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"AUTOMATIC SOLAR TRACKING SYSTEM WITH OVERCHARGING PROTECTION"

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Abstract: The AUTOMATIC SOLAR TRACKING SYSTEM WITH OVERCHARGING PROTECTION System project aims to develop a solar tracking system that enhances the performance of photovoltaic modules in a solar energy system. By continuously aligning the photovoltaic modules with the sun's rays, the system maximizes their exposure to sunlight, thereby increasing power generation efficiency. The project involves the design, implementation, and programming of hardware components, including servo motors, LDRs, and an Arduino UNO microcontroller.

The system utilizes an ATmega328P microcontroller to control the movement of two servo motors, which adjust the orientation of the solar panel in two axes. The microcontroller receives inputs from four photo sensors located near the solar panel to accurately determine the angle of rotation. At the conclusion of the project, a fully functional solar tracking system is designed and implemented, capable of aligning the solar panel with the sun or any light source repeatedly. Furthermore, the study compares the energy conversion efficiency of photovoltaic modules with and without solar tracking systems. The analysis demonstrates that a dual-axis solar tracking system generates 31.3% more power than a fixed photovoltaic module, highlighting the effectiveness of solar tracking technology in maximizing power output.

Keywords: Dual Axis, LDR, Microcontroller, Servomotor, Solar Tracker, Solar energy, Automatic solar tracking system, Arduino microcontroller, maximum illumination, reduction in cost, maximum efficiency.

I. INTRODUCTION

With the inevitable depletion of fossil fuel sources in the future, renewable forms of energy have garnered significant attention from researchers, experts, investors, and policymakers worldwide. Emerging renewable energy sources include hydroelectricity, bioenergy, solar, wind, geothermal energy, tidal power, and wave power. Due to their renewable nature, they are considered viable alternatives to fossil fuel sources.

Among these energy types, solar photovoltaic (PV) energy stands out as one of the most abundant resources. This technology has seen widespread adoption for residential use, thanks to ongoing research and development efforts aimed at improving solar cell performance and reducing costs. According to the International Energy Agency (IEA), global PV capacity has been growing at an average rate of 49% per year since the mid-2000s, indicating the increasing significance of solar PV energy in the future energy landscape.

However, despite its advantages, solar PV energy still faces challenges in fully replacing traditional energy sources. Maximizing the power output of PV systems in regions with limited solar radiation remains a key challenge. Further advancements are required from manufacturers to enhance the efficiency of PV materials. Nevertheless, improving system design and module deployment offers a practical approach to increasing the efficiency of solar PV power generation, making it a reliable option for consumers.

In line with this objective, the AUTOMATIC SOLAR TRACKING SYSTEM WITH OVERCHARGING PROTECTION System project aims to enhance the efficiency of solar PV energy generation by maximizing the exposure of solar panels to the sun's radiation. The project involves the development of a prototype light tracking system that can be scaled for practical applications in various solar energy systems. The system utilizes an ATmega328P microcontroller to control the movement of two servo motors, which rotate the solar panel in two axes. The rotation of the panel is determined based on inputs retrieved from four Light Dependent Resistors (LDRs) located on the top and bottom sides of the panel.

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II. PROJECT OBJECTIVE

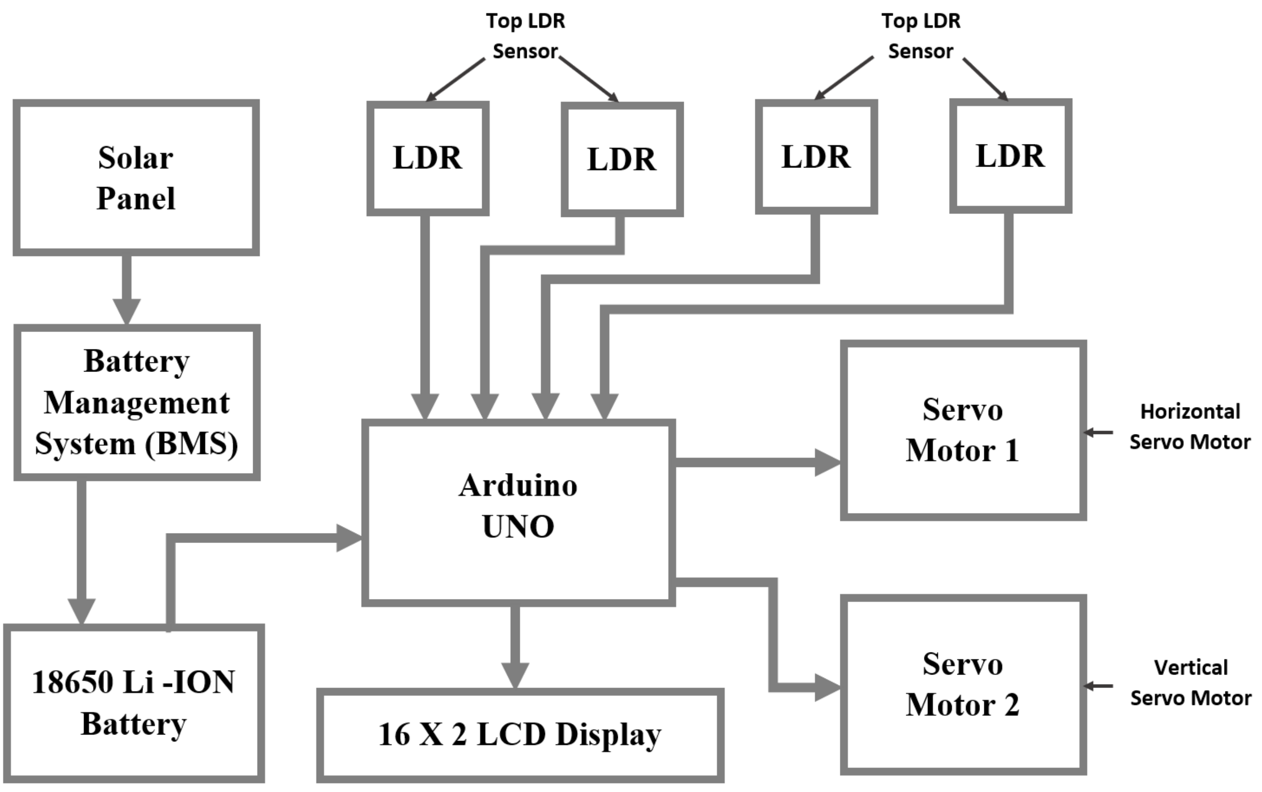
1. Optimize solar energy capture.
2. Ensure alignment with the sun's rays throughout the day.
3. Control servo motors for dual-axis adjustment.
4. Utilize LDRs to determine optimal panel position.
5. Maximize exposure to sunlight for increased power generation.
6. Serve as a reference for future advancements in solar tracking systems.

III. LITERATURE REVIEW

The exploration of AUTOMATIC SOLAR TRACKING SYSTEM WITH OVERCHARGING PROTECTION systems in literature underscores a concerted endeavor to optimize the efficiency of solar energy capture by dynamically aligning solar panels with the sun's trajectory. Hossein Mousazadeh et al. (2011) demonstrated a notable 30% increase in energy collection using a mobile sun-tracking system equipped with four light-dependent resistive sensors and a microcontroller-driven electronic drive board for precise control. This innovative approach not only showcases the potential for significant energy gains but also underscores the feasibility of integrating advanced sensor and control technologies into solar tracking systems for enhanced performance.

Moreover, K.S. Madhu et al. (2012) underscored the efficacy of dual-axis trackers in augmenting power efficiency by 26 to 38% compared to fixed plates, particularly under normal weather conditions. Their findings corroborate the substantial impact of dual-axis tracking mechanisms in maximizing solar energy capture, emphasizing the importance of adaptable systems that can effectively follow the sun's movement throughout the day. These studies collectively highlight the pivotal role of dual-axis solar tracking systems in advancing renewable energy technologies, offering practical insights into design considerations, control strategies, and the tangible benefits of dynamic panel alignment for optimized energy harvesting.

IV. BASIC BLOCK DIAGRAM



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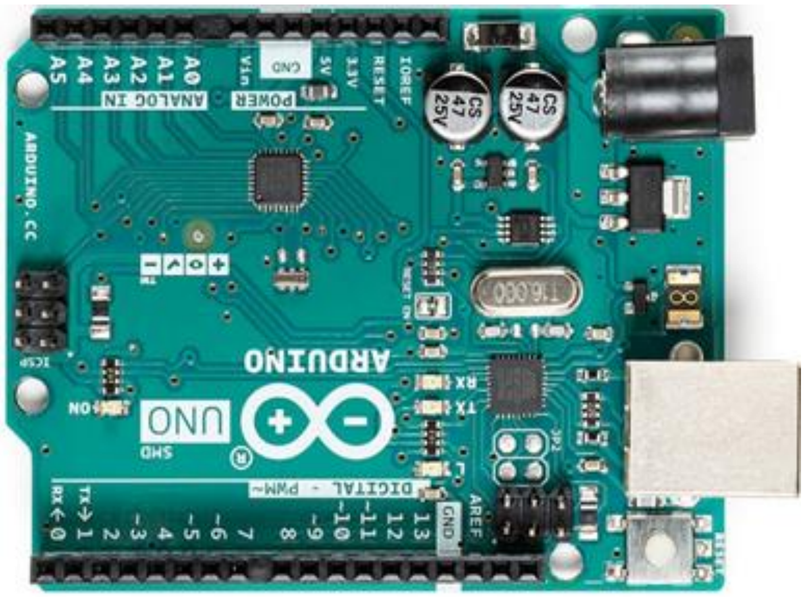
1. Arduino UNO Acts as the brain of the system, receiving input from sensors and controlling servo motors.
2. LDR Sensors are Two pairs of Light Dependent Resistors detect sunlight intensity from the top and bottom sides.
3. The 10k Ohm resistor forms a voltage divider circuit with LDRs to measure sunlight intensity accurately.
4. Servo Motors is One for vertical (tilt) and one for horizontal (pan) movement, adjusting the solar panel's position.
5. Solar Panel 5V captures solar energy, positioning controlled by servo motors.
6. 16 x 2 LCD Display is provides real-time feedback on system status and solar panel position.

V. COMPONENTS

Arduino UNO

This is the central processing unit of the system. It receives input from the LDR sensors and controls the movement of the servo motors based on this input.



Servo Motor

Servo Motor for Vertical & Horizontal adjusts the position of the solar panel based on commands from the Arduino UNO. One motor controls the vertical movement (tilt), and the other controls the horizontal movement (pan).

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Solar Panel 5V

This is the main component that captures solar energy. Its position is adjusted by the servo motors to maximize exposure to sunlight.

LDR

LDR is 2 LDR for Top Side, 2 LDR for Bottom Side. These Light Dependent Resistors act as sunlight sensors. They detect the intensity and direction of sunlight and send this information to the Arduino UNO.

Resistor

Resistors 10k Ohm are likely used in the circuit with the LDRs to form a voltage divider, which allows the Arduino UNO to measure the light levels detected by the LDRs.

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16 x 2 LCD Display

This display shows real-time information about the system, such as the current position of the solar panel or the intensity of sunlight detected by the LDRs.

VI. ADVANTAGE

1. Increased Energy Output is dual-axis trackers that optimize sunlight exposure, leading to higher energy production.
2. Efficiency is they track the sun throughout the day and seasons, ensuring optimal energy capture.
3. Space Conservation is dual-axis systems that require less space per unit of energy generated.
4. Flexibility is they can adjust to various terrains and obstacles, making them versatile.
5. Compensation for Limited Power: Surplus electricity can be fed back into the grid, aiding grid stability.
6. Increased Power Generation is dual-axis trackers that can generate up to 40% more electricity than fixed systems.
7. Customizability is that these systems can be tailored to specific locations and optimized for local conditions.

VII. APPLICATION

1. **Solar Farms:** Dual-axis tracking systems are crucial for large-scale solar farms, ensuring optimal sunlight exposure for numerous panels, thus maximizing energy production.

2. **Residential Installations:** Homeowners can benefit from dual-axis tracking systems to enhance energy generation from solar panels, reducing electricity bills and environmental impact.

3. **Commercial Buildings:** Dual-axis trackers are valuable for commercial structures with ample roof space, enabling them to generate significant solar power for their operations.

4. **Remote Areas:** In areas with limited grid access, dual-axis tracking systems offer a reliable off-grid power solution, promoting energy independence.

5. **Space-Constrained Areas:** Due to their efficiency, dual-axis systems are suitable for compact spaces, generating more power compared to fixed panels in the same area.

6. **Educational Purposes:** Educational institutions use dual-axis trackers for research and teaching, providing hands-on experience with solar energy technology.

7. **Industrial Applications:** Industries employ dual-axis tracking systems to supplement their energy needs, reducing reliance on conventional power sources and cutting costs.

VIII. FUTURE SCOPE

1. **Integration with IoT:** The future of dual-axis solar tracking systems entails integration with IoT technology, allowing for remote monitoring and control to enhance usability and efficiency.

2. **AI and Machine Learning Implementation:** Implementing AI algorithms can optimize the positioning of solar panels based on historical weather data, thereby improving the system's performance.

3. **Energy Storage Integration:** Future advancements may involve integrating efficient energy storage systems to store surplus energy for use during periods of low sunlight availability.

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4. **Hybrid System Development:** There is potential for integrating dual-axis solar tracking systems with other renewable energy sources like wind to create hybrid systems, further increasing overall efficiency.

5. **Scalable Models:** Research may focus on developing scalable models that can be easily expanded for large-scale solar farms, catering to the growing demand for renewable energy solutions.

6. **Enhanced Efficiency:** Studies suggest that dual-axis solar tracking systems can significantly increase electrical energy output compared to fixed PV systems, indicating a promising future for improving energy efficiency.

7. **Market Dominance Projection:** With their superior ability to collect sunlight, dual-axis solar tracking systems are anticipated to dominate the market in the coming years, driven by their high energy output and efficiency.

IX. ACTUAL MODEL

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BIOGRAPHY

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