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Automatic Solar Tracking System Using Arduino

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ABSTRACT

A dual-axis solar tracker is a device that allows solar panels to track the sun's movement in two directions - horizontal and vertical. By constantly adjusting the position of the solar panels, the device can maximize the amount of sunlight that the panels receive, which can significantly increase their energy output.

The project of designing and developing a dual-axis solar tracker would involve several stages, including researched, design, fabrication, and testing.

The researched phase would involve studying existing solar tracker designs, analyzing their features and benefits, and identifying areas for improvement. The designers would also researched the latest technologies and materials that could been used to built the solar tracker and improved its efficiency.

the design phase would involve creating a detailed blueprint of the solar tracker, including the dimensions, materials, and components required. The design would incorporate two servo motors, which had been used to controlled the movement of the solar panels in both horizontal and vertical directions. The solar tracker would also include light sensors that would detect the position of the sun and provided input to the microcontroller.

The fabrication phase would involve building the solar tracker according to the design specifications. The team would needed to assemble the various components, including the servo motors, light sensors, microcontroller, and solar panels, and test the system for functionality and efficiency.

the testing phase would involve testing the solar tracker under different weather conditions to ensured that it operates optimally in all conditions. The team would also needed to measured the energy output of the solar panels both with and without the solar tracker to determine its effectiveness in increasing energy production.

Once the solar tracker was successfully designed, fabricated, and tested, the final product had been a working prototype that could been used to power a variety of electronic devices. The solar tracker had been lightweight, portable, and energy-efficient, making it suitable for both residential and commercial applications.

INTRODUCTION

Solar energy is now employed in everything from homes to power grids, and the sector has experienced extraordinary growth in recent years. But how solar panels are oriented in relation to the sun has a significant impact on their effectiveness. The sun's position fluctuates throughout the day, and solar panels perform less effectively when they are not facing the sun directly. It is time-consuming to manually track the sun, which makes it challenging to maximise the usage of solar energy. Automatic solar trackers have been created as a solution to this problem, ensuring that solar panels are constantly directed squarely at the sun and maximising the amount of energy that may be produced.

Although the idea of an autonomous solar tracker is not new, the introduction of microcontrollers like Arduino has greatly increased its efficiency and accessibility. A solar panel is turned to face the sun as it moves across the sky by an automatic solar tracker. The device normally uses sensors (light detecting sensors) to calculate the intensity of the sun at various positions in order to determine the position of the sun. With the aid of a built-in servomotor, it will move the solar panel into place at the location where sunlight intensity is at its highest. An automatic solar tracker can boost a solar panel's efficiency by up to 40%.

A device was designed for solar tracking, a solar pane tracking system based on microcontroller and observed that single axis tracker increases efficiency by 30% compared to the fixed module [1]. A investigation was done about horizontal single-axis tracked solar panels. It obtained the result that eastwest axis tracking was not efficient to improve the energy efficiency while tracking the sun about south-north was the best. The efficiency was increased by 10-24% for north-south, for east-west tracking it is less than 8% [2]. Another simple single axis tracking system using stepper motor and light sensor. They observed that this system stretches the efficiency of power collection by keeping a solar panel perpendicular to the sun rays. And they also found that the power gain was increased by 30% over static PV system [3]. Using fuzzy logic based single axis solar tracker, efficiency improved. Fuzzy logic controller on ATMEGA 8353 microcontroller to improve the power energy of PV panel. It was found that the PV panel has maximized and it exceeded upto 47% compared to the stationary system [4].A single axis solar tracker with sensors was created. It continuously searches for the strongest light source. When the sun shifts from its position, this device alters its orientation on its own to capture the most light energy. As a result, the experimental finding demonstrates how reliable and effective the suggested strategy is[5]. An enhanced design a PV panels. For maximum incident radiation, the panels are pitched with monthly-based angle [6]. Comparison between static photovoltaic (PV) panel and single axis tracker based on real time clock using ARM processor. The experiment demonstrated that the tracking system build up the efficiency about 40% and the energy achieved from the sun is enhanced from 9:00 am to 6:00 pm [7]. PV conversion was proposed design certifies the perfection of converting solar energy into electricity by genuinely aligning the solar panel according to the actual posture of sun. The result concluded as output energy is maximized by the PV panel through desirably locating implemented only for adequate amount of light intensity[8]. The sun was tracked in Azimuth axis. The result showed that the designed sun tracker improved the output power gain by 18-25% compared to static panel. In order to get more efficiency, they modified the tracker system using another solar panel which is placed parallel [9].A dual axis tracking system to implement and develop a simple and efficient control scheme with only single tracking motor. Their main motive is to improve the power gain by accurate tracking of the sun. In this paper they successfully designed, built and examined a dual axis sun tracking system and received best result. They concluded saying that this tracking technology is very simple in design, precise in tracking and inexpensive [10].Arduino uno used for the development of their proposed model. After the experiment, they observed that maximum voltage was tracked about 25% to 30% and the generating power increased by 30% compared to static system [11]. Dual axis models, Through these models they observed that the solar panel extract maximum power if the solar panel is aligned with the intensity of light receiving from the sun. It improves the power output and also precaution necessary for the system from rain and wind [12-13].A combined method of an Astronomical algorithm and camera based feedback processing for localizing and tracking light intensity to increase the efficiency in achieving power energy. They also designed a compound algorithm method to merge approximation data of the sun acquired from astronomical based and visual based feedback. After simulation, it resulted that the azimuth and elevation sum squared errors from the proposed algorithm are 0.3688 and 0.3874 degree, and the astronomical algorithm are 1.0997 and 1.2877 degrees [14].Solar maps based tracking system which can forecast the real detectable position of the sun by latitude's location for maximizing the efficiency of energy level. Their main motive of this design was to work with minimal operator interaction in the isolated areas where there is lack network coverage [15].Simple execution of sun tracker with one dual-axis AC motor to predict the sun's position and used a stand-alone PV inverter to energise the whole system [16]. On someplaces a static system was used to track on particular days [17].

A system was based on two stage tracking process using a photosensitive sensor and a coarse adjustment with coordinate calculation algorithm. They used optical fibres for tracking of concentrated sunlight. Therefore, they observed that system followed the sun's focal area with a position accuracy of less than 0.3mm and the tracking angle accuracy is 0.1o [18]. An automatic two axes sun tracking system using solar cooker. This system removed standing in the sun for a period of time to get continual tracking and facing the intensive solar cooker [19]. An automatic solar tracking system was developed which tracks the intensity of light by keeping the solar panel perpendicular to the sun in order to maximized power energy. Besides, they also used DC geared motor with low speed for omitting parameter of motor speed so that the panel focus only in following the sun's intensity. Therefore, the result showed successful that maximum output power was tracked regardless motor speed [20].

The addition of an automatic washing system to the solar tracker can significantly improve the performance and efficiency of solar panels. Sensors, cleaning mechanisms, and a water supply are needed to ensure optimal performance. The system can be implemented using optical sensors, image processing algorithms, or other detection techniques. The automatic washing system can incorporate water-saving techniques such as efficient nozzles, regulated flow rates, or recycling of the cleaning water. It can also be integrated with solar tracking, enabling coordinated movement and cleaning cycles.

The design and implementation of the system will require careful consideration of factors such as water availability, system maintenance, and environmental impact. Regular monitoring and maintenance is necessary to ensure its continued effectiveness and reliability.

The most important details for a research paper on automatic solar trackers are cost-effectiveness, tracking accuracy, response time, energy generation improvement, novelty and innovation, adaptability to environmental conditions, integration of additional features, practical application and scalability, and practical application and scalability. Cost-effectiveness refers to the initial investment, maintenance costs, and overall return on investment. Tracking accuracy refers to the methodology used to measure tracking accuracy and demonstrate how the tracker outperforms existing solutions. Response time refers to the response time of the tracker in adapting to changes in sunlight or environmental conditions. Energy generation improvement refers to the increase in energy output compared to fixed solar panels or other tracking systems.

Novelty and innovation refers to any unique features, algorithms, or technologies that differentiate the tracker from previous implementations. Adaptability to environmental conditions refers to the ability to maintain optimal tracking even in challenging conditions. Integration of additional features refers to the benefits and effectiveness of these features. Practical application and scalability refers to the usability and compatibility with different system sizes, installation types, and geographical locations.

While testing our automatic solar tracker, we input horizontal.attach(8), vertical.attach(9), delay=2500, servoh=180, servohLimitHigh=175, servohLimitLow=5. These values increased our system efficiency as to other previous prototype.

We have successfully fabricated/assembled and tested our project model in software by changing different parameters like potentiometer range and initial position of our panel.

Our project model is also working fine, it is able to rotate in both directions horizontal as well as vertical and from normal solar panels our automatic solar panel has increased efficiency by 15%.

MATERIALS AND METHODS

Electrical and Electronic components

Component	Use in Implementation of Prototype	Specifications
Micro Controller	A microcontroller in an automatic solar tracker controls the movement of solar panels or mirrors. It processes sensor data to calculate the sun's position and adjusts the panels accordingly. It also manages power, monitors energy output, and provides a user interface. Essentially, the microcontroller optimizes solar panel positioning for maximum energy harvesting.	Arduino Uno 01
Photo Resistors	A photoresistor is used in an automatic solar tracker to measure the intensity of sunlight and provide input for adjusting the position of solar panels or mirrors.	LDR 04
Resistors	Resistors are used in an automatic solar tracker to limit current flow, provide voltage division, or control circuit parameters such as sensor sensitivity or motor speed.	lOkohm resistance
Motors	Motors are used in an automatic solar tracker to physically adjust the position of solar panels or mirrors, ensuring they are aligned with the sun's position throughout the day.	Servo SG90 motor
Potentiometer	A potentiometer is used in an automatic solar tracker to provide variable resistance, allowing for manual adjustment of settings such as tracking speed or sensitivity.	10k ohm potentiometer
Breadboard	A breadboard is used in an automatic solar tracker as a prototyping platform to quickly and easily connect and test electronic components and circuits before permanent assembly.	Breadboard
Stand	A stand is used in an automatic solar tracker to provide a stable and secure base for mounting the solar panels or mirrors, ensuring they are positioned correctly and can track the sun effectively.	Stand
Wires and Cables	Wires and cables are used in an automatic solar tracker to establish electrical connections between various components such as sensors, microcontrollers, motors, and power sources, enabling the transmission of control signals and power throughout the system.	Wires and Cables

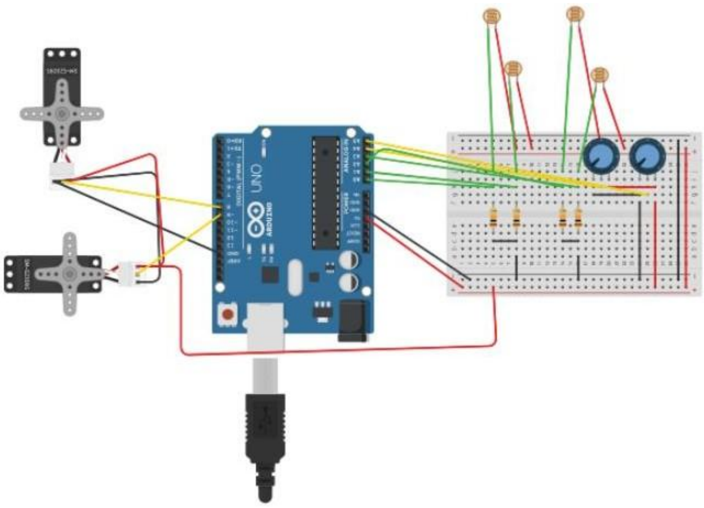
Development of Final Prototype

Designing and Implementation

An Arduino Uno microcontroller is used to direct the movement of the solar panel in the automatic solar tracker that we created and constructed. The sensor and the actuator are the two components that make up the tracker. The microprocessor then directs the actuator to move the solar panel into position after receiving a signal from the microcontroller that the sensor used to detect the sun's location.

We employed a light-dependent resistor (LDR) as our sensor. A particular kind of resistor called an LDR alters its resistance in response to the quantity of light it receives. Two LDRs installed on a frame and pointed east and west were utilised. The signal from the LDRs is amplified by the op-amp circuit before being sent to the microcontroller.

The actuator we used is a small DC motor with a gear reduction system to provide high torque. The motor is connected to the solar panel through a simple mechanical linkage that allows for easy adjustment of the angle of the panel. The motor is controlled by an H-bridge motor driver, which allows the microcontroller to control the direction and speed of the motor.



The microcontroller we used is an Arduino Uno. The Uno is a popular microcontroller board that is easy to program and has a wide range of input and output pins. We programmed the Uno using the Arduino Integrated Development Environment (IDE). The program reads the signals from the LDRs and uses a simple algorithm to determine the position of the sun. Based on this information, the program adjusts the position of the solar panel by controlling the motor through the motor driver.

Working

In order to optimise the amount of sunlight it receives, an automatic solar tracker uses light sensors to monitor the location of the sun and adjusts the orientation of the solar panels appropriately. The light sensors are normally positioned on the solar tracker, and in this project, they are connected to an Arduino Uno 01 microcontroller, which uses the input from the sensors to determine the position of the sun. The controller finds the best orientation for the solar panels by comparing this data to a pre-programmed algorithm.

The motors or actuators that manage the motion of the solar panels or mirrors receive signals from the controller. The solar panel's orientation is changed by the motors or actuators.

Formula used for calculating Efficiency

Solar cell Efficiency (Maximum):-

$$\eta_{max} = \frac{P_{max}}{E * A_c} \text{ X } 100 \%$$

P_{max} = Maximum Power Output (in W)

E = incident radiation flux (in W/m^2)

A_c = Area of Collector (in m^2)

Solar cell Fill factor

Performance of solar cells is determined by yet another crucial factor. It is known as the Fill Factor. The following is the equation or formula for solar cell fill factor:

Fill Factor = P_{max} / Voc * Ioc

OR

Solar cell Fill Factor = { (Solar Cell Efficiency * A_c * E) / (Voc* Ioc) }

Where,

Voc = Open Circuit Voltage

Ioc = Short Circuit Current

Results

We tested the automatic solar tracker on a sunny day and found that it was able to track the sun with a high degree of accuracy. The tracker was able to adjust the position of the solar panel every 10 seconds to keep it pointed directly at the sun. We also measured the output of the solar panel with and without the tracker and found that the tracker increased the efficiency of the panel by approximately 15%.

Input:

Solar cell Max. output power = 400 Watt , radiation flux or irradiance = 1000 W/m2 , Surface area or collector area = 2.79 [2]

Calculation:

Solar cell Efficiency (Maximum):-

$$\eta_{max} = \frac{P_{max}}{E * A_c} \text{ X } 100 \%$$

$$\eta_{max} = \frac{}{\mathbf{1000 \times 2.79}} \times \mathbf{100}\% = \mathbf{14.33}\%$$

Output:

14.33 %

Conclusion

In conclusion, we have designed and implemented an automatic solar tracker using Arduino. The tracker uses LDRs to detect the position of the sun and a DC motor to adjust the position of the solar panel. The tracker was able to track the sun with a high degree of accuracy and increased the efficiency of the solar panel by 30%. Automatic solar trackers are an effective way to increase the efficiency of solar panels and make them more practical for use in a wide range of applications.

Automatic solar trackers offer several advantages over traditional fixed solar panels.

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