INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

IJARIIT

ISSN: 2454-132X

Impact factor: 4.295

(Volume3, Issue2)

Available online at www.ijariit.com

Maximum Solar Power Tracker Mechanically By Using Dual Axis Tracker

B. Balaji
CK College Of Engineering & Technology, Cuddalore, Tamil Nadu
balaji.bc91@gmail.com

A. Arulvizhi
CK College Of Engineering & Technology, Cuddalore, Tamil Nadu
balaji.bc91@gmail.com

J. Jayashree
CK College Of Engineering & Technology, Cuddalore, Tamil Nadu
Jjshree79@gmail.com

Abstract: To formulate a method for harvesting the maximum solar irradiance and thereby increase the output of the system. To reduce the energy expenditure by solar tracking system and conserve energy without any extra hardware components. The solar power is tracked mechanically in both the axis by using dual axis tracker efficiently to obtain maximum irradiance available from the sun.

Keywords: Dual Axis Tracker, Azhimuth Angle, Zenith Angle, LDR.

I. INTRODUCTION

Energy is essential for the economic growth and social development of any country. The quality of life is closely related to energy consumption, which has continuously increased over the last few decades in developing countries.

Diesel generators are the main source of electricity in most of the isolated islands and the electricity demand is constantly increasing in these isolated islands. Heavy oil costs for diesel generators involve buying, transport, and storage costs. To avoid global warming, the consumption of fossil fuels must be reduced. Hence, the installation of renewable energy power production plants has become a burning issue not only for isolated islands but also all over the world. Among various renewable energy systems, photovoltaic power generation systems (PV systems) are expected to play an important role as a clean electricity power source in meeting future electricity demands. The superiority of the solar energy is mentioned by many types of research. Energy generated from PV panels is related to temperature, irradiance and incident angle of the solar radiation and so on. The efficiency of a panel can be increased by sun tracking systems which are investigated by many types of research.

One way of sun tracking is flat PV system. Two axis tracking PV theoretically propose 41% energy entrance improvement in a mid-latitude region with respect to the fixed PV panels. Besides, the improvement for one-axis tracking system is 36%. Captured solar energy by sun tracking system is related to regional and meteorological conditions. Many times, the improvement of a solar system is achieved using tracking controller structures by increasing the collected solar energy ratio. The tracking system includes microprocessors or another control mechanism to determine the best position. For optimal efficiency of solar panels solar tracking systems are designed such that solar panels are perpendicular to sunlight, where **illumination is strongest, to achieve this, an ideal tracker would compensate for changes in both sun's altitude** and latitudinal angles through both day and seasonal changes and change in azimuth angle.

II. SOLAR RADIATION & PHOTOVOLTAIC CONCEPTS OF SOLAR RADIATION

Before talking about the solar tracking systems, we will review some basic concepts concerning solar radiation and mention some important values to better understand the results of this work. The sun, at an estimated temperature of 5800 K, emits a high amount of energy in the form of radiation, which reaches the planets of the solar system. Sunlight has two components, the direct beam, and the diffuse beam. Direct radiation (also called beam radiation) is the solar radiation of the sun that has not been scattered (causes shadow). Direct beam carries about 90% of the solar energy and the "diffuse sunlight" that carries the remainder. The diffuser portion is the blue sky on a clear day and increases as a proportion on cloudy days. The diffuse radiation is the sun radiation that has been scattered (complete radiation on cloudy days). The reflected radiation is the incident radiation (beam and diffuse) that has been reflected by the earth. The sum of beams, diffuse and reflected radiation is considered as the global radiation on a surface. As the majority of the energy is in the direct beam, maximizing collection requires the sun to be visible to the panels as long as possible. The main aspects of getting maximum power are Declination Angle, Hour Angle, solar altitude **(θz)**, solar azimuth, zenith angle, local solar time, apparent solar time.

III. INSOLATION

A) Insolation

Insolation is a measure of solar radiation energy received on a given surface area and recorded during a given time. It is also called solar irradiation and expressed as hourly irradiation if recorded during an hour, daily irradiation if recorded during a day, for example. The unit recommended by the World Meteorological Organization is MJ/m2 (megajoules per square meter) or J/cm2 (joules per square centimeter). Practitioners in the business of solar energy may use the unit Wh/m2 (watt-hours per square meter). If this energy is divided by the recording time in hours, it is then a density of power called irradiance, expressed in W/m2 (watts per square meter). Over the course of a year the average solar radiation arriving at the top of the Earth's

The atmosphere at any point in time is roughly 1366 watts per square meter. The Sun's rays are attenuated as they **pass through the atmosphere, thus reducing the irradiance at the Earth's surface to approximately 1000 W m−2**

For a surface perpendicular to the Sun's rays at sea level on a clear day. The insolation of the sun can also be expressed in Suns, where one Sun equals 1000 W/m2.

B) Photovoltaics

Photovoltaics are the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, electric current results that can be used as electricity.

A solar cell (also called photovoltaic cell or photoelectric cell) is a solid-state electrical device that converts the energy of light directly into electricity by the photovoltaic effect. Crystalline silicon PV cells are the most common photovoltaic cells in use today. A number of solar cells electrically connected to each other and mounted in a support structure or frame are called a photovoltaic module. Modules are designed to supply electricity at a certain voltage, such as a common 12 volts system. The current produced is directly dependent on how much light strikes the 20 module. Multiple modules can be wired together to form an array. In general, the larger the area of a module or array, the more electricity will be produced. Photovoltaic modules and arrays produce direct-current (DC) electricity. They can be connected in both series and parallel electrical arrangements to produce any required voltage and current combination.

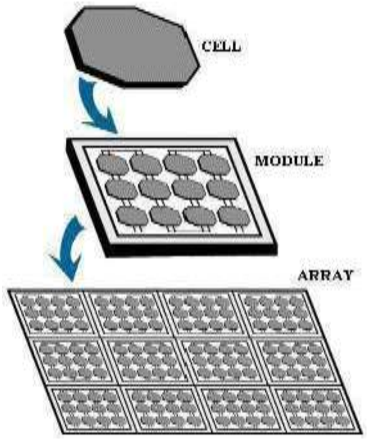

Fig. 2 Photovoltaic Panel or Array

IV. SOLAR TRACKER

A) Solar Tracker

In order to produce maximum power by utilizing the solar energy, the solar trackers were used. There are different methods of tracking and they are Passive tracking, chronical tracking, active tracking etc. from these methods active tracking method is used here.

Active Tracker

Active trackers use motors and gear trains to direct the tracker as commanded by a controller responding to the solar direction. Light-sensing trackers typically have two or more photosensors, such as photodiodes, configured differentially so that they output a null when receiving the same light flux. Mechanically, they should be omnidirectional (i.e. flat) and are aimed 90 degrees apart. This will cause the steepest part of their cosine transfer functions to balance at the steepest part, which translates into maximum sensitivity. Since the motors consume energy, one wants to use them only as necessary. So instead of a continuous motion, the heliostat is moved in discrete steps. Also, if the light is below some threshold there would not be enough power generated to warrant reorientation. This is also true when there is not enough difference in light level from one direction to another, such as when clouds are passing overhead. Consideration must be made to keep the tracker from wasting energy during cloudy periods. The different types of active trackers are as follows

- *Single axis trackers*

Single axis trackers have one degree of freedom that acts as an axis of rotation. The axis of rotation of single axis trackers is typically aligned along a true North meridian. There are several common implementations of single axis trackers. These 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).

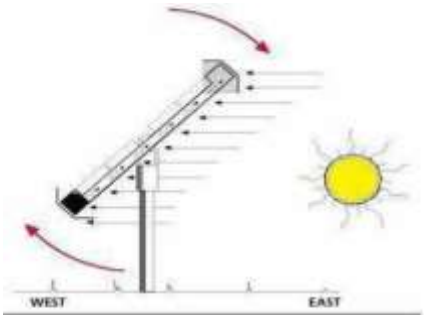

Fig.3. Single axis tracker

Fig.4 Dual axis tracker

- *Dual axis trackers*

Dual axis trackers have 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. Two common implementations are tip-tilt dual axis trackers (TTDAT) and azimuth-altitude dual axis trackers (AADAT).

Tip–tilt:

A tip–tilt dual axis tracker (TTDAT) is so-named because the panel array is mounted on the top of a pole. Normally the east–west movement is driven by rotating the array around the top of the pole. On top of the rotating bearing is a T- or H-shaped mechanism that provides vertical rotation of the panels and provides the main mounting points for the array. The posts at either end of the primary axis of rotation of a tip–tilt dual axis tracker can be shared between trackers to lower installation costs.

Azimuth-altitude:

An azimuth–altitude dual axis tracker (AADAT) has its primary axis (the azimuth axis) vertical to the ground. The secondary axis often called elevation axis, is then typically normal to the primary axis. Instead of rotating the array around the top of the pole, AADAT systems can use a large ring mounted on the ground with the array mounted on a series of rollers. The main advantage of this arrangement is the weight of the array is distributed over a portion of the ring, as opposed to the single loading point of the pole in the TTDAT. This allows AADAT to support much larger arrays. The AADAT system cannot be placed closer together than the diameter of the ring, which may reduce the system density, especially considering inter-tracker shading.

V. ACTIVE TRACKING METHODS OF SOLAR PANNELS

Design and Control Circuit of the Sun Tracker

A simple tracking system was proposed. Its precision was calculated in terms of the angle between the two LDR sensors. LDR (light dependent resistor) are photoresistors which have high resistance when placed in a

Dark environment and have the least amount of resistance when exposed to light radiations. The photo sensors are **used to discriminate the sun's position and to send electrical signals proportional to the error to the controller,**

Which actuates the motors to track the sun. Established system has180° horizontal and 90° vertical moving ability. For the horizontal axis, a DC motor with 0–180 °moving ability was used. Higher difference values of the light intensity that the sensors measured than the reference value trigger the movement of the DC motor in both directions.

DC motor is driven by increasing the current via a transistor. Direction control is made by using four transistors. Q1 and Q4 are conducted when the motor turns to the east, Q2 and Q3 are conducted when it turns to the west. Our panel can rotate180° on the horizontal axis (i.e. east–west direction). Our circuit is fed with 9Vand uses light sensors (LDR-A and LDR-B) which are identical. Two sensors are connected in series and the connected at the point X. The rotation direction of the motor is controlled by using two differential amplifiers (Op-Amp-A ve Op-Amp-B). Reference voltage values are entered to the op-amps via voltage dividing resistors (POT-A, POT-B, R1, R2). Again with the voltage dividing resistors (POT-A, POT-B, R1, R2), reference voltage Point-Y is connected tonumber-2(minus) port of op-amp-A and Point-Z is connected to number - 5 (plus) port of Op-Amp-B.

When the light sensors have the same amount of resistance values (i.e. when the same rate of light is taken), point X becomes 4.5V. In this case (sensors get the same amount of lights), point Y is set to be 4.73 and point Z is set to be 4.27V.

Additionally, op-amps give the same output (0V) and since the potential difference at the motor terminals is zero, the panel does not rotate. Circuit scheme of the designed system for horizontal axis is shown in Fig.

When the sun goes to the west, LDR-A will get lighter and its resistance will decrease. In this case, the voltage at point X will rise over 4.5 V and when it passes 4.73, Op-Amp-A and Op-Amp-B will give 9 V and 0V, respectively. Our engine will start to turn towards to the west. Thus, the resistance of LDR-B starts to drop and so does the voltage of point X. When the voltage at point X goes below to 4.73V, op-amps gives the same output (0V) and the motor stops. Therefore, when the sun goes to the west, our panels also turns to the west.

The Same process also occurs when the sun goes to the east. When the sun rises, LDR-B will get more sunlight and the resistance will fall. In this case, the voltage at the point X will drop below to 4.5 V and when it passes 4.27 V, Op- Amp-A and Op-Amp-B will give 0V and 9 V, respectively. Our motor will start to turn towards to the east. Thus the resistance of LDR-A will decrease and the voltage at point X will rise. When the voltage at point X goes above 4.27 V, op-amps give again the same output (0V) and the motor stops. If this requirement does not take place, our panel continues to turn towards to the east. For vertical axis, a step motor with 0–90° moving ability was used. Difference values which are higher than the reference value of the light intensity measured by the sensors trigger the step motor to rotate in both directions. The step motor is driven by increasing the current via MOSFETs. Direction control is performed by using 4-MOSFETs.When motor rotated downward, Q1 and Q2 are in transmission, when it goes upward Q3 and Q4 is in transmission stage. Our panel can rotate on the vertical axis (i.e. up and down).

Our circuit is fed with 5 V and the light sensors of LDR-C and LDR-D are identical. The rotation direction of the motor is controlled by using two differential amplifiers (Op-Amp-C and Op-Amp-D). Again with the voltage dividing resistors (POT-C, R3, R4), reference voltage values were entered to the op-amps. Point Y1 is connected to the port-3 of Op-Amp-C (plus), point Z1 is connected to port-6 of Op-Amp-D (minus). Outputs of the op-amps are connected to RA0 and RA1 pins of PIC. In addition, by passing op-amp outputs through a NAND gate, they are connected to RA2 port of PIC. While light sensors have the same resistance values (i. e. when they receive the same amount of light), point X1 becomes 2.5 V. In this position (when sensors get the same amount of light), point Y1 is set as 2 .76 V and point Z1 is set as 2.24V. In this case, op-amps give the same output (5 V) (RA0=1 andRA1=1) and the output of the NAND gate becomes 0(zero) and the signal of 0 (zero) goes to RA2. When RA2=0, the motor will not rotate. Circuit scheme of the designed system for vertical axis is shown in Fig. 5.2.2

When the sun goes to the upward, LDR-C will have more light and its resistance will decrease. In this case, the voltage at point X1 will rise and it starts to be more than 2.5 V and when it passes 2.76 V, Op-Amp-C and Op-Amp-D will give 0 V and 5 V, respectively. Our engine will start to turn upward. Thus, the resistance of LDR-D starts to decrease and the voltage at point X1 will drop. When the voltage at point X1 drops below to 2.76 V, op-amps will again give the same output (5 V) and the motor stops. Thus, when the sun goes upward, our panel also turns to the upward. When the sun goes down, LDR-D will have more light and its resistance will fall. In this case, the voltage at point X1 will drop and becomes lower than 2.5 V and when it passes 2.24 V, Op-Amp-C and Op-Amp-D will give 5 V and 0V, respectively. Our motor will start to turn downward. Thus the resistance of LDR-C will drop and the voltage at point X1 will rise. When the voltage at point X1 goes above 2.24V, op-amps give again the same value (5 V) and the motor stops. Thus, the more the sun goes down, the more our panels rotates to towards to downward.

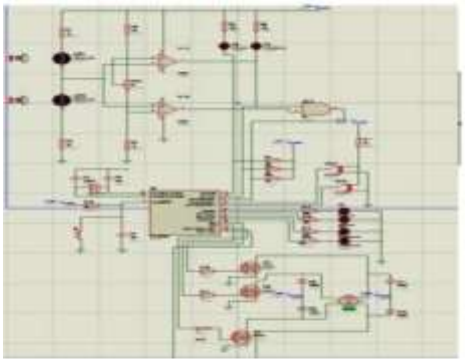

Fig. 5 Circuit scheme of the designed system for vertical axis

VI. **SIMULATION OF THE CIRCUIT SCHEME OF THE PROPOSED SYSTEM**

The circuit scheme was designed and simulated using Proteus 7.1 professional software.

Simulation For LDR Working

The schematic circuit is used to explain how the LDR sensors work in the solar tracker. In this a torch LDR tool is used from the library of the lab center and is connected to a power source and a ground terminal. A voltage sensor probe is inserted as shown. When the LDR is not illuminated the resistance will be in the order of several megaohms and the voltage across the probe will be 5 V as it is illuminated by a light source the resistance of the LDR decreases and the voltage starts to flow across it and will so a drop as shown in the fig

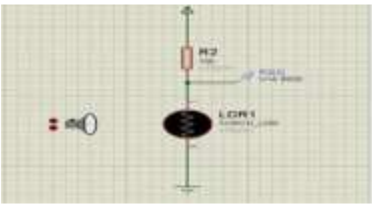

Fig. 6 Simulated model for LDR working

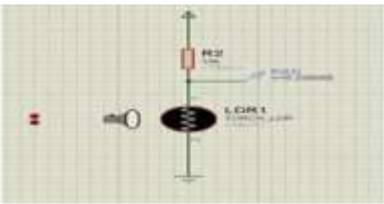

Fig. 7. The voltage drop across LDR

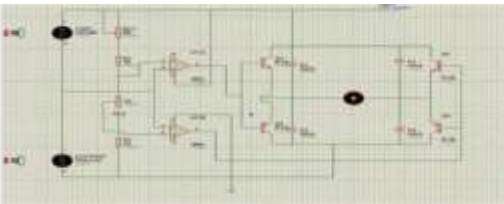

Fig.8. Circuit scheme for horizontal axis tracking

Modeling Of the Circuit Scheme

The given circuit scheme as explained in the above paragraph is modeled using Proteus 7.1 Professional. The tools are taken from the library and are placed on the PCB layout as given the schematic diagram.

Inference

The circuit scheme designed in PROTEUS 7.1 PROFESSIONAL software explains the working of the solar tracker circuit for the horizontal axis. When LDR east is illuminated the motor rotates in the clockwise direction and when LDR west goes high the motor rotates in the counter-clockwise direction. When panel connected to the motor via gears the corresponding orientation changes occur.

The circuit simulated explains how the pic controller is programmed to produce the elevation angle when the **LDR's detect changes in the radiation received. The stepper motor is varied correspondingly and when the** panel has connected the change in the elevation of panel occurs.

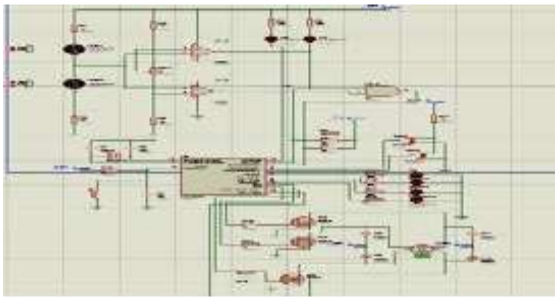

Fig.9. Circuit scheme of vertical axis tracking

VII. CHRONOLOGICAL METHOD OF TRACKING

Solar Radiation Calculation

Sun tracking systems monitor the sun during the day as the sun is continuously moving. It is well known that the electricity generation capacity of a PV panel depends on solar radiation exposure which will be provided by the sun tracking systems in this matter.

Solar radiation can be calculated as follows:

- Calculate local standard time meridian using the

Formula LSTM = 15° TGMT

ΔTGMT is the difference between the local time meridian and the Greenwich Mean Time and 15° is used because the earth rotates 15° in an hour.

• Calculate the B value using the formula B = 360/365 * (d- 81) Where d is the count of the day in a year (i.e. January 1 is counted as day 1and from that it proceeds up to 365). Calculate the EOT using the formula EOT = 9.87 sin (2B) – 7.53 cos (B) – 1.5 sin (B)

The equation of time (EOT) (in minutes) is an empirical equation that corrects for the eccentricity of the Earth's orbit and the Earth's axial tilt.

• Calculate the time correction factor using the formula TC =
4(longitude – LSTM) + EOT

The net Time Correction Factor (in minutes) accounts for the variation of the Local Solar Time (LST) within a given time zone due to the longitude variations within the time zone and also incorporates the EoT above. The factor of 4 minutes comes from the fact that the Earth rotates 1° every 4 minutes.

Calculate the Local solar time (LST) LST = LT + TC/60

The Local Solar Time (LST) can be found by using the previous time correction factor to adjust the local time (LT).

Development Of Matlab Program To Calculate Sun Angle

This program calculates the solar zenith and azimuth angles in the period from the year -2000 to 6000, with uncertainties of +/- 0.0003 degrees based on the date, time, and location on Earth. The following result was generated with the location (13.0826 N and 80.2707 S) and date (12 /10/2015) and time (12:30:40)

Algorithm for proposed program:

Step 1: First the location latitude and longitude values are entered.
Step 2: The GMT of the location is noted and the local time meridian is calculated.
Step 3: The factors B is calculated and using it the equation of time is calculated.
Step 4: The time correction factor is found.
Step 5: Local solar time and hour angle are calculated.
Step 6: The declination angle is found.
Step 7: The elevation and azimuth angle are found.

Fig.9. Simulated output showing the location and time

Fig.10. Simulated output showing the calculated sun angles

CONCLUSION

The simulation of the active tracking method using Proteus 7.1 Professional explains how the circuit scheme is used to drive the motor which tilts the panels accordingly in both azimuth and elevation angle. This is the orientation of the panel is aided by the usage of the light sensor (LDR).

The next method of tracking to be implemented (i.e.) the chronological method was discussed and the steps to calculate the sun angles was shown and the mat lab program for the calculation of the sun angle was done and the results were shown. Thus the simulation of the two methods to be used in the solar tracker was successfully studied and simulated.

REFERENCES

1.Saban Yilmaz, Hasan Riza Ozcalik, Osman Dogmus, Furkan Dincer, Oguzhan Akgol, Muharrem Karaaslan **‘Design of two axes sun tracking controller with analytically solar radiation calculations’** - Renewable and Sustainable Energy Reviews 43 (2015) 997–1005.

2. Nader Barsoum, Pandian Vasant ‘Design of solar tracker based on PIC16F84A microcontroller’. Sol Energy 2009; 85:2757–70.

3. Saheli Ray ‘calculation of Sun Position and tracking the path of Sun for a particular Geographical location’- (ISSN 2250-2459, Volume 2, Issue 9, September 2012)

4. Iulia Stamatescu, Ioana Făgărăşan, Grigore Stamatescu, Nicoleta Arghira, Sergiu Stelian Iliescu ‘Design and Implementation of a Solar- **Tracking Algorithm** ’- Procedia Engineering 69 (2014) 500 – 507.

5.Yingxue Yao, Yeguang Hu, Shengdong Gao, Gang Yang, Ji**nguang Du ‘A multipurpose dual**-axis solar **tracker with two tracking strategies’**-Renewable Energy 72 (2014) 88e98.

6. Ibrahim Reda and Afshin Andreas ‘Solar Position Algorithm for Solar Radiation Application’-NREL /TP-560-34302.