IJCRT.ORG ISSN : 2320-2882
INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

DUAL AXIS SOLAR TRACKING WITH IOT-BASED LOAD SHEDDING

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Abstract: This project presents an innovative solution combining IoT technology with a dual-axis solar tracking system to optimize energy management through load shedding. Load shedding is essential for effective power distribution, especially in regions susceptible to energy shortages. The dual-axis solar tracking system enhances solar panel efficiency by dynamically adjusting its orientation to maximize sunlight exposure. Leveraging IoT capabilities, the system enables real-time monitoring and intelligent decision-making for load shedding based on energy demand and availability. This report outlines the design, implementation, and evaluation of the integrated system, showcasing promising results in energy efficiency and load-shedding effectiveness. The fusion of IoT and solar tracking technologies holds significant promise for addressing energy challenges and promoting sustainable energy practices in various settings.

***Index Terms* -** Arduion uno, Battery cells,Lcd display,Dc motor,.Matlab simulator.

I. INTRODUCTION

The pursuit of accessible and eco-friendly electric power in the face of persistent electricity shortages has spurred interest in renewable energy sources. Among these, solar energy, drawn from natural resources like sunlight, emerges as a promising solution. Malaysia, recognizing its solar energy potential, has integrated solar power into its electricity generation mix, leveraging its high solar radiation levels. Solar energy, being inherently clean and renewable, undergoes conversion into electricity through the photoelectric effect. Despite its benefits, maximizing the efficiency of solar energy harnessing requires advancements in technology, particularly in solar tracking systems like dual-axis trackers, which optimize energy capture by aligning solar panels with the sun's position. Research efforts have focused on enhancing dual-axis solar tracking systems to maximize sunlight exposure for power generation. Utilizing technologies such as Arduino UNO, PLCs, and microcontrollers like ATMega328P, researchers have developed innovative solar tracking mechanisms. Comparisons between dual-axis trackers and fixed-angle systems consistently demonstrate significant increases in electricity generation, with dual-axis trackers exhibiting improvements of up to 25% in output. These findings underscore the efficacy of dual-axis solar tracking systems in enhancing energy production and highlight their potential as a viable solution for meeting energy demands while minimizing environmental impact. Moreover, studies emphasize the importance of efficiency and reliability in solar panel performance, highlighting the role of microcontroller chips and sophisticated tracking systems. The integration of sensors, servo motors, and WI-FI modules enables real-time monitoring and control of solar tracking systems, enhancing their usability and practicality. Ongoing research aims to refine and optimize solar tracking technologies further, ensuring the efficient conversion of solar energy into electricity. By addressing challenges related to system design, reliability, and maintenance, solar tracking systems are poised to play a crucial role in sustainable energy infrastructure, contributing to global efforts to combat climate change and promote renewable energy.

II.METHODOLOGY

1. Problem Definition and Objectives:

- Clearly define the problem of optimizing energy utilization in a grid-connected system through IoT based load shedding and dual-axis solar tracking.
- Establish objectives, including maximizing solar energy utilization, minimizing grid dependency, and ensuring efficient load management.

2. System Architecture Design:

- Design the system architecture encompassing hardware and software components.
- LDRs for solar tracking, load monitoring, and environmental parameters, ensuring compatibility with IoT platforms.

3. Hardware and Sensor Deployment:

- Implement dual-axis solar tracking mechanisms to dynamically orient solar panels for maximum sun exposure.
- Install solar panels equipped with sensors for real-time tracking of solar irradiance and panel orientation.
- Deploy IoT devices for load monitoring and control, integrating sensors and actuators for seamless operation.

4. Software Development and Control Logic:

- Develop firmware for IoT devices to collect and process data from sensors, implementing algorithms for solar tracking and load shedding.
- Implement intelligent load shedding algorithms based on real-time data from solar tracking and load monitoring.
- Design control logic to dynamically adjust load shedding strategies based on solar availability.

5. Integration and Testing:

- Integrate hardware and software components into a unified system, ensuring interoperability and functionality.
- Conduct comprehensive testing under various environmental conditions to validate system performance.

III.HARDWARE

The hardware development phase of the dual-axis solar tracker project involves selecting and integrating components such as sensors, actuators, microcontrollers, and power management systems. These components are carefully chosen to ensure compatibility and efficiency in the system. Mechanical design considerations include constructing a sturdy frame to support the solar panel and mounting servo motors for precise rotation. Rigorous testing procedures are conducted to assess functionality, durability, and reliability, with real-world testing helping to identify areas for improvement. The goal is to create a fully functional solar tracker capable of efficiently capturing solar energy and optimizing electricity generation.

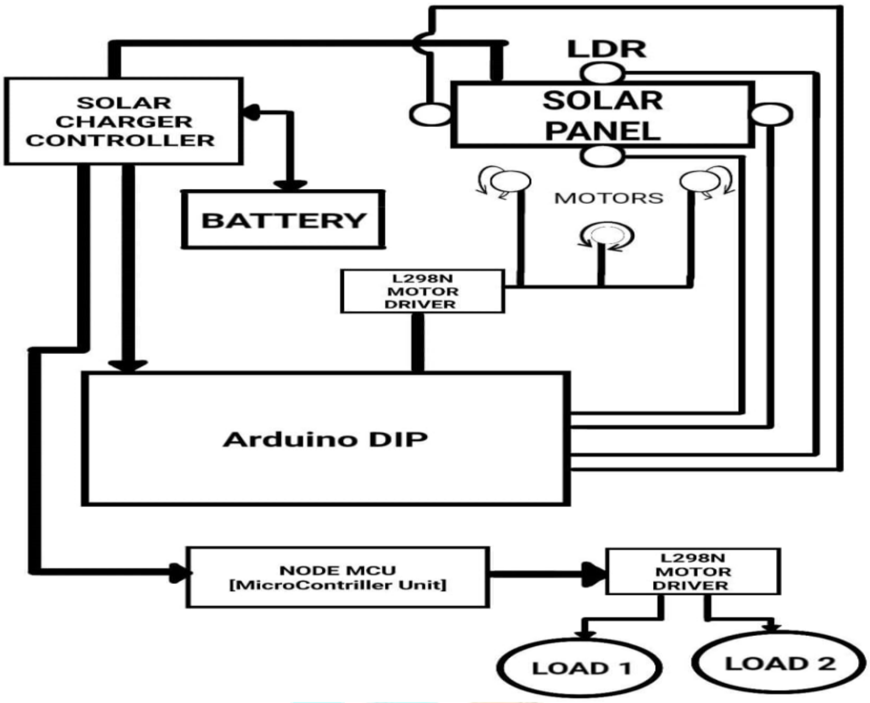

Figure 2. Dual axis control circuit

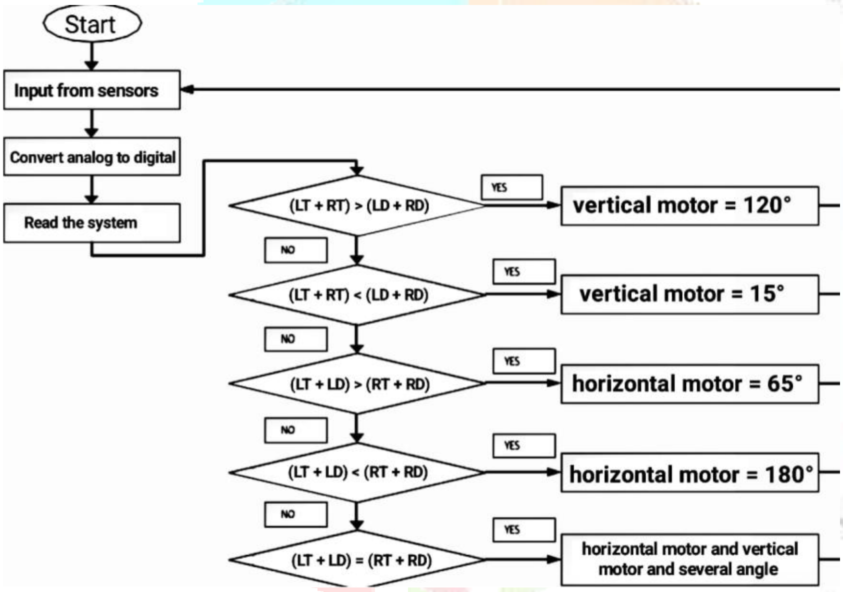

Figure 3. Flow chart for Dual axis control system

COMPONENTS USED

1.Johnson motor (12v): The Johnson motor can be integrated into the dual-axis solar tracking mechanism to adjust the tilt and azimuth angles of solar panels. By controlling the rotation of the motor, the solar panels can be dynamically oriented to maximize sun exposure throughout the day, optimizing energy generation. The system can achieve higher energy efficiency by maximizing solar energy utilization. Moreover, by usage of this motor the shaft of the motor can withstand equipment of more weight.

Figure 4. Johnson motor (12v)

2. DC motor (12v): The DC motor enables precise control over the tilt and azimuth angles of the panels, ensuring optimal alignment with the sun's position throughout the day. This controlled movement, facilitated by the DC motor, enhances the system's ability to capture maximum sunlight, thereby improving energy efficiency and reducing dependency on the grid. Experimental validation of the DC motor's performance validates its effectiveness in driving the solar tracking mechanism and contributing to the overall efficiency of the system.

Figure 5. DC motor (12v)

3.Arduino DIP: The Arduino Due in Peripheral serves as a pivotal component for data acquisition, processing, and control. Its high computational power and advanced features make it suitable for handling real-time sensor data, executing complex algorithms, and coordinating system operations.

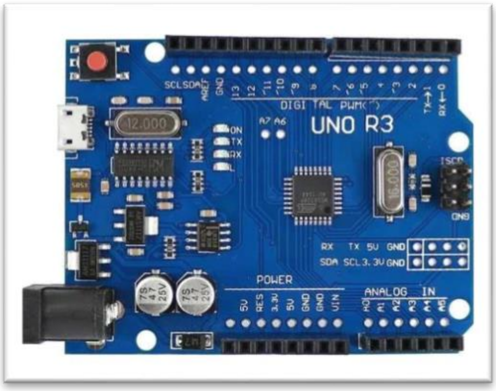

Figure 6. Arduino DIP

4.Battery (12V, 1.3A): A 12V battery is a rechargeable battery that provides a nominal voltage of 12 volts DC (Direct Current). which are made up of several cells wired in series to achieve a total voltage of 12 volts. where individual cell produce 1.3 to 3.7 volts. They are widely used in various applications due to their versatility and ability to store a decent amount of energy.some of their applications are Powering 12V DC devices,DC-to-DC converter in solar power systems ,etc…

Figure 7. 12v Battery

5.Light Dependent Resistors (LDRs): LDRs serve as pivotal sensors for tracking the position of the sun and optimizing the orientation of solar panels. Placed strategically on the solar panel array, LDRs detect variations in sunlight intensity, providing real-time feedback on the sun's direction. This information enables the control system to calculate the required adjustments in panel tilt and azimuth angles, ensuring panels are always aligned optimally to capture maximum sunlight.

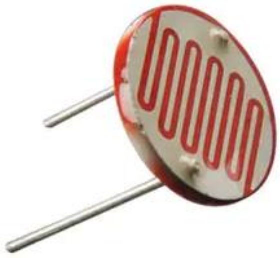

Figure 8. LDR

6.Charge Controller: A charge controller plays a critical role in regulating the flow of energy between the solar panels, batteries, and loads. Integrated between the solar panels and the battery bank, the charge controller manages the charging process, ensuring optimal charging efficiency and preventing overcharging or deep discharging of the batteries. Additionally, the charge controller facilitates the distribution of solar energy to the loads, prioritizing essential loads during periods of low solar availability and shedding non-critical loads to maintain system stability.

Figure 8. Charge Controller

7.Solar Panel: Solar panels are the primary energy generation source, converting sunlight into electrical energy. Positioned within the dual-axis solar tracking mechanism, the solar panels dynamically adjust their orientation to maximize sun exposure throughout the day, optimizing energy production. Integrated with sensors for tracking solar irradiance and panel orientation, the solar panels provide real-time data for efficient solar tracking and energy management. By harnessing renewable solar energy, the solar panels reduce dependency on the grid.

Figure 9. Solar Panel

8.ESP8266 CH340 NodeMCU: NodeMCU serves as a crucial component for data acquisition, processing, and communication. Integrated into the system architecture, the NodeMCU interfaces with sensors measuring solar irradiance, panel orientation, and load consumption, collecting real-time data for analysis. With its Wi-Fi connectivity and compatibility with IoT platforms, the NodeMCU facilitates seamless communication between devices and the central control system, enabling remote monitoring and control. Additionally, the NodeMCU executes algorithms for intelligent load shedding based on solar tracking data, dynamically adjusting energy distribution to optimize energy utilization. Through its versatile capabilities

Figure 10. ESP8266 CH340 NodeMCU

9.L298N Motor driver: The L298N motor drivers play a vital role in controlling the movement of motors responsible for adjusting the orientation of solar panels. Integrated into the system, the L298N motor drivers receive commands from the control logic based on real-time sensor data, instructing the motors to rotate and align the solar panels for optimal sunlight capture. With its dual H-bridge configuration, the L298N efficiently drives DC motors, providing bidirectional control and precise speed regulation.

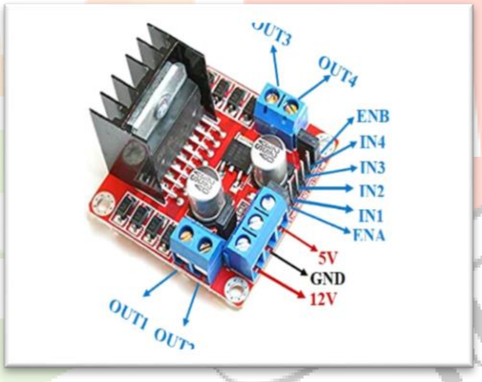

Figure 11. L298N Motor driver

IV. WORKING:

Dual-Axis Solar Tracking:

Dual-axis solar tracking optimizes solar panel orientation to maximize sunlight absorption throughout the day. Horizontal axis tracking aligns panels east-west, following the sun's apparent motion. Vertical axis tracking adjusts tilt angles north-south to account for changes in the sun's elevation. Sensors detect sunlight position, triggering motors to adjust panel orientation. Integration of horizontal and vertical tracking ensures continuous alignment for maximum energy capture. Control systems process real-time data to calculate optimal angles. Feedback mechanisms account for environmental factors like shading. This technology enhances solar panel efficiency, especially in variable weather conditions. It contributes to increased energy yield and system performance. Dual-axis tracking is particularly beneficial in regions with high solar incidence angles. Overall, it improves the sustainability and effectiveness of solar installations.

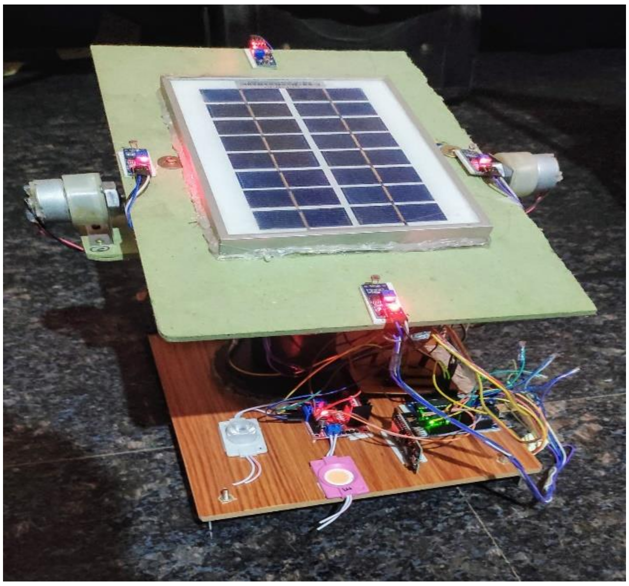

Figure 12: Dual-Axis Solar Tracking

IoT-Based Load Shedding:

IoT-based load shedding employs open-source apps like Blynk IoT for real-time energy management. Devices like smart plugs integrate with Blynk IoT, enabling remote monitoring and control. Data acquisition begins with IoT devices collecting energy consumption data. Load-shedding decisions are made through the Blynk IoT app interface, allowing users to set rules or schedules. Actuation and control mechanisms are executed through the app, remotely turning off selected appliances. Continuous monitoring and feedback loops enable users to track energy savings and optimize strategies. Blynk IoT provides real-time data on energy usage and load-shedding events. Users can adjust settings to meet changing preferences or priorities. This approach empowers users to take control of their energy consumption and optimize efficiency. It offers a scalable solution for managing energy usage at the individual or household level.

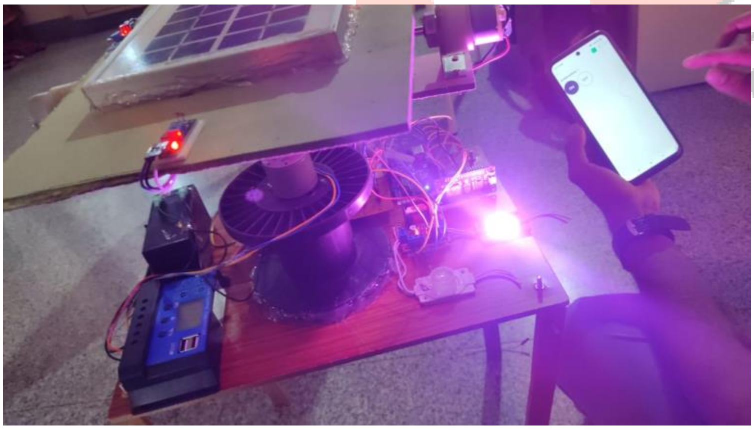

Figure 13: IoT-Based Load Shedding

V. CONCLUSION:

Integrating dual-axis solar tracking and IoT-based load shedding represents a significant advancement in renewable energy and smart grid technologies. By optimizing solar panel orientation and dynamically managing energy consumption, these innovations offer tangible benefits in terms of increased energy efficiency, grid stability, and sustainability. Dual-axis solar tracking enhances solar panel performance by maximizing sunlight absorption, especially in regions with variable weather conditions. Meanwhile, IoT-based load shedding empowers users to actively manage their energy usage, reducing waste and optimizing efficiency. Together, these technologies pave the way for a more resilient and environmentally friendly energy ecosystem. Moving forward, further research and development in these areas will be essential to unlock their full potential and accelerate the transition towards a cleaner and more sustainable energy future.

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