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## **Sun Tracking Solar Panel**

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**ABSTRACT**: This Internet of Things (IoT) sun-tracking solar panel project tracks the sun's position dynamically to maximize solar energy efficiency all day long. With the use of stepper motors, light-dependent resistors (LDRs), and a computer, the system automatically adjusts the panel's orientation to maximize solar absorption. Through a cloud platform and online or mobile application, customers can access maintenance insights and performance data in real-time through IoT connectivity. Compared to fixed panels, this intelligent, self-sufficient solution greatly increases energy yield, showcasing the potential of IoT to advance renewable energy technologies.

KEYWORDS: Solar panel, LDR sensors, servo motor.

#### I. INTRODUCTION

#### 1.1 PREAMBLE

Smart, networked systems that maximize performance and efficiency have been made possible by the Internet of Things (IoT), revolutionizing a number of sectors. IoT application to solar energy systems offers a major opportunity to improve energy capture and usage in the renewable energy sector. Static orientation is a common limitation of traditional fixed solar panels, leading to subpar absorption of solar energy. Solar panels may dynamically change their position to follow the course of the sun by integrating IoT with sun-tracking technologies, which maximizes energy yield. This project examines the creation of an Internet of Things (IoT)-based sun-tracking solar panel system, emphasizing the advantages, application, and architecture of such a clever, self-sufficient system.

#### 1.2 SUN TRACKING SOLAR

The sun-tracking solar panel technology continuously aligns the panel with the sun's position throughout the day to maximize solar energy efficiency. Light-dependent resistors (LDRs) use an Arduino or Raspberry Pi microcontroller to sense the amount of sunshine coming from various angles. Stepper motors then change the panel's tilt for the best exposure. With IoT connectivity, real-time performance data and maintenance insights may be accessed through web or mobile applications, allowing for remote monitoring and control via a cloud platform. Compared to fixed panels, this intelligent, autonomous technology maximizes energy capture, greatly increasing energy production and advancing sustainable energy solutions.

#### 1.3 PROBLEM DESCRIPTION

The static orientation of traditional fixed solar panels limits its ability to continuously adjust to the sun's position during the day, resulting in inefficient energy capture. The total efficacy of solar power systems is decreased as a result of this inefficiency, which causes a large loss of potential solar energy. In order to meet energy needs responsibly, it is imperative to optimize solar panel efficiency as the demand for renewable energy sources rises. Creating a system that can dynamically track the sun's movement and modify the angle of the solar panel to guarantee maximum sun exposure at all times is the challenge. Optimizing performance and maintenance also requires incorporating IoT technology, which presents a considerable hurdle, to enable real-time monitoring and management of the system. By developing an Internet of Things (IoT)-based sun-tracking solar panel system that automatically changes to the location of the sun, this project seeks to overcome these problems by greatly boosting energy capture and efficiency.

#### 1.4 **OBJECTIVE**

Creating an Internet of Things (IoT)-based sun-tracking solar panel system with dynamically adjusted panel orientation to track the sun's movement throughout the day is the aim of this project. The technology uses stepper motors for accurate positioning and light-dependent resistors (LDRs) for sunshine detection in an effort to greatly increase energy





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efficiency over conventional fixed solar panels. In order to guarantee optimal operation and system lifetime, the project also aims to integrate IoT technology for real-time monitoring and remote control via a cloud platform. This would give users access to performance statistics and maintenance notifications. By increasing the efficiency of solar power generation, the project hopes to contribute to sustainable energy solutions.

#### 1.5 **SCOPE**

In order to provide real-time sun tracking, the Internet of Things (IoT)-based sun-tracking solar panel project entails building and integrating hardware elements including an Arduino or Raspberry Pi microcontroller, stepper motors, and light-dependent resistors (LDRs). It entails building an IoT network for real-time data transfer to a cloud platform, developing firmware for processing sensor data and motor control, and designing an interface for remote monitoring and control. The project also includes extensive system testing and optimization, performance comparison with stationary solar panels, and detailed documentation and deployment for scalability and real-world application.

#### **II. SYSTEM SPECIFICATION**

#### 2.1 HARDWARE SPECIFICATION:

- Microcontroller Arduino UNO
- Sensor LDR Sensor
- Other Components Solar panel

#### 2.2 SOFTWARE SPECIFICATION:

- Operating system Windows OS
- IDE Arduino IDE

#### **III. SYSTEM ANALYSIS**

#### **3.1 EXISTING SYSTEM**

The majority of solar panel systems that are now in use use permanent mounts, which keep their orientation stable with respect to the ground. This causes suboptimal energy capture because of the sun's movement across the sky. Several sun-tracking systems have been developed to get around this restriction. These systems use mechanical or electronic devices to dynamically modify the direction of the panels. Although these systems guarantee that the panels are always facing the sun, which greatly increases efficiency, they frequently call for extra gear, are more expensive, and might not have the ability to monitor the panels remotely. Despite these obstacles, continuous developments in automation and the Internet of Things offer chances to improve sun-tracking solar panel systems' functionality and accessibility even more, spurring innovation in the field of sustainable energy production.

#### Disadvantages

- Inefficiency
- Cost
- Wear
- Sensor
- Glitches
- Connectivity

#### 3.2 PROPOSED SYSTEM

With its dynamically adjusted solar panel orientation, the suggested sun-tracking solar panel system seeks to overcome the drawbacks of conventional fixed mounts and optimize energy capture all day long. By utilizing cuttingedge IoT technology, the system combines actuators, sensors, and a microcontroller to track the sun's position and modify panel angles on its own. Real-time panel orientation optimization is achieved by accurate movement of stepper motors guided by light-dependent resistors (LDRs), which sense the intensity of sunshine. IoT connectivity also makes it possible to remotely monitor and operate devices through a cloud platform, giving users access to warnings, maintenance insights, and performance data. The suggested approach promises to boost overall solar power generating capabilities for sustainable energy solutions, decrease reliance on fixed mounts, and improve energy efficiency dramatically.





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#### Advantages

- Efficiency
- Adaptability
- Precision
- Sustainability
- Accessibility

#### **IV. PROJECT DESCRIPTION**

#### 4.1 BLOCK DIAGRAM





#### 4.2 PROJECT EXPLANATION

#### 4.2.1. LDR Sensor

The Light Dependent Resistor (LDR) is a type of photocell that exhibits a change in resistance based on the intensity of light falling on its surface. This semiconductor device consists of a light-sensitive material, often cadmium sulfide (CdS) or cadmium selenide (CdSe), sandwiched between two conductive electrodes. When exposed to light, the LDR's resistance decreases, allowing more current to flow through it. Conversely, in darkness, its resistance increases, restricting current flow. This property makes LDRs useful for various applications, including light detection, automatic lighting controls, and in this context, for detecting sunlight intensity to facilitate sun-tracking mechanisms in solar panel systems. LDRs offer a simple and cost-effective solution for measuring light levels, enabling precise adjustments of solar panel orientations for optimal energy capture



FIG 2. LDR Sensor





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#### 4.2.2 Arduino UNO

Arduino Uno is a popular open-source microcontroller board, renowned for its versatility and ease of use in electronics projects. Featuring an ATmega328P microcontroller, it offers a range of digital and analog input/output pins, making it ideal for interfacing with sensors, actuators, and other electronic components. With a USB connection for programming and power supply, it simplifies the development process for both beginners and experienced makers. Arduino Uno supports a wide range of programming languages and development environments, enabling users to quickly prototype and deploy projects in various fields such as robotics, home automation, and IoT applications. Its affordability and vast community support make it a staple in the maker community.



FIG 3. Arduino UNO

Digital Pins (0 - 13):

- D0 (RX): Digital pin used for receiving serial data.
- D1 (TX): Digital pin used for transmitting serial data.
- D2: General-purpose digital input/output pin.
- D3: General-purpose digital input/output pin.
- D4: General-purpose digital input/output pin.
- D5: General-purpose digital input/output pin.
- D6: General-purpose digital input/output pin.
- D7: General-purpose digital input/output pin.
- D8: General-purpose digital input/output pin.
- D9: General-purpose digital input/output pin.
- D10: General-purpose digital input/output pin. Also used as SPI SS (Slave Select) pin.
- D11: General-purpose digital input/output pin. Also used as SPI MOSI (Master Out Slave In) pin.
- D12: General-purpose digital input/output pin. Also used as SPI MISO (Master In Slave Out) pin.
- D13: General-purpose digital input/output pin. Also used as SPI SCK (Serial Clock) pin.

Analog Pins (A0 - A5):

- A0: Analog input pin for reading analog voltage levels.
- A1: Analog input pin for reading analog voltage levels.
- A2: Analog input pin for reading analog voltage levels.
- A3: Analog input pin for reading analog voltage levels.
- A4: Analog input pin. Also used as I2C SDA (Serial Data) pin.
- A5: Analog input pin. Also used as I2C SCL (Serial Clock) pin.





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**Special Function Pins:** RESET: Pin used to reset the microcontroller. 5V: Provides regulated 5V power output. 3.3V: Provides regulated 3.3V power output. GND: Ground pins for providing reference voltage. AREF: Analog reference voltage pin. Used to set the reference voltage for analog-to-digital conversion.

**Communication Pins:** 

TX (Transmit) and RX (Receive): Pins 0 and 1 for serial communication (UART) with external devices like computers. I2C Communication: SDA: Serial Data Line for I2C communication. SCL: Serial Clock Line for I2C communication. SPI Communication:

MISO: Master In Slave Out for SPI communication.

SCK: Serial Clock for SPI communication.

#### 4.2.3. Servo motor

A servo motor is a rotary actuator that allows for precise control of angular position. It consists of a motor coupled with a sensor for position feedback, typically a potentiometer. Servo motors are commonly used in applications where precise positioning and speed control are required, such as robotics, RC vehicles, and automation systems. They operate by receiving a control signal, usually in the form of a pulse-width modulation (PWM) signal, which determines the desired position of the motor shaft. The motor's internal control circuitry then adjusts the motor's speed and direction to move the shaft to the specified position. Servo motors offer high torque-to-size ratio, accurate positioning, and fast response times, making them ideal for various motion control applications, including the precise adjustment of solar panels in sun-tracking systems.



FIG 4. Buzzer.





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4.3 CIIRCUIT DIAGRAM



FIG 5. CIRCUIT DIAGRAM

#### V. IMPLEMENTATION

#### 5.1 STEPS TO CONNECT:

Components Needed: •Arduino UNO •LDR Sensor •Jumper wires

**Identify Pins:** 

Identify the pins on your Arduino UNO, which typically include VCC, GND, AO (Analog Output), and D0 (Digital Output).

Connections:

•Connect LDR Sensors between them.

•And then make a connection with the Arduino Board.

•Connect the servo motor with the Arduino Board.

Upload and Run:

•Write a simple program using the Arduino IDE or another preferred development environment.

•Use the appropriate analog or digital pin in your code to read the sensor's output.

#### 5.2 WORKING

sunshine Detection: To measure the amount of sunshine, light-dependent resistors (LDRs) or other comparable light sensors are mounted on the solar panel array.

**Sensor Data Processing**: Based on the relative intensity of light recorded by the sensors, a microcontroller (such an Arduino or Raspberry Pi) processes the sensor data to calculate the direction of the sun.

**Angle Calculation:** The microcontroller determines the ideal angle for the solar panels to be orientated at in order to maximize solar energy capture based on the processed sensor data.

**Motor Control:** Servo motors or stepper motors mounted on the solar panel are given orders by the microcontroller. These motors move the solar panels in both horizontal and vertical directions to line them up with the position of the sun.





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**Continuous Adjustment:** To track the sun's movement throughout the day, the system continuously measures the intensity of the sun's rays and modifies the solar panels' orientation accordingly.

Energy Conversion: Using photovoltaic cells, the aligned solar panels transform sunlight into electrical energy.

**Energy Usage and Storage:** The electrical energy produced can either be immediately used to power electrical equipment or stored in batteries for later use.

#### VI. RESULT ANALYSIS

Result analysis of a sun-tracking solar panel system involves evaluating its performance, energy efficiency, and economic viability. By comparing the energy output of the sun-tracking system with fixed solar panels, one can determine the increase in energy yield achieved. Additionally, assessing the system's efficiency in tracking the sun's movement throughout the day provides insights into its effectiveness in optimizing energy capture. Cost-benefit analysis helps in understanding whether the initial investment in a sun-tracking system outweighs the long-term energy savings. Furthermore, evaluating the environmental impact, reliability, and user satisfaction provides a holistic view of the system's performance and usability. Identifying areas for future improvements ensures ongoing optimization and enhancement of the system's capabilities.

#### VII. CONCLUSION

In conclusion, the analysis of a sun-tracking solar panel system reveals its significant potential in enhancing energy yield, efficiency, and sustainability. By dynamically adjusting panel orientation to track the sun's movement, the system offers a notable increase in energy output compared to fixed panels. While initial costs may be higher, the long-term benefits in energy savings and environmental impact make sun-tracking systems a viable investment. Additionally, user satisfaction and reliability play crucial roles in ensuring the system's success and widespread adoption. With continuous improvements and advancements, sun-tracking solar panel systems hold promise in contributing to a greener and more sustainable future.

#### VIII. FUTURE ENHANCEMENT

The Sun Tracking solar panel using project can evolve and stay ahead of the curve by incorporating future enhancements. Here are some ideas to consider for advancing the project:

- Advanced Tracking Algorithms
- Integration of Artificial Intelligence (AI)
- Optimized Mechanical Design
- Enhanced IoT Connectivity
- Energy Storage Integration

#### WORKING IMAGE



FIG.6 SENSOR CONNECTION





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