

“Review of Semi Automatic Dual Axis Solar Tracking”

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Abstract: - Several studies reflect that scholars had made many types of research on solar panels, Conversion of solar energy into electric energy, tracking of sun, etc. In continuation of aforesaid research, this paper highlights the work done in experimenting with the Semiautomatic Dual Axis Solar Tracking of solar panels. Eventually, some researchers had done sun tracking through the LDR, light sensor and a photodetector. And it has been observed that these tracking systems, help in generating 20-23% extra power in comparison to fixed axis solar panel system. We will deploy the solar tracking system and experiment it by using the Actuator (by programming C) which will be optimized with the help of Keil software through microcontrollers. The actuator will design by me has Motor which runs via C programming and will be based on displacement. Thus, it will be 5 times cheaper than other tracking system counterpart available in market value. The experiment will conduct in Madhya Pradesh state located in the centre of India and has about 300 sunny days per year with annual mean daily global solar radiation in the range of 5-7 kWh/m²/day. Hence, the experiment duration chosen for solar tracking will be from 8 am (IST) to 4 pm (IST), during which sun rays are almost perpendicular on the panel. During my study, it was observed that the other technology/equipment used for sun tracking, were less successful mainly because of seasonal variations and unable to move according to Sun path. These gaps were overcome to large extent through programming-based motor operated Actuator, where the Sun can be tracked in all the seasons (Summer, Spring, Monsoon, Winter) ensuring that Sun rays are perpendicular and help in maximizing output at a reasonable cost. Although initially, it is costly in comparison to fixing axis panel, but in long run yields to more maximum output.

Keywords: Solar energy, solar tracker, actuator, solar panel, Single axis tracking, Dual-axis tracking, Keil software, microcontroller, pro software.

I. REASONS FOR PREFERRING SUN OVER OTHER RENEWABLE ENERGY SOURCES

Different types of non-conventional geothermal energy sources such as ocean tides, wind, and Sun. All non-conventional energy sources have geographical limitations. But solar energy has less geographic limits than other non-conventional energy sources because solar energy is available all over the world, and only the size of the collector area needs to be increased to provide the same amount of heat or electricity. It amounts to the primary function of the solar energy System designer, the quality and time of solar energy

is available at the selected site to set up a solar energy conversion system in order to determine among all this solar energy seems to hold out the greatest promise to humanity. It is free, unbreakable, non-polluting and devoid of political control. Solar water heaters, space heaters, and cookers are already on the market and seem economically viable. Will be solar photovoltaic cells, solar refrigerators, and solar thermal power plants. Technically and economically viable in a short time. It is optimistic that 50% of world power requirements will come only from solar energy in the middle of the 21st century. Substantial progress has been made during the past two decades to develop direct energy conversion systems to increase plant efficiency from 60% to 70% by avoiding changes in mechanical energy of thermal energy. Yet the technology is on the threshold of success and it is hoped that this will also lead to an important role in power generation in the coming future. [1]

II. ENERGY FROM SUN

In one minute, the sun provides enough energy to supply the world's energy needs for a year. In one day, it offers more energy than the world's population could consume in 27 years. Energy is free, and supply is unlimited. All we need to do is to find a way to use it. The largest solar power generating plant in the world produces a maximum of 354 megawatts (MW) of electricity and is located in Kramer Junction, California. Since India has abundant sources of sunlight, in particular, it can cater to all the energy needs of the country. The country receives average radiation of 5 kWh per square metre (m) per day and 2300 to 3200 sunshine hours per annum. Therefore, the potential of solar photovoltaic is estimated at 20 MW per sq km and solar thermal applications are 35 MW per sq m.

III. WAYS FOR CONVERTING SOLAR ENERGY INTO ELECTRICAL ENERGY

There are two ways by which we can convert solar energy into electrical energy. These areas are shown in figure 1.

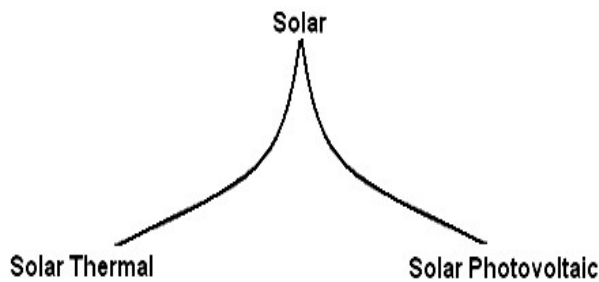


Figure 1: Ways of Converting Solar Energy into Electrical Energy [1]

IV. LITERATURE REVIEW

Literature Survey

F.R. Rubio (2007) Presented a sun tracker that is capable of adhering to the sun with high accuracy without requiring either an accurate process of installation or recalibration. The hybrid tracking system consists of a combination of open loop tracking strategies based on solar movement models and closed-loop strategies using a dynamic feedback controller. Energy-saving factors are taken into account, which implies that, among other factors, the sun is not constantly tracked with the same accuracy, to prevent energy overconsumption by motors. Simulations and experimental results with a low-cost two-axes solar tracker are exposed, including a classical open loop tracking strategy and comparison between the proposed hybrid one. [2]

J. Rizk, [2008], World Economy of Science Engg. & Tech. states the potential system benefits of simple tracking solar system using a stepper motor and light sensor. A solar tracking system is reportedly designed, implemented and experimentally tested. The design details and experimental results are discussed. A solar tracker is designed employing small solar cells to function as self-adjusting light sensors, providing a variable indicative of their relative angle to the sun by detecting their voltage output. By using this method, the solar tracker is found to be successful in maintaining a solar array at a sufficiently perpendicular angle to the sun. The power increase gained over a fixed horizontal array was in excess of 30%. [3]

Ahmed Rhif et al., (2012), review the literature on the tracking process for the dual axis sun tracker by a sliding mode control law. The sun tracker considered in this study has two degrees of freedom and is significant due to the lack of sensors. In this way, the tracker will have a set of sun positions at every second during the day for a period of five years. After sunset, the tracker goes back to the initial position corresponding to sunrise. Experimental measurements show that this autonomic dual axis sun tracker increases the power production by over 40%. Experimental results show the effectiveness of the sliding mode control in the tracking process, its robustness and the high estimation quality of the sliding mode observer. [4]

V. OBJECTIVES

To develop a solar tracking system that could work under all weather conditions

Design & fabrication of structure for Dual Solar Tracking system

Design of Actuator Arm for solar time tracking & its programming to increase the power efficiency by Dual tracking and compare it with the non-tracking system.

VI. CONCEPTS ON 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 high amounts of energy such as radiation, which reaches the planets of the solar system. Sunlight has two components, direct beams, and diffuse beams. Direct radiation (also called beam radiation) is the solar radiation of the sun that has not been scattered (causes shade). The direct beam carries about 90% of the solar energy and "diffuse sunlight" that carries the remainder. The diffuser part is the blue sky on a clear day and the cloudy day's increases as a proportion on diffuse radiation are the solar radiation that has been scattered (complete radiation on cloudy days). The reflected radiation is the incident radiation (beam and diffuse) that the earth has shown. The sum of beam diffuses and amplified radiation is considered as global radiation on a surface. As most of the energy is in the direct beam, the maximum collection is required by the sun to appear to the panels if possible. [5]

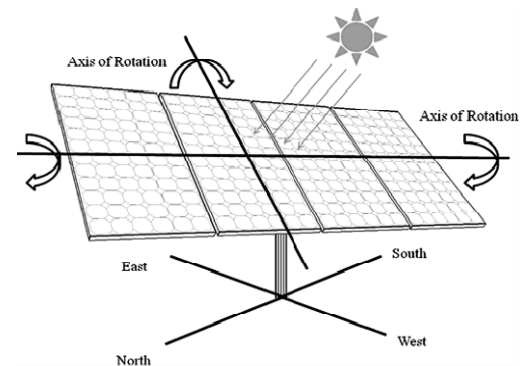


Figure 2: Dual Axis Tracking Solar System

Declination Angle-

The Declination of the sun is the angle between the equator and the line drawn from the centre of the Earth to the centre of the Sun. (23.450) (June 21 and December 22 in India) the Declination angle, marked by δ , changes the weather due to the tilt of the Earth on its axis of rotation and the rotation of the earth around the sun. If the earth is not bent on its axis of rotation; Declination will always be 0° . However, the earth is tilted towards 23.45° and the Declination angle varies with this amount. Only the spring and Fall Equinox has a

Declination angle equal to 0 degrees. [6]

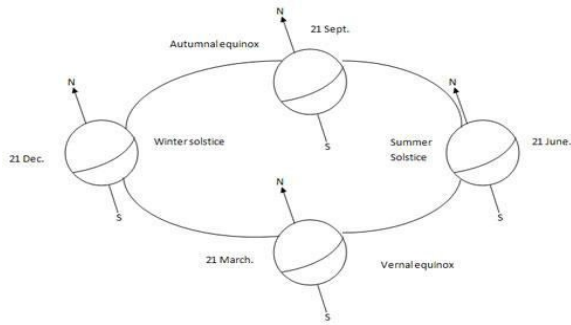


Figure 3 The Declination Angles

Hour Angle

The Hour Angle is the angular distance that the earth has rotated in a day. It is equal to 15 degrees multiplied by the number of hours from local solar noon. This is based on the nominal time, 24 hours, required for the earth to rotate once i.e. 360 degrees.

Solar hour angle is zero when the sun is straight overhead, negative before noon, and positive afternoon. (here noon means 12.00 hour). [6]

Solar Altitude (θ_z)

The solar altitude is the vertical angle between the horizontal and the line connecting to the sun. At sunset/sunrise altitude is 0 and is 90 degrees when the sun is at the zenith. The altitude relates to the latitude of the site, the declination angle and the hour angle. [7]

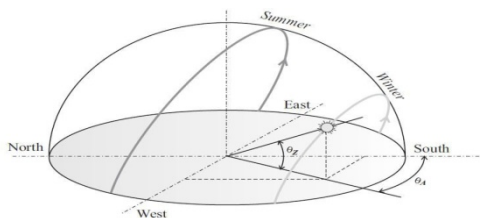


Figure 4: Solar Altitudes and Azimuths typical Behavior of Sun Path [7]

Solar Azimuth (θ_A)

The azimuth angle is the angle within the horizontal plane measured from true South or North. The azimuth angle is measured clockwise from the zero azimuth. For example, if you're in the Northern Hemisphere and the zero azimuth is set to South, the azimuth angle value will be negative before solar noon, and positive after solar noon. [7]

How Does Photovoltaics Work?

Photovoltaics is 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, an electric current result 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.

Many solar cells are electrically connected to each other and mounted in a support structure or frame called a photovoltaic module. Modules are designed to supply power at a certain voltage, as a common 12volt system. The current produced is directly dependent on how much light the module strikes. Multiple modules can be wired together to form an array. In general, large areas of a module or array, more power will be produced. Photovoltaic modules and Arrays produce direct current (DC) electricity. They can be added in both series and parallel power systems to produce any required voltage and current combinations

Misalignment (Angle i)

When the sun rays do not fall perpendicularly over the panel, misalignment takes place which results in loss of power.

Table 1 Direct Power Lost (%) due to Misalignment (Angle i)

Misalignment (angle i)	Direct power lost (%) = $1 - \cos(i)$
0°	0
1°	.015
3°	.14
8°	1
23.4°	8.3
30°	13.4
45°	30
60°	>50
75°	>75

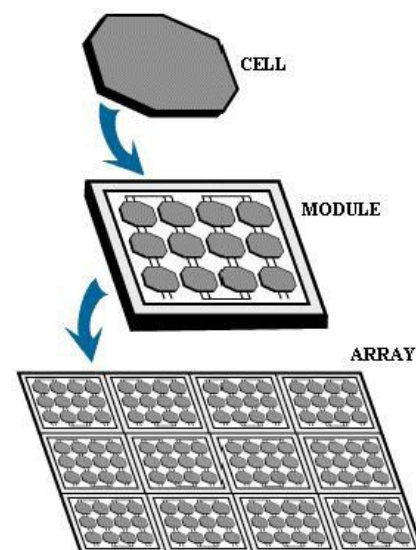


Figure 5: Photovoltaic Panel or Array [5]

The efficiency of Solar Panels

The efficiency is the parameter most commonly used to compare the performance of one solar cell to another. It is the ratio of energy output from the solar panel to input energy from the sun. In addition to reflecting on the performance of solar cells, it will depend on the spectrum and intensity of the incident sunlight and the temperature of the solar cell. As a result, conditions under which efficiency is to be measured must be controlled carefully to compare the performance of the various devices.

The efficiency of solar cells is determined as the fraction of incident power that is converted to electricity. It is defined as:

where V_{oc} is the open-circuit voltage;

I_{sc} is the short-circuit current

FF is the fill factor η is the efficiency.

The input power for efficiency calculations is 1 kW/m^2 or 100 mW/cm^2 . Thus, the input power for a $100 \times 100 \text{ mm}^2$ cell is 10 W .

Need for Solar Tracker

The energy contributed by the direct beam drops off with the cosine of the angle between the incoming light and the panel.

The sun travels through 360 degrees east-west a day, but from the perspective of any fixed location, the visible portion is 180 degrees during a 1/2-day period. Local horizon effects reduce this somewhat, making the effective motion about 150 degrees. A solar panel in fixed orientation between the dawn and sunset extremes will see a motion of 75 degrees on either side and thus, according to the table above, will lose 75% of the energy in the morning and evening. Rotating the panels to the east and west can help recapture these losses. A tracker rotating in the east-west direction is known as a single-axis tracker.

The sun also moves through 46 degrees north-south over the period of a year. The same set of panels set at the midpoint between the two local extremes will thus see the sun move 23 degrees on either side, causing losses of 8.3%. A tracker that accounts for both the daily and seasonal motions is known as a dual-axis tracker.

Single axis trackers

Single axis trackers have one degree of freedom that acts as the axis of rotation. The axis of rotation of single axis trackers is aligned along the meridian of the true North. With advanced tracking algorithms, it is possible to align them in any cardinal direction. Common implementations of single axis trackers 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)

Dual axis trackers

Dual axis trackers have two degrees of freedom that act as axes of rotation. These axes are typically normal to each other. The primary axis is the one that is fixed with respect to the ground. The secondary axis is the one reference to the primary axis. There are various common implementations of dual trackers. Their classification is based on the orientation of their primary axes with respect to the ground.



Figure 6: Dual axis solar tracker.

Fixed and tracking collector's Solar energy can be harnessed using either fixed or movable collectors.

Fixed collectors

Fixed collectors are growing on places that have greater sunlight and are at a relatively good angle in relation to the sun. These include roofs. The main objective is to expose the panel to maximum hours a day without the need for tracking the technology. Therefore, there is a significant reduction in the cost of maintenance and installation. Most containers are of certain types. When using these collectors, it is important to know the position of the sun in different seasons and year time so that the collector has an optimum orientation when it is being installed. It gives maximum solar energy through the year.

Effect of light intensity

Change of the light intensity incident on solar cell changes all the parameters, including the open circuit voltage, short circuit current, the fill factor, efficiency and impact of series and shunt resistances. Therefore, the increase or decrease has a proportional effect on the amount of power output from the panel.

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