also provides the enhancement in the performance of energy harnessing through the PV panels by using solar tracker in compare to the fixed panels.

II.SOLAR TRACKER

Solar tracking is a mechanism by which we can create a system to tilt the solar panel in the direction of movement of the sun. It is essential to perform sun tracking, in order to enhance the performance of the system. It can result in the collection of more than 30% extra energy from the same collector (Tiwari, A., Vora, M., Shewate, P. and Waghmare, V., 2016). Solar tracking system approaches with higher accuracy can be achieved by Single Axis schemes and Dual Axis structure.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 7, July 2021 ||

| DOI:10.15662/IJAREEIE.2021.1007063 |

1. Single Axis Solar Tracker

Single Axis trackers have one axis of rotation. There are several possibilities for implementation of Single Axis solar trackers. Which include horizontal single axis trackers (HSAT), horizontal single axis tracker with tilted modules (HTSAT), vertical single axis trackers (VSAT), tilted single axis trackers (TSAT) and polar aligned single axis trackers (PSAT). The tracking schemes are designed such that maximum beam of radiation over given period of time. The use of single axis solar tracker can increase the electricity output as much as 27% to 32% (Tiwari, A., Vora, M., Shewate, P.and Waghmare, V., 2016).

2. Dual Axis Solar Tracker

Dual Axis Solar trackers have two-degree axis of rotation one is along vertical axis and another is along horizontal axis. It gives maximum solar exposure because of its ability to follow the sun, irrespective of sun position in the sky, dual axis trackers enable the PV panel to align itself in the direction of sun (Çinar, S.M., Hocaoğlu, F.O. and Orhun, M., 2014). In dual axis solar tracker vertical axis follows the angular height position of the sun in the sky and horizontal axis follows the east to west movement of the sun. According to (Tiwari, A., Vora, M., Shewate, P. and Waghmare, V., 2016), dual axis tracking shows 35% to 40% increase in power output.

3. Components Used in Solar Tracking Device

∟ LDR (Light Dependent Resistor)

∟ LDR is the sensing element in the project, its resistance varies as the intensity of the light changes. It is positioned on each corner of the solar panel with a resistance in series with it. Each of the 4 LDR sends an analog input to the microcontroller which further control motors.

∟ Solar Panel

∟ Solar panel is made to rotate in two different directions viz (horizontal and vertical movement) by the two different servo motors of different ratings, the panel is controlled by the two servo motors, one servo motor is connected at base of
the setup (for horizontal movement) and another is with the side arm support of the panel (for vertical movement).

∟ Microcontroller AT-mega 328

∟ Microcontroller is the heart of this project, as all the computations of the values of the LDR input followed by A/D conversion and generating actuating signals for the servo motors at right instant at each motor for the movement of the panel is solely done by this microcontroller. It is powered by 9V DC battery.

∟ DC Servomotor

∟ Servomotor is a normal DC motor which is controlled by the help of servomechanism. Servomechanism provides a closed loop feedback control system. The main objective of using a servomotor is to provides angular precision i.e., it will rotate as per the signal given to it. In this setup two servomotors are employed; each servomotor has a different a rating and placed according to their ratings.

4. Algorithm used in Arduino Uno

Step1: Start
Step2: Define the initial position value to Servos.
Step3: Assign analog LDR outputs & PWM servomotor inputs to the Arduino.
Step4: Capturing analog values of each LDR i.e., topl (Top left), topr (Top right), botl (Bottom left) & botr (Bottom
right).
Step5: Now calculating the average i.e., avgtop (Average of top), avgbot (Average of bottom), avgleft (Average of left) & avgright (Average of right).
Step6: Check the panel alignment.
Step7: If avgtop is greater than avgbot then increase the value of servomotor1 by 1 unit, give delay.
Step8: Else If, avgbot is greater than avgtop then decrease the value of servomotor1 by 1 unit, give delay.
Step9: (Simultaneous along with step7) If avgleft is less than avgright, then increase the value of servomotor2 by 1 unit, give delay.
Step10: Else if, avgleft is more than avgright then decrease the value of servomotor2 by 1 unit, give delay.
Step11: Go to Step 6.
Step12: End

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|
|| Volume 10, Issue 7, July 2021 ||
| DOI:10.15662/IJAREEIE.2021.1007063 |

5. Designing of System
The whole system is dependent on automatic tracking mechanism instead of a predefined motion. The sensors are the feedback constituents as they provide signals to the control system. Microcontroller plays an important role in controlling
mechanism or control system. The aim of microcontroller is to determine the direction of motor rotation, according to the signal receives from the respective LDR. So, the whole system adjusts itself for the sunlight to fall directly on the panel.

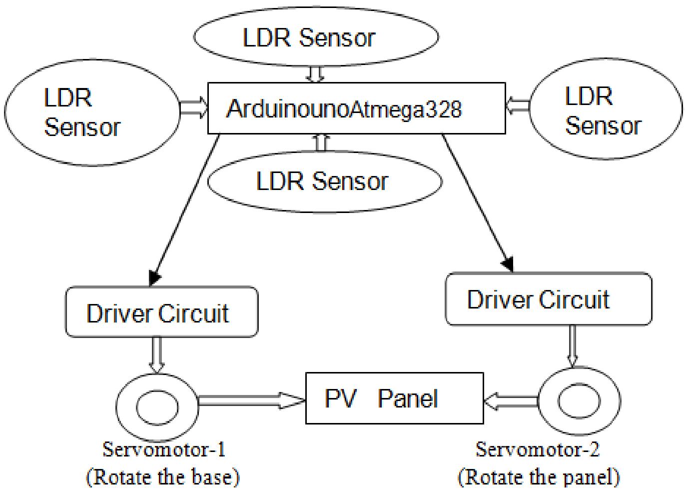

Fig. 1- Block Diagram of whole system realizes automatic dual tracking mechanism.

III. HARDWARE DESIGN SETUP

Implementation of dual axis solar tracker is simple but we have to must take care while designing it. Circuit comprises of 4 LDR and 4 resistors, connected in such a way that they act as a voltage divider and output is provided to analog input pins of Arduino. Pin no. 9 and 10 of Arduino are responsible for providing PWM inputs to the two servos. LDRs are used to sense the presence of light. The two servomotors are put on the structure in such a manner that one responsible for horizontal movement and another for vertical movement. Now the program is uploaded for Arduino to the microcontroller.

Project is working as follows.
∟ Four LDR sense the presence of maximum sunlight, which are situated at four corner of PV panel.
∟ For east to west tracking, if the analog values of top LDRs are more in compared to bottom two LDRs, then vertical servo will move in that particular direction
∟ If the bottom LDRs receives more light, the servo moves in that particular direction.
∟ For the angular deflection of the solar panel, if the left sets of LDRs receive more light than the right set, the horizontal servo will move in that particular direction.
∟ If the right set of LDRs receives more light, the servo moves in that particular direction.

1. Base Servomotor and Base Arm
All the rotating mechanism of the project is lied on this structure, which serves two purposes, primarily it provides the rigidity and stability to the complete structure against the odds of the nature, such as high-speed winds, secondly if makes the movement much more refine as these three supports on base takes all the weight of the setup from the motor shaft and thus allow the motor to precisely deflects the setup. A vertical servo is mounted on the sidearm support with the panel and fixed in the side arm support.

2. Complete Hardware
Finally, to make automatic dual axis movement solar tracker, we make proper connections of all the hardware, so that

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 7, July 2021 ||

| DOI:10.15662/IJAREEIE.2021.1007063 |

they work to track the sun. It was very important concern while designing the system because the slightest movement of sun could be tracked. The complete circuit used to track the sun is shown in figure 2. As the circuit shows we used 4 LDRs in order to track the sun on two axes. Each pair of LDRs is responsible for tracking the sun on each of the two adjacent LDRs are measured and that output is fed to four inputs in the microcontroller.

A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes an array of photovoltaic modules, an inverter, a battery pack for storage, interconnection wiring, and optionally a solar tracking mechanism.

The principle of the solar tracking system is done by Light Dependent Resistor (LDR). Four LDR's are connected to Arduino analog pin AO to A4 that acts as the input for the system. The inputs are from analog value of LDR, Arduino as the controller and the DC motor will be the output. LDR1 and LDR2, LDR3 and LDR4 are taken as pair .If one of the LDR in a pair gets more light intensity than the other, a difference will occur on node voltages sent to the respective Arduino channel to take necessary action.

A gear motor or stepping motor is a dc brushless electric motor that divides a full rotation into a display device is an output device for presentation of information in visual or tactile form. When the input information is supplied has an electrical signal, the display is called an electronic display number of equal step.

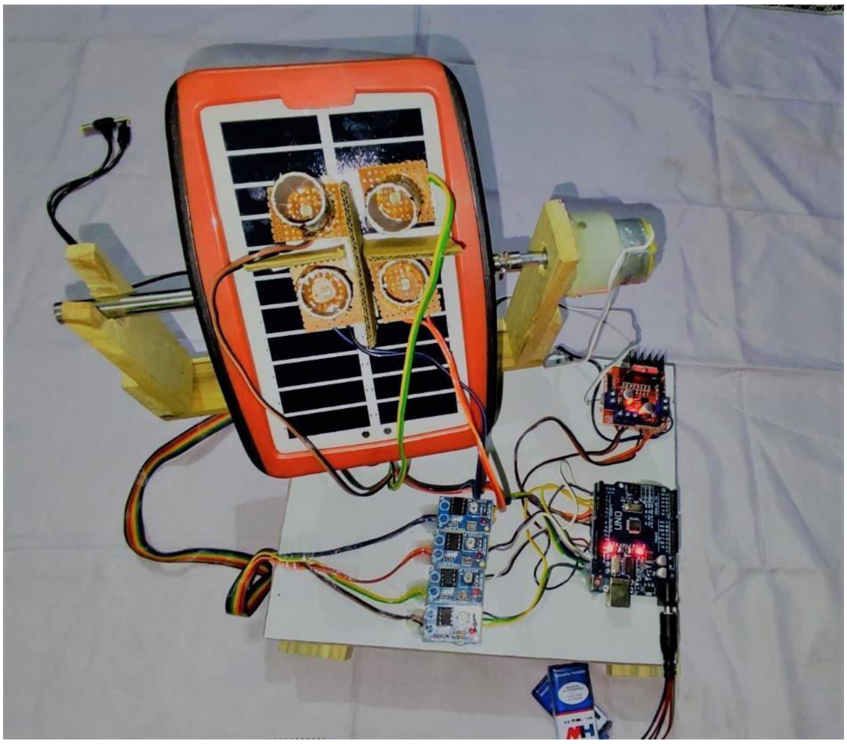

Fig.2 Final Purposed Hardware Setup to Find the Efficiency of Solar Panel.

As the circuit shows we used 4 LDRs After inversions in the Analog to Digital converter I had to deal with 4 outputs that would individually determine which way the system should rotate in order to track the sun. As each servomotor have to rotate in accordance to the respective pulses from the microcontroller for each of the servomotors.

IV. EXPERIMENTAL RESULT

Experiments results were performed by placing the designed system in open air. Table1 Observe the output power for PV systems (stationary module (without tracking) and dual axis tracking (with tracking)). These observations were performed on 11 July, 2021 for two cases. The output power data is collected during 9:00 A.M. to 5:00 P.M. In table 2 Observe the comparison of output power for stationary module and dual axis tracking.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 7, July 2021 ||

| DOI:10.15662/IJAREEIE.2021.1007063 |

Table 1- Experimental Result for Without and With Tracking of Solar

$$Normalized\ Enhanced\ \eta\ \% = \frac{Dual\ Axis\ (Watt) - Fixed\ Array(Watt)}{Maximum\ Power(Watt)} \times 100$$

Without Tracking				**With Tracking**		
Time	**Voltage (V)**	**Current (mA)**	**Power (Watt)**	**Voltage (V)**	**Current (mA)**	**Power (Watt)**
9:00 AM	11.83	13.4	0.158	12.75	33.0	0.42
10:00 AM	12.86	61.2	0.787	13.13	103.7	1.36
11:00 AM	12.65	119.7	1.514	12.94	163.4	2.11
12:00 PM	12.76	119.7	1.527	12.95	161.4	2.09
1:00 PM	13.71	156.5	2.145	13.00	164.5	2.13
2:00 PM	13.28	119.5	1.586	12.94	150.6	1.94
3:00 PM	13.14	82.5	1.084	13.31	147.2	1.95
4:00 PM	12.94	56.5	0.731	13.10	121.2	1.58
5:00 PM	12.02	20.0	0.240	12.98	102.0	1.32

Table 1. provides an experimental result when purposed hardware setup is fixed with standard latitude of the given region and experimental result when purposed hardware setup is movable in order to track the sun. Comparison of Power in Without Tracking and With Tracking

Table 2- Experimental data for Enhanced η (Efficiency)

Time	**Fixed Array**	**Dual Axis**	**Normalized Performance Enhancement (in %)**
9:00 AM	0.158	0.42	12.186
10:00 AM	0.787	1.36	26.651
11:00 AM	1.514	2.11	27.721
12:00 PM	1.527	2.09	26.186
1:00 PM	2.145	2.150	0.2325
2:00 PM	1.586	1.94	16.465
3:00 PM	1.084	1.95	40.279
4:00 PM	0.731	1.58	39.488
5:00 PM	0.240	1.32	50.2325

Table2. Provide an Experimental data for Enhanced η of solar panel is comparison between output powers in the two cases. We performed graphical comparison for two cases by plotting two power curves for two cases with the help of data provided in

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 7, July 2021 ||

| DOI:10.15662/IJAREEIE.2021.1007063 |

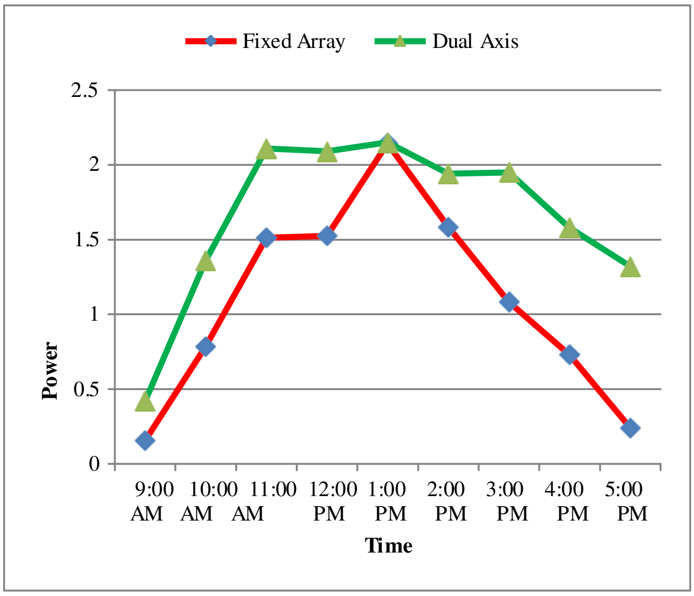

Fig.3Comparison of power for with and without tracking.

V.CONCLUSION

As we know the world is facing shortage of energy due to continuous depletion of non-renewable energy resources. As we have been using conventional sources of energy since ages. We are now planning to harness solar energy to bridge the gap between demand and supply in rural areas. The use of solar energy is free, does not create pollution, and if used widely it can help in reducing dependency on other costly and damaging sources of energy. This project emphasizes on harnessing the maximum amount of solar energy from the solar panel with the help of two-axis tracking mechanism through the microcontroller as compared to the static solar panel, the method of two-axis tracking increases the share of the solar power in the total power production from the non-conventional energy resources and thus tends to make our environment pollution free and thus development is sustainable.

REFERENCES

[1] Sharma, D. K., & Purohit, G. (2014). Improving the Liveability of Cities: The Role of Solar Energy in Urban and Peri-urban Areas. In The Security of Water, Food, Energy and Liveability of Cities, (pp. 151-162). Springer Netherlands,

[2] Quesada, G., Guillon, L., Rousse, D.R., Mehrtash, M., Dutil, Y. & Paradis, P.L., (2015). Tracking strategy for photovoltaic solar systems in high latitudes. Energy Conversion and Management, 103, pp.147-156.

[3] Khanduri, Naman, Arvind Kukreti, and Neeraj Shah. "Implementation of solar time-basedsun tracking systems for mobile platforms and smart cities." In IEEE Region 10 Symposium (TENSYMP), 2017, pp. 1-5. IEEE,2017.

[4] Çinar, S.M., Hocaoğlu, F.O. and Orhun, M., 2014. A remotely accessible solar tracker system design. Journal of Renewable and Sustainable Energy, 6(3), p.033143.

[5] Tiwari, A., Vora, M., Shewate, P. and Waghmare, V., 2016. Sun Tracking Solar Panel with Maximum Power Point Tracking. International Journal of Engineering Science, 2451.

[6] Bhote, M.V. and Singh, J., 2014. Implementation of dual axis solar tracker model by using microcontroller. International Journal of Engineering Research and General Science, 2(4), pp.780-784.