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Dual Axis Solar Tracker Using Arduino

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Abstract: The biggest crisis we are heading into is the climate change due to excessive use of fossil fuels and to overcome these issues, we have only one solution that is utilizing Renewable Energy. Renewable energy is a type of energy that is harnessed from the nature without causing ill effects to the environment. One of the most prominent kinds of renewable energy is solar energy. The output electrical energy depends on the amount of sunlight falling on the solar panel. Traditionally, solar panels are fixed and the movement of sun over the horizon means that the solar panel does not harness maximum energy most of the time. In order to maximize the power from the solar panel, the panel should face the sun all time. In Arduino based solar tracker with the help of LDR and servo motor is used to generate maximum power.
Keywords: Arduino controller, solar panel orientation, Sun tracking, Light sensors, Stepper motors, microcontroller programming, solar tracking algorithms, solar energy optimization, renewable energy system

I. INTRODUCTION

An Arduino-based Dual axis Solar Tracker is an intelligent system designed to optimize the efficiency of solar panels. It uses Arduino microcontrollers and various sensors, such as Light Dependent Resistors (LDRs) or sun tracking algorithms, to continuously monitor the sun's position. By tracking the sun's movement, it adjusts the orientation of solar panels to keep them facing the sun, ensuring maximum exposure to sunlight throughout the day. It is a smart system designed to improve the performance of solar panels. By utilizing this data, it controls a Servo motor to adjust the solar panel's position, ensuring it continuously faces the sun for maximum energy capture. Unlike fixed solar panels, which remain stationary, dual-axis trackers move solar panels in two directions: azimuth (east-west) and elevation (north-south Dual-axis trackers are equipped with sensors that monitor the sun's position throughout the day. By tracking the sun's movement across the sky, they can precisely adjust the orientation of solar panels to face the sun directly. Dual-axis trackers are particularly effective in regions with significant seasonal variations or at higher latitudes. Dual-axis trackers can increase energy production by up to 45% compared to fixed panels, making them an attractive option for both residential and commercial solar installations.

A. Literature

Arduino, an open-source electronics platform, was introduced in 2005. Its ease of use, affordability, and versatility quickly gained popularity among hobbyists, students, and tinkerers interested in electronics and automation. Its community and ecosystem of libraries and resources made it accessible to a wide range of enthusiasts and engineers. In the 2010s, research efforts focused on optimizing Arduino-based solar trackers. This included developing more efficient algorithms for sun tracking, improving the accuracy of sensors, and exploring the economic and environmental benefits of such systems. As of my knowledge cutoff date in September 2021, Arduino-based solar trackers continued to evolve. Innovations included the integration of wireless communication for remote monitoring and control, as well as advancements in materials and sensors for increased durability and efficiency. A literature survey on Arduino-based solar trackers reveals several studies and research papers that explore various aspects of this technology. Many studies focus on the development and optimization of solar tracking algorithms.

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II. DESIGN METHODOLOGY

The overall functioning of the System is explained through the block diagram shown in figure. It represents the general order and hierarchy of various working blocks of the project. Select an appropriate Arduino board (e.g., Arduino Uno, Arduino Mega). Use Light Dependent Resistors (LDRs) or other light sensors to detect sunlight. Employ Servo motors or stepper motors to move the solar panel. Ensure a reliable power source, which may include a solar panel and batteries. Calibrate the LDRs or light sensors to accurately measure light intensity and determine the sun's position. Ensure that the sensors are placed strategically to cover a wide range and minimize shading. Develop or select a tracking algorithm (e.g., single-axis or dual-axis tracking) to calculate the optimal position for the solar panel. Implement the algorithm in the Arduino code to control the servo or stepper motor movements. Program the Arduino to control the servo or stepper motor's position based on the sensor data and tracking algorithm. Ensure smooth and precise movements to track the sun's path. Implement power management features to conserve energy, especially if you're using batteries. Consider sleep modes for the Arduino to reduce power consumption during idle periods.

III. COMPONENTS USED

A. Arduino Microcontroller

Used in solar tracker systems to perform several essential functions. These functions help in the precise tracking of the sun's position and the adjustment of solar panels for optimal energy capture. Arduino reads data from light sensors (e.g., LDRs) to determine the sun's position and intensity. Based on sensor data and algorithms, Arduino controls the movement of motors (usually servo motors) responsible for adjusting the solar panel's orientation. Arduino continuously monitors the solar panel's position and makes real-time adjustments to keep it aligned with the sun.

B. LDR (Light Dependent Resistor)

Light-dependent resistors are made from semiconductor material having light-sensitive properties and hence are very sensitive to light. The resistance of LDR changes according to the light that falls on it and it is inversely proportional to the intensity of light. That is resistance of the LDR will increase at high-intensity light and vice versa. As a result, the LDR's resistance decreases as the incident light becomes brighter... LDRs have an inverse relationship between resistance and light intensity. In other words: High Light Intensity → Low Resistance and Low Light Intensity → High Resistance

C. Resistors

Resistors are commonly used to restrict the amount of current flowing through a particular part of a circuit. By offering resistance to the flow of electrons, they help prevent excessive current that could damage components.

D. Servo Motor

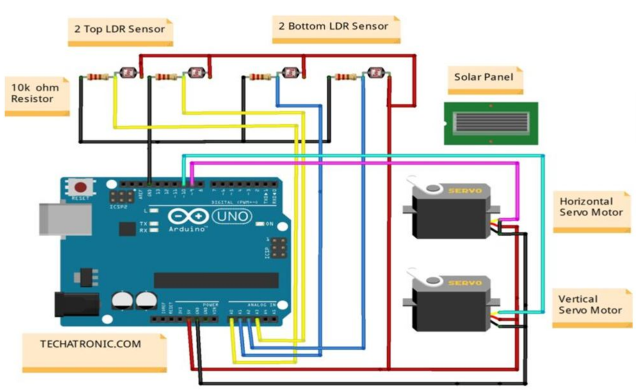
Servo motors used in solar trackers are designed to precisely control the orientation of solar panels to track the movement of the sun throughout the day. Solar trackers require accurate positioning, so servo motors are chosen for their precision and ability to move to specific angles with minimal error.

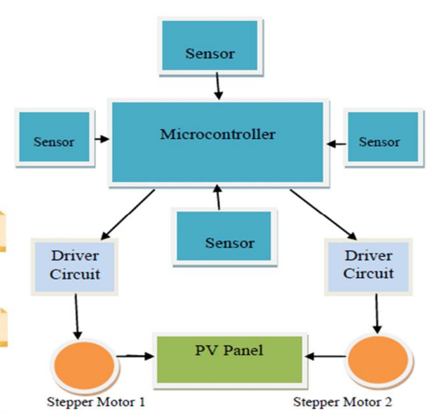
IV. WORKING PRINCIPLE

A dual-axis solar tracker using Arduino operates by using sensors to detect the sun's position and then controlling servo motors or actuators to adjust the orientation of solar panels.

A. Working

1) *Sun Position Sensing:* Light sensors are placed on the solar tracker to detect the sun's position. These sensors can measure the intensity of light or shadows created by the sun. The Arduino reads the sensor values and determines the sun's position relative to the tracker's orientation.
2) *Calculating Tracking Angles:* Based on the sensor data and desired tracking algorithm (e.g., a solar tracking algorithm that calculates azimuth and elevation angles), the Arduino calculates the required angles for both azimuth (east-west) and elevation (north-south) tracking.
3) *Servo Control:* The Arduino sends control signals to the servo motors to adjust the orientation of the solar panels. For azimuth tracking, the servo motor responsible for east-west movement is adjusted to align the panels with the sun's east-west position. For elevation tracking, the other servo motor tilts the panels up or down to match the sun's elevation angle.:
4) *Power Management:* To conserve power, the Arduino can be programmed to put the servos in a sleep mode or idle state when the sun is close to its zenith (directly overhead) or during the night.





Circuit Connection Block Diagram Of Dual Axis Solar Tracker

V. FUTURE SCOPE

The future scope of using dual-axis solar trackers in the renewable energy industry is promising and is likely to continue growing. Dual-axis solar trackers will remain essential for maximizing the efficiency of solar power generation. As solar technology advances, the integration of dual-axis trackers with advanced algorithms and sensors will become more common, further optimizing energy capture. As energy storage solutions like batteries become more widespread, dual-axis solar trackers will play a crucial role in optimizing energy capture and storage. The future scope of dual-axis solar trackers encompasses a wide range of applications, from increasing energy efficiency in established solar farms to supporting emerging technologies like energy storage and hybrid systems. As the renewable energy sector continues to expand, dual-axis solar trackers will play a crucial role in achieving sustainability goals and maximizing the potential of solar power.

With advancements in grid integration, solar trackers can be used more effectively in conjunction with energy storage systems and power grids. This can help stabilize the grid and make solar energy a more reliable source of power. Dual-axis solar trackers can be used in agriculture for precision agriculture and aquaculture to power water pumps and other equipment. These applications can improve food production and reduce operating costs.

VI. CONCLUSION

The use of dual-axis solar trackers with Arduino-based control systems offers a dynamic and cost-effective solution for maximizing the efficiency of solar panel installations. Arduino-based control systems enable precise tracking of the sun's position, ensuring that solar panels are always aligned for optimal energy capture. Arduino is a cost-effective platform for implementing dual-axis solar trackers, making this technology more accessible to a wide range of users and applications. Dual-axis solar trackers using Arduino offer an accessible and adaptable solution for improving the energy efficiency of solar panel systems. Their affordability and customization capabilities make them particularly appealing for small to medium-scale projects, educational purposes, and applications where technical expertise is available. Properly designed and maintained, Arduino-based dual-axis solar trackers can enhance energy generation and contribute to a sustainable energy future.

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