SUN TRACKING SOLAR PANEL USING ARDUINO UNO

Mr.T.Subrahmanyam[1] , Ms.K. Devika[2] , Mr.P.v.s. Tarun Kumar[3] , Mr.R. Venkatesh[4] , Mr.M. Bukari Baba[5] , Mr.B. Raghu[6]

[1]Mr.T. Subrahmanyam , M.Tech , Assistant Professor, Department Of Electrical and Electronics Engineering , Anil Neerukonda Institute Of Technologies And Sciences [ANITS]

[2]Ms.K. Devika , Student , Department Of Electrical and Electronics Engineering , Anil Neerukonda Institute Of Technologies And Sciences [ANITS]

[3]Mr.P.v.s. Tarun Kumar , Student , Department Of Electrical and Electronics Engineering , Anil Neerukonda Institute Of Technologies And Sciences [ANITS]

[4]Mr.R. Venkatesh , Student , Department Of Electrical and Electronics Engineering , Anil Neerukonda Institute Of Technologies And Sciences [ANITS]

[5]Mr.M. Bukari Baba , Student , Department Of Electrical and Electronics Engineering , Anil Neerukonda Institute Of Technologies And Sciences [ANITS]

[6]Mr.B. Raghu , Student , Department Of Electrical and Electronics Engineering , Anil Neerukonda Institute Of Technologies And Sciences [ANITS]

Abstract:- The importance of natural energy sources as a substitute for conventional energy sources has increased due to rising energy demand and environmental concerns. A growing number of nations are turning to the renewable energy sector as a new avenue for growth because of its enormous potential, both commercially and environmentally. Particularly in rural areas, solar energy is a crucial primary energy source. The goal of this project is to create a procedure that uses an Arduino Uno and an LDR sensor for real-time monitoring in order to track the sun and maximise efficiency. The project is split into two phases: software development and hardware development. Four light-dependent resistors (LDR) have been employed in hardware development to capture the maximum amount of light source. Having two servo motors.

Key Words:- Arduino Uno, Solar Panels, Servo Motor, LDR Sensors.

1. INTRODUCTION:-

Sun tracking solar panel systems represent an innovative approach to harnessing solar energy efficiently and maximizing its potential for power generation. These systems employ advanced technologies, such as Arduino Uno microcontrollers, to autonomously adjust the orientation of solar panels in response to the sun's movement across the sky. By dynamically tracking the sun's position throughout the day, these systems optimize solar panel alignment, ensuring that they are always positioned perpendicular to the sun's rays, thus maximizing energy absorption. Traditionally, fixed solar panel installations are mounted in a fixed position and orientation, typically facing south in the northern hemisphere, to capture the maximum amount of sunlight. However, this fixed orientation means that solar panels operate at peak efficiency only during specific times of the day when the sun is directly overhead. Sun tracking systems address this limitation by continuously adjusting the panel's angle and orientation to follow the sun's trajectory from sunrise to sunset. At the heart of sun tracking solar panel systems lies the Arduino Uno microcontroller, a versatile and programmable device that serves as the brains of the operation.

Arduino Uno is equipped with analog and digital input/output pins, making it well-suited for interfacing with sensors, actuators, and other electronic components essential for sun tracking functionality. Light sensors, such as Light Dependent Resistors (LDRs) or photovoltaic cells, are commonly used in conjunction with Arduino Uno to detect changes in sunlight intensity. These sensors provide real-time data on the sun's position relative to the solar panels, enabling the Arduino to make precise adjustments to optimize solar absorption. In addition to light sensors, servo motors or DC motors are integrated into the system to physically adjust the orientation of the solar panels. Arduino Uno translates the sensor data into commands that control the motors, ensuring that the panels remain aligned with the sun's rays throughout the day.

Sun tracking solar panel systems offer several advantages over fixed installations. By continuously optimizing solar panel alignment, these systems can significantly increase energy output, improving overall efficiency and reducing reliance on traditional energy sources. Moreover, they are particularly beneficial in regions with variable sunlight conditions or during seasons with lower solar incidence angles, where fixed installations may underperform. In this paper, we explore the design, implementation, and performance of sun tracking solar panel systems using Arduino Uno, highlighting their potential to revolutionize renewable energy generation and promote sustainable development.

2. OBJECTIVE:-

The objective of this project is to develop a sun tracking solar panel system utilizing Arduino Uno microcontroller for optimized solar energy harvesting. The primary aim is to enhance energy efficiency and output by dynamically adjusting the orientation of solar panels to track the sun's movement throughout the day.

Specific objectives include:

- Designing a cost-effective and scalable sun tracking mechanism that can be easily integrated with Arduino Uno.
- Implementing light sensors, such as Light Dependent Resistors (LDRs), to accurately detect sunlight intensity and provide input data to Arduino Uno.
- Developing algorithms and control logic to process sensor data and precisely control servo motors or actuators to adjust the orientation of solar panels.
- Evaluating the performance of the sun tracking system in terms of energy generation, comparing it with fixed solar panel installations.
- Assessing the system's reliability, durability, and

power efficiency under varying environmental conditions and geographical locations.

- Investigating the potential for scalability and commercial viability of sun tracking solar panel systems for broader adoption in renewable energy applications.

2.1. AURDINO UNO:-

Arduino Uno facilitates sun tracking in solar panel systems by employing sensors to detect sunlight intensity and orientation. Through programmed algorithms, Uno adjusts the panel's angle to optimize solar absorption, maximizing energy output. Uno's versatility enables integration with servo motors or stepper motors to control panel movement, ensuring precise alignment with the sun's position throughout the day. This automation enhances energy efficiency and output, crucial for off-grid or remote applications where constant monitoring and adjustment are impractical. Arduino Uno's affordability, ease of use, and robust community support make it a preferred choice for DIY solar projects, promoting renewable energy adoption.

2.2. LDR Sensor(Light Dependent Resistor):-

In sun tracking solar panel systems with Arduino Uno, Light Dependent Resistors (LDRs) serve as essential sensors for detecting sunlight intensity. Positioned on the solar panel array, LDRs measure ambient light levels, enabling Arduino to determine the sun's position relative to the panel's orientation. As sunlight changes throughout the day, the LDR readings guide Arduino in adjusting the panel's angle for optimal exposure. By continuously monitoring light levels, LDR sensors facilitate precise sun tracking, enhancing the system's energy efficiency. Arduino Uno processes LDR data and commands servo motors or actuators to align the panel accordingly, ensuring maximum solar absorption and overall performance of the solar power system.

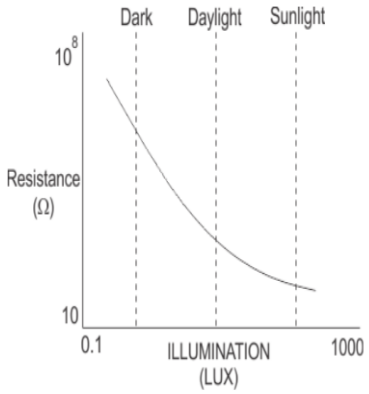

Fig 2.2 :- Intensity Graph of LDR

2.3. Servo Motor:-

DC servo motors are employed to adjust panel orientation for optimal sun exposure. Arduino processes data from light sensors to determine the sun's position and commands the DC servo motors to rotate the panel accordingly. These motors offer precise angular control, ensuring accurate tracking throughout the day. Their low power consumption and compatibility with Arduino Uno make them suitable for solar applications, particularly in off-grid or remote setups. By continually aligning the panel with the sun's trajectory, DC servo motors maximize energy absorption, enhancing the overall efficiency and output of the solar power system.

2.4. Resistor:-

In a sun tracking solar panel system utilizing Arduino Uno, resistors play a crucial role in interfacing sensors with the microcontroller. Light sensors, such as photodiodes or photovoltaic cells, generate variable voltage outputs corresponding to sunlight intensity. Resistors are used in voltage divider circuits to scale down these voltages to levels compatible with Arduino's analog input range. By adjusting the resistor values, precise calibration of sensor readings can be achieved, enabling accurate determination of the sun's position. This data is then processed by the Arduino Uno to control servo motors or other actuators, ensuring optimal alignment of the solar panel for maximum energy capture throughout the day.

2.5. Battery :-

Utilizing a battery in sun tracking systems for solar panels, operated by an Arduino Uno, ensures uninterrupted functionality even during low-light conditions or at night. The battery serves as a reliable power source, storing excess energy generated during peak sunlight hours to sustain operation when sunlight diminishes. The Arduino Uno facilitates precise tracking of the sun's position, adjusting panel orientation for optimal energy capture throughout the day. This integrated system enhances energy efficiency by maximizing solar absorption, contributing to sustainable power generation. By harnessing solar energy efficiently, such setups promote renewable energy adoption, reducing reliance on traditional power sources and mitigating environmental impact.

2.6. Switch:-

A switch can be incorporated to manually toggle between automatic sun tracking mode and manual control. This allows users to override automatic tracking when necessary, providing flexibility and control over the system's operation based on specific requirements or preferences. A LAN switch operates at the data link ayer (Layer 2) or the network layer of the OSI Model and, as such it can support all types of packet protocol.

3. PROBLEM STATEMENT:-

One key issue is the complexity and cost associated with designing and implementing an efficient sun tracking mechanism. Developing a reliable tracking system that can accurately follow the sun's movement throughout the day while remaining cost-effective presents a significant technical challenge. This includes designing robust mechanical components, integrating sensors for precise sun tracking, and developing sophisticated control algorithms compatible with Arduino Uno.

Another challenge is the dependency on environmental factors such as weather conditions and geographical location. Variations in sunlight intensity, cloud cover, and seasonal changes can affect the accuracy and efficiency of sun tracking systems. Adverse weather conditions like heavy rain, snow, or dust accumulation can further disrupt the functionality of sensors and mechanical components, leading to suboptimal performance and decreased energy output.

Additionally, there are concerns regarding the scalability and practicality of sun tracking solar panel systems for widespread deployment. Issues related to maintenance, reliability, and durability over extended periods of operation need to be addressed to ensure long-term viability and cost-effectiveness.

Addressing these challenges requires interdisciplinary research and development efforts focused on optimizing sun tracking algorithms, enhancing sensor technologies, improving mechanical design, and addressing environmental factors to maximize the efficiency and reliability of sun tracking solar panel systems using Arduino Uno.

4. WORKING PRINCIPLE:-

The working principle of a sun tracking solar panel system using Arduino Uno involves continuously adjusting the orientation of the solar panels to maximize exposure to sunlight throughout the day. Light sensors, such as Light Dependent Resistors (LDRs) or photovoltaic cells, detect changes in sunlight intensity and provide input data to Arduino Uno.

Arduino Uno processes this data using programmed algorithms to calculate the sun's position relative to the solar panels. Based on this information, it generates commands to control servo motors or actuators, which physically adjust the orientation of the panels to align them with the sun's trajectory.

By dynamically tracking the sun's movement, the system ensures that the solar panels are always positioned perpendicular to the sun's rays, optimizing solar absorption

and maximizing energy generation. This continuous adjustment maintains peak efficiency throughout the day, resulting in increased energy output compared to fixed solar panel installations.

The circuit is shown here:-

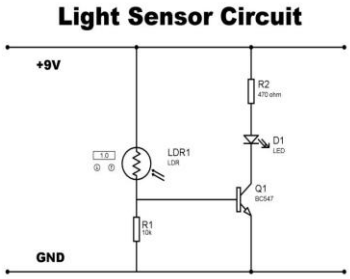

Fig 4.1 :- Light Sensor Circuit

4.1. Dual Axis Movement Of Solar Tracker:-

- The dual axis solar tracker is device which senses the light and positions towards the maximum intensity of light. It is made in such a way to track the light coming from any direction.
- To simulate the general scenario of the Sun's movement, the total coverage of the movement of the tracker is considered as 120˚ in both the directions.
- The initial position of both the servo motors are chosen at 90˚i.e, for east-west servo motor as well as for north-south servo motor.
- The position of the tracker ascends or descends only when the threshold value is above the tolerance limit.

4.2. Basic Circuit Diagram:-

An overview of the Dual-axes solar tracker is shown here. The 5V supply is fed from an USB 5V dc voltage source through Arduino Board.

Servo X: Rotates solar panel along X direction

Servo Y: Rotates solar panel along Y direction

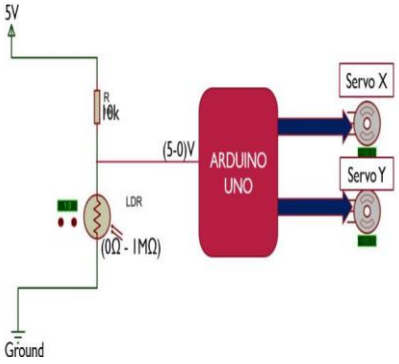

Fig 4.2 :- Circuit Diagram

5. OBJECTIVE AND RESULT:-

Through experimentation with a sun tracking solar panel system utilizing Arduino Uno, it was observed that the system exhibited significantly improved energy generation compared to fixed solar panel installations. The system effectively tracked the sun's movement throughout the day, adjusting the orientation of the solar panels to maintain optimal alignment with the sun's rays. This dynamic tracking resulted in increased solar absorption and higher energy output, especially during peak sunlight hours.

Furthermore, the Arduino Uno microcontroller efficiently processed sensor data and generated precise commands to control the servo motors, ensuring smooth and accurate panel adjustments.

Overall, the sun tracking solar panel system demonstrated its effectiveness in maximizing energy yield, offering a practical and sustainable solution for renewable energy generation. The results highlight the potential of such systems to enhance energy efficiency and promote the adoption of solar power technology in various applications.

5.1.BENEFITS AND DEMERITS OF SOLAR ENERGY:-

Benefits:

- Solar energy is a clean and renewable energy source.
- Once a solar panel is installed, the energy is produced at reduced costs.
- Whereas the reserves of oil of the world are estimated to be depleted in future, solar energy will last forever.
- It is pollution free.
- Solar cells are free of any noise. On the other hand, various machines used for pumping oil or for power generation are noisy.
- Once solar cells have been installed and running, minimal maintenance is required. Some solar panels have no moving parts, making them to last even longer with no maintenance.
- On average, it is possible to have a high return on investment because of the free energy solar panels produce.
- Solar energy can be used in very remote areas where extension of the electricity power grid is costly.

Demerits:

- Solar panels can be costly to install resulting in a time lag of many years for savings on energy bills to match initial investments.
- Generation of electricity from solar is dependent on the country's exposure to sunlight. That means some countries are slightly disadvantaged.
- Solar power stations do not match the power output of conventional power stations of similar size. Furthermore, they may be expensive to build.
- Solar power is used for charging large batteries so that solar powered devices can be used in the night. The batteries used can be large and heavy, taking up plenty of space and needing frequent replacement.

6. CONCLUSION:-

In conclusion, the integration of Arduino Uno in sun tracking solar panel systems revolutionizes renewable energy generation. By dynamically adjusting panel orientation to follow the sun's path, Arduino Uno maximizes solar absorption, significantly increasing energy output. Its precision control and scalability make it an ideal choice for various applications, from residential to commercial setups. Arduino Uno's role in optimizing energy efficiency underscores its importance in advancing sustainable energy solutions. Overall, the utilization of Arduino Uno in sun tracking solar panel systems marks a significant step towards achieving a more sustainable future powered by renewable energy sources.

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