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Design and Development of Smart Solar Tracking System

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ABSTRACT: This paper presents the hardware design and implementation of a system that ensures a perpendicular profile of the solar panel with the sun in order to extract maximum energy falling on it renewable energy is rapidly gaining importance as an energy resource as fossil fuel prices fluctuate. The unique feature of the proposed system is that instead of taking the earth as its reference, it takes the sun as a guiding source. Its active sensor constantly monitors the sunlight and rotates the panel towards the direction where the intensity of sunlight is maximum. The light dependent resistor's do the job of sensing the change in the position of the sun which is dealt by the respective change in the solar panel's position by switching on and off the geared motor the control circuit does the job of fetching the input from the sensor and gives command to the motor to run in order to tackle the change in the position of the sun. With the implementation the proposed system the additional energy generated is around 25% to 30% with very less consumption by the system itself. In this paper, an improvement in the hardware design of the existing solar energy collector system has been implemented in order to provide higher efficiency at lower cost

KEYWORDS: Four quadrant sensor, Light Dependent Resistor (LDR), Automatic Solar Tracking System (ASTS)

I. INTRODUCTION

The solar energy is known to be one of the preferred renewable green energies, which is much cleaner and free from harmful production to the environment compared with the conventional counterparts. Maximizing power output from a solar system is desirable to increase efficiency. In order to maximize power output from the solar panels, one need is to keep the panels aligned with the sun, means that the tracking of the sun is required. Solar trackers are the most appropriate and proven technology to increase the efficiency of solar panels through keeping the panels aligned with the sun's position. Solar trackers get popularized around the world in recent days to harness solar energy in most efficient way. The main objective of this paper is to design the sun tracking solar system model which is a device that follow the movement of the Sun regardless of motor speed. Besides that, it is to improve the overall electricity generation using single axis sun tracking system and also to provide the design for residential use.

Solar power is considered as a very viable potential renewable energy source because the largest energy source available is the sun, which supplies practically limitless energy. The energy available from the sun far exceeds any foreseeable future demand. The sun provides energy to sustain life in our solar system. According to, in one hour, the

earth receives enough from the sun to meet its energy needs for a year this is 5000 times the input to the earth's energy budget from all other sources. Despite the immense energy output of the sun, harvesting solar energy has proved to be a great challenge because of the limited efficiency of solar cells. The efficiency of solar cells has been estimated to be between 10-20 percent. This project is based on the concept of improving this efficiency by means of a solar tracking mechanism.

The main purpose of a solar tracking system is to track the position of the sun in order to expose a solar panel to maximum radiation at any given time of the day, as mentioned. This is because the position of the sun with respect to the earth changes in a cyclic manner in the course of the year. Solar tracking is seen to improve the efficiency of solar energy production. It has been shown that use of solar tracking improves the efficiency of solar energy production by up to 30-40%.

II. LITERATURE SURVEY

1. Abhijit Kumar Bhagat - Solar energy is the most important renewable source of energy. The demand of Photovoltaic system is due to the fact that they produce electric power without hampering the environment. Solar PV modules directly convert solar energy into electrical energy. Solar energy is clean and completely natural energy. By using the Solar Tracking System solar module able to maintain the position that sun's rays are always perpendicular to it. Solar Tracking system increases the output from of solar module. This paper reviews the progressive development of the technology used for solar tracking system. This paper also tries to emphasize the various practices and methods to promote the benefits of solar tracker and also discusses other techniques to increase the efficiency of solar module.

2. Nikesh . D . Watane , et.al - This paper presents the hardware design and implementation of a system that ensures a perpendicular profile of the solar panel with the sun in order to extract maximum energy falling on it renewable energy is rapidly gaining importance as an energy resource as fossil fuel prices fluctuate. The unique feature of the proposed system is that instead of taking the earth as its reference, it takes the sun as a guiding source. Its active sensor constantly monitors the sunlight and rotates the panel towards the direction where the intensity of sunlight is maximum. The light dependent resistor's do the job of sensing the change in the position of the sun which is dealt by the respective change in the solar panel's position by switching on and off the geared motor the control circuit does the job of fetching the input from the sensor and gives command to the motor to run in order to tackle the change in the position of the sun. With the implementation the proposed system the additional energy generated is around 25% to 30% with very less consumption by the system itself. In this paper, an improvement in the hardware design of the existing solar energy collector system has been implemented in order to provide higher efficiency at lower cost.

3. S.Sumathi, G.Gayathri, et.al - The dual problems of energy shortage and global warming brought at the forefront of public interest the development of strategies for harnessing renewable energy resources. Solar power is among the most promising sources of renewable energy. Sun trackers can significantly improve a photovoltaic (PV) system's electricity production. This paper presents a novel approach to design of an automatic dual-axis solar tracking system is designed and developed on a mechanical structure with gear arrangement using Light Dependent Resistor (LDR) and DC motors. Using the ARDUINO UNO controller based on Sun-Earth Geometry, two-axis solar monitoring (azimuth angle as well as altitude angle) is implemented.

4. Bhupendra Gupta, et.al - This paper concerns the design and construction of a Hybrid solar tracking system. The constructed device was implemented by integrating it with Amorphous & Crystalline Solar Panel, three dimensional freedom mechanism and microcontroller. The amount of power available from a photovoltaic panel is determined by three parameters, the type of solar tracker, materials of solar panel and the intensity of the sunlight. The objective of this paper is to present analysis on the use of two different material of Solar panel like Amorphous & Crystalline in a Solar tracking system at Stationary, Single Axis, Dual Axis & Hybrid Axis solar tracker to have better performance with minimum losses to the surroundings, as this device ensures maximum intensity of sun rays hitting the surface of the panel from sunrise to sunset.

III.PROJECT EXECUTION

EVOLUTION OF SOLAR TRACKERS:

4.1 Necessity of Solar Tracking System

All solar panels are rated by the DC power they produce in standard test conditions. A typical solar panel produces about 200 Watts of electricity based on the efficiency and size of what is installed.

The factors affecting the amount of power produced by solar panel systems are

1. Sun intensity- The power produced is directly proportional to the sun intensity
2. Solar cell efficiency- higher efficiency means higher power output
3. Solar panel size
4. The amount of sunlight directly hitting the panel.

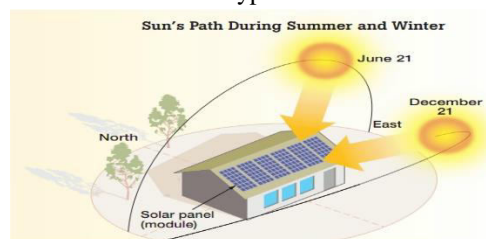


Fig :1 Solar Panel

The main purpose of a solar tracking PV system is to track the position of the sun in order to expose a solar panel to maximum radiation at any given time of the day, as mentioned in . This is because the position of the sun with respect to the earth changes with respect to the earth in a cyclic manner in the course of the year. Solar tracking is seen to improve the efficiency of solar energy production. It has been shown that use of solar tracking improves the efficiency of solar energy production by up to 30-40%, this is according to .As mentioned in , approximately 50% more energy can be collected in the summer in a dry climate such as that found in Phoenix, Arizona, by using a tracking collector. During winter months, however, only about 20% more energy is collected using a tracker. In Seattle, Washington, which receives somewhat more diffuse sunlight than Phoenix, a tracking collector will collect about 35% more in the summer but only 9% more energy compared to an optimized fixed collector in the winter. These studies show that the efficiency improvement of tracking the sun depends on the season and the climate of the region. Despite the major benefits involved in using solar tracking systems, there are a few limitations, which include:

4.2 Sun Tracking Losses:

Sun is moving across the sky during the day. In the case of fixed solar collectors, the projection of the collector area on the plane, which is perpendicular to the radiation direction, is given by function cosine of the angle of incidence. Sun tracking loss occurs when the single or dual axes of tracking solar panels are not set at the optimum orientation, or are misaligned due to a mechanical failure. The most efficient and popular sun-tracking device was found to be in the form of polar-axis and azimuth/elevation types.



4.3 Shading Losses

Shading loss occurs when PV modules are shaded by buildings, trees or other objects in proximity to PV modules. Since the output current of the PV module is a function of solar irradiance, a reduction in solar irradiance as a result of partial or complete shading will affect the performance of the PV module. The PV system is troubled with a

weakness of nonlinearity between current and voltage under partially shaded condition. According to statistic studies the power loss can vary from 10% to 70% .



4.4 Soiling Losses in PV Panel:

Soiling losses refer to loss in power resulting from snow, dirt, dust and other particles that cover the surface of the PV module. Dust is a thin layer that covers the surface of the solar array, and the typical dust particles are less than 10 μm in diameter but this depends on the location and its environment. Dust is generated from many sources such as pollution by wind, pedestrian volcanic eruptions, and vehicular movements among many others. The accumulated dust over time aggravates the soiling effect. In fact, the amount of accumulated dust on the surface of the PV module affects the overall energy delivered from the PV module on a daily, monthly, seasonal and annual basis.



IV. DESIGN CALCULATION

Torque calculation:

$$M = 12 \text{ kg}$$

$$W = 12 \times 9.81$$

$$W = 117.72 \text{ N}$$

$$T = \text{weight of structure} \times \text{perpendicular distance between motor shaft and the panel}$$

$$= 12 \times 9.81 \times 0.05$$

$$= 5.9 \text{ Nm}$$

So we select 7Nm torque motor

Motor Torque :

$$\text{Weight of Solar Panel} = 6.6 \text{ kg}$$

Therefore,

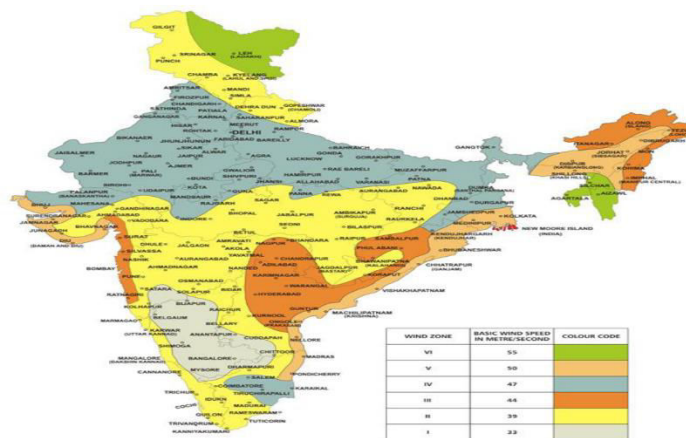
$$\text{Torque required to rotate the panel}$$

$$= \text{Weight of panel} \times \text{perpendicular distance between motor shaft and the panel}$$

$$\text{Torque required to rotate the panel} = 5.9 \text{ Nm}$$

$$\text{Torque required to rotate whole system of 12 (approximate) is } 5.9 \text{ Nm}$$

So we selected 7 Nm torque motor

**Wind Load Calculations :**

$$F_{\perp} = \rho \times v^2 \times S \times \sin^2 \theta$$

Where:

ρ = the air density , $\text{kg/m}^3 = 1.127 \text{ kg/m}^3$

v = the wind speed , $\text{m/s} = 60 \text{ m/s}$

S = The surface area of the solar panel , $\text{m}^2 = 0.5829 \text{ m}^2$

θ = the inclination of solar panel = 45°

$$= 1.127 \times 60^2 \times 0.5829 \times \sin(45)^2$$

$$= 1182.470 \text{ N}$$

this is the highest wind load that the design must withstand according to this method.

SELECTION OF BATTERY:

12V battery is ideally used for DC motor.

We have selected DC motor of 50W.

For same wattage usage

Lead acid battery	Lithium ion battery
Used in inverter and for DC motor.	Used in solar cars.
Cost is about Rupees 950.	Cost is about Rupees 3000 to 5000.
Size is more.	Size is less.

Battery calculations :

$$\text{Battery Power} = \text{Voltage} \times \text{Current}$$

$$\text{Battery Power} = 12 \text{ V} \times 14 \text{ Ah}$$

$$\text{Battery Power} = 168 \text{ Whr}$$

$$\text{Battery can be dischargeable up to } 80 \% \text{ Therefore, Actual Power} = 168 \times 0.8$$

$$\text{Actual Power} = 134.4 \text{ Whr}$$

V. DESIGN & IMPLEMENTATION

SOLAR PLATE

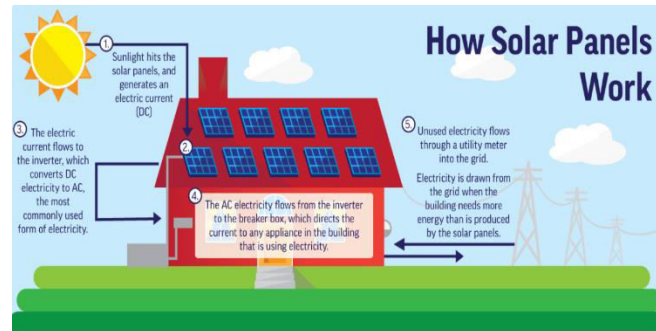


Fig.Working Of Solar Plate

Basic Steps in Solar Energy Generation and Transmission

- Sunlight hits the solar panels, and creates an electric field.
- The electricity generated flows to the edge of the panel, and into a conductive wire.
- The conductive wire brings the electricity to the inverter, where it is transformed from DC electricity to AC, which is used to power buildings.
- Another wire transports the AC electricity from the inverter to the electric panel on the property (also called a breaker box), which distributes the electricity throughout the building as needed.

The Science Behind Solar PV Cells

Solar PV panels are comprised of many small photovoltaic cells – photovoltaic meaning they can convert sunlight into electricity. These cells are made of semi-conductive materials, most often silicon, a material that can conduct electricity while maintaining the electrical imbalance needed to create an electric field.

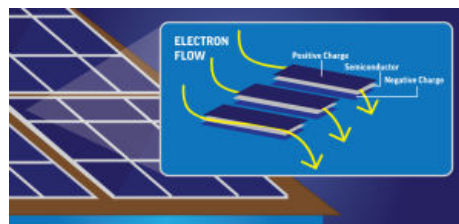


FIG.WORKING OF PV CELL

VI.CONCLUSION

The main aim of this project was to improve the efficiency of solar PV panels by use of a solar tracking system. The designed and implemented single axis solar tracking system proved to be sufficient and was seen to improve the efficiency sufficiently. The project was done within the allocated time and using the available resources to produce a low-cost but effective prototype that solves the problem at hand.

VII. FUTURE SCOPE

The use of solar PV panels is increasing day by day for small scale energy production in houses, offices and at public places. The trackers can be used at the following places.

1. In solar PV panels over the houses, offices.
2. In solar PV panels over the street lights.
3. In solar PV panels energy generation units.



It is the need of the hour that not even a single fraction of energy available must be wasted. Hence a vast research and development is been carried in every field where there is a scope to increase the efficiency of energy generating units.

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