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Dual Axis Solar Tracker

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Abstract: The dual-axis solar tracker represents a significant advancement in solar energy technology, designed to optimize the solar energy capture by dynamically adjusting the position of photovoltaic (PV) panels. This system utilizes two degrees of freedom: azimuthal (horizontal) and elevational (vertical) adjustments, allowing the solar panels to follow the sun's trajectory across the sky. By aligning the panels perpendicular to the sun's rays throughout the day, the tracker can increase energy absorption by up to 25-45% compared to fixed installations.

This technology is particularly advantageous for applications requiring high energy yield and space efficiency, such as in residential solar power systems and large-scale solar farms. However, the complexity and cost of dual-axis trackers can be a consideration, as they involve more sophisticated mechanisms and maintenance compared to single-axis or fixed systems.

Keywords: Microcontroller, Solar Energy Systems, Tracking Mechanism, Energy Efficiency, Sun Tracking System

I. INTRODUCTION

In the pursuit of maximizing the efficiency of solar energy systems, the dual-axis solar tracker has emerged as a pivotal innovation.

Traditional solar panel installations often rely on fixed mounts that limit their ability to capture optimal sunlight throughout the day and year. In contrast, dual-axis solar trackers actively adjust the orientation of photovoltaic (PV) panels to align with the sun’s position in both horizontal and vertical planes. This dynamic adjustment significantly enhances the amount of solar irradiance that the panels receive, thereby increasing energy production.

This introduction outlines the fundamental principles behind dual- axis solar tracking, including the mechanics of its operation and the potential benefits it offers in terms of energy efficiency and system performance. It also briefly touches on the challenges and considerations associated with implementing dual-axis trackers, such as cost, complexity, and maintenance requirements

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The advancement in solar tracking technology, driven by increasing demand for renewable energy and the quest for higher efficiency, positions dual-axis trackers as a critical component in modern solar energy systems. Their ability to adapt to varying solar angles makes them an invaluable asset for both residential and commercial solar power applications, contributing to the broader goals of sustainable energy production and environmental conservation.

II. LITERATURE REVIEW

A. Design and implementation of a dual axis solar tracking system

The proposed dual-axis solar tracking system is characterized by a fairly simple and economical electromechanical setup and ease of installation and operation. Since the base is designed to rotate in the horizontal direction, thus determining the movement of the solar panel in 1 degree of freedom, its dimensions should be a bit bigger than those of the panel to ensure the dynamical stability of the device. Instead, it should be suitable for smalland medium-sized applications, such as individual rooftop solar tracking systems.

B. Design and implementation of IOT based dual axis solar tracking system

This paper deals with explanation of how robotics are often applied to different fields of agriculture. The foremost important occupations in a developing country like India is agriculture. It’s important to boost the effectiveness and productivity of agriculture by swapping laborers with intelligent machines like robots using new technologies. The paper proposes a brand new strategy to interchange humans in various agricultural operations like detection of presence of pests, spraying of pesticides, spraying of fertilizers, etc. there by providing safety to the farmers and precision agriculture.

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The developed system involves developing a prototype which uses simple cost effective elements like microprocessors, wireless camera, different motors and terminal elements which helps the farmers in different crop field activities.

C. A dual-axis solar tracking system with minimized tracking error through optimization technique

novel Artificial Neural Network (ANN) model and a recently developed Particle Swarm Optimisation (PSO) technique known as the randomly occurring dispersed delaying particle swarm optimization methodare combined in this framework. This approach is used to broaden the search area and improve the trainingof the ANN system by lowering the danger of becoming stuck in local optima

D. Implementation of Dual Axis Solar tracking system

Generally, by using the traditional dollar per watt rate, fixed-mount systems initially cost less. Fixed- mount solar can also be a good choice due to geographical and site constraints, such as soil type and unit location [5]. The production of solar energy is much more costly than traditional energy sources, partlydue to the cost of manufacturing PV modules and partly due to the conversion performance of the equipment. Solar installations can produce no power at all at any stage, which could lead to a shortage of energy if toomuch of the electricity in a region comes from solar power.

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III. METHODOLOGY

Sensor Array Setup:

• Use the 4 LDR sensors to create a light sensor array. Place two pairs of LDRs on the solar panel, one pairfor detecting the azimuth (left/right) and one pair for elevation (up/down).

Signal Processing with LM358:

• Connect the LDR sensors to the LM358 IC to amplify and process the signals. Use one LM358 IC for theazimuth sensors and another for the elevation sensors.

• The difference in light intensity between each pair of LDRs will generate a voltage difference which canbe used to determine the direction of movement.

Control Circuit with 555 Timer:

• Use the 555 Timer IC to generate a clock pulse to drive the control signals. This can be used to create apulse-width modulation (PWM) signal for the servos.

Motor Driver Circuit (L293D):

• Connect the outputs from the LM358 IC to the inputs of the L293D motor driver IC. This will control theMG996 servo motor for both azimuth and elevation adjustments.

• Ensure the motor driver is properly powered using the 18650 battery and the DC-DC boost converter tomaintain a consistent voltage.

Servo Motor Control:

• Attach the MG996 servo motor to the solar panel mount. The servos will adjust the panel's position based on the signals received from the L293D motor driver.

Power Management:

Use the 5V 6W solar panel to power the system and charge the 18650 battery using the TP4056 LiPobattery charger module.

Circuit Assembly:

Assemble the circuit on a breadboard or PCB, ensuring all components are correctly connected. Use resistors, capacitors, and diodes as necessary to stabilize and protect the circuit.

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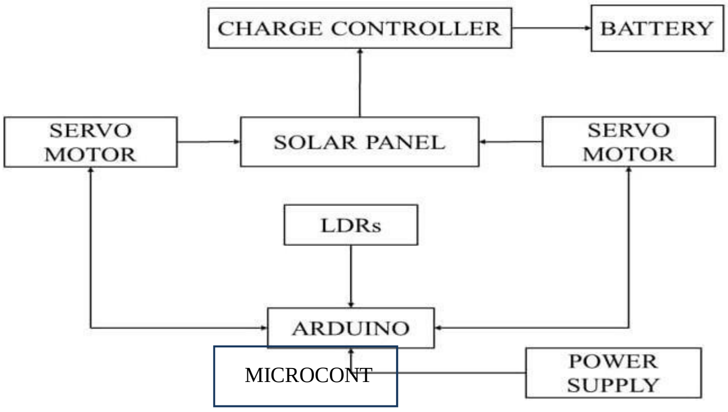

Fig 1: Block Representation

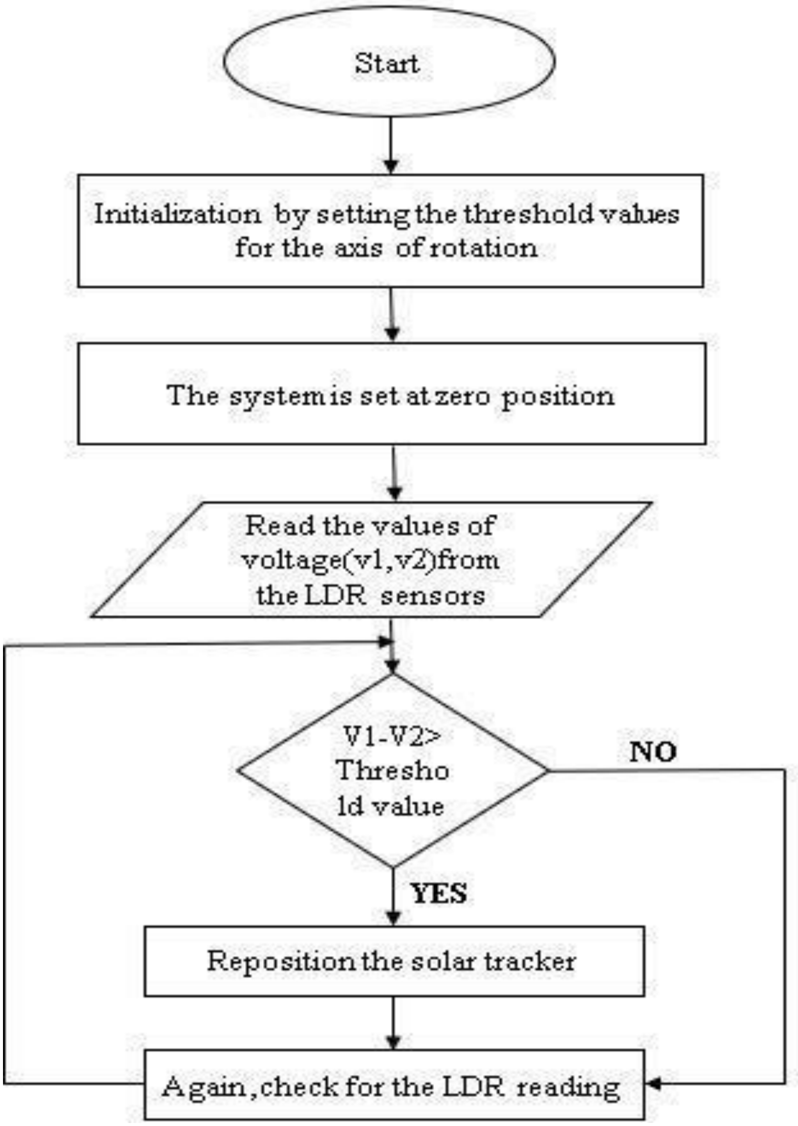

Fig 2: Flowchart

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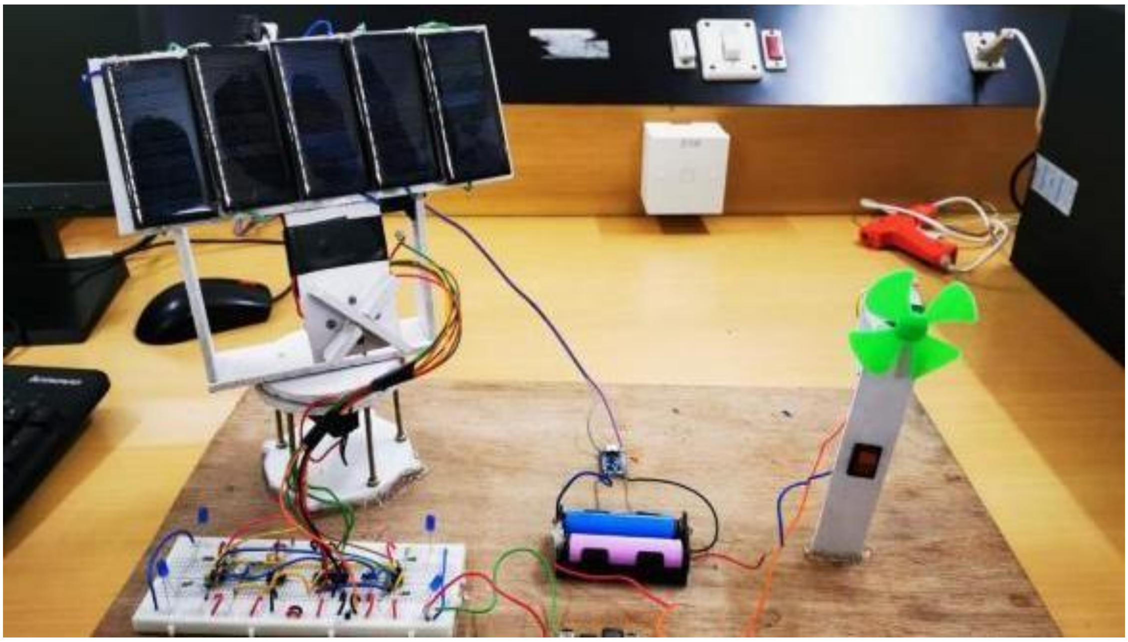
Hardware Components Uses:

1. LM358 IC
2. 555 timer IC
3. Ldr sensor x 4
4. L293d motor driver IC
5. Mg996 servo motor
6. 5v 6w solar panel
7. Lipo battery charger module mini tp4056 ic
8. 104pf and 103pf capacitors
9. 10k and 100k variable resistors
10. 4148 diode x 2
11. Dc to dc boost converter lm2587

IV. RESULTS

After the successful completion of the project we observed that the solar tracker:

1. Is capable of producing more efficient power compared to fixed solar pannels.
2. Is capable of self operating.
3. Is capable of producing more power from single pannel compared to fixed solar pannel.



V. CONCLUSION AND FUTURE SCOPE

The dual-axis solar tracker significantly enhances the efficiency and effectiveness of solar energy systems. By continuously adjusting the position of the solar panels to track the sun's movement, the tracker maximizes sunlight exposure and energy capture, resulting in higher power output compared to fixed systems

Future scope

A. *Predictive Maintenance*: Use machine learning algorithms to predict and schedule maintenance, reducing downtime and extending the lifespan of the system.

B. *Artificial Intelligence*: Implement AI-based tracking algorithms that can predict the sun's path moreaccurately and adjust the panel position dynamically based on weather conditions and historical data.

C. *Adaptive Tracking*: Develop adaptive tracking systems that can optimize tracking efficiency by considering factors such as panel orientation, shading, and local climate conditions.

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