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Efficient Solar Tracking System Using Reflector

Prof. Ms. M. M. Shete[1], Ashutosh Vikram Mote[2], Akshaykumar Rajaram Madgulkar[3], Parikshit Vinayak Pawar[4].

[1]Guide, [2,3,4,5]Students

B. E. Mechanical. PES's Modern College of Engineering Pune – 411 005

ABSTRACT:

A new model of Solar tracking System are proposed, aiming to reduce cost and complexity without sacrificing efficiency of traditional, more complex neural net-based solar trackers. The project aims to develop a small pilot tracker – based solar plant for testing purposes and to develop a useable technology for the ever-growing demand for green power. By tracking the solar, more and more energy is to be generated as the panel is always perpendicular to the Sun's intensity. Renewable energy is rapidly gaining importance as an energy resource as fossil fuel prices fluctuate. The solar tracker will tend to maximize the amount of power absorbed by Photo Voltaic systems. Development of solar panel tracking system has been ongoing for several years. It is advantageous to have the solar tracking system tracks the location of the high light intensity region, such that it generates more energy by absorbing the rays which is radiated from the sun. The objective is to design and implement an automatic solar tracking mechanism using embedded system design with minimum cost and reliable structure. 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. This project aims at the development of process to track the sun and attain maximum efficiency using Arduino Uno for real time monitoring. The project is divided into two stages, which are hardware and software development Servo motor has been used to move the solar panel at maximum light source location sensing by LDR.

Keywords: Solar energy concentrating system, fixed cylindrical reflector, Receiver tracking method, Optical efficiency.

1. Introduction:

Solar energy is rapidly gaining notoriety as an important means of expanding renewable energy resources. As such, it is vital that those in engineering fields understand the technologies associated with this area. This project includes the design and construction of a microcontroller-based solar panel tracking system. Solar tracking allows more energy to be produced because the solar array is able to remain aligned to the sun. This system builds upon topics learned in this course. To make solar energy more viable, the efficiency of solar array systems must be maximized. A feasible approach for maximizing the efficiency of solar array systems is sun tracking. This is a system that controls the movement of a solar array so that it is constantly aligned towards the direction of the sun. Solar modules are devices that cleanly convert sunlight into electricity and offer a practical solution to the problem of power generation in remote areas. The solar tracker designed and constructed in this project offers a reliable and affordable method of aligning a solar module with the sun in order to maximize its energy output. Automatic Sun Tracking System is a hybrid hardware/software prototype, which automatically provides best alignment of solar panel with the sun, to get maximum output (electricity) ideate the design. Problems and possible improvements will also be presented. Solar panel has been used increasingly in recent years to convert solar energy to electrical energy. The solar panel can be used either as a stand-alone system or as a large solar system that is connected to the electricity grids. We are trying to consume more energy from the sun using solar panel. In order to maximize the conversion from solar to electrical energy, the solar panels have to be positioned perpendicular to the sun. Thus, the tracking of the sun's location and positioning of the solar panel are important. The goal of this project is to design an automatic tracking system, which can locate position of the sun. The tracking system will move the solar panel so that it is positioned perpendicular to the sun for maximum energy conversion at all time. Photoresistors will be used as sensors in this system. The system will consist of light sensing system, microcontroller, gear motor system, and a solar panel. Our system will output up to 40% more energy than solar panels without tracking systems. The output power of PV panels is improved through many different solar tracking technologies in modern years. Since solar power is hopeful to be one of the most implemented types of sources for pollution free electricity generation, developing a low cost and higher efficiency solar electrical system is in high needs. The panel efficiency is improved by using reflective sheets that are smooth depending on the sun's position to absorb the maximum power output during any time of the day. This work proposes the dual axis solar tracker with reflectors reflection for optimum output of solar panel by using Arduino unoR3 as the control unit.

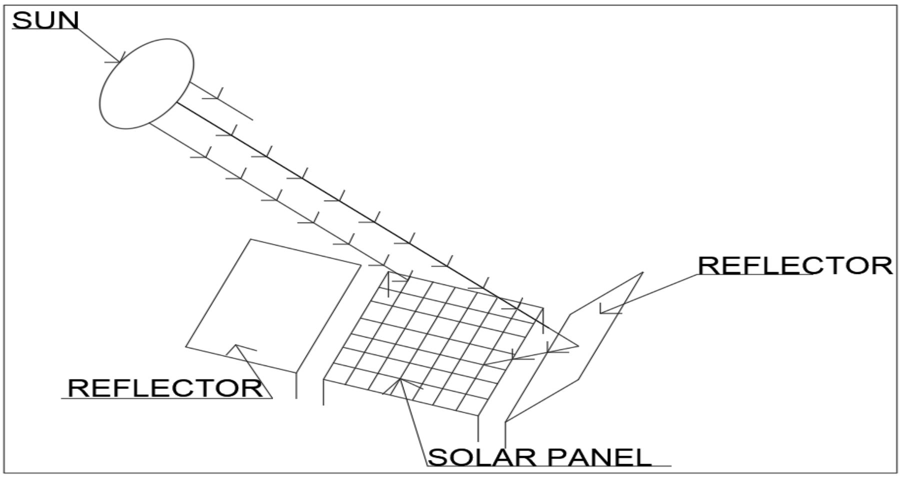


Fig 1 - Solar Tracking System

Solar Tracking Control

In this particular study, the focus is on solar thermal systems, and particularly on controlling the movement of a CSP system in an energy efficient manner. For this purpose, a control system needs to be designed around continuous orientation or positioning of the CSP solar concentrating tracking system with respect to the sun vector. The sun vector SQ (γs, θs) describes the sun's angle and elevation from the perspective of a specific Global Positioning System (GPS) orientation on the earth (Reda and Andreas, 2008). Since accuracy and stability are two of the primary design parameters for a CSP solar tracking system, various control strategy options have been proposed, tested and reported on in the general literature. These include open loop control systems, closed-loop control systems and in some cases an integrated or hybrid-loop control system where open-loop and closed-loop control configurations are combined. There are four main categories of control elements that will need to be considered in open-loop and closed-loop controllers in order to meet the design criteria for this study. These include:

1. **Position of the sun:** To determine the sun vector SQ (γs, θs) from the location of the CSP system;
2. **Effective drive system:** To be able to move the structure efficiently so that it points directly towards the sun;
3. **Control inputs:** Type of control inputs to use, e.g., sun vector algorithm, photo-diodes or camera;
4. **Control system:** Control sequence and intelligence (state diagrams) to manage the electric motors and drives that move the payload or Stirling power system

Methodology:

1. **Research and Literature Review:** Conduct an extensive literature review to gain insights into solar tracking systems and reflector technologies. Analyse relevant research papers and technical documentation to identify best practices and design considerations.
2. **System Design:** Design a solar tracking system that incorporates reflectors on both sides of the solar panel. Determine the optimal size, shape, and placement of the reflectors to maximize sunlight reflection onto the solar panel.
3. **Component Selection and Integration:** Select high-quality reflector materials known for their excellent reflectivity and durability. Choose servo motors that are compatible with the reflector design and capable of precise movement control.
4. **Arduino Programming**: Develop the necessary code using Arduino Uno to control the servo motors and enable accurate movement of the reflectors. Program the Arduino to adjust the reflectors' angles based on the sun's position, considering factors such as time of day and geographical location.
5. **Experimental Setup and Data Collection:** Set up an experimental environment to measure and evaluate the efficiency of the solar tracking system with reflectors. Install sensors to collect data, including solar irradiance, panel output, reflector positions, and other relevant performance metrics

Construction:

To modify domestic solar panel, two adjustable reflectors are situated on both sides of solar panel. The low rpm and high torque motors is connected to hollow shaft of reflector support stand and reflector are placed in that stand. Motors are fixed at top corner of reflectors at 60° from vertical on reflector stand, so that reflectors can stand at 30° inclination from horizontal.

There is Arduino is connected to motor for programming. And one small battery cell of 9 volt is connected to Arduino. This all-programming unit is placed in box and box is fitted at below of panel. So, it can be protected from sunlight and rain.

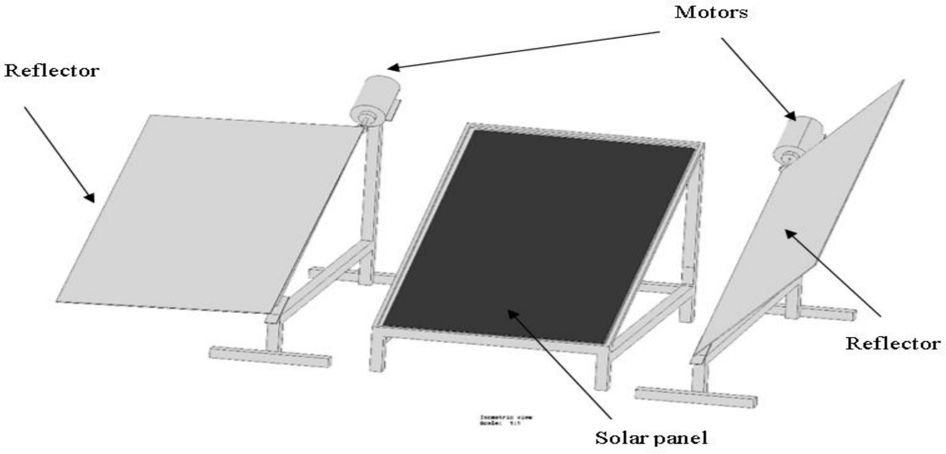


Fig.2 - 3D modelling of solar tracking system

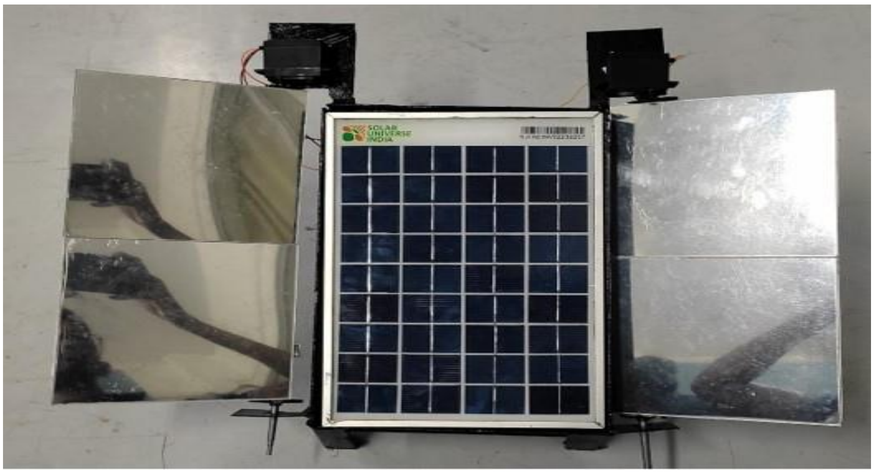


Fig.3 – Actual Setup

Working

For movement of the reflector at accurate time accurate program is needed. So, after making of program on the basis of reading of angle of reflector on particular time. So, reflector automatically can take that particular position to reflect sunlight. Therefore, according to program, at the time early in the morning when there is no any reflect able sunlight at that time reflector are in horizontal position. After some time approx. 9:00 am when there is little bit sunlight can reflect, that time the reflector of opposite side of sun will stand up and reflect sunlight on solar. Up to 11:00 am there is no more photons in sunlight to produce approximately peak power. So, to produce peak power in all day, reflector reflect more photons on solar.

As sun is rising upward, to take corresponding angle for reflect sunlight, reflector also moving downward gradually up to 11:00 am. After 11:00am to 3:30 pm there is no need of reflection because of sufficient sunlight is present to produce peak voltage. Time between 11:00 am to 3:30 pm, both reflectors take horizontal position. After 3:30 pm when peak voltage can't produce due to insufficient sunlight, then other reflector starts to move upward and reflect more photons.

As sun is lowering, reflector rotate upward to take corresponding angle to reflect sunlight. After approximately 6:00 pm when no reflection is possible then reflector take horizontal position. And production of electricity is stopped. This cycle repeats every day. Also, in rainy days and winter, when there is no sufficient sunlight also at the 12:00 pm. That time by using both reflectors can reflect more photons and produce peak voltage.

Block Diagram:

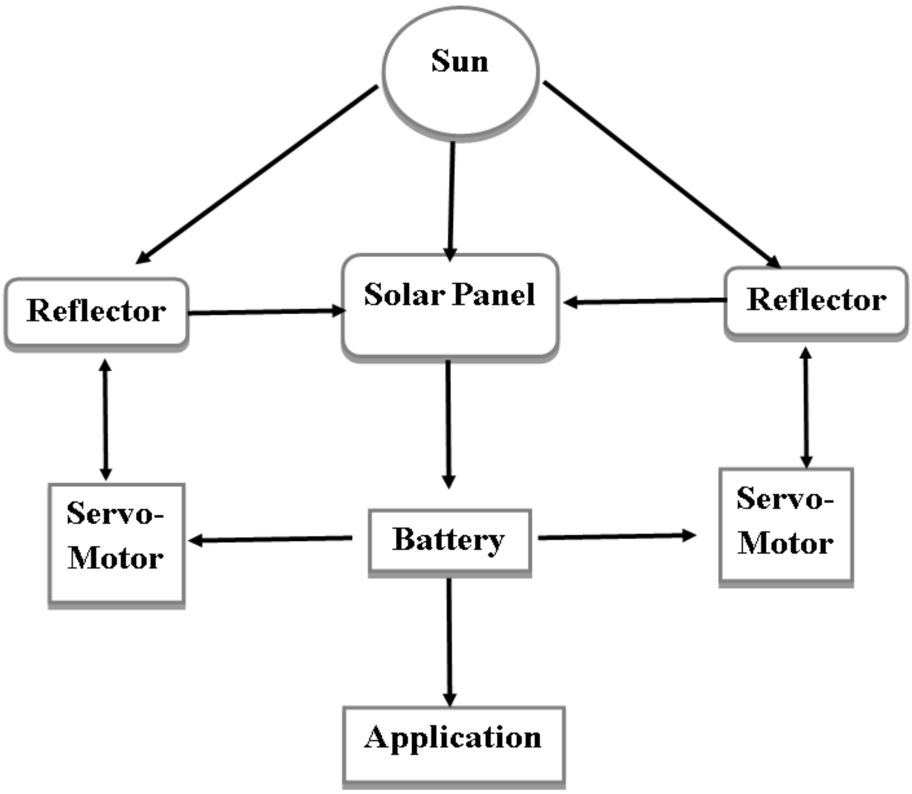


Fig.4 – Block Diagram

Angle calculation

1. Assumption – Sun is rotating (15°/ hr. speed) and earth is stationery…… [360°/24hr =15°]
2. We know that, at 12 pm sun is at mid position i.e., perpendicular to earth surface.
3. An at 9 am sun is at 45° angle from earth surface.
4. So, at 9 am reflector will be perpendicular to horizontal. So that it can reflect sunlight on panel perfectly.

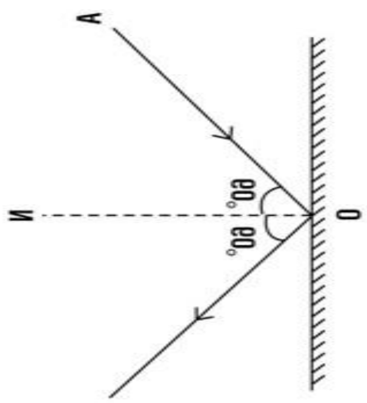
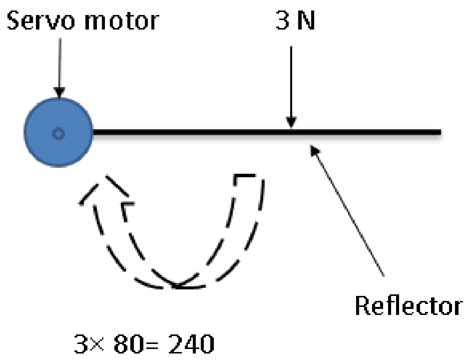


Fig-5 Law of reflection of light

Selection of motor

- The torque which motor have to lift is 240N-mm So for lifting torque of **240N-mm** i.e., **2.4 kg-cm**

- MG 996R high torque low rpm motor is used which is of 11 kg-cm torque.



Results

Actual power output of solar panel

TIME	OUTPUT WITHOUT REFLECTOR(Watt)	OUTPUT WITH REFLECTOR(Watt)
9 A.M	3.72	4.62
10A.M	4.36	5.60
11A.M	5.44	6.28
12P.M	6.26	7.23
1P.M	5.64	6.56
2P.M	5.24	6.31
3P.M	3.92	5.01
4P.M	2.96	3.86

Table 1 -Actual Output

∴ Actual power production per day without reflector is

= 3.72+4.36+5.44+6.26+5.64+5.24+3.92+2.96

= 32 Watt-hr/day

And Actual power production per day with reflector is

= 4.62+5.60+6.28+7.23+6.56+6.31+5.01+3.86

= 46 Watt-hr/day

1. Therefore 14 watt-hr. is extra power produced after using reflector
2. By subtracting power consumption of motor and Arduino we can get net power produced after using reflector.

= 14 – 2.75

= 11.25 watt- hr. / day

Conclusion

The main objective of this project was to maximize the utilization of solar energy in domestic applications. The existing solar electricity generation systems often exhibit peak production during specific fixed times, primarily around noon. However, to ensure the optimal use of solar energy during periods of high demand. The utilization of a reflector specifically designed for domestic applications enhances the efficiency of solar energy capture, increasing the overall energy output.

By implementing this system, homeowners can reduce their reliance on conventional grid electricity, lower their energy costs, and contribute to a greener and more sustainable future.

Overall, this project successfully demonstrates the feasibility and effectiveness of integrating a reflector-based solar energy system with battery storage for domestic applications. It highlights the potential of solar energy as a viable alternative to traditional energy sources, showcasing its ability to meet the electricity needs of households even during periods of low sunlight or high demand.

Output

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List all the material used from various sources for making this project proposal

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