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Control Of Single Axis And Dual Axis Solar Tracking System

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Abstract: Renewable energy is derived from natural, replenishing sources like sunlight, wind, and geothermal heat. One common method for harnessing solar energy is the Solar Tracking System, which maximizes power generation by adjusting the orientation of solar panels to follow the sun. This system uses Light Dependent Resistors (LDRs) to detect sunlight intensity and align the panels accordingly. The solar panels capture the sunlight, convert it into electricity, and store the energy in a battery. The stored energy can then be used to power electrical devices, making it a simple and efficient way to generate clean, renewable energy.

***Index Terms* -** Renewable energy, the Solar Tracking System, solar panels, Light Dependent Resistors (LDRs)

I. INTRODUCTION

The "Automatic Solar Tracking System" is a project designed to optimize solar energy utilization by tracking the movement of the Sun. In today's fast-paced world, energy plays a crucial role in sustaining civilization, and the rising demand for conventional energy sources like coal, oil, and natural gas has led to concerns about their depletion. Additionally, the burning of fossil fuels contributes to environmental pollution, making it essential to explore renewable energy alternatives.

Solar energy, being one of the most abundant and freely available sources, presents a viable solution. The history of solar panels dates back to 1881, with further advancements made in 1941 through the invention of the solar cell by Russell Ohl. Over the years, solar technology has evolved, increasing efficiency and effectiveness. This project is designed to harness solar energy efficiently using a photovoltaic array, a DC motor, and an LDR module.

The system operates by utilizing an LDR module to detect sunlight intensity, allowing the solar panel to adjust its position according to the Sun's movement. The DC motor aids in this tracking process, ensuring maximum energy absorption. By continuously aligning with the Sun, the system maximizes energy conversion while reducing wastage. Unlike conventional energy sources, this system is environmentally friendly and does not emit pollutants.

With only 10 to 20 percent of solar cells being commercially utilized, there is significant potential for further development in solar energy applications. The automatic solar tracking system enhances efficiency, making solar power more accessible and economically viable. Given the growing environmental concerns and the need for sustainable energy solutions, this project provides an innovative and eco-friendly alternative to conventional power sources, offering hope for a cleaner and greener future.

II. OBJECTIVES

The primary objectives of control of single axis and dual axis solar tracking system are as follows:

1. A single-axis solar tracking system adjusts the solar panel along one direction, either horizontal or vertical, to follow the Sun's movement and improve energy absorption.
2. A dual-axis solar tracking system moves the panel in both horizontal and vertical directions, ensuring maximum sunlight capture throughout the day.
3. Both systems aim to increase energy efficiency by continuously positioning the solar panels at the best angle for sunlight exposure.
4. They help in reducing energy waste by optimizing solar power collection compared to fixed panels.
5. The goal is to enhance renewable energy use, making solar power more efficient, sustainable, and cost-effective for various applications.

III. COMPONENTS USED

A solar tracking system is designed to enhance the efficiency of solar panels by ensuring they continuously align with the Sun's movement. The system comprises various electronic components and mechanical structures, which are categorized into three main sections: the solar input, the controlling circuit, and the driving motors.

1.Solar Input Components

These components are responsible for capturing solar energy and converting it into electrical energy.

- Solar Panel: The primary component that absorbs sunlight and converts it into electricity through photovoltaic cells.
- Photovoltaic (PV) Array: A combination of multiple solar panels that enhances the energy generation capacity.
- Light Dependent Resistors (LDRs): These sensors detect the intensity of sunlight and help determine the optimal position for the solar panel.

2.Controlling Circuit Components

The controlling circuit ensures the system's proper operation by processing sensor inputs and directing the panel's movement.

- Microcontroller (e.g., Arduino, PIC, or ESP32): Acts as the central processing unit that interprets data from the LDR sensors and sends signals to the motors for movement.
- Motor Driver (L293D or L298N): Regulates the power supply to the motors, enabling controlled movement of the solar panel.
- Power Supply Unit: Provides the necessary electrical energy for the circuit components, often sourced from the solar panel or an external battery.
- Voltage Regulator (e.g., LM7805 or LM317): Maintains a stable voltage supply to the microcontroller and other components.
- Diodes (e.g., IN4007): Prevents backflow of current, ensuring the circuit operates safely.
- Capacitors and Resistors: These components stabilize the circuit, filter noise, and regulate current flow.

3.Driving Motors and Mechanical Structure

The mechanical section ensures the movement of the solar panel according to the Sun's position.

- DC Motor / Stepper Motor / Servo Motor: Provides rotational motion to the solar panel based on signals received from the controller.
- Steel Rods and Frame: Serve as the structural foundation for the solar panel, ensuring stability and support.
- Rotational Axis / Shaft: Allows smooth movement of the solar panel as it follows the Sun.
- Bearings and Hinges: Facilitate the controlled movement of the panel, reducing friction and enhancing durability.

IV. SYSTEM ARCHITECTURE

The architecture of the solar tracking system is structured into three key components: the solar input system, the control circuit, and the mechanical driving system. These components work together to ensure the efficient tracking and utilization of solar energy.

Solar Input System

The solar input system consists of a solar panel or photovoltaic (PV) array that captures sunlight and converts it into electrical energy. Light-dependent resistors (LDRs) are placed on the panel to detect the intensity and direction of sunlight. These sensors provide real-time data to determine the optimal panel positioning.

2. Control Circuit

At the heart of the system is a microcontroller (such as Arduino, PIC, or ESP32), which processes input signals from the LDRs and determines the necessary adjustments for panel alignment. A motor driver circuit (L298N or L293D) controls the movement of the motors based on the commands from the microcontroller. The power supply unit ensures stable voltage and current flow, while additional components such as voltage regulators, capacitors, and resistors help maintain circuit stability.

3. Mechanical Driving System

The mechanical structure consists of DC motors, stepper motors, or servo motors responsible for rotating the solar panel. In a single-axis system, the panel moves along one direction, while in a dual-axis system, it moves in both horizontal and vertical directions. Steel rods, bearings, and a rotational axis provide structural support, allowing smooth motion.

V. WORKING PRINCIPLE

The working principle of a solar tracking system revolves around optimizing solar panel alignment to capture maximum sunlight throughout the day. This system functions by detecting the Sun's position using Light Dependent Resistors (LDRs), which sense variations in light intensity. The detected data is then processed by a microcontroller (such as Arduino or PIC), which determines the optimal angle for the solar panel. Based on this input, the motor driver activates DC motors, stepper motors, or servo motors to adjust the panel's position accordingly.

In a single-axis solar tracking system, the panel moves along a single direction, either horizontally (east-west) or vertically (up-down), depending on the setup. The LDR sensors compare light intensity on both sides of the panel, and if an imbalance is detected, the microcontroller commands the motor to rotate the panel until balance is restored. This ensures the panel remains aligned with the Sun from sunrise to sunset.

In a dual-axis solar tracking system, the panel moves in two directions, allowing it to track both the Sun's daily east-west movement and its seasonal variation in altitude. Two sets of LDR sensors detect light intensity from multiple angles, and two motors adjust the panel's position to maximize sunlight exposure throughout the day and across different seasons.

Both tracking systems significantly increase energy efficiency compared to fixed solar panels, as they allow for better absorption of sunlight. This results in higher power output and improved utilization of renewable solar energy. Additionally, these systems reduce energy waste and enhance the overall effectiveness of solar power generation, making them an environmentally friendly and sustainable alternative to conventional energy sources.

VI. RESULTS AND OBSERVATIONS

The implementation of the Solar Tracking System demonstrated significant improvements in solar energy utilization compared to fixed solar panels. The system effectively adjusted the solar panel's orientation in response to the Sun's movement, ensuring optimal energy capture throughout the day. The results were analysed based on energy efficiency, power output, and system performance.

Key Findings

1. Enhanced Energy Efficiency
    - The tracking system allowed the solar panel to maintain the best possible angle with respect to sunlight, increasing power generation efficiency.
    - The single-axis system improved energy absorption by 20-30%, while the dual-axis system showed an increase of up to 40% compared to a fixed solar panel.

2. Improved Power Output
   - Measurements indicated that the system consistently produced higher voltage and current compared to stationary panels, especially during early morning and late afternoon when the Sun is at lower angles.
   - The dual-axis tracker demonstrated greater energy capture, particularly on cloudy days, by adjusting to indirect sunlight.
3. Automatic and Responsive Operation
   - The LDR sensors accurately detected sunlight intensity, and the microcontroller-controlled motors efficiently adjusted the panel’s position.
   - The system operated smoothly with minimal energy consumption, making it a sustainable solution for solar energy harvesting.
4. Structural and Mechanical Performance
   - The mechanical components, including steel rods and motorized axis rotation, provided stable and reliable movement of the panel.
   - Bearings and hinges reduced friction, allowing seamless tracking without excessive wear and tear.

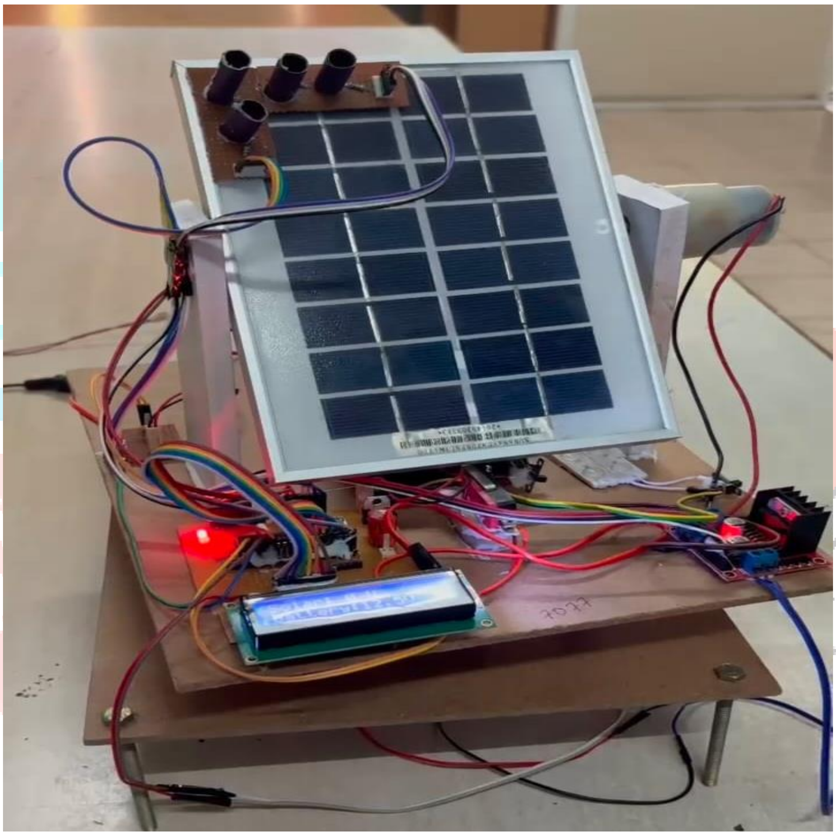

Fig: CONTROL OF SINGLE AXIS AND DUAL AXIS SOLAR TRACKING SYSTEM

VII. ADVANTAGES

- The system increases solar panel efficiency by ensuring maximum sunlight exposure throughout the day.
- It reduces energy waste by continuously adjusting the panel’s position to capture optimal sunlight.
- The use of renewable solar energy helps in reducing dependency on fossil fuels.
- It minimizes environmental pollution by providing a clean and sustainable energy source.
- Automation improves performance by using sensors and motors to track the Sun without manual adjustments.
- The project enhances the lifespan of solar panels by optimizing energy absorption and reducing strain.
- It provides a cost-effective solution by increasing energy generation without requiring additional panels.
- The system is versatile and can be used in residential, commercial, and industrial applications.
- Dual-axis tracking ensures higher energy conversion compared to fixed solar panels.

- It contributes to technological advancement by integrating automation and renewable energy solutions.
- The project is user-friendly and requires minimal maintenance after installation.

VIII. EXISTING SYSTEM DISADVANTAGES

- The system requires additional components like sensors, motors, and controllers, making it more expensive than fixed solar panels.
- Regular maintenance is needed to ensure smooth operation, as moving parts may wear out over time.
- Power consumption by the motors reduces the net energy output, which slightly impacts overall efficiency.
- Dual-axis systems, while more efficient, require a more robust structural design, increasing material and labour costs.
- The movement of the system can introduce mechanical noise, which may not be suitable for all locations.

IX. CONCLUSION

The solar tracking system enhances energy efficiency by ensuring that solar panels continuously align with the Sun's movement. By integrating sensors, microcontrollers, and motor-driven mechanisms, the system maximizes energy absorption while reducing wastage. A single-axis system offers a simpler, cost-effective solution, whereas a dual-axis system provides greater efficiency by tracking sunlight in two directions. This project demonstrates the potential of renewable energy solutions, contributing to sustainability and reducing dependence on fossil fuels. With increasing energy demands, such innovations play a crucial role in promoting eco-friendly alternatives, making solar energy more efficient, accessible, and viable for the future.

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