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Dual-Axis Sun Tracking Solar Panel using ATmega328

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ABSTRACT:

Sun tracking solar panels, with their ability to optimize solar energy capture throughout the day, have garnered significant attention for improving the efficiency of solar energy systems. This research paper focuses on the design and implementation of dual-axis sun tracking solar panels utilizing microcontroller. Solar panel has been used increasingly in recent years to convert solar energy to electrical energy. The solar panel can be used either as a stand-alone system or as a large solar system that is connected to the electricity grids. The earth receives 84 Terawatts of power and our world consumes about 12 Terawatts of power per day. We are trying to consume more energy from the sun using solar panel. In order to maximize the conversion from solar to electrical energy, the solar panels have to be positioned perpendicular to the sun. Thus the tracking of the sun's location and positioning of the solar panel are important. The goal of this project is to design an automatic tracking system, which can locate position of the sun.

KEYWORDS: Sun tracking, solar panel, ATmega328, dual-axis tracking, LDR's energy efficiency.

I. INTRODUCTION

Solar energy is a renewable and sustainable source of power that holds immense potential for addressing energy needs while mitigating environmental impact. It seems you can't walk down the street these days without coming across a solar panel. You can find them lighting up crosswalk signs, mobile power for construction, as well as simple little sidewalk path lights. Solar is easy to use, readily available, and inexpensive. So why aren't we using it to power our homes? For the most part our common every day solar cells run at an efficiency of 18-20%, meaning they convert 18-20% of the every they receive into electricity. While this is far better than the 3-6% efficiency that most green plants end up with, it doesn't quite meet our power needs. To bring in enough power we either need to improve the efficiency of our panels or find ways of getting more from our current solar panels. Every panel you see in your day to day life is in a fixed position, most likely facing south at a 45 degree angle. While this approach is extremely simple and meets the needs of most small applications, it isn't producing as much energy as it could be. The single most simple way of getting more energy out of a solar panel is to have it track the sun. In fact solar panels that track the sun create around 30% more energy per day than a fixed panel. With that kind of power increase you'd think everyone would be doing it, but there are some good reasons why it's not overly common. First, the initial cost of setup is higher since it requires moving parts. Second, it also require maintenance and upkeep since they'd be exposed to outdoors conditions year round. Third, you'd need to power this equipment in order to keep it running and moving which then takes away from your output. Our tracker is a dual axis tracker, meaning it tracks in both X and

Y. To put it into even more simple terms, it goes left, right, up, and down. This means once you have your tracker set up you will never need to change or adjust anything, since anywhere the sun moves your tracker will follow. This also impresses people at parties because you can have it track a flashlight around. This method gives the best results for power generation.

II. DESIGN AND COMPONENTS

This section details the design and components required for constructing a dual-axis sun tracking system using Atmega328. It discusses:

Hardware components: Sensors (light-dependent resistors), actuators (servo motors), and supporting electronics (PCB, ATmega328 IC, Connectors & connecting wires, Foam sheets).

Software components: Arduino programming environment (Arduino IDE), control algorithms for tracking the sun's position.

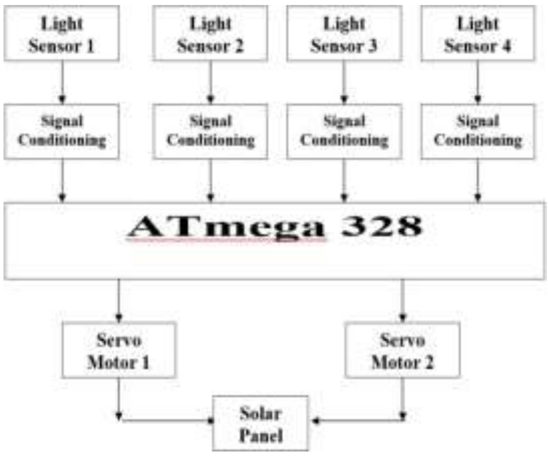
III. DUAL-AXIS TRACKING ALGORITHM

The dual-axis tracking algorithm is crucial for accurately positioning the solar panels to track the sun's movement in both azimuth and elevation angles. This section presents the implementation of the tracking algorithm using ATmega328, including:

1. Calculation of solar position based on time, date, and geographic location.
2. Feedback control loop to adjust the orientation of the solar panels in real-time.
3. Compare current and Target Angles, Calculate the difference between the current azimuth and elevation angles of the solar panel and the desired (target) angles based on the sun's position.
4. Consider factors such as the speed of movement, energy consumption, and tracking accuracy.
5. Implement Tracking movement i.e Use motors or actuators controlled by the microcontroller to move the solar panel along the azimuth and elevation axes.Ensure smooth and continuous movement to track the sun's position.
6. Feedback and Correction. Incorporate feedback sensors (e.g., light sensors, position sensors) to monitor the actual position of the solar panel. Compare the feedback data with the calculated target angles and make corrections as necessary to maintain accurate tracking.
7. Optimization and Efficiency.Fine-tune the tracking algorithm to optimize energy generation based on factors such as cloud cover, shading, and seasonal variations.

IV. BLOCK DIAGRAM & DESCRIPTION

The construction process of the dual-axis sun tracking system is described, including assembly procedures.



The four light sensitive (detecting) resistors, also known as LDRs. Again, these are super common and you can often find them in outdoor garden lights or indoor night lights. They work by changing their resistance level based on how much light is hitting them. The more light, the less resistance they have. Overall LDRs play a valuable role in sun tracking solar panels by providing reliable light intensity data for efficient tracking algorithms, contributing to increased energy output and system performance.

Output of light sensor is change in resistor. But IC doesn't know resistance, so it is given to signal conditioning block. Signal conditioning means converting input according to requirement of next stage.

The next stage is microcontroller (ATmega328). Its requirement is analog signal. So resistance is converted into analog signal.The ATmega328 is a single-chip microcontroller created by Atmel in the mega AVR family (later Microchip Technology acquired Atmel in 2016). It has a modified Harvard architecture 8-bit RISC processor core. the ATmega328 IC is well-suited for controlling and coordinating the various components of a sun tracking solar panel system, offering a balance of performance, efficiency, and flexibility required for effective solar energy harvesting.

The servo circuitry is built right inside the motor unit and has a positionable shaft, which usually is fitted with a gear (as shown below). The motor is controlled with an electric signal which determines the amount of movement of the shaft. A servo motor is connected to the mechanism that allows the solar panel to rotate along the horizontal axis (azimuth). The microcontroller calculates the desired azimuth angle based on the sun's position and sends a corresponding control signal to the servo motor. The servo motor then adjusts the panel's orientation to face the sun.

Solar cells convert sunlight directly into electricity. Solar cells are often used to power calculators and watches. They are made of semiconducting materials similar to those used in computer chips. When sunlight is absorbed by these materials, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity. Solar Panels are a key component of solar power systems and are widely used to generate clean and renewable electricity. solar panels are a versatile and sustainable technology with a wide range of applications in residential, commercial, and industrial sectors, contributing to a cleaner and greener energy future.

V. SOFTWARE COMPONENT

The Arduino IDE is an open-source software, which is used to write and upload code to the Arduino boards. The IDE application is suitable for different operating systems such as Windows, Mac OS X, and Linux. It supports the programming languages C and C++. Here, IDE stands for Integrated Development Environment.The program or code written in the Arduino IDE is often called as sketching. We need to connect the Genuino and Arduino board with the IDE to upload the sketch written in the Arduino IDE software. The sketch is saved with the extension '.ino.'

VI. RESULTS

The results of the experimental validation are presented and discussed in this section. The tracking accuracy, energy output, and efficiency gains achieved by the dual-axis sun tracking system will increase . Additionally, the feasibility and practicality of using ATmega328 IC for sun tracking applications are evaluated based on performance, cost-effectiveness, and ease of implementation.

VII. REAL-WORLD APPLICATIONS AND FUTURE DIRECTIONS

The potential real-world applications of dual-axis sun tracking systems are explored, including residential rooftop installations, off-grid power systems, and educational projects,heating, cooling, desalination, cooking and mainly the electricity generation. Positioning photovoltaic (PV) panels (solar panels) so that they remain perpendicular to the Sun's rays and positioning space telescopes so that they can determine the Sun's direction

Future research directions, such as integration with renewable energy storage systems and scalability for large-scale installations, are also discussed. Their flexibility and adaptablility will make them useful tool for wide range of solar energy applications ultimately the development of solar tracking technology will help the world to move towards more sustainable and energy efficient future.

VIII. CONCLUSION

In conclusion, this research paper demonstrates the design and implementation of dual-axis sun tracking solar panels using ATmega328. The global energy challenge today is to tackle the threat of climate change, meet the rising demand for energy and to safeguard the security of energy supplies. Solar energy is one of the most effective power technologies and it is one of the growing sources of electricity generation in the world. By an automated solar energy tracking system with movable solar panel arrangement the optimum solar energy can be tracked. By making the movable solar panel arrangement the efficiency of the system will be increased between 30-40% and the return on the investment time will be reduced. microcontroller has demonstrated significant advantages in maximizing solar energy utilization. By dynamically adjusting the orientation of the solar panel to face the sun throughout the day, the system has achieved increased energy generation compared to fixed panels. The use of ATmega328 allowed for precise control and accurate tracking based on real-time sun position calculations. However, it's important to note that further optimizations can be explored, such as implementing more sophisticated algorithms for tracking and integrating feedback mechanisms for improved performance in varying weather conditions. Overall, this project showcases the potential of microcontroller-based sun tracking systems in enhancing the efficiency and output of solar energy systems

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