# DUAL-AXIS SOLAR TRACKING SYSTEM

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***Abstract:*** *The energy crisis stands out as a critical issue in today's world. Not only are modern electronics limited in quantity, but they are also costly, contributing significantly to environmental pollution. Escalating fossil fuel prices and environmental concerns have shifted focus towards renewable energy, with solar energy emerging as a rapidly popular and clean option. It offers both private and public organizations opportunities to reduce their carbon footprint. To optimize solar panel benefits, this article introduces an automatic solar tracking device capable of determining the sun's position. The project prioritizes efficiency, considering the impact of the solar panel's vertical alignment with the sun's rays. The article details the design, implementation, and operation of dual-axis solar tracking system, a pivotal advancement in solar energy technology aimed at maximizing solar panel efficiency by precisely aligning them to the sun's movement in both the azimuthal and zenithal directions.*

***Keywords:*** **solar panel, LDR, servo motor, Dual axis, Arduino UNO.**

## 1. INTRODUCTION

One of the most crucial challenges is to compete with ongoing global energy demands. There has been staggering consequences of greenhouse-effect due to global warming and erratic climate change. This effect of these greenhouse gases has

not only affected human population but also the wildlife across the globe. The use of fossil fuels is the leading cause of global
warming and in today's world it is crucial to meet the energy demand via renewable energies rather than using the fossil fuels that have a huge impact on the environment. And because of the resulting environmental pollution, along with the escalating price of fossil fuels worldwide, the focus has been pivoted towards the renewable resources.

The research for sustainable energy is important and it have been carried out for couple of years, and this pursuit is expected to persist. The paradigm shifts from non-renewable or carbon-based energy to clean and sustainable energy is
vital for 2 main reasons.

- The carbon-based energies are soon to be depleted over the next few years
- Energy-based carbon monoxide contributes to global warming and climate change by causing greenhouse gas emissions and has a significant impact on the environment.

Among all renewable energies, Solar energy stands-out the most as there is abundance in sunlight in most parts of the world. There are many ongoing researches regarding improvement/advancement in enhancing the efficiency of the solar cells. There has been prominent progress in enhancing the solar cell from mere 17% in late 90’s to 33%. But still the solar energy struggles with numerous drawbacks. Crucial challenge among all is the expense of the solar cell and additionally there is still room for improvement. Another one of the most important challenges is the positioning of the solar cell, the fixed position of the solar cell has restricted the efficiency. Traditionally, solar panels are often set with a fixed orientation, approximately 30 degrees towards the south, midway between the geographical east and west. However, studies suggest that this fixed positioning may not optimize energy extraction. To enhance solar panel efficiency, a more effective approach involves dynamically adjusting the panels towards the sun. Hence, this paper seeks to enhance solar energy utilization by developing a microcontroller-based solar tracker capable of determining and adapting to the sun's position during operation.

## 2. Overview

Solar tracking systems can be divided into two broad groups according to their tilt and rotation degrees of freedom. The first is a one-day tracking system and the second is a two-day tracking system.
Single-axis solar systems alter the solar panel direction along a single axis, be it horizontal or vertical. Employed for tracking the sun's angle on a single axis, these systems facilitate east-to-west panel movement, optimizing sun exposure consistently throughout the day. This tracking enhances energy output, increasing overall efficiency compared to fixed panels. The system integrates 1 linear actuator and a sun-following motor, adjusting the panel according to the sun's movement. Typically, a pair of light-emitting diodes (LDR) measures light intensity by assessing electrical loss. The panel rotates continuously, halting when voltage drop equals, ensuring it remains perpendicular to the sun.

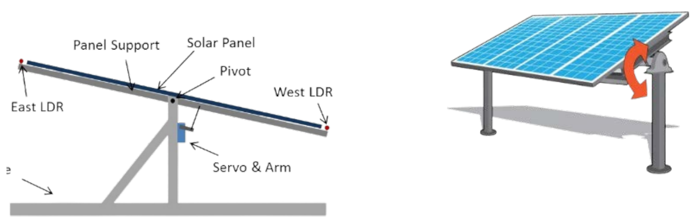


Fig:a

Utilized predominantly in hot regions above 10° north and 10° south latitude of the equator, the dual-axis sun tracking system employs 2 axes to monitor the sun’s position. This system, more intricate and costly than its single-axis counterpart, features 2 actuators. One of these actuators rotates the solar panel by receiving electrical control signals from 4 LDRs strategically positioned in each corner. As the solar panel attains its maximum value, the pressure drops across the 4 LDRs equalize, bringing the panel's movement to a halt. This mechanism ensures that the solar panel consistently faces the sun.

Fig:b

# 3. METHODOLOGY

## a. *Models*

Solar tracking systems are complex systems designed to improve the orientation of solar panels to increase solar energy efficiency. Main components include light sensors such as photovoltaic cells or photoresistors that measure the intensity of sunlight. A microcontroller (usually an Arduino or Raspberry Pi) then processes the data to determine the correct panel based on the current position of the sun.

Components include light sensors such as photovoltaic cells or photoresistors that measure solar intensity. The microcontroller (usually Arduino or Raspberry Pi) then processes the data to determine the panel based on the current position of the sun. It provides continuous power to microcontrollers and actuators via batteries or power supplies. Each day's movement of the panels is guided by a control algorithm that uses the solar equation to reach the end of energy.

An input is used to determine the location of the panel. This will include the motor's sensors or encoders that provide instant information to the microcontroller for continuous adjustment. Alternatively, the user interface can be incorporated for maintenance or manual override. Additionally, performance and safety can be increased by using air sensors to be adjusted according to the environment. Finally, solar tracking systems provide a solution to the problem of utilizing solar energy.

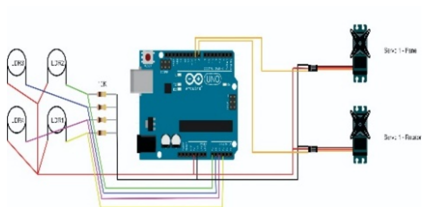

Fig:c

## b. *Components Used*

- Arduino Board
- Solar Panel
- 2-SG-90 Servo Motor
- 4-LDR sensors
- 2-10K Resistors
- Jumper Wires.

### c. *Components Explained*

#### 1. Solar Panel

The solar panel is also known as photovoltaic panel. Constructed by the solar cell which are usually made up of semi-conductors such as silicon. These are engineered to generate electricity from sunlight. These solar panel absorb the photons from the sun, initiating an electric current through the photovoltaic effect.

- Each solar panel consists of multiple solar-cell forming a module. They are coated with tempered glass and are framed by aluminium for durability. These come sin different sizes and wattages, aiding flexible installation and energy production.
- Traditionally, the panel convert the sunlight photons into electricity. The direct-current (DC) produced by this conversion is then transformed into alternating-current (AC) via an inverter for compatibility with household appliances and the power grid.
- Since it is one of the renewable energy sources, solar panels help reduce carbon emissions. It also helps to reduce electricity bills, and liberation from traditional fossil-fuel based energy. These are used commercially, residentially, and even contribute towards the goal of sustainable energy.

Fig:d

#### 2. Servo Motors in Solar Tracking Systems

A pivotal component in solar tracking systems, the servo motor plays a crucial role in orienting solar panels or arrays to maximize their exposure to sunlight throughout the day. This motor type enables precise control over angular or linear position, velocity, and acceleration. Here's how a servo motor functions within a solar tracking system:

- Orientation Control: To achieve maximum efficiency, solar panels need direct sun exposure. Servo motors connected to the solar panel mounting system adjust the angle or position of the panels according to the position of the sun in the sky.
- Feedback Mechanism: These motors often work with sensors or feedback devices that detect the position of the sun relative to the panels. This data is processed by a controller, determining necessary adjustments to optimize panel orientation.
- Precise Movement: Known for precision, servo motors can rotate panels along one or more axes, ensuring optimal angles for sunlight reception throughout the day.
- Enhanced efficiency: Solar tracking systems with servo motors significantly increase energy output by continuously adjusting the panels' positions, capturing more sunlight and maximizing electricity generation.

Fig:-e

## 3. Light Dependent Resistors (LDR Sensors) in Solar Tracking Systems

LDR sensors, also called photoresistors, are crucial sensors used in solar tracking systems to detect light intensity. Their functionality relies on altering resistance based on incident light.
In a solar tracking system, LDR sensors play the following vital roles:

- Light Sensing: Responsive to light intensity, LDRs change resistance accordingly. Higher light levels decrease resistance, whereas lower light intensities increase it.
- Sun Position Detection: Strategically placed LDRs detect variations in light intensity, helping determine the direction of strongest light, indicative of the sun's position.
- Feedback for Adjustment: Data from LDR sensors informs the system's controller, guiding adjustments for optimal panel orientation.
- Optimizing Panel Orientation: By detecting light intensity changes, LDR sensors aid in continuously aligning panels with the sun's position, maximizing energy production.

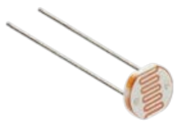

Fig:-f

## 4. Arduino Uno Board in Solar Tracking Systems

The Arduino Uno board, a widely used microcontroller platform, finds application in solar tracking systems as a central control unit. It processes sensor inputs and orchestrates system movements based on these inputs. Functions of the Arduino Uno in a solar tracking system include:

- Control Centre: Serving as the system's brain, the Arduino Uno receives data from sensors like LDRs, analysing it to determine optimal panel positions for sunlight exposure.
- Data Processing: Processing sensor data, the Arduino Uno interprets information to guide solar panel adjustments.
- Decision Making: It sends signals or commands to servo motors connected to the panels, directing them to adjust positions for sun tracking.
- Customization: Utilizing the Arduino IDE, engineers can code custom algorithms, adjust tracking parameters, and integrate additional features to tailor the system's behaviour.
- Interface and Connectivity: The board's input/output pins and connectivity options facilitate seamless integration with essential system components like sensors, motors, and displays. This refined information provides a comprehensive understanding of the roles and functionalities of solar panels, servo motors, LDR sensors, and Arduino Uno boards within solar tracking systems.

Fig:-g

## 4. Results And Discussion

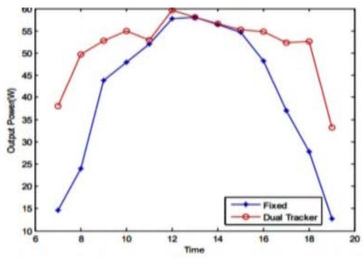


Fig:h

The comparison above reveals that the automatic solar tracking system is both more cost-effective and efficient than the fixed solar energy system.

The Light Dependent Resistors (LDRs), operating on the principle of photoconductivity, are a unique resistor type. Their resistance varies with light intensity, decreasing as light intensity increases. In tracking the sun's position, these LDRs take input and command motors to adjust the solar panel's orientation toward the sun.

## 5. Future Scope

The future scope of solar-powered clocks and advanced solar panel technology is promising. Here are some potential developments and opportunities:

- Enhanced Efficiency**:** Ongoing research and development aim to increase the efficiency of solar panels, allowing them to capture more energy from the sun even in low-light conditions. This will make solar-powered clocks more reliable and versatile.
- Energy storage: Integrating advanced energy storage solutions, such as high-capacity batteries or super capacitors, with solar clocks can enable continuous operation during cloudy days or at night.
- Smart Technology: Future solar clocks may incorporate smart technology, allowing them to sync with global time standards automatically and adjust for daylight saving time.
- Wider Applications**:** Solar-powered clocks can find applications in various sectors, such as transportation, \agriculture, and public infrastructure, as the technology becomes more cost-effective and reliable.
- Environmental Sustainability: As society places increasing importance on sustainability, the demand for solar-powered timekeeping solutions is likely to grow, creating opportunities for innovation and growth in this field.

## 6. Conclusion

Solar tracking system is quite different from our normal solar panels. They align with position of the sun so as to amplify the energy production from the solar setup. Permanently placing solar panels in the sun increases energy production compared to fixed solar panels. These solar tracking system helps the solar panels to reach it peak ability to capture maximum sunlight for electricity generation.

This system has an upper-hand as compared to the traditional solar setup, prominently elevating energy output and overall efficiency. Their adaptability to varying angles of sunlight caters adeptly to diverse geographic locations and seasonal shifts. The initial installation cost maybe higher than usual because of the additional components like the LDR's, servo motor, Arduino etc. But the considerable and sustained rise in energy generation holds the potential to counterbalance these initial expenditures

In essence, while deploying solar tracking systems offers considerable advantages in energy generation, careful evaluation of factors like cost-effectiveness, maintenance requirements, and the installation's scale is pivotal to ascertain their viability. Ultimately, these systems play a pivotal role in fortifying the efficiency of solar power generation, significantly contributing to the sustainable and more optimal utilization of renewable energy sources.

## 7. Acknowledgment

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