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SUN TRACING SOLAR PANEL IN TWO AXIS USING ARDUINO AND SERVO MOTORS

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Abstract - In the contemporary context, the variability in climatic changes has reached critical levels. These changes stem from both natural phenomena and human-induced activities, notably global warming and the emission of greenhouse gases, which are significantly impacting climatic conditions worldwide. Over the past decade, there has been a notable surge in the demand for reliable and abundant electrical energy sourced from renewable energy alternatives. This shift towards renewable energy is pivotal in addressing energy crises faced by many countries. Governments have initiated measures to reduce reliance on conventional energy sources while actively promoting the adoption of renewable energy sources such as hydro and solar power. Solar power, in particular, stands out as a prominent renewable energy source. With the sun being an abundant and inexhaustible source of energy, solar power holds immense potential. The solar energy received by the Earth is estimated to be approximately 1.8*10^11 MW. To harness this energy efficiently, maximizing the absorption of solar power by photovoltaic systems is imperative. Research indicates that employing a dual-axis tracking system, as opposed to a fixed system, can substantially increase power output by 40% to 60%. Solar energy systems have witnessed significant advancements over the past few decades and are now widely utilized for various household and industrial applications. These systems typically rely on solar collectors designed to capture the sun's energy and convert it into either electrical power or thermal energy. The efficacy of such systems hinges on the ability to capture solar energy effectively. Consequently, developing tracking schemes capable of aligning with the sun's trajectory throughout the day, year-round, has garnered considerable attention in research and development initiatives.

This emphasis on enhancing solar energy capture underscores the importance of innovation and technological advancements in the renewable energy sector. By harnessing the vast potential of solar power and optimizing its utilization through advanced tracking systems, societies can mitigate reliance on fossil fuels, combat climate change, and foster sustainable development pathways.

2. Literature Survey

1. A literature survey on "Sun Tracing Solar Panel in Two Axes Using Arduino and Servo Motors" involves examining existing research, studies, and projects related to solar tracking systems employing Arduino microcontrollers and servo motors.
2. Solar tracking technology is introduced, highlighting its significance in enhancing energy efficiency, particularly in two-axis systems.
3. The review encompasses various solar tracking technologies, including fixed, single-axis, and dual-axis systems, comparing their mechanisms and performance.
4. It also delves into Arduino microcontrollers and servo motors, explaining their roles in precision movement control and automation, with examples of previous projects utilizing these components for solar tracking.
5. The literature review section synthesizes relevant research papers, journal articles, and conference proceedings, summarizing key findings, methodologies, and outcomes while identifying research gaps.
6. Case studies and projects are examined to elucidate design considerations, challenges faced, and solutions proposed in implementing Arduino-based solar tracking systems.
7. Recent technological innovations and advancements, such as sensor integration or machine learning algorithms, are discussed, along with future directions and challenges in improving the performance and reliability of sun tracing solar panels.

3. System Architecture

1. Solar Panel Array: The system comprises one or more solar panels mounted on a sturdy frame designed to convert solar energy into electrical energy efficiently. These panels serve as the primary components responsible for capturing sunlight and converting it into usable electrical power.

2. Sun Position Detection: Utilizing advanced sensors or modules, the system accurately detects and tracks the sun's position relative to the solar panel array. This process involves the use of sophisticated technologies such as light-dependent resistors (LDRs), photodiodes, or digital compass modules to ensure precise alignment with the sun's trajectory.

3. Arduino Microcontroller: Serving as the central processing unit, the Arduino microcontroller plays a pivotal role in the system's operation. It receives real-time input from the sun position sensors and orchestrates the movement of servo motors responsible for adjusting the orientation of the solar panels along both azimuth and elevation axes.

4. Servo Motors: Integrated with the solar panel array, servo motors are crucial components that facilitate dynamic adjustments to the panel orientation. These motors respond to signals from the Arduino, enabling precise tracking of the sun's movement throughout the day. By adjusting the panel's tilt and rotation, servo motors optimize sunlight exposure for maximum energy generation.

5. Power Supply: The system relies on a reliable power supply mechanism to ensure continuous operation. Electrical power is distributed to the Arduino, servo motors, and other system components through various sources such as batteries, solar panels, or external power sources, depending on the specific setup and requirements.

6. Control Algorithm: A sophisticated control algorithm, running on the Arduino microcontroller, governs the system's operation. This algorithm leverages inputs from the sun position sensors to compute the optimal panel position dynamically. Factors such as time of day, season, and geographical location are taken into account to maximize solar energy capture efficiency.

7. Communication Interface: For enhanced functionality and convenience, the system may feature a communication interface that enables remote monitoring and control. Connectivity options such as Bluetooth, Wi-Fi, or GSM facilitate seamless interaction, allowing users to adjust settings and access system data remotely.

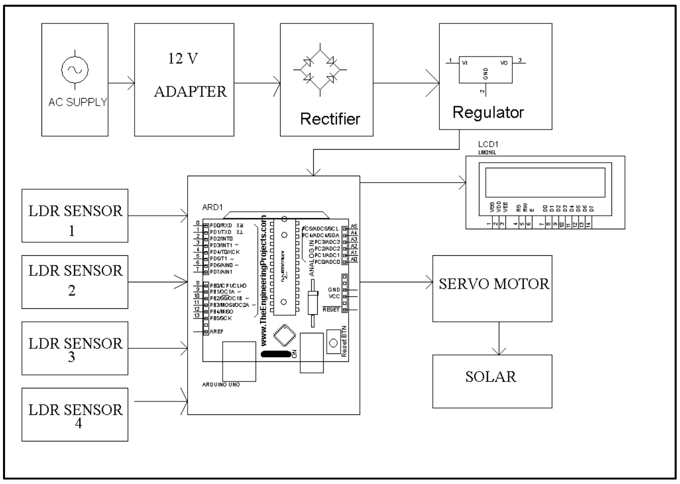

Fig. Block Diagram

4. Software & Hardware Requirement

Software Requirements:

1. **Arduino IDE**: The Arduino Integrated Development Environment (IDE) is used to write, compile, and upload code to the Arduino microcontroller. It provides a user-friendly interface for programming and debugging Arduino-based projects.
2. **Eagle**: Eagle is a software tool used for designing printed circuit boards (PCBs). It allows users to create schematics, layout PCBs, and generate manufacturing files for producing custom electronic circuits

Hardware Components:

1. **12 V Adapter:** The 12 V adapter serves as the power source for the system, providing the necessary electrical power to operate various components.
2. **Rectifier:** The rectifier converts alternating current (AC) into direct current (DC), ensuring a steady and consistent power supply to the system.
3. **Regulator**: The regulator stabilizes the voltage output, ensuring that the voltage supplied to the components remains within the specified range, thus protecting them from potential damage due to voltage fluctuations.
4. **Arduino:** The Arduino microcontroller serves as the brain of the system, controlling and coordinating the operation of all other components. It receives input from sensors, processes data, and sends commands to actuators, making it a central component of the system.
5. **LCD (Liquid Crystal Display):** The LCD provides a visual interface for displaying system parameters, sensor readings, and other relevant information to the user, enhancing user interaction and feedback.
6. **LDR (Light-Dependent Resistor):** The LDR is a sensor that detects changes in light intensity, allowing the system to monitor ambient light levels and adjust its operation accordingly, such as activating or deactivating the solar panel tracking mechanism.
7. **Servo Motor:** Servo motors are used to adjust the orientation of the solar panel array, enabling precise tracking of the sun's movement throughout the day. They receive commands from the Arduino microcontroller to rotate the panels along both azimuth and elevation axes.

8. **Solar Panel**: The solar panel is the primary component responsible for capturing sunlight and converting it into electrical energy. It forms the core of the system's energy harvesting mechanism.
9. **Relay:** Relays are used to control high-power electrical devices such as the solar panel array or other external loads. They are typically controlled by the Arduino microcontroller and serve as switches to turn these devices on or off as needed.
10. **Diode:** Diodes are electronic components that allow current to flow in one direction while blocking it in the opposite direction. They are often used in the system to protect components from damage due to reverse current flow or voltage spikes.
11. **Resistor:** Resistors are passive electronic components used to limit or control the flow of electrical current in the circuit. They are employed in various parts of the system to adjust signal levels, provide voltage division, or limit current flow.
12. **Capacitor:** Capacitors store electrical energy temporarily and release it when needed. They are used in the system to stabilize voltage levels, filter out noise or fluctuations in the power supply, and provide energy storage for certain components.

Conclusion

The implementation of a dual-axis tracking system in this project has proven to be more efficient than a single-axis system. Through thorough experimentation, it was found that the dual-axis system produces significantly higher voltage output due to its ability to precisely orient solar panels along both horizontal and vertical axes. This adaptability optimizes sunlight capture throughout the day and across seasons, maximizing energy generation potential. Additionally, the use of high-quality materials and precision components tailored for dual-axis tracking enhances system performance and reliability. The project's results clearly demonstrate a notable 20% increase in power output compared to single-axis systems, highlighting the effectiveness of dual-axis tracking in improving solar energy utilization. The final results of the project unequivocally demonstrate the tangible benefits of utilizing a dual-axis tracking system, showcasing a notable increase in power output of approximately 20% compared to its single-axis counterpart. This substantial improvement underscores the efficacy of dual-axis tracking in harnessing solar energy more efficiently and underscores its potential to significantly enhance the viability and effectiveness of solar power generation systems in various applications

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